

INVESTIGATING THE IMPACTS OF PIT LATRINES ON GROUNDWATER QUALITY IN BENUE STATE, NIGERIA

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Table of contents

Table of contents	ii
List of figures	xii
List of tables	xv
List of Plates.....	xviii
List of abbreviations.....	xx
Acknowledgement.....	xxi
Abstract	xxiii
Chapter 1: Introduction	1
1.1 Introduction	1
1.2 Access to safe water and sanitation in Nigeria.....	4
1.3 Statement of Research Problem	6
1.4 Aim and objectives of the study	9
1.5 Justification for the study	9
1.6 Outline of the Thesis Report	12
Chapter 2: Review of Related Literature	16
2.1 Introduction	16
2.2 Improved Sanitation and Water Access with Respect to the Millennium Development Goals (MDGs).....	16
2.3 The Joint Monitoring Programme for water and sanitation	19
2.4 Comparing the Millennium Development Goals (MDGs) and Sustainable Development Goals (SDGs).....	22
2.5 Sustainable Development Goals.....	22

2.5.1	Updated JMP Ladders for drinking Water, Sanitation and Hygiene	25
2.6	Recent Developments in Water and Sanitation Research	28
2.6.1	Faecal Flow Diagrams (FFDs)	28
2.6.2	Community Led Total Sanitation (CLTS)	28
2.7	A critical look at improved and unimproved sanitation	30
2.8	Access to improved water and sanitation in low- and middle-income countries..	34
2.9	‘Pro-Poor’ Water Supply and Privatisation.....	37
2.9.1	The growth of interest in the privatisation of water supply	37
2.9.2	Historical development of Water and Sanitation Privatisation.....	38
2.9.3	Critiques and challenges of privatisation	40
2.10	Gender and Water Supply	43
2.10.1	Background to Gender and WASH.....	43
2.10.2	Challenges to WASH and gender	45
2.10.3	Considerations beyond Gender	45
2.11	Causes of Poor Access to Water and Sanitation in Nigeria	46
2.11.1	Lack of political will	46
2.11.2	Inadequate funding.....	47
2.11.3	Management and Technical Limitations.....	48
2.12	Effects of Poor Water, Sanitation and Hygiene (WASH)	49
2.12.1	Health Related problems.....	49
2.12.2	Non-Health Related Problems	53
2.13	Possible Solutions to Poor Water Supply and Sanitation.....	55
2.13.1	Governments’ commitment to addressing water supply and sanitation	55
2.13.2	Increased funding to water and sanitation.....	56
2.13.3	Use of appropriate Technology and Management of facilities for Sustainable Development.	56
2.14	The nature of water quality standards	59
2.15	Improved/Unimproved Water and Sanitation Facilities’ Construction and usage and social aspects of contamination	62

2.16	Basic Groundwater Hydrology.....	66
2.17	Groundwater pollutants	68
2.18	Groundwater and Bacteria Movement through the Soil.....	70
2.19	Groundwater contamination	72
2.19.1	Sources of contamination.....	75
2.19.2	Contamination from different Groundwater sources.	80
2.19.3	Seasonal variation in contamination	81
2.20	Water Conflicts from Contamination and Resource Scarcity	82
2.20.1	The Complex Nature of Water.....	82
2.20.2	Water Security.....	83
2.20.3	Sanitation and Agriculture-related Contamination and Conflicts.....	84
2.20.4	Water conflicts among users, land uses and other interests.....	85
2.20.5	Examples of Water Conflicts creating crises	85
2.21	Conclusion.....	86
Chapter 3: The Study Area.....		88
3.1	Introduction	88
3.2	Background Information about Nigeria	88
3.2.1	Historical Background	88
3.2.2	Physical Background.....	90
3.2.3	Socio-Economic Background	92
3.2.4	Population trends and rural/urban and regional distribution in Nigeria.....	93
3.2.5	Key rural-urban differences	95
3.2.6	Urban and rural areas categories.	96
3.3	Benue State.....	96
3.3.1	Location and Extent of Benue State.....	96
3.3.2	Geology and Relief	99
3.3.3	Soils.....	100
3.3.4	Climatic Conditions	102
3.3.5	Drainage	103

3.3.6	Groundwater Resources	104
3.4	Water and Sanitation in Benue state.....	105
3.5	Conclusion.....	107
Chapter 4: Research Methodology and Methods.....		108
4.1	Introduction	108
4.2	Pilot survey.....	108
4.3	Ontological and Epistemological considerations for the study	109
4.4	Methodological Approach.....	112
4.5	Justification for choosing Benue State for the research	113
4.6	Brief Background Information about the Study sites.....	117
4.6.1	Makurdi (urban sites).....	117
4.6.2	Tse-Agberagba (Rural sites)	120
4.7	Integrating the different research approaches	122
4.8	Research Population and Sample	123
4.9	Data Collection and Sources	125
4.10	Methods of Data Collection	126
4.10.1	Questionnaires.....	126
4.10.2	Development and Testing of the Questionnaire.....	126
4.10.3	Administering the Questionnaire	127
4.11	Water Quality Analysis	129
4.11.1	Petrifilms.....	130
4.11.2	Procedure for using petrifilm	131
4.11.3	Reliability of petrifilms.....	132
4.11.4	Classification of colony count.....	134
4.11.5	Physico-chemical Parameters	138
4.12	Semi-structured Interviews.....	140
4.13	Other methods of Data collection.....	142

4.14	Analytical Techniques	147
4.15	Positionality.....	150
4.16	Survey Bias.....	152
4.17	Ethical Considerations.....	152
4.18	Methodological Limitations	153
4.19	Problems Encountered in the Field during Data Collection.....	154
4.20	Conclusion.....	157
Chapter 5: Nigeria Demographic and Health Surveys Data Analysis		158
5.1	Introduction	158
5.2	DHS Data Collection Times and Procedures	159
5.3	Background to the Demographic and Health Surveys	161
5.3.1	Demographic and health surveys regions and questions	163
5.3.2	Water supply and sanitation questions among the DHS surveys.....	166
5.3.3	Changes among the surveys	170
5.4	Water Supply Coverage (Nigeria).....	171
5.5	Sanitation coverage (Nigeria).....	172
5.6	North Central Region Water Supply	174
5.7	Sanitation (North Central Region)	175
5.8	Trends from North Central Region	177
5.8.1	Water Supply Trends	177
5.8.2	Sanitation Trends	178
5.9	Trends from Benue State	178
5.9.1	Water supply trends	178
5.9.2	Sanitation Trends	179
5.10	Benue State DHS Analysis.....	179
5.10.1	Water Supply.....	180

5.10.2	Improved and Unimproved Benue Water Sources	181
5.10.3	Improved and Unimproved Benue Sanitation.....	183
5.11	Variation in access to improved water and sanitation by rural/urban categories	186
5.12	Access to improved water and sanitation by socio-economic factors.....	188
5.12.1	Access to water and sanitation based on age	189
5.12.2	Access to improved water and sanitation based on gender.....	191
5.12.3	Access to water and sanitation based on Education.....	193
5.12.4	Access to water and sanitation based on wealth index	196
5.13	Questions raised by the DHS data in Benue State.....	200
5.13.1	Water supply questions	200
5.13.2	Sanitation questions	201
5.14	Conclusion.....	201
Chapter 6: Water Quality Data Analysis.....		203
6.1	Introduction	203
6.2	Distribution of wells according to improved and unimproved in the study sites	203
6.3	Distribution of Latrines based on Urban and Rural Sites.....	208
6.4	Physico-chemical Water Parameters data Presentation.....	211
6.4.1	pH Data Analysis.	211
6.4.2	pH statistical analysis.....	213
6.4.3	Temperature Analysis	215
6.4.4	Conductivity Analysis.....	217
6.4.5	Conductivity Statistical Analysis	219
6.4.6	Total Dissolved Solids (TDS) (ppt) Analysis	220
6.4.7	Total Dissolved Solids (TDS) Statistical Analysis	221
6.4.8	Nitrate Analysis.....	222
6.4.9	Nitrate Statistical Analysis.....	224
6.4.10	Chloride Analysis.....	226
6.4.11	Chloride Statistical Analysis	228
6.4.12	Chloride contamination and sediments types.....	230

6.4.13	Fluorides Analysis.....	231
6.4.14	Fluoride Statistical Analysis	233
6.5	Faecal Coliforms	235
6.5.1	Well-Latrine Distance	235
6.5.2	Faecal Coliform test results.....	239
6.5.3	Faecal Coliforms statistical analysis in the urban/rural sites and dry/wet seasons ..	248
6.6	Distribution of Faecal Coliform Counts based on Improved/Unimproved Wells	249
6.6.1	Faecal Contamination Statistical results	252
6.7	Possible Relationship among well characteristics variable	255
6.8	Faecal coliform contamination and sediment type	258
6.9	Conclusions	259
Chapter 7: Quantitative Analysis of Water Supply and Sanitation in Benue State		262
7.1	Introduction	262
7.2	Demographic Characteristics of Respondents.....	262
7.2.1	Breakdown of Respondents by Gender and Region	262
7.2.2	Education	264
7.2.3	Income.....	265
7.2.4	Employment Status	267
7.3	Access to Improved Water Supply	269
7.3.1	Improved water access definitions based on MDGs and SDGs.....	269
7.3.2	Improved water access in the study areas	271
7.3.3	Education and access to Improved Water supply	275
7.3.4	Access to improved water and income level.....	276
7.3.5	Round trip Duration for getting Drinking Water	277
7.4	Water Treatment.....	282
7.4.1	Status of Water Treatment in the Rural and Urban areas.....	282
7.4.2	Health risks associated with drinking unimproved water sources.	287

7.4.3	Understanding good quality wells and drinking Water.	288
7.4.4	Awareness on Water Contamination Levels.	290
7.4.5	Provision of potable water facilities by the government.	291
7.5	Sanitation.	293
7.5.1	Improved Sanitation Definitions based on MDGs and SDGs.	293
7.5.2	Toilet Sharing.	298
7.5.3	Toilet Sharing Status based on Educational Level.	300
7.5.4	Toilet Facility Sharing and Income Level.	301
7.5.5	Toilet Sharing Status according to Educational level	303
7.5.6	Toilet Sharing Status and Income Level	304
7.5.7	Disposal of Children’s faeces.	305
7.6	Environmental Awareness Matters	307
7.6.1	Understanding of risks of poor Environmental quality.	307
7.6.2	Hand washing at critical times.	308
7.6.3	Government’s involvement in Sanitation activities.	309
7.7	Conclusions	311
Chapter 8:	Qualitative Analysis of Water, Sanitation and Hygiene	313
8.1	Introduction	313
8.2	Follow-up questions from DHS analysis on Water supply	315
8.2.1	Access to improved water and sanitation.	315
8.2.2	Potable Water Supply Responsibilities	319
8.2.3	Effectiveness in tackling Water supply Responsibilities	321
8.2.4	Low tap water access and use of alternative sources	324
8.2.5	Low access to boreholes	328
8.2.6	Low use of rainwater.	329
8.2.7	Why surface water is used	330
8.2.8	Seasonality in the use of water sources.	330
8.2.9	Awareness of water quality and exposure to awareness campaigns	334
8.2.10	Water problem solutions	338
8.3	Follow-up questions from DHS analysis on Sanitation	340

8.3.1	Low access to improved sanitation	340
8.3.2	Low access to Ventilated Improved Pit (VIP) latrine and other improved sanitation facilities	342
8.3.3	Sanitation and hygiene-related public health campaigns	344
8.3.4	Effectiveness of stakeholders in tackling sanitation problems	346
8.3.5	Environmental Sanitation.....	349
8.3.6	Suggestions to improve sanitation	352
8.4	Conclusions	358
Chapter 9: Conclusion.....		363
9.1	Introduction	363
9.2	Trends in access to water and sanitation in urban and rural areas	364
9.2.1	Trends in access to improved water supply	364
9.2.2	Trends in access to improved Sanitation.....	371
9.3	Factors in well water Contamination and its awareness in Urban and Rural areas	374
9.4	Recommendations from the Study	376
9.4.1	Access to improved water supply	376
9.4.2	Access to improved sanitation	378
9.4.3	Well water contamination awareness.....	379
9.5	Strengths and Limitations of the Research.....	380
9.5.1	Strengths of the Study	380
9.5.2	Limitations of the Study.....	381
9.6	Concluding Remarks	382
9.7	Suggested areas for further research	383
References		385
Appendix 1: Household Survey Questionnaire		425
Appendix 2: Letter of Introduction for Interview with Government agencies		431

Appendix 3: Interview Guides for Government Agencies.....	432
Appendix 4: Participants’ Consent Form	433
Appendix 5: Household semi-structured interview guides	435
Appendix 6: DHS Water supply questions with options.....	439
Appendix 7: Report of Pilot Survey on Agencies involved in Water and Sanitation in Nigeria	442

List of figures

Figure 2.1: Groundwater flow	71
Figure 2.2 Schematic geological section (the vertical scale has been distorted to facilitate viewing).....	78
Figure 2.3: Illustration of Groundwater Contamination from Pit Latrines	79
Figure 3.1 Nigeria Showing Geo-political Zones	90
Figure 3.2 Nigeria Showing Administrative Boundaries and Benue State	91
Figure 3.3 Nigeria showing Benue state	97
Figure 3.4 Benue state showing the study areas.....	98
Figure 3.5 Geological Map of Benue State	100
Figure 3.6 Soil map of Benue State.....	101
Figure 4.1 Map of Makurdi Town.....	119
Figure 4.2 Satellite Images Map of Tse-Agberagba	121
Figure 5.1 Map of Nigeria showing the six Geo-political zones	164
Figure 5.2 Sources of drinking water for Nigeria	171
Figure 5.3 Types of toilet facility for Nigeria across DHS	172
Figure 5.4 Ventilated Improved Pit Latrine (VIP)	173
Figure 5.5 Sources of Drinking water for North Central, 1999-2013.	174
Figure 5.6 Types of Toilet Facilities for North Central for 1999-2013.	176
Figure 5.7 Benue State showing Local Government Areas	180
Figure 5.8 Source of Drinking Water Summary (%) (Whole of Benue state)	181
Figure 5.9 Improved and Unimproved Sources of Drinking water for Benue State.....	182
Figure 5.10 Toilet facilities for Benue State.	184
Figure 5.11 Improved and Unimproved Sanitation for Benue State.....	185
Figure 5.12 Access to improved water and sanitation on urban/rural basis (1999-2013).....	188

Figure 5.13 Access to improved water and sanitation based on age for 1999, 2003, 2008. ..	191
Figure 5.14 Access to improved water and sanitation based on age for 2010 and 2013.	191
Figure 5.15 Access to improved water and sanitation based on gender for 1999-2013	193
Figure 5.16 Water and Sanitation access based on Educational level for 1999, 2003 and 2008	195
Figure 5.17 Water and Sanitation access based on Educational level for 2010 and 2013	195
Figure 5.18 Access to water and sanitation based on wealth index for 2003 and 2008.....	199
Figure 5.19 Access to water and sanitation based on wealth index for 2010 and 2013.....	199
Figure 6.1 Urban Wells in Makurdi	205
Figure 6.2 Improved and unimproved well locations in Makurdi.....	206
Figure 6.3 Well site locations in Tse-Agberagba	207
Figure 6.4 Improved and unimproved Wells locations in Tse-Agberagba	208
Figure 6.5: Well-latrine location in urban sites (Sketch not to scale)	237
Figure 6.6: Another Well-Latrine Location Sample in urban sites (Sketch not to scale)	238
Figure 6.7: Well-latrine location in rural sites	238
Figure 6.8 Total Coliform Counts for Dry Season on Improved/Unimproved and Urban/Rural basis.....	246
Figure 6.9 Total Coliform Counts for Wet Season based on Improved/Unimproved and Urban/Rural	247
Figure 6.10 Dry Season Total Coliform Counts in Improved/Unimproved Wells	251
Figure 6.11 Wet Season Total Coliform Counts in Improved/Unimproved Wells.....	251
Figure 7.1 Educational Level of Respondents.	265
Figure 7.2 Income Level of Respondents.....	267
Figure 7.3 Employment Status in the Study Areas.	269
Figure 7.4 Main Sources of Drinking Water for Urban and Rural Sites.....	273

Figure 7.5 Access to improved and unimproved water by educational status	276
Figure 7.6 Access to Improved Water based on Income Level	277
Figure 7.7 Drinking Water Round Trip for Rural and Urban sites	279
Figure 7.8 Water hauling time and those involved	282
Figure 7.9 Water Treatment by Educational level	284
Figure 7.10 Water Treatment by Income level	285
Figure 7.11 Treatment of Improved/unimproved Water Sources	286
Figure 7.12 Diseases Suffered by Respondents	288
Figure 7.13 Good quality drinking water as perceived by respondents	289
Figure 7.14 Awareness of causes of diseases by the respondents.....	291
Figure 7.15 Respondents' Suggested Solution Strategies	293
Figure 7.16 Household Toilet Facility	295
Figure 7.17 Household Toilet facility according to Educational level	297
Figure 7.18 Household Toilet Facility based on Income level	298
Figure 7.19 Number of households Sharing Toilets	300
Figure 7.20 Toilet Sharing Based on Educational Level	301
Figure 7.21 Toilet Sharing based on Income Level	302
Figure 7.22 Toilet Sharing Status according to Educational level.	304
Figure 7.23 Toilet Sharing Status based on Income level.....	305
Figure 7.24 Child's Stool Disposal	306
Figure 7.25 Examples of problems associated with poor Sanitation	308
Figure 7.26 Respondents' Satisfaction with Government Agencies.....	310

List of tables

Table 2.1 Improved and Unimproved sanitation facilities.....	20
Table 2.2 Improved and Unimproved drinking water facilities.....	21
Table 2.3 Water Target and Normative Interpretation	23
Table 2.4: Sanitation Target and Normative Interpretation	24
Table 2.5 Categories of water, sanitation, and hygiene-related diseases	50
Table 2.6 Global Morbidity and mortality rates for WASH related diseases	51
Table 2.7 WHO and NSDWQ guidelines for some parameters of drinking water	60
Table 2.8 Minimum Distance (M) from Well	65
Table 2.9 Sources and pathways for urban groundwater contamination in SSA.....	76
Table 2.10 Some Latrine-Water recommended separation distances	77
Table 3.1 Population estimates for Nigeria	94
Table 3.2 Some Demographic Variables for Nigeria	94
Table 3.3 Soil codes and their description for soil map of Benue State	102
Table 3.4 Mean monthly rainfall from 1971-2000.....	103
Table 4.1 Activities undertaken in Urban and Rural Sites	124
Table 4.2 E.coli Risk Level Groupings	134
Table 5.1 Scales of Data Analysis in Nigeria Demographic and Health Surveys	163
Table 5.2 Water supply questions	166
Table 5.3 DHS sanitation questions with options	167
Table 5.4: Sanitation Questions with options.....	169
Table 5.5 Percentage of Household possession of consumer goods	197
Table 6.1 Study sites and their codes	205
Table 6.2 Mean Dry and Wet Season pH Values for Urban Sites	212
Table 6.3 Mean Dry and Wet Season pH Values for Rural Sites	213

Table 6.4 Kruskal-Wallis Summary Table for pH	214
Table 6.5 Mean Dry and Wet Season Temperature values for Urban Sites.....	216
Table 6.6 Mean Dry and Wet Season Temperature values for Rural Sites.....	217
Table 6.7: Mean Dry and Wet Season Conductivity (ms) values for Urban sites	218
Table 6.8 Mean Dry and Wet Season Conductivity values for rural sites	218
Table 6.9: Kruskal-wallis summary table for conductivity	219
Table 6.10 Mean Dry and Wet Season Total Dissolved Solids (ppt) Values for Urban Sites	220
Table 6.11 Mean Dry and Wet Season Total Dissolved Solids (ppt) values for Rural Sites .	221
Table 6.12 Kruskal-Wallis Summary Table for Total Dissolved Solids.....	221
Table 6.13 Mean Dry and Wet Season Nitrate values for Urban Sites.....	223
Table 6.14 Dry and Wet Season Nitrate Values for Rural Sites	223
Table 6.15 Kruskal-wallis Summary Table for Nitrates	224
Table 6.16 Mann-Whitney U Summary Table for Nitrates	226
Table 6.17 Mean Dry and Wet Season Chloride (mg/l) values for Urban Sites	227
Table 6.18 Mean Dry and Wet Season Chloride Values for Rural Sites	228
Table 6.19 Kruskal-Wallis summary table for chloride	229
Table 6.20 Mann-Whitney U summary table for chloride	230
Table 6.21 Mean Dry and Wet Season Fluoride values for Urban Sites	232
Table 6.22 Mean Dry and Wet Season Fluoride Values for Rural Sites.....	232
Table 6.23 Kruskal-wallis summary table for Fluoride	233
Table 6.24 Mann-Whitney U Summary Table for Fluoride.....	235
Table 6.25 Total descriptive statistics for well-latrine distance.....	236
Table 6.26: Descriptive statistics for well-latrine distance for urban and rural sites	236
Table 6.27 Well-Latrine distance	237
Table 6.28 Mean Dry and Wet Season Coliform without gas bubble values for Urban Sites	240

Table 6.29 Mean Dry and Wet Season Coliform without gas bubbles values for Rural Sites	241
Table 6.30 Mean Dry and Wet season Coliform with gas bubbles values for Urban Sites ...	242
Table 6.31 Mean Dry and Wet season Coliform with gas bubbles values for rural Sites.....	242
Table 6.32 Mean Dry and Wet Season Total Coliform Counts for Urban Sites.....	243
Table 6.33 Mean Dry and Wet Season Total Coliform (cfu) values for Rural Sites	243
Table 6.34: Dry Season Coliform Counts based on Improved and Unimproved Categories.	245
Table 6.35: Wet Season Coliform Counts Summary based on Rural/Urban and Well Improved/Unimproved Categories.	245
Table 6.36: Kruskal-wallis Summary Table for Faecal coliform.....	249
Table 6.37: Mann-Whitney U Summary Table for Faecal coliform.....	253
Table 7.1: Breakdown of Respondents by Gender and region.....	263
Table 8.1: Activities of government agencies working in water and/or sanitation in Benue State	320

List of Plates

Plate 1.1: A polluted drainage channel in Makurdi and Plate 1.2: A polluted channel enters River Benue.....	8
Plate 1.3: Water hauling at Tse-Agberagba and Plate 1.4: Collecting water at the Dam at Tse-Agberagba	8
Plate 2.1: Water, Sanitation and Hygiene Ladders.....	27
Plate 4.1 Well-Latrine distance measurement (A) and well depth measurement (b).....	129
Plate 4.2 Cooler for water samples (A) and sterile water sample bottles (B)	130
Plate 4.3 Borehole Sampling.....	136
Plate 4.4 Petrifilm Inoculation	137
Plate 4.5 No growth on Distilled Water (A) and Petrifilm Sample with growth (B).....	138
Plate 4.6 Physical field Water Testing	139
Plate 4.7 Fluoride chemical testing (A) and Nitrate chemical testing (B)	140
Plate 4.8 Chloride chemical testing sample	140
Plate 4.9 Questionnaire Interviews (A) and semi-structured Interviews (B)	143
Plate 4.10 Poor sanitary condition at Kanshio (A) and poor sanitary condition at Wurukum (B)	143
Plate 4.11 A poorly constructed toilet in Wadata.....	144
Plate 4.12 Drawing water from an unimproved well in North Bank	145
Plate 4.13 Borehole Queue in dry season at Tse-Agberagba	145
Plate 4.14 A sample of a compound with tenants in Makurdi	146
Plate 4.15 A dry season urban water source.....	146
Plate 4.16 A polluted drainage channel going into River Benue	147
Plate 6.1 An improved well in Tse-Agberagba (a) and an unimproved well in Makurdi (b)	204

Plate 6.2 An improved Latrine in Makurdi (a) and an unimproved latrine in Tse-Agberagba (b)	210
Plate 6.3 An inside of an improved latrine (a) and an outside of an Improved Latrine (b) ...	210
Plate 6.4 Labelled and incubated Coliform Count Plates.....	239
Plate 6.5: An example of a compound with well	255
Plate 6.6 Surface Water Supply (A) and borehole Water Supply in Dry in Tse-Agberagba .	255
Plate 8.1: Water buying in Makurdi (a) and Borehole queues at Tse-Agberagba (b).....	333
Plate 8.2:Surface water at Tse-Agberagba (a), Sample of surface water at Tse-Agberagba(b)	336
Plate 8.3: A compound with Toilet sharing in Makurdi (a) An unimproved Toilet in Tse-Agberagba (b).....	344
Plate 8.4: A roadside rubbish at Tse-Agberagba (a) and a polluted drainage in Makurdi (b)	352

List of abbreviations

ARGOSS.....Assessing the Risk to Groundwater from On-Site Sanitation

BENSESA.....Benue State Sanitation Authority

BERWASSA.....Benue Rural Water Supply and Sanitation Agency

CLTS..... Community Led Total Sanitation

FEPA..... Federal Environmental Protection Agency

FFD.....Faecal Flow Diagrams

JMP.....Joint Monitoring Programme

MDGs.....Millennium Development Goals

MICS.....Multiple Indicator Cluster Survey

NDHS.....Nigeria Demographic and Health Surveys

NSDWQ..... Nigeria Standard for Drinking Water Quality

POU.....Point-of-use-treatment

SDGs.....Sustainable Development Goals

TDS.....Total Dissolved Solids

UNDP.....United Nations Development Programme

UNICEF.....United Nations Children Emergency Fund

WASH.....Water Sanitation and Hygiene

WHO.....World Health Organisation

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Abstract

The study investigated the impacts of pit latrines on groundwater quality in Benue State, Nigeria. A mixed methods approach was adopted for the investigation. Initially, a desk-based study using Demographic and Health Survey (DHS) data was carried out for a period of thirteen years (1999-2013) to get trends in access to improved water supply and sanitation in Nigeria and Benue State. Water testing, questionnaire administration and semi-structured interviews administration were carried out in the field. The findings showed that access to water and sanitation were low in the study areas. The DHS analysis showed that access to improved water supply in Nigeria and Benue State in form of tap water on average was below 30% for all the survey years while access to improved sanitation (flush toilets) had been below 20% on average in the survey years. In both cases, the urban areas had higher access to improved water and sanitation than the rural areas. On average, educated people had twice as much access to improved water and three times as much access to improved sanitation than uneducated people. Urban residents had an advantage over rural dwellers and wealthier people were twice as likely to have access to improved water than the poor and up to three times more likely to have access to improved sanitation. Of the wells sampled, 65% were improved and 35% were unimproved based on JMP definitions.

Petrifilm count plates were used to test water for faecal coliforms. The results were considered under main categories of improved/unimproved wells, rural/urban locations and dry/wet seasons. Improved wells on the whole had 92% of contaminated samples falling into the ‘very high’ contamination range compared with unimproved wells that had 97% of the samples that showed ‘very high’ category. A breakdown into seasons and locations show that the dry season improved wells in the urban areas had 90% of samples falling into the ‘very high’ contamination group while the rural areas showed 94% in the ‘very high’ contamination range. Unimproved wells on the other hand had 95% of samples with ‘very high’ contamination in the urban areas

and 100% ‘very high’ contamination in the rural areas. In the wet season, improved wells displayed 97% ‘very high’ contamination in the urban areas compared with the rural areas having 65% of samples falling in the ‘very high’ contamination group. In the case of unimproved wells, the urban areas had 95% ‘very high’ contamination while the rural areas had 69% of the samples in the ‘very high’ contamination category. Well-latrines distance, number of well users and well depth were also linked with contamination but showed a relationship of less than 30% in each of the variables investigated. On contamination awareness, 60% of urban respondents and 73% of rural respondents reported being aware of poor water, sanitation and others causing diseases from contamination. Water treatment (improved) was carried out by 78% and (unimproved) 22% of urban dwellers compared with (improved) 87% and (unimproved) 13% of those in the rural areas. Most of the treatments were straining the water through a cloth which is not effective according to JMP.

The poor level of access to water and sanitation reported in the DHS surveys was confirmed in the field. Consequently, 40% of urban respondents and 66% of rural respondents reported being affected or having relatives affected with water-related diseases such as typhoid or diarrhoea. The government was not able to provide potable water for the people and 38% urban and 64% rural people opined that the provision of tap water by the government would help to solve the water problems.

General environmental sanitation was also poor with some contamination risks observed and photographed. In the semi-structured interviews many respondents, in the dry season, especially in the rural areas travelled or waited at water collection points for an average of three hours to get drinking water from boreholes and unprotected springs. The scarcity of water in the dry season affected sanitation and hygiene practices. Many people were not aware of groundwater contamination, confirming findings from questionnaire surveys. The government agencies

acknowledged contamination issues but identified funding, labour shortages, equipment and other logistics issues to have limited their performance.

It was recommended that issues militating against government agencies' operations should be addressed so that the people can be provided with potable water in the form of tap water to ease the problem of poor water supply and water borne diseases. Low cost sanitation and more hygiene practises were also recommended.

Chapter 1: Introduction

1.1 Introduction

For quite some time, the international community has been aware of the need for improved water supply and sanitation as important amenities for living. These were highlighted during the Stockholm Conference in 1971 and again at the UNCED conference in Rio de Janeiro, Brazil in 1992 (see Chapter 2:). Consequently in 2000, the Millennium Development Goals (MDGs) were set. The seventh goal of the (MDGs) targets was to halve, by 2015, the proportion of the population without sustainable access to safe drinking water ([World Health Organisation and United Nations Children's Fund, 2010](#)). Following the 2002 World Summit conference on Sustainable Development in Johannesburg, South Africa, a sanitation-related target was added to the UN Millennium Development Goals which set out to halve, the proportion of people without access to basic sanitation by 2015 ([World Health Organisation and United Nations Children's Fund, 2010](#)). This was not achieved by many nations including Nigeria.

The Sustainable Development Goals (SDGs) which transitioned from the MDGs also has targets to achieve water and sanitation for all by 2030. Details about the goals are found in Chapter 2:. In the efforts towards improving living conditions, the United Nations acknowledges and recognises the basic human rights to water and sanitation as evidenced in its general assembly resolutions ([Gupta *et al.*, 2010](#)). Pursuant to this, Sustainable Development Goal (SDG) 6 aims ‘to achieve universal and equitable access to safe and affordable drinking water for all by 2030’ and ‘achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations’ ([World Health Organisation and United Nations Children's Fund, 2017a](#)). Therefore, good living conditions imply access to good water supply, good sanitation and basic hygiene, yet these things are not always readily available in Nigeria, as evidenced from the earlier Demographic and Health Surveys (DHS) data analysis found in Chapter 5:.

According to [World Bank \(2017\)](https://data.worldbank.org/indicator/SP.POP.TOTL) (<https://data.worldbank.org/indicator/SP.POP.TOTL>) the global population figures were 7.357 billion in 2015, upon which the JMP based their report. Subsequent water and sanitation access figures are therefore based on these global population figures. For instance, the [World Health Organisation and United Nations Children's Fund \(2017a\)](#) reports that about 2.1 billion people in the world do not have access to safely managed water. Out of this number, 844 million do not have basic drinking water services. Some 263 million people spend over 30 minutes per trip collecting water from sources outside their house while 159 million people drink water from surface sources such as streams or lake ([World Health Organisation and United Nations Children's Fund, 2017b](#)). In terms of sanitation the [World Health Organisation and United Nations Children's Fund \(2017a\)](#) reports that 4.5 billion globally do not have access to safely managed sanitation services while 2.3 billion people do not have basic sanitation services. Some 600 million people share sanitation services with other households and 892 million defecate in the open, especially in rural areas. The report also noted that open defecation is on the increase in absolute terms in Sub-Saharan Africa due to population growth.

Another report by the United Nations Sustainable Development Goals (SDGs) also reveal that 2.6 billion people have gained access to improved drinking water sources since 1990, but 663 million people are still without. At least 1.8 billion people globally use a source of drinking water that is faecally contaminated and 2.4 billion people lack access to basic sanitation services, such as toilets or latrines ([World Health Organisation and United Nations Children's Fund, 2017a](#)).

Due to the poor water and sanitation access in developing countries, diarrhoea is reported to cause 842,000 deaths yearly including 361,000 children under five years of age. The absence of water in some places affects handwashing and increases the risk of diarrhoea and other diseases. Although diarrhoea is more popular, some 240 million are affected by schistosomiasis,

a condition which is caused by a parasitic worm from infested water ([World Health Organisation and United Nations Children's Fund, 2017a](#)). The UNDP report that half the hospital beds in developing countries are filled with people suffering from diseases caused by poor water, sanitation and hygiene (UNDP: Human Development Report, 2006, cited in [WaterAid \(2014\)](#)). While basic hygiene is helpful, it is not always practised in developing countries. In line with this, the World Bank stressed that hygiene promotion is the most cost-effective health intervention [WaterAid \(2017a\)](#).

With reference to Africa, [World Health Organisation and United Nations Children's Fund \(2015\)](#) noted:

“The urban population without sanitation services doubled from 88 million in 1990 to 175 million in 2008, and similarly, the number of people without access to fresh water increased from 29 million in 1990 to 57 million in 2008. Access to safe drinking water and sanitation is even more restricted in densely populated areas, slums and peripheries. Residents therefore often depend on informal water vendors and are forced to pay prices between 20 and 100 percent higher than the costs for drinking water from public or private utilities”.

According to the MDG monitoring programme, [World Health Organisation and United Nations Children's Fund \(2010\)](#), Sub-Saharan Africa is one of the most vulnerable regions with regards to the impacts of water scarcity and sanitation. The proportion of population using an improved water source between 1990 and 2008 in Sub-Saharan Africa was 49% ([World Health Organisation and United Nations Children's Fund, 2010](#)). There appears to be little progress as [World Health Organisation and United Nations Children's Fund \(2017a\)](#)'s snapshot for Africa reported that 404 million people in WHO African region lacked a basic drinking water service in 2015 and 84% of whom live in the rural areas. In terms of sanitation, the same report stated that in the WHO African region, 687 million people lacked a basic sanitation service in 2015 and 216 million practise open defecation. This is partly because the region is limited both in its technical and financial capacities to address effectively its water challenges. In addition, socio-cultural norms and the low levels of environmental education have resulted in water use and

sanitation habits that have compromised drinking water quality at many locations ([World Health Organisation and United Nations Children's Fund, 2010](#)). While the MDGs era has passed, the targets were not achieved, and we are now in the SDG era.

1.2 Access to safe water and sanitation in Nigeria.

[WaterAid \(2014\)](#) reports that 63.2 million Nigerians don't have access to improved water sources while over 112 million don't have access to improved sanitation. Apart from other hardships associated with these problems, an estimated 970,000 suffer from water and sanitation related diseases every year. Nigeria's cities generally have no central sewer systems, leaving residents with household closed-pit sewer units (soak-aways) and, in some cases, pit latrines (shallow wells dug for toilet usage). It is also common to see liquid waste (leachate), emanating from dysfunctional household toilets and bathrooms, flowing openly in backyards. Sometimes effluents from septic tanks flow into open drains and rivers. Many Nigerian towns also lack access to piped water sources. Instead, households rely on shallow groundwater wells for their drinking water because the city public water supplies are unreliable and sometimes completely absent for weeks or even months. Most people therefore rely on wells and water from surface water sources such as streams. To get water, people construct hand dug wells, many of which are unlined or uncovered (and therefore vulnerable to faecal contamination), from which they draw water for drinking and other domestic purposes ([Ubogu and Rimomson, 2008](#)). Reliance on unimproved wells and streams as key water sources is an indication of the poor quality of water people use ([Ubogu and Rimomson, 2008](#)).

[Mustafa and Yusuf \(1999\)](#) observed that the location of sanitation facilities is also very important as they affect the quality of drinking water sources. The construction of pit latrines within compounds or close to dwelling units can result in the contamination of groundwater with effluent from pit latrines; especially when pit latrines are constructed close to shallow, unlined or uncovered wells. [Mustafa and Yusuf \(1999\)](#) noted that faeces and urine pose health

risks due to the presence of pathogens in faeces and the mobility of nutrients and micro pollutants in urine. Therefore, for a sanitation system to be sustainable, it has to be economically viable, socially acceptable and technically and institutionally appropriate and should protect environment and natural resources ([Katukiza *et al.*, 2012](#); [Langergraber, 2013](#)).

Access to improved water and sanitation has been low in Nigeria as the country did not meet the water and sanitation targets of the MDGs. Considering this, the [World Health Organisation and United Nations Children's Fund \(2017a\)](#) snap shot for drinking water, sanitation and hygiene further reported that in Nigeria 59 million people had no access to basic water services in 2015 while 47 million people practice open defecation in 2015. The figure given by JMP is less than that given by WaterAid probably due to a reduction in open defecation after 2014.

A detailed analysis of the Demographic and Health Survey [DHS \(2013\)](#) data for Benue State showed poor access to water and sanitation. In the survey years, both water and sanitation access were less than 20%. This informed and also justified the choice of Benue State for a detailed study. The research took place in Benue State, Nigeria which, despite its relatively high levels of natural and human capital, is one of the poorest states in the North Central region. The study area has been chosen because of its low levels of access to improved water and sanitation in order to understand the detailed situation with a view to solving the problem. Benue State falls among the lowest state with access to improved water and sanitation in Nigeria.

This research seeks to investigate how water contamination levels vary between wells with different construction, use, ownership and locational characteristics in urban and rural areas of Benue State. These mentioned characteristics are common pathways of groundwater contamination and hence are important to incorporate into the study. The WHO/UNICEF Joint Monitoring Programme's (JMP) definitions of 'improved' versus 'unimproved' water and sanitation facilities (found in Chapter 2:) are central to the research which involved simple water

quality tests to measure faecal contamination levels and selected physico-chemical parameters in wells that can be characterised, according to their construction characteristics, as ‘improved’ and ‘unimproved.’

1.3 Statement of Research Problem

The problem of water and sanitation is common in Nigeria and has attracted media and academic attention. For instance, in the Punch (a national Nigeria) newspaper, the following report was made in Lagos: “a new finding has revealed that residents who use water from bore holes constructed within their compounds in well-off areas of Lagos state such as Ikoyi and Lekki might unknowingly be drinking or using water contaminated with their own human faeces”. The Punch report went on to highlight the impacts of human waste disposal in Lagos lagoon and suggest that the construction of septic tanks in these well-off parts of Lagos was risky, due to waste seepage from the septic tanks into the ground ([DEOLU, 2013](#)).

Consequently, there are reports of diseases mostly related to water and sanitation in many parts of the country. For instance [Adebayo \(2016\)](#) reported that cholera had killed six people in Isolo local government area of Lagos State and 39 were under investigation and receiving treatment in the hospital. It was stated in the paper that the victims had eaten contaminated food caused by a bacterium *vibrio cholerae* characterised by acute diarrhoea with or without vomiting. According to the newspaper report, the commissioner for health, Lagos State, said:

“The main suspected source of infection is the salad called Abacha, a staple food that is consumed regularly in the area. Samples of the local salad and the well water they consume in the area revealed the presence of *vibrio cholerae*, *Salmonella* species and *E. coli* in Abacha and the water sample taken from one of the two wells in the area” ([Adebayo, 2016](#)).

In the same vein, [Gummi \(2017\)](#) reported that 80 people died of cholera in one month in Zamfara state and is quoted here:

“The Commissioner for Health in Zamfara, Alhaji Suleiman Gummi, said that no fewer than 80 people had been killed by cholera outbreak in the state in the last one month. The commissioner told newsmen on Tuesday in

Gusau that 500 others were currently receiving treatment at various health facilities in the state. He said the disease had spread to 10 out of the 14 local government areas of the state.....The commissioner appealed to the citizens of the state to keep their environments clean and ensure to prepare their food under hygienic conditions” (Gummi, 2017).

The paper went further and explained that cholera is an infectious disease which can lead to dehydration and may even result in death if not treated. The problem of water and sanitation is a serious one in Nigeria and Benue State in particular. Both rural and urban areas of the state are affected. Of particular note and concern is the seasonal variation in water. In the dry season, the problem of getting water for drinking and other domestic uses is more pronounced. Residents in urban areas depend on water vendors for purchasing water and in some cases are not aware of the sources of such water. In rural areas, few water vendors are present, and people have to queue at limited boreholes or travel several kilometres to water sources and carry it home on their heads (see Plate 1.3 and Plate 1.4).

There are also challenges with sanitation and while most people can construct latrines in their compound others still practice open defecation; often in busy yet hidden places. Some people do not have a soak-away to collect faeces, so latrine waste travels via open drains to the river Benue (see Plate 1.1) shows a drainage channel in Wadata, Makurdi. The river water is used by many people for a range of purposes including drinking, creating environmental health risks in the process (see Plate 1.2).



Plate 1.1: A polluted drainage channel in Makurdi and Plate 1.2: A polluted channel enters River Benue
Source: Fieldwork 2016



Plate 1.3: Water hauling at Tse-Agberagba and Plate 1.4: Collecting water at the Dam at Tse-Agberagba
Source: Fieldwork 2016

1.4 Aim and objectives of the study

The aim of the study is to investigate faecal contamination of well water in Benue state, and to explore the extent to which this varies between improved and unimproved facilities as defined by the UN's Joint Monitoring Programme.

To achieve the aim, the following objectives are set out:

1. To analyse DHS datasets from 1999 to 2013 to:
 - Identify trends in access to improved water supply and sanitation facilities in Benue state and Nigeria as a whole.
 - Identify variations in access to improved water supply and sanitation by socio-economic factors and rural/urban locations in Benue state.
2. To select, sample and test for faecal coliforms from well water samples from improved and unimproved wells that are situated in the same compounds as both improved and unimproved pit latrines in urban and rural areas of Benue state.
3. To collect baseline data on wells sampled including the nature of their location (rural/urban), construction type (improved/unimproved), ownership and usage (i.e. owned/used by a single family or shared and if so by how many people and animals) and distance between wells and pit latrines in the same compound.
4. To explore different stakeholders' understanding of well water contamination levels and causes and how these are perceived to vary in different types of wells in rural and urban areas of Benue state.

1.5 Justification for the study

The problem of inadequate water supply and sanitation has been a serious issue of concern among the populace in Nigeria and Benue State. The Nigeria Demographic and Health Surveys analysed from 1999 to 2013 showed the trends of poor access to improved water and sanitation

in all the survey years. There are also many reports of diseases caused by poor water and sanitation in the study area ([Utsev and Aho, 2012](#); [Maxwell et al., 2012](#)). The problem of poor access to water and sanitation has attracted the attention of even government officials such as ministers, senators and even the presidency. In the media, the problem has featured on the radio, television and even in churches. Some major NGOs such as UNICEF and WHO have raised concerns and even intervened in some areas on water, sanitation and hygiene. Some politicians also use the problem of water, sanitation and other social services as items of campaign to be voted into offices. There have been public outcries from various groups/stakeholders about water supply and sanitation situation. It is clear that the problem of inadequate water supply and sanitation requires more research with a view to elucidate the problems and pave way to solutions.

While the problems of water and sanitation linger on, the media has been playing a role in bringing the problem to the fore. Academic researches have been carried out on the problems in the study area including a PhD thesis by [Akange \(2016\)](#) submitted to Walden University. He looked at the relationship between potable water availability and economic development of North Senatorial District of Benue State. He concluded that lack of potable water has negative effects on the economic development of Benue State. He suggested that developing a state model would improve water supply which could have positive impact on health, economic and social development of Benue State and Nigeria. Research for a M.Ed. was undertaken by [Obute \(2010\)](#) and submitted to University of Nigeria, Nsukka which examined service delivery, constraints and prospects of water and sanitation in Benue State. The study found out that potable water, refuse disposal and sewage disposal were inadequate. The constraints were inadequate funding, lack of government legislation and inadequate manpower. In another study submitted to the same University, [KIMBI \(2013\)](#) looked at Water management and sanitation practices in Katsina Ala local government area of Benue State. The study concluded that dug

wells, boreholes and rainwater were the main water sources available in the study sites. The sanitation systems include landfills, uncontrolled dumping, traditional pit latrine and bush were the methods of solid and sewage waste disposal practices and these did not vary with demographic variables. Apart from these, some studies have been carried out on water and sanitation in Benue State including [Jombo *et al.* \(2007\)](#)'s report on the relationship between potable water, sewage disposal and intestinal parasitism. They concluded that in areas where the quality of water supply and methods of sewage disposal are poor, multiple parasitic infestation were common. As disease intensity is high, they recommended Federal Government's intervention by providing potable water to the communities. [Oluma *et al.* \(2010\)](#)'s article investigated water quality in Benue State and reported that shallow wells were contaminated with faecal coliform beyond accepted WHO limits and were unsafe for drinking. [Aper and Agbehi \(2011\)](#) while researching determinants of rural water supply in Benue State concluded that water needs by the people well exceeded supply with no community having adequate supply. [Maxwell *et al.* \(2012\)](#) profiled water related diseases in Benue State and concluded that the disease incidence was high and in order of magnitude included malaria, diarrhoea, dysentery, filariasis, onchocerciasis, schistosomiasis, typhoid and cholera. They advocated safe water supply for the people. [Okoye and Nyiatagher \(2009\)](#)'s article studied water quality in Gboko, Benue State and reported that shallow wells had elevated levels of iron and copper in line with WHO limits. They also found chromium and lead which indicated anthropogenic activities. [Utsev and Aho \(2012\)](#) on health impacts associated with water shortage in Benue State reported that water sources in the study sites were unsafe for drinking and shortage of water was associated with health impacts as people could not avoid using the poor water sources. [BANKE *et al.* \(2017\)](#) studied the relationship between gastro-intestinal parasites and the availability of sanitary facilities among school children in Makurdi. They reported that gastro-intestinal parasites were higher in schools with high ratios of pupils per

toilet than in schools with lower ratios of pupils per toilet and [Akali *et al.* \(2014\)](#) studied provision of sustainable water supply system in Benue State and concluded that due to poor or lack of maintenance, the existing water system broke down. Consequently, the people depend on drinking water from unprotected wells, rivers and streams which can cause sanitation and water related diseases such as diarrhoea and cholera.

These studies mentioned above have considered many aspects related to water supply and sanitation, including some health impacts associated with water supply and sanitation inadequacies and other issues related to water and sanitation in Benue State. However, none of the studies investigated the problem of water and sanitation in enough detail to create a grounded understanding of the issues. Benue's water and sanitation problems are therefore under researched and consequently not well understood. There is a knowledge gap occasioned by the worsening situation of water and sanitation issues in the area. This study is therefore justified as it will further understanding of water and sanitation problems affecting Nigeria and Benue State and help to identify ways for addressing or solving these problems. The study will help policy makers and contribute to both the theory and practice of water supply and sanitation in Nigeria and South-Saharan Africa generally.

1.6 Outline of the Thesis Report

The thesis is organised in nine chapters. The outline of each of the following chapters is presented as follows:

Chapter one: Introduction

This chapter introduces the entire thesis and contextualises the research. It considers background to the study, the statement of the research problem, the aim and objectives of the study, purpose of the study and finally, justification for carrying out the research.

Chapter Two: Literature Review

This chapter focuses on presenting a review of literature related to the main items covered in the research. These include concepts of improved and unimproved water and sanitation in relation to the Millennium Development Goals (MDGs) along with background on the JMP's approach to monitoring access to improved water and sanitation in the developing world. The concepts of water quality improved and unimproved sanitation technologies and use are also discussed along with related issues of groundwater pollution and groundwater flow. The debate on pro-poor water and privatisation, gender and water supply, water contamination and conflicts were covered in this chapter. Since the research made use of JMP definitions from the beginning, the Sustainable Development Goals (SDGs) now in operation to monitor progress in water and sanitation are also being used in the research. Some new and related developments in water and sanitation were also included in this chapter.

Chapter Three: The study area

This chapter provides details on Nigeria's physical and socio-cultural contexts. It then goes on to provide background information on Benue state including climate, water resources, geology, relief, soils and drainage followed by an overview of water and sanitation policy for Benue State.

Chapter Four: Methodology and Methods

This chapter outlines the methodology adopted to investigate the research problem as well the tools employed to achieve this. The ontological and epistemological considerations of the study are explored, and the chosen methodology is set out and justified. Information is provided on the selection of the study sites and the research samples followed by an explanation of data collection methods and analytical techniques used for the study. This chapter also provides

information on researcher positionality, ethical considerations, problems encountered in the field with associated solutions and methodological limitations.

Chapter Five: Nigeria Demographic and Health Surveys Data Analysis

This chapter analyses Nigerian Demographic and Health Surveys (NDHS) data from 1999 to 2013 and highlights trends in access to water supply and sanitation in Nigeria and Benue State during this period. The trends from the analysis show that access to water supply and sanitation in Benue State has been low and the data analysis results justify the selection of Benue State as the study site. The analysis also helped in identifying areas for detailed investigations in the field.

Chapter Six: Water quality Data Analysis

The data collected from the testing of water samples are presented in this chapter. Using tables and statistical techniques, comparisons are made between improved and unimproved wells, urban and rural water samples, variations in contamination among various sites and seasons and other considerations.

Chapter Seven: Water and sanitation

This chapter focuses on the analyses of water and sanitation data acquired mainly from the questionnaire survey. Access to water and sanitation is compared between urban and rural areas, improved and unimproved wells, dry and wet seasons with a range of demographic variables being considered in the process. Other issues considered were contamination awareness, water treatment, and health issues associated with poor water and sanitation and respondents' opinions on water and sanitation matters.

Chapter Eight: Qualitative analysis of WASH using Semi-Structured Interviews

This chapter presents information followed up on respondents from the DHS analysis questions found in chapter five. Awareness of contamination, and other WASH issues were considered and were based on data collected through semi-structured interviews conducted with residents and government agencies involved in water and sanitation. Comparisons were made between urban and rural sites in the process of data presentation and analysis.

Chapter Nine: Conclusions

This chapter draws conclusions on the major findings of the study in line with the aim and objectives set that guided the entire study. The highlights include the observation that access to water and sanitation were low according to both MDG and SDG criteria and confirm patterns arising from the DHS data analysis. The rural sites had poorer access compared to the urban sites. The wells sampled were heavily contaminated with faecal coliform and contamination was higher in the dry than the wet season and higher in urban sites. Contamination was influenced by well-latrine-distance, the number of well users and other well characteristics. There was some awareness of contamination (more in the rural than urban areas) but no significant treatment of water resources even though respondents were not satisfied with the quality of the water they used. The residents are of the view that the provision of potable water by the government and legislation and enforcement would help to improve water and sanitation in the study sites. The government agencies were also aware of contamination issues but could not address the issues well due to insufficient resources and other problems. The chapter identifies the strengths and limitations of the study and outlines areas needing further research.

Chapter 2: Review of Related Literature

2.1 Introduction

From the DHS data analysis, literature and observations in the field, improved water and sanitation access are low in the study sites. In the preceding chapter, a general introduction to the entire investigation was presented. In the present chapter, a review of literature on water and sanitation issues is carried out. The first parts of the review consider the broad background and concepts related to water and sanitation and their developments over the past three decades. The next parts look at water and sanitation in the developing world with particular attention to Nigeria. The Joint Monitoring Programme (JMP) on water and sanitation is explored. Other topics covered include pro-poor water supply and sanitation and privatisation debates; gender and water supply; groundwater contamination and conflicts; groundwater concepts; well construction; Sustainable Development Goals (SDGs); causes, effects and problems of poor water and sanitation; and other recent developments in water and sanitation sector.

2.2 Improved Sanitation and Water Access with Respect to the Millennium Development Goals (MDGs).

The post-World War II era has experienced reconstruction and development efforts by many nations under the umbrella of the Bretton Woods institutions. Preparatory to the Millennium Development Goals (MDGs), many international conferences led by the United Nations took place which finally resulted in the development of the MDGs.

In June 1972, there was a United Nations (UN) Conference on the Human Environment in Stockholm, Sweden popularly known as the Stockholm Conference. This followed from a proposal by Sweden for an international conference to examine problems of the human environment and to identify how to address them through international cooperation and agreement ([Ki-Moon, 2013](#)). The conference was not silent on water supply. It noted that future work on water issues would be in the context of waste management. But before the

commencement of waste management, the International Environmental Technology Centre (IETC) had facilitated the implementation of Environmentally Sound Technologies (ESTs) for water to improve resource efficiency and to enhance ecosystem management practices. These activities were undertaken through the demonstration of ESTs in ecologically sensitive and water scarce areas (UNEP, 2016). The Stockholm Conference produced a declaration on the human environment, an action plan for the human environment and a resolution on institutional and financial arrangements. The major outcomes of the Stockholm Conference were 26 principles concerning environment and development (UNEP, 2016). Of these principles, only principle '2' mentioned water stating, "The natural resources of the earth, including the air, water, land, flora and fauna and especially representative samples of natural ecosystems, must be safeguarded for the benefit of present and future generations through careful planning or management, as appropriate" (UNEP, 2016). Sanitation was not mentioned in any of the principles.

Following the Stockholm conference was the water conference held in Mar del Plata, Argentina in 1977. The conference set to address the challenges of poor water supply in some parts of the world, especially Africa and Asia. This led to the international water supply and sanitation decade (1981-90). The main goal of this decade was to provide all people with water of safe quality in adequate quantity and basic sanitation facilities by 1990. The decade achieved significant coverage and set the foundation for a radical approach to water and sanitation sector development. The failure of the decade was its reliance on community participation and management, which was not better than national government institutions arrangements (O'Rourke, 1992). Monitoring efforts were also made by the United Nations and other international organisations to provide basic water services. It should be noted here that at this time, sanitation was not an item of attention on its own.

In June 1992, the United Nations Conference on Environment and Development (UNCED) was held in Rio de Janeiro, Brazil. A key output of the conference was Agenda 21, the Rio Declaration on Environment and Development, the Statement of Forests Principles, the UN Framework Conventions on Climate Change and the UN Convention on Biological Diversity. In terms of water and sanitation, the latter was only mentioned in Agenda 21 chapter 18.5 sub-section (d) as part of a broader discussion on ‘Drinking water supply and sanitation’ (United Nations Conference on Environment and Development, ([United Nations, 1997](#))). The rest of the items were all focused on water. This illustrates the tendency to place far more emphasis on water than sanitation.

The conference also highlighted that in developing countries, annually, about 4 billion cases of diarrhoea and 2.2 million deaths occur; intestinal worms infect about 10% of the population, while about 6 million people are blind from trachoma and 200 million people are affected with schistosomiasis ([United Nations, 1997](#)). In pursuit of “Water for All”, the Water Supply and Sanitation Collaborative Council at the Second World Water Forum at The Hague, in March 2000, presented global targets as part of the Vision 21 global target for water supply and sanitation. These targets were:

1. By 2015, reduce by one-half, the proportion of people without access to hygienic facilities.
2. By 2015, reduce by one-half, the proportion of people without sustainable access to adequate quantities of affordable and safe water.
3. By 2025, provide water, sanitation and hygiene for all.

To improve the quality of life, many nations agreed, in the year 2000, to 8 key goals based upon the millennium declarations which sought to accelerate development. These became known as the Millennium Development Goals (MDGs) and included goals to:

1. Eradicate extreme poverty and hunger
2. Achieve universal primary education
3. Promote gender equality and empower women
4. Reduce child mortality
5. Improve maternal health
6. Combat HIV/AIDS, malaria and other diseases
7. Ensure environmental sustainability.
8. Develop a global partnership for development ([Ki-Moon, 2013](#)).

Water was one of the original MDG targets which came under goal 7 (Ensure environmental sustainability) and sought to halve, by 2015, the proportion of the population without sustainable access to safe drinking water ([Ki-Moon, 2013](#)). Indicating the neglect of sanitation compared to water, a sanitation-related target was only added to the MDGs following lobbying at the 2002 World Summit conference on Sustainable Development. This target was essentially copied from the water target with the aim of halving the proportion of people without access to basic sanitation by 2015 ([Ki-Moon, 2013](#)). These goals are interwoven, as work on some touches on others. However, in this chapter, attention is mostly paid to improved sanitation and water access, which is the key focus of the MDG water and sanitation targets.

2.3 The Joint Monitoring Programme for water and sanitation

The World Health Organisation (WHO) and United Nations Children's Fund (UNICEF) established the Joint Monitoring Programme for water supply and sanitation at the end of International Drinking Water and Sanitation decade (1981-1990). The JMP's main aim is to provide global reports on water supply and sanitation and to help countries to improve their

monitoring performance for better planning and management at the local level. It therefore provided information to the United Nations on Millennium Development Goals (MDGs) in respect of water and sanitation ([World Health Organisation and United Nations Children's Fund, 2015](#)).

As part of its monitoring activities, the JMP uses household surveys and censuses. A key tool is the use of national Demographic and Health Surveys (DHS) to collect data on a wide range of monitoring and impact evaluation indicators related to population, health and nutrition. The surveys are funded by the U.S. Agency for International Development (USAID). The sample sizes for the surveys range from 2,000-30,000 households and the aim is to conduct the surveys every five years. Other surveys used by the JMP are Multiple Indicator Cluster Surveys (MICS), World Health Surveys (WHS), Living Standards Measurement Surveys (LSMS) and Population and Housing Surveys ([World Health Organisation and United Nations Children's Fund, 2015](#)). However, only the DHS and population and housing census are discussed here because they are more comprehensive in coverage and more popular. It is from these surveys that the JMP processes and disseminates information on water and sanitation access in different countries.

The WHO/UNICEF JMP defines an ‘improved’ facility as one that hygienically separates human excreta from human contact (see Table 2.1). Unimproved sanitation facilities, by contrast, do not ensure hygienic separation of human excreta from human contact (Table 2.1).

Table 2.1 Improved and Unimproved sanitation facilities.

Improved sanitation	Unimproved sanitation
flush toilets	flush/pour flush to elsewhere
piped sewer systems	pit latrines without slab
septic tanks	buckets
flush/pour flush to pit latrines	hanging toilets or hanging latrines
ventilated improved pit latrine (VIP)	no facilities/bush/fields/water
pit latrines with slab	faeces disposal with solid waste.
composting toilets	
special cases	

Source: Adapted from [World Health Organisation and United Nations Children's Fund \(2015\)](#).

‘Improved’ drinking water sources, on the other hand, are defined as ‘ones that by the nature of their construction or through active intervention are protected from outside contamination, in particular from contamination with faecal matter’ (see Table 2.2). Unimproved sources of drinking water, by contrast, are not regarded as free from contamination. It follows from these definitions that an improved water supply and improved sanitation exist where human beings are free from faecal contamination.

Table 2.2 Improved and Unimproved drinking water facilities.

Improved drinking water	Unimproved drinking water
piped water into dwelling	unprotected springs
piped water to yard/plot	unprotected dug wells
public tap or standpipe	carts with small tanks/drums
tube wells or borehole	tanker-trucks
protected dug wells	surface water
protected springs	bottled water*
rainwater	

Source: Adapted from WHO/UNICEF JMP for water and sanitation 2015

*While bottled water was considered an unimproved water sources in the MDGs era, the present Sustainable Development Goals (SDGs) classed bottled water as an improved source, provided it is located on premises, available when needed, and free from faecal and chemical contamination.

The concepts of a water and a sanitation ‘ladder’ is central to the JMP’s monitoring of access to improved water and sanitation and helps to quantify levels of access to different types of facilities that fall within the definition of ‘improved’ and ‘unimproved’ water and sanitation. Table 2.1 illustrates the types of sanitation facility classified as improved and unimproved. The drinking water ladder shows the global proportion of those drinking water directly from surface sources (like rivers, ponds, lakes, etc), those using other unimproved sources, those using improved sources other than household connections and those benefitting from household connections in a dwelling, yard or plot ([World Health Organisation and United Nations Children's Fund, 2015](#)). All of these concepts provide a means for understanding and comparing water and sanitation access across the international community.

2.4 Comparing the Millennium Development Goals (MDGs) and Sustainable Development Goals (SDGs)

Target 7c of the MDGs aimed to halve the proportion of population without access to improved water and sanitation by 2015. The SDG targets 6.1 and 6.2 on the other hand relates to Water, sanitation and Hygiene (WASH) and are more ambitious than the MDGs in many ways: Firstly, the SDGs emphasise universal and equitable access for all, implying elimination of inequalities in service levels. Also, the SDGs include hygiene which was not addressed in the MDGs. Furthermore, the SDGs clearly stated that water should be safe and affordable, and sanitation be adequate. Finally, the need to end open defecation is clearly stated and the needs of women, girls and those in vulnerable situations are highlighted in the SDGs ([World Health Organisation and United Nations Children's Fund, 2017a](#)). There are normative elements and their interpretation as well as service ladders for WASH (see Table 2.3 and Table 2.4 of this chapter).

2.5 Sustainable Development Goals

The post-2015 development agenda has been associated with the adoption of more aspirational, extensive and ambitious ‘Sustainable Development Goals’ (SDGs) which came into effect on 25th September 2015 ([World Health Organisation and United Nations Children's Fund, 2017a](#)). These goals were adopted as a means to end poverty, protect the planet and ensure prosperity for all as part of a new sustainable development agenda and have specific targets to achieve by 2030. There are 17 goals in total. These include: (1) No poverty (2) Zero hunger (3) Good Health and Well-being (4) Quality Education (5) Gender Equality (6) Clean Water and Sanitation (7) Affordable and clean Energy (8) Decent Work and Economic Growth (9) Industry, Innovation Infrastructure (10) Reduced Inequalities (11) Sustainable cities and Communities (12) Responsible Consumption and Production (13) Climate Action (14) Life below Water (15) Life on Land (16) Peace, Justice and strong Institutions (17) Partnership for the goals ([World Health Organisation and United Nations Children's Fund, 2015](#)). With regard

to water and sanitation, there has been emphasis on addressing the unfinished business of the MDG targets ([World Health Organisation and United Nations Children's Fund, 2017a](#)). For instance, according to the [World Health Organisation and United Nations Children's Fund \(2017a\)](#):

- Water scarcity affects more than 40 per cent of the global population and is projected to rise. Over 1.7 billion people are currently living in river basins where water use exceeds recharge.
- Each day, nearly 1,000 children die due to preventable water and sanitation-related diarrhoeal diseases.

The most relevant of SDG to the present research is goal 6, targets 6.1 and 6.2. Target 6.1 seeks to: “achieve universal and equitable access to safe and affordable drinking-water for all” and 6.2 aims to: “achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations”. The normative interpretation of targets 6.1 and 6.2 can be found below:

Target 6.1: By 2030, achieve universal and equitable access to safe and affordable drinking water for all.

Table 2.3 Water Target and Normative Interpretation

Target Language	Normative Interpretation
universal	Implies all exposures and settings including households, schools, health facilities, workplaces, and public spaces
and equitable	Implies progressive reduction and elimination of inequalities between population subgroups
access	Implies sufficient water to meet domestic needs is reliably available close to home
to safe	Safe drinking water is free from pathogens and elevated levels of toxic chemicals at all times
and affordable	Payment for services does not present a barrier to access or prevent people meeting other basic human needs
drinking water	Water used for drinking, cooking, food preparation and personal hygiene
for all	Suitable for use by men, women, girls and boys of all ages including people living with disabilities

Source: [World Health Organisation and United Nations Children's Fund \(2017a\)](#).

Target 6.2: By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations.

Table 2.4: Sanitation Target and Normative Interpretation

Target Language	Normative Interpretation
access	Implies facilities close to home that can be easily reached and used as needed
to adequate	Implies a system which hygienically separates excreta from human contact as well as safe reuse/treatment of excreta in situ, or safe transport and treatment off-site
and equitable	Implies progressive reduction and elimination of inequalities between population sub-groups
sanitation	Sanitation is the provision of facilities and services for safe management and disposal of human urine and faeces
and hygiene	Hygiene is the conditions and practices that help maintain health and prevent the spread of disease including handwashing, menstrual hygiene management and food hygiene
for all	Suitable for use by men, women, girls and boys of all ages including people living with disabilities
end open defecation	Excreta of adults or children are deposited (directly or after being covered by a layer of earth) in the bush, a field, a beach, or other open area; discharged directly into a drainage channel, river, sea, or other water body; or are wrapped in temporary material and discarded
paying special attention to the needs of women and girls	Implies reducing the burden of water collection and enabling women and girls to manage sanitation and hygiene needs with dignity. Special attention should be given to the needs of women and girls in ‘high use’ settings such as schools and workplaces, and ‘high risk’ settings such as health care facilities and detention centres
and those in vulnerable situations	Implies attention to specific WASH needs found in ‘special cases’ including refugee camps, detention centres, mass gatherings and pilgrimages

Source: WHO/UNICEF JMP 2017 WASH in the 2030 agenda

My concerns and critiques here are that the ‘improved/unimproved’ definitions in water and sanitation used for monitoring are still based on earlier technology-focused definitions by the JMP. By focusing on access to particular technologies, the JMP may pronounce some facilities as improved despite the fact that they may not successfully separate human excreta from human contact. For instance, the fact that a well is covered does not necessarily suggest that it is safe for drinking (Bain *et al.*, 2012b). Even if covered, a poorly managed well may become contaminated in the process of use. Therefore, the SDGs and the normative definition are more

comprehensive and ambitious in monitoring access to water and sanitation services accessed by the people.

2.5.1 Updated JMP Ladders for drinking Water, Sanitation and Hygiene

Since the start of the SDG era, new global indicators have been developed by the JMP for monitoring drinking water, sanitation and hygiene (WASH). Since the scope of WASH activities cut across countries, the JMP had retained a ‘service ladder’ approach to track progress across countries but has added an additional top rung to monitor ‘safely managed’ sanitation. This refers to facilities that are not shared with other households and from which excreta are safely disposed in-situ or transported and treated off-site.

The other rungs remain similar to those used in MDG monitoring. A ‘basic’ level of service provision is associated with an ‘improved’ sanitation facility which is defined in a very similar (technology-oriented) way as was the case during the MDGs period. An improved sanitation facility is one that hygienically separates human waste from human contact. An improved sanitation facility that is shared between two or more households is considered as a limited service in the SDG sanitation ladder. An improved facility not shared with other households and where excreta is safely disposed in-situ or transported and treated or treated off-site falls within the safely managed rung on the sanitation ladder. Unimproved facilities have the same definitions as in the MDGs era. The SDGs are therefore more specific and detailed. While the MDGs simply had improved, the SDG group improved services into limited, basic and safely managed. Likewise, while the MDGs merged unimproved facilities together, under SDG monitoring we have specific unimproved facilities.

There have also been some changes with regard to how access to improved water sources is determined. In contrast to the MDG era when bottled, tanker truck and sachet water was classed as unimproved, these sources are classified as improved under the SDG monitoring system so

long as they meet the criteria of being located on premises, available when needed and compliant with faecal and chemical safety standards. The SDG indicators are also more ambitious. [World Health Organisation and United Nations Children's Fund \(2017a\)](#) in the new set up, the use of improved water has incorporated normative human rights criteria including accessibility, availability and quality. The accessibility criteria expect the water to be located on premises. This addresses the problems associated with users taking a long time to reach, collect the water and come back and helps to reduce the exposure of water to contamination risks. The availability component has to be met by water always being ready to be exploited. There should be no issue that water is needed but it is not there. And finally, water should be of acceptable quality and should comply with faecal and chemical standards. When a water source has these three criteria, it is considered to be a 'safely managed' service. If the water source is safe and collection takes under 30 minutes including queuing time, it is considered to be a 'basic' service. Beyond 30 minutes collection time, a water source is classed as being a 'limited' service. The SDGs therefore are more specific on the categories that are improved or unimproved. Since the present research raises issues of accessibility, availability, and quality, these will be followed up later in the research.

Hygiene, though important, was not included in the MDGs but has been added now as part of SDG 6 and includes menstrual hygiene, food hygiene and handwashing with soap and water as important components. In this research attention is focused on handwashing with soap and water because it is a basic action to help in preventing diseases. Plate 2.1 provides the ladders with their respective definitions of service provision levels. The colours also follow the ones used by JMP which are mainly to clearly distinguish the various components of the ladders.

Drinking Water Ladder	Sanitation Ladder	Hygiene Ladder
Safely managed Drinking water from an improved water source which is located on premises, available when needed and free from faecal and priority contamination	Safely managed Use of an improved sanitation facility which is not shared with other households and where excreta are safely disposed in situ or transported and treated off-site	Basic Hand washing facility with soap and water in the household
Basic Drinking water from an improved source provided collection time is not more than 30 minutes for a roundtrip including queuing	Basic Use of improved facilities which are not shared with other households	
Limited Drinking water from an improved source where collection time exceeds 30 minutes for a roundtrip, including queuing	Limited Use of improved facilities shared between two or more households	Limited Handwashing facility without soap or water
Unimproved Drinking water from an unprotected dug well or unprotected spring	Unimproved Use of pit latrines without a slab or platform, hanging latrines and bucket latrines	
Surface water Drinking water directly from a river, dam, lake, pond, stream, canal or irrigation channel	Open defecation Disposal of human faeces in fields, forest, bushes, open bodies of water, beaches or other open spaces or with solid waste	No facility No handwashing facility

Plate 2.1: Water, Sanitation and Hygiene Ladders

Source: Adapted from WHO/UNICEF JMP 2017 WASH in the 2030 Agenda

The new definitions and additions are more embracing and ambitious but despite the addition of the ‘safely managed’ rung, the definitions of improved water and sanitation are designed to increase the likelihood of separating human excreta from human contact but cannot guarantee the safety of the water sources. For instance, as earlier mentioned, just because a well is protected or covered does not guarantee its safety for drinking (Bain *et al.*, 2012b). Similarly, a facility separating human waste from human contact is not necessarily safe, even though the SDGs have tried to group them into basic and limited services. Another issue of concern is that with the new developments and definitions in SDGs, some monitoring bodies such as DHS and

MICS still use the old criteria and definitions of improved/unimproved in their current surveys. Also, it is worth noting that monitoring of ‘sustainably managed’ ladder is more likely to be targeted initially at higher income countries with sewerage systems. For instance, in Nigeria and the study sites, emphasis is on achieving basic sanitation/water access rather than ‘safely managed’ ladders.

2.6 Recent Developments in Water and Sanitation Research

2.6.1 Faecal Flow Diagrams (FFDs)

Globally, far fewer people use sewerage systems than onsite sanitation, many of which have poor faecal sludge management which causes them to pollute and contaminate the wider environment. As part of the emphasis on monitoring sustainably managed sanitation, faecal flow diagrams have been developed by the Sustainable Sanitation Alliance (SuSanA), Water Engineering and Development Centre (WEDC) and others to estimate the proportion of faecal matter that is safely contained or treated. Faecal flow diagrams are increasingly being used by city stakeholders, development agencies and NGOs in order to map information on the treatment and management of faecal waste produced by cities. According to the Sustainable Sanitation Alliance, FFDs offer ‘a new and innovative way to engage sanitation experts, political leaders and civil society in coordinated discussions about excreta management in their city’ ([Sustainable Sanitation Alliance, 2018](#)).

2.6.2 Community Led Total Sanitation (CLTS)

Community Led Total Sanitation (CLTS) is a relatively new method used to mobilize communities to completely eliminate open defecation (OD) ([Kar and Chambers, 2008](#)). Participating communities are taught to appraise and analyse OD and take actions by themselves to achieve open defecation free (ODF) targets ([Kar and Chambers, 2008](#)).

In many previous sanitation initiatives, communities were provided with toilets or offered subsidies, but this was found to be ineffective and hence the strategy to encourage people to take charge to end OD themselves. Rather than focusing on the provision of subsidised hardware, CLTS focuses on providing socio-culturally oriented ‘software’ which emphasises behaviour change which can make communities take action and this becomes more sustainable (Kar and Chambers, 2008).

This concept’s origin is traced to Kamar Kar, a development consultant from India, together with a Village Education Resource Centre (VERC), a partner of WaterAid in Bangladesh. Kar persuaded an NGO to stop subsidies for toilet construction and instead pursue a change in institutional attitude and mobilise local people to analyse their sanitation and waste situation and make a collective decision to stop OD. CLTS spread from Bangladesh to India, Indonesia and parts of Africa with the help of some NGOs such as Water and Sanitation Programme (WSP), World Bank, UNICEF, WaterAid and the others. Now the programme is found in Africa, Latin America, the Pacific and the Middle East (Kar and Chambers, 2008). This programme is still important and relevant now as part of the ambitious efforts to attain the SDGs.

Harvey (2008) cited an example of Community Led Total Sanitation (CLTS) which started in Bangladesh and is now being used in Asia and Africa. Furthermore, Harvey highlighted how the CLTS increased coverage in sanitation in Zambia from 23% to 88% where the peoples’ eyes were opened, and they resolved and acted to curtail open defecation. CLTS is a way of educating the masses to take it upon themselves to provide sanitation facilities and end open defecation, which is a form of education. These are evidences of where education, persuasion and even legislation is more helpful than providing ‘hardware’ or toilet facilities to the people where they may not be convinced about them and may even abandon them.

2.7 A critical look at improved and unimproved sanitation

The approaches used by the JMP for monitoring water and sanitation access have not been without their critics, however. In particular, the need for JMP tools and procedures to show greater sensitivity to different cultural and technological capacities has been highlighted. [Kvarnström *et al.* \(2011\)](#) criticised the ladder for its emphasis on technology over function and highlight the need for a greater consideration of issues like quality, longer term sustainability and user acceptability. In particular, they stressed that the technology-based classification of ‘improved’ and ‘unimproved’ facilities does not guarantee water quality as facilities that are not used and maintained properly would not provide the intended health and environmental benefits. They also criticised technology-prescriptive regulatory frameworks for hindering improvements and innovation in the sanitation sector as any facility that doesn’t fit the existing rather narrowly defined technology-based criteria for ‘improved’ sanitation was classified as ‘unimproved’ and ineligible to contribute towards the MDG sanitation target. One example that they discussed was sanitation systems with urine-diversion technologies, which despite their ability to contain excreta as well as providing potential environmental benefits, were unlikely to be promoted as they were not recognised as an ‘improved’ technology that would count towards MDG targets. [Kvarnström *et al.* \(2011\)](#) therefore, proposed the use of a more function-based ladder for classifying sanitation facilities which includes health functions from rung 1-4 and higher environmental functions from rung 5-7. In line with the propositions of [Kvarnström *et al.* \(2011\)](#), Sustainable Development Goal 6 (SDGs) considers issues of accessibility, availability and quality of services. The highest service ladder in SDGs is ‘safely managed water’ which is defined as ‘drinking water from an improved source, which is located on premises, available when needed, and free from faecal and priority contamination’.

[Jewitt and Ryley \(2015\)](#) noted that ‘improved sanitation’ does not reflect the needs of women and girls in relation to menstrual hygiene management, violence, safety, privacy and dignity.

These issues are addressed in SDG target 6.2. which emphasizes ‘paying special attention to the needs of women and girls and those in vulnerable situations’ (SDGs). [Jewitt and Ryley \(2015\)](#) further noted that the inclusion of additional functions and monitoring mechanisms to address gender sanitation priorities could be helpful. The authors found that girls were not happy using school toilets as they were poorly constructed, often malfunction and were limited in number to cope with demand especially during break times. Also reported were fears of attack from male pupils as the toilets were not clean and well lit, and had broken doors compromising privacy. [Jewitt and Ryley \(2015\)](#) reported that girls preferred individual toilets rather than blocks, built of solid materials (rather than corrugated iron sheets which could have holes and boys could watch them), were well lit with lockable doors for privacy and safety and soap and water for hands and menstrual washing. Therefore, gender-based toilet facilities should consider these.

In a study of access to and quality of water facilities in Kazakhstan, [O'Hara *et al.* \(2008\)](#) found that government baseline data on access to safe water was both misleading and unreliable. In contrast to official figures reporting that 95% of the population had access to safe water, [O'Hara *et al.* \(2008\)](#)'s survey data indicated that the figure was closer to 27%. They argued that although protected wells and boreholes were considered ‘safe’ according to UN definitions, over 40% of households surveyed treated water from these sources. Some individuals using wells with sucker rods had 23% of reported cases of gastroenteritis compared to less than 8% from households reliant on communal wells. Access to piped water also did not necessarily mean access to safe water as many piped water sources suffered from frequent supply interruptions. The authors quoted a respondent in the survey to have said that ‘the water is salty and hard and contaminated because of the obsolete water pipeline system’ (p.12). [O'Hara *et al.* \(2008\)](#) also highlighted the inappropriateness of the use of distance to define access to safe

water, pointing out that travelling 1000m to a water source can be extremely difficult in bad weather and terrain.

Similar issues are reported by [Christenson *et al.* \(2014\)](#) with respect to ‘improved’ drinking water proven to be contaminated in Nigeria. The authors also critically considered the proposed post-2015 water and sanitation monitoring programme; questioning the translation of the assumption that water quality is worse in urban than rural areas. The authors- also criticised the proposed post-2015 Sustainable Development Goal (SDG) targets that classify urban protected dug wells as unimproved but consider rural ones as improved. In their findings from Nigeria which were based on surveys of improved and unimproved facilities, they found that thermo-tolerant coliforms (TTC) were 1.6 to 2.3 times more likely in rural, compared to urban water sources depending on the urban definition ([Christenson *et al.*, 2014](#)). Sanitary risks were also higher in rural areas, in addition to the higher presence of TTC contaminants. The authors therefore critically question the decision to separate definitions of rural versus urban in definitions of improved and unimproved water access.

In recognition of these problems and as a means of achieving improved water supply in Iceland, [Gunnarsdottir *et al.* \(2015\)](#) proposed the development of a holistic national framework that includes legal provisions for water protection, surveillance of drinking water quality and performance of the water supply system and systematic prevention management. They also pointed out the need for improved guidance and control by central governments, implementation of water safety plans (which are becoming widespread now) by local authorities and adequate communication to the public and between stakeholders. This holistic approach corresponds well with the environmental functions in rungs 5-7 of [Kvarnström *et al.* \(2011\)](#)’s proposed sanitation ladder as it would encourage integrated resource management.

In the process of monitoring water and sanitation access, the Joint Monitoring Programme has revealed significant rural-urban inequalities. [Bain *et al.* \(2014b\)](#) blame the urban bias in water and sanitation monitoring and reporting for such inequalities, observing that the proportion of people using improved water supply is lower in rural than urban areas. In particular, they highlight a recent JMP report indicating that only 4% of the global urban population use unimproved sources of drinking water compared to 19% of the global rural population. Inequalities between urban and rural water supply can be found in terms of accessibility, quantity, continuity of supply and quality issues (WHO 2011, cited in [Bain *et al.* \(2014b\)](#)). These inequalities are reflected in health statistics as children in rural areas are more likely to have diarrhoea than their urban counterparts. Inequalities in access to improved sanitation in rural and urban areas can also have an influence on the availability of safe water as pit latrines are common in rural areas and often negatively influence water quality as a result of faecal contamination ([Graham and Polizzotto, 2013](#)). [Bain *et al.* \(2014b\)](#) study report implies that abundance of pit latrines could contaminate well water, reflected in high diarrhoea rates.

An additional limitation of the JMP data is that it pays little attention to seasonal variations when monitoring water quality and access, yet faecal contamination levels are likely to vary with wet and dry season conditions ([Kostyla *et al.*, 2015](#)). In a systematic review of 22 studies in developing countries, [Kostyla *et al.* \(2015\)](#) found that faecal contamination in improved drinking water sources followed a seasonal trend with significantly higher levels of contamination in the rainy season than in the dry season. Such differences were apparent across faecal indicator bacteria, climatic zones and rural-urban boundaries. The authors therefore argued that seasonal water monitoring by WHO and other agencies could lead to improved assessments of access to safe drinking water. Although faecal flow diagrams use water table levels to predict the proportion of safely managed sanitation, they don't do this seasonally ([Jewitt *et al.*, 2018](#)). SDG 6 also includes changes in monitoring and emphasises safely

managed sanitation, but it is silent on seasonal monitoring. To achieve sustainable sanitation, [Jewitt *et al.* \(2018\)](#) advocated for seasonal monitoring of use, quality and continuity of access to sanitation facilities and capturing of data on sanitation stacking.

While the SDGs have improved upon MDG definitions of ‘improved’ water and sanitation and ‘access’, the data upon which progress is measured is unreliable due to poor government information. Some monitoring mechanisms use data sets produced by multiple indicator cluster survey (MICS) which still use the old definitions. These are some of the issues echoed by [O'Hara *et al.* \(2008\)](#) in a survey carried out in Kazakhstan in which they found misleading statistics. They also noted that the survey had more general relevance and argued that more specific issues related to regions/countries be considered for monitoring and progress measured rather than focusing on global comparisons. They further observed that improved water and sanitation should be done in line with the country’s situation, making it easier to monitor progress and more relevance to the host government.

2.8 Access to improved water and sanitation in low- and middle-income countries

[Ki-Moon \(2013\)](#) noted that for many poorer populations, one of the greatest challenges to health remains the continued use of untreated water. According to the [World Health Organisation and United Nations Children's Fund \(2017a\)](#), in 2015 71% of the global population (5.2 billion people) used a safely managed drinking water service i.e. one located on premises, available when needed and free from contamination. However, the same report stated that 844 million people still lacked even a basic drinking water service; 263 million people spent over 30 minutes per round trip to collect water from an improved source while 159 million people still collected water directly from surface water sources, of which 58% live in Sub-Saharan Africa ([World Health Organisation and United Nations Children's Fund, 2017a](#)). [WaterAid \(2017b\)](#) reported on the top ten countries without improved toilets and stated that the top is Ethiopia, with only 7.1% of the population having access to improved toilets by percentage, and 46

million people with no improved sanitation facilities although Ethiopia has succeeded in reducing open defecation. Chad was ranked second with only 9.5% of the population having access to improved toilets with 9,150 children dying every year from diarrhoea caused by dirty water and poor toilet facilities. In Sierra-Leone, [WaterAid \(2017b\)](#) observed that although sanitation improved from 10% in 2000 to 15% in 2015, 5.5 million out of 6 million do not have access to improved toilets. Poor sanitation and non-availability of clean water causes the death of 2000 children every year from sepsis and other conditions arising from unhygienic environments in the country. In terms of the top ten worst countries with access to basic sanitation in numbers, Nigeria comes third (after India 732,207,000 being 56%) and China 343,499,264 being 25%), with 7 in 10 persons lacking access to basic sanitation. On open defecation, Nigeria's percentage increased from 22.6% in 2000 to 25.5% (46,529,909 people) in 2015 ([WaterAid, 2017b](#)). Many settlements in Africa lack good sanitation systems and access to improved water, and many people use unprotected pit latrines that could contaminate groundwater. For instance, [Zingoni et al. \(2005\)](#) investigated water quality in Epworth, Zimbabwe and found that groundwater (from bore holes and wells) was contaminated with nitrates and coliform bacteria in most of the water sources in the settlement. Some zones' water was so heavily contaminated that it was unfit for domestic and even agricultural purposes. This was possibly due to the high density of unprotected pit latrines in the zones investigated.

[Maxwell et al. \(2012\)](#) noted that access to water and sanitation across Africa is poor resulting in high incidence of diseases. For instance, in Ghana, typhoid was reported as the commonest water disease accounting for 58.6%, followed by bilhaziasis (31.6%), guinea worm (2.5%) and cholera (6.3%). The disease situation was explained to be as a result of poor sanitation services such as open drains, lack of toilet facilities in many homes, hence open defecation and open waste dumps favouring breeding of vectors (Ghana: Water and sanitation in ([Maxwell et al., 2012](#))). Also, in Ghana, an outbreak of cholera in the Accra region was reported resulting in

4,190 recorded cases and 36 deaths. The health officials attributed the epidemic to poor sanitation and hygiene systems including open defecation (Maxwell *et al.*, 2012). In Harare Zimbabwe, outbreaks of typhoid, diarrhoea and dysentery were reported. The latest typhoid was reported to have affected about 300 people in Harare and Chitungwiza and there were possibilities of going higher. Dube 2012, cited in (Maxwell *et al.*, 2012). The incidence of the disease was explained to have arisen from the lack of political will by the city authorities to address the water supply problem facing the residents (The Guardian 2012, cited in (Maxwell *et al.*, 2012).

With regard to the monitoring of sanitation and water MDG targets, Satterthwaite (2003) highlights the need to treat what he calls “nonsense statistics” with caution. Using the example of aggregate statistics which report that only 1.2% of urban Kenya’s population live in poverty, he draws attention to high mortality rates and the fact that only a small proportion of households in informal settlements have their own toilets with up to 200 people sharing each pit latrine. Satterthwaite (2003) further observed that statistics from WHO and UNICEF show limitations in available data and highlights the misleading ways in which international monitoring programs use them to represent the proportion of the population with adequate provision. In terms of water access, proximity to improved water sources is often considered to represent adequate provision without considering whether people can actually access these water sources or not. The SDGs have addressed these critiques with the considerations of quality and access. While the MDGs used the indicator of ‘use of an improved source of drinking water’ to represent ‘safe drinking water’ the SDGs goal indicator ‘proportion of population using safely managed drinking water services’ is defined as an improved drinking water source which is located on premises, available when needed and compliant with faecal and priority chemical standards. These normative criteria incorporated in the SDGs have addressed issues of quality

and access thereby making the monitoring and target more ambitious (World Health Organisation and United Nations Children's Fund, 2017a).

2.9 'Pro-Poor' Water Supply and Privatisation

In the midst of inadequate potable water supply in many places, especially among the poor, arguments have been made for the private sector to step in (Serageldin, 1995; Nickson and Franceys, 2003; Winpenny, 2005; Galil, 2006). The meaning, background, historical development, case studies and criticisms of privatisation are considered in this section.

2.9.1 The growth of interest in the privatisation of water supply

Generally, privatisation is concerned with ownership of enterprises and the main aim of running them is for profit. For instance, the University of San Francisco (<https://onlinempadegree.usfca.edu>) considers private and public sectors thus:

“The public sector is focused on serving the general public and looking after their interests, while the private sector’s fundamental concern is creating markets to enable earning profits. While the public sector is focused on addressing public concerns, these organizations are also being watched by many interest groups and oversight agencies”.

Privatisation therefore refers to the use of market principles solely for profit making (Ramanadham, 2002, 2019). Similarly, privatisation is seen as the private sector taking over public assets and running them for profit as contrasted with the public sector whose main aim is public welfare (Savas, 1987; Gayle and Goodrich, 1990; Adejumobi, 1999; Cross and Morel, 2005).

Proponents of water privatisation argue that the private sector is efficient, offers improved management and better access to finance than the public sector and could therefore provide water and sanitation services more effectively (Serageldin, 1995; Nickson and Franceys, 2003; Winpenny, 2005; Galil, 2006). Others have maintained that privatisation can benefit the poor as they would pay lower unit costs for piped connections than they pay to water vendors for

supplies of uncertain quality (Serageldin, 1995; Rivera, 1996; Franceys, 1997; des Eaux, 1998; Shirley, 2002; Ochieng, 2002; Kooy, 2003; Bank, 2004; Winpenny, 2005).

2.9.2 Historical development of Water and Sanitation Privatisation

Prior to the 19th century, water supply and sanitation in industrialised countries such as England, France and the USA was based on a philosophy of privatisation. Consequently, service providers would only connect the wealthiest neighbourhoods until the 19th century when cholera struck and links were made between water quality and hygiene (Warner, 1987; Goubert, 1989; Ward, 1997; Hassan, 1998; Ogle, 1999; Castro *et al.*, 2003; Swyngedouw, 2005).

In London, in the 1840s, the water monopoly companies ignored the poorest neighbourhoods and water and sanitation services were returned to the public sector. There was then a general agreement that providing universal access to water and sanitation was the duty of the government and should not be left into the hands of unregulated private providers (Mukhopadhyay, 1975; Luckin, 1986; Millward, 1991; Ward, 1997; Hassan, 1998; Castro *et al.*, 2003; Finer, 2016).

Similarly, in the USA in the 1800s the private management of water had attendant issues with expensive tariffs, inefficiencies as well as inadequate service standards and limited access by the poor while the sewerage coverage was entirely a public concern (Schultz and McShane, 1978; Warner, 1987; Ogle, 1999; Council, 2002; Hukka and Katko, 2003).

Castro *et al.* (2003) reported that in France, in 1800s in the local authority areas, 75% of the population was serviced by the municipal corporation which provided water at about half the price of water provided by the private sector. The same situation was reported in the various regions of Latin America (Catenazzi and Kullock, 1997; Connolly, 1997; Aboites Aguilar, 1998; Swyngedouw, 1999; Rezende and Heller, 2002; Hukka and Katko, 2003).

In the 1990s, the water crisis was associated with calls for privatisation in the global South with the hope of introducing market-oriented water reforms to address government failures to provide adequate water and sanitation services (Rogers and Hall, 2003; Bakker, 2007; Liddle *et al.*, 2015). These were viewed as neoliberal approaches to the solution of environmental problems that supported full water pricing (Haughton, 2002; Bakker, 2005; McDonald and Ruiters, 2005; Swyngedouw, 2005; Goldman, 2007). Some even took the form of water law establishing it as a tradeable and economic good (Klees *et al.*, 1999; Carty, 2002; Bank, 2004, 2005). Nigeria, along with other low income countries, shifted towards privatisation as part of an attempt to participate in the wealth and financial gains of neo-liberalism (United Nations, 1997; Lahiri and Chanthaphone, 2003; Bank, 2003).

However, historically in Nigeria, water supply and other social services are managed by the government as inherited from colonialism and the people based on that to improve life of the masses. Also welfare of the people has been the state's priority as opposed to profit making (Adejumobi, 1999). Emphasis on welfare of the public dates back to the days of Adam Smith's classical economics. Sleeman (1979), cited in Adejumobi (1999) argues that the state is involved in social services to prevent the populace from falling below the poverty line; to redistribute income in society by providing social services to promote equal opportunities; and empower people.

Nigeria's privatisation started in 1988 and was taken forwards by the Public Enterprises Bureau in 1993. Water supply was considered a public good to be provided by the state governments and so was not privatised. The Nigeria Telecommunication Services (NITEL) and National Electric Power Authority (NEPA) were privatised and the services became too expensive and workers were retrenched resulting in unemployment and NITEL collapsed completely (Adejumobi, 1999). A look at privatisation from the United Kingdom, USA, France, Latin

America and some parts of Africa shows that it had issues in addressing water problems, especially for the poor.

2.9.3 Critiques and challenges of privatisation

Despite largescale shifts towards water supply privatisation from the 1990s, the process was criticised on a number of grounds. A key critique with relevance for low income countries relates to the high upfront costs of piped connections versus the ability to obtain water on credit from water vendors; despite the questionable quality of such water ([Adejumobi, 1999](#); [Bakker, 2005](#); [Goldman, 2007](#)). An additional problem is that although limited access to clean water might create business opportunities for service providers, privatisation may not address the basic needs of poorer segments of the population ([Bayliss and Hall, 2002](#); [Grusky, 2002](#); [Hall et al., 2002](#); [Hall, 2003](#); [Barlow and Clarke, 2017](#)). For instance, in Johannesburg, the price of water rose by 50% following privatisation in black towns of the city and water related diseases became widespread among people that were unable to afford potable water ([Bond, 2003](#)). The privatisation of water services has also been critiqued for its gendered impacts with [Radcliffe et al. \(2004\)](#) highlighting how privatised water often has particularly detrimental economic impacts for women given their tendency to have responsibility for water collection.

Privatisation generally is not welcomed by the Nigerian public and recent attempts have been resisted and criticised:

“The World Bank ‘s involvement in water and sanitation projects in Nigeria is wholly externally induced and driven.... there are no clear evidences that the private sector will serve the purpose of the poor more than the public sector. The failed African Development Bank (ADB)-funded water supply scheme and the incomplete Ikpoba Dam projects in Benin City were apt case studies of disastrous World Bank supported water projects in Nigeria” ([Hall et al., 2015](#)) (p.8).

[Brendan \(1993\)](#); [Omoleke \(2010\)](#) critique privatisation as a solution for Nigerian public enterprises given the number of citizens facing severe poverty while few elites and multinational firms flourish. Past privatization initiatives in Nigeria were associated with job losses, diseases resulting from people drinking contaminated water (because they could not afford expensive private supplies) and illiteracy due to people not been able to afford education. In light of this, [Stewart \(1991\)](#); [Ayodele \(1994\)](#); [Adejumobi \(1999\)](#) noted that privatisation does not help in the delivery of social services. Restructuring, good governance, accountability and responsiveness are therefore needed to improve the water sector.

For private sector water companies, meanwhile, it is challenging to provide water to the poor on profitable terms as cost recovery can be very difficult. John Talbot, an employee of a private water firm is quoted to have said:

“Cost recovery from the poor majority is not feasible, and the private sector may not be the place to tap for investments in these sectors.... The scale of the need far out-reaches the financial and risk-taking capacities of the private sector. As a result, subsidies and soft loans would be necessary to make the endeavour worthwhile. Even Europe and USA subsidize services.” ([Goldman, 2007](#)) (p.796).

In support of the profit maximisation agenda illustrated above, [Hall and Lobina \(2007\)](#) report:

“For each firm, supplying water or sewerage services to marginal populations in developing countries is no different from providing support services for advanced aircraft factories in France. Populations in developing countries without water supply are a potential market: where they are profitable, then the firm will want to obtain that market, and displace the main competitor, which is the local public sector; where they are not profitable, the firm will not want that market”. ([Hall and Lobina, 2007](#)) (p.776).

Because of the difficulty of profiting from supplying water to the poor, many private sector companies have withdrawn from their least profitable contracts ([Smith *et al.*, 1999](#); [Hukka and Katko, 2003](#)).

In some cases, withdrawals have been stimulated by opposition to different aspects of the privatisation process ([Laurie and Crespo, 2002](#); [Trawick, 2003](#); [Gutierrez, 2003](#); [McDonald and](#)

Ruiters, 2005; Swyngedouw, 2005; Barlow and Clarke, 2017). In La Paz and Cochabamba protests against price hikes resulted in the government's withdrawal from the contract (Laurie and Marvin, 1999; Goldman, 2007) while in Gambia, Guinea, Kenya, Mozambique, South Africa and Zimbabwe, the contracts were ended by either the government or companies themselves due to protests. By 2004, one-third of the contracts in Africa were nullified due to mass-based political activities (Goldman, 2007).

Other critiques of privatisation have focused on their tendency to act as avenues for corruption. Bakre and Lauwo (2016) noted that privatisation was used to undervalue assets and transfer them to political elites for their private use. Similar findings were reported by Bardhan (1997) and Shleifer and Vishny (1993) while Bakker (2005) reported that in Jakarta, the award of contracts was characterised by corruption in which the government and private sector officials colluded to get money from the government.

In Nigeria, the privatisation process was linked to allegations of endemic corruption plus a lack of transparency and accountability in relation to water resource management (Hawley, 2000; Uddin and Hopper, 2003; Shiraz Rahaman *et al.*, 2007; Stiglitz, 2008; Witness, 2010; Andrews, 2013; Integrity, 2013; Bakre and Lauwo, 2016; Lassou and Hopper, 2016). Nigeria was also reported to have ineffective regulatory frameworks, poor audit systems, weak legal institutions and unethical accounting practices which encouraged cronyism in its socio-economic and political system (Bakre, 2011).

Widespread critiques of water supply privatisation inevitably led to comparisons of the effectiveness of public and private approaches with the World Bank chief economist and noble Laureate for economics, Stiglitz, being reported to have said that privatisation has made matters worse by corruption, increasing poverty and inequality (Castro, 2007b). While the shortcomings of public sector water provision were recognised, attention was drawn to

successful examples of public sector in Sao Paulo, Cambodia, Honduras and Burkina Faso, Chile, Zimbabwe and Botswana ([Ingram and Kessides, 1994](#); [Nickson *et al.*, 1996](#); [Lobina, 2000](#); [Hall, 2001](#); [Hall *et al.*, 2002](#); [McIntosh, 2003](#)) and examples that illustrate levels of efficiency that compare well with those claimed for the private sector ([Caves and Christensen, 1980](#); [Millward, 1982](#); [Atkinson and Halvorsen, 1986](#); [Gayle and Goodrich, 1990](#); [Yahaya, 1993](#); [Adejumobi, 1999](#); [Willner, 2001](#); [Chang, 2003](#); [Gutierrez, 2003](#); [Trujillo *et al.*, 2005](#); [Estache and Fay, 2007](#); [Castro, 2007a](#); [Gelting *et al.*, 2013](#)). As [Bakker \(2007\)](#) points out, the public sector's under-provision of water to poor households has not been redressed by the private sector and privatisation often offers few benefits compared to state ownership and control. Another important difference between private and public sector water provision is that while private firms may exit from non-profitable contracts, the public sector cannot do this ([Hall and Lobina, 2007](#)). [Bakker \(2007\)](#) goes on to argue that the problem is not one of private versus public sector provision but rather that incentives need to be applied for success in water and sanitation services provision.

2.10 Gender and Water Supply

This section looks at gender and water supply and argues that women are central to water matters. This stems from the fact that women are household water managers and also have more specialised needs for water compared to men. However, with respect to my studies, it does not necessarily imply that water issues are exclusively the concerns of women as also reported by [Sultana \(2009b\)](#).

2.10.1 Background to Gender and WASH

Water politics and policing became conspicuous internationally in the 1990s. Gender issues on the other hand received little attention internationally before 1975 when the United Nations launched the decade for women ([Laurie, 2011](#)). Gender started to feature in WASH debates following the United Nations Water Conference at Mar del Plata in 1977 but also received

attention during the International Drinking Water and Sanitation decade from 1981-90. Other significant events that sought to collate gender and WASH concerns include the 1992 Dublin International Conference on Water and Environment; Agenda 21 of the Rio Conference, the 'Water for Life' decade (2005-2015) and the emphasis of SDG 6 on the needs of women and girls. Despite these developments, [Laurie \(2011\)](#) notes how women were often neglected or under-represented in interventions in water and sanitation despite the fact that they often have prime responsibility for collecting water. [Harris \(2009\)](#), meanwhile, questions neo-liberalism's support for gender and highlights the complexity of nature-society relationships and the tendency to neglect spiritual and psychological meanings attached to water.

In many cultures, there are taboos surrounding women and defecation which need private management ([Sweetman and Medland, 2017](#)). [Rajagopal and Mathur \(2017\)](#) note that many societies segregate women from family and community life as menstruation is considered to be linked to pollution. Women therefore need adequate water and sanitation to manage themselves well in those situations. Menstrual hygiene education needs to be carried out to clear stigma and give women equal opportunities and enable them to be involved in WASH planning ([Rajagopal and Mathur, 2017](#); [Hanson, 2017](#)).

Biologically too women, during menstruation, pregnancy, childbirth, and menopause need adequate availability of water and sanitation and unavailability of these can bring hygiene, health and other wellbeing problems for women, especially in resource constrained environments ([Rajagopal and Mathur, 2017](#)). Women also frequently have responsibility for the WASH needs of their families which involves them fetching large quantities of water ([Geere et al., 2010](#); [Graham et al., 2016](#)). In situations where sanitation facilities are inadequate, women may face harassment from boys and men when they practice open defecation ([Sweetman and Medland, 2017](#); [Kulkarni et al., 2017](#)).

2.10.2 Challenges to WASH and gender

Sometimes economic and social capabilities limit women's access to WASH services. [Briceno et al. \(2004\)](#); [Estache and Fay \(2007\)](#); [Thara \(2017\)](#); [Button \(2017\)](#) noted that the issue of cost and affordability limit the access of rural women to WASH services and create problems especially for the poorest in both rural and urban areas. This amounts to deprivation on the basis of economic and social handicaps confronting many women. Access to poor WASH has been reported to cause health problems in the global south needing education and attitudinal change in the delivery of WASH services ([Say et al., 2014](#)).

WASH is surrounded by different social norms and contexts in which the services are accessed and used by people. Women's specific body needs are sometimes met with discrimination and stigmatisation which could hinder them from participating in WASH and other activities ([Carter et al., 2017](#)). [Leahy et al. \(2017\)](#) noted that differences among women should be identified and addressed.

Although women often have responsibility for WASH, they often lack decision-making power on the type of WASH facilities they use. To address this, [Sweetman and Medland \(2017\)](#); [Leder et al. \(2017\)](#) noted that WASH programmes should leave no one behind and should seek to eliminate marginalisation and inequalities linked to race, caste, lone heads of households, disability, etc. Similarly, [Radcliffe et al. \(2004\)](#); [Leahy et al. \(2017\)](#); [Carter et al. \(2017\)](#); [Hanson \(2017\)](#) advocated for women's involvement and empowerment in WASH services.

2.10.3 Considerations beyond Gender

One of the dangers of focusing on gender is that it can lead to the neglect of important intersecting variables like class, age and other socio-cultural factors ([Ahlers and Zwarteveen, 2009](#)). [Sultana \(2009a\)](#)'s analysis of the natural, spatial and societal factors within which the gender-water emotions operate highlights how men are affected emotionally by arsenic

contamination in Bangladesh as they can feel that their masculinity is challenged by their inability to afford deep wells. [Laurie and Marvin \(1999\)](#); [Clark and Laurie \(2000\)](#) highlight the influence of age and reported the exclusion of older women from some key benefits and services including those related to water which cause social, economic and political biases towards women in older age groups. With regard to India, meanwhile, ([O'Reilly *et al.*, 2009](#)) highlight how caste, restrictions in women's mobility and concerns about maintaining women's honour can influence intra-household decisions on the construction of water and sanitation facilities.

2.11 Causes of Poor Access to Water and Sanitation in Nigeria

In this section, attention is paid to the causes of poor access to water and sanitation in Nigeria. These mainly centre on lack of political will to provide the services, inadequate funding and management issues.

2.11.1 Lack of political will

As in many countries of the developing world, matters relating to provision of utilities such as water supply, sanitation monitoring are carried out by the government. The budgetary allocations in this sector are low in Nigeria and Africa compared to the continents. For instance, [Annamraju *et al.* \(2001\)](#) reported that allocation to water and sanitation are 1% in SSA compared to 3% in Latin America and the Caribbean. When the will is not there, then access to improved services are affected. [Montgomery and Elimelech \(2007\)](#) have identified barriers to improvements in water and sanitation services which include poor or low investment, lack of political will and maintenance of services. There are no water quality standards and their limitation in enforcement make improvement in health outcomes poor. Even where standards exist, there are problems of a lack of personnel, monitoring equipment and political will to ensure the standards are enforced to bring out health outcomes ([Howard and Bartram, 2005a](#)). [Isunju *et al.* \(2011a\)](#) while commenting on low prioritization of sanitation services observed that it appears water and sanitation should go hand in hand with water supply. But in reality,

more resources are typically allocated to water supply while sanitation is under-resourced, and its activities are divided between ministries. They gave an example in Uganda where water supply and sewerage are administered by the national government while sanitation is administered by line ministries such as ministries of education (sanitation in schools), health (sanitation in homes), water and environment (sanitation around water resources).

2.11.2 Inadequate funding.

Closely related to the issue of political will is the problem of poor funding for water and sanitation. [Howard and Bartram \(2005a\)](#) identified barriers to effective water and sanitation as including a lack of financial resources and low priority accorded to water and sanitation which limits their expansion and maintenance in many developing countries. Also, a lack of accountability, corruption and inefficient management affects the smooth operation of water and sanitation.

[Isunju *et al.* \(2011a\)](#) identified the limiting factors to water and sanitation services as a lack of funding, the implementation of inappropriate technologies and the problem of sharing of responsibilities. As sanitation is segmented, so is the allocation of resources with the result that very few resources are allocated to sanitation. This is comparable to Kenya, where sanitation only took 2.6% of the total budget allocated for water supply and sanitation in 2003/2004. They also noted that there has been a consistent decline for the past five years.

[News Agency of Nigeria \(2017\)](#) reported in Newsverge newspaper dated 29th September 2017, that the World Bank advised Nigeria to triple the allocation for the water and sanitation sector in order to achieve SDG targets by 2030. The paper went further to state that between 2006 and 2010, Nigeria spent 0.4% of GDP in the sector. The paper stated that only 31% of Nigerians have access to improved water while only 29% have access to improved sanitation:

“There are no recent estimates for expenditure in the sector, but the sector used to spend close to \$1 billion per year, that is 0.4 per cent of GDP between 2006 and 2010” “Access to piped water on the premises in urban areas has declined from 32 per cent in 1990 to 7 per cent in 2015, in the case of sanitation, only 29 per cent of Nigerians have access to improved sanitation.” ([News Agency of Nigeria \(2017\)](#)).

2.11.3 Management and Technical Limitations

Another barrier reflects problems relating to the sustainable long-term use and operation of water and sanitation projects. There is an example in Indonesia where at the end of a multi-million-dollar rural water and sanitation project, fewer than half of the 3 million people meant to benefit from the project received the needed services. Also after 4 years of completing the project, only 30-40% of the water and sanitation facilities constructed were functioning. [Harvey and Reed \(2004\)](#) reported that in Africa, there are issues of continuity of service. They stated that of the 250,000 hand installed pumps, less than 50% were estimated to be operational. A similar example is cited in Kenya, where projects included chlorine disinfection and safe storage, but six months after implementation of the project, only 33% of households had evidence of using the Point-Of-Use (POU) treatment and less than 20% had purchased storage pots. Project participation in some villages was highly variable, ranging from 0-76% ([Makutsa et al., 2001](#)). Similar situations apply to Nigeria.

In a study of pro-poor sanitation, [Paterson et al. \(2007\)](#) noted that decentralised small-bore sewerage which connects small groups of homes was more technically and economically suitable to low-income and high density areas. But even here, the authors highlighted the lack of funds coupled with a lack of water supply in homes to make flushing of the toilet difficult. So many people sharing the toilets compounds the problem as people would not share the responsibilities. Due to pressure from economic and other problems where survival is the main aim, shared responsibilities like maintaining sanitation are not priorities. [Isunju et al. \(2011a\)](#) noted that in urban areas, some people would not be ready to share responsibilities in ensuring

sanitation services are in order, especially where livelihoods are precarious. Another management issue involving sanitation relates to tenants and landlords. In urban contexts especially slums, [Gulyani and Talukdar \(2008\)](#) and [Katukiza *et al.* \(2010\)](#) noted that tenants depend on sanitation services provided by landlords. Where demand by tenants is low for improved sanitation, there would be low demand for housing with improved sanitation facilities. Also, in tight accommodation markets, tenants may reduce their demands in order to get housing. Tenants who are transient often would not want to pay for accommodation with sanitation improvements.

On some aspects of sanitation management, [Jewitt \(2011\)](#) observed that cultural taboos have affected attention given to spatial inequalities in access to sanitation and attendant environmental and human health risks. Such beliefs hinder the development of appropriate excreta management systems to combat environmental health challenges.

2.12 Effects of Poor Water, Sanitation and Hygiene (WASH)

2.12.1 Health Related problems.

Health related issues are the most common problems associated with poor WASH and are well represented in the literature. For instance, [Lopez *et al.* \(2006\)](#) and [Isunju *et al.* \(2011a\)](#) noted that close to 90% of the diarrhoeal disease burden is caused by unsafe WASH. The authors further observed that urban slum areas are more at risk as they have higher rates of child malnourishment, prevalence of diarrhoea, malnutrition and hunger, HIV and generally low life expectancy. [Isunju *et al.* \(2011a\)](#) noted that in densely populated slums, inadequate sanitation facilities force residents to use unhygienic pit latrines, polythene bags or direct discharge into drains. These cause environmental pollution and disease-related hazards.

Many studies have linked waste and waste dumps to groundwater contamination. For instance [Oyeku and Eludoyin \(2010\)](#) investigated contamination from wells and boreholes from

dumpsites in Ojota, Lagos, Nigeria and found that sites within 2kms were contaminated with Iron (Fe), Copper (Cu), Lead (Pb), and Zinc (Zn). Similarly, in Akure in Nigeria, [Akinbile and Yusoff \(2011\)](#) found high nitrate (36-61 mg/l), pb and zn concentrations in boreholes near waste dumps. In Lagos, [Longe and Balogun \(2010\)](#) found high concentrations of nitrate (mean 38.5 mg/l), phosphate (mean 10.7 mg/l) and ammonium (mean 0.2 mg/l) and TDS (3-23 g/l) in wells between 10 and 400 m from a municipal landfill. In terms of up/down gradient, [Kassenga and Mbuligwe \(2009\)](#) found faecal coliform contamination to be higher in down gradients compared to the up gradient of the dumpsite in Dar-es-Salam, Tanzania.

The health issues associated with WASH are very complex. [Montgomery and Elimelech \(2007\)](#) have tried to categorise these as water-borne, water-related and so on as well as highlighting morbidity and mortality incidences associated with WASH as shown below:

Table 2.5 Categories of water, sanitation, and hygiene-related diseases

Category	Description/Diseases
Waterborne	Caused by the ingestion of water contaminated by human or animal excreta or urine containing pathogenic bacteria or viruses; includes cholera, typhoid, amoebic and bacillary dysentery, and other diarrheal diseases.
Water-based	Caused by parasites found in intermediate organisms living in water; includes dracunculiasis, schistosomiasis and some other helminths.
Water-related	Caused by microorganisms with life cycles associated with insects that live or breed in water; includes dengue fever, lymphatic filariasis, malaria, onchocerciasis, and yellow fever.
Excreta-related	Caused by direct or indirect contact with pathogens associated with excreta and/or vectors breeding in excreta; includes trachoma and most waterborne diseases.
Water collection and storage	Caused by contamination that occurs during or after collection, often because of poorly designed, open containers and improper hygiene and handling.
Toxin-related	Caused by toxic bacteria, such as cyanobacteria, which are linked to eutrophication of surface-water bodies; causes gastrointestinal and hepatic illnesses.

Source: [Montgomery and Elimelech \(2007\)](#).

Table 2.6 Global Morbidity and mortality rates for WASH related diseases

Disease	Estimated morbidity (episodes per year)	Estimated mortality (deaths per year)	Cause/Link			
			Unsanitary disposal of excreta	Unsafe drinking water	Poor hygiene	Water resources development ^a
Diarrheal diseases	1 billion	2.2 million	✓	✓	✓	✓
Intestinal helminths	1.5 billion	100,000	✓	✓	✓	-
Schistosomiasis	200 million	200,000	✓	-	-	✓
Trachoma	150 million ^b	-	✓	-	✓	-

^a Water resources development refers to dams and farm irrigation schemes that have increased snail habitat, a vector for the schistosomiasis-causing parasites, and the likelihood of exposure with additional individuals working in irrigated fields where the snail breeds.

^b This reflects the number of active cases. Approximately 6 million cases of preventable blindness are due to trachoma.

Source: Adapted from [Montgomery and Elimelech \(2007\)](#)

[WaterAid \(2017b\)](#) noted the effects of poor sanitation on women and girls at childhood, adolescence, adulthood, motherhood and old age. At childhood, babies die due to infection from unsafe environments. Diarrhoea kills 289,000 children under five every year globally due to poor WASH conditions. The survivors are unable to absorb nutrients and get stunted which affect mental, physical development and weakened immune systems. At adolescence, girls who use unhygienic toilets have health risks. Adult women who don't have decent toilets and facilities for managing menstruation in the workplace miss work during such periods. During motherhood, malnourished women have stunted babies. Also, hookworm which spreads by open defecation causes diarrhoea, anaemia and weight loss in women which results in low weight birth and slow child growth. Poor sanitation and hygiene can bring infection during and after childbirth which explains 11% of maternal deaths from sepsis worldwide. WASH in health care facilities is therefore important for maternal and neo-natal health ([Velleman et al., 2014b](#)).

Peri-menopausal women often suffer from irregular and excessive bleeding which results from hormonal changes and requires good access to hygienic facilities. In line with this, [Bhakta et al. \(2017\)](#) noted that at perimenopause, women need water for baths which needs to be accommodated in the WASH sector. The authors hinted that as global population ages, there is more need for provision of gender sensitive infrastructure. Also they need to urinate more often and sometimes have decreased physical mobility, making access to an improved toilet a key priority ([WaterAid, 2017b](#)).

In the same vein, [Maxwell et al. \(2012\)](#) characterised water-related diseases into four: water-borne, water washed, water-based and water-related. Water-borne diseases are those caused by drinking water that is contaminated by faeces or urine containing pathogenic bacteria or viruses. Examples are cholera, typhoid, and diarrhoea, amoebic and bacillary dysentery. Water washed diseases result from poor personal hygiene which allows contaminated water to come in contact with skin or eyes and cause diseases including scabies, trachoma and flea, lice or tick-borne illness. Water-based diseases are those caused by parasites in contaminated water and examples include dracunculiasis, schistosomiasis and helminths. Water-related diseases arise from insect vectors that breed in water and they include filariasis, malaria, onchocerciasis, trypanosomiasis and yellow fever.

With regard to water-related diseases in Benue State, [Maxwell et al. \(2012\)](#) reported the most significant to be malaria, followed by diarrhoea, dysentery, filariasis, onchocerciasis, schistosomiasis, typhoid and cholera. Although the authors noted that they had seen some decline in water related diseases in Benue State within the period under consideration, more improvements were needed as the rate of diseases was still high. They recommended public enlightenment programs promoting personal hygiene, provision of improved water supply, rehabilitation of broken-down water facilities and a re-commitment by the government and NGO to tackle water-related diseases in the state.

2.12.2 Non-Health Related Problems

Apart from diseases, there are other problems associated with inadequate water and sanitation. For instance the fetching of water is heavily borne by women and children who often spend up to 6 hours per day searching for water to meet household needs ([World Health Organisation and United Nations Children's Fund, 2005](#)). In the process of looking for water, children may lose the opportunity to attend school. It is clear that time spent collecting water affects girls' education ([Doyle, 1995a](#)). In line with this, it is reported that a reduction in walking time for collecting water increases girls' school enrolment ([van de Walle and Koolwal, 2010](#)). Also, women lose opportunities to be engaged in activities like growing and selling vegetables. Time wasted on water collection can be used for getting more income or other productive tasks ([Koppen, 1997](#); [Touré, 1998](#); [Joshi and Fawcett, 2001](#)). [Devoto et al. \(2012\)](#) reported that although time saved from household connections was not used for income generation in all places, families nevertheless reported a decrease in stress levels and greater happiness.

Water collection is stressful as women hurry to return home to look after children and do other productive tasks while their husbands often worry (or become suspicious) over the time women take during water collection ([Henley et al., 2014](#)). Carrying of water on the head over long distances can affect the health of women and girls by damaging their muscles and bones; causing pain, exhaustion and discomfort ([Hoy et al., 2003](#)). In the process of water collection at many times and many places, there are cases of misunderstandings and it is reported that inadequate WASH facilities make women vulnerable to quarrels, harassment and assault ([Sultana, 2009b](#); [House et al., 2014a](#)). Due to these problems, there are some studies linking poor WASH access to psychosocial stress and emotional problems, etc. ([Stevenson et al., 2012a](#); [Hirve et al., 2015b](#)).

The most under privileged people have additional challenges. For instance, disabled women face particular difficulties if they are unable to access WASH services ([Jones and Reed, 2005](#)).

Also lower caste women may sometimes be excluded from some projects meant to benefit them (Joshi and Fawcett, 2001).

Inadequate water supply can also hinder hygiene practices such as handwashing at critical times such as after going to the toilet, before cooking and even washing clothes. A lack of water can also hinder the production of vegetables which can deprive people of essential nutrients. Long term diarrhoea has been linked with secondary health impacts such as malnutrition which is also linked to water scarcity (Keusch *et al.*, 2006). WaterAid (2017b) noted that improved sanitation in schools enhances girls' enrolment. There are many other benefits, apart from health-related ones, that can be linked to improved sanitation. For instance, Cairncross (2003), Jenkins and Sugden (2006) and Isunju *et al.* (2011a) have noted that improvements in sanitation are beneficial in terms of privacy, safety for women and children, especially at night time. Montgomery and Elimelech (2007) reported that women who don't have toilet facilities at their workplace may miss work some days when menstruating. In school, meanwhile, a lack of good sanitation facilities has been linked to schoolgirl absenteeism (Jewitt and Ryley, 2014) whilst a lack of toilets and menstrual hygiene management services in schools can affect girls' educational development (Sommer *et al.*, 2015). Additional advantages of good sanitation access include comfort, convenience, cleanliness, dignity, social status, modernity, property and value rental incomes, minimised conflicts with neighbours and reduction in odours, flies and accidents.

A key problem related to poor access to water is conflict. At the local level especially, where there are water shortages, people have conflicts that if not carefully handled could even lead to deaths. For example, there is a reported case in Oju in Benue State, where there is serious water scarcity. In 2008 there was a crisis between students from the college of education in Oju and the host community and a student was killed in the process (Utsev and Aho, 2012). Conflicts

are likely to be more pronounced during the dry season when water scarcity is at the peak. More about water related conflicts are found in the water conflicts section (2.20).

2.13 Possible Solutions to Poor Water Supply and Sanitation

[Ducrot \(2017\)](#) noted that the failure of governments to implement and sustainably manage rural water resources has led to Community Based Management (CBM) of water. According to the author, sustainability of water infrastructure is defined as ‘continued, satisfactory functioning and effective use of infrastructure’ (UNICEF 2010 in ([Ducrot, 2017](#))). Community based management involves participation, control over decision making, ownership and cost sharing and is considered to be important in sustainable water management ([Ducrot, 2017](#)).

2.13.1 Governments’ commitment to addressing water supply and sanitation

From the literature, there are many observations that governments’ commitment to solve water and sanitation problems is very important. For instance, [Gutierrez \(2007b\)](#) argued that water and sanitation provision is considered as an essential commodity service that governments need to prioritize and poverty reduction budgets should be accommodated for this purpose. Also [Maxwell et al. \(2012\)](#) recommended re-commitment of the government to provide water for the people, water quality surveillance and public enlightenment on personal hygiene. [Isunju et al. \(2011a\)](#) also observed that in developing countries, sanitation is not considered a priority as governments either allocate little money or combine it with other ministries where sanitation is not well attended to. Barriers to improvement in water and sanitation services have been identified. These include poor or low investment, lack of political will and maintenance of services. These can be overcome by collaboration among water, health and education sectors in conducting community based research with a view to proffering solutions to the problems ([Montgomery and Elimelech, 2007](#)). Working on the issue of accountability and corruption and ensuring good management would be helpful. There should be set standards for water and sanitation with monitoring mechanisms provided for by availability of personnel and

equipment. Availability of pressure groups and other NGOs could also mount pressure on the governments to live up to their responsibilities ([Bartram and Howard, 2003](#)).

2.13.2 Increased funding to water and sanitation

It has been shown that improved water and sanitation can also help in achieving other sustainable development goals. In spite of this, inadequate funding always affects the operations of the water and sanitation sector. In Nigeria, the World Bank group was said to have advised the Nigerian government to invest three times more in water and sanitation than what is obtainable now to achieve SDGs in 2030. In Kenya, [Isunju *et al.* \(2011a\)](#) stated that sanitation only took 2.6% of the total budget allocated for water supply and sanitation in 2003/2004. They also noted that there has been a consistent decline in budget allocations to water and sanitation for the past five years. As noted by the vice president of Nigeria, there should be more efforts by all tiers of governments and NGOs to fund sanitation although there is a need for strict implementation and accountability to reduce the potential for corruption ([Howard and Bartram, 2005a](#)).

2.13.3 Use of appropriate Technology and Management of facilities for Sustainable Development.

[Montgomery and Elimelech \(2007\)](#) observed that efforts should be placed on demand-side, rather than supply-side implementation. Communities should also participate by joining with the government and non-governmental agencies in the establishment and monitoring of financial systems whereby government and non-governmental organisations both fund ongoing maintenance and improvement of projects.

It is reported that centralised systems of water treatment have not been effective and Point-Of-Use (POU) treatment recommended. In rural areas, the population is sparse and the proportion of the population to be served is less than in the urban areas. In such areas, the traditional approach of lending bodies and national governments of implementing centralised treatment

systems does not fit well here. Also, rapidly growing unplanned areas are not suitable for centralised treatment systems. Centralised approaches often have high capital costs, a lack of sound operation and dependence on treatments that are hard to maintain. Considering these shortfalls, a decentralised approach that depends on household water treatment and sanitation may be more appropriate ([Mintz *et al.*, 2001](#); [Souter *et al.*, 2003](#); [Wilderer, 2005](#); [Elimelech, 2006](#)).

Where centralised treatment system is not effective, POU is ideal. This minimises pathogen exposure immediately before consumption. Even when water is safe, poor hygiene during collection, handling and storage may lead to contamination. [Fewtrell *et al.* \(2005\)](#) noted that reduction in diarrhoea is doubled when water is treated immediately before use. Research has shown that low cost and acceptable technologies at the household and community level are capable of improving microbial quality of stored water and can reduce the occurrence of diarrhoea diseases and deaths ([Mintz *et al.*, 2001](#); [Sobsey *et al.*, 2002](#)). [Mintz *et al.* \(2001\)](#); [Chiller *et al.* \(2006\)](#) and [Rose *et al.* \(2006\)](#) have reported that POU treatment leads to reduction in diarrhoeal diseases by 40% for PUR (a flocculant/disinfectant sold in packets) and solar disinfection while the treatment of water by chlorine reduced diarrhoea by 85% in Kenya, Guatemala and India.

However, differences in methodologies and communities make it difficult to conclude on the best health outcomes. For instance, in Malawi incorrect dosage (8-100%) resulted in chlorine use being less than the recommended guideline ([Roberts *et al.*, 2001](#)). Again, confusion comes regarding whether the health outcomes are due to a particular treatment or due to confounding variables such as culture, economic wellbeing, education and handwashing. For instance, a study of drinking water and handwashing in Karachi, Pakistan found no significant difference in diarrhoea reduction between households that used POU technologies only (64%),

handwashing alone (51%) and a combination of handwashing with soap and POU treatment (55%) ([Luby et al., 2006a](#)).

The POU treatment by households is influenced by many factors such as affordability, aesthetics and taste preferences and the manufacture of the POU locally. High costs of POU may hinder people from acquiring and using it. When people are unable to purchase and use POU materials because of their cost, there are likely to be social and health problems ([Mujwahuzi, 2002](#)). Therefore, after the end of the initial funding, some locally made water treatments such as chlorine can be packaged and distributed to the people. As reductions in health issues are noted, there is likely to be more effort to acquire the products ([Mujwahuzi, 2002](#)).

Ecological sanitation has been identified for nutrient recycling where excreta is used for agricultural manure helping to promote increased crop yields and nutritional improvements ([Langergraber and Muellegger, 2005](#)). Eco-sanitation toilets usually consist of a superstructure which sits on a sealed vault. The toilet usually diverts urine and faeces into separate chambers within the vault. The nitrogen and phosphorous contained in urine are diluted with water and applied to crops for fertilisation. The excreta is allowed to stay several months in the vault to allow pathogen removal by die-off, desiccation and predation by microorganisms ([Langergraber and Muellegger, 2005](#)). When the excreta are safe to handle, it is applied to crops. Ecological sanitation is advantageous as the vault is reused and the system produces organic fertilizer and prevents the groundwater pollution that often arises from unsealed pits located near aquifers. Low cost sanitation can have many additional benefits such as reduced smell, cleanliness and privacy ([Jenkins and Curtis, 2005](#)).

2.14 The nature of water quality standards

In 1970, Emmanuel Kant argued that assessment of quality were judgments based partly on objective characteristics but interpreted within the *a priori* subjective framework of the observer (Chapelle *et al.*, 2009). Quality, therefore, can never be solely objective or solely subjective; rather it is always a combination of the two. Furthermore, because everybody's *a priori* subjective framework is different; judgments of quality necessarily differ between people.

Water quality standards are an example of what Kant would consider aesthetic judgments. There are objective characteristics of the water (e.g. concentrations of dissolved and particulate matter) to consider. This is achieved by analytical methods for assessing the chemistry and microbiology of water. The objectivity is limited by uncertainty associated with analytical methods. There are also the subjective needs and expectations of the people using the water to consider.

The regulatory bodies are based on the use to which the water is put. For human consumption, *primary* standards limit the level of specific constituents that can adversely affect public health, which is an objective inclination. For instance, drinking water should not contain measureable amounts of *salmonella typhi* which is a pathogen that can cause deadly typhoid in humans (Chapelle *et al.*, 2009). The primary standards are legally enforceable. The other categories of standards are secondary or *aesthetic* in nature. These are not enforceable guidelines and include discoloration effects, taste, and odour and colour (World Health Organisation, 2011). These correspond to the subjective characteristics of water that people tend to prefer (Chapelle *et al.*, 2009). World Health Organisation (2011) stated that water should be free of tastes and odours that would be objectionable to consumers. Generally, consumers always evaluate water quality using their senses. Although microbial, chemical and physical constituents could affect the appearance, odour or taste of the water, consumers evaluate water quality based on these criteria. While they have no direct health effects, consumers may conclude a water is unsafe

based on these aesthetic criteria. Sometimes a water source may be rejected by consumers as being unsafe on aesthetic grounds and accept water that is aesthetically pleasant but unsafe. WHO therefore notes that both health related guidelines and aesthetic criteria should be taken into account when assessing water and developing regulations and standards. Therefore, sometimes it is necessary to integrate subjective methods. In Nigeria, water quality is measured based on Nigerian standards for drinking water quality approved by the Standards Organisation of Nigeria (SON) (Table 2.1). However, many people assess water quality based on aesthetic considerations. For instance, if water looks clean, it is considered ‘pure’ without thinking about possible contamination.

Therefore, water quality judgments refer to how water of a given composition fits the perceived needs of the individual, group or ecosystem using it. Human judgments are dynamic and objective judgments improve with technology. Below is a table showing water quality guidelines based on World Health Organisation (WHO) and Nigeria Standards for Drinking Water Quality (NSDWQ) guidelines (Table 2.7).

Table 2.7 WHO and NSDWQ guidelines for some parameters of drinking water

Parameters	Guideline Values	
	WHO	NSDWQ
Temperature ($^{\circ}\text{C}$)	N/A	N/A
Turbidity (NTU)	5	5
Total Dissolved Solids (mg/l)	1000*	2000
Total Suspended Solids (mg/l)	30	30
Electrical Conductivity (us cm/l)	N/A	N/A
PH	6.5-8.5	6.5-8.5
Dissolved Oxygen (mg/l)	N/A	30
Odour	Odourless	Odourless
Colour	Colourless	Colourless
Total Hardness (mg/l)	100-300	150
Nitrate (mg/l)	50	50
Nitrite (mg/l)	3	0.2
Sulphate (mg/l)	250	100
Iron Content (mg/l)	0.30	<1
E. coli (cfu/100ml)	0 in 100ml	0 in 100ml
Faecal streptococci (cfu/100ml)	0 in 100ml	0 in 100ml

N/A- Not Available, *Tolerance limit

Source: Adapted from WHO and NSDWQ.

Does 'good' water quality mean the absence of human-made or natural contaminants? Does it mean that such contaminants may be present, but the concentrations are below Maximum Contaminants Limits (MCLs)? Or as in the example given above, does it mean that it should satisfy the expectations of the people drinking it? In other words, does water quality depend on the characteristics of the water itself or is it merely what people happen to like?

[Mustafa and Yusuf \(1999\)](#) observed that potable water for household consumption must be free from pathogenic bacteria, suspended sediments, corrosive, harmful or objectionable minerals and be aesthetically acceptable to the users. The standards centre on physical, chemical and microbiological parameters. Some of the parameters are of health significance and include hard metals, coliform organisms, fluorides, while some of these parameters are aesthetically objectionable such as colour, turbidity, iron and hardness.

Among the water quality parameters, bacteriological standards are more important as they have direct impacts on health, such as total coliform count or thermotolerant coliform or *E. coli* which can cause health problems such as typhoid, cholera or hepatitis. Heavy metals, especially lead, are toxic to health and their accumulation in the human body could cause neurological damage in children leading to intellectual and psychological impairment ([UNICEF, 2007](#)).

Aluminium is also known to be associated with problems of the central nervous system and thus residual aluminium should not exceed 0.2mg/l. The concentration of fluorides should be low enough to prevent fluorosis, dental disease in children ([Mustafa and Yusuf, 1999](#)). Excess fluoride can lead to severe bone damage and the recommended standard of fluorides is 1.5-2.0mg/l. Most synthetic organic compounds which enter ground and surface water sources are carcinogenic, mutagenic, and teratogenic. The reaction of chlorine used for disinfection of water with organic matter such as humus produces a category of organic compound called trihalomethanes (THM) ([Mustafa and Yusuf, 1999](#)). A recommended value for THMs is

0.1mg/l. It should be noted that where water-borne diseases are predominant, the treatment of water with chlorine should be more important than THMs. The latter can be reduced to a minimum by removing colour and turbidity to low levels which reduces the potential for the formation of THMs ([Mustafa and Yusuf, 1999](#)).

2.15 Improved/Unimproved Water and Sanitation Facilities' Construction and usage and social aspects of contamination

In low income countries with a gross national income per capital of less than or equal to US\$1,025 (World Bank, cited in [Graham and Polizzotto \(2013\)](#), many households use improved and unimproved pit latrines because of their low cost and availability. A common design of an improved pit latrine is a circular, rectangular or square pit dug into the ground and covered with a concrete slab or floor with a hole through which faeces pass. Unimproved ones do not have slabs or a platform ([Graham and Polizzotto, 2013](#)). Because most pit latrines generally lack a physical barrier, such as concrete, between stored excreta and soil and or groundwater, contaminants from pit latrine excreta may potentially leach into groundwater and threaten human health through well water contamination as they are not constructed to local laid down standards ([Sustainable Sanitation Alliance, 2018](#)).

[Kiptum and Ndambuki \(2012\)](#) undertook research on well water contamination by pit latrines in Kenya and reported that faecal contamination varies with different features of wells such as type of cover, number of inhabitants using the well, distance to the nearest latrine and rainfall amount. They found out that wells with concrete covers recorded low faecal coliform counts, while those with timber covers had higher coliform counts. The authors concluded that concrete covers protect wells against surface run-off, windblown substances and spilled water which might carry faecal matter into the wells, while timber covers are less effective in this regard. Again, [Kiptum and Ndambuki \(2012\)](#), identified nearness of wells to unlined pit latrines as a source of contamination to groundwater. They carried out a study in Langas, a peri-urban

settlement of Eldoret in Kenya to investigate well water contamination. They found that contamination was high in the shallow wells and increased with nearness to pit latrines; exceeding WHO guidelines of 0 count for bacteria and 50mg/l for nitrate. They concluded that the contamination could have come from the nearby pit latrines. While this research was carried out in Kenya, the findings may be equally applicable to Nigeria and Benue State.

In Benue state most residential compounds have a well and a pit latrine. This is because tap water is not readily available spatially and temporally. The location of water and sanitation facilities within the same compound (within the confines of between 50m and 100m) is a cause of concern. Although many people are of the view that distance between the facilities is not an issue, this has attracted attention in the literature. On the other hand, many wells in Benue state are not lined and are shallow and therefore tend to be more contaminated than deeper wells ([Isikwue et al., 2011](#)).

Regarding social aspects of water contamination, [Graham and Polizzotto \(2013\)](#), observed that the potential for wide spread groundwater contamination from pit latrines is also affected by social factors such as latrine use, latrine densities, maintenance and groundwater pumping. Latrine type, design, materials and construction quality also influence contaminant containment and leaching from pit latrines. They concluded that to effectively evaluate the safety of pit latrine and groundwater source proximity, both environmental and anthropogenic factors must be considered ([Graham and Polizzotto, 2013](#)). Similarly, in consideration of anthropogenic activities, [Kiptum and Ndambuki \(2012\)](#) considered the number of well users, amount of water drawn and amount of water discharged into latrines. They found that the amount of water drawn from a well is linked to higher hydraulic gradients between the well and latrine, with larger withdrawal rates from wells being linked to greater contamination from pit latrines. The authors illustrated in their study that a well with 66 users recorded the highest amount of nitrate concentration levels (157.5mg/l) while a well with 7 users recorded the lowest nitrate

concentration (2.2mg/l). They concluded that the number of well users, type of well cover and distance to the nearest latrine are interrelated and so timber coverings on well, short well-latrine distance and a high number of users tend to be linked to heavy contamination levels. Groundwater contamination concerns have also been raised by [Mara \(2003\)](#) who argues that research over the years confirm that bacteria can be transported some distance through the ground by liquid leachate from pit latrines which could contaminate groundwater. [Muruka et al. \(2012\)](#) also emphasised that pit latrine-well distance affect contamination levels by exchange of leachate from latrines to wells.

Because of possible contamination of wells from pit latrines, the WHO simple latrine fact sheet 3.3 [World Health Organisation and United Nations Children's Fund \(2017a\)](#) recommends that pit latrines should be located downhill from water sources. They should not be built uphill of a well, especially in areas of fissured rock such as limestone, as faecal pollution may be carried directly through the cracks and joints in the rock to the wells. The WHO also recommends that pit latrines should not penetrate groundwater and be at least 2 m above the water table and that latrines should be sited at least 30 m away from drinking water sources. Emphasis is also placed on preventing access by flies to latrines (as they carry diseases on their bodies to food), keeping latrine surfaces clean, odour-free and closing openings in the latrine slab when the latrine is not in use.

Further advice on physical well location is provided by [Schneider \(2014\)](#) who observed that wells should be located:

- At least 30 meters (98 feet) from any part of a human waste disposal area such as septic drain field and latrine
- At least 15 meters (49 feet) from any food or related wastewater disposal area, kitchen and/or laundry wash water disposal areas

- At least 30 meters (98 feet) from any confined animal feeding areas, animal housing or manure storage
- At least 150 meters (492 feet) from any solid waste landfill dump or chemical or industrial waste disposal area.

Schneider (2014) went further and highlighted that wells should be located in an area that is:

- On a higher land surface elevation or if the groundwater flow direction is known, at a location of a higher ground water head
- Located where it can easily be accessed by those using it especially if it is the point of water distribution for individuals
- Free from contamination from wild and open range animals and livestock
- Not within a floodplain or area prone to regular flooding from surface rainwater drainage.

In the same vein, the Republic of Sierra Leone (2014) also provide some guidelines about construction of dug wells. According to their guidelines, a well should be sited at least 30 meters from latrines and other possible contaminant sources. The ministry has other minimum distances from other water sources. The information is found in Table 2.8 below.

Table 2.8 Minimum Distance (M) from Well

Existing Structures	Minimum distance from Well (m)
Existing public water points (well/borehole)	20
Other existing water wells	10
Latrines/septic tanks/soak ways	30
Streams, canals, irrigation ditches	20
Buildings	3
Approved or informal solid waste dumps, burial grounds, lubricant depots	500
Coastline	100

Source: Government of Sierra Leone.

From the literature cited above, it is recommended that wells should be located at least 30 meters from latrines and other potential contaminant sources. In the study sites, most of the wells are located very much closer than 30 meters to latrines and other contaminants sources.

Another influence on access to safe water and sanitation is poverty. Poor people are often at the losing end in the provision of services, as they contribute by paying taxes while the benefits are taken over by the wealthy. This is also the case in Ghana where waste collection is more efficient in the wealthy parts of the town while the poor residents suffer with their waste uncollected for a long time. The dumping is also done in the vicinity of the poor residents as reported by [Baabereyir *et al.* \(2012\)](#). In Nigeria too, even though the poor also pay taxes, the provision of services such as water supply and environmental sanitation are made available mainly to the ‘special’ class.

2.16 Basic Groundwater Hydrology

Soil can dispose of water and human wastes very effectively. While organic material for plants and other organisms is an important constituent of soil, the original parent material of soil is solid rock from the Earth’s outer surface. Weathered and eroded by wind or water, the loose deposits may have moved great distances. Soil depths and composition are, therefore, variable and may be directly related, or bear no relation, to the underlying weathered rocks. Most water in the soil comes from rainfall. Water seeps through the pore space by gravity and surface tension and its pathways are smoothened by a thin film of hygroscopic water on each of the soil particles. The hygroscopic moisture is held tightly by electrostatic forces and is not readily moved by other forces, including plant roots ([Cave and Kolsky, 1999](#)). These forces are measured as the moisture potential (y) or soil tension. The soil is saturated when y is equal to zero. There are three zones of varying degrees of water saturation in soil. In the unsaturated, or aeration zone the voids in the soil are filled with varying amounts of air and water vapour. The aeration zone is a complex mixture of solid particles, liquids and gases. Below the aeration zone

lies the saturated capillary zone, a layer of saturated soil where all the pore space is occupied by water. In this zone, the water is at less than atmospheric pressure and is held by capillary forces between soil particles. The water table is defined as the surface over which the pressure equals atmospheric pressure. In the saturated or groundwater zone below the water table, the water pressure exceeds atmospheric pressure. The extent of the capillary zone depends on the composition of the soil and the packing of the soil particles, and can range from a few centimetres in a coarse sandy soil to a few metres in a clay soil (Cave and Kolsky, 1999). The rate at which soil dries is a function of the pore size of the soil or rock. Sandy soils and certain sandstones have relatively large pores which drain at quite low tensions (negative pressures). Clays and silts, however, do not drain well but retain water and have relatively large moisture contents over a wide range of tensions. The actual distribution of pore size is expensive to determine, so descriptive soil classifications are based on the distribution of grain sizes (Cave and Kolsky, 1999). In sands and sandy soils, the pore size is usually the size of the void between individual grains. Groundwater velocities in unsaturated soils do not normally exceed 0.3 m/d. If the soil has high clay content and/or a lot of organic matter the soil particles can aggregate. Voids can form under these conditions, which can be promoted or accentuated by plant roots. At shallow depths all rocks contain sub-planar voids known collectively as fissures. The water is usually at low tension within these voids, as their aperture is relatively large compared to the inter-granular pores. At moisture tensions below 0.2m the larger fissures can conduct water and the hydraulic conductivity increases enormously. Velocities can exceed 5m/d and the potential for groundwater contamination increases (Cave and Kolsky, 1999). As the soil reaches saturation, liquid flows directly through the pores, rather than along the circuitous layer adjacent to the particles.

2.17 Groundwater pollutants

In addition to the hydrogen and nitrogen atoms that form water, groundwater contains naturally dissolved gases from the atmosphere and dissolved minerals and gases from the soil and rocks through which it passes. Although the soil filters the water, absorbs and removes contaminants ([Isikwue et al., 2011](#)), some will pass through unhindered. A thin soil layer, high permeability, close to the surface water table is fertile ground for the soil to less likely adequately treat contamination. By this, the excess contamination may pass through the zone of aeration and enter the groundwater in the zone of saturation. This results in a plume ([Winter, 1999](#)). According to [Winter \(1999\)](#), “A plume is an underground pattern of contaminant concentrations created by the movement of groundwater beneath a contaminant source. The contaminant spread mostly laterally in the direction of groundwater movement. The site of original contamination has the highest concentration of contaminants and the concentration decreases as it moves further away from the source.” Groundwater has many contaminant sources below the land surface. These include: Municipal sources like landfills, leaky sewer lines; industrial sources like pipelines, underground storage tanks, agricultural sources like underground storage tanks, wells which are poorly constructed or abandoned and individual sources like septic systems, wells which are poorly constructed or abandoned.

[Kiptum and Ndambuki \(2012\)](#) and [Zingoni et al. \(2005\)](#) observe that the main risk to groundwater quality is from bacteria, especially coliform bacteria. The physical properties and mineral constituents can purify water by diluting, purifying and reducing it to simpler products by chemical reactions. This process delays the transport of contaminants through aquifers and may reduce their concentration. But in a fractured aquifer, contaminants can rapidly pass through the unsaturated zone to the water table and the effect of the purifying process is significantly reduced, particularly after a period of intense or prolonged rainfall. As water flows through the saturated zone, contaminants are diluted by the mixing of water in different flow

paths, flowing at different speeds in the complex tortuous pore passages in the aquifer. [Zingoni et al. \(2005\)](#) observed that nitrates, nitrite and faecal indicator organisms are indicators of groundwater pollution which can often be traced to the uncontrolled siting of un-sewered sanitation systems. The pollution can be related to parameters such as hydraulic loading, depth to water table, movement in the unsaturated zone and geological aquifer type. Experience has shown that many unprotected dug wells are affected by pollution ([Kiptum and Ndambuki, 2012](#)).

Groundwater can be contaminated by bacteria through anthropogenic activities like the use of fertilizers and pesticides in agricultural practices, landscape alteration, urbanization and demand for domestic and public drinking water, various industrial activities and tourism in coastal areas ([Khitoliya, 2004](#)). These can make pollutants to percolate with water and contaminate groundwater. For instance, [Okoye and Nyiatagher \(2009\)](#) found dug wells contaminated with chromium and lead in vicinity of heavy metal works in Gboko, Benue State. Aquifers are overloaded with pollutants derived from agricultural and industrial operations, domestic waste and industrial waters, infiltration of pollutants from surface and intrusion of saline water, and all of these affect groundwater quality ([Khitoliya, 2004](#)). The dangerous increase in contaminated subsurface of wells with chemicals and microbial pathogens bring with it health risks to humans ([Bain et al., 2014b](#)). [Freeze \(1979\)](#) maintains that groundwater contamination originates primarily from deep well injection of liquid waste and sanitary landfill for solid wastes. They also identified subsurface pollution by leakage from ponds and lagoons which are used as components of larger waste disposal systems, leaching from animal waste, fertilizers and pesticides from agricultural soils. However, it is interesting to note that apart from these major sources mentioned, pit latrines too can contaminate groundwater, especially given their densities and many accelerating factors as observed by ([Bain et al., 2014b](#)).

[Odeyemi et al. \(2010\)](#) observed that *Enterococci* found in faeces can stay outside the enteric environment for a long time without dying and possess the unique ability to acquire and transfer antibiotic resistance. Some studies, such as [Rice et al. \(1995\)](#) have identified *Enterococci* as a relevant indicator of water quality. Some key groundwater pollutants include total coliform count, faecal coliform, taste, odour, colour, temperature, PH, total dissolved solids, conductivity, total hardness, total alkalinity, total titratable acidity, chloride and nitrate.

2.18 Groundwater and Bacteria Movement through the Soil

Groundwater moves from areas of higher elevation or a higher pressure/hydraulic head (recharge areas) to areas of lower elevation or pressure/hydraulic head. By this method, groundwater is released into streams, lakes, wetlands or springs (discharge areas). It is groundwater that forms the base flow of streams and rivers, which flows continuously between storm events ([Winter, 1999](#)).

The direction of water flow follows the topography of the land surface. On a watershed for instance, water will flow to either direction. Groundwater moves inside the soil slowly, covering some inches per day, but can move over a kilometre in less than five years. In sandy soils, it moves faster ([Winter, 1999](#)). The groundwater movement is illustrated below.

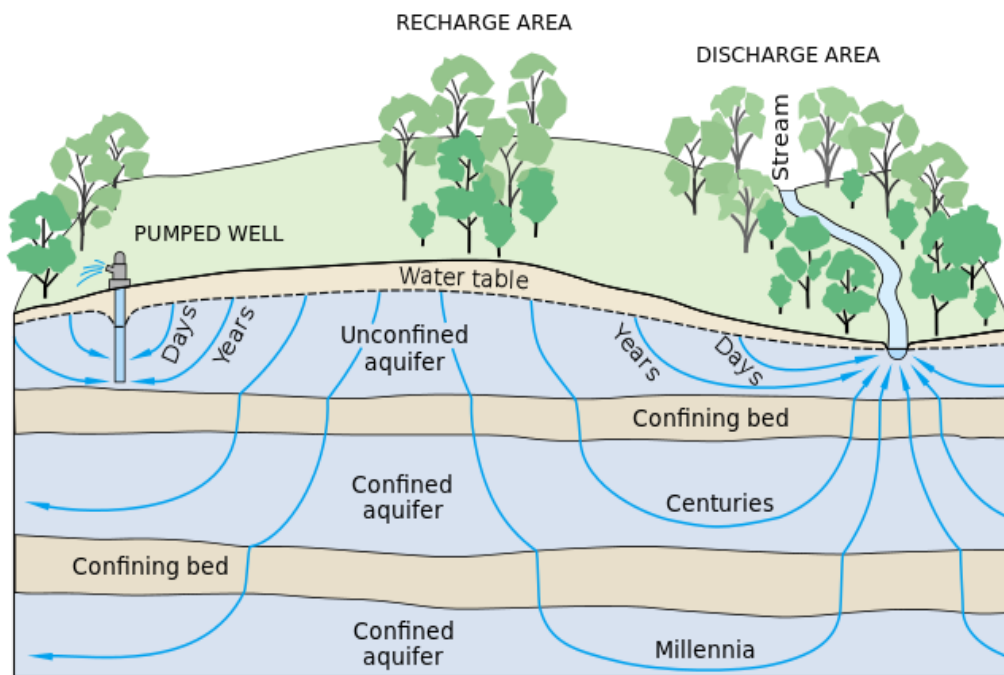


Figure 2.1: Groundwater flow

Source: [Winter \(1998\)](#).

This implies that an unlined pit latrine located uphill can contaminate nearby wells by groundwater movement. [Coyne et al. \(1997\)](#) experimented and reported that bacteria move in the soil. They extracted intact soil blocks (13x13x13 inches) from two soils: a Nolin silt loam and a Lowell silt loam. They were placed on a collection chamber that partitioned leachate into 100 individual sections (10x10 inches). Manure was placed on top of the soil and watered to represent rainfall and the leachate tested for coliform bacteria. The results tested positive. In both soils tested, it was discovered that the rapidly flowing sections accounted for almost 100% of the faecal coliform that leached. The leachate increased with time. It was more intensified with increased addition of water to represent rainfall. The pore spaces also accelerated the movement of bacteria in the soil. While most of the bacteria occurs at or near the soil surface, bacteria moving past this zone can be transported to whatever depth pores remain continuous. The potential for bacterial movement depends on soil characteristics such as soil structure and will affect groundwater to different extents depending on rainfall intensity and duration and the depth of soil to groundwater. This supports the idea that bacteria could contaminate the groundwater in the study area. The soil characteristics in the study area also support this.

[Jamieson et al. \(2002\)](#) also studied movement of bacteria in the soil. They observed that availability of pathogens for leachate during precipitation is influenced by the die-off rate of enteric bacteria in the soil and groundwater, which could be 2 to 4 months. Subsurface flow of bacteria is faster in coarser soil materials and more moisture-laden soils. Bacteria survival rates decrease with increases in temperature while a soil pH of 6 to 7 is optimum for bacteria survival. [Jamieson et al. \(2002\)](#) further observed that factors influencing faecal bacteria survival include moisture, soil type, temperature, pH, manure application rate, nutrient availability and competition. In order to address these shortfalls, it has become necessary to strategize and devise additional measures towards achieving water, sanitation and hygiene goals.

2.19 Groundwater contamination

This section looks at groundwater contamination: its processes, sources, seasonality, and contamination from different groundwater sources and well-latrines separating distances. Water supply in the form of groundwater is a common source in developing countries which is under threat from contamination. Water is needed for daily usage such as for drinking, cooking, washing and hygiene. The United Nations also consider water as an important element in food security ([Martínez-Santos et al., 2017b](#)). Groundwater resources in the form of shallow wells are very important ([MacDonald et al., 2012](#); [Lapworth et al., 2017a](#)). Shallow wells are ubiquitous in sub-Saharan Africa though they are vulnerable to contamination and droughts ([Mkandawire, 2008](#); [Pritchard et al., 2008](#); [Machado and Bordalo, 2014](#); [Wanke et al., 2014](#); [Liddle et al., 2015](#); [Okotto-Okotto et al., 2015](#); [Lapworth et al., 2017b](#)). While there has been some increase in on-site sanitation systems as a means of combating open defecation and improving lives of the people, sanitation systems bring threats to water quality as reported by many authors ([Dzwairo et al., 2006](#); [Kiptum and Ndambuki, 2012](#); [Nyenje et al., 2014](#); [Shivendra and Ramaraju, 2015](#); [Sorensen et al., 2016](#)).

Martínez-Santos *et al.* (2017b) noted that the threat to groundwater is common as wells are frequently constructed in close proximity to pit latrines and shallow wells are in many cases unlined. Similarly, Verheyen *et al.* (2009b) linked viral contamination to pit latrine proximity. Where sanitation facilities are high in number, indicating high population, the risk is intensified. For instance, Wright *et al.* (2013) found that nitrate and chloride correlated significantly with pit latrine density within a 100 m radius. The population and density of sanitation facilities accelerate contamination while the travel time of effluents is another factor. Based on Darcy's law, the effluent transport is proportional to hydraulic conductivity, the flow section and the hydraulic gradient but others (Taylor *et al.*, 2004; Harvey, 2007) observe that under some hydrological conditions such as in fractured media, effluents could move faster than expected and some pathogens could have longer life spans than indicator bacteria, causing groundwater contamination.

In terms of the common parameters of contamination, Martínez-Santos *et al.* (2017b) reported that nitrate and chloride were high in areas with unsewered sanitation. They also found that latrine proximity, population and well density were found to explain groundwater contamination. High nitrate concentrations are associated with faecal indicator bacteria. Nitrate is commonly used as an indicator of anthropogenic pollution in SSA particularly linked to pit latrines. Studies have also linked nitrate concentration to pit latrines (Faye *et al.*, 2004; Ugbaja and Edet, 2004; Tijani and Onodera, 2007; Goshu *et al.*, 2010; Orebiyi *et al.*, 2010; Vala *et al.*, 2011; Goshu and Akoma, 2011).

Microbial contamination and diseases are key challenges faced in sub-Saharan Africa, especially in low income groups and among children (Lapworth *et al.*, 2017a). Faecal waste is considered the largest contamination source in SSA where inadequate sanitation systems affect groundwater from high density housing with inadequate sanitation systems. Apart from faecal coliforms, nitrate, chloride, ammonium and phosphates have been traced to contamination from

pit latrines and leaking sewers as demonstrated in Lusaka (Zambia); Abeokuta and Calabar (Nigeria) and Mekelle (Ethiopia) (Cidu *et al.*, 2003; Ugbaja and Edet, 2004; Taiwo *et al.*, 2011).

Although for health purposes, chemical contaminants such as nitrates are less problematic than microbial ones (Lapworth *et al.*, 2017a), they still threaten water quality. Threats from nitrates from on-site sanitation have been reported by many studies (Tandia *et al.*, 1999; Zingoni *et al.*, 2005; Kimani-Murage and Ngindu, 2007; Vinger *et al.*, 2012; Wright *et al.*, 2013). Since nitrates sometimes indicate the presence of microbial pathogens, they are also health threats.

The identification of safe distances between pit latrines and groundwater sources has proved challenging. Jimmy *et al.* (2013) reported no statistical significance between well-latrine distance, while Graham and Polizzotto (2013) estimated that travel distances laterally could be 1-25 m for water sources to be affected by pit latrines. Chidavaenzi *et al.* (2000); Still and Nash (2002); Dzwauro *et al.* (2006) reported that beyond 5 metres from pit latrines, there is a reduction in contamination.

The recommended separating distances between pit latrine and groundwater sources are around 5 to 50 m. However, these studies may lack spatial resolutions to draw conclusions and variations within which attenuation processes could minimise effluent migration (Tandia *et al.*, 1999; Schijven and Hassanizadeh, 2000; Banks *et al.*, 2002; Howard *et al.*, 2003a; Escamilla *et al.*, 2013; Wright *et al.*, 2013; Nyenje *et al.*, 2014). The different complexities of recharge and pathways in various hydrological settings constrain generalisation. Soil permeability and types and macro-pore flow paths are other considerations. In light of this, Graham and Polizzotto (2013) concluded from their review that since research investigating links between latrines and groundwater contamination are few, there is a need for improved measurements and drawing of better criteria for locating pit latrines in different contexts and environments. In the same vein, Drangert *et al.* (1996) advocate collaboration among anthropologists, medical

practitioners, microbiologists, policy makers and local authorities and residents for addressing the multi-dimensional nature of water safety and health issues.

2.19.1 Sources of contamination

There are many sources of groundwater contamination. The commonest ones and those of concern to this research are pit latrines, septic tanks, soakaways and waste pits which are mainly sub-surface sources. On-site sanitation systems and poor waste management and aquifer vulnerability threaten shallow groundwater sources used by low income earners ([Palamuleni, 2002b](#); [Nkhuwa et al., 2006](#); [Kulabako et al., 2007](#); [Lapworth et al., 2017b](#); [Martínez-Santos et al., 2017b](#)). Faecal sludge contains microbial pathways which are of health concern and high nitrate contents which are persistent due to the confined nature of pit latrines and some mass loss in liquid form can infiltrate and enter the soil and eventually groundwater ([Lawrence et al., 2001](#); [Pedley et al., 2006](#); [Bain et al., 2014c](#); [Cho et al., 2016](#)). Since there is no physical barrier between the stored excreta and groundwater, and since such water is not treated and not monitored, it could pose health risks ([Fourie and Van Ryneveld, 1995](#); [Rosa and Clasen, 2010](#)). [Lawrence et al. \(2001\)](#); [Graham and Polizzotto \(2013\)](#); [Bain et al. \(2014c\)](#) therefore note that there is a need to understand the link between latrine sources and groundwater abstraction points as well as the possible associated health risks. Another helpful way to minimise the risks could be use of guidelines for separating distances between the facilities which internationally are between 10 to 75m. Nationally some guidelines might not exist or may not be complied with. Sometimes the data is sparse or not at required scales or resolution and is sometimes out dated and lacking the necessary details ([Franceys et al., 1992](#); [Still and Nash, 2002](#); [Howard et al., 2003c](#); [Banerjee, 2011](#); [Graham and Polizzotto, 2013](#); [WaterAid, 2013](#); [Martínez-Santos et al., 2017a](#)). The following table has given an idea of various contamination sources.

Table 2.9 Sources and pathways for urban groundwater contamination in SSA

Component	Category	Risk
Regional considerations	-	Population density Land use and land cover Physical relief/slope Rainfall amount and intensity
Sources	Municipal and household level sources including domestic livestock and urban agriculture	<i>Surface sources:</i> Open defecation from humans and animals Surface waste sites and incineration sites Fertilisers and pesticides and waste use (solid/liquid) Atmospheric deposition of combustion products <i>Sub-surface sources:</i> Pit latrines Septic tanks Soak-aways Waste pits Cemetery or other burial sites Open sewers/drains—most common type in SSA Reticulated sewers—very limited coverage Other potential sources: Market places, abattoir waste, both liquid and solid
	Hospital or treatment centre	<i>Surface and subsurface sources:</i> Liquid waste discharge to soak-aways/surface channels Solid medical waste disposal Latrines/septic tanks on site
	Industry e.g. mining	<i>Surface and subsurface sources:</i> Process plant effluent Solid waste disposal sites Storage tanks including petroleum products Site runoff and leaching from mine spoil
Pathways	Horizontal and vertical pathways in unsaturated and saturated zone	<i>Shallow sub horizontal pathways in tropical soil:</i> Tropical soils, e.g. Plithosol/Ferrasol horizons present Shallow depth to water table Thin soils and low organic matter content Natural rapid bypass from tree roots and burrows <i>Vertical and horizontal pathways in saturated zone:</i> Thin low-permeability zone above weathered basement Thickness and maturity of weathered basement zone Fracture size, length and density in the more competent bedrock below weathered basement
	Local/headwork pathways	Lack of dug well headwall and/or lining Lack of well cover Use of bucket and rope—soil/animal/human contact Gap between apron and well lining Damaged well apron Propensity for surface flooding Gap between borehole riser/apron Damaged borehole apron Eroded or de-vegetated spring backfill

Source: [Lapworth et al. \(2017a\)](#)

Human and animal faeces have been identified as the main source of pathogen contamination which contain microbes which come from pit latrines, septic tanks and open defecation (Nkhuwa *et al.*, 2006; Nyenje *et al.*, 2014; Lapworth *et al.*, 2017a; Martínez-Santos *et al.*, 2017b). The micro organisms have been thought to be attenuated (that is to have reduced effects) quickly but many studies (Schijven and Hassanizadeh, 2000; Pedley *et al.*, 2006; Charles *et al.*, 2009; Verheyen *et al.*, 2009b) have shown that viruses can stay for a long time. Taylor *et al.* (2010) noted that microbe attenuation is a function of hydrological conditions and permeability of the aquifer. Dzwauro *et al.* (2006) found a reduction in faecal coliform beyond 5 m from pit latrines in Zimbabwe while Still and Nash (2002) found coliform attenuation of less than 10cfu/100 ml just beyond 1 m from pit latrines in South Africa. By contrast, Chidavaenzi *et al.* (1997); Verheyen *et al.* (2009b) found coliforms up to 20 m and 50 m respectively away from pit latrines. In Nigeria, Sangodoyin (1993) found coliform attenuation to be correlated with distance from the sources as well as groundwater depth. In Kenya, Kimani-Murage and Ngindu (2007) reported that that 50% of wells located within 30 m distance of a pit latrine tested positive for faecal coliforms. There are therefore varying distances within which effluent movement varies and groundwater is affected by microbes. Below is a table showing some recommended distances.

Table 2.10 Some Latrine-Water recommended separation distances

Location	Distance (m)	Authors
WHO	15	Franceys <i>et al.</i> (1992)
Haiti	30	Reed <i>et al.</i> (2013)
WaterAid	50	Project (2011)
South Africa	75	Still and Nash (2002)
Bangladesh	15	Parker and Carlier (2009)
Burkina Faso	25	Parker and Carlier (2009)
Ethiopia	30	Parker and Carlier (2009)
Ghana	50	Parker and Carlier (2009)
India	3 or 10 depending on water table depth	Parker and Carlier (2009)
Mali	15	Parker and Carlier (2009)
Uganda	50 and 30 per sanitation guidance	Parker and Carlier (2009)
Mozambique	50 (per well drilling guidance)	Parker and Carlier (2009)
Malawi	30	Back <i>et al.</i> (2018)

Source: Authors's compilation

As of 2009, Madagascar, Nepal, Nigeria, Pakistan, Papua New Guinea, Tanzania, Timor Leste and Zambia had no set guidelines ([Parker and Carlier, 2009](#)).

As mentioned earlier, pit latrines have been identified as the major contamination source to drinking water. Below are illustrations of groundwater contamination from pit latrines.

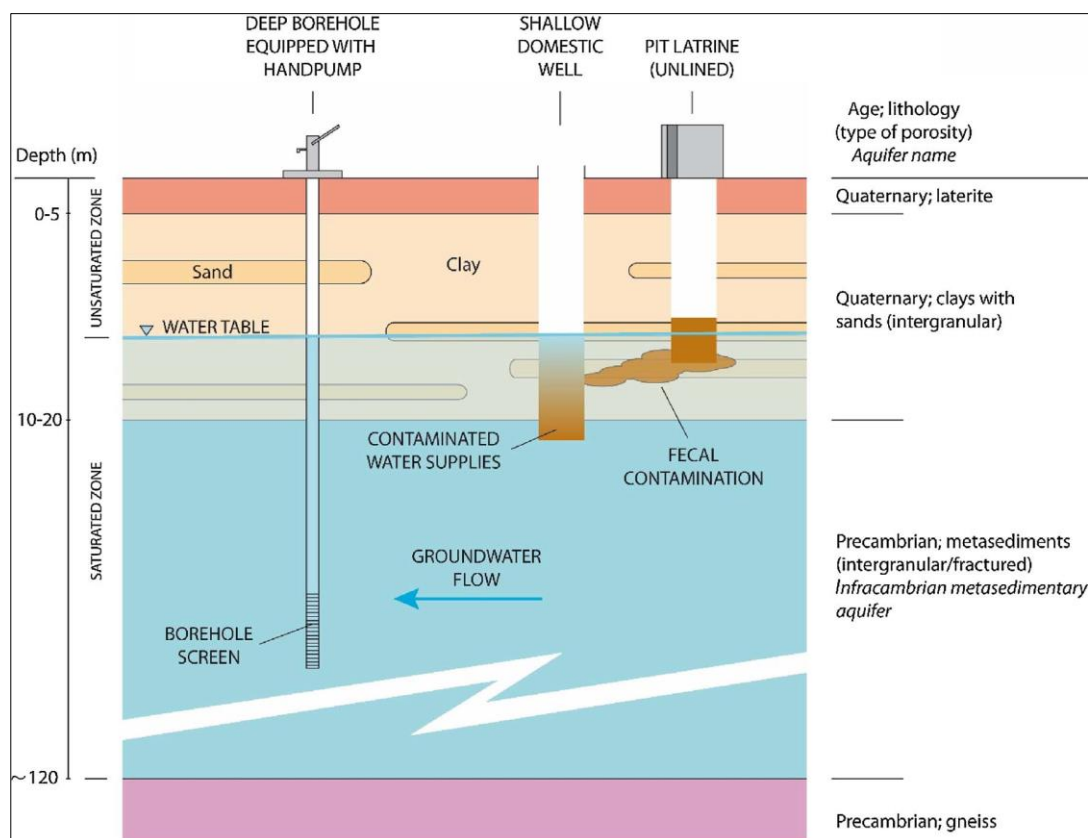


Figure 2.2 Schematic geological section (the vertical scale has been distorted to facilitate viewing).

Source: [Martínez-Santos et al. \(2017a\)](#).

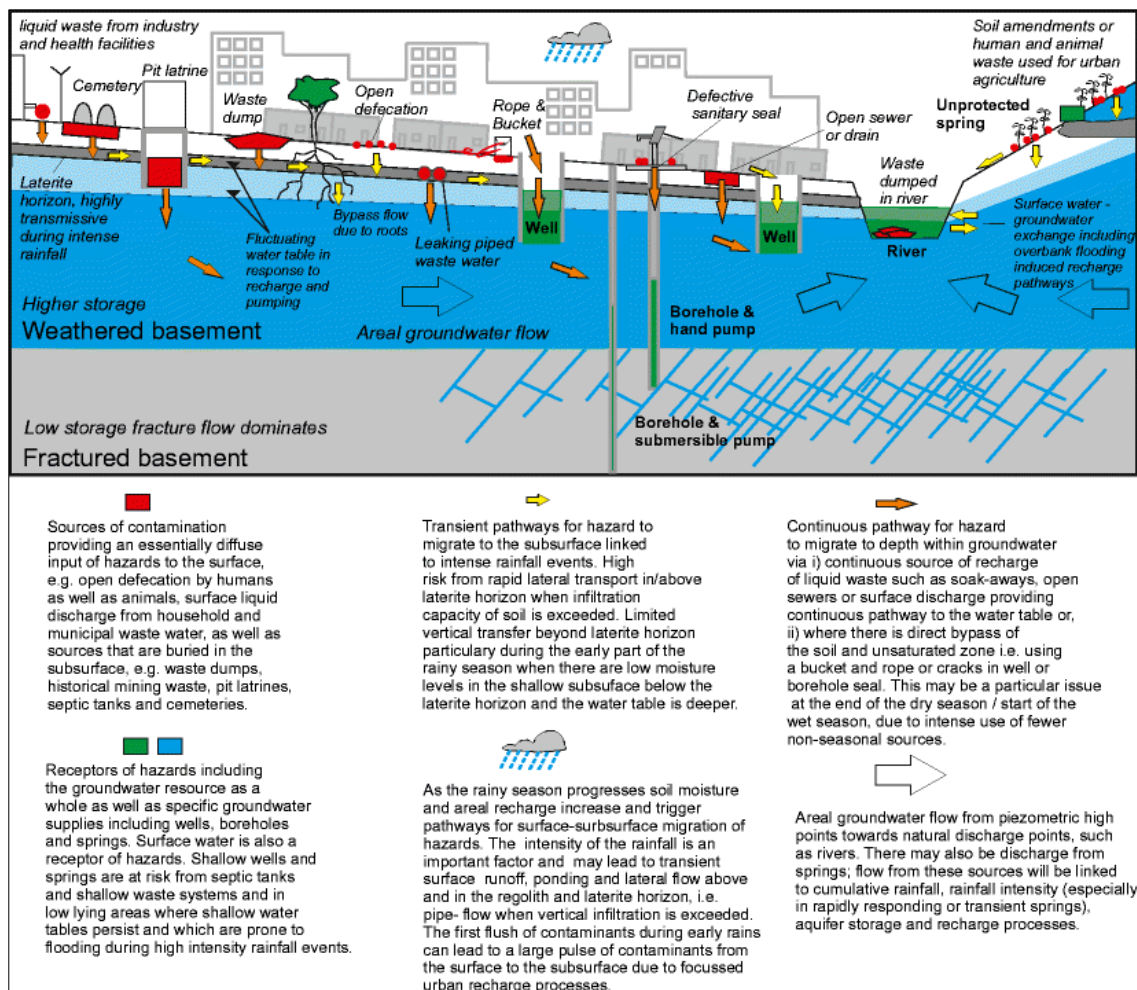


Figure 2.3: Illustration of Groundwater Contamination from Pit Latrines

Source: [Lapworth et al. \(2017a\)](#)

Soil and the unsaturated zone are key barriers to groundwater movement. However, when micro-organisms enter groundwater, their movement and survival is controlled by many processes. Contamination is caused at source as well as from pollutants entering the water environment. In many cases, the aquifer has some role to play. Contaminants move through the aquifer as well as through faulty construction channels of boreholes or wells. Where contaminated water comes in contact with the head works of boreholes and wells and a pathway exists to facilitate mixing of the water supply, infiltration into the sub-surface near wells or boreholes and the existence of fast horizontal pathways to the supply system all accelerate the occurrence of contamination ([Lapworth et al., 2017a](#)). Therefore, pathways of contamination include their movement through constructions, fractured basement, vertical pathways such as

burrows, tree roots and man-made pathways. Surface pathways such as run-off can contaminate surface and sub-surface water hydrologically such as shallow sub-surface water where there is hydraulic continuity such as liquid discharge from buried sources such as pit latrines, cemeteries or municipal waste.

Considering the risks to groundwater contamination, [Martínez-Santos *et al.* \(2017b\)](#) observed that household water treatment is important. In their study area, many people treated water by chlorinating the wells while some treat the water with chlorine using buckets; the latter being a better option. However, people complain that the chemical is expensive for them to buy.

Ecological sanitation pit latrines are very good alternatives. They can provide nutrients from excreta for use in agriculture, and reduce waste to environment and health risks ([Langergraber *et al.*, 2004](#); [Mariwah and Drangert, 2011](#); [Endale *et al.*, 2012](#); [Back *et al.*, 2018](#)). [Chunga *et al.* \(2016\)](#); [Morgan *et al.* \(2017\)](#) reported a shortage of these in some of parts of Malawi, which was ascribed to later maintenance costs.

2.19.2 Contamination from different Groundwater sources.

Open and unlined wells have generally been found to be more contaminated than improved wells ([Godfrey *et al.*, 2006](#); [Sorensen *et al.*, 2015a](#)) and my findings also support this, although there are cases where improved wells have contamination above WHO limits ([Nsubuga *et al.*, 2004](#)). Water from boreholes is usually of higher quality, although [Takem *et al.* \(2010\)](#) reported springs to provide water of better quality than boreholes. [Palamuleni \(2002a\)](#) found better water quality from boreholes, while [Abiye \(2008\)](#) found faecal coliform contamination comparable from both sources. Generally, in terms of microbiological water quality, many authors agree that boreholes are the best water source, followed by springs, then improved wells and lastly traditional wells ([Wright, 1986](#); [Palamuleni, 2002a](#); [Zingoni *et al.*, 2005](#); [Kulabako *et al.*, 2007](#);

Obiri-Danso *et al.*, 2009; Ewodo *et al.*, 2009; Takem *et al.*, 2010; Bonsor *et al.*, 2014; Sorensen *et al.*, 2015a).

Zingoni *et al.* (2005); Back *et al.* (2018) noted that pit latrine density, distance, and reciprocal distance are important factors for groundwater contamination. They observed that closer latrines may pose higher risks but may be obscured by average latrines. Also, age of latrine, number of well users, floods, management factors such as the presence of stagnant water around boreholes which could attract animals, the existence of protective walls to protect boreholes, the condition of the borehole and cleanliness around it are also risk factors. Increased numbers of borehole users are likely to accumulate water at the borehole which could infiltrate and get contaminated by excreta from animals. There was also a correlation between microbial contamination, number of well users and protection of water head.

2.19.3 Seasonal variation in contamination

Howard *et al.* (2003a); Sorensen *et al.* (2015a); Sorensen *et al.* (2015b) have carried out detailed research on seasonal groundwater contamination, characterising risk factors in springs in Uganda and shallow wells and boreholes in Zambia. They found higher contamination after rainfall periods, suggesting changes in water quality in response to the recharge of shallow groundwater. On the otherhand, Kulabako *et al.* (2007) in their resarch in Uganda and Palamuleni (2002a) in Malawi reported higher streptococcal counts in the dry season compared to the wet season. These could be explained by the pulse in contaminats at the commencement of the rainy season. In terms of nitrate, higher concentrations were reported in the wet season in studies carried out in Uganda and the Democratic Republic of Congo by Kulabako *et al.* (2007); Vala *et al.* (2011). However, in the study carried out by Taigbenu and Mangore (2004) in Zimbabwe, lower values of nitrate were reported which could be due to the effect of dilution.

2.20 Water Conflicts from Contamination and Resource Scarcity

This section explores the complex nature of water followed by the identification of conflicts which arise due to contamination of groundwater and water scarcity or arise among competing land uses, water users and even among communities or nations.

2.20.1 The Complex Nature of Water

O'Reilly *et al.* (2009) noted that water means different things to different people in various cultural settings. Some see water as a gift from the gods, others see it as an economic good. Mosse (2008) reported that in both Asia and Africa, water is central and symbolic and a source of social conflict and goes beyond disputes involving material resources.

As water is central to life, there are conflicts arising from infringement of rights over its use. Laurie and Crespo (2002,2007) noted that increases in water rights and user identity were intensified by the introduction of social agenda of indigenisation. Privatisation in Cochabamba was problematic because people saw it as infringement on their rights (Laurie, 2007; Mosse, 2008; Von Schnitzler, 2008). Laurie and Crespo (2002) reported that this affected non-profit community water networks that existed before, resulting in serious protests. Although Laurie (2005) argued that male masculinities featured in the Cochabamba water wars, these were fuelled by alleged human rights infringement primarily.

While the nature of water is complex, this is often ignored. In light of this, Mosse (1997) observed that social science literature ignores the religious, political and cultural significance of water. For instance, Mosse (2008) reported that in Africa and rural India, water is deeply rooted in the politics of caste and gender and water institutions are the basis for party politics and the complexity of water is captured thus:

What African and Indian cases show is the complex ways in which social power is embedded in water systems; and that this is usually poorly understood by outside developers, whether colonial or contemporary. These have tried to impose or improve with modern efficient designs, to centralise state control, treat water simply as an economic good. But in the face of these efforts, the moral-political nature of water rights is constantly reasserted ([Mosse, 2008](#))(p.947).

Water is linked to power, being shaped by, and also shaping social and political relations as in Tamil myths in south India and in Zimbabwean rainmaking ([Mosse, 1999, 2003, 2008](#)). [Mitchell \(2002\)](#) noted that the social purpose of irrigation management was undermined by separating irrigation from society for engineering works to control water in India.

The historical and religious background of water make sense and is supported by many studies. For instance, in the account of creation in the Bible, Genesis 1:2 says ‘...and the spirit of God was moving over the water’. In the Gospel of St Luke 3:21, it is reported that Jesus was baptised with water and the Holy Spirit descended upon him ([Societies, 1976](#)). These and other similar circumstances show the religious significance of water.

2.20.2 Water Security

Water security and water governance are important concepts in water and conflict management and are briefly considered here. Water security is defined as a tolerable water-related risk to humans and ecosystems as well as availability of water in terms of quantity and quality to support livelihoods, national security, and human health and ecosystems services ([Bakker and Issues, 2003](#); [Cook and Bakker, 2012](#); [Bakker and Morinville, 2013](#)). Water governance is defined as a range of political, organisational and administrative activities in which interests of the communities are highlighted, their inputs included, decisions are taken and implemented and the decision makers are accountable in the development and management of water resources as well as delivery of water services ([Bakker and Issues, 2003](#)). [Bakker and Morinville \(2013\)](#) saw governance as being critical to water security and sustainability. [Norman](#)

et al. (2013) advocated for water security status indicator assessment methods which embrace water governance.

Closely linked to water security is social power. Bakker and Morinville (2013) noted that power dynamics are very important in water security. Power factors such as gender, race, caste and class influence how resources are allocated and implicitly determine water security and conflicts (Cleaver, 1998; Ashgate, 2005; Singh, 2008; Harris, 2009; Sultana, 2009a; Boelens *et al.*, 2010). Social networks, partnerships, research programmes and policy visions are reported to be helpful in solving the issues of social exclusion as in the case of La Paz-EL Alto in Bolivia and thereby minimising conflicts (Laurie and Crespo, 2007; Bakker, 2012; Pearson *et al.*, 2015; Dunn *et al.*, 2017).

Social factors also affect water security and conflicts. For instance, land grabbing was reported in Turkey where development projects take over people's land and deny them their rights. Taking over water resources has been behind land acquisitions where local people are not even involved in the land negotiations which fuel conflicts (Bossio *et al.*, 2012; Islar, 2012; Mehta *et al.*, 2012; Woodhouse, 2012).

2.20.3 Sanitation and Agriculture-related Contamination and Conflicts

Many of the conflicts come from contamination related to agricultural practices such as pesticides, nitrates and other agricultural products contaminating groundwater. Contaminated groundwater also affects agricultural production, especially where it is used for irrigation leading to conflicts (Lamelas *et al.*, 2008; Junior *et al.*, 2014; Gurdak *et al.*, 2017; Kelly *et al.*, 2017; Zahedi, 2017; Kulkarni *et al.*, 2018; Zang *et al.*, 2018).

In terms of sanitation many authors reported conflicts from groundwater contamination arising from pit latrines and other onsite sanitation systems which conflicts with Integrated Water Resource Management principles (Banks *et al.*, 2002; Dzwauro *et al.*, 2006; Saidi *et al.*, 2013).

Some conflicts were reported to have emerged from conflicts between land use and groundwater which affect the quality of groundwater resources especially from anthropogenic activities. Also, over-pumping of groundwater is reported to bring shortages along with pollution ([Henriksen *et al.*, 2007](#); [Lerner and Harris, 2009](#); [Junior *et al.*, 2014](#); [Vengosh *et al.*, 2014](#); [Pacheco *et al.*, 2018](#)). Similarly, contamination from mineral deposits and from shale and oil gas drilling have also been reported to bring about conflicts ([Crowe *et al.*, 2015](#); [Bloomfield and Doolin, 2017](#); [Alabjah *et al.*, 2018](#)).

2.20.4 Water conflicts among users, land uses and other interests

[Butler Jr \(2009\)](#) noted that groundwater is the only source of water in some places. Over production/exploitation of groundwater and contamination from conflicts can also affect groundwater as in the case of uranium from war in 1999 in Yugoslavia affecting groundwater by leaching and other environmental pollution and damage ([Sansone *et al.*, 2001](#); [Durante and Pugliese, 2003](#); [Weir, 2015](#)). Groundwater conflicts may also stems from disagreements among stakeholders and users over water rights ([Kite-Powell and Harding, 2006](#); [Llamas and Garrido, 2007](#); [Singh, 2008](#); [Megdal *et al.*, 2015](#); [Alizadeh *et al.*, 2017](#); [Huang *et al.*, 2018](#)).

2.20.5 Examples of Water Conflicts creating crises

Although the Syrian crisis which started in 2012 had many causes such as political, religious and social disputes, [Gleick \(2014\)](#); [Robins and Fergusson \(2014\)](#) argue that the conflicts were a consequence of water shortages, inadequate watershed management and effects of climate change on hydrology. Similar water conflicts have been reported in Yemen, Somalia and associated with tensions between Israel and Palestine; and between Vietnam, Laos, Cambodia and China ([Levy and Sidel, 2011](#); [Givental and Meredith, 2016](#)).

[Kilgour and Hipel \(2005\)](#); [Molina *et al.* \(2011\)](#); [Gorelick and Zheng \(2015\)](#) reported conflicts due to transboundary overexploitation, physical hazards, as well as competing demand for

groundwater for human consumption, food production and the environment. Conflicts in Spain have been linked to intensive groundwater use especially for irrigation.

It is clear from this section that groundwater contamination and scarcity have significant potential for creating conflict. Since groundwater is an important resource, its effective management is essential for sustainable development and also for reducing threats to human and environmental security from violent and non-violent conflicts (Bakker and Morinville, 2013). There is therefore need for robust and multi-level (transnational, national and local) attempts to resolve conflicts among users, sectors and nation-states (Pahl-Wostl *et al.*, 2008; Cohen and Bakker, 2014).

2.21 Conclusion

This chapter has considered relevant areas of the literature including concepts related to water and sanitation in low- and middle-income countries in the light of the MDGs and SDGs. Specifically, the definition of improved water and sanitation and the critiques were considered. With the introduction of the SDGs, their concepts were also incorporated, and the changes elucidated such as the new definitions and service ladders, especially the new one for hygiene. A comparison was made between the MDGs and SDGs and new developments in WASH such as CLTS and faecal flow diagrams were considered. Debates over pro-poor water and privatisation were outlined with arguments presented in support (Serageldin, 1995; Nickson and Franceys, 2003; Winpenny, 2005; Galil, 2006) as well as against these (Bayliss and Hall, 2002; Grusky, 2002; Hall *et al.*, 2002; Hall, 2003; Barlow and Clarke, 2017). The gendered nature of water access and use was highlighted along with the importance of women as water users and managers (Harris, 2009; Laurie, 2011). It was reported that in resource constrained areas, unavailability of improved water and sanitation can often have disproportionate effects on female hygiene and well-being (Rajagopal and Mathur, 2017). The process of collecting water by women for themselves and family members is often highly burdensome (Geere *et al.*,

2010; [Graham et al., 2016](#)) and women and girls often face risks of being harassed by boys and men when attempting open defecation in the midst of inadequate toilet facilities ([Kulkarni et al., 2017](#); [Sweetman and Medland, 2017](#)).

Other issues covered focused on basic groundwater hydrology, effluent transport and intervening factors. The literature makes close links between the contamination of groundwater, on-site sanitation systems and poor waste management ([Palamuleni, 2002a](#); [Nkhuwa et al., 2006](#); [Kulabako et al., 2007](#); [Lapworth et al., 2017a](#); [Martínez-Santos et al., 2017b](#)). Water was identified as a complex and problematic commodity ([Mosse, 2008](#); [Laurie, 2011](#)) and a lack of political will, inadequate funding, management and technical limitations were identified as hindrances to improving access to improved water and sanitation ([Annamraju et al., 2001](#); [Howard and Bartram, 2005a](#); [Elimelech, 2006](#); [Montgomery and Elimelech, 2007](#); [Isunju et al., 2011a](#)). Conflicts linked to water scarcity and contamination are also highlighted in relation to sanitation and agriculture ([Lamelas et al., 2008](#); [Junior et al., 2014](#); [Gurdak et al., 2017](#); [Zahedi, 2017](#); [Kulkarni et al., 2018](#); [Zang et al., 2018](#); [Kelly et al., 2018](#)) as well as to competition among users, land uses and other interests ([Sansone et al., 2001](#); [Durante and Pugliese, 2003](#); [Kite-Powell and Harding, 2006](#); [Singh, 2008](#); [Lamelas et al., 2008](#); [Megdal et al., 2015](#); [Weir, 2015](#); [Alizadeh et al., 2017](#); [Huang et al., 2018](#)). The next chapter will consider the water and sanitation access within the broader Nigerian context and the study areas in which the research is based.

Chapter 3: The Study Area

3.1 Introduction

The previous chapter dealt with a review of related literature for the research. This chapter considers the study area. It first looks at Nigeria's background historically, physically and socially. The key rural-urban differences are explored as well as population trends in rural and urban contexts. The characteristics of Benue State in terms of location, soils, geology, climatic conditions, drainage, water resources and water and sanitation situation are then considered.

3.2 Background Information about Nigeria

3.2.1 Historical Background

The pre-Nigeria society (prior to 1848) was characterised by separate dynamic societies with developed political systems. Notable societies included the Hausa-Fulani in the North, Yoruba in the West, Igbo in the East and Tiv in North Central Nigeria. The rest had organised political systems while the Tiv and Igbo were described as "stateless" societies by the colonial government. This description was because of a lack of organised political systems. Many themes characterised Nigeria's development and have influenced life in the country. The spread of Islam in the North and West parts of the country, the creation of the Sokoto caliphate and Jihad in 1804-8 brought Islamic influence in Nigeria and accounts for the North-South dichotomy within the country ([Federal Government of Nigeria, 2013](#)).

The existence of Nigeria's name as a country is linked with colonialism. The evolution of Nigeria from about 1849-1960 was influenced by British colonialism which transformed and had impact on the people of Nigeria. The name "Nigeria" was suggested by a British journalist, Flora Shaw in the 1890s who later became the wife of colonial Governor Lord Lugard and the name was given after the great Niger River ([Federal Government of Nigeria, 2013](#)).

The British had advanced, sometime around 1849, into the Bight of Benin (a place in the pre-colonial era) and Biafra, which were notorious for the slave trade. By 1897, the Niger coast protectorate, which had been under the foreign secretary, was renamed the protectorate of Southern Nigeria and brought under the colonial secretary. The Royal Niger Company was later changed to the protectorate of Northern Nigeria. In 1914, the two protectorates were amalgamated into one country. The British governed Nigeria until 1960 when the latter gained independence ([Federal Government of Nigeria, 2013](#)).

Nigeria at present, has a range of geo-political zones or regions which in turn contain a number of states. There are six zones or regions and they roughly follow the cardinal points. They are:

1. North Central: Benue, Kogi, Kwara, Nassarawa, Niger, Plateau and Federal Capital Territory Abuja
2. North East: Adamawa, Bauchi, Borno, Gombe, Taraba and Yobe
3. North West: Jigawa, Kaduna, Kano, Katsina, Kebbi, Sokoto, and Zamfara
4. South East: Abia, Anambra, Ebonyi, Enugu and Imo
5. South-South: Akwaibom, Bayelsa, Cross River, Delta, Edo and Rivers
6. South West: Ekiti, Lagos, Ogun, Ondo, Osun and Oyo. (These zones are shown in figure 3.1.).



Figure 3.1 Nigeria Showing Geo-political Zones
Source: Digitized from Google Maps

3.2.2 Physical Background

Nigeria is found in West Africa bordering the Gulf of Guinea, between Benin and Cameroon. It has a total land area of 923,768 square kilometres. Its geographical coordinates are $10^{\circ} 00'N$, $8^{\circ} 00'E$ (See map in Figure 3.1).



Figure 3.2 Nigeria Showing Administrative Boundaries and Benue State
Source: Digitized from Google Maps

Nigeria has both lowlands and highlands. However, the country is dominated by lowlands. The highland areas are mountains rising up to 7,963 feet (2,419m). Also, in the North is a broad upland, generally flat to rolling, averaging 2000ft (610m), covering central Nigeria. The highest part of about 5,843ft (1,781m) above sea level is found on the Jos Plateau. In the western part of the country are the Western highlands. Apart from these highland areas, the rest of the areas are lowlands. The lowland belt stretches from the confluences of the rivers Niger and Benue, known as the Benue trough down to the Niger Delta region (Ileje, 2001).

The major water bodies are the rivers Niger and River Benue with their tributaries. In the North there are smaller rivers which carry water for only some parts of the year, while in the south, the rivers are short but carry water almost all year round.

In terms of climate, Nigeria lies about 4 to 14° north of the equator and has a tropical climate that varies from North to South. In the south, there are southerly winds from the sea during most parts of the year with about 70 inches (1,780mm) of rainfall along the western part of the coast. The average temperature is about 27°C. The northern part of the country is dominated by dry periods for most parts of the year. Most of central Nigeria receives about 25 to 50 inches of rain (635 to 1,270mm) each year in summer as winter is virtually without rain. Temperature generally averages 32°C. with the coolest month having 21°C (Ileoje, 2001).

With respect to vegetation, the southern part of the country has mangrove swamp forests and tropical rainforests. The middle part of the country is dominated by savannah vegetation, with less forests but a lot of trees while in the far north grasses dominate with small trees. The vegetation reflects the rainfall distribution which is higher in the Southern part than in the Northern part of the country (Ileoje, 2001).

3.2.3 Socio-Economic Background

Nigeria has many ethnic groups. The major ones are the Hausa-Fulani, Yoruba, Igbo and Tiv. These account for 70% of the population. There are several groups numbering over one million members each, together accounting for 10% of the population. These include the Kanuri and Ibibio. The remaining 20% of the population is made up of more than 300 smaller ethnic groups. Apart from English, there are 400 native Nigerian languages spoken out of which some are being threatened with extinction. The official language of Nigeria is English. In terms of religion, Nigeria is a religious country with Christians 45%, Muslims 45% and a mixture of different indigenous religions accounting for the remaining 10% (Federal Government of Nigeria, 2013).

3.2.4 Population trends and rural/urban and regional distribution in Nigeria

In terms of population update, Nigeria is the most populous country in Africa and it has the highest population density in Africa ([Federal Government of Nigeria, 2013](#)). Based on 2009 estimates, [Index Mundi \(2013\)](#) maintains that the age structure of Nigeria's population was 41.5% in the 0-14years age range, 55.5% in the age range of 15-64 years and 3% over 65 years. The 2009 population growth rate was 2% while the birth rate (births/1000 population) was 36.7 births/1000 and the death rate (deaths/1000 population) was 16.6 deaths/1000. The infant mortality rate (deaths/1000 live births) was 94.35 deaths/1000 live births and ranks among regions with high child mortality rates globally. Total fertility rate (children born/woman) was 4.91 children born/woman. Life expectancy at birth for the total population was 46.9 years. Nigeria's urban population based on 2008 data was estimated to comprise 48% of the total population while the urbanisation rate is 3.8%/year based on a 2005-10 estimate. The net migration rate (migrants/1000 population) was 0.1 migrants/1000 population. This is defined as the figure for the difference between the number of persons entering and leaving a country during the year per 1,000 persons (based on the mid-year population) and for Nigeria, it was -0.22 ([Index Mundi, 2013](#)). Available data from [World Bank \(2017\)](#) estimated the population of Nigeria to be 190,886,311 people in 2017.

To have a better picture of water supply and sanitation changes, it would be useful to have population estimates for Nigeria. There is, however, dearth of data on population statistics in Nigeria, as most information we have are based on estimates. The last population census in Nigeria was 2006. There are general indications that the population of Nigeria is on the increase. According to [Index Mundi \(2014\)](#) Nigeria has population figures based on a 2.54% growth rate (2013 estimates) as shown in the table below:

Table 3.1 Population estimates for Nigeria

Year	Population
1999	115,766,000
2003	133,881,700
2008	146,255,300
2010	152,217,300
2013	174,507,539
2014	178,571,721

Source: [Index Mundi \(2014\)](#).

The table above shows population estimates for Nigeria based on the world Population review.

Based on the assumed growth rate of 2.48%, it shows from the table that the population is on the increase. The world population review defines the growth rate as:

“The average annual percent change in the population, resulting from a surplus (or deficit) of births over deaths and the balance of migrants entering and leaving a country. The rate may be positive or negative. The growth rate is a factor in determining how great a burden would be imposed on a country by the changing needs of its people for infrastructure (e.g., schools, hospitals, housing, roads), resources (e.g., food, water, electricity), and jobs. Rapid population growth can be seen as threatening by neighbouring countries.” ([Index Mundi, 2014](#))

From the most recent information based on 2017 estimates, the following data was reported by [Index Mundi \(2018\)](#):

Table 3.2 Some Demographic Variables for Nigeria

Variable	Rate
Age structure (0-14) years	42.54% (male 41,506,288/female 39,595,720)
Age structure (15-24 years)	9.61% (male 19,094,899/female 18,289,513)
Age structure (25-54 years)	30.74% (male 30,066,196/female 28,537,846)
Age structure (55-64 years)	3.97% (male 3,699,947/female 3,870,080)
Age structure (65 years and over)	3.13% (male 2,825,134/female 3,146,638)
Total dependency ratio	88.2
Youth dependency ratio	83
Elderly dependency ratio	5.1
Potential support ratio	19.4 (2015 estimate)
Total median age	18.4 years
Male median age	18.3 years
Female median age	18.5 years (2017 estimate)
Population growth rate	2.43% (2017 est.)
Birth rate	36.9 births/1,000 population (2017 est.)
Death rate	12.4 deaths/1,000 population (2017 est.)
Net migration rate	-0.2 migrant(s)/1,000 population (2017 est.)
Urbanization urban population	49.4% of total population (2017)
Rate of urbanization	4.3% annual rate of change (2015-20 est.)

Source: Adapted from [Index Mundi \(2018\)](#).

With regards to its economy, Nigeria is an oil rich economy. However, this has been affected by political instability, corruption, inadequate infrastructure and poor micro-economic management. Many reforms have been carried out by successive governments with little progress. Fuel prices have been deregulated. GDP has been growing for about five decades and rose strongly in 2007 and 2008. Infrastructure is the main impediment to growth. The government is working towards developing stronger public-private partnerships for electricity provision and roads. Information available from Nigeria National Bureau of Statistics, the contribution to GDP by various sectors in 2017 were as follows: Agriculture, forestry and fishing: 43.71%; Mining and quarrying: 12.23%; Manufacturing: 14.82%; Information and communication: 18.76%; Education: 4.29%; other service activities: 6.19%. The rate of unemployment was reported to be 14%. However, the actual situation on the ground suggests that the rate of unemployment could be higher ([National Bureau of Statistics, 2018](#)).

3.2.5 Key rural-urban differences

In Nigeria, the rural areas are dominated by agricultural and other primary production activities which are characterised by more labour-intensive than capital-intensive technology. Urbanisation processes commonly stem from people clustering in cities for employment and to take advantage of many social amenities. In many cases, people migrate from rural areas to settle in urban areas. Such migration is currently high in Nigerian cities, causing rapid urbanisation and a lag in the provision of infrastructural facilities which in turn causes environmental health problems ([Nigeria Rural-Urban Linkages, 2013](#)). Because of high demand for food products, the rural areas grow these crops and sell them to the urban centres. Because of rural-urban migration, labour shortages (especially of males) occur in the agricultural sector. This forces the roles traditionally assigned to men to change to women to meet demand for food products in the urban centres ([Nigeria Rural-Urban Linkages, 2013](#)). There are linkages between rural and urban areas, but the latter have more social

amenities/infrastructures which lure many people from rural to urban areas. This makes cities incapable of coping resulting in urban problems like overcrowding, and pressure on infrastructures like water and sanitation facilities ([Nigeria Rural-Urban Linkages, 2013](#)).

3.2.6 Urban and rural areas categories.

As is the case with population growth, there is a scarcity of data on the definition of urban and rural areas. Generally, in Nigeria, urban areas are characterised by high population density, good infrastructure and amenities, varied occupation and are described as cities or towns. Rural areas on the other hand, have low population, mostly engaged in agriculture and primary production and are described as countryside. In the years of the surveys, they have been the same.

3.3 Benue State

3.3.1 Location and Extent of Benue State

Benue State is located within the coordinates of Latitude $6^{\circ} 25^1$ and $8^{\circ} 08^1$ north of the Equator and Longitude $7^{\circ} 47^1$ and $10^{\circ} 00^1$ East of the Greenwich Meridian. It is found within the North Central area of Nigeria. It has an area extent of 31,276.709 square kilometres ([National Population Commission, 2006](#)) and is bounded by Nasarawa state to the North, Taraba state to the East, Ebonyi, Enugu and Cross River to South and Kogi State to the west (Figure 3.3).

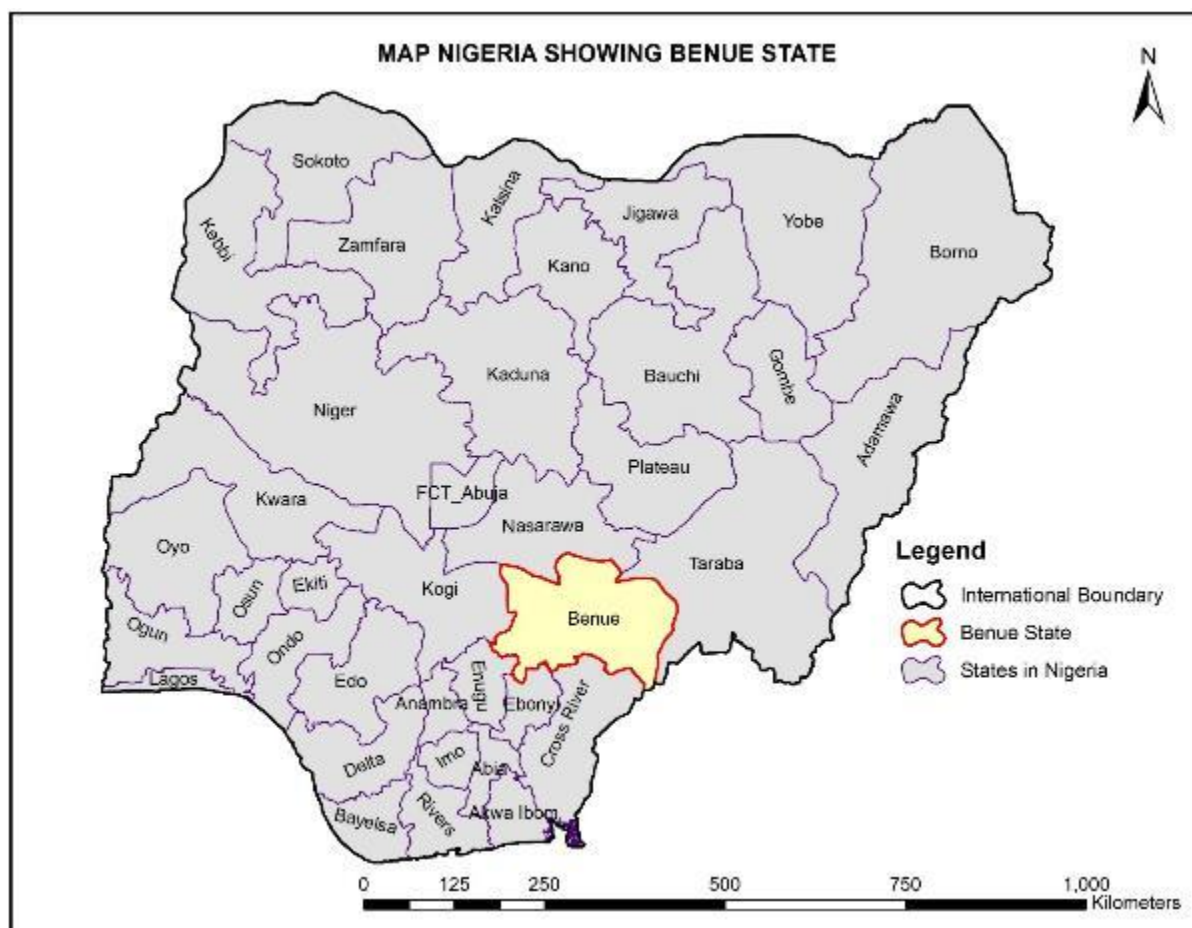


Figure 3.3 Nigeria showing Benue state
Source: Digitised from Google map

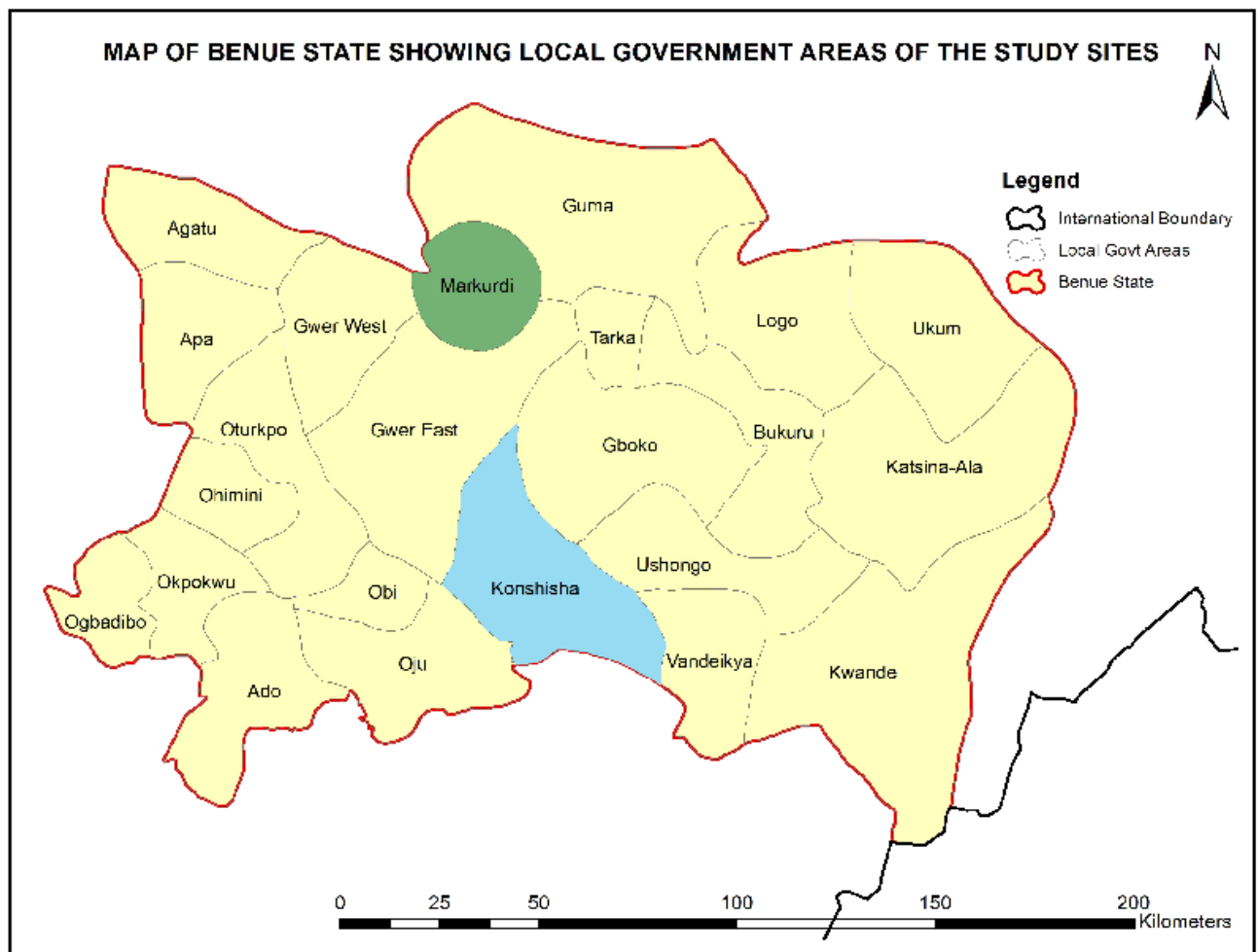


Figure 3.4 Benue state showing the study areas
Source: Digitised from Google Map

Benue state also shares a small section of the Nation's international boundary with the republic of Cameroon to the South East of the state. The state, which was created on 13th February 1976 from the former Benue-plateau state, is named after the River Benue ([Lyam, 2005](#)).

According to the 2006 population census, Benue State had a population of 4,253,641 million people. The dominant people are Tiv, Idoma and Igede. Others are Etulo and Abakwa. Benue State has 14 languages altogether and 23 Local Government Areas (LGAs). Makurdi is Benue State's capital and other important towns include Gboko, Otukpo, Katsina Ala, Vandeikya, and Adikpo. Major economic activities in the state are civil service work, trading, technical works, farming, fishing and other activities ([Lyam, 2005](#)).

The information on geology and relief, soil, climate, drainage and groundwater resources provided in sections 3.3.2, 3.3.3, 3.3.4, 3.3.5 and 3.3.6 are to provide background information on the study area, as a physical component of the research, that is measuring faecal coliforms in the light of vicinity of sanitation facilities is involved.

3.3.2 Geology and Relief

Benue state falls within the Benue valley/trough. This area is believed to have been transgressed by the waters of the Atlantic Ocean during the tertiary and possibly the interglacial periods of the quaternary glaciations. As a result, marine sediments form the dominant surface geology of much of Benue state. These sediments have undergone varying degrees of metamorphism (Lyam, 2005). The sediments are underlain by the basement complex. The meta-sediments are prominent in the southern LGAs such as Ado, Ogbadibo and Okpowu, where the sediments may be more than 20m thick. The meta-sediments are predominantly sandstone, but also contain shale, siltstone, limestone, and quartzite. On the floodplains of Benue are river Katsina-Ala and other smaller rivers, alluvial deposits comprising clay, sand, gravel and pebbles which overlie the meta-sediments and form the superficial geology. There are volcanoes found in Guma LGA around Gbajimba. These volcanoes are believed to have been responsible for some economic minerals such as salt springs (Lyam, 2005).

In terms of relief, the topography of Benue state is generally low, but undulating with heights averaging between 120 and 250m above sea level. Occasionally, inselbergs, lateritic mesas, buttes, knolls, and low ridges can be seen breaking the undulating monotony of interfluves which alternate with shallow open valleys (Nyagba, 1995). The observable terrain towards the South East is of hilly granitic plutons which mark the Western edge of the Cameroun ranges, which extends down to the Southern parts of the state up to Oju local government area. Around Kwande area, in the southern part of Benue are found hill ranges which are extensions of the Cameroun Mountains (Ogezi, 2002). Below is the geological map of Benue state.

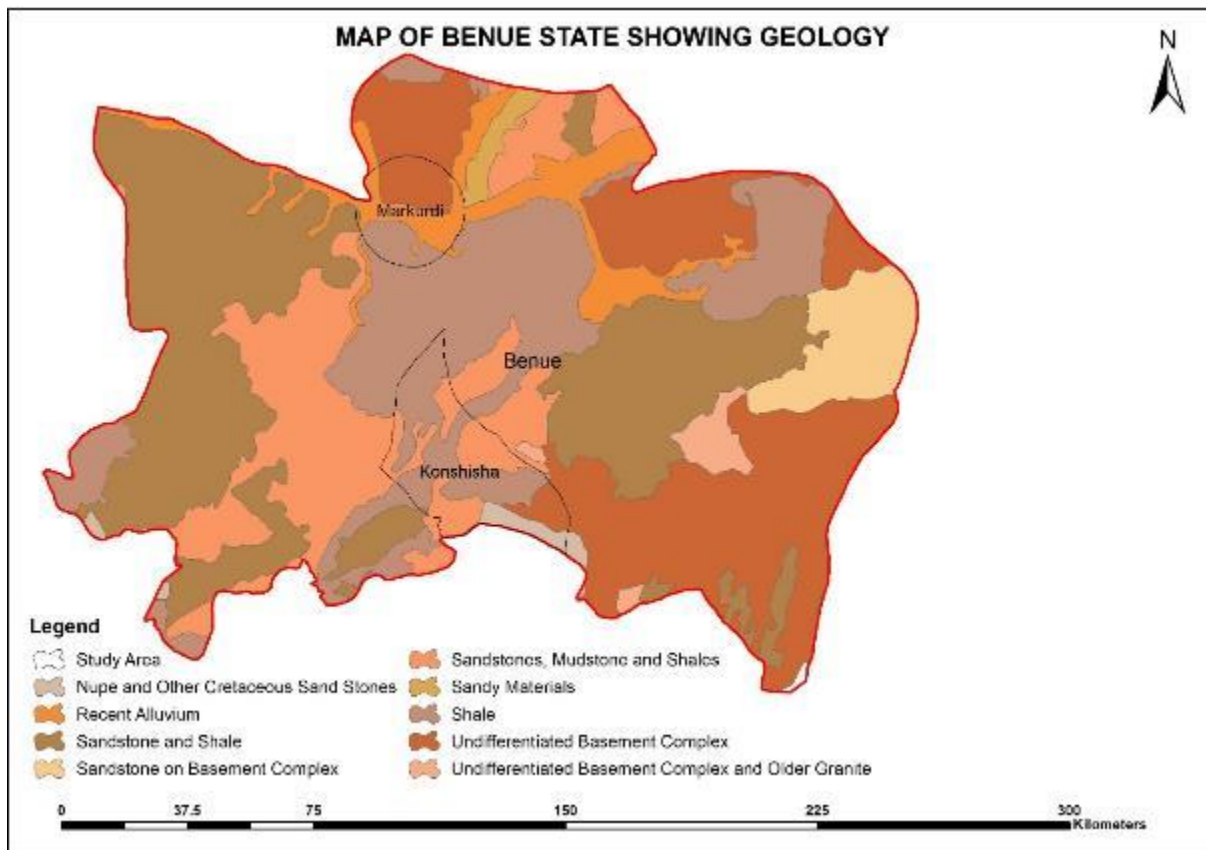


Figure 3.5 Geological Map of Benue State
Source: Office of the Surveyor-General for Nigeria.

3.3.3 Soils

According to [Lyam \(2005\)](#), there are about seven different types of soils covering Benue's topography. These include lithosols, aerosols, luvisols, flusols, nifisols, cambisols and regosols. However, the most extensively distributed soil types are the luvisols which are most noticeable in the Western and Southern parts of the state. This soil type is actually found in all the local government areas of the state except Kwande, Vandeikya and Ado. Acrisols dominate Kwande and Vandeikya, while fluvisols dominate the Ado local government area. Generally, the quality of Benue soils in the context of their usefulness to agriculture have very much been affected by the micro changes in climate, geomorphology and human activities within the area. Below is the soil map and the corresponding codes for explanation.

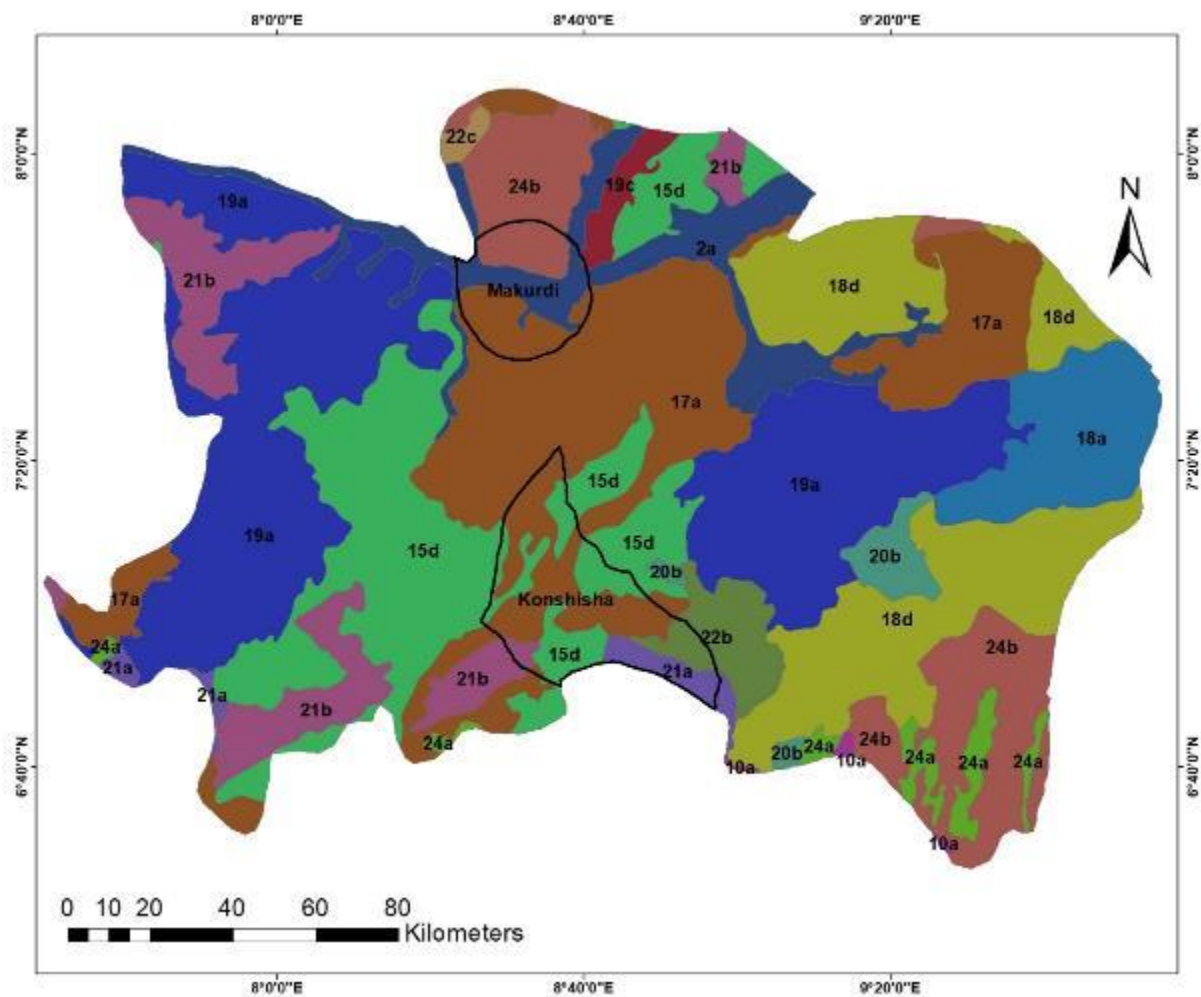


Figure 3.6 Soil map of Benue State
Source: Office of the Surveyor-General for Nigeria.

Table 3.3 Soil codes and their description for soil map of Benue State

Soil Code	SOIL_DESC
10a	Deep to very deep well drained soils; loam, loamy sand, sandy loam or sandy clay loam surfaces over gravelly sandy clay, clay loam, clay or sandy loam subsoils.
15d	Deep well drained soils; loamy sand to sandy loam surface over sandy loam to sandy clay loam subsoils.
17a	Mostly deep well drained, few poorly drained soils; loamy sand to sandy loam surfaces over sandy clay loam to sandy clay and few ferruginised subsoils.
18a	Deep to very deep well drained soils; sand to loamy sand surfaces over sandy loam to sandy clay loam subsoils.
18d	Generally deep well drained with few poorly drained soils; loamy sand surfaces over sandy loam to sandy clay loam and sometimes gravelly subsoils.
19a	Mostly deep well drained with few poorly drained soils; mostly sandy loam with very few gravelly surfaces over sandy clay loam and very few gravelly subsoils.
19c	Deep well drained soils; loamy sand to sandy loam surfaces over sandy clay loam to sandy clay subsoils.
20b	Moderately deep to deep few shallow, well drained and few somewhat poorly drained soils, loamy sand to sandy loam surfaces over sandy clay loam to sandy clay subsoils.
21a	Moderately deep well drained with few poorly drained soils loamy sand surfaces over sandy loam to sandy clay loam and sometimes gravelly subsoils.
21b	Deep well and somewhat poorly drained soils; loamy sand to sandy loam surfaces over sandy loam to sandy clay loam subsoils.
22b	Generally deep with some shallow well drained soils; loamy sand to sandy loam and sometimes gravelly surfaces over sandy clay loam to sandy clay sometimes gravelly subsoils.
22c	Shallow and moderately deep to deep well drained and somewhat poorly to poorly drained soils; loamy sand to sandy loamy and sometimes gravelly surfaces over sandy clay loam to sandy clay and sometimes gravelly subsoils.
24a	Deep imperfectly drained soils, over sandy clay loam surfaces over gravelly for concretionary clay subsoils.
24b	Very shallow to shallow and deep well drained soils; loamy sand to sandy loam surfaces, sometimes gravelly and over bedrocks, over sandy clay loam subsoils sometimes gravelly.
2a	Deep well drained and deep poorly drained soils; sand, sandy loam, loamy sand or sandy clay loamy sand or sand clay loam surface over sand, sandy clay, sandy clay loam, clay, clay loam or loamy sand, sometimes gravelly subsoils.

3.3.4 Climatic Conditions

Based on Koppen's scheme of climate classification, Benue state generally lies within the AW climate—a seasonal wet- and- dry climate, which receives about seven months of rainfall a year. The rainfall starts in April and ends in October while the dry season starts in November and ends in March. There may however, occur one or more out-of-season rains in January or

February or even March from East-West moving depressions known as line squalls Nyagba in (Denga, 1995). The climate is controlled by two air masses which are responsible for both rainy and dry seasons. Annual rainfall totals range from 1500-2000mm (Ocheri, 2010). Generally, the rainfall regime in Benue state is only able to support the guinea savannah biome. That is to say, apart from some cases of excess rainfall, the amount of rainfall in Benue is about 2000mm with distinct wet and dry seasons as contrasted with the coastal areas where we have rainfall almost all year round and yearly rainfall totals about 4000mm. The mean annual temperature is about 32⁰ C. In the rainy season, because of the effects of cloud cover, the temperature reduces to about 30⁰ C. The highest temperature occurs around March and can be as much as 40⁰ C. Below is the mean monthly rainfall.

Table 3.4 Mean monthly rainfall from 1971-2000

Month	Mean Rainfall
January	13 mm
February	04 mm
March	26 mm
April	78 mm
May	138 mm
June	185 mm
July	192 mm
August	238 mm
September	211 mm
October	101 mm
November	20 mm
December	09 mm

Source: Benue State University Makurdi, Nigeria.

From the data, the rainiest months are July, August and September with the peak in August.

3.3.5 Drainage

The Rivers Benue and Katsina-Ala constitute the main drainage networks in the state. Other smaller rivers include Amire-u-tamen and Amire-u-kiriki, Yooyo, Dura, Mkomon, Moon, Loko, Sambe, Logo, Mu, Gwer, Orori and Guma, which drain into the Katsina-Ala and the Benue. The Aya, Konshisha, Kpa, Ombi, Be and Oyongo drain into the Cross-River basin. Many of these smaller rivers have very little water in them during the dry season and some may

even dry up completely during the driest months. This is most noticeable in parts of Guma, Gwer-West, Oturkpo and Oju local government areas. Expectedly, these are also areas of severe water shortages in the dry season since the water level in some cases may drop even 20m below ground level. In such places, small ponds along the river beds may become the only source of water shared by many villages (Lyam, 2005).

Surface drainage has generally been regarded as good in Benue State, with the exception, perhaps of a few enclaves such as in Oweto areas of Otukpo and Ugbokolo town. Near the banks of some major rivers, occasional flood plains with swamps are seen. These sites are mostly located in Apa, Agatu, Kwande, Katsina-Ala, Buruku and Guma local government areas. These extensive flood plains have potential for dry season irrigated agriculture if appropriately managed (Lyam, 2005).

3.3.6 Groundwater Resources

During the dry season, the only source of water available for many people is groundwater which is accessed mostly in the form of hand-dug wells, which in many cases are not lined and/or covered, tapping into the unconfined aquifer. Isikwue *et al.* (2011) noted that most of the wells in Benue state are sand point wells (wells that are without casings). In some cases, they are lined with red bricks and covered with timber, aluminium or metal lids. Isikwue *et al.* (2011) further maintained that a survey carried out in the Wurukum flood plain area of Makurdi shows that nine out of 10 households depend on entirely on these dug wells for their drinking water. The wells in most parts of Makurdi have depths of between 0.87m and 8.2m. In terms of pit latrines, Kiptum and Ndambuki (2012) stated that most of the latrines are unlined and are often situated near water sources. The authors recommend at least 48m between pit latrines and wells. Based on the 2006 population and housing census figures, Benue had 35% of the population dependent on well water (the data did not specify whether the wells were improved or not improved) for drinking and other domestic uses. At the same time, in areas where the well water

is the dominant source of drinking water, there are no centralised sewerage sanitation systems and people depend on pit toilets, septic tanks, etc. but the population data did not specify whether they belong to improved or unimproved categories.

3.4 Water and Sanitation in Benue state

The water and sanitation situation in Benue state is challenging. For instance the [Benue State Government \(2010\)](#) in water and sanitation policy document states that ‘The estimated total demand for water to meet the needs of the people is 380,000m³/day, but only about one-third of the population is adequately served.’ The situation makes water supply and sanitation provision an area of critical concern to the Benue State Government. The same document also states that, ‘In Benue State available statistics indicate that 30% of the urban/small towns and 84% of rural people still lack access to safe water supply and sanitation services in the State.’ Health statistics also show that about 49% of Benue people, particularly women and children, suffer from water related diseases.

The provision of water in the state is handled by the Benue State Water Board, which is responsible for management, operation and maintenance of urban and small-town schemes. The Benue Rural Water Supply and Sanitation Agency (BERWASSA) is saddled with the responsibility of providing safe drinking water in the rural areas. Sanitation provision in both communities and schools has been an integral component of the water supply schemes, particularly in the rural areas. The Federal Government and some development partners such as UNICEF, DFID and WaterAid are supporting State Government's initiatives aimed at achieving increased and sustainable access to safe water supply and sanitation ([Benue State Government, 2010](#)). With these, the problem of water and sanitation is still acute in Benue State. According to the policy the challenges being faced by the Benue State government in providing water and sanitation in the state include:

- Frequent breakdown of installations
- Inadequate and erratic power supply
- Weak institutional framework
- High cost of operation and maintenance
- Limited distribution network
- Lack of requisite personnel, especially the technical class
- Poor tariff collection
- Absence of private sector participation
- Lack of effective legal framework
- Poor collaboration and coordination amongst service providers
- Inadequate allocation and timely release of financial resources
- Little or no community participation and management.

Consequently, there has not been much progress on water and sanitation in the state. There have been targets and promises that the services would be provided for the people and raising of their hopes in vain. This could be basis of people expecting much from the government. Some of the elusive targets made by the state government on water and sanitation are quoted below:

Water: -

- Complete Greater Makurdi Water Works and rehabilitate urban water works in Kastina Ala, Otobi and Ameladu by the end of 2009.
- Reactivate existing rural water schemes and establish new ones in LGAs where none exists by the middle of 2010.
- Provide water to 5 rural communities in each LGA per year
- Construct 9 (three per senatorial zone) earth dams to boost surface water reserves by 2011.
- Reorganize and properly fund and equip Ministry of Water Resources and Environment and its agencies to meet the above targets.

Targets tied to times for water supply is as below:

40% - 50%	-	2009
50% - 60%	-	2011
60% - 70%	-	2013
70% - 80%	-	2015

Sanitation:

- Expand the construction of drainage throughout the State within 4 years
- Construct and maintain 500,000 public conveniences across rural, small towns and urban communities by use of innovative and effective programmes that will include Community- Led Total Sanitation (CL TS) by 2011.
- Develop a comprehensive waste disposal policy for industrial, domestic, solid and liquid in 2008.
- Identify and prepare a site in each LGA headquarters and urban areas for integrated waste management facilities by 2009.
- Construction of central sewage systems in urban centers in the State.
- Enhance awareness in the adoption of cost-effective technologies and environmentally friendly disposal practices in households by the year 2009 (on-going).

50% - 60%	-	2009
60% -70%	-	2011
70% - 80%	-	2013
80% -	-	2015

The above are the targets which are taken directly from the Benue State government document and the target were never met against the targeted times. The contents of the documents coupled with government pronouncements raised hope of seeing these benefits. That is why many questionnaire and semi-structured interview respondents (Chapter 7: and Chapter 8:) complained bitterly of the government not living up to their expectations. For instance, while targets for water and sanitation have planned to be 80% in 2015, we are now in 2019 and it is not clear whether even 50% have been attained. Implementation therefore seems to be a problem.

3.5 Conclusion

This chapter has considered the study area. A brief background of Nigeria's physical, socio-economic and water characteristic was provided before focusing on the physical and social characteristics of Benue state. The next chapter will focus on methodology and methods employed for the research.

Chapter 4: Research Methodology and Methods

4.1 Introduction

This chapter focuses on methodology and methods for the research. Methodology refers to the framework underpinning the research process. This follows a particular philosophical framework and fundamental assumptions underlying how research is carried out in a specific discipline. Methods on the other hand, refer to the techniques of data collection and analysis like a quantitative instrument or qualitative analysis of data (Creswell and Clark, 2017). In this chapter, ontological matters are discussed, followed by the choice of study sites, samples, instruments used for data collection and actual field data collection. Ethical issues and problems encountered during data collection are also highlighted and details are provided on how these issues were handled.

4.2 Pilot survey

Prior to the main fieldwork, two pilot surveys were carried out in the study areas. The first was conducted from December 2013 to January 2014 and involved making initial contacts with the agencies and NGOs involved in water supply and sanitation provision and or regulation. All the agencies contacted had work related to water and sanitation. The agencies and NGOs interviewed were Federal Ministry of Water Resources, Federal Ministry of Environment, World Health Organisation (WHO), United Nations Children Fund (UNICEF), WaterAid, Benue State Ministry of Water Resources, Benue State Rural Water and Sanitation Agency (BERWASSA) and Benue State Sanitation Agency (BENSESA). A report on this pilot work is available in appendix (Appendix 7: Report of Pilot Survey on Agencies involved in Water and Sanitation in Nigeria). The second pilot survey involved the selection of respondents by purposively sampling them for questionnaires, semi-structured interviews and water quality testing. Wells were selected based on their construction types (improved/unimproved) and their location in the same compounds as improved or unimproved pit latrines. In the process, baseline

data was collected on the wells regarding whether they were in rural/urban locations, their ownership and usage (i.e. owned/used by a single family and shared, and if so, by how many people), whether animals were present around them and the distance between the wells and pit latrines in the same compound. The distance was found using a measuring tape graduated in meters. Well depths were also measured by using a tape which was dipped into the well in order to record depth in meters. The GPS coordinates of the wells and latrines were taken and recorded in the field notebook.

These pilot visits helped me to familiarise myself with the study area in preparation for the main fieldwork. During the second pilot survey the draft household survey questionnaire found in appendix (Appendix 1: Household Survey Questionnaire), was tested with 20 households to determine its reliability and validity. The items on the questionnaire that needed corrections were amended with supervisors' input. The interview guides for semi-structured interviews in appendix (Appendix 5: Household semi-structured interview guides) were also piloted with two respondents purposively selected within the study sites. These interviews were transcribed and sent to the supervisors for comments and amendments were made before the main fieldwork. The water samples collected during the pilot visit were tested for physico-chemical and microbial parameters and the methods used for testing them were found to be suitable before the main fieldwork was undertaken.

4.3 Ontological and Epistemological considerations for the study

Ontology refers to a set of assumptions that underpin a theory or system or system of ideas, i.e. which can be known ([Kitchen and Tate, 2000](#); [Hoggart *et al.*, 2002](#)). Epistemology is concerned with how knowledge is derived or arrived at, the assumptions on how we can know about the real world ([Kitchen and Tate, 2000](#)). Therefore, what is knowable and how it can be achieved underline a process of inquiry. Philosophy is indispensable because in the process of research, one has to see what others have done and why and also to find an approach to base one's

research on and provide the theoretical contexts in which one's findings are justified Hill 1981, cited in ([Kitchen and Tate, 2000](#)).

A popular school of thought is positivism which emphasises the discovery of laws of society, involving empiricist commitment to quantitative methods. It believes that the world is objectively given and objective efforts should be applied to acquire the truth ([Hoggart et al., 2002](#)). While an artificial dichotomy seems to exist between quantitative and qualitative research, adherents of quantitative approaches are of the view that researchers' success in investigations stem from specific attachment to a methodological approach. To this school of thought, methods should be objective and devoid of context ([Nagel, 1989](#); [Johnson and Onwuegbuzie, 2004](#)). Experiments and questionnaire surveys are methods of inquiry within positivism.

On the contrary, interpretative or hermeneutical philosophy believes that knowledge is known by the interpretation we make of the world and the meaning thereof, unlike in the natural sciences. Human beings can intend to do things, have reasons for doing them and can reflect over what they are doing. Intentionality, rationality and reflexivity are fundamental characteristics of human beings which is the subject matter of social sciences while in the natural sciences, they respond to forces of nature without any of these human qualities ([Graham, 2002](#)). Therefore, the qualitative camp such as constructivists and interpretivists reject this rigid approach and consider the importance of context and the lived-experience of research subjects ([Nagel, 1989](#); [Johnson and Onwuegbuzie, 2004](#)). The methods of inquiry in interpretation include in-depth interviews, observations, photography and documents. These are collectively described as qualitative research.

Advocating a combination of the two distinct approaches, [Simonovich \(2017\)](#) is of the view that using qualitative and quantitative approaches over time would build collaboration among academic and practice departments as well as interdisciplinary research. [Simonovich \(2017\)](#)

further asserts that developing a mixed method programme of research brings better understanding of one another within our community of scholars, a larger audience profile of our research, a robust interest and a perfect understanding of the truth. Bridging the gap between quantitative and qualitative is known as mixed methods research. [Creswell and Clark \(2017\)](#) have advocated a mixed method approach thus:

- Mixed methods research provides strengths that offset the weaknesses of both quantitative and qualitative research.
- It provides more sound evidence for studying a research problem than either quantitative or qualitative research alone.
- It helps to answer questions that cannot be answered by quantitative or qualitative research alone.
- It helps to encourage collaborations across different relationships between quantitative and qualitative researchers.
- It encourages the use of multiple paradigms.
- The researcher is free to use all possible methods to address a research problem, thus making mixed methods more practical.

From the foregoing, it is appropriate to employ a mixed methods research design. The mixed methods research design is good as it provides opportunities to obtain better and more reliable data and to minimise the chance of biased findings. The varied nature of the data required and different sources from which they can be gathered make the mixed method approach appropriate for this research. The research tools to be used for both quantitative and qualitative approaches include interviews, questionnaires, water quality analysis, field observation and documentary analysis.

4.4 Methodological Approach

The varied nature of the topic necessitated the use of a mixed methods approach. Data were needed from various angles to answer the research questions. The topic looks at investigating the impacts of pit latrines on ground water quality in Benue State, Nigeria. This involved water quality testing to ascertain the quality of water for drinking in the study sites, obtain well characteristics such as well-latrines-distance, well depth, improved/unimproved wells and latrines (quantitative), stakeholders' awareness of contamination and detailed investigations into water, sanitation and hygiene issues (quantitative by questionnaire, qualitative by semi-structured interviews). With this widely scoped topic, data were collected by questionnaires, water testing, interviews, field observation and documentary sources. These data therefore involved the integration of both qualitative and quantitative data to get a comprehensive view of the topic. The mixed method approach was therefore necessary to:

- Achieve triangulation where various data sources could help address research questions.
- One method could check and complement another. For instance, in the field work, water quality testing showed high chloride values and respondents complained, during semi-structured interviews, of water being salty in the dry season, indicating the presence of sodium chloride, especially in the rural areas. Therefore, water testing (quantitative) and semi-structured interviews (qualitative) complemented each other.
- It allowed the research to touch on many facets and reflect real-life complexities. For instance, aside from water testing, respondents were encouraged to express their understanding of the issues. The poor water quality was reflected in people's expression of water-borne diseases in the last 12 months. Issues of water and sanitation problems and possible solutions were investigated by receiving detailed responses from the research

subjects by semi-structured interviews, illustrating how such problems can be investigated from many angles.

- In-depth knowledge arising from interviews and informal discussions could not have been achieved with only questionnaires or water testing. Therefore, with the mixture and complementary usage of qualitative and quantitative data, a mixed method approach was relevant and justifiable in the present study.

4.5 Justification for choosing Benue State for the research

In Benue state, as in other parts of Nigeria, good water supply and sanitation facilities are grossly inadequate. [WaterAid \(2014\)](#) reports that during the dry season, residents of Ugbolojor, a village in Benue state, North Central Nigeria, get up at 5:00 am by foot to collect water from a stream and carry it on their heads, taking around two hours to collect it. This supports the UNDP's Human Development Report that women in Africa and Asia carry water on their heads weighing 20kg; the same as the average UK airport luggage allowance. In the same way, WaterAid quoted Victoria, a mother of five, saying: *"During the dry season, the water is coloured because of the leaves that fall in. Animals go and drink the same water. That's the water I give my children...it means they get sick-sicknesses like cholera, diarrhoea, typhoid, and others"* ([WaterAid, 2014](#)).

Based on the 2006 population and housing census figures, about 70% of the population from Benue State drink water from unimproved sources like surface water and 'unimproved, unlined or uncovered/unprotected wells and use the same water for other domestic purposes. The most common sanitation systems here are pit toilets and open defecation with less than 10% having access to central sewer systems in 2013 and 26% depending on pit toilets and septic tanks. Echoing [Satterthwaite \(2003\)](#)'s emphasis on "nonsense statistics", many of these systems are officially classified as "improved" yet in reality are often poorly constructed, too shallow and equally too close to drinking water sources.

Research undertaken in Benue state to investigate water quality issues confirm these low levels of access to improved water and sanitation systems whilst revealing significant gaps in knowledge regarding investigation into comprehensive water and sanitation facilities. [Magaji and Aondoakaa \(2009\)](#) studied problems and prospects of water supply in Otukpa, a semi-urban area in Benue state and reported that water supply was inadequate and of poor quality but did not investigate the contamination of water by faecal matter. There was also no reference to improved and unimproved facilities and construction facilities, which the present research seeks to incorporate. [Ocheri and Ogwuche \(2012\)](#), analysed water samples in the laboratory and reported the contamination of wells but did not categorise the wells into improved or unimproved or investigate chemical and bacteriological parameters other than lead. In a study on the influence of well depth on groundwater contamination in Makurdi, the capital of Benue state, [Isikwue *et al.* \(2011\)](#) at Makurdi, found that shallow wells were more contaminated with coliform bacteria than deep wells. Although the wells that they sampled were not categorised as improved/unimproved they suggest that shallow wells are more contaminated because they were not deep enough for the contaminants to be filtered through as the longer, they travel the better filtered they become. The authors maintained that the main sources of contaminants were from pit latrines, soak-away pits, septic tanks and refuse dumps. They further maintained that continued use of drinking water from these wells has resulted in many water-borne diseases like tularaemia, leptospirosis, typhoid fever, cholera, hepatitis. These disease peak around July/August as confirmed from hospital records, when there is higher contamination due to higher water table levels. However, this research did not survey awareness about contamination and possible sources of contamination even though the risks seem high. [Isikwue *et al.* \(2011\)](#)'s research did not specifically investigate improved and unimproved water sources and there was no study on local knowledge or education initiatives that focused on improved water and sanitation so these are gaps that will be explored in this study.

Highlighting the importance of seasonality as an influence on water quality, [Idoko et al. \(2012\)](#) looked at temporal variability of heavy metal concentrations in rural groundwater in Benue state and found that groundwater was more contaminated in the wet season than in the dry season with heavy metals such as iron, manganese, lead and zinc. Almost all the heavy metals had higher concentrations in the wet season, exceeding the WHO limits. These authors concluded that rural areas are also affected with contamination with heavy metals and identified a need for further studies to frequently monitor groundwater quality to know changes in the chemistry of the groundwater and to possibly put remedial measures in place.

[Oluma et al. \(2010\)](#) conducted research on groundwater from wells (types unspecified) in two rural communities of Obi and Oju in Benue state and found that the water samples were contaminated with significant levels of coliform bacteria in shallow well water samples due to the sanitary integrity of the wells being compromised by roaming animals and human waste from open defecation. The study did not examine the construction characteristics of the wells studied, their location relative to sanitation facilities and local awareness of contamination sources.

Most existing studies of well water quality in Benue have not undertaken faecal coliform testing on well water or explored associations between the presence of faecal coliforms, the nature of well and latrine construction and broader social aspects associated with improved water supply and sanitation. The studies mentioned above have not investigated in detail whether levels of groundwater contamination varied between ‘improved’ (protected/lined) and ‘unimproved’ (unprotected/unlined) wells or according to the proximity of ‘improved’ or ‘unimproved’ sanitation facilities. This study seeks to fill this important gap by exploring the extent to which faecal contamination of well water between improved and unimproved facilities and in association with wider awareness of the causes of well water contamination. My research therefore carries out water testing as well as interactions with respondents in questionnaire and

semi-structured interviews. This encompasses qualitative and quantitative approaches towards a detailed investigation and solution to this complex problem.

Benue state is a good example of low access to water and sanitation. For instance, from the Demographic and Health Surveys (DHS) surveys, there were indications that access to improved water supply was low. Similarly, in the case of sanitation, the NDHS data available showed that provision for improved sanitation was low, a large proportion of respondents had no access to sanitation facilities and practiced open defecation. This means that access to improved water and sanitation in Benue State was less than 30% for most of the period between 1999 and 2013 which compares badly with other Nigerian states like Oyo, Kaduna, Osun, Abia, Edo where access to improved facilities exceeds 50%. The low level of access to improved water and sanitation facilities therefore makes Benue an interesting case study. Again, my familiarity with the study sites accords me an opportunity to collect data without many problems. Other areas have security issues where it would be risky to even carry out research. These issues were all addressed in the risk assessment prior to undertaking the fieldwork.

Having chosen Benue state as the focus of this study, the next stage of the research involved choosing a mixture of rural and urban study sites in which to conduct the research. Using the 2006 Nigeria population and housing census report, Makurdi and Tse-Agberagba were selected for study as the figures show low access to water and sanitation. Based on the 2006 population and housing census, Agberagba had 54% and 44% using pit latrines and wells respectively, compared to other areas such as Katsina-Ala which had 27% and 37% of households using pit latrines and wells respectively. Therefore, my choice of the study sites was influenced by poor levels of access to improved water and sanitation in Benue state and Konshisha local government which Makurdi and Tse-Agberagba respectively fall under. Both areas have characteristics that the study wishes to use such as compounds having water and sanitation facilities. In designing the research, the plan was to compare urban and rural sites. Since the

desk-based study used DHS data to set Benue into the context of investigation, an obvious urban area would be the state capital. In the same DHS and population and housing census data, Tse-Agberagba was identified as being representative of other local governments and towns in the state on the criteria of low access to water and sanitation and was chosen for detailed investigation.

Makurdi was chosen as the second main study site. It is an urban area located in roughly the same climatic zone as Tse-Agberagba but with greater socio-economic and cultural diversity. Furthermore, Makurdi is located in a different geological zone to Tse-Agberagba. While Makurdi is sandy and clayey in some places, probably due to its being close to the River Benue, Tse-Agberagba is in a largely clayey area where wet seasons are characterised by muddy surfaces which quickly get dried and cracked in the dry season. The two areas therefore accorded an opportunity to research two distinctly characterised locations.

4.6 Brief Background Information about the Study sites

4.6.1 Makurdi (urban sites)

Makurdi is located on lat. 7°44' N and Long. 8°31'E. It is the capital of Benue State as well as the capital of Makurdi local government council. The town was founded by 1927 when the railroad from Port Harcourt was extended to Jos and Kaduna. Makurdi then developed as transportation and market centre. In 1927 it was the capital of the then Benue province ([Britannica, 2017](#)). It served as a river port and became a trading depot by companies such as John Holt and UAC. The construction of the rail bridge in 1937 also facilitated transportation and business activities as it serves as a transit point linking the south and north of the country ([Benue State Government, 2017](#)). The major settlements in Makurdi are High Level, Wurukum, Wadata, North Bank and Kanshio. They are other places such as the old and New GRA, BNARDA, Akephe, Ankpa quarters and many other newer satellite settlements. For this research, data collection was mainly in High Level, Wurukum, Wadata, North bank and

Kanshio, as these are the main settlements in Makurdi within the 16 km radius of the town known as ‘greater Makurdi.’ It is from these settlements that the well samples were tested in both improved and unimproved wells in both the dry and wet seasons (see Figure 4.1 and Figure 4.2) for maps of Makurdi town and Tse-Agberagba respectively. The well locations and improved/unimproved categories locational maps are found in Figure 6.1, Figure 6.2, Figure 6.3 and Figure 6.4 where improved and unimproved wells are also described.

In terms of climate, Makurdi has dry and wet seasons like all the other places in the middle part of the country. The rainy season starts in April and ends in October while the dry season starts from November to March. Temperatures are generally very high averaging over 36⁰C. The dry season temperatures are higher reaching 40⁰C sometimes. The vegetation is generally of guinea savannah type with tall trees and grasses. Human activities have seriously impacted on vegetation making it difficult to have the original guinea (rich vegetation with trees) savannah.

As a state and local government headquarters, Makurdi has many human activities including civil service work, trading, small scale industries, technical works, transport, banking, farming, fishing (from River Benue), etc. The town is a local trade centre for yams, sorghum, millet, rice, cassava, sheanuts, sesame oil, peanuts (groundnuts), soybeans, and cotton raised by the Tiv, Idoma, and Iggede people of the surrounding area ([Britannica, 2017](#)). Makurdi people come from different cultures. The Tiv are the dominant people, followed by Idoma and Iggede. Other tribes include Hausa, Etulo, Abakpa, Jukun, Igbo, Yoruba and many other tribes.

As a state capital, Makurdi has light, road networks, tap water in some places. There are two universities (Federal University of Agriculture and Benue State University), a college of Advanced and Professional Studies, a school of nursing and midwifery, many secondary and primary schools. There are many government and private offices, hospitals, churches, etc. As tap water is not everywhere and always available, many people use boreholes, wells and rainwater for drinking.

4.6.2 Tse-Agberagba (Rural sites)

Tse-Agberagba is located on Latitude 7⁰ 04¹ North and Longitude 8⁰ 38¹ East. It is one of the local government headquarters of the 23 local governments in Benue State. It is headed by a chairman who is the head of the local government council. Tse-Aberagba is approximate 75 km away from Makurdi town as the crow flies (Google maps).

The Catholic church divided the town into four zones roughly corresponding to the major roads of the town. These are Alemenyi, Dam, Konshisha and Secretariat. These zones were therefore used as data collection sites for their convenience (see Figure 4.2). Like any other location in Nigeria, Tse-Agberagba has two distinct seasons: dry and wet seasons. The wet season starts in April and ends in October while the dry season starts in November and ends in March.

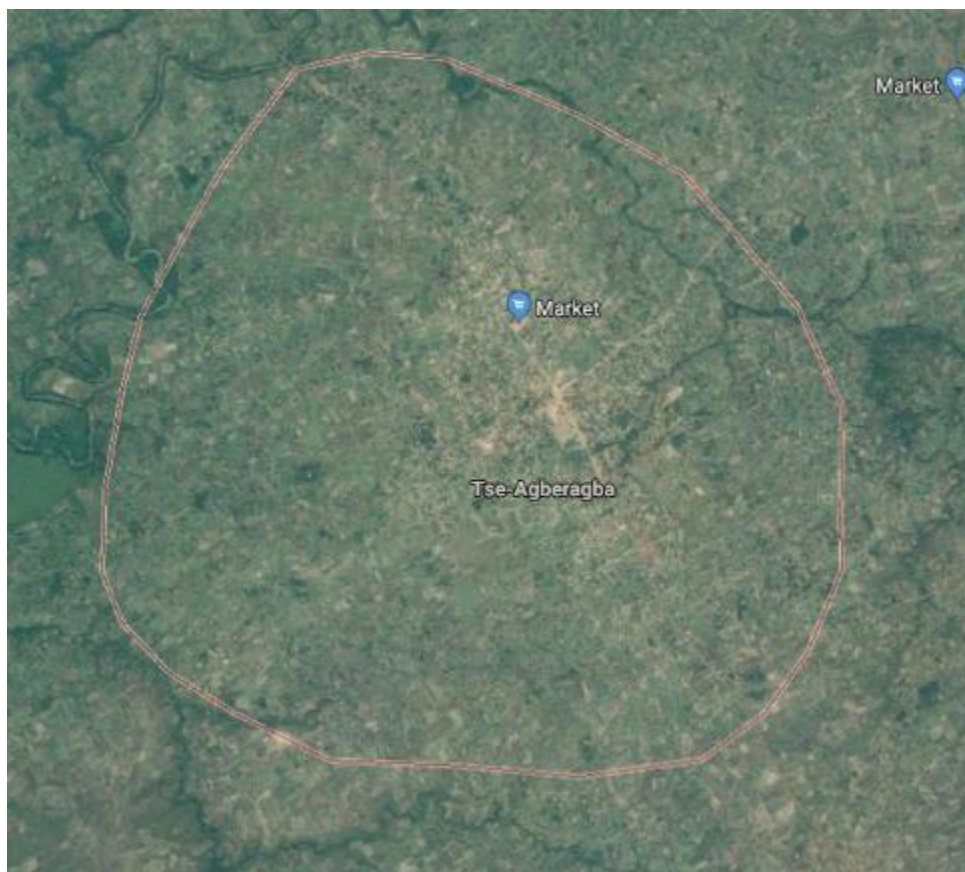


Figure 4.2 Satellite Images Map of Tse-Agberagba
Source: Google maps

The town is mostly agrarian, and crops produced in large quantities include yams, groundnuts, maize, guinea corn, rice, cassava, Bambara nuts, while citrus crops, mainly oranges are also produced in large quantities. The above produce provides the raw materials for the potential establishment of cottage industries such as rice milling industry, garri processing, bread industry and fruit juice industry. Livestock like cattle, goats, pigs and sheep are found in this local government. Food and cash crops are the major commodities for commerce in the local government. Some other people are engaged in civil service work such as workers at the local

government secretariat. There are also some State zonal establishments such as the Ministry of Works, General hospital, Independent National Electoral Commission (INEC), etc. where some people work. Tse-Agberagba has many schools (primary and secondary) so some people are engaged in teaching (Fieldwork March 2016) and ([Benue State Government, 2017](#)). There are also skilled craftsmen in the area. The people produce unique perforated pots (buufu) and other pots, hoes, spears, bows and arrows, cutlasses, mats, very large baskets and beautiful carving. There are some hotels and other private business ventures in Tse-Agberagba ([Benue State Government, 2017](#)).

Tse-Agberagba has recently been connected to the power supply. It is also linked by some roads, which make communication possible. The major water sources are wells, boreholes, streams. There is also an earth dam which is the main water supply in the area during dry season. Water is very scarce in the area in the dry season as most of the wells get dried in the clayey and cracked soils. Boreholes and water from rivers are also used in the dry season.

4.7 Integrating the different research approaches

The overall aim of examining groundwater contamination was achieved by using different methods earlier mentioned in the mixed methods section. An initial desk-based study was done using DHS data to get trends in access to water and sanitation for a fourteen-year period (1999-2013). This gave a summary of water and sanitation in Nigeria and Benue State, justifying the study as well as pointing areas for further research in the field. This therefore helped highlighting the WASH situation and identification of areas to direct the research. For instance, the trends raised questions of why water and sanitation access are poor. The water testing actually tested the well water samples to ascertain whether the water people were drinking is safe. The questionnaire got information from the people about their major concerns where water and sanitation were identified and a further inquiry conducted to find out if the people were happy or not with the quality of water they were drinking, the sanitation facilities being used

and awareness on contamination issues. Their knowledge or otherwise of contamination matters were compared with the water quality tests. While the questionnaires were brief and, in most cases, pre-coded, the semi-structured interviews allowed people to freely express their opinions on issues of water and sanitation raised. These quotations supported or contradicted some other findings in other methods and elsewhere. For instance, where government agencies said there were no problem and the respondents said there were problems, the respondent's views are juxtaposed with agencies' views and conclusions drawn. Documentary sources such as newspapers were checked for up to date information on water and sanitation. The reports supported field findings. Photographs captured various scenes related to water and sanitation which confirmed other field methods. When the environment and water agencies commented positively on their activities, queues at water points, vendors and even open sources were captured thereby supporting what was observed on the field. Therefore, the different methods worked together to get rounded data on water and sanitation in the study sites. These could be generalised to other similar areas.

4.8 Research Population and Sample

As Makurdi and Tse-Agberagba have a significant population of households using water from dug wells and using pit latrines, their populations formed the target group for the research. A total of 600 questionnaires were administered, 300 each in Makurdi and Tse-Agberagba. The details of the sample distribution are found in Chapter 7: under the demographic characteristics of respondents and also shown in Table 4.1. As the study sought to compare rural and urban sites, the same sample size was deliberately chosen to make comparisons easier.

Table 4.1 Activities undertaken in Urban and Rural Sites

S/No	Location	Rural/Urban	No of questionnaire interviews	No of semi-structured interviews	No of water samples
1	High Level	Urban	60	4	10
2	Kanshio	Urban	60	4	10
3	North Bank	Urban	60	4	10
4	Wadata	Urban	60	4	10
5	Wurukum	Urban	60	4	10
6	Alemenyi	Rural	75	5	12
7	Dam	Rural	75	5	12
8	Konshisha	Rural	75	5	12
9	Secretariat	Rural	75	5	14
Total	9		600	40	100

Source: Fieldwork 2016

In the semi-structured interviews, twenty respondents were chosen in each of the urban and rural sites. This number was chosen to provide enough data for qualitative analysis which is based on the depth of the investigation and not necessarily on quantity. As for the government agencies, all of them that had work related to water and sanitation were interviewed. In each of the offices, a representative chosen by the organisation was interviewed on their behalf. I therefore had no control on who would be interviewed and no option to request access to female interviewees. The agencies that I sought interviews with were the Ministry of water resources and Environment, Benue State water Board, Benue State Rural Water Supply and Sanitation Agency (BERWASSA) and Benue State Environmental Sanitation Authority (BENSESA). When I requested interviews with staff from these organisations, interviewees were chosen, on the basis of their ability to represent the views of the agency on the issues I was interested in and as a researcher, I had to work with the people that were assigned to speak to me and had no option to request discussions with additional people or female staff members (of which there were not infact there).

In terms of water testing, the water samples were collected from both rural and urban sites to test for physico-chemical and faecal coliform parameters. Again, since one of the intentions was to compare contamination among the sites, equal samples of 50 wells each were taken from

both rural and urban sites in both dry and wet seasons, making 100 samples in the dry and another 100 samples in the wet seasons. This number of samples was taken to allow statistical tests to be undertaken ([Pallant, 2016](#)) and also because most of the reagents are available in packs of 100s, this figure was more convenient. Furthermore, with limited resources at hand, this number was arrived at to manage the available resources within the fieldwork budget. The breakdown of the samples in the respective locations are found in Table 4.1. It is worth pointing out here that the design of the research for all the data collection was based on samples of households that had wells and pit latrines in the same compounds ensuring an even spread in the process. Thus, only houses with these criteria were sampled. Houses having flush toilets were excluded from the sample as were the many households using other unimproved water and sanitation facilities such as drinking water from open water sources and practicing open defecation. This makes the percentage of improved samples in the study sites appear higher than reports from DHS data.

4.9 Data Collection and Sources

Data collection was done in both dry and wet seasons. In the dry season which lasted longer (from September 2015 to April 2016), questionnaires, semi-structured interviews and water testing as well as well characteristic measurements such as well-latrine-distance, well depth, well and latrine co-ordinates were carried out. During this season, serious water scarcity was observed, especially in the rural areas where long queues formed at boreholes and many people drew unclean water from Dam (an open water source). In the urban area, the problem was not as severe as in the rural sites as there were many water hawkers present which meant that it did not take as long to get water as in the rural sites. But even here, waiting time increased in the dry season and people carried the burden of purchasing water for all household needs. Demand would therefore be higher than supply resulting in increased waiting times to get the water vendors. This also placed some financial stress on the people. The wet season fieldwork (only

water quality testing) took place between September and November 2016 in both rural and urban areas. The actual water testing took place between September and October.

Both primary and secondary data were collected. Primary data comprised of questionnaire surveys, water testing and semi-structured interviews and photographs. Secondary data comprised mainly of DHS data, newspaper articles and other documented sources.

4.10 Methods of Data Collection

4.10.1 Questionnaires

Questionnaires are widely used in survey research where data is to be collected on people, their attitude, behaviours, beliefs, awareness, etc. This study was designed to investigate stakeholders' understandings of the existence and causes of well water contamination, their sanitation and hygiene awareness, and their views on possible solutions to any water, sanitation or hygiene related problems identified. A questionnaire was chosen as a data collection tool because it allows data to be collected on standardised variables and questionnaires are easy to administer without interference from the interviewer ([Kitchen and Tate, 2000](#)).

4.10.2 Development and Testing of the Questionnaire

The questionnaire was divided into demographic, water supply, sanitation and hygiene sections and used both closed and open-ended questions. In the former, respondents were asked to choose among the provided options, while in the latter, there was provision for respondents to give a little more detail on their opinions.

The development of the questionnaire was influenced by the JMP's approach to collecting information on water and sanitation with some of the questions recommended by the JMP which were used in the DHS and replicated in the questionnaire to allow comparability with existing DHS and MICS surveys used by the JMP to track progress towards the MDGs and now

the SDGs. Examples of such questions include: ‘What is the main source of drinking water for members of your household?’ ‘How long does it take to go there, get the drinking water, and come back?’ ‘What kind of toilet facility do members of your household usually use?’ ‘Do you share this facility with other households?’

Before being administered, the questionnaire was tested in the pilot survey and adapted to improve clarity and logical progression and then sent to the supervisors for further inputs. This helped to ensure the validity and reliability of the instrument; i.e. its ability to measure what it was intended to and give consistent results under similar conditions. The households were selected based on availability of wells and pit latrines in the selected sites.

4.10.3 Administering the Questionnaire

The criteria for selection of respondents for questionnaire administration within the study areas were those living in houses with pit latrines and wells in the same compounds. The questionnaire was administered by myself and two research assistants who were well trained for the purpose and enabled me to avoid the potential risks associated with lone working during the fieldwork.

Before the actual questionnaire interviews, permission was sought from the leaders of the study sites. In all cases, permission was given. A member of the team would introduce the purpose of the research to the head of household and approval would be obtained before administering the questionnaire. All respondents were interviewed, and we filled in the questionnaire ourselves. This method was adopted because some questions might have confused the respondents if the questionnaire had been left with them to complete and our presence allowed clarification to be undertaken where needed. Again, the problem of leaving questionnaires behind and some getting lost, unintended persons completing them and getting incomplete responses were

avoided using this approach. The downside is the time consumed but since the main aims were achieved, the time consumption was worth the exercise.

The field assistants and I all spoke and understood the dominant language in the study areas which is Tiv. In the urban sites, some people who did not understand Tiv language were interviewed in English (and broken English called 'pidgin' in Nigeria). In some places, particularly North Bank where some people did not speak English, questionnaire interviews were undertaken in 'Pidgin English'. In the rural sites, most respondents spoke Tiv and we would speak with them in the local language and administer the questionnaires easily. In some compounds where there were many households living in the same compound more than one household was interviewed simultaneously (by me and the field assistants). This helped in cross-checking and confirming what the respondents were saying. For instance, if respondent A said there were five households sharing a toilet facility and respondent B said the same thing, it would be clear that the right responses were given since they were interviewed separately and simultaneously.

This method of administering the questionnaires was advantageous in many ways. Firstly, there was a high response rate and no loss of questionnaires because there was no issue of giving the questionnaire to return later or posting where many questionnaires could be missing. This also ensured that respondents were the ones that actually answered the questions and those who were sampled were the ones who actually gave their opinions. This proved to be a useful method as it addressed most of the criticisms levied against questionnaire administration in the literature (Kitchen and Tate, 2000) such as poor response rates, loss of questionnaires and actual respondents not filling the questionnaires. Although time consuming, the exercise went well and achieved the purpose intended.

4.11 Water Quality Analysis

In addition to the questionnaire administration, water quality tests were carried out to test for faecal coliforms and physico-chemical parameters in order to address objective two of the research. As earlier mentioned, water scarcity was very serious in the dry season at Tse-Agberagba with long queues forming at boreholes (Plate 4.13) and many people using water from Dam (Plate 8.2). Alongside the water testing, baseline data were collected on the nature of the well construction, the distance of wells from the nearest latrine; well depth (See Plate 4.1.); number of well and latrine users; well and latrine coordinates; education and income level of household heads and whether the well water was used for drinking or not.



Plate 4.1 Well-Latrine distance measurement (A) and well depth measurement (b)

Source: Fieldwork 2016

Water quality analysis was carried out in both urban and rural areas of Benue State, Nigeria. Observations were also made of water and sanitation facilities in the sample areas and photographs were taken of the wells and sanitation facilities there.

Data were collected in both dry and wet seasons on water quality and associated well characteristics. Water samples from dug wells were collected using sterile bottles from the

School of Geography laboratory of the University of Nottingham and kept in a cooler (Plate 4.2). The criteria for sampling wells included wells with pit latrines in the same compounds in both rural and urban areas. The bottles were carefully opened, rinsed with the sample twice before water collection. In the process, care was taken not to contaminate the sample in the process of collection. The fact that the control samples tested negative confirms careful and non-contamination of samples during collection.



Plate 4.2 Cooler for water samples (A) and sterile water sample bottles (B)
Source: Fieldwork 2016

4.11.1 Petrifilms

These are count plate materials used to test for faecal coliform in well water samples. Since they were an important tool in the research, it is desirable to have some background information about them, hence their inclusion here. The 3M Petrifilm Aqua Coliform Count Plates (AQCC) is a sample ready culture medium system which contains Violet Red Bile (VRB) nutrients, a cold-water soluble gelling agent, and a tetrazolium indicator that facilitates colony enumeration. They are used for the enumeration of coliforms in the bottled water industry. On the 3M petrifilm Aqua AQCC plates, coliform colonies are indicated by red colonies associated with

gas. Gas trapped around red coliforms colonies indicate confirmed coliforms, eliminating the need for a subsequent confirmation step ([Petrifilm, 1999](#)).

[Ball \(n.d.\)](#) noted that coliform count (cc) plates are designed to enumerate coliform bacteria, which are members of the family of *Enterobacteriaceae*. They ferment lactose to produce gas and their presence is an indication of faecal contamination. [Ball \(n.d.\)](#) also noted that there are many types of petrifilms but the four suggested for use in education (probably due to their accuracy) are: Aerobic Count (AC) plates which are used to enumerate common aerobic bacteria. Coliform Count (CC) plates are used for enumeration of coliform bacteria (used in this study). E. coli/coliform (EC) plates are used to count all coliforms in a sample and also identify E. coli as a subset of the coliforms. Yeast and Mould Count (YM) plates are used for counting all the yeast and mould species in a sample.

Escherichia coli/coliform count plates provide a good opportunity for water quality monitoring due to their inexpensive nature. As some other modern water quality monitoring tools are expensive, frequent water monitoring is limited and petrifilms are useful in such cases ([Nelson et al., 2012](#)). In the absence of modern equipment for the detection and removal of organisms, the detection of nominal E.coli and coliforms as indicator organisms provide water authorities an efficient and simple method to monitor contamination events ([Nelson et al., 2012](#)). This brief piece on petrifilm considers the classification of petrifilm count results, how it is plated, its reliability and a conclusion.

4.11.2 Procedure for using petrifilm

Petrifilm plates are first labelled after being placed on a flat surface. Using a pipette or sterile instrument, one millilitre of the sample is drawn and dropped perpendicular onto the opened 3M plate and closed gently to avoid trapping air bubbles. Using a spreader with the flat surface down, it is placed on the sample with pressure applied at the centre for an even spread of the

sample unto the plate and removed without twisting it. The plate is then allowed to stand for 1 minute before incubation. The samples are placed in the incubator with the coliform side up in stacks of up to 20. The samples are incubated for 24 plus/minus two hours for total coliform results. For interpretation, the indicator colour for colonies is red and the top film traps gas produced by coliforms. The colonies associated with gas bubbles are counted as coliforms. Red colonies not associated with gas are also counted as coliforms. The colonies outside the circle are not counted because they are not under the influence of the media. The preferable counting range is up to 150 colonies per plate. Over 150 colonies, the counts are estimated. This is done by counting the colonies in one square and multiplying by 20 and this gives the total estimated counts ([Petrifilm, 1999](#)).

4.11.3 Reliability of petrifilms

Many studies have been carried out using petrifilms and their reliability is reported in the literature. For instance, in a study carried out by [Beloti *et al.* \(2003\)](#), it was found that results using standard methods such as Most Probable Number (MPN) and petrifilms presented good correlations regardless of the culture medium used in the presumptive phase. Good correlations were also obtained between traditional methods and petrifilm. For *E.coli* too, the petrifilm showed great correlation with standard methods. [Beloti *et al.* \(2003\)](#) further noted that Petrifilm is four times quicker than MPN methods for total coliform enumeration and twice as fast as for *E. coli* enumeration. Petrifilm High Sensitivity (HS) and *E.coli*/Coliform Count (EC) plates are more practical to use and read results, avoiding replication and use of a great quantity of glassware and culture medium as is used in standard methods ([Beloti *et al.*, 2003](#)).

In comparing petrifilms with other water testing agents, [Murcott *et al.* \(2015\)](#), using a present/absent (P/A) records, observed that petrifilm has true results with 71% accuracy. They also observed that since petrifilms use 1 ml of water, they have high false negatives; that is faecal coliform could be present but not detected. But in my research the petrifilm actually

detected a lot of coliform which means the samples were really contaminated. They also noted that petrifilms perform better in total coliform detection. For the purpose of my research, even a P/A would have sufficed as this would indicate and establish that contamination has occurred in the sampled areas. [Seib \(2011\)](#) used petrifilms for testing total coliform in water in Mali and found it to be a reliable testing medium. He classed them into 0, >0, >50, >100 and >150 cfu. This supports the grouping of the total coliform results found in water samples to give a better interpretation of the results.

[Crowly *et al.* \(n.d.\)](#) compared the 3M petrifilm Aqua AQCC plate method and the endo LES agar method, Standard Method for the Examination of Water and Wastewater (SMEWW). They found out the log coliform count per filter was not significantly different between the 3M petrifilm Aqua AQCC plate method and endo LES agar method at the low inoculation level with the P value of 0.43. They however noted that at high inoculation levels, the mean log coliform count per filter was significantly different between that obtained by the 3M petrifilm AQCC plate method and the mean log count from the endo LES agar method with a value of $P=0.16$. The average count from petrifilm were reported to be greater.

In their work in Brazil, [Taniwaki *et al.* \(2001\)](#), compared the efficacy of three culture media: dichloran rose Bengal chloramphenicol (DRBC), dichloran 18% glycerol agar (DG18) and photo dextrose agar (PDA) supplement with two antibiotics with the simplate and petrifilm techniques for mould and yeast enumeration in various foods. They found that the correlation coefficients for petrifilm versus culture media were acceptable.

Similarly, [Beuchat *et al.* \(1990\)](#) compared the yeast and mould (YM) plate to acidified potato dextrose agar (APDA) and chloramphenicol-supplemented plate count agar (CPCA) using pour and surface plating techniques for its ability to recover yeasts and moulds from eight various foods. The correlation coefficients for petrifilm YM plates versus pour-APDA, surface APDA,

pour CPCA and surface-CPCA for recovering total yeasts and moulds from a composite of eight foods tests were respectively 0.993, 0.993, 0.994 and 0.995. The coefficient of variation for total yeast and mould populations recovered on petrifilm YM plates was 1.0% compared to 1.2 to 1.7% for traditional enumeration systems. After incubation, the yeast or total yeast and mould population detected from the food were not significantly lower than the respective population detected using traditional pour-and surface plating techniques and media. Therefore, the petrifilm YM plates were considered to provide an acceptable alternative to traditional methods of enumerating of yeast and mould in dairy and high acid products. Although the last two tests [Taniwaki *et al.* \(2001\)](#) and [Beuchat *et al.* \(1990\)](#) were not on water, but foods, they give an indication of petrifilms' reliability and acceptability for carrying out tests.

4.11.4 Classification of colony count

[Chuang \(2010\)](#) attempted to classify risks levels in *E. coli* in water sample (cfu/100ml) of water thus:

Table 4.2 *E.coli* Risk Level Groupings

Risk level	<i>E. coli</i> in sample (cfu/100ml)
Conformity	<1
Low	1-10
Intermediate	10-100
High	100-1000
Very high	>1000.

Source: [Chuang \(2010\)](#).

This classification is based on a 100ml sample, while petrifilms use 1ml sample. Again, the classification may not apply in practical terms. For instance, the colony counts are not supposed to be up to 1000 to be considered very high. Since this relates to health, colony counts of about 100 or less should be considered very high. However, this gives an idea to group the colony count to help interpreting health risks associated with contamination. Many authors also grouped colony forming units in bands into 1-10 or 1-9 cfu/100ml, 11-100 or 10-99 cfu/100ml,

and >99 or 100 cfu/100 ml (Jensen *et al.*, 2004; Gundry *et al.*, 2004; Gundry *et al.*, 2006; Brown *et al.*, 2008b).

On the coliform interpretation guide Petrifilm (1999), the counts considered low are three colony forming units (3 cfu) while those considered high are 10 - 30 cfu. It is therefore logical to group the colony counts into: No growth (0 cfu), low (1-9cfu), high (10-30cfu) and very high (above 31 cfu). This classification/grouping was therefore adopted in this research.

Nelson *et al.* (2012) noted that petrifilm plates provide easily interpretable information concerning faecal coliforms. They are extremely light weight and compact, being inexpensive to transport. They avoid difficulties with traditional methods like petri dishes, perishable media and sterilisation of equipment. Only incubators are required, and onsite testing is easily carried out. Therefore, petrifilms are considered an appropriate technology for water quality monitoring in developing nations. The technology is reliable, easy to use with minimal training, compact for transporting and inexpensive.

The parameters on which data were collected are faecal coliforms (measured as total coliform counts). The water samples were collected from the field and placed into the sterile bottles, labelled, kept into a cooler and taken immediately to the Microbiology laboratory of Benue State University Makurdi. Coliform tests involved the use of 3M petrifilms provided by the University of Nottingham Geography laboratory. A pipette set to 1ml was used to place one millilitre of the water sample onto the petrifilm. To check the reliability of the petrifilms, every tenth sample was tested five times. The petrifilms were covered and incubated for 24 hours after which the colonies were counted. The coliform count plates contained both coliform colonies with gas bubbles (Plate 4.5), and without gas bubbles and both were counted. The gas producing colonies are confirmed faecal coliforms as stated in the 3M petrifilm 'Aqua Coliform Count Plates' interpretation guide. Photographs of the incubated petrifilms were taken. For

simplification of the results of the coliform count plates, the coliform data were classed into low (0-9) high (10-30) and very high (31 and above) counts ([Petrifilm, 1999](#)). This guide is given in the interpretation guide and similar guidelines were identified in the literature. To check for the effectiveness of the petrifilms, some water samples from autoclaved water and deionised water were also inoculated and incubated. After the incubation, there was no growth in any of them (Plate 4.5a).



Plate 4.3 Borehole Sampling
Source: Fieldwork 2016

Houses with wells and latrines were selected. In terms of boreholes, one was sampled in each of the locations in both urban and rural areas as all the locations had at least one borehole. A further control was made using borehole and sachet water. Some borehole and sachet water had coliform growths on them. It shows that the petrifilms were effective and reliable.

The main purpose of the water samples analyses was to identify the presence of faecal contamination in well water. The procedure for testing water with petrifilm was as follows:

- The Petrifilm count plate was placed on a level surface and labelled. The top film was then lifted. With a pipette perpendicular to Petrifilm count plate, 1 ml of sample was placed onto the centre of the bottom film.
- The top film was carefully rolled down to avoid trapping air bubbles.
- With the flat side down, the spreader was placed on the top film over the inoculum. Gentle pressure was applied on the spreader to distribute the sample over the circular area before a gel was formed. The gel was given one minute to solidify.
- Count plates were incubated with the clear side up in stacks up to 20 for 24 hours ([Petrifilm, 1999](#)). Petrifilm count plates were counted manually under lit conditions.



Plate 4.4 Petrifilm Inoculation
Source: Fieldwork 2016

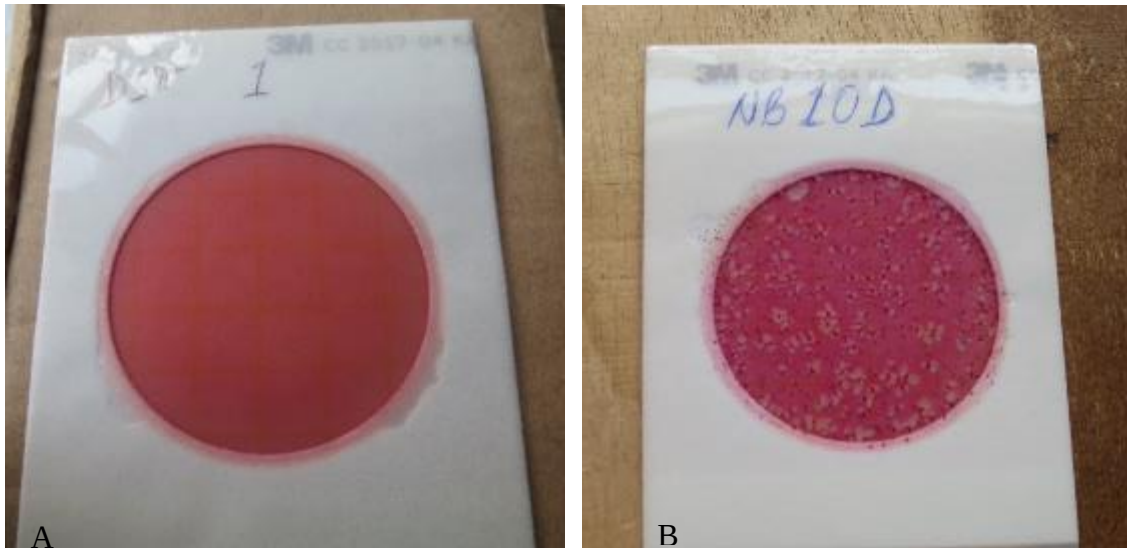


Plate 4.5 No growth on Distilled Water (A) and Petrifilm Sample with growth (B)
Source: Fieldwork 2016

4.11.5 Physico-chemical Parameters

The physico-chemical parameters of the well water tested include nitrate, chloride, fluoride, pH, temperature, total dissolved solids and conductivity. Nitrite was planned to be tested but it was not carried out due to non-availability of reagents. PH, temperature, total dissolved solids and conductivity were tested using a ‘Hanna’ combined meter probe provided by the University of Nottingham Geography laboratory. After calibration, the meter was dipped into the well water samples immediately after collection and readings were taken immediately on site (See Plate 4.6).



Plate 4.6 Physical field Water Testing
Source: Fieldwork 2016

As for nitrate, chloride and fluoride, the palintest tablets were dissolved in the water samples following the procedures outlined by the manufacturers. The chemical tests were done using count tablets method (palintest) lovibond products following the standard procedures laid down by the manufacturers. After dissolving the tablets in water following the instructions and timings, the colours were matched in the appropriate disk and readings taken. About 9 boreholes were also tested from both study sites and some of them tested contaminated with faecal and chemical contamination.



Plate 4.7 Fluoride chemical testing (A) and Nitrate chemical testing (B)
Source: Fieldwork 2016



Plate 4.8 Chloride chemical testing sample
Source: Fieldwork 2016

4.12 Semi-structured Interviews

The interview guides were designed to reflect the objectives of the study. After preparation, they were sent to the supervisors for their comments. The revised questions were then piloted

in the field, transcribed, and sent to the supervisors for comments and revised to improve clarity. The interviews were administered only by me and were undertaken after the water testing and questionnaire survey was complete. The semi-structured interviews aimed to explore particular aspects of how key stakeholders understand water and sanitation issues and they were targeted at government agencies and individual households in the study sites.

The Government agencies targeted were: Ministry of Water Resources and Environment; Benue State Water Board; Benue Rural Water and Sanitation Agency (BERWASSA); and Benue State Environmental Sanitation Agency (BENSESA). Representatives from these organisations were interviewed because they have work related to water and sanitation in Benue state. Major issues covered were scope of their work, spatial coverage of their activities and problems encountered in the process of discharging their duties and how these can be overcome. The interview guides for Government agencies can be found at the end of the report as appendix (Appendix 3: Interview Guides for Government Agencies).

Semi-structured interviews with individual households in the study sites were targeted at residents in the areas where questionnaires were administered. Twenty respondents each from Makurdi and Tse-Agberagba were interviewed for this element of the research. A total of 40 respondents were interviewed in both urban and rural sites. The interviews focused on issues relating to water supply sources and contamination awareness, sanitation and hygiene matters as well as their opinions on how the problems can be solved or minimised. The interviews were conducted by asking the respondents questions prepared in the interview guides and having the responses recorded on an Olympus voice recording device.

Before the actual interview I made some physical contacts with the government agencies and arranged for interviews. I attached the interview guides and the appointment form (Appendix 2: Letter of Introduction for Interview with Government agencies). On the interview date I

would arrive early, meet and greet them humbly. This is expected in Nigerian culture. Before the interviews I would make them understand that the research was for academic purposes and all responses would be confidential and anonymised. I requested to record the interview and there was a general acceptance. However, there were no issues of too much familiarity or closeness with the research subjects as to negatively affect the research progress. I was familiar with some places but not familiar with individuals I had interviewed. Some of them were meeting me for the first time during the research. Therefore, while I was not a ‘complete stranger’, I was not a ‘complete insider’ either. The research followed the research questions and the interview guides. Emerging questions from the detailed interview guides guided the investigation and all went well. The same thing applied to the questionnaire administration. In terms of water quality testing, it was purely a matter of results from the tests and involved little contact with local residents apart from receiving permission before having access to their water and sanitation facilities.

Interviews with respondents other than government employees were associated with fewer protocols. Many of them accepted and were happy to be part of the research. Others said they learned from the exercise, and very few refused to participate. On the whole the response rate was very good, and the interviews were successful.

4.13 Other methods of Data collection

Apart from water testing (Plate 4.4), questionnaire administration and semi-structured interviews were also carried out (Plate 4.9). Additional methods used to collect data included field observation (Plate 4.10) and documentary sources.



Plate 4.9 Questionnaire Interviews (A) and semi-structured Interviews (B)
Source: Fieldwork 2016



Plate 4.10 Poor sanitary condition at Kanshio (A) and poor sanitary condition at Wurukum (B)
Source: Fieldwork 2016

Field observations comprised mainly of classifying the nature of the wells and latrine facilities in the study areas according to JMP criteria. In particular, I observed the physical appearance of these facilities, the nature of their construction, whether the wells were covered or not, the

presence of animals around and general cleanliness around the wells and made notes about the presence of animals in the compound that could present potential risks in terms of faecal contamination. The observations also confirmed other documented sources such as DHS data in terms of the extent of improved and unimproved facilities.



Plate 4.11 A poorly constructed toilet in Wadata
Source: Fieldwork 2016

Documentary sources such as newspapers, photographs and other written sources were useful in getting information related to the subjects under study. For instance, photographs show a compound in an urban site (Plate 4.14), water vendors in urban sites (Plate 4.15), a drainage channel polluting river Benue (Plate 1.2). Informal interviews with government agencies and other households were also useful. For instance, in the High-Level area, one respondent observed that drinking water from dug wells in the urban centre was not safe. She observed that when bucket latrines were being used, they were drinking water from the wells but now that soak-aways are dug in the ground, in the same compounds, it is possible that faeces could mix with well water. This gave an impression that some respondents were aware of risks associated

with poor water and sanitation. Plate 4.12 and Plate 4.13 showing water sources in the dry season in urban and rural areas and illustrate and complement data gathered through other sources.



Plate 4.12 Drawing water from an unimproved well in North Bank
Source: Fieldwork 2016



Plate 4.13 Borehole Queue in dry season at Tse-Agberagba
Source: Fieldwork 2016



Plate 4.14 A sample of a compound with tenants in Makurdi
Source: Fieldwork 2016



Plate 4.15 A dry season urban water source
Source: Fieldwork 2016



Plate 4.16 A polluted drainage channel going into River Benue
Source: Fieldwork 2016

4.14 Analytical Techniques

The data generated were both quantitative and qualitative. The quantitative data were obtained through the questionnaire and water quality testing. The questionnaire and water quality data were entered into SPSS 21 for Windows. From there detailed data tables were made and bar graphs were produced using Microsoft Excel to compare contamination between rural and urban sites, wet and dry seasons, well and latrine types and among the constituent locations. Bar graphs were also constructed to compare access to water supply and sanitation based on demographic variables such as education and income.

Also, some statistical tests such as Kruskal-Wallis, Wilcoxon ranked test, Man-Whitney U test and Chi-Square tests were carried out to analyse relationships between demographic variables and water access, seasonal variation among contaminations and variation in contamination among the sites. In testing for physico-chemical parameters, the Kruskal-Wallis test was used

to compare pH, temperature, conductivity, total dissolved solids, nitrate, fluoride and chloride among urban and rural sites in the dry and wet seasons. The Kruskal-Wallis test was also employed to compare contamination among the sediment types for both physico-chemical parameters and faecal coliforms. To test for faecal coliforms, The Kruskal-Wallis was used to compare contamination in coliforms among urban and rural sites in both dry and wet seasons. This test was chosen because it allows you to compare the scores on continuous variables for three or more groups (Elisante and Muzuka, 2016; Pallant, 2016; Sisay *et al.*, 2017). In this case it is employed to compare the scores of the various parameters' values among the various sites at both seasons. It is a non-parametric alternative to the one-way between groups analysis of variance (Pallant, 2016). In this test, scores are converted to ranks and the mean rank for each group is compared. As this is a 'between groups' analysis, different groups must be in each of the different categories (Pallant, 2016).

The Wilcoxon ranked test was used to test for variation in contamination between dry and wet seasons in pH, temperature, conductivity, total dissolved solids (TDS), fluoride, nitrate and chloride. In the microbial test, the Wilcoxon ranked test was used to test for variation in faecal coliform contamination between dry and wet seasons (seasonal variations). This test is adopted because it is designed for use with repeated measures; that is when the same participants are measured on two occasions (in this case, same wells tested in dry and wet seasons) (Elisante and Muzuka, 2016; Pallant, 2016).

The Mann-Whitney U test was employed to test for nitrate, chloride and fluoride in improved and unimproved wells, in rural and urban wells in both dry and wet seasons. In the microbial analysis, the Mann-Whitney U test was employed to compare coliforms in improved and unimproved wells, urban and rural wells in both the dry and wet seasons. This test is employed because it tests for differences between two independent groups on a continuous measure. It is a non-parametric alternative to t-test independent samples. It compares median rather than

means as is the case with t-test (Pallant, 2016; Sisay *et al.*, 2017; Woldeab *et al.*, 2018). The results of these analyses are shown in Chapter 6:.

The Chi-Square test for independence was used to test for the relationship between education and improved water access and education and improved sanitation access in water and sanitation situation in the study sites in Chapter 7:.. The Chi-Square test for independence was used because it explores the relationship between two categorical variables. The variables can have two or more categories (Pallant, 2016). In this test, the relationship between education and improved water access; and education and improved sanitation access were tested, in which both water and sanitation had two or more categories. The Spearman rank correlation was used to test for correlation among the well characteristics such as distance, well depth and number of users (Pallant, 2016; Woldeab *et al.*, 2018).

These are non-parametric statistics and were used because the data collected violated the rule of normal distribution. The parametric tests were done before the non-parametric tests, but at the end of it I discovered that the results from parametric and non-parametric tests were the same. This confirmed observations from the literature that normality does not really matter in large samples (as my sample was also large).

The qualitative data were obtained from the semi-structured interviews and notes from observation. After the fieldwork, the recorded interviews were transcribed and entered into Nvivo version 11 pro for Windows which helped to organise the data for easy retrieval. The data were then coded into the software at nodes and sub-nodes based on rural urban categories and other major water and sanitation themes such as well water contamination awareness, major environmental problems, good water quality, water problem solution strategies, knowledge and practice of hygiene, main drinking water, water treatment, sanitation facility, sanitation education, sanitation problem solution. As for government agencies, the

major themes were contamination awareness, organisational activities, problem solution strategies, future plans and operational constraints.

The Nigeria Demographic and Health Survey (DHS) data were obtained and analysed to get trends in access to improved water and sanitation. The datasets were downloaded into SPSS 21 for Windows. Some tables and graphs were produced to visualise the trends in access to water and sanitation in Nigeria and Benue State. The results from the analysis helped in planning questions for the questionnaires and semi-structured interviews to get details of water and sanitation issues (details are found in Chapter 5:). The actual quality of water from wells was tested and reported in Chapter 6:). Questionnaire interviews to investigate poor access to water and sanitation identified from the trends in the DHS analysis were carried out and reported in Chapter 7:). The detailed inquiry in water and sanitation access by semi-structured interviews based on questions raised from the DHS analysis were reported in Chapter 8: while conclusions were drawn based on all the research strands in Chapter 9:).

4.15 Positionality

In qualitative research, it is argued that the success or otherwise of the research depends on the researcher's identity in relation to his subjects (Sack, 1974; Hirsch, 1976; Pratt and Loizos, 1992). The concept also relates to where one stands in relation to 'the other' and relates to ascendancy, hegemony, subjugation, status and in regards to the politics of knowledge and reconstruction (England, 1994; Rose, 1997; Merriam *et al.*, 2001). If a researcher is perceived as an insider, s/he might be received with less suspicion which may encourage potential research subjects to participate in the research. Nevertheless, there is a risk that researchers that are familiar with their research subjects and topic might take things for granted and miss important things. England (1994); Merriam *et al.* (2001) and Rose (1997) noted that the reconstruction of one's insider/outsider status in one's personality in terms of education, class, race, gender, culture and other factors provide better opportunities to understand the dynamics

of researching within and across cultures. Since bias occurs naturally, researchers have to explore their positionality to reflect on the research in the light of different contexts they find themselves (England, 1994). These discussions help the researcher to consider objectivity and subjectivity where they are situated within the many aspects of perspective and personality and not necessarily to invalidate the research findings (Lave *et al.*, 1991). These are therefore important issues that a researcher needs to be aware of.

As I am a Nigerian and hail from Benue state, an advantage of undertaking research in Benue is that I was in a position to obtain the information I needed to select and gain access to the study sites. My knowledge of the study sites, access to respondents and ability to speak the local language (Tiv) as well as potential to access and influence policymakers facilitated the progress of the research. Although I am a student at a foreign university (University of Nottingham), my position as an indigene of Nigeria and knowledge of the culture made me an ‘insider’. This made it easier to have access to information whereas an ‘outsider’ would have been likely to be looked at with suspicion and may have been given limited access to information. My conduct of research in Nigeria and Benue State made me an insider rather than being seen as a foreigner carrying out research in the study sites. As a result of this, even some of my research subjects who did not understand details of the research accepted and co-operated on the understanding that the researcher is one of them and so could not be harmful. My familiarity was not a problem for the research because I was only familiar with the general environment and the offices and not individual research subjects. Most of the people I interviewed were meeting me for the first time.

Not being a complete stranger, some of my research subjects thought my research might create direct solutions to their problems, especially potable water supply. Others even thought the government had sent me to investigate their needs for implementation. I clearly explained the purpose of the research to them to clarify some misconceptions.

My ‘positionality’ and ‘reflexivity’ were therefore of great help echoing [Valentine \(1997\)](#) emphasis on how ‘sharing the same background or a similar identity to your informant can have a positive effect, facilitating the development of a rapport between interviewer and interviewee and thus producing a rich, detailed conversation based on empathy and mutual respect and understanding.’

4.16 Survey Bias

I was aware of survey bias and sought to ensure that I did not ‘lead’ respondents with my questions. Although a general introduction was made, a broad discussion was carried out before heading to an area of interest. For instance, a question on water was explored by asking general questions about environmental conditions. Questions were not asked in ways that would be likely to influence an answer with interviewees being invited to tell me about particular topics from my interview schedule as advised by [Valentine \(1997\)](#). I was careful to ensure that my respondents understood that the research was for academic purposes and had no direct solution to their problems. This was done to avoid misconceptions and the potential for respondents to answer questions in ways that they thought might result in benefits for them. Furthermore, most of the issues focused on by the research were both identifiable and observable (i.e. poor access to good quality water) and photographs were taken to capture the situation. Therefore, although survey bias does occur in research, I made efforts to ensure that it was well managed and didn’t influence the research in a negative way. Again, as just mentioned above, my knowledge of the area was in general and not connected with individual subjects in ways likely to have led to bias.

4.17 Ethical Considerations

Ethical issues were taken into consideration in accordance with the University of Nottingham’s ethical guidelines and ethical approval was obtained prior to the commencement of the field research. During the course of the field work, I told all my research subjects that all responses

would be confidentially handled and anonymised. They were also made to understand that their participation was voluntary, and they could withdraw at any time if they wished. Before the semi-structured interviews, the participants were asked to sign consent forms (Appendix 4: Participants' Consent Form). During the course of the fieldwork, all respondents who were happy to participate actually participated. In Wadata area, after explaining that the research would be confidential, one man said 'You can even mention my name, no problem. I know what I am talking about. They do not provide water for us here. It is not a hidden problem'.

The issue of getting permission before acceptance to access the facilities was also addressed in the conduct of the research and fieldwork. I did not just take things for granted because I was an 'insider'. For instance, in the North Bank area which is dominated by Hausa-Muslims communities, I went and obtained the necessary permission from the chief, identifying myself with my student ID card and a letter from my supervisors before embarking on the field data collection. At Tse-Agberagba also, I obtained the necessary permission from the appropriate community head and the police before carrying out fieldwork. At the household level, permission was first sought from the head of household before the questionnaire, interview and water sample collection activities were carried out.

4.18 Methodological Limitations

The questionnaire sample size was 600 in total, 300 each in both urban and rural sites as my initial plan to take a larger sample size was constrained by the limitation of resources. This number was settled on because it was a good representation of the respondents and the research involved other forms of data collection including direct observation of water and sanitation facilities, semi-structured interviews and water testing and so could complement the questionnaire interviews. The water samples were limited to 100 per season, 200 samples in total due to the high costs of water quality testing and other considerations (I also tested some boreholes, satchet water and some control samples so the total samples exceeded 200). The

difficulty of getting reagents prevented nitrite tests from being carried out even though it was intended to be tested.

The faecal coliforms were measured by petrifilms in which the colonies were manually counted. In the process of manual counting, some colonies might be missing and there could be a possible error in terms of accuracy, and this is hereby acknowledged. This, however, does not invalidate the results as most of the plates had many colonies indicating high levels of contamination.

Also, the well-latrine distances were measured manually with a tape from the centre of the well to the centre of the sanitation facilities. In the process, there could be some little errors in the measurement affecting 100% accuracy and precision in the measurement. Again, this does not affect the results as the main distances were measured and recorded exhibiting consistencies.

4.19 Problems Encountered in the Field during Data Collection

Although the fieldwork was conducted successfully, there were some issues that had to be overcome. Firstly, I initially arrived in the field in October, but I had problems in obtaining the reagents. I used all the ones I had and found it impossible to source additional supplies locally. I needed to carry out the nitrite tests, but the lack of reagents prevented this from being tested. This was the last month of rainfall in the study sites and although the study intended to collect data in both dry and wet seasons in one field trip, it was not possible to get the wet season data collection done in time. Therefore, I did the dry season data collection and had to return to the field the following wet season to get the wet season data.

A majority of the respondents were willing to be involved (both in semi-structured interviews and questionnaire surveys) but a very small number objected because they were busy, and some were suspicious about the purpose of the research. But once an interview commenced, all respondents participated to the end. Some respondents asked why I needed to collect water samples more than once. In a location in North Bank area, one man asked, ‘I think you came here the other time and collected water samples?’ I explained to them that data was needed to

be collected in both dry and wet seasons to compare if there were any variations. One man objected to this and asked us to leave his compound. His sample was immediately replaced by another.

Some respondents wondered if my research would help them in obtaining potable water, especially at Tse-Agberagba where water scarcity was a very serious problem. I explained that I was conducting research but hoped that in the long term it might benefit policy makers which could potentially also benefit them, but I was careful to explain that the research would not have the capacity to solve their problems directly in the short term.

There were also issues linked to insufficient funds in the field. This was pronounced when a fuel scarcity crisis hit the entire country. As a result, the cost of transportation, goods and services rose by over 200%. The School of Geography gave me £500 for fieldwork in addition to booking flights for me. This money was not sufficient to support six months of fieldwork, so I had to support this from my personal savings. For the second period of fieldwork, my supervisors assisted me in getting £700 of research support from the school of Geography which was a great help with the fieldwork.

Some people expected financial rewards, especially when they learnt I was undertaking my degree programme in England. One respondent remarked that ‘This man you very stingy, you came here last time, we co-operated with you to get data. You went back and coming all the way from there, you cannot say take this or that.’ They thought I had a lot of money, but I explained that I was a student and was only doing research. I further explained that it is my host school that supported and booked flights for me to attend the fieldwork.

There were some misconceptions about the purpose of my research by some respondents with political inclinations who did not welcome policies and plans from non-interested political groups. Reflecting this, some respondents tried to find out if I had such

connections so I clarified that I had no political connections and explained my research was purely for academic purposes and all responses would be confidential and completely anonymised. For instance, in Benue State, some people were not happy with what they saw as ‘unnecessary’ taxes being implemented by the present administration. On one field visit, one of my field assistants wore T-shirts reading ‘Pay Your Tax’. When we entered one compound, the response was cold and when we got to the next compound, a lady said: ‘Sir, I can see that you are purely for research But your man is wearing a tax related T-shirt. So, I am advising you to please change this dressing otherwise you could be pursued somewhere on the misconception that you are a tax enforcement agent.’ On hearing this, I understood the cold and poor reception obtained earlier and I told my assistant to change the T-shirt immediately.

Another issue was that the cooler I was using to collect samples looked like the one local immunisation officers use, so some people thought we were doing immunisation. Some little children even ran away from us as they were scared, they might get an injection, so we reassured them we were not doing immunisation.

Some respondents were not around, and call backs were sometimes needed for the administration of questionnaires or the collection of water samples. In the case of water samples, it was easier to collect the water samples and test the parameters on site. When people were not around, we aimed to reach the sites early in the next morning before they went out.

The questionnaires took a long time to complete. Some respondents complained of this, but I explained that due to the depth of the investigation, the questionnaire needed to gather sufficient data to achieve its purpose. All respondents accepted this and agreed to continue once started.

At the end of fieldwork, I started to suffer from frequent and severe migraine headaches. Unfortunately, these headaches have continued since the end of my fieldwork and my inability

to work when they occur has delayed the completion of the thesis. But I am grateful to God I was able to carry out the fieldwork to conclusion.

4.20 Conclusion

This chapter has considered ontological and epistemological considerations underpinning the present research. Due to the varied nature of the data required, a mixed method approach was adopted and the various methods of data collection as well as analytical techniques and limitations associated with the chosen methods have been highlighted in the sections above. The next chapter will look at the other part of mixed method approach which is the analysis and discussion from the demographic and health surveys data from 1999 to 2013.

Chapter 5: Nigeria Demographic and Health Surveys Data Analysis

5.1 Introduction

In chapter four the methodology and methods for the research were presented and the mixed methods approach adopted with some specific methods. In this chapter, attention is given to the Nigeria Demographic and Health Survey (DHS) data that has already been analysed. Initially a desk-based study was carried out using DHS data to get trends in access to improved water and sanitation. The analysis of these data helped in identifying for follow-up in the questionnaire and semi-structured interviews.

The DHS data are recognised as high-quality data and are widely used by many donor organisations such as WHO, UNICEF, World Bank and also for academic research purposes. Examples of researchers that have used the data include [Fink et al. \(2011\)](#); [UNESCO Institute for Statistics \(2013\)](#); [Isara and Aigbokhaode \(2014\)](#); [Muruka et al. \(2012\)](#); [Okotto-Okotto et al. \(2015\)](#); [Bain et al. \(2012b\)](#); [Palamuleni \(2002a\)](#); [Liddle et al. \(2015\)](#); [Shivendra and Ramaraju \(2015\)](#); [Pickering and Davis \(2012\)](#); [Kimani-Murage and Ngindu \(2007\)](#); [Jiménez and Pérez-Foguet \(2011\)](#); [Bandyopadhyay et al. \(2011\)](#); [Fledderjohann et al. \(2015\)](#); [Pullan et al. \(2014\)](#); [Hopewell and Graham \(2014\)](#); [Beyene et al. \(2015\)](#).

These data are part of the methodology for this research. The analysis was done to get the trends in access to water and sanitation in Nigeria and Benue State. This justified the research and guided the detailed investigation. The Nigeria wide situation is presented first followed by investigation of water and sanitation trends within the North Central region and finally within Benue State. In all these the various sources of drinking water and sanitation are presented separately to show details of the constituent sources (Fig. 5.2-5.11) while in the Benue State analysis based on various categories, the improved/unimproved water and sanitation are presented side by side (Fig. 5.12-5.19).

5.2 DHS Data Collection Times and Procedures

This section considers the timings and procedures for DHS data collection for all the survey years under review. Immediately after the training exercise, NDHS field personnel for 1999 survey went to the field for data collection. The field staff consisted of 34 teams, each composed of one supervisor, one field editor, four female interviewers, one male interviewer, and a driver. Fieldwork was carried out in 400 EAs nationwide between 29 March and 29 May 1999. This survey was therefore conducted in the dry season.

Fieldwork for the 2003 NDHS took place over a five-month period, from March to August 2003. Although the data collection started in dry season, it ran into wet season but can be said to be in the wet season since it had more of wet than dry season months. Twelve interviewing teams carried out data collection. Each team consisted of one team supervisor, one field editor, four female interviewers, one male interviewer, and one driver. Special care was taken to monitor the quality of data collection. First, the field editor was responsible for reviewing all questionnaires for quality and consistency before the team's departure from the cluster. The field editor and supervisor would also sit in on interviews periodically. Twelve staff assigned from the National Population Commission (NPC) coordinated fieldwork activities and visited the teams at regular intervals to monitor the work. In addition, quality control personnel independently re-interviewed selected households after the departure of the teams. These checks were performed periodically through the duration of the fieldwork by Macro International Inc.

Data collection took place over a four-month period from June to October 2008 (completely in the rainy season). Thirty-seven interviewing teams carried out data collection for the 2008 NDHS. Each team consisted of 1 supervisor (team leader), 1 field editor, 4 female interviewers, 2 male interviewers, and 2 drivers. Nineteen senior staff members from NPC, designated as zonal coordinators, coordinated and supervised fieldwork activities.

In 2010, data collection took place over a three-month period, from October through December 2010. This data collection was carried out in the dry season. One Quality Control (QC) interviewer was assigned to each zone. The QC interviewers, however, did not travel with the survey teams. Instead, they trailed the teams to revisit and re-administer the Household and Women's questionnaires during the first two weeks of data collection and for two weeks prior to the end of the field work. The re-interviews were done in approximately 10 percent of all the completed households.

Fieldwork for year 2013 was conducted from February 15, to the end of May 2013. This was done in the dry season, although it also touched the rainy season. except for the two teams in Kano and Lagos, who completed fieldwork in June). Unlike the previous DHS surveys, fieldwork was launched in the six zones (rather than all of the states); the teams in each zone remained together, and the first clusters were assigned in the vicinity. This enabled close supervision of the teams, as three to four trainers were available in each zone. Interviewers had ample opportunities to build their confidence before they were finally dispatched to their respective states. Fieldwork for the 2013 NDHS was carried out by 37 interviewing teams, one for each of the 36 states of the country and Federal Capital Territory. Each team consisted of a supervisor, a field editor, four female interviewers, two male interviewers, and two drivers.

The distinct seasons in Nigeria are dry (November to March) and wet (April to October). It is clear that DHS did not carry out seasonal water monitoring. Some surveys took place in the dry season (2010 and 2013) and this could help to explain low access to rainwater in surveys for which data was collected between November and May. The 1999, 2003 and 2008 surveys took place in the wet season. The non-seasonal water monitoring created a gap in the DHS surveys which the present study has filled by collecting data in two seasons. This has not invalidated or impacted on the DHS data. However, as access to improved water vary between seasons, with some people who drink improved water in the wet season switch to unimproved water sources

in the dry season, the answer as to whether drinking improved or unimproved water would depend on the season under consideration. In spite of this shortcoming, the DHS data are useful in giving an idea of access to improved water and comparing these among countries for monitoring purposes. Considering seasonal variation in water access, the study seeks to explore the issue of seasonality in water access and quality by conducting fieldwork in both the rainy and the dry seasons. This is one of the contributions the present research has made.

5.3 Background to the Demographic and Health Surveys

DHS surveys are nationally representative household surveys largely financed by the United States Agency for International Development (USAID) and implemented by Macro International in collaboration with national statistical agencies (see <http://www.measuredhs.com>). The DHS data are collected under monitored conditions by qualified personnel employed by the United States Agency for International Development (USAID). Demographic and health surveys are nationally representative household surveys which provide data for many monitoring and impact evaluation indicators in areas of population, health and nutrition (Nigeria National Population Commission and Macro, 2000). According to the country specific report of 2013 for Nigeria, specific issues covered are fertility levels, marriage, fertility awareness, preferences and use of family planning methods, child feeding practices, nutritional status of women and children, HIV, mortality, female genital mutilation and domestic violence. It targets women aged 15-49 and height and weight of children aged 0-5. All these assists in making policies based on the available data showing trends in demographic issues. In this research, efforts are concentrated on household characteristics relating to water and sanitation.

The DHS runs two types of surveys: standard and interim. The standard DHS surveys have a large sample size (between 5,000 and 30,000 households) and are aimed to be conducted every five years so that comparisons between surveys can be made. Interim surveys, however, do not

cover comprehensive impact evaluation measures. Rather they are based on key performance monitoring indicators between rounds of surveys. They are nationally representative like standard DHS but have smaller samples and shorter questionnaires than standard DHS surveys.

The first DHS survey was conducted in Nigeria in 1999. This was followed by surveys in 2003, 2008, 2010 (called Malaria Indicator Survey (MIS) based on the fact that it dealt mostly with malaria issues) and 2013. The surveys are conducted by the National Population Commission (NPC), the agency charged with the responsibility of collecting, collating and analyzing the demographic data for Nigeria. The financial and technical assistance is provided by ICF through the USAID-funded measure DHS programme. The United Kingdom Department for International Development (DFID) and United Nations Population Fund (UNFPA) also provide assistance ([National Population Commission and Macro, 2014](#)).

Generally, the surveys are based on the existing enumeration areas (EAs). This forms the primary sampling units referred to as clusters. These are chosen from rural and urban areas. A household listing is then done to serve as the sampling frame for the selection of households. A fixed sample of households is selected for the enumeration area or cluster. In the case of 2013, 45 households were selected per cluster. In the interviewed households, men and women aged 15-49 are interviewed.

The questionnaire is always used for the interviews or surveys. There are household, men's and women's questionnaires used in DHS surveys, with the men focusing on issues relating to men, while the women's focus on reproductive health and domestic violence. The household questionnaire collects information on the household characteristics generally like age, sex, marital status, education, relationship to head of household, school attendance, orphans and vulnerable children. Other issues covered in household questionnaires are housing characteristics like source of drinking water, type of toilet facility, materials used for the floor,

ownership of goods, etc. These data are then processed to give output in the form of tables and reports. For the purpose of this research only water and sanitation related data were analyzed.

5.3.1 Demographic and health surveys regions and questions

In the DHS the data were collected and reported on various levels. These include sample domain, stratification, region, type of place of residence, and place of residence (see Table 5.1).

Table 5.1 Scales of Data Analysis in Nigeria Demographic and Health Surveys

1999	2003	2008	2010	2013
Sample domain:(All states, urban and rural)	Sample domain: Regions (urban and rural)	Sample domain: National and all states	Stratification us:(regions: urban and rural)	Stratification us:(states' regions: urban and rural)
Region: North East, North west, South west, south East, Central.	Regions: North Central, North East, North West, South East, South-South, South West.	Regions: North Central, North East, North West, South East, South-South, South West.	Regions: North Central, North East, North West, South East, South-South, South West	Regions: North Central, North East, North West, South East, South-South, South West
Type of place of residence: (urban, rural)	Type of place of residence: (urban, rural)	Type of place of residence: (urban, rural)	Type of place of residence: (urban, rural)	Type of place of residence: (urban, rural)
Place of residence: 0=capital, large city 1=small city 2=Town 3=countryside	Place of residence: 0=capital, large city 1=small city 2=Town 3=countryside	Place of residence: 0=capital, large city 1=small city 2=Town 3=countryside	Place of residence: 0=capital, large city 1=small city 2=Town 3=countryside	Place of residence: 0=capital, large city 1=small city 2=Town 3=countryside

Source: Nigeria Demographic and Health Surveys data

As can be seen from Table 5.1, in the 1999 survey, sample domain was used. This was made up of all the states of the country with urban and rural divisions. Regions were also used but were five instead of the normal six regions. The report for 1999 maintained that the regions used here did not follow the normal political regions, but were statistical regions, different from the six geo-political zones. The regions are: North East, North West, South West, South East and Central. Generally, the Geo-political zones are fixed and have not changed across the

surveys except that the 1999 survey used only five regions which they explained as statistical regions. The map of the six geo-political zones is presented in Figure 5.1.

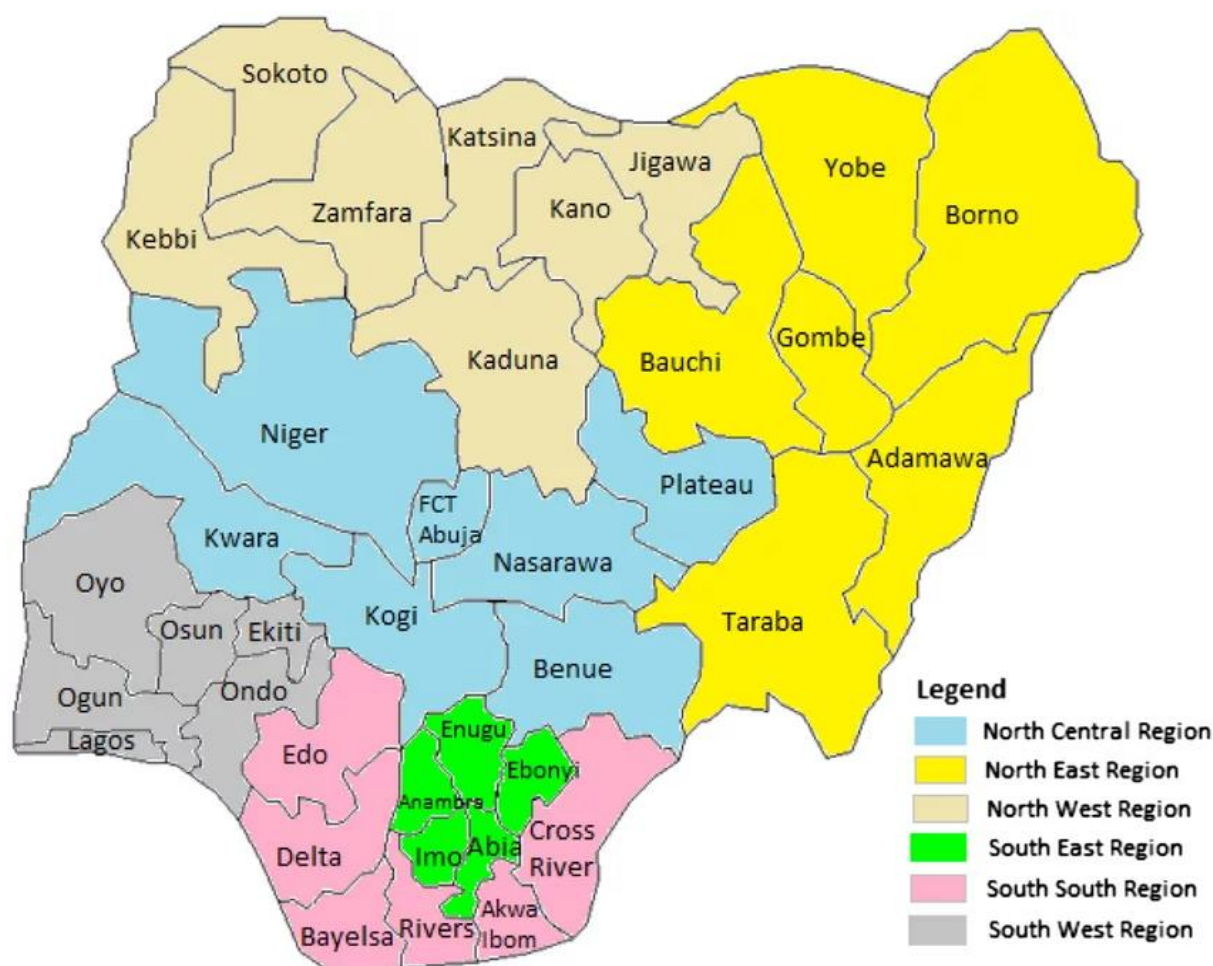


Figure 5.1 Map of Nigeria showing the six Geo-political zones

Source: Digitized from Google maps

Type of place of residence was also used. This was simply grouped into urban and rural areas.

The DHS is quiet on urban/rural definition and information on this is rare. Although rural and urban areas have many definitions, in simple terms, rural areas are places that are not urbanized and dominated by people in agriculture and primary production while urban areas are more built up with high population densities and varied occupations. For the purpose of the surveys, these areas had the same definition throughout the surveys, with no significant changes. This is common to all the surveys. Another category the 1999 survey used was place of residence. This

comprised the capital, large city, small city, and town and countryside with this categorization being common to all the surveys.

In the 2003 survey, the term “sample domain” was used which comprised of regions, subdivided into urban and rural definitions. Regions were also included, and they were the normal six geo-political zones. These are: North Central, North West, North East, South west, South-South and South East. Type of place of residence is urban/rural as in the 1999 survey, which is common. Place of residence- (capital, large city, small city, town and countryside) was the same as in the 1999 survey and to all the other DHS surveys.

In the 2008 survey, the sample domain referred to all states of the federation. Regions used here were same six geo-political zones or regions. The type of place of residence was the same urban/rural with the same definitions in other surveys.

In the 2010 Malaria Indicator Survey (MIS), stratification was used. Its definition was regions, subdivided into urban/rural areas. This name is different to the one used in other surveys. Regions remain the same with the same definition as in other surveys. The type of place of residence was defined as urban/rural as in other surveys with the same definitions. The place of residence was also the same, with the same definitions as the others.

In 2013, the stratification was based on states’ regions, subdivided into urban and rural. Six regions were used -North Central, North West, North East, South west, South- South and South East (Table 5.1) with the same definition with other surveys. The same place of residence was used.

The geographical units that are common among all the surveys are “Regions”, “Type of place of residence”, and “Place of residence”. In addition to being common to all the surveys, they have the same definitions. The only difference is the 1999 survey had five instead of six regions. However, it is ideal to analyze the data along these regions for comparison. Regions and type

of place of residence are preferred due to their simplicity and convenience. The rural/urban categorization also conforms with the objectives of the present research and therefore adopted. Comparisons can be made along these across the surveys and inferences drawn. Data is also found on all the states in the country, though with different names. This would also be useful for analysis. The analysis was therefore conveniently done based on regions and type of place of residence. The state basis was also good to be able to bring out Benue State, which is the study area.

5.3.2 Water supply and sanitation questions among the DHS surveys

Questions on water supply and sanitation are found in Table 5.2 and Table 5.3 respectively.

Table 5.2 Water supply questions

1999	2003	2008	2010	2013
1 What is the main source of drinking water for members of your household?	1 What is the main source of drinking water for members of your household?	1 What is the main source of drinking water for members of your household?	1 What is the main source of drinking water for members of your household?	1 What is the main source of drinking water for members of your household?
2 How long does it take you to get there, get water and come back?	2 How long does it take you to get there, get water and come back?	2 What is the main source of water used by your household for other purposes such as cooking and hand washing?	Nil	2 Where is that water source located?
Nil	Nil	3 where is that water source located?	Nil	3 How long does it take to go there, get water and come back?
Nil	Nil	4 How long does it take to go there, get water and come back?	Nil	4 Do you do anything to the water to make it safer to drink?
Nil	Nil	5 Who usually goes to this source to fetch the water for your household?	Nil	5 What do you usually do to make the water safer to drink?
Nil	Nil	6 Do you do anything to the water to make it safer to drink?	Nil	Nil
Nil	Nil	7 What do you usually do to make the water safer to drink?	Nil	Nil

Source: DHS Data for 1999, 2003, 2008, 2010 and 2013.

Table 5.3 DHS sanitation questions with options

1999	2003	2008	2010	2013
1 What kind of toilet facilities does your household have?	1 What kind of toilet facilities does your household have?	1 What kind of toilet facility do members of your household usually use?	1 What kind of toilet facility do members of your household usually use?	1 What kind of toilet facility do members of your household usually use?
Nil	2 Do you share these facilities with other households?	2 Do you share this toilet facility with other households?	Nil	2 Do you share this toilet facility with other households
Nil	Where do you usually wash your hands?	3 How many households use this toilet facility?	Nil	3 How many households use this toilet facility?

Source: DHS Data for 1999, 2003, 2008, 2010 and 2013.

In all the surveys, the first question was, “What kind of toilet facilities do your household have?” The second question, “Do you share these facilities with other households”? Is only applicable to the 2003, 2008 and 2013 surveys, as the 1999 and 2010 surveys has no second question. The third question, “How many households use this toilet facility?” is only applicable to 2008 and 2013 surveys. The third question in the 2003 survey is, “Where do you usually wash your hands?” which is different from the other ones. There is no third question in the 1999 and 2010 surveys. The questions therefore vary and change and are even absent in some surveys. The first question is common among all the surveys and can be analyzed to get longitudinal information on sanitation in Nigeria. Information on water supply questions and options is found in appendix (Appendix 6: DHS Water supply questions with options). It is large and therefore placed in appendix. The absence of some questions did not affect the analysis as they were all checked and harmonized with the common ones for analysis.

Table 5.2 provides information on water supply questions with options. As earlier mentioned, water supply questions vary among the surveys. The only question common among the surveys

is “What is the main source of drinking water for members of your household?” Because the sources of water supply in Nigeria have not changed significantly, most of the options are applicable to all the water questions across all the surveys. The common options are “Piped into dwelling”, “Piped into yard plot”, “Public tap”, “Open well in Dwelling”, “Open well in yard/plot”, “Open public well”, “Protected well/borehole in dwelling”, “Protected Well/borehole in yard/plot”, “Protected Public well/borehole”, “Spring”, “River/stream”, “Pond/Lake”, “Dam”, “Rainwater”, “Tanker/truck”, “Bottled Water”, “Other”.

Some minor differences occur. For instance, in 2003, one of the options is pond/lake, but changes to surface water/river/lake/stream in 2008, 2010 and 2013 surveys. Again, in some surveys like 1999, the option “well” stood on its own, but in 2008, 2010 and 2013, mention is made of tube well or borehole. In 1999, there is an option of “Public tap” while in 2008, 2010 and 2013 there is an option “Public tap/standpipe”.

However, all these do not hinder analysis, as the meanings were the same and useful comparisons can be made between the surveys. For instance, it is convenient to classify “Pipe into residence/yard/plot with “Public tap” as access to piped water, since they are improved according to JMP definition. Again “Public well” and “Well in residence/yard/plot” can be grouped together as well water sources. Therefore, the options for the common questions can be used and inferences drawn from them to give a broader picture of water and sanitation access. In some surveys, there is no second question, or it is different from other ones. However, the common question suffices for analysis to get information on water supply trends in Nigeria. Information on sanitation questions with options is presented in Table 5.4.

Table 5.4: Sanitation Questions with options

1999	2003	2008	2010	2013
1 What kind of toilet facilities does your household have?	1 What kind of toilet facilities does your household have?	1 What kind of toilet facility do members of your household usually use?	1 What kind of toilet facility do members of your household usually use?	1 What kind of toilet facility do members of your household usually use?
*Own water closet *Shared flush toilet *Traditional pit toilet *Ventilated improved pit (VIP) latrine *Bucket toilet *No facility/Bush/Field/River	*Flush toilet *Traditional pit toilet *Ventilated improved pit (VIP) latrine *Bush/Field *River *Other	*Flush to piped sewer system *Flush to septic tank *Flush to pit latrine *Flush to somewhere else *Flush, don't know where *Ventilated improved pit latrine *Pit latrine with slab *Pit latrine without slab/open pit *Composting toilet *Bucket toilet *Hanging toilet/Hanging latrine *No facility/bush/field *Other	*Flush to piped sewer system *Flush to septic tank *Flush to pit latrine *Flush to somewhere else *Flush, don't know where *Ventilated improved pit latrine *Pit latrine with slab *Pit latrine without slab/open pit *Composting toilet *Bucket toilet *Hanging toilet/Hanging latrine *No facility/bush/field *Other	*Flush to piped sewer system *Flush to septic tank *Flush to pit latrine *Flush to somewhere else *Flush, don't know where *Ventilated improved pit latrine *Pit latrine with slab *Pit latrine without slab/open pit *Composting toilet *Bucket toilet *Hanging toilet/Hanging latrine *No facility/bush/field *Other
2 There is no second question	2 Do you share these facilities with other households?	2 Do you share this toilet facility with other households?	2 There is no second question	2 Do you share this toilet facility with other households?

Source: DHS Data for 1999, 2003, 2008, 2010 and 2013.

As in the case of sanitation, there is only one question, the first one that is common to all the surveys. The question is, “What kind of toilet facilities does your household have?” The options are varied and there are some of them in the 2008, 2010 and 2013 surveys. This could be

probably due to new options provided in the other surveys. The common options (2003 survey) are “Flushed to piped sewer system”, “Flush to septic tank”, “Flush to pit latrine”, “Flush to somewhere else”, “Flush don’t know where”, “Ventilated Improved Pit Latrine”, “Pit Latrine with slab”, “Pit Latrine without slab/open pit”, “Composting toilet”, “Bucket toilet”, “Hanging toilet/hanging latrine”, “No facility/bush/field”, “Other”.

The differences in the options are not significant and do not affect analysis. For instance, “Flush to piped sewer system”, “Flush to septic tank”, “Flush to pit latrine” can conveniently be classed as “Flush toilet” to match other surveys using “Flush toilet” since they are improved according to JMP definition. Again, the major toilet facilities in Nigeria are found among the options across the surveys.

5.3.3 Changes among the surveys

Generally, DHS surveys are concerned with collecting and analyzing data on population and health characteristics and there are only small changes among the surveys. For instance, the sample size varies among the surveys. In the 1999 survey, the sample size was 7,647 households; in 2003 the sample size was 7,225 households; in 2008 it was 34,070; in 2010 the sample size was 5,895 households and 2013 had the highest sample size of 38,522 households. Apart from the sample size, some of the questions among the surveys vary or are absent. This is considered in Table 5.2 and Table 5.3.

There were some additions in the scope of some of the surveys. For instance, in 1999, the scope of the survey was extended to cover housing facilities and awareness and behaviour with regards to HIV/AIDS. The 2003 survey provided information on violence against women and malaria and testing for salt. The 2008 survey, for the first time, collected information on 36 states and the Federal Capital Territory (FCT).

So far, the written analysis has given a brief background of DHS surveys and brief explanation and interpretation to the DHS report. Basically, a look is taken at the regions or units upon which the demographic surveys were based. These were many, but regions, type of place of residence and place of residence and state were common across all the DHS surveys. Due to their simplicity, the regions, type of place of residence and states are preferred. The water and sanitation questions have changed among the surveys, but they are common ones that can be analysed and this was done to depict the trend of water supply and sanitation in Nigeria. Having analysed and considered the common questions in the DHS, attention will be now focused on looking at data across the surveys to bring out key trends in water and sanitation in Nigeria.

5.4 Water Supply Coverage (Nigeria)

A look is taken at the coverage of water supply in Nigeria for the survey years under consideration. This information is presented in Figure 5.2

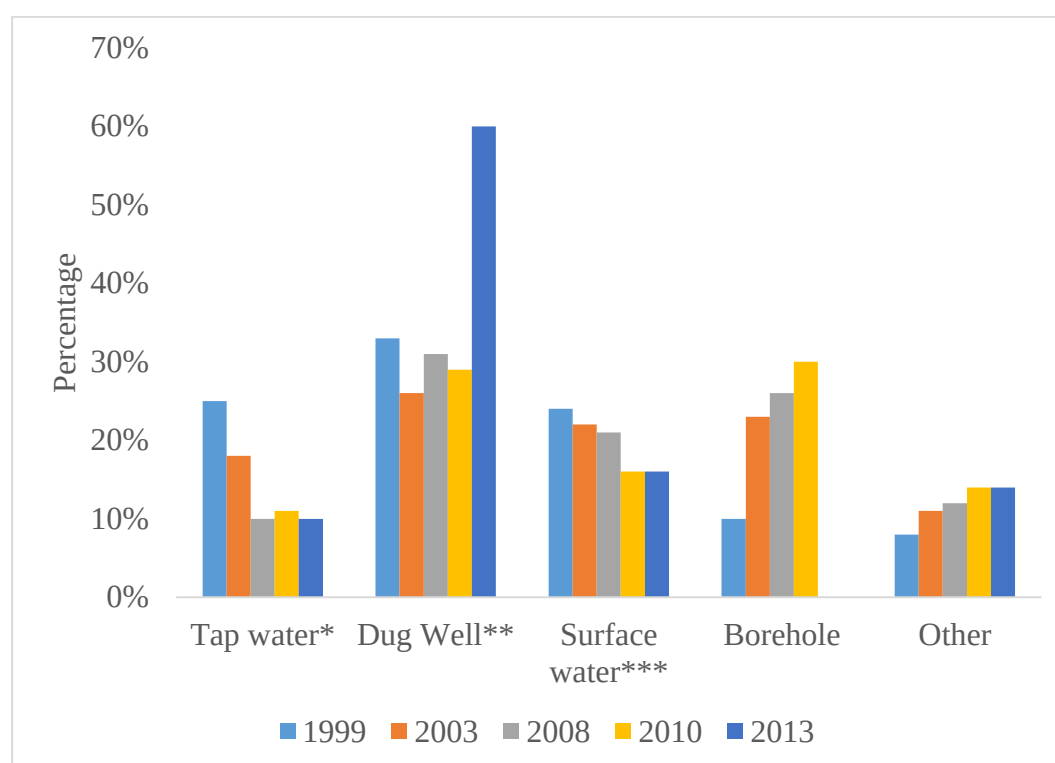


Figure 5.2 Sources of drinking water for Nigeria

Source: DHS data for 1999, 2003, 2008, 2010 and 2013

Tap water* includes tap into residence, yard, plot or public tap.

Dug well** includes well located on residence, yard, plot or public well

Surface water*** includes water from river, stream, pond, lake and dam

Dug wells are made by hand and have a diameter of less than one meter. They are also shallow, between 2-8 meters tapping water from shallow aquifers (Plate 6.1). Boreholes on the other hand are sunk using machines. They have small diameters of less than 30 centimeters and are deep, reaching hundreds of meters. They are sealed and water is pumped using a hand pump (Plate 4.3). Both are common in the study areas.

From Figure 5.2, it can be seen that tap water access declined from 25% in 1999 to 10% in 2013. The major sources of drinking water were wells (which was 33% in 1999 and 60% in 2013), surface water (24% in 1999 and 16% in 2013) and boreholes (10% in 1999 and 30% in 2010 as there was no data for boreholes in 2013).

5.5 Sanitation coverage (Nigeria)

As in the case of water, sanitation will be approached by looking at various systems. Information on sanitation in the whole country is presented in figure 5.3

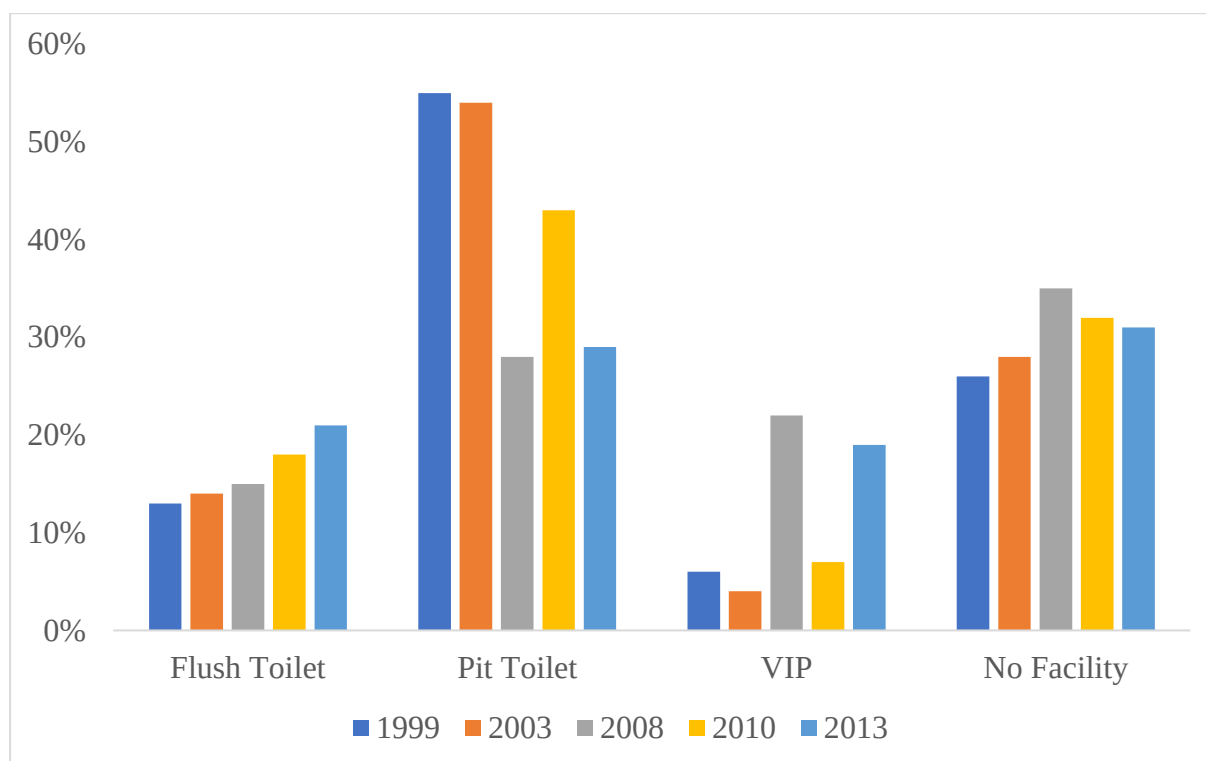


Figure 5.3 Types of toilet facility for Nigeria across DHS
Source: DHS Data for 1999, 2003, 2008, 2010 and 2013.

It can be seen from Figure 5.3 that apart from 2013, flush toilets had been below 20% of coverage in Nigeria. Pit toilets and open defecation in the bush dominated, followed by ventilated improved latrine.

A Ventilated Improved Pit Latrine (VIP) (Figure 5.4) is a latrine which has a vent pipe at the back for release of air. This helps to reduce the nuisance of flies as a net is covered on top of the vent pipe. The movement of the air also reduces odour in the cubicle if kept clean. The VIP also has a more substantial superstructure than an ordinary pit latrine. Apart from controlling odours and flies, it allows users to clean themselves with hard materials like newspapers and leaves which would not be suitable for use in a flush toilet (Reed *et al.*, 2013).

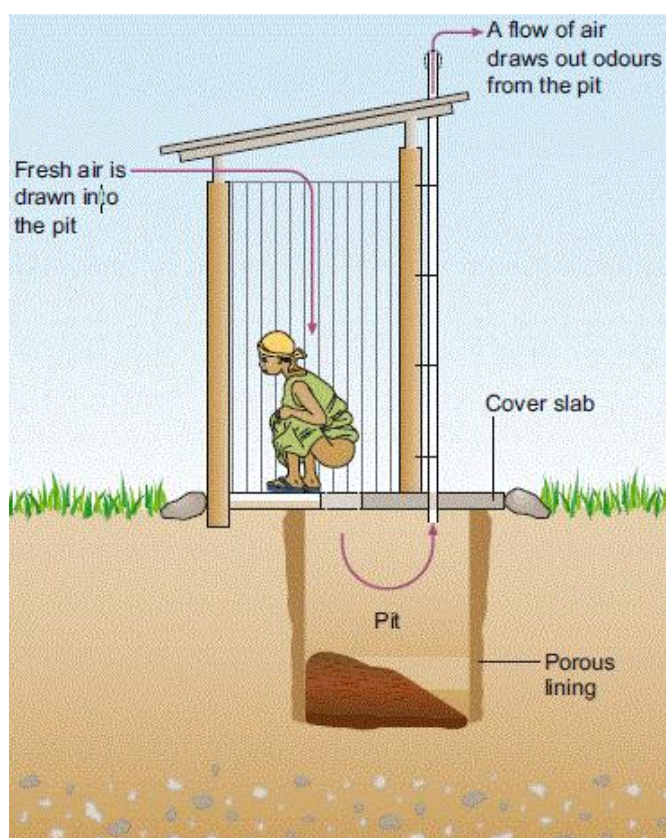


Figure 5.4 Ventilated Improved Pit Latrine (VIP)

Source: Open University Britain. Available online at: <https://www.open.edu/openlearncreate/mod/oucontent/view.php?id=80510&section=6.1>

5.6 North Central Region Water Supply

North Central is the one of the six major geo-political zones in Nigeria. Benue State falls under this region. As the name implies, it lies in the North central part of the country. The sources of water supply for the region are presented in Figure 5.5 with some interpretation given thereafter.

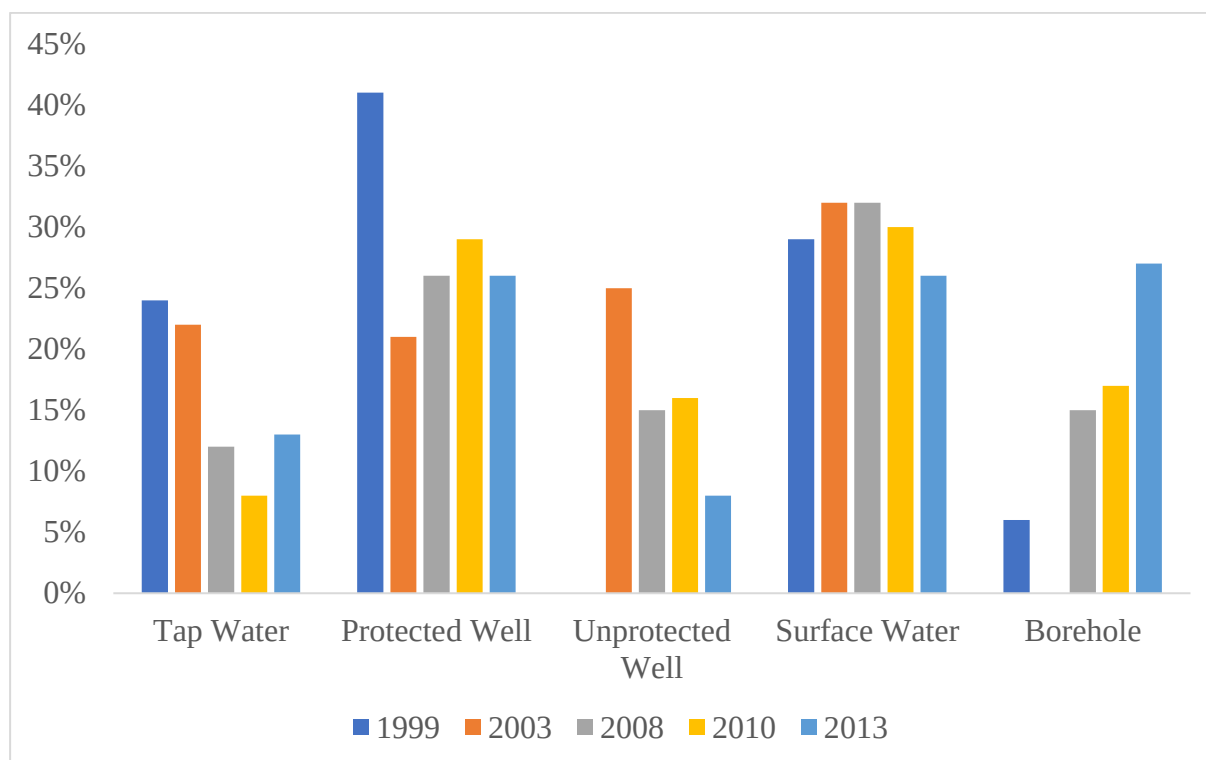


Figure 5.5 Sources of Drinking water for North Central, 1999-2013.

Source: DHS data 1999-2013.

N.B. In 1999, the data did not distinguish between protected and unprotected well. In 2003, protected well was merged with borehole so no separate data for borehole.

At the regional level, similar sanitation and water supply trends are apparent. From Figure 5.5, it can be seen that the major sources of drinking water in the North Central region in 1999 were surface water (29%), protected wells (41% merged with unprotected wells) and tap (24%).

In 2003, access to improved water was low as the water from surface water accounted for 32%, compared to 29% in 1999; well water represented about 46% (sum of protected and unprotected wells) as against 41% in 1999, followed by tap 22%, compared to 24% in 1999 (Figure 5.5).

In 2008 (Figure 5.5), also show low access to improved water sources as the main source of drinking water was from surface sources (32%). Protected wells accounted for 26%,

unprotected well 15% and tube wells made up 15%. The proportion of the population using surface water was the same in 2003 (32%) while there seemed to be not much change also in well water usage.

There was a decline in improved water access in 2010. The major drinking water sources in 2010 in the North Central region was surface water (30%) which was roughly the same in 2008, and a slight improved water access as there was a decline in unprotected well (16%) compared with 15% in 2008.

In 2013, it can be seen that access to improved water supply was also very low. Well water was the dominant source; mostly from covered wells (26%) but generally, there was a little improvement in 2013 but surface water consumption was still high (26%) in 2013. Borehole usage increased from 17% in 2010 to 27% in 2013 but access to tap water was low and declined from 24% in 1999 to 22% in 2003 then 12% in 2008, 8% in 2010 and rose slightly to 13% in 2013. These data indicate that access to an improved water supply was low.

In summary therefore, the main sources of drinking water for North Central Nigeria between 1999 and 2013 were wells (both improved and unimproved wells, as the data did not differentiate this in 1999). This was followed by surface water and boreholes and tap water. These data reveal low access to improved water sources in the North Central region. An analysis of the sanitation data is presented in the next section.

5.7 Sanitation (North Central Region)

The types of toilet facilities available for the region are summarised in Figure 5.6. Generally, access to improved sanitation was low with open defecation being very high. The major ones in order of importance are open defecation (No facility/Bush/ Field), pit toilet, flush toilet and Ventilated Improved Pit (VIP) latrine. The sanitation facilities for individual years are presented in bar graphs below. The commonest facilities were 'No facility/bush' which accounted for

32%, 39%, 53%, 53% and 50% in 1999, 2003, 2008, 2010 and 2015 respectively. This was followed by pit toilets. These accounted for 52%, 45%, 11%, 30% and 12% respectively for 1999, 2003, 2008, 2010 and 2013. Flush toilets averaged less than 20% in the period under study. The details of sanitation facilities in the respective years are found in (Figure 5.6).

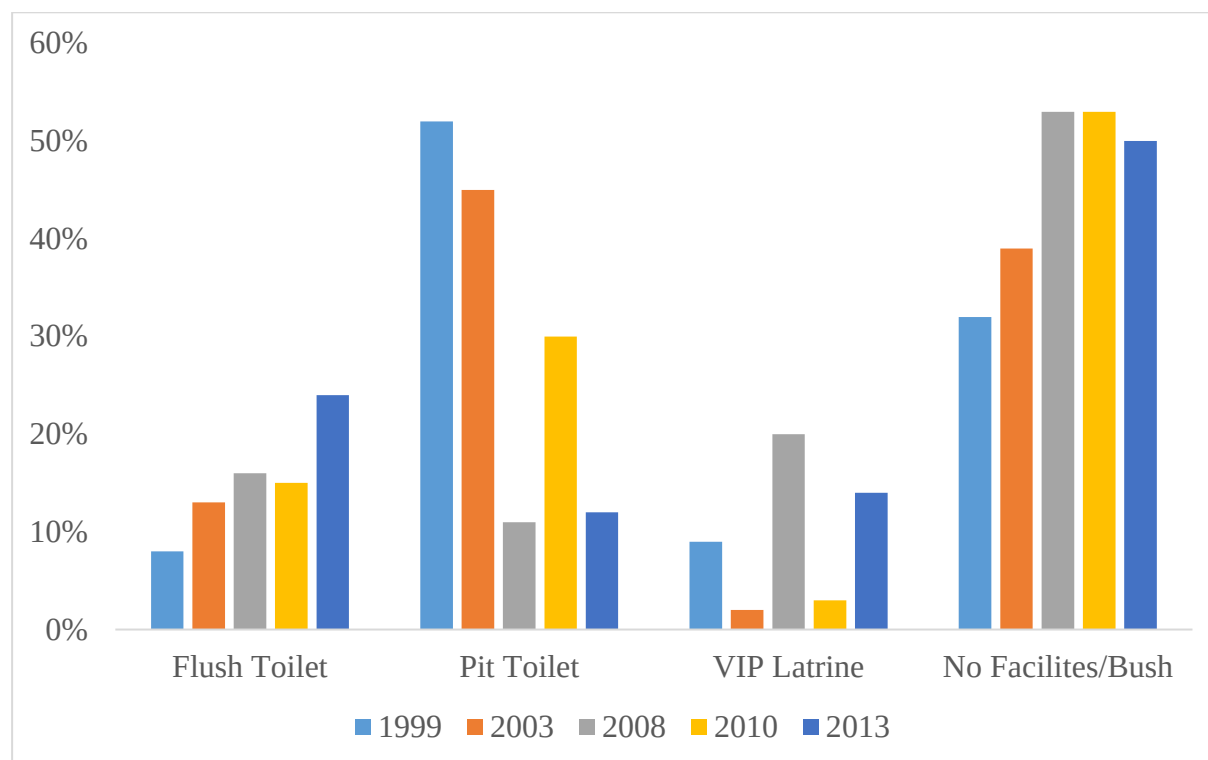


Figure 5.6 Types of Toilet Facilities for North Central for 1999-2013.

Source: DHS data for North Central in 1999, 2003, 2008, 2010 and 2013

From Figure 5.6, the major types of toilet facility for North Central in 1999 was traditional pit toilet (the data did not differentiate between improved and unimproved toilets), Open defecation (an unimproved form of sanitation) and flush toilets.

In 2003 and 1999, the major toilet facilities for the North Central region were traditional pit toilet (45%) and (52%) open defecation (39%) and (32%) and flush toilet (improved) (13%) and (8%). There was a little improvement in flush toilet and pit toilet usage in 2003 but with an increase in open defecation in the same year.

From Figure 5.6, the major toilet facilities in 2008 were open defecation (53%), compared to (39%) in 2003, increasing instead of decreasing. VIP constituted 20% as against 2% in 2003

(which was probably due to the mis-categorisation of ordinary pit latrine as VIP), and flush toilets made up 16% compared to 13% in 2003. Pit toilets made up 11%. There was improvement in 2008 in VIP and flush toilet, but an increase in open defecation.

In 2010, No facility/bush/field dominated with 53%, followed by pit toilet 30% and flush toilet at 15%. Unimproved sanitation facilities dominated in 2013. Open defecation alone accounted for 50%, pit latrines (both improved and unimproved) had 12% coverage while VIP and flush toilets accounted for 14% and 24% respectively (Figure 5.6).

Figure 5.6 shows the situation of sanitation in the North Central region for the fourteen-year period. It can be clearly seen that the major sanitation systems were ‘No facility/Bush/Field,’ ‘pit toilet’ and ‘flush toilet’ with the latter having the lowest percentage of 8% in 1999. The trend of water supply for North Central region is found in the next section.

5.8 Trends from North Central Region

5.8.1 Water Supply Trends

During the analysis of the DHS data, many trends emerged and are found below, starting with water trends. Tap water access decreased from 1999 to 2010 and increased in 2013. Although the data is silent on this, the decrease could be due to increasing population without a corresponding increase in infrastructure while the increase in 2013 could reflect some improvement in tap water provision. Well water supply has been increasing throughout the period of analysis. Spring water use has been very low over the years (less than 5% in each year). Surface water increased, especially in 2003 and 2010 but decreased in 2013, but it is the second major source of drinking water next to well water. Rainwater was very low (less than 1% in each year). In the study sites, rainwater harvesting is popular but may be under-reported because some of the surveys took place in the dry season (such as 2010 and 2013) when rain was no longer falling, and any rainwater supplies captured in the rainy season would have been

depleted. Borehole water supply had been low (less than 10% in each year) and water sachet usage rose in 2010 to 5% reflecting the increasing availability of this source. Overall, however, unimproved sources of water were more widely consumed than improved sources in the North Central Region.

5.8.2 Sanitation Trends

The key sanitation trends that emerged included an increase in flush toilets from 1999 to 2013 although this never rose above 25% even in the peak year (2013). Pit toilets (both improved and unimproved) decreased and increased before decreasing again. Access to ventilated Improved Pit (VIP) latrines increased slightly in 1999 and 2008 (peaking at 20% in 2013) but accounted for less than 5% of sanitation facilities in 2008 and 2010. This could be due to the mis-categorisation of pit and VIP latrines as a more likely cause of the dramatic fluctuation. Open defecation (bush) is widespread and increased from 1999 to 2010, probably due to poverty and a lack of awareness of faecal-oral transmission routes. Composting toilets seemed to be non-existent in the region.

5.9 Trends from Benue State

Benue State's capital is Makurdi. Below are trends in access to water and sanitation (details are found in the study area Chapter 3:).

5.9.1 Water supply trends

Tap water access has generally been below 10% in all the survey years. It decreased in 2008, 2010 and increased in 2013. The general decline is evidence of inadequate infrastructure by the government. Well water has been the dominant drinking water source with about 18% on average of the wells being unprotected, over the 14-year period. This supports other researchers' views that well water has been the major source of drinking water supply ([Aper and Agbehi, 2011](#); [Utsev and Aho, 2012](#)). Spring water use has generally been less than 5%.

Surface water sources have been the second major source of drinking water after wells. Rainwater use has been less than 5% across the survey years. Borehole water supply has not been high generally, and sachet water rose to 5% in 2013. Conclusively, most of the drinking water sources from Benue State are unimproved ones.

5.9.2 Sanitation Trends

Flush toilet access was 10% in 1999 but increased in 2013 to 15%. Pit toilet access decreased in 2008 and rose again. Ventilated Improved Pit (VIP) use rose a little, peaking in 2008 at about 18%. The bush has been the major type of sanitation used in the whole of the 14-year period and has averaged 50% over the length of the DHS survey period, with the result that unimproved sanitation sources dominated in Benue State from 1999-2013. This is roughly the same in terms of the regional and country picture but a bit worse in Benue State.

5.10 Benue State DHS Analysis

After analysis of water and sanitation for the whole of Nigeria and the regions, attention is paid to Benue state. The trend analysis begins with water supply. The map of Benue State is shown in Figure 5.7.

5.10.1 Water Supply

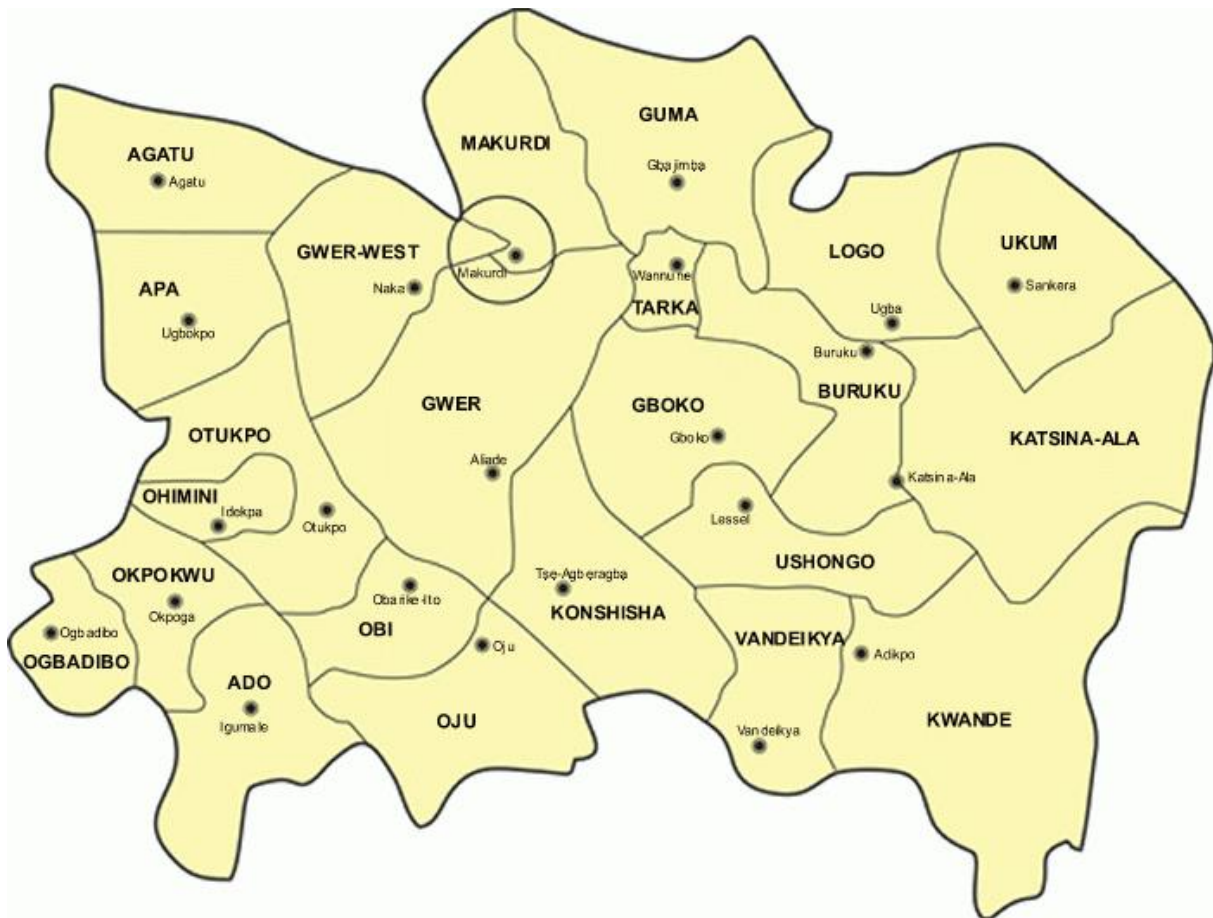


Figure 5.7 Benue State showing Local Government Areas
Source: Digitized from Google Map

In 1999, the total number of respondents were 340, in 2003 there were 291, in 2008 there were 890, and in 2010 there were 200 while in 2013 the total number was 971. The data on drinking water supply is presented in Figure 5.8. It is clear that the proportion of people using unimproved water sources is higher than the proportion using improved sources in all the survey years.

Information from the graph in Figure 5.8 shows that the major sources of drinking water for Benue State in order of importance in the period considered had been well, surface water and tap. The sources of water supply are categorised into improved and unimproved based on JMP definitions.

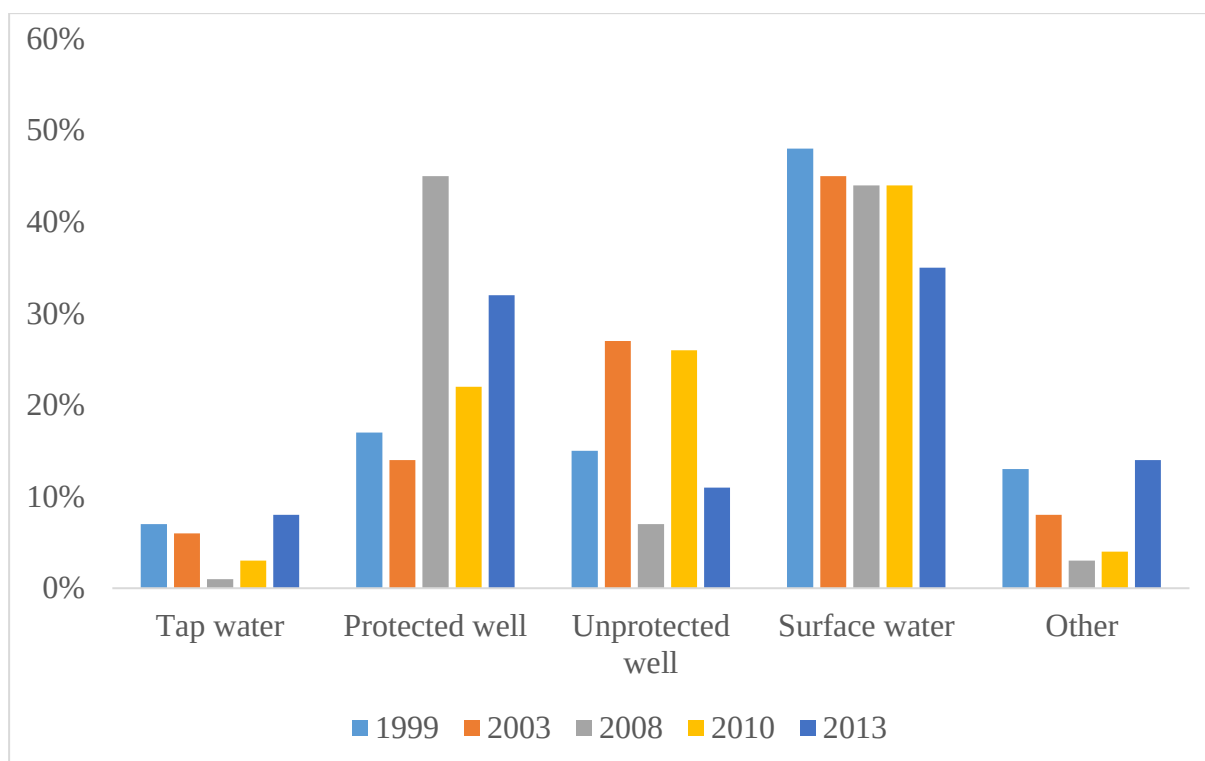


Figure 5.8 Source of Drinking Water Summary (%) (Whole of Benue state)

Source: DHS data for 1999**, 2003**, 2008**, 2010* and 2013*.

*Dry season surveys

**Wet season surveys

5.10.2 Improved and Unimproved Benue Water Sources

In Benue State, most of the water sources are unimproved. Although both the surface and well water sources were declining, the usage was still significant. For instance, from the survey, the major source of drinking water is from surface water sources, accounting for 48%, 45%, 44%, 44% and 35% in 1999, 2003, 2008, 2010 and 2013 respectively. This was followed by wells in which case a good proportion of the population use water from unprotected ones. The unprotected wells, as revealed by the data, accounted for 27%, 7%, 26% and 11% in 2003, 2008, 2010 and 2013 respectively. The 1999 survey did not distinguish between protected and unprotected wells in the data. All the other survey data distinguished between protected and unprotected wells. However, for summary of data, these were merged, but later identified and separated to show improved and unimproved water categories. The proportion of the population taking their drinking water from wells in 1999 was 31% (improved or unimproved). Other sources are tanker/truck and sachet water, each being less than 7% in the survey years.

On the side of improved water sources, tap water provision has always been less than 10% in all the years of the survey. For instance, it has been 7%, 6%, 1%, 3% and 8% in 1999, 2003, 2008, 2010 and 2013 respectively. Protected wells were used by 14%, 45%, 22%, and 32% of respondents in 2003, 2008, 2010 and 2013 respectively. There was no distinction between protected and unprotected wells in the 1999 survey. The other sources are insignificant as they have low percentages. Improved water sources comprise of tap water, protected wells, protected spring, borehole, rainwater and bottled water. Unimproved water sources comprise of surface water, unprotected wells, unprotected springs, tanker trucks, tanker vendors, sachet water and other sources. The graphical presentation of the improved and unimproved water sources is presented in Figure 5.9

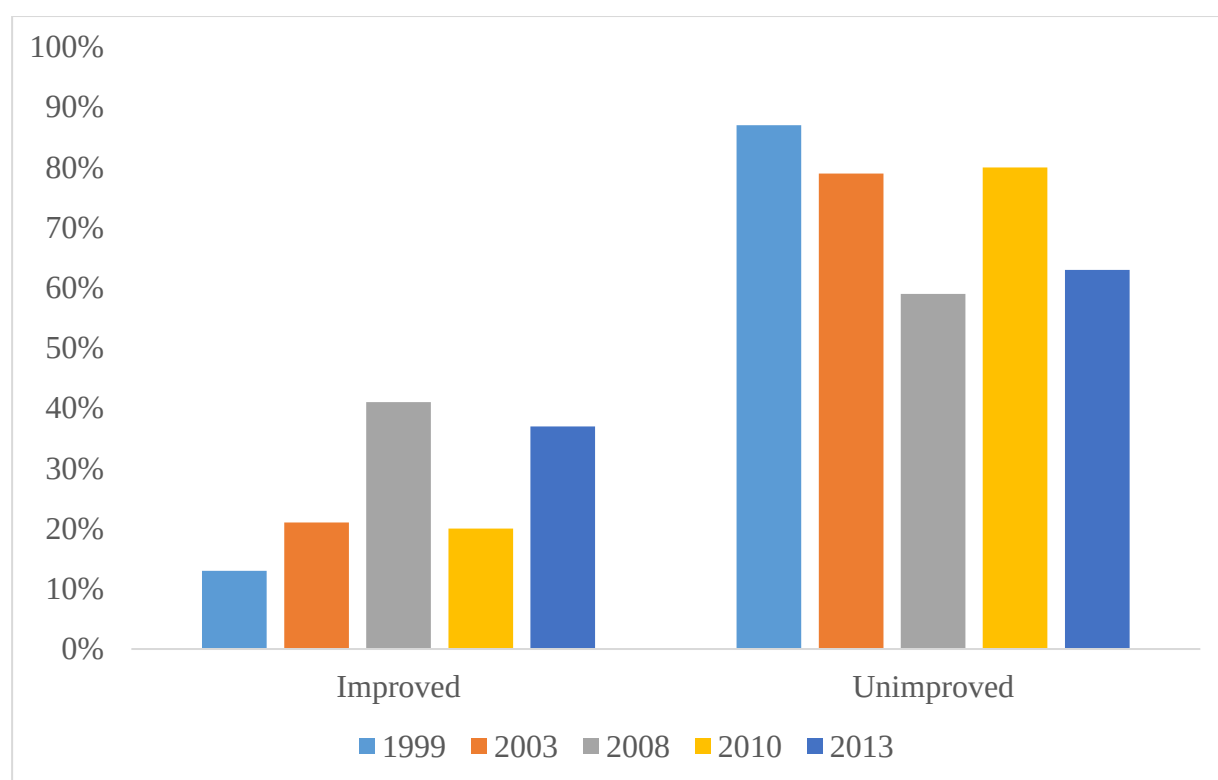


Figure 5.9 Improved and Unimproved Sources of Drinking water for Benue State.

Source: DHS Analysis 1999, 2003, 2008 2010 and 2013

It is important to note that there was no distinction between protected and unprotected wells in the 1999 surveys. It is clear from the graphs that unimproved water sources were far more patronised than the improved ones.

It would be interesting to know whether supply has decreased or whether it is more the case that supply has failed to keep pace with population growth. Investigations from numbers and percentages indicate that water supply has actually decreased, and not that supply failed to keep pace with population growth. For instance, in 1999, the sample of respondents surveyed was 340 and it was found that tap water access was 7%. In 2003, a sample of 291 people produced a statistic of 6.2% while a 200-person sample in 2010 returned a value of 2.5%. Again, an investigation of the bar graph of water supply for Benue over the 14-year period (Figure 5.9) shows a decrease in improved water access followed by an increase in 2013. Well water and surface water were still significant, although they decreased slightly from 2008 to 2013. In summary, the tap water access remains low and few people have access to the facility.

5.10.3 Improved and Unimproved Benue Sanitation

The WHO/UNICEF joint monitoring programme looked at improved sanitation as facilities that are expected to ensure hygienic separation of human excreta from human contact based on the definitions in the MDGs. Details of these were discussed earlier (section 2.3). The toilet facilities for Benue are presented in Figure 5.10.

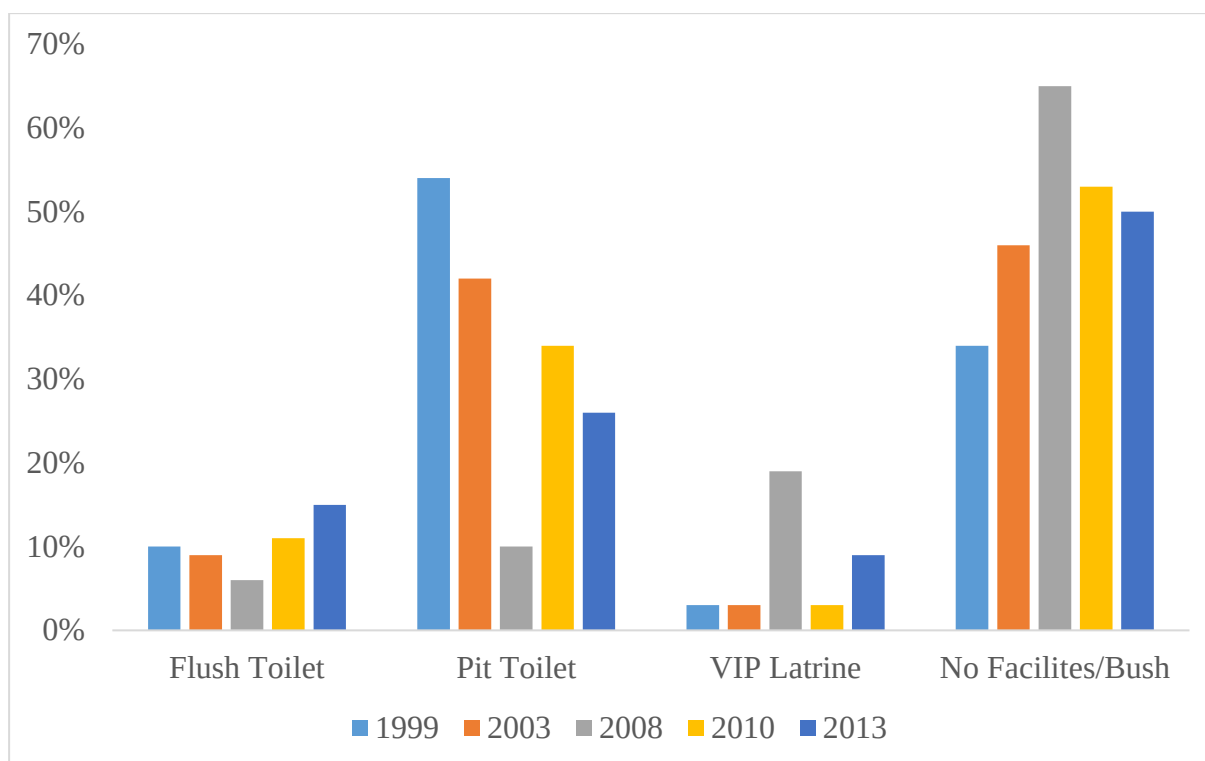


Figure 5.10 Toilet facilities for Benue State.

Source: NDHS data: 1999, 2003, 2008, 2010 and 2013.

From Figure 5.10 above, it is clear that the majority of the population of Benue state does not have access to improved sanitation with a large proportion having no facilities at all and thus defecating in the open. Between 10% and 54% of the population have access to pit toilets while only between 6% and 15% have access to a flush toilet facility. In Figure 5.11, the key improved toilet facilities are highlighted in blue while the unimproved key toilet facilities are highlighted in red. Based on the NDHS data available, a large proportion of respondents had no access to sanitation facilities and practiced open defecation. This practice accounted for 34%, 46%, 65%, 53% and 50% of responses in 1999, 2003, 2008, 2010 and 2013 respectively (Figure 5.10). The most widely used sanitation facility was the pit latrine, most/many of which were classified as unimproved as they did not have slabs. For instance, the percentage without slabs was 5%, 5%, and 18% in 2008, 2010 and 2013 respectively. There was no distinction between how pit latrines were classified in 1999 and 2003 surveys.

Improved facilities which include flush toilets, ventilated improved pit (VIP), latrines with slabs and composting toilets were used by less than 20% of sanitation facilities each in all survey

years. More precisely, flush toilets accounted for 10%, 9%, 6%, 11% and 15% of facilities for 1999, 2003, 2008, 2010 and 2013 respectively. VIP latrines accounted for 3%, 3%, 19%, 3% and 9% of facilities for the respective years of the survey while pit latrines with slabs accounted for 5%, 29% and 8% in 2008, 2010 and 2013 respectively. There was no distinction between pit latrines with and without slabs in 1999 and 2003 as earlier mentioned. Improved and unimproved sources of sanitation are presented in Figure 5.11.

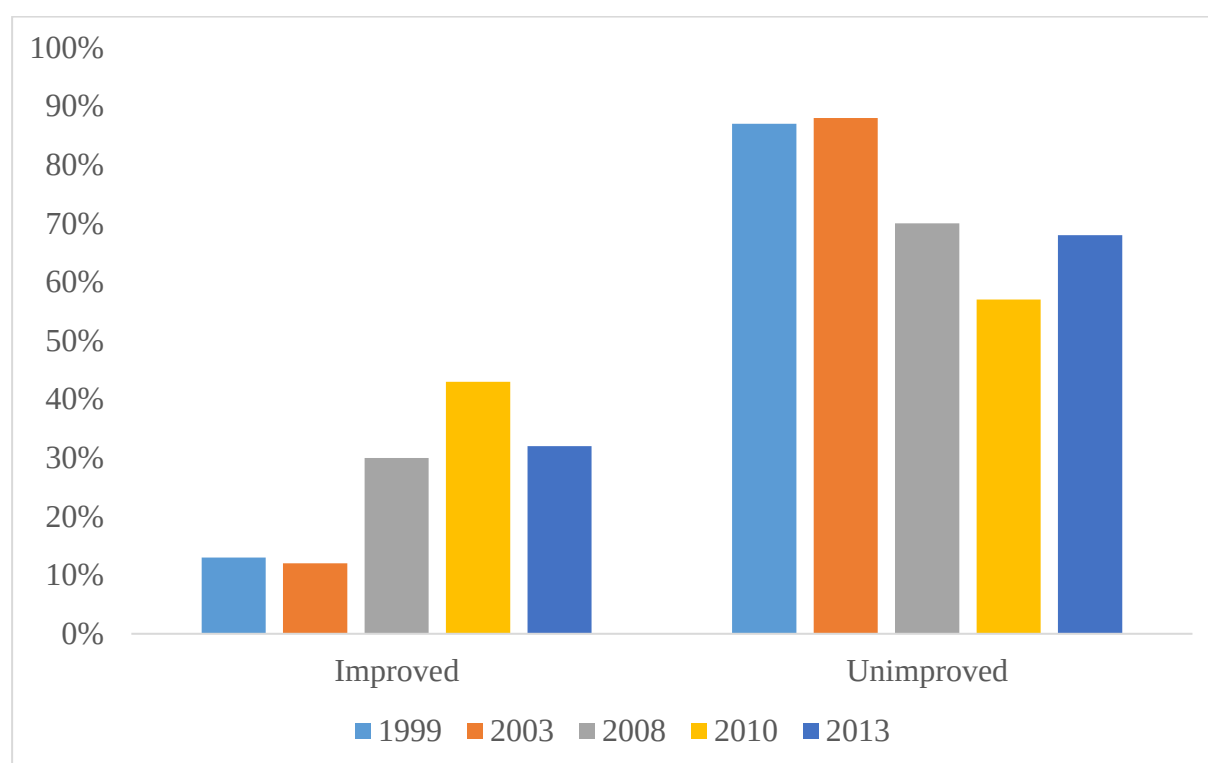


Figure 5.11 Improved and Unimproved Sanitation for Benue State.

Source: DHS data for 1999, 2003, 2008 2010 and 2103.

A quick look at the graphs show that unimproved sanitation was far more widely used in the survey years. Similarly, in the case of sanitation too, it would be interesting to know whether supply has decreased or if it is more the case that supply has failed to keep pace with population growth. Investigations from numbers and percentages indicate that sanitation access has actually decreased, and not that supply has failed to keep pace with population growth.

5.11 Variation in access to improved water and sanitation by rural/urban categories

Having considered the trends in access to improved water and sanitation in Nigeria and Benue State, attention is now focused on identifying trends in access to water and sanitation in Benue State based on rural/urban categories. The next section considers access to improved water and sanitation by socio-economic categories. These answer the second part of objective one. The data are considered on main categories that could be easily understood such as improved and unimproved water and sanitation as classified by the JMP. These are based on individual years and give information on access to water and sanitation in the years considered. The analysed data are presented in 100% each for improved/unimproved on rural/urban categories for water and sanitation. This is done so as to compare each of the constituent units with each other easily and simultaneously. For all the years, rural areas had lower access to both improved water and sanitation than the urban areas.

The rural/urban category analysis (Figure 5.12) shows that in 1999, the dominant water sources in the rural areas were unimproved such as streams accounting for 59%. Improved water appeared to be very high (78% in urban) and (41% in rural) because the data did not specify whether the wells and springs were protected or not and assumed to be improved during the analysis. Similarly, access to improved sanitation was poorer in the rural areas compared to the urban locations. The unimproved sanitation usage was 93% in the rural areas compared with just 55% in the urban areas.

In 2003, unimproved water sources accounted for over 66% and unimproved sanitation 68% in the urban areas while in the rural areas unimproved water was 84% and unimproved sanitation was 94%. Improved water on the other hand was 34% and improved sanitation was 32% in the urban areas compared with improved water 16% and improved sanitation 6% in the rural areas. This shows how rural areas are disadvantaged (Figure 5.12).

Access to improved water and sanitation in the rural and urban areas of Benue state in 2008 show that unimproved water sources were mostly consumed in the rural areas (58%) and unimproved sanitation 62%. The urban areas were more advantageous having 74% both in improved water and sanitation. The unimproved water and sanitation were low in the urban area both at 26% (Figure 5.12).

In 2010 too, the urban areas had higher access to improved water sources (60%) and sanitation (95%) compared to the rural areas having access to improved water (21%) and sanitation (36%). Unimproved water source consumption on the other hand was (79%) and sanitation (64%) in the rural areas compared with the urban areas 40% access to unimproved water and 5% unimproved sanitation (Figure 5.12).

In 2013, the rural areas' use of unimproved water sources such as 'unprotected well', 'unprotected spring', 'surface water' was 51% while unimproved sanitation recorded 62%. The urban counterparts had less access to unimproved water (28%) and sanitation (26%). Improved water sources on the other hand recorded higher access (72%) and sanitation (74%) in the urban areas compared to rural areas having just 49% for improved water and improved sanitation (38%). Although improved water access was generally low, compared with the other years, 2013 had a little increase in improved water and sanitation access. The reason for this is unknown, but it could have been a small rise in access to tap or borehole water. There seemed to be some improvement in sanitation in this year too as flush toilets have been accessed by the rural people up to average of 27%. Therefore, although there was a little improvement, access was lower in the rural areas compared to their urban counterpart (Figure 5.12).

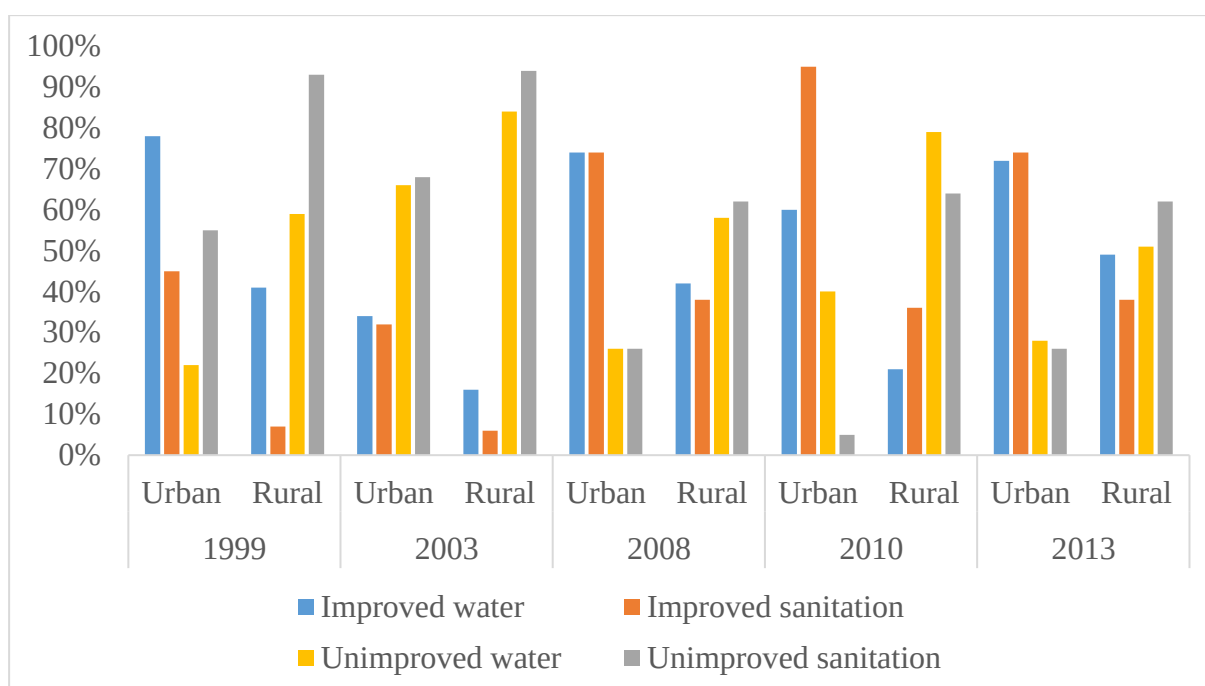


Figure 5.12 Access to improved water and sanitation on urban/rural basis (1999-2013).
Source: DHS data for 1999, 2003, 2008, 2010 and 2013

5.12 Access to improved water and sanitation by socio-economic factors

Apart from rural/urban categories, the research intends to investigate access to improved water and sanitation by socio-economic factors. The ones considered here are education, income (measured as wealth index), age and gender. These variables are considered because they are likely to influence the level of access to water and sanitation. For instance, an educated person could be more conscious of the water and sanitation they use. Also, wealthier people could demand better quality water and sanitation since these are not provided for everybody by the government. Age influences access to water and sanitation because at productive age, people are better positioned to demand for water and sanitation services. Gender is also considered as collecting water has been carried out mostly by women. Here too, analyses are considered by combination of individual years for summary of information. The 1999 data had no specific data on wealth index, but possession of consumer durable goods was considered as summarised in the DHS report for that year. The data analysis and presentation are found in the next section.

5.12.1 Access to water and sanitation based on age

Analysis based on age was categorised into age groups 17 years and under, 18-35 years and 36 years and over. The 17 and under are children who are mostly dependents who have little to demand for water and sanitation services. Nigerian society considers youth to fall within the 18-35 years bracket. This is considered the productive age when many people are able to demand for water and sanitation services and facilities. The category over 35 years are considered adults. At this stage, in practice, more people are settled and more equipped to influence water and sanitation services. This was done to collapse unnecessary age groupings and make the graph more legible and give WASH and age information a better meaning. Also, these are the most significant age groups in which water and sanitation decisions are made in Nigeria. There were many differences in access based on age. In 1999, the children's age group had slightly higher access to improved water (100%) and sanitation (50%) compared with adults who had improved water access of 46% and sanitation 15%. The youth had improved water access (46%) and sanitation 9%. Possibly because children are more vulnerable to diseases, they are being looked after to have better access to water and sanitation and are living with adults who are better equipped to access improved WASH. The youth may be less attached to the parents and may be struggling to find their way economically and unable to demand better access to improved WASH (Figure 5.13).

In 2003, the children's age group seemed to have more access to improved water (100%) but in terms of sanitation had access to unimproved (100%). Adults and youth had low access to improved water of 20% each which had a slightly higher access to improved sanitation (14%) compared with adult (11%). Access to improved water and sanitation was low for the other age groups apart from children (Figure 5.13).

In 2008, there appeared to be little differences in access to improved water and sanitation among the three age groups. Adult, children and youth respectively had access to improved water of

53%, 48% and 52% and improved sanitation 49%, 45%, and 49%. Unimproved water access was 47%, 52% and 48% while unimproved sanitation access was 51%, 55% and 51% respectively. All the age groups had less than 50% access to improved sanitation(Figure 5.13). Access to improved water and sanitation based on age in 2010 showed higher access by children (having 100% access to both improved water and sanitation) than the youth and adult. The adult age group had a lower access to improved water (24%) and sanitation (46%) compared to the youth having 25% and 35% access respectively for improved water and sanitation. On the otherhand, youth had low access to improved water, having access to unimproved water (75%) and unimproved sanitation 65%. Similarly, adult had access of 76% and 54% respectively for unimproved water and unimproved sanitation (Figure 5.14).

In 2013, the adult age group appeared to have the highest access to improved water sources (60%) and sanitation (53%) followed by youth 55% and 52% respectively for water and sanitation. Children this time had a lower access to improved water (42%) and improved sanitation (38%). Unimproved water consumption rose among the children age group to 58% and unimproved sanitation rose to 62% compared with 45% of youth having access to unimproved water and 48% having access to unimproved sanitation. Adult had access of 40% and 47% respectively for unimproved water and unimproved sanitation. Possibly, the children here had parents of low income (Figure 5.14).

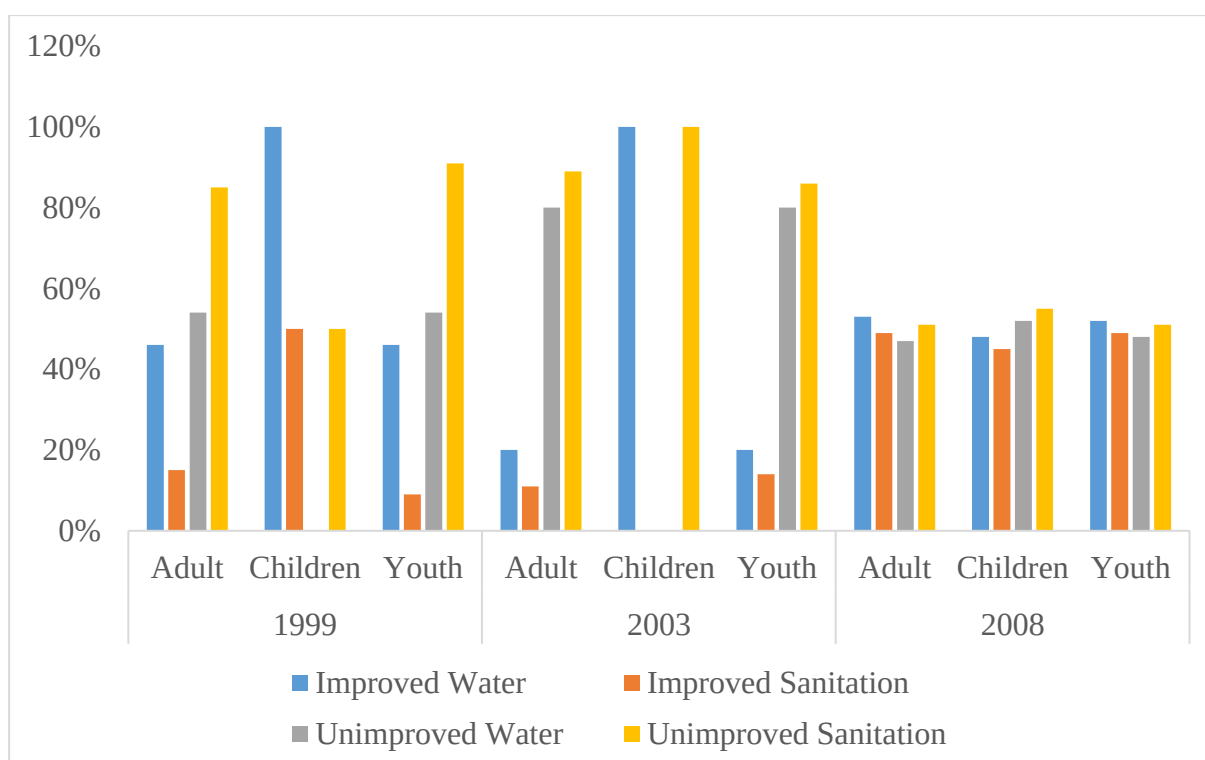


Figure 5.13 Access to improved water and sanitation based on age for 1999, 2003, 2008.
Source: DHS data for 1999, 2003, 2008, 2010 and 2013.

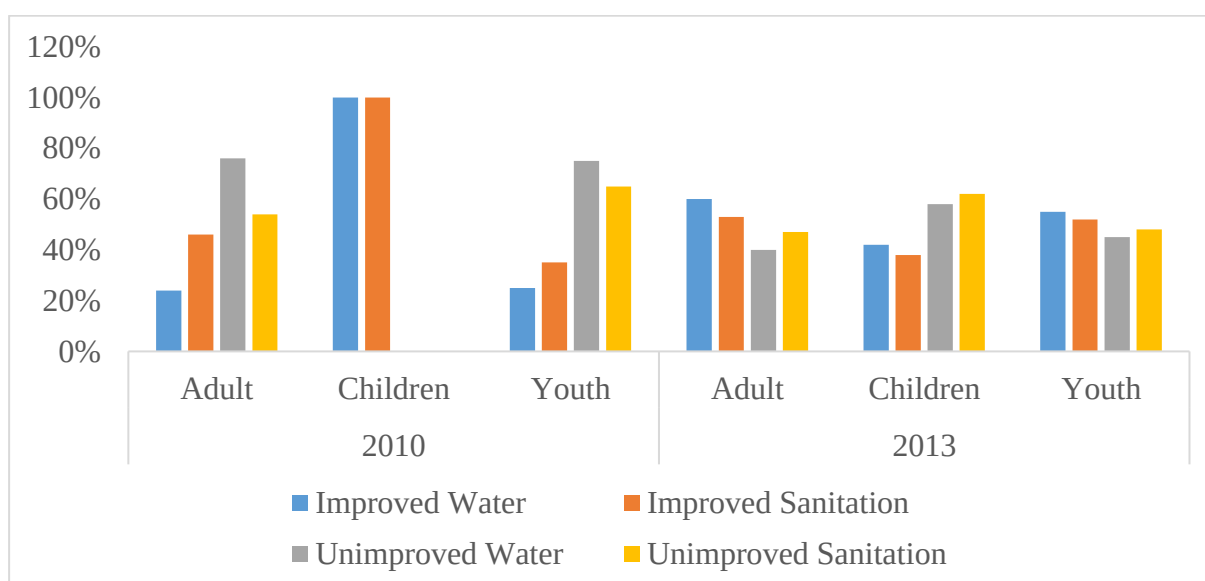


Figure 5.14 Access to improved water and sanitation based on age for 2010 and 2013.
Source: DHS data for 1999, 2003, 2008, 2010 and 2013.

5.12.2 Access to improved water and sanitation based on gender

As earlier mentioned, water and sanitation access have some gender variations. For instance, women tend to have greater responsibility for collecting water and greater need for it. Sanitation

and hygienic practices also depend to a large extent on availability of improved water supply. Access to both improved water and sanitation was generally higher by males than females. This should not be so but may reflect the fact that there are more male heads of household.

In the 1999 DHS surveys, analysis showed slightly more access to improved water by men (48%) compared with women (35%) and improved sanitation access of 13% for each of the sexes. Females had a higher percentage of access to unimproved water (65%) compared with men (52%) but in terms of unimproved sanitation both males and females had 87% access (Figure 5.15).

In 2003, improved water access between males (20%) and females (21%) differed little but there was slightly higher access to improved sanitation among males (13%) compared to females (9%). Unimproved water access was 80% for males and 79% for females but unimproved sanitation access was higher among females (91%) compared to males (87%) (Figure 5.15). This pattern could be due to the fact that men have more control over decisions relating to water and sanitation.

Access to improved water was higher among females (59%) compared to males (51%) in 2008. Improved sanitation was 49% for each of the sexes. Female access to unimproved water was higher being 49% compared to male (41%). Unimproved sanitation was high for both sexes with each having 51% (Figure 5.15).

In 2010 and 2013, access to improved water for males was 24% and 57% respectively, while for female it was 35% and 63% respectively. Unimproved water was accessed by 76% and 43% of males, while female access to unimproved water was 65% and 37% respectively for 2010 and 2013. In terms of sanitation, male access to improved sanitation was 43% and 52% and female access was 35% and 52% respectively for 2010 and 2013. Unimproved sanitation was

accessed by 57% and 48% of males and 65% and 48% of females respectively for 2010 and 2013 (Figure 5.15).

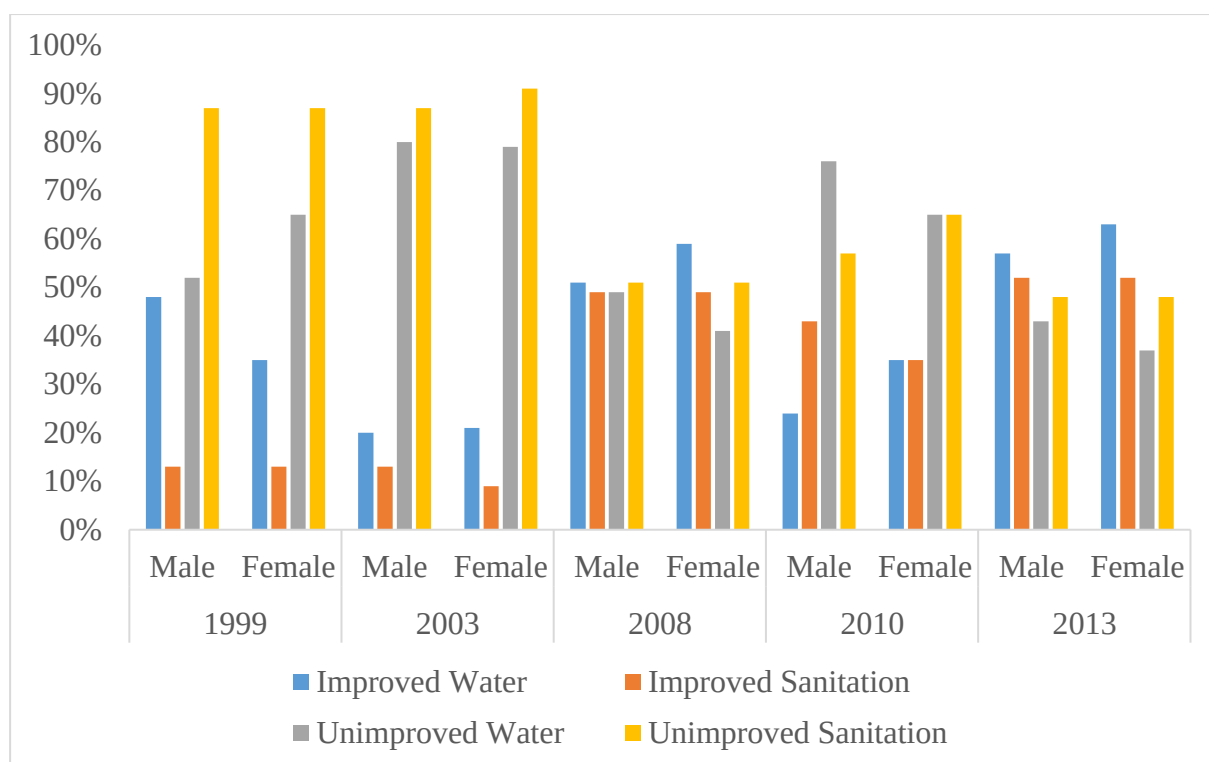


Figure 5.15 Access to improved water and sanitation based on gender for 1999-2013

Source: DHS data for 1999, 2003, 2008, 2010 and 2013

5.12.3 Access to water and sanitation based on Education

The DHS report 1999 states that education is often used as an indicator of social economic development of the country ([Demographic, 1999](#)). Education also affects proper hygiene. In the DHS report, 41% of women aged 15-49 had never been to school compared to 25% of men. From the analyses, it is clear that access to improved water and sanitation has links with socio-economic factors such as education and income. People who are educated have more exposure to information on the dangers of using poor water quality and sanitation facilities. Information from the graph in 1999 shows that improved water sources such as tap water were mostly accessed by those who were educated to higher levels. People with no education had improved water access of just 40% and improved sanitation (9%) compared with those with primary education who had 46% access to improved water and 14% access to improved sanitation. The

secondary and higher educated people had access levels of 63% each for improved water but access to improved sanitation was greater amongst the higher educated group (38%) compared to those with secondary education (17%) (Figure 5.16).

Access to improved water and sanitation also improved with the level of education acquired in 2003. Among those with no education, 14% had access to improved water while 3% had access to improved sanitation. Among those with primary education, 20% had access to improved water and 13% to improved sanitation. Figures for those with secondary education were 23% and 14% access for improved water and sanitation respectively whilst figures for people with higher education were 33% for improved water and 30 % for improved sanitation (Figure 5.16).

Similarly, in 2008 the 42% of the group with ‘no education’ had access to improved water and 37% had access to improved sanitation. Among the ‘Primary school’ educated group, 53% had access to improved water and 47% access to improved sanitation whilst the figures for the group with secondary education were 57% and 55% access. The higher educated group had the highest levels of access: 68% to improved water and 77% access to sanitation (Figure 5.16).

In both 2010 and 2013, improved water and sanitation access continued to increase with rising education levels. For instance, in 2010 the group with no education had 16% access to improved water and 43% access to improved sanitation; the group with primary education had 21% and 26% respectively for water and sanitation. The group with secondary education had 33% and 39% respectively for improved water and sanitation while the higher educated group had the greatest access to improved water (38%) and sanitation (75%). In 2013 also, the higher educated people had greatest access to improved water (67%) and improved sanitation (78%) compared with ‘non- educated’ group which had access of 51% for improved water and 40% access to improved sanitation. (Figure 5.17).

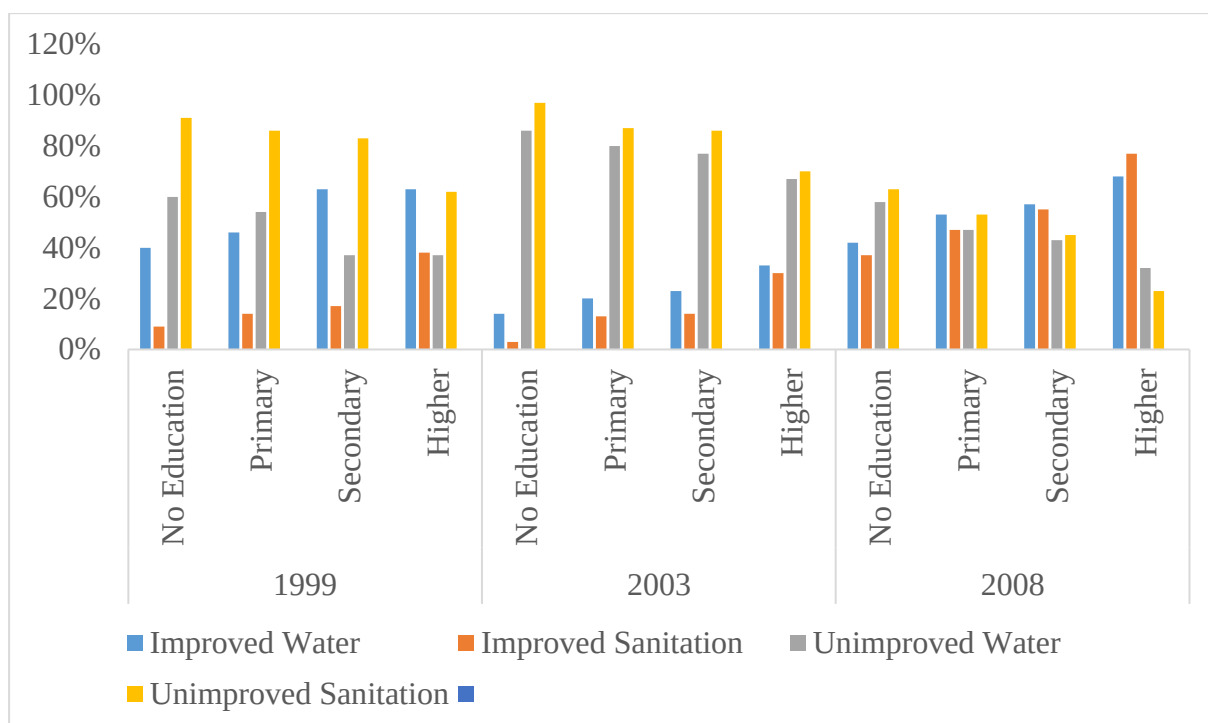


Figure 5.16 Water and Sanitation access based on Educational level for 1999, 2003 and 2008
Source: DHS data for 1999, 2003 and 2008.

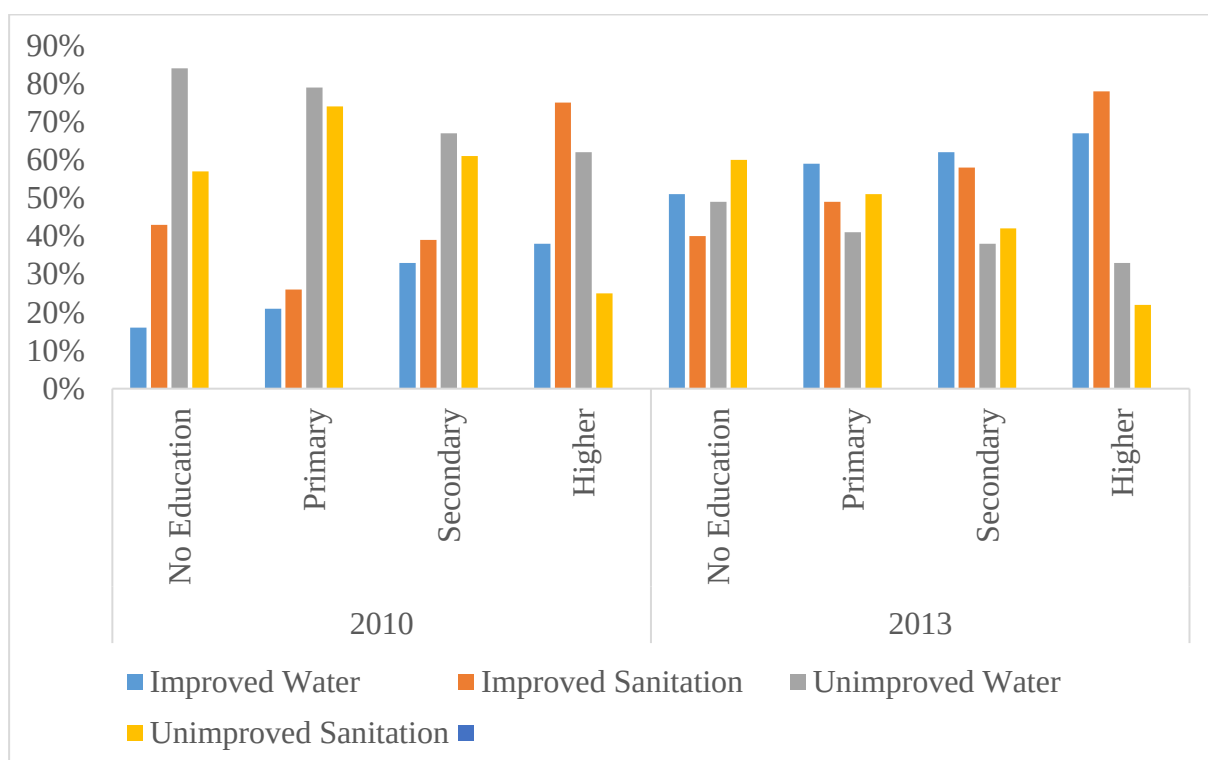


Figure 5.17 Water and Sanitation access based on Educational level for 2010 and 2013
Source: DHS data for 2010 and 2013.

5.12.4 Access to water and sanitation based on wealth index

The DHS calculated the wealth index using household assets data and principal component analysis (Macro, 2003). It was based on household ownership of consumer items such as television, bicycle, a car as well as dwelling characteristics such as drinking water source, type of sanitation facilities and type of materials used in flooring. These were calculated to arrive at a wealth index which was divided into quintiles from one (lowest) to five (highest) (Macro, 2003).

Unlike for the 2003, 2008, 2010 and 2013 DHS datasets which had a wealth index component, the 1999 datasets did not have a specific ‘wealth index’ variable. Despite this, it has data on ownership of consumer durable goods, similar to the wealth index variable used in the other surveys. Ownership of consumer goods provides information on socio-economic status of households and their benefits to the owners. In the 1999 survey, 62% owned a radio, 31% had electric fans, 26% had televisions, 24% had electric irons, and 24% had bicycles. Just 2% had a telephone while 8% owned private cars and 5% had a gas cooker. Urban areas had more of these than their rural counterparts. For example, urban private car ownership (15%) is thrice that in rural areas (5%). Access to improved water and sanitation also correlated with ownership of consumer durable goods which indicate that the wealthier had better access to WASH. A look at water and sanitation access on a rural/urban basis (Table 5.5) shows more improved access among the urban dwellers, who also own more consumer durable goods. A table showing ownership of consumer durable goods by residence is shown in Table 5.5.

Table 5.5 Percentage of Household possession of consumer goods

DHS Household durable goods for Nigeria 1999			
Consumer goods	Urban	Rural	Total
Radio	78%	55%	62%
Television	53%	14%	26%
Telephone	5%	0.2%	2%
Refrigerator	34%	7%	15%
Bicycle	10%	31%	24%
Motorcycle	14%	13%	14%
Private car	15%	5%	8%
Gas Cooker	10%	2%	5%
Electric Iron	50%	13%	24%
Electric fan	65	16%	31%
Donkey/Horse/Camel	0.1%	5%	3%
Canoe/Boat/Ship	0.2%	4%	3%
None (Radio through car	16%	34%	29%
None of the above	13%	30%	25%
Number of households	2,313	5,334	7,647

Source: DHS Report, 1999

From 2003, wealth index data were available and reveal that wealthier respondents tend to have the ability to demand better water and sanitation than poorer ones, as earlier mentioned. These are also reflected in the analyses over the years. The DHS data for 2003 showed that access to improved water was higher among the highest wealthy category. For instance, 50% of the ‘highest’ wealth group had access to improved water and 75% had access to improved sanitation. The middle wealth group had 29% and 13% access respectively for improved water and sanitation while the ‘lowest’ wealth group had 1% access to improved water and 0% access to improved sanitation (Figure 5.18). Unimproved water and sanitation were dominated by the lowest income group.

In 2008, the data reveals that among those who accessed improved water and sanitation, 80% and 92% respectively for improved water and improved sanitation fell into the ‘richest’ group while the ‘poorest’ had just 23% access to improved water and 21% access to improved sanitation. (Figure 5.18).

In 2010, access to improved water and sanitation by income appears more glaring as improved water and sanitation were mostly accessed by the richest group. For instance, while the 52% of the richest group had access to improved water and 96% had access to improved sanitation, only 23% and 26% of the poorest respectively had access to improved water and improved sanitation (Figure 5.19).

The DHS data for 2013 like the other survey years indicate that improved water and sanitation favoured the wealthy more than the poor. For instance, while 70% of the richest group had access to improved water and 91% to improved sanitation, the middle group had 60% and 40% access and the poorest group had 33% and 26% access respectively to improved water and improved sanitation (Figure 5.19). Access to improved water and sanitation therefore links with wealth status with the richest accessing the best services and facilities while the poor are limited to the poorest services and facilities. Similar findings were obtained in the field in the questionnaire, semi-structured interviews and even field observations.

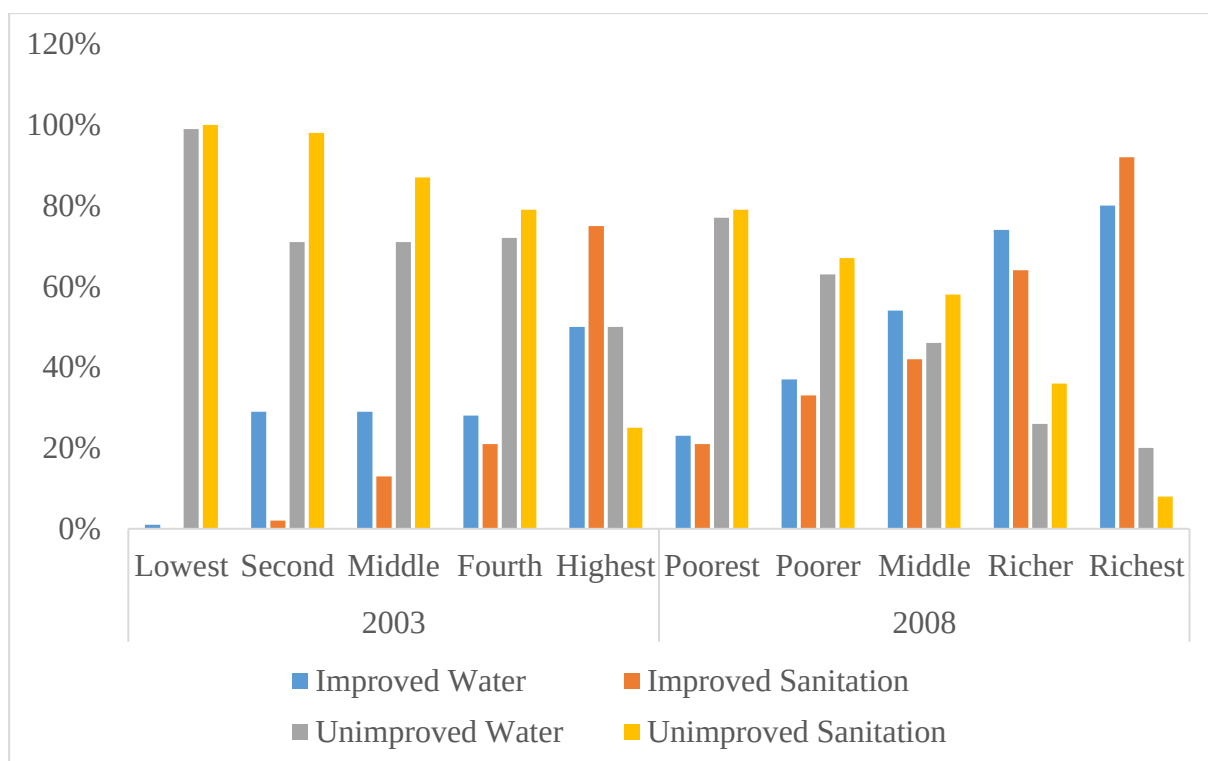


Figure 5.18 Access to water and sanitation based on wealth index for 2003 and 2008
Source: DHS data for 2003 and 2008. (These are wet season surveys)

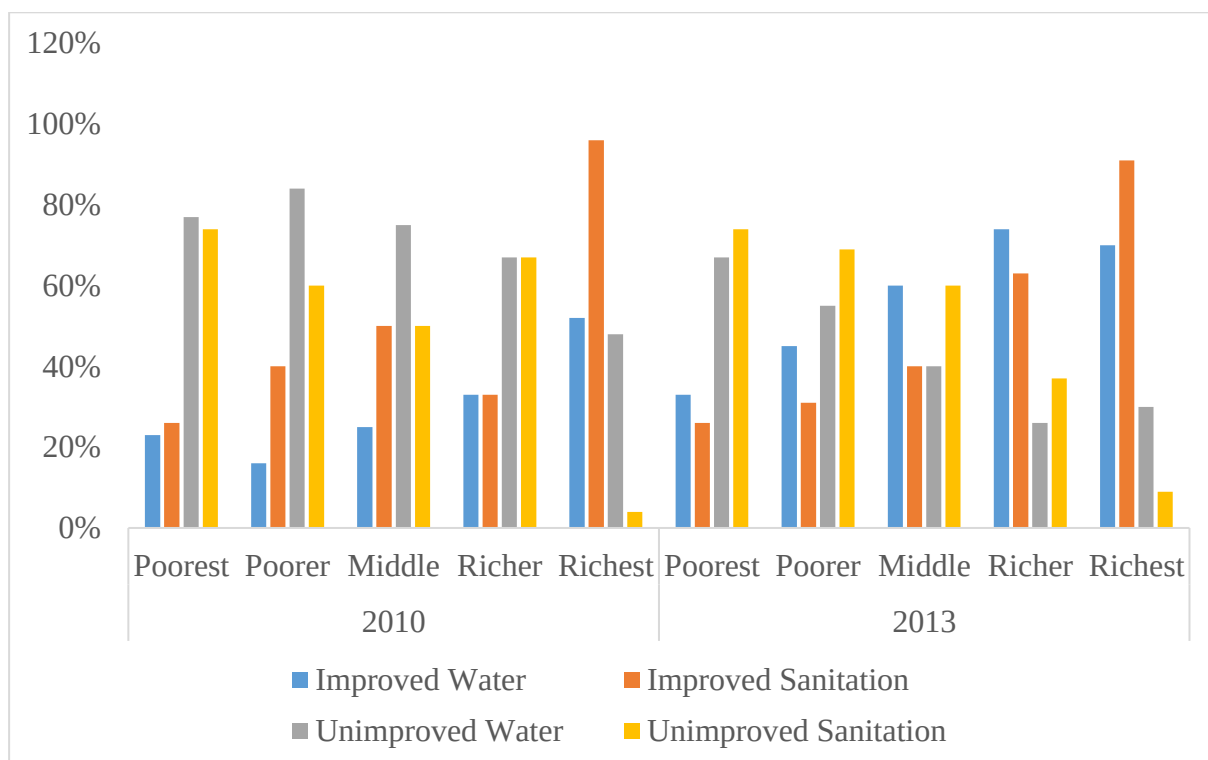


Figure 5.19 Access to water and sanitation based on wealth index for 2010 and 2013
Source: DHS data for 2010 and 2013 (These are dry season surveys).

In summary, rural/urban water and sanitation access in Benue State as revealed by DHS data show that although access was generally low, the rural areas had poorer access to both water and sanitation. This was consistent for the survey years under review (1999-2013). On the part of socio-economic factors, age and gender had little influence on access to water and sanitation. However, the age group 35 years and above appeared to have slightly more access to improved water and sanitation. This could be that older people could have been more financially established to have better access to these services. Gender analysis showed far more access to improved water and sanitation by males than females. This bias could reflect the fact that men were the more likely to be interviewed as heads of household. Education and income were found to have influenced improved water and improved sanitation access. People who were more educated had higher access to improved water sources and sanitation than the non-educated and less educated. Income level also correlated with improved water and improved sanitation access as those who had higher incomes had higher access to improved water and sanitation than the poorer ones. Access to improved water and improved sanitation therefore varied based on rural/urban category and socio-economic factors.

5.13 Questions raised by the DHS data in Benue State

From the foregoing, it is clear that access to improved water and sanitation in Benue State is low. The trends have revealed very important questions. The following questions emerged from the data and some of them were investigated in the field during the fieldwork.

5.13.1 Water supply questions

1. Why is access to improved water sources low in the survey years?
2. Who has been in charge of developing water supply facilities?
3. How effective are the stakeholders concerned in tackling water supply?
4. Why is tap water access generally low (less than 10%) in all the survey years?
5. Why has there been a high level of reliance on wells?

6. Why has access to boreholes been low?
7. Why has the use of rainwater been low in all the survey years?
8. Why do some respondents rely heavily on surface water as their major source of drinking water?
9. Do the sources of water used vary seasonally?
11. How aware are respondents of the risks presented by poor quality drinking water and have there been awareness campaigns to increase knowledge of these?
12. What measures can be taken to address water supply problems?

5.13.2 Sanitation questions

1. Why has sanitation not shown significant positive development over the years?
2. What is the cause of poor sanitation and why is open defecation so widespread?
3. Why has access to Ventilated Improved Pit (VIP) latrines been low in the survey years?
4. Who has been in charge of developing these sanitation facilities?
5. What are the perceptions of and actions promoting improved environmental quality?
6. Have there been some public health campaigns on improved sanitation and hygiene?
7. How effective are the stakeholders concerned in tackling sanitation?
8. How could sanitation and hygiene be improved?

5.14 Conclusion

This chapter has analysed DHS data from 1999 to 2013. The changes over the years have shown that water supply and sanitation in Nigeria, North Central and Benue State has been low over the survey years. Well water has been the main source of drinking water which had been between 33% and 60% from 1999 to 2013. Surface water consumption had also been high (16%

to 24%) and borehole access was between 10% and 30% in the survey years. As access to improved water varies between seasons, with the dry season experiencing a shift to unimproved water sources, the actual access to improved water could be under reported in the wet season as the dry season situation might not be captured. In terms of sanitation, pit toilets were the dominant facilities followed by open defecation. In the North Central region, the main water sources were well and surface water. Tap water access was low, having the highest access of 24% in a year. In terms of sanitation, pit toilets and open defecation were more popular. Flush toilets had the highest access of 24% in a year. In Benue State, surface water was the most widely accessed water source, followed by protected and unprotected wells. Tap water access was less than 10% in all the survey years. The urban areas had better access to improved water and sanitation than their rural counterparts. People aged 35 years and above appeared to have slightly higher access than those under 35 years of age. Access to improved water and sanitation was dominated by males and the bias came as men were those interviewed as heads of household. The more educated had better access to water and sanitation than the less educated ones. The wealthier groups also had higher access to water and sanitation than the poorest ones. The dominant sanitation practice was open defecation, followed by pit toilets. Access to improved water and sanitation was therefore low at national, regional and in Benue State. At the end of the analysis, some questions to guide investigations in water and sanitation research were postulated. The next chapter will focus on quantitative analysis of water quality data obtained from the field.

Chapter 6: Water Quality Data Analysis

6.1 Introduction

Chapter five presented an analysis of DHS data from 1999 to 2013 which showed the trends in poor access to water and sanitation in Nigeria, North Central region and Benue State. This chapter presents the results of the water quality analysis carried out in the field to establish the quality of water available to the residents. The same wells in Makurdi (urban) and Tse-Agberagba (rural) were tested in both dry and wet seasons (See 6.2 for well maps). The urban sites included High Level, Kanshio, North Bank, Wadata and Wurukum while rural sites were Alemenyi, Dam, Konshisha and Secretariat. The data are presented in tables, showing the detailed values of the parameters in both seasons in urban and rural areas. This is done to ease comparisons and to show details of the results for the parameters concerned. Further analyses using statistical techniques were employed to test for the differences in contamination values among the sites and seasons. The physico-chemical parameters namely temperature, conductivity, total dissolved solids (TDS), and pH were measured directly in the field using a ‘Hanna Combo’ meter following manufacturers’ instructions. This methodology was also used by [Oyem *et al.* \(2014\)](#) and [Parihar *et al.* \(2012\)](#). Other parameters are nitrate, chloride and fluoride. These were tested using palintest tablet test kits following the manufacturers’ instructions. The faecal parameter considered was total coliforms, comprising gas and non-gas associated colony counts, using petrifilm plates as instructed by the manufacturers (details in Chapter 4:). The physico-chemical parameters are considered first, followed by faecal coliform data.

6.2 Distribution of wells according to improved and unimproved in the study sites

Since the study used the JMP criteria of improved/unimproved wells, the data were collected to reflect the JMP definitions. These definitions were given in Chapter 2:. A total of 100 wells were sampled: 50 in rural and 50 in urban locations for each of dry and wet seasons. Sixty-five

percent of the wells would be categorised as improved with wells in rural areas being slightly more likely to be improved (34%) compared to those located in urban areas (31%). Thirty-five percent of the wells were considered unimproved.

Improved wells such as the one shown in Plate 6.1(a) located in Konshisha are considered improved because they are protected or covered based on JMP definitions. The (b) part of Plate 6.1 shows an example of an unimproved well which is located in the site of North Bank Makurdi. It is considered to be unimproved because it is not covered or protected. Maps showing locations of the wells in urban and rural sites are found in Figure 6.1, Figure 6.2, Figure 6.3 and Figure 6.4



Plate 6.1 An improved well in Tse-Agberagba (a) and an unimproved well in Makurdi (b)
Source: Fieldwork 2016

The dry season parameters are labelled '1', while wet season is labelled '2'. For example, total counts 1 refers to dry season samples and total counts 2 refers to wet season samples. The urban and rural locations, nine sites in total, were also coded. The analyses are presented in section 6.4.

Table 6.1 Study sites and their codes

Urban	Rural
HL= High Level	AL= Alemenyi
KS=Kanshio	DM=Dam
NB=North Bank	KSH=Konshisha
WD= Wadata	ST=Secretariat
WK=Wurukum	

Source: Fieldwork 2016

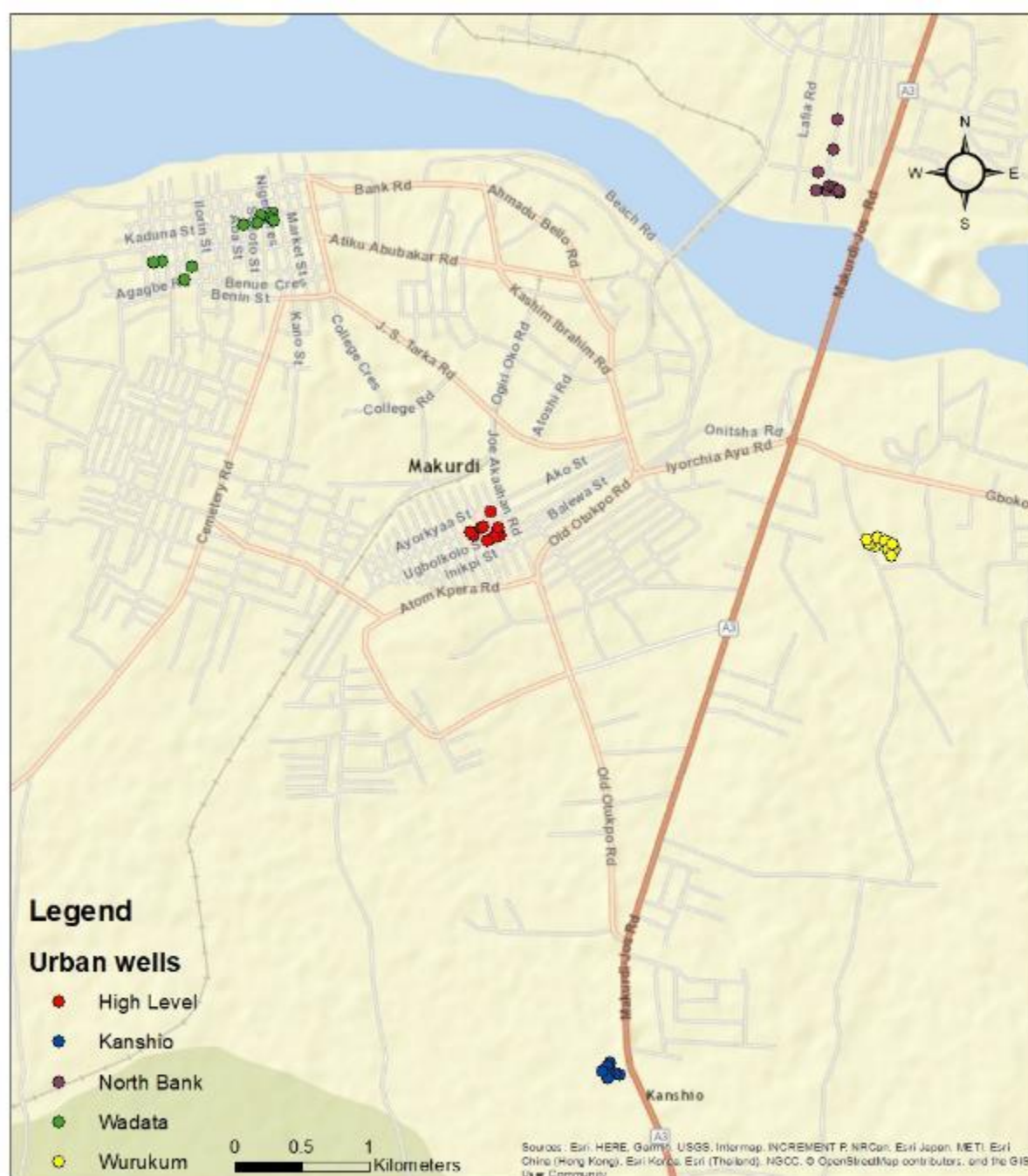


Figure 6.1 Urban Wells in Makurdi

Source: Fieldwork 2016, collected GPS points plotted and overlaid on Google map



Figure 6.2 Improved and unimproved well locations in Makurdi
Source: Fieldwork 2016, collected GPS points plotted and overlaid on Google map

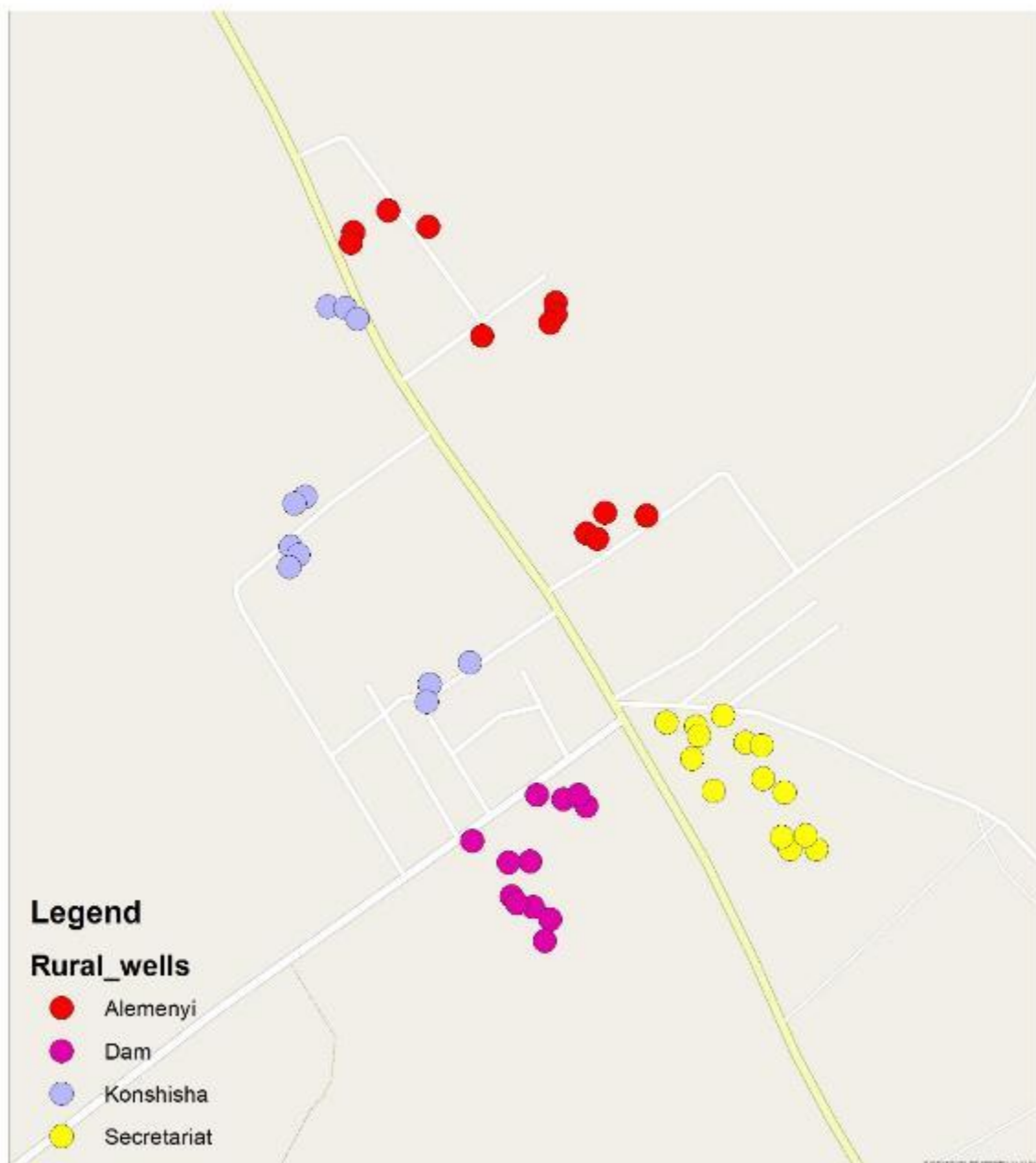


Figure 6.3 Well site locations in Tse-Agberagba

Source: Fieldwork 2016, collected GPS points plotted and overlaid on Google map

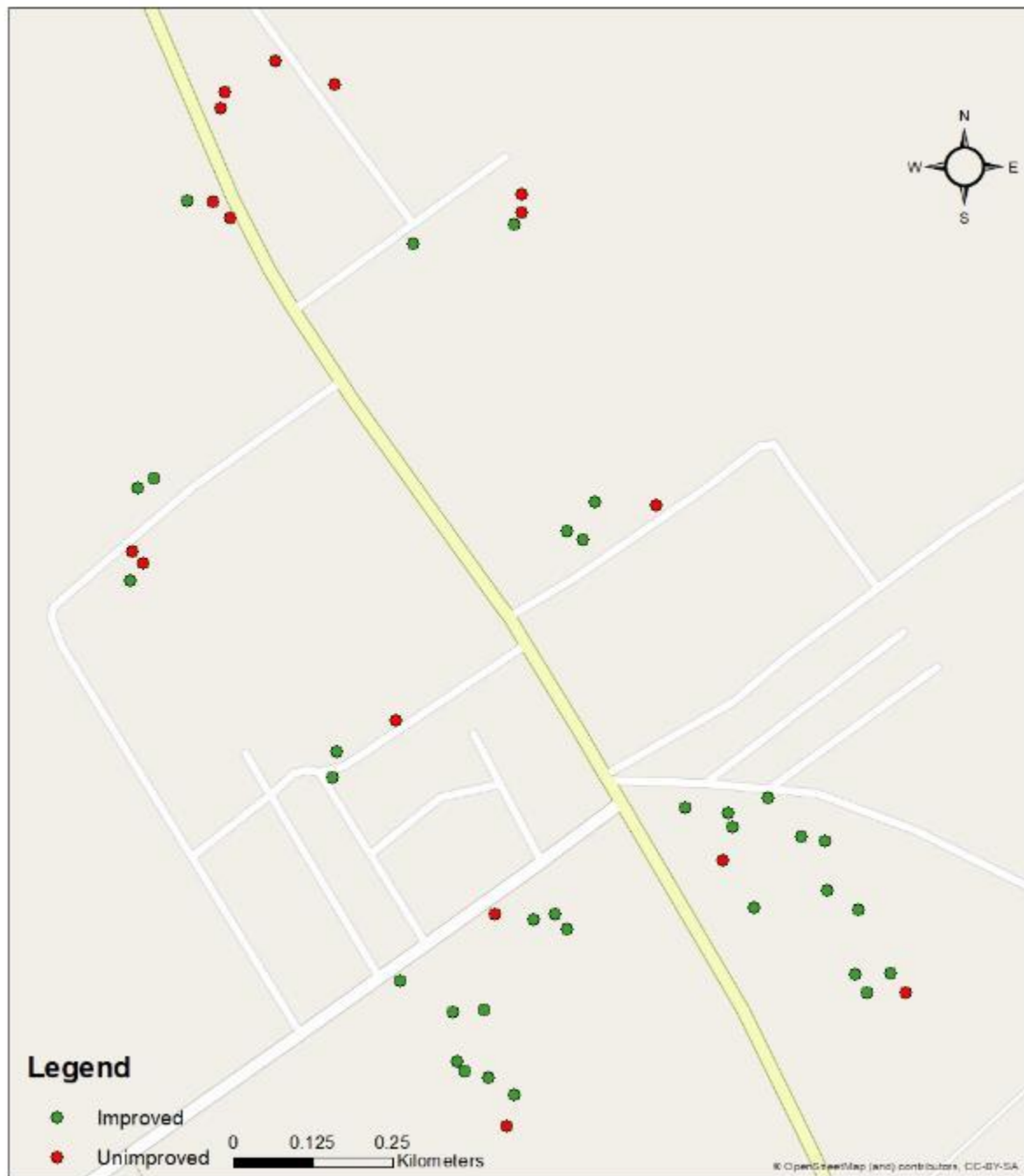


Figure 6.4 Improved and unimproved Wells locations in Tse-Agberagba
Source: Fieldwork 2016, collected GPS points plotted and overlaid on Google map

6.3 Distribution of Latrines based on Urban and Rural Sites

As latrines are also very important in the research, an attempt was made to get data on improved and unimproved latrines and how they are distributed in the rural and urban areas. Following the JMP definitions of improved and unimproved sanitation systems, there appear to be more improved latrines in the areas sampled, with urban areas having more improved latrines than

rural areas. For instance, sanitation in the urban sites comprised of 98% improved latrines and only 2% unimproved latrines. The rural counterparts contrastingly comprised of 62% unimproved latrines and 38% improved latrines. I also wish to point out that some of the improved latrines are not well constructed but can be classed as improved based on JMP definitions. Some pictures of the latrines found in Plate 6.2 (a & b) are examples of improved and unimproved sanitation. According to JMP definitions an improved sanitation is expected to hygienically separate faeces from human contact. But in reality, faeces are not far from the immediate environment. Generally, [Zingoni *et al.* \(2005\)](#); [Graham and Polizzotto \(2013\)](#); [Kostyla *et al.* \(2015\)](#) noted that proximity of pit latrines to groundwater sources pose some risk of groundwater contamination and the study sites are not exception to this. As can be seen in

Plate 6.3 which is a picture taken at an urban site, the soak-away pit is dug close to the toilet situated at the back of it, the well is less than 20m away. The squatting platform is just separated from the pit dug in the ground by a pipe. Sometimes, heat and foul smells emanate from the pit to the squatting platform with flies perching on the squatting platform. Sometimes cockroaches enter the pit and move around the squatting platform and in the toilet. Although some of these could be considered improved according to the simple definition of ‘improved’ used for MDG and SDG monitoring, they would not meet the ‘safely managed’ criteria developed for SDGs.

Plate 6.3 (a) shows the inside of the platform from where the faeces are flushed to the soakaway pit at the back. Plate 6.2 (b) is an example of a pit latrine without a slab. Here water is not used to flush, but the faeces go directly into the pit. This photo was taken from a rural site. An improved version of the unimproved latrine is shown in (Plate 6.3a). The main difference here is the presence or absence of a squatting slab. By the JMP definition, it is improved in the sense that it separates faeces from human contact. But it is just separated by a pipe between the

squatting platform and the pit which is constructed at the back. As in the case of the other toilets shown in (Plate 6.3a), heat and foul smells can emanate from the pit to the squatting platform. Although not all toilets of this type emanate stench and heat, a lot do. This is particularly the case where the distance from the squatting platform is very close to the soak-away pit, narrowly separated by a pipe. A small white object close to the latrine (Plate 6.3b) is the vent to release air from the soak away pit.



Plate 6.2 An improved Latrine in Makurdi (a) and an unimproved latrine in Tse-Agberagba (b)
Source: Fieldwork 2016



Plate 6.3 An inside of an improved latrine (a) and an outside of an Improved Latrine (b)
Source: Fieldwork 2016.

6.4 Physico-chemical Water Parameters data Presentation

The physico-chemical parameters were also measured in the 100 sampled wells in both the dry and wet seasons. The parameters measured were pH, temperature, conductivity and total Dissolved Solids (TDS). These parameters were also used by other researchers such as [Okoye and Nyiatagher \(2009\)](#); [Oyem *et al.* \(2014\)](#); [Parihar *et al.* \(2012\)](#); [Daud *et al.* \(2017\)](#). These were all measured using a Hanna waterproof tester. The measurements were taken directly and immediately on site after collecting the water samples. Other parameters were nitrate, chloride and fluoride. These were measured using palintest tablets following the manufacturers' procedures (details in Chapter 4:). The parameters had small variations between dry and wet seasons. Their characteristics are as detailed below.

6.4.1 pH Data Analysis.

The pH values relate to the acidity or alkalinity of water. It is a measure of the relative amount of free hydrogen or hydroxyl ions in water. The presence of more hydrogen ions indicates acidic conditions while more hydroxyl ions indicate basic conditions. The pH scale ranges from 0 (acidic) to (alkaline) 14. A pH of 7 is neutral ([Garbarino *et al.*, 2002](#)). The values change due to the different dissolved gases and solids ([Daud *et al.*, 2017](#)). The acceptable value for drinking water as given by WHO is between 6.5 and 8.5 and is important in determining the corrosive nature of water ([Word Health Organisation, 2011](#)). The lower the pH value, the higher the corrosive nature of water. While corrosive water in itself does not necessarily cause problems, it can dissolve the materials it comes into contact with such as lead used in soldering pipes and other materials and mix with drinking water which could be harmful if taken ([Swistock and Clemens, 2013](#)). Corrosive water can therefore dissolve some poisonous materials into the water systems which can bring about health threats. Generally, the values in the study areas fall

within the acceptable limits. There were variations in the pH concentration between different sites in the urban centres in the dry season with Wadata having the highest mean. In the wet season, Wadata also had a higher pH value than all the other locations. Wadata therefore had the highest pH concentration among the urban sites in both dry and wet seasons. The study sites have the locations coded. The urban and rural sites and their codes are shown in Table 6.1.

In the wet season, all the areas had higher than 6.00 pH values with Secretariat having 6.49. These values are similar to those found elsewhere (Oyem *et al.*, 2014; Woldeab *et al.*, 2018). There appear to be seasonal significant variations in pH levels between dry and wet seasons in the rural areas with Konshisha having a higher standard deviation of 5.79. This implies the water could be corrosive due to conditions obtainable from clayey soils in the wet season, as the rural areas are dominated by clayey soils. This information is found in Table 6.2 while the rural data are presented in Table 6.3.

Table 6.2 Mean Dry and Wet Season pH Values for Urban Sites

Season	Site	Mean	Standard Deviation
Dry	HL	7.31	0.31
Wet	HL	6.13	0.47
Dry	KS	7.47	0.20
Wet	KS	7.02	0.28
Dry	NB	7.30	0.22
Wet	NB	6.78	0.20
Dry	WD	8.17	0.28
Wet	WD	7.35	0.23
Dry	WK	7.91	0.40
Wet	WK	7.07	0.30

Source: Field work 2016

As can be seen from Table 6.2, the values of pH are slightly consistently higher in the dry season than the wet season in the urban sites. This implies that in the dry season, there appears to be a higher concentration of dissolved gases and more organic and inorganic solutes in water than in the wet season (Parihar *et al.*, 2012; Utsev and Aho, 2012). Utsev and Aho (2012) reported that geology formations may affect the pH. The clayey nature of the soil in the rural

sites could account for high pH in the dry season. The pH values fall within the range of 6.5-8.5 guideline by WHO. [Oyem et al. \(2014\)](#) reported that water falling within this range is good for drinking.

Table 6.3 Mean Dry and Wet Season pH Values for Rural Sites

Season	Site	Mean	Standard Deviation
Dry	AL	7.68	0.68
Wet	AL	5.96	0.29
Dry	DM	7.70	0.34
Wet	DM	5.88	0.35
Dry	KSH	7.34	0.49
Wet	KSH	5.97	0.29
Dry	ST	8.33	0.42
Wet	ST	6.49	0.60

Source: Field work 2016

As the table shows, there is a significant seasonal variation in the pH values between dry and wet seasons in the rural areas. While in the dry season, they are relatively high in both urban and rural sites, in the wet season, the values decrease. [Woldeab et al. \(2018\)](#); [Atobatele and Ugwumba \(2008\)](#); [Araoye \(2009\)](#) and [Sisay et al. \(2017\)](#) also reported decrease in pH in the wet season. [Araoye \(2009\)](#) attributed the decrease in pH in the wet season to decomposition of vegetation due to increased water levels while [Atobatele and Ugwumba \(2008\)](#) reported that pH generally decreases with increased rainfall. This is consistent in all the sites.

6.4.2 pH statistical analysis

A further statistical look is taken at the pH values to compare their levels among the urban and rural sites in the dry and wet seasons, as well as between dry and wet seasons. To achieve this the Kruskal-Wallis test was employed. This test allows you to compare the scores on continuous variables for three or more groups ([Elisante and Muzuka, 2016](#); [Pallant, 2016](#)). In this case it is employed to compare the scores of pH values among the various sites during the wet and then the dry season. It is a non-parametric alternative to the one-way between groups analysis of variance ([Pallant, 2016](#)). In this test, scores are converted to ranks and the mean rank for each

group is compared. As this is a ‘between groups’ analysis, different groups must be in each of the different categories (Pallant, 2016). In the Kruskal-Wallis test, the main information needed from the test are chi-square value, the degree of freedom (df), and the significance level. If the significant value is less than 0.05 (as it is in this test), it means there is a significant statistical difference among the population cases. The mean rank also shows groups that have highest overall rankings that correspond to the highest scores on the continuous variable (in this test). The highest ranked locations are indicated on Table 6.4 and *n* refers to the number of cases in each category. The dry and wet season comparison of pH is done using the Wilcoxon ranked test. This test was chosen because it is designed for use with repeated measures; that is when the same participants are measured on two occasions (in this case dry and wet seasons) (Elisante and Muzuka, 2016; Pallant, 2016).

The results from the Kruskal-Wallis test show that pH had statistically significant differences among the urban and rural sites in the dry and wet season. Thus, in the urban dry and wet seasons, Wadata had higher values while in the rural dry and wet seasons, Secretariat had higher pH values. As higher pH values indicate some form of pollution (Roger, 1982), these sites appear to be more contaminated. They also correspond to poor environmental conditions. The higher median values signify higher contamination values and correspond to the locations that bear them.

Table 6.4 Kruskal-Wallis Summary Table for pH

Sites and seasons	Chi-square	df	n	Sig. level	Mean Rank
Urban dry season	28.11	4	50	.000	8.13 (WD)
Urban wet season	33.81	4	50	.000	7.30 (WD)
Rural dry season	20.23	3	50	.000	8.27 (KSH)
Rural wet season	8.71	3	50	.03	6.52 (ST)

Source: Field work 2016

The pH was tested to determine its variation due to dilution with rain changing the chemical composition of ground water between the two seasons. The findings show that pH differences were statistically significant between dry and wet seasons. In this section, unlike the preceding

one, comparisons are made between the seasons and not among the various sites. The detailed report is found below.

The Wilcoxon ranked test revealed a statistically significant difference between dry and wet season pH values. $Z=-8.68$, $p<.001$, with large effect size ($r=.61$). The median score on dry season pH values decreased from $md=7.71$ to $md=6.48$ in the wet season. This means there were higher pH values in the dry than wet season.

Therefore, there was a statistically significant difference in pH levels in urban and rural areas in both the dry and wet seasons. Between wet and dry seasons, there was also a significant variation with pH values being higher in the dry than wet season. This results supports the findings by [Woldeab *et al.* \(2018\)](#); [Atobatele and Ugwumba \(2008\)](#); [Araoye \(2009\)](#) and [Sisay *et al.* \(2017\)](#). These could be due to geology, especially dissolved materials from clayey soils in the rural sites, where clayey soils dominate.

6.4.3 Temperature Analysis

As the study sites are in hot regions, temperatures between 20 to 25⁰C are considered low and temperatures beyond 30⁰C are considered high. Although there was a little variation between the dry and wet seasons, temperatures were generally very high. In the dry season, North Bank and Wadata each had higher temperatures of 30⁰C, while in the rural sites, Alemenyi and Dam had high temperatures of 30⁰C. In the wet season, High Level, Kanshio and Wadata had the highest temperatures of 29⁰C while in the rural areas, only Konshisha had the highest temperature of 29⁰C. This is not surprising as temperatures generally decline in the wet season due to effects of cloud cover. Water temperature influences the rate of physical, chemical and biological activities in water ([Oyem *et al.*, 2014](#)). [Oyem *et al.* \(2014\)](#) also reported that high water temperatures impact water quality by enhancing the growth of organisms which may alter taste, odour, and colour and corrosion problems. Cool water is generally preferred to warm

water. High water temperature enhances the growth of micro-organisms because they find it a good environment. On the other hand, when temperatures are cold, the activities of bacteria are lowered. High temperatures may accelerate the problem of taste, odour and corrosion. There is no guideline value recommended for water temperature. Due to the fact that warm temperatures facilitate the activities of microorganisms and lower temperatures inhibit their activities, we can say there is a link between high temperature and faecal matter as warm temperatures accelerate activities of micro-organisms (Yilmaz and Koç, 2014). The mean temperature values are found in Table 6.5 and Table 6.6

Table 6.5 Mean Dry and Wet Season Temperature values for Urban Sites

Season	Site	Mean	Standard Deviation
Dry	HL	29.51	0.39
Wet	HL	29.64	0.41
Dry	KS	29.25	0.45
Wet	KS	29.23	0.45
Dry	NB	30.77	0.33
Wet	NB	28.78	0.38
Dry	WD	30.49	0.68
Wet	WD	29.04	0.45
Dry	WK	29.66	0.40
Wet	WK	28.66	0.40

Source: Field work 2016

Temperatures are generally very high in the study sites as they are located within the tropics. There are however some seasonal variations with higher temperatures recorded in the dry than the wet season. Higher temperatures in the dry season were also reported by Atobatele and Ugwumba (2008) and Woldeab *et al.* (2018). As earlier mentioned, temperatures are lower in the wet season due to the effects of cloud cover and rainfall. Within the sites, the temperatures are slightly higher in Wadata, North Bank and Kanshio areas. This could partly explain the poorer water quality in Wadata and North Bank. The lowest temperatures values are found in High Level and Wurukum.

Table 6.6 Mean Dry and Wet Season Temperature values for Rural Sites

Season	Site	Mean	Standard Deviation
Dry	AL	30.13	0.44
Wet	AL	28.44	0.21
Dry	DM	30.28	0.51
Wet	DM	28.57	0.50
Dry	KSH	29.58	0.35
Wet	KSH	29.33	0.45
Dry	ST	29.48	0.79
Wet	ST	28.68	0.51

Source: Field work 2016

The temperature trend is similar in the rural sites. The dry season temperatures are slightly higher than the wet season values. In terms of site, Dam and Alemenyi appear to have slightly higher water temperatures.

It is clear from tables 6.5 and 6.6 that temperature values were generally high in the study areas but slightly higher in the dry season, both in the rural and urban sites. The temperatures, however, do not in themselves pose a threat to drinking water quality.

6.4.4 Conductivity Analysis

This is a measure of the ability of water to conduct an electric current. It is sensitive to variations in dissolved solids, which in most cases are mineral salts. Total Dissolved Solids (TDS) and conductivity are related. As concentration of mineral salts increases, conductivity rises ([Hu et al., 2005](#); [Daud et al., 2017](#)). There is no WHO guideline value for it. Dry season conductivity (ms) values ranged from 0.04 to 2.85ms with a mean of 0.73 and a standard deviation of 0.63. The wet season values ranged from 0.03 to 4.34 with mean of 0.59 and standard deviation of 0.67, showing higher values in the wet season. We measure it to determine water quality. The higher dissolved solid and mineral salt levels in water, the less palatable the water becomes. Generally, the values in the study sites are not too high. The mean values are found in Table 6.7

Table 6.7: Mean Dry and Wet Season Conductivity (ms) values for Urban sites

Season	Site	Mean	Standard Deviation
Dry	HL	1.06	0.37
Wet	HL	0.70	0.22
Dry	KS	0.80	0.18
Wet	KS	0.67	0.23
Dry	NB	1.26	0.37
Wet	NB	1.01	0.23
Dry	WD	1.71	0.62
Wet	WD	1.47	0.45
Dry	WK	1.21	0.66
Wet	WK	1.36	1.25

Source: Field work 2016

The table above shows that conductivity values were higher in the wet than the dry season in some samples in Wurukum. In High Level, conductivity values were consistently higher in the dry season than the wet season. In Wadata area, most of the samples had higher conductivity values in the dry season. In North bank, apart from sample 9, all the other samples had higher values in the dry season. In Kansio, roughly half of the samples have higher conductivity values in the dry season.

Table 6.8 Mean Dry and Wet Season Conductivity values for rural sites

Site	Season	Mean	Standard deviation
AL	Dry	0.25	0.23
AL	Wet	0.06	0.03
DM	Dry	0.27	0.12
DM	Wet	0.12	0.07
KSH	Dry	0.16	0.14
KSH	Wet	0.09	0.03
ST	Dry	0.30	0.17
ST	Wet	0.23	0.12

Source: Field work 2016

In the rural areas, based on the data presented in Table 6.8, almost all the locations had higher conductivity values in the dry season. This could probably be due to high amounts of dissolved mineral salts (Daud *et al.*, 2017).

6.4.5 Conductivity Statistical Analysis

In order to perform a statistical test on conductivity values to compare their levels among the urban and rural sites in the dry and wet season, the Kruskal-Wallis test was employed. The results show statistically significant differences in the urban and rural dry and wet season's values. In the urban sites in both dry and wet seasons, Wadata had the higher median score for dry and wet season respectively as (md=1.76) and (md=1.50). This means Wadata had the highest conductivity values in both seasons. In the rural areas in both dry and wet season, Secretariat site had higher conductivity values than all other sites of Alemenyi, Dam and Konshisha. Secretariat had higher median in dry season (md=0.40) and wet season (md=.21). It implies secretariat had higher dissolved materials probably from the soil conditions. [Sisay et al. \(2017\)](#) also found variations among sites using Kruskal-Wallis test and attribute the higher conductivity values to the high concentration of dissolved ions. Table 6.9 shows summary of the statistics.

Table 6.9: Kruskal-wallis summary table for conductivity

Conductivity	Chi-square	df	n	Sig. level	Mean Rank
Urban dry season	18.45	4	50	.001	1.76 (WD)
Urban wet season	22.90	4	50	.000	1.50 (WD)
Rural dry season	7.08	3	50	.07	0.40 (ST)
Rural wet season	27.59	3	50	.000	0.21 (ST)

Source: Field work 2016

In comparing the dry and wet seasons, the Wilcoxon ranked test shows statistically significant differences in conductivity between dry and wet seasons:

$Z=-5.66$, $p<.001$, with medium effect size ($r=.40$). The median value for the dry season decreased from md=.61 to md=.37 in the wet season. This means the conductivity values were higher in the dry than the wet season with medium effect size. The seasonal variation in conductivity is also reported by [Woldeab et al. \(2018\)](#).

6.4.6 Total Dissolved Solids (TDS) (ppt) Analysis

This refers to the total amount of solid materials dissolved in water. The more there are, the less palatable the water becomes. TDS levels of less than 600mg/litre are considered good but there are no specific WHO guideline values for TDS in water. The potential health effects of TDS are undesirable taste, gastro-intestinal irritation, corrosion or incrustation ([Patil et al., 2014](#)). TDS (ppt) values for dry season ranged from .02 to 1.42, with a mean value of 0.37 and standard deviation of 0.31 while wet season values ranged from 0.02 to 2.60 with a mean of 0.35 and standard deviation of 0.40. The values were therefore slightly higher in the wet season. The data are presented in Table 6.10 and Table 6.11.

This means most of the samples had significantly higher amounts of total dissolved solids in the wet season. That explains why the values are mostly positive and being clustered in the centre. [Lapworth et al. \(2017a\)](#) attribute this situation to contamination from household septic tanks and pit latrines. This indicates a normal curve where there appears to be a significant peak range. The data are shown in the tables below.

Table 6.10 Mean Dry and Wet Season Total Dissolved Solids (ppt) Values for Urban Sites

Season	Site	Mean	Standard Deviation
Dry	HL	0.53	0.19
Wet	HL	0.41	0.13
Dry	KS	0.40	0.09
Wet	KS	0.39	0.14
Dry	NB	0.63	0.18
Wet	NB	0.57	0.13
Dry	WD	0.85	0.31
Wet	WD	0.87	0.27
Dry	WK	0.60	0.33
Wet	WK	0.82	0.75

Source: Field work 2016

Although the variation is slight, the values of total dissolved solids were higher in the wet than dry season in all of the urban locations. This is due to higher amounts of dissolved materials in

the wet season due to an abundance of water and a rise in the water table. This partly explains why some respondents noted that water quality sometimes declines in the wet season.

Table 6.11 Mean Dry and Wet Season Total Dissolved Solids (ppt) values for Rural Sites

Site	Season	Mean	Standard deviation
AL	Dry	0.12	0.12
AL	Wet	0.04	0.02
DM	Dry	0.13	0.06
DM	Wet	0.08	0.04
KSH	Dry	0.08	0.07
KSH	Wet	0.05	0.02
ST	Dry	3.92	10.13
ST	Wet	3.70	9.03

Source: Field work 2016

In the rural areas, a good number of samples showed higher values of TDS in the wet season. However, there are some cases where the values are higher in the dry season. This could partly be explained by the contamination of water sources from sanitation systems and other waste within the environment ([Lapworth *et al.*, 2017a](#)).

6.4.7 Total Dissolved Solids (TDS) Statistical Analysis

Statistical tests for significance were done using the Kruskal-Wallis test. Wadata had the highest TDS values in dry and wet seasons reflected in the higher median scores respectively (md=.88) and (md=.89). This means Wadata had higher contamination among the urban sites in both the dry and wet seasons. In the rural sites in the dry season, there was no statistically significant difference in TDS. Secretariat had a higher median score (md=.20). In the wet season, Secretariat has statistically differed in the TDS values with the median score (md=.12) implying it had higher values of TDS. The main statistics are summarised in Table 6.12.

Table 6.12 Kruskal-Wallis Summary Table for Total Dissolved Solids

Sites and seasons	Chi-square	df	n	Sig. level	Mean Rank
Urban sites in the dry season	18.31	4	50	.001	0.88 (WD)
Urban sites in the wet season	22.54	4	50	.000	0.89 (WD)
Rural sites in the dry season	6.97	3	50	.07	0.20 (ST)
Rural sites in the wet season	28.15	3	50	.000	0.12 (ST)

Source: Field work 2016

In terms of seasonal variation, TDS were tested in both dry and wet seasons to determine if they had the same contamination levels between the two seasons. The Wilcoxon ranked test was employed to investigate this. The TDS data did not reveal a statistically significant difference between dry and wet seasons: $Z=-2.74$, $p>.001$, with small effect size ($r=.19$). The median decreased from ($md=.30$) to ($md=.22$). This means the wet season TDS values were higher than the dry season, though not statistically significant. [Woldeab *et al.* \(2018\)](#) however, reported higher TDS values in the dry season, which could have been due to other factors. The dissolution of materials is accelerated during the wet season due to higher rainfall. Therefore, apart from the rural sites in the dry season, TDS values had significantly differed in their distribution in the urban and rural sites in both seasons.

6.4.8 Nitrate Analysis

Nitrate comes from agricultural activities, such as run-off from fertilizer use and from animal and human faeces, in the form of leakage from septic tanks, sewerage and from erosion of natural deposits. Many researchers such as [Ahmed *et al.* \(2002\)](#); [Pedley *et al.* \(2006\)](#) and [Fourie and Van Ryneveld \(1995\)](#) consider nitrate as a common chemical issue from onsite sanitation systems. This could perhaps explain why nitrate is often considered when faecal contamination is investigated. High concentration of nitrates could have health concerns, such effects are mostly on infants below the age of six months. Symptoms include shortness of breath and blue baby syndrome ([Patil *et al.*, 2012](#); [Moyo, 2013](#)). The WHO guideline for nitrate is 50mg/l. In the study sites the values are higher in some places, implying some health risks. Because of their possible origin (from agricultural activities and human faeces), nitrates are very important to consider when doing research involving faecal contamination. High rates of nitrates give rise to methaemoglobinaemia in young children. The Mann-Whitney U test showed no significant difference in nitrate contamination between improved and unimproved wells in the wet season. The values for nitrates in the study sites are presented in Table 6.13 and Table 6.14.

Table 6.13 Mean Dry and Wet Season Nitrate values for Urban Sites

Season	Site	Mean	Standard Deviation
Dry	HL	44.00	28.29
Wet	HL	46.64	20.97
Dry	KS	27.72	25.07
Wet	KS	47.52	23.45
Dry	NB	30.36	30.94
Wet	NB	66.00	0.00
Dry	WD	62.04	12.52
Wet	WD	59.84	19.48
Dry	WK	10.12	7.77
Wet	WK	29.04	20.97

Source: Field work 2016

As can be seen from the table above, the nitrate values have been mostly higher in the wet than the dry season. [Graham and Polizzotto \(2013\)](#) reported contamination to be active in wet and sandy soil conditions. As the urban sites are sandy, it is possible for contaminants to be active as an abundance of water could facilitate the dissolution and transport of materials in sandy soils in the wet season. Many researchers such as [Zingoni *et al.* \(2005\)](#); [Tandia *et al.* \(1999\)](#); [Vinger *et al.* \(2012\)](#); [Wright *et al.* \(2013\)](#) have linked nitrates with contamination from pit latrines. [Graham and Polizzotto \(2013\)](#) reported that the wet season is generally more contaminated than the dry season.

Table 6.14 Dry and Wet Season Nitrate Values for Rural Sites

Site	Season	Mean	Standard deviation
AL	Dry	16.50	17.61
AL	Wet	13.56	8.28
DM	Dry	10.27	10.50
DM	Wet	39.23	19.36
KSH	Dry	10.63	7.38
KSH	Wet	21.63	13.33
ST	Dry	31.89	33.55
ST	Wet	30.49	22.07

Source: Field work 2016

Similarly, in the rural sites, the values for nitrate are higher in the wet than the dry season. This could be due to a rise in the water table and accelerated dilution and transport of chemicals in

the ground in the wet season compared to the dry season as also reported elsewhere (Vala *et al.*, 2011)

6.4.9 Nitrate Statistical Analysis

The Kruskal-Wallis test results show that there were statistically significant differences in nitrate among the sites in urban dry, urban wet, rural wet and between dry and wet seasons, but not in the rural dry season. In the urban dry and wet season, Wadata had higher nitrate levels. In the rural dry and wet seasons, Secretariat and Dam respectively had higher concentrations. The sites with higher concentration were also reflected in the higher median scores (Table 6.15). Seasonally, the wet season was more contaminated than the dry season. This tallies with reports by Barrett *et al.* (2000) and Sorensen *et al.* (2015a) which show that higher contamination occur after rainfall events. This is believed to be accelerated by rapid recharge of shallow groundwater which reflects in shallow well contamination. Apart from latrines being a substantial source of nitrate in well water, Kassenga and Mbuligwe (2009) identified waste dumps to contribute to nitrate loading in well water. The sites with high nitrate values corresponds with the most polluted sites. The nitrate contamination therefore showed a significant variation among the sites and between the seasons.

Table 6.15 Kruskal-wallis Summary Table for Nitrates

Sites and seasons	Chi-square	df	n	Sig. level	Mean Rank
Urban sites in the dry season	16.94	4	50	.002	66.00 (WD)
Urban sites in the wet season	17.57	4	50	.001	66.00 (WD)
Rural sites in the dry season	2.49	3	50	.48	11.00 (ST)
Rural sites in the wet season	14.95	3	50	.002	35.20 (DM)

Source: Field work 2016

There was a statistically significant difference in nitrate contamination levels between the dry and wet seasons according to the Wilcoxon ranked test: $z=-4.74$, $p<.001$, with a medium effect size ($r=.34$). The median score on nitrates increased from dry season ($md=11$) to rainy season ($md=35.2$). Nitrates levels were therefore higher in the wet than dry season. This tallies with

findings reported by other researchers of higher nitrate concentration in the wet than dry season (Kulabako *et al.*, 2007; Vala *et al.*, 2011; Dotro *et al.*, 2017)

As stated in the methodology, the Mann-Whitney U test was employed to test for nitrate in improved and unimproved wells, rural and urban wells in both the dry and wet seasons. This test was adopted because it tests for differences between two independent groups on a continuous measure. In the test, m =median, n =number of cases in each group, u =Mann-Whitney U value and z = standardized test statistics, p =significant value (if it is less than .05, it is significant, otherwise, it is not) and r = the effect size, which is not given but calculated as $r=z/\text{square root of } N$, where N = total number of cases. Generally, Cohen (1988) gave the criteria of .1=small effect, .3=medium effect, .5=large effect.

In the nitrate in improved and unimproved wells in the dry season, the results show that there is no statistically significant difference in nitrate contamination between improved and unimproved wells, although unimproved wells had a higher median value. That means unimproved wells were more contaminated. Higher contamination from unimproved than improved wells have been reported by other researchers (Godfrey *et al.*, 2006; Sorensen *et al.*, 2015a). The results here give the same information as the ones earlier shown in charts, therefore confirming earlier results and thereby using one method to check another.

Between urban and rural wells in the dry season, the Mann-Whitney U test revealed that there is a statistically significant difference in nitrate contamination between rural and urban wells with the latter having higher contamination. As there is a statistically significant difference between urban and rural nitrate levels, the median value in the urban sites is higher due to its higher nitrate concentration. This could be due to poor sanitation systems with higher population concentrations in the urban area, especially from nitrogen loading in latrines (Zingoni *et al.*, 2005).

In the wet season, the urban and rural wells test results from the Mann-Whitney U test show that there is a statistically significant difference (since .000 is less than .05) in nitrate contamination between rural and urban wet season wells. Nitrate had higher values in the urban than the rural areas in the wet season. This tallies with [Isunju *et al.* \(2011a\)](#)'s view that urban areas have higher nitrogen loading from on-site sanitation systems than their rural counterparts. Threats from nitrate from on-site sanitation have been reported by many reserachers ([Tandia *et al.*, 1999](#); [Zingoni *et al.*, 2005](#); [Kimani-Murage and Ngindu, 2007](#); [Vinger *et al.*, 2012](#); [Wright *et al.*, 2013](#)). The Mann-Whitney U test statistics are summarised in the table below. For a recap, md1, n = median and number of cases in the first category; md2, n = median and number of cases in the second category; U = Mann-Whitney U value; z = standardised test statistics, p = significant value and r = the effect size.

Table 6.16 Mann-Whitney U Summary Table for Nitrates

Nitrates	Md1, n	Md2, n	U	z	p	r
Improved and unimproved wells in dry season	Improved md=17.6, n=65	Unimproved Md=112, n=35	1098	-3.0	.77	.03
Improved and unimproved wells in wet season	Improved Md=35.2, n=65	Unimproved Md=35.2, n=35	1077	-4.5	.65	.04
urban and rural wells in the dry season	Urban Md=26.4, n=50	Rural Md=8.80, n=50	801	-3.22	.001	.03
urban and rural wells in wet season	Urban Md=66, n=50	Rural Md=17.6, n=50	589	-4.67	.000	4.7

Source: Field work 2016

6.4.10 Chloride Analysis

Chloride originates from rocks and is related to the surrounding geology. It may come from sodium in drinking water when available in high concentrations. It could come from mineral dissolution, industrial and domestic waste. Their effects are deteriorating plumbing, water heaters, municipal water equipment and taste ([Garbarino *et al.*, 2002](#)). It also comes from fertilizers and faeces ([Wright *et al.*, 2013](#)). [Graham and Polizzotto \(2013\)](#) noted that after nitrate, chloride is the most commonly investigated chemical indicator of groundwater

contamination from latrines due to its high concentration in excreta and its mobility in the subsurface. Chloride is transported during groundwater flow with minimal retention and track with nitrate levels (Banks *et al.*, 2002). The effects of chloride in water is that it reacts with organic matter to form trihalomethanes, notably chloroform CHCl_3 which is a suspected liver carcinogen in humans. Other health effects are eye/nose irritation, stomach discomfort and increased corrosive nature of water (Fewtrell, 2004). The study sites are significantly contaminated by chloride which suggest high risks from drinking such water. The respondents also mentioned the salty nature of water during semi-structured interviews, indicating high potassium chloride content. The chloride values are presented in Table 6.17 and Table 6.18.

Table 6.17 Mean Dry and Wet Season Chloride (mg/l) values for Urban Sites

Season	Site	Mean	Standard Deviation
Dry	HL	80.00	63.25
Wet	HL	50.00	52.70
Dry	KS	80.00	42.16
Wet	KS	40.00	51.64
Dry	NB	100.00	47.14
Wet	NB	100.00	47.14
Dry	WD	140.00	51.64
Wet	WD	110.00	73.79
Dry	WK	140.00	117.38
Wet	WK	210.00	228.28

Source: Field work 2016

It can be seen from the table above that values of chloride were very high in the study sites. There appears to be higher values of chloride in the dry season in some locations. Chloride levels were generally higher in Wurukum as only one sample (sample 8) had 0mg/l of chloride in the dry season. The levels were also higher in Wadata and North Bank areas with High Level and Kanshio having the lower levels of concentration as eight samples each had 0mg/l chloride. Since chloride is linked with waste (Roger, 1982), the sites having high chlorides also corresponds to areas with more waste and dirty surroundings.

Table 6.18 Mean Dry and Wet Season Chloride Values for Rural Sites

Site	Season	Mean	Standard deviation
AL	Dry	100.00	0.00
AL	Wet	16.67	38.92
DM	Dry	83.33	38.92
DM	Wet	0.00	0.00
KSH	Dry	75.00	45.23
KSH	Wet	0.00	0.00
ST	Dry	89.91	25.66
ST	Wet	4.05	10.30

Source: Field work 2016

Generally, chloride values appear to be lower in the rural than urban sites. In the dry season, the values of chloride had been consistently 100mg/l while in the wet season almost all sites had 0mg/l chloride apart from Alemenyi where sample five and twelve had 100mg/l chloride. It appears that the dry season has more risk in terms of chloride in the rural sites. [Godfrey *et al.* \(2006\)](#) reported that well water quality in the dry season may be affected by usage rates. They explained that as they are fewer sources of water to depend on in the dry season, the rate of contamination increases due to contamination from the materials used to draw water, especially for unimproved sources. In the study sites too, in the dry season, there are few water sources, and this brings a lot of pressure on them. This conforms to what respondents complained of water being salty. This shows that sodium chloride content of the water was higher in the dry season.

6.4.11 Chloride Statistical Analysis

The Kruskal-Wallis test was employed to statistically analyse chloride among the sites and seasons. The test revealed that there is no statistically significant difference in the chloride contamination among the urban sites in the dry season, rural sites in the dry season and rural sites in the wet season. Chloride was only statistically significant in the urban sites in the wet season. Higher chloride values were recorded in North Bank and Wadata, corresponding to environmentally challenging sanitation sites. Many researchers also reported higher

groundwater contamination by chloride in the urban areas due to due to latrine density (Verheyen *et al.*, 2009b; Wright *et al.*, 2013; Martínez-Santos *et al.*, 2017a). Details of the results and their corresponding mean ranks are found in Table 6.19.

Table 6.19 Kruskal-Wallis summary table for chloride

Sites and seasons	Chi-square	df	n	Sig. level	Mean Rank
Urban sites in the dry season	7.90	4	50	.095	100.00 (ALL)*
Urban sites in the wet season	16.61	4	50	.002	100.00 (ALL)*
Rural sites in the dry season	6.35	3	50	.10	100.00 (ALL)*
Rural sites in the wet season	6.47	3	50	.09	00.00 (ALL)*

Source: Field work 2016

*Means all the locations had same mean rank

In terms of seasonal variation, the Wilcoxon test showed a statistically significant difference between the dry and wet seasons, with the dry season having higher contamination: $Z=-5.66$, $p<.001$, with a medium effect size ($r=.40$). The median score on chloride in the dry season decreased from $md=100$ to $md=0.00$ in the wet season. As mentioned earlier Godfrey *et al.* (2006) explained that usage in the dry season tends to increase contamination rates.

Chloride was tested in both improved and unimproved wells in the urban sites in the dry season. The study sites are significantly contaminated by chloride which suggest high risks from drinking such water. The Mann-Whitney test was employed to compare chloride contamination between improved and unimproved wells in the dry season. The test revealed that there is no statistically significant difference in chloride contamination between improved and unimproved wells. Both improved and unimproved wells had the same median value meaning that contamination levels were the same. Some researchers also found that both improved and unimproved wells have been found to be contaminated to unacceptable levels (Lapworth *et al.*, 2017a).

The Mann-Whitney U test showed that there is no statistically significant difference in chloride contamination between improved and unimproved wells in the wet season. Furthermore, both improved and unimproved wells had same median scores.

In terms of chloride between rural and urban wells in the dry season, the Mann-Whitney U test show that there is no statistically significant difference in chloride contamination between rural and urban wells. Chloride levels in both sites are similar. They also have similar median values.

The Mann-Whitney U test revealed a statistically significant difference (since .000 is less than .05) in chloride contamination between rural and urban wet season wells. Therefore, chloride also had higher values in the urban than rural areas in the wet season with large effect. This could probably be due to high nitrogen loading from sanitation systems from high urban populations ([Cidu et al., 2003](#); [Ugbaja and Edet, 2004](#); [Isunju et al., 2011a](#); [Taiwo et al., 2011](#)).

Table 6.20 Mann-Whitney U summary table for chloride

Chloride	Md1, n	Md2, n	U	z	p	r
Improved and unimproved wells in dry season	Improved md=100, n=65	Unimproved Md=100, n=35	1033.5	-1.078	.28	.11
Improved and unimproved wells in wet season	Improved Md=00, n=65	Unimproved Md=00, n=35	1094.5	-.36	.72	.04
urban and rural wells in the dry season	Urban Md=100, n=50	Rural Md=100, n=50	1120	-1.29	.20	.13
urban and rural wells in wet season	Urban Md=100, n=50	Rural Md=00, n=50	392	-6.90	.000	.69

Source: Field work 2016

6.4.12 Chloride contamination and sediments types

Data was collected on the various sediment types in which the wells were found. The sediment types are: clay, sand and sandstone. [Graham and Polizzotto \(2013\)](#) reported that geology and soil conditions affect microbial contamination from pit latrines. The Kruskal-Wallis Test was employed to test for the differences in contamination among the soil types. The results show that in the dry season, there was no significant difference in chloride contamination among the sediment types clay (n=73), sand (n=20) and sandstone (n=7), $p=.152$ ($p>.05$). All three soil types have the same median value (md=100). In the wet season, there was a statistically significant difference in contamination among the sediment types with sand and sandstone

being higher: clay (n=73), sand (n=20), and sandstone (n=7), $p=.001(p<.05)$. Sand and sandstone both recorded a higher median score (md=100) than clay which had median (md=.000). This means higher chloride values were recorded in sand and sandstone sediments.

Most of the results obtained were influenced by geology. For instance, the high levels of chloride could also have some relationship with geology. Benue State as a whole is in a lowland area underlain by sedimentary formations where sodium chloride is found. [Patil *et al.* \(2012\)](#) noted that the quality of groundwater depends on various chemical constituents and their concentrations, which are influenced by the geology of the area. The Makurdi area is entirely a sandy area possibly with sandstone and permeable structures in the geology system. [Banerjee \(2011\)](#) found that in the wet season in saturated and unsaturated soil, gravel, sand, silt, clay and laterite, movement of chloride tracers were limited to less than 10.2 meters from pits. There are also reports in the literature that under some geological conditions such as in fractured media, effluents can move faster than expected ([Taylor *et al.*, 2004](#); [Harvey, 2007](#)).

6.4.13 Fluorides Analysis

Fluorides are generally released into the environment by weathering processes and volcanic activities. They are chemical compounds found in air, water, soil and almost all foods. Fluorides help in preventing tooth decay by protecting enamel against acids that cause tooth decay. They can also create health concerns. Higher concentrations are linked to dental problems in children and in adults and skeletal fluorosis which makes bones increase in density and become more brittle ([Blondes *et al.*, 2016](#); [Municipal and Environment, 2017](#)). Data on fluorides are found in Table 6.21 and Table 6.22.

Table 6.21 Mean Dry and Wet Season Fluoride values for Urban Sites

Season	Site	Mean	Standard Deviation
Dry	HL	0.56	0.34
Wet	HL	0.68	0.17
Dry	KS	0.90	0.41
Wet	KS	1.22	0.30
Dry	NB	1.49	0.03
Wet	NB	1.50	0.00
Dry	WD	1.02	0.39
Wet	WD	1.32	0.18
Dry	WK	1.00	0.27
Wet	WK	1.06	0.32

Source: Field work 2016

From the table above, values for fluoride have been as high as 1.5mg/l F in the North Bank area in both the dry and wet seasons. Another site where fluoride levels have been high is Wadata where higher values appear to be in the wet rather than the dry season. Wurukum had a higher concentration of fluorides in the wet than the dry season in some samples but not as high as in North Bank. The lowest values of fluorides are found in High Level with the highest value being 0.68mg/l F with no significant variation between the dry and wet seasons.

Table 6.22 Mean Dry and Wet Season Fluoride Values for Rural Sites

Site	Season	Mean	Standard deviation
AL	Dry	0.53	0.27
AL	Wet	0.50	0.23
DM	Dry	0.92	0.45
DM	Wet	0.38	0.36
KSH	Dry	0.93	0.40
KSH	Wet	0.40	0.30
ST	Dry	1.11	1.44
ST	Wet	2.00	3.92

Source: Field work 2016

Generally, fluoride levels are lower in the rural than urban areas. In terms of seasonal variations, the dry season appears to have a higher concentration than the wet season, apart from Secretariat. [Maheshwari \(2006\)](#) reported that fluoride values higher than 1.0mg/l could have some health impacts. Levels in the dry season appear to be higher in Dam, Konshisha and Alemenyi sites with Alemenyi having the lowest values.

6.4.14 Fluoride Statistical Analysis

The Kruska-wallis test was used to compare fluoride values among the urban and rural sites in the dry and wet seasons. The results revealed a statistically significant difference in fluoride contamination among the urban sites in the dry season, urban sites in the wet season with North Bank having higher contamination in both seasons. Among the rural sites in the dry season, the values were high with Konshisha having higher values. The sites also have higher corresponding mean ranks. Only the rural sites in the wet season had no statistically significant differences among the sites. The sites also have same median score (md=.60) (Table 6.23).

Spatial fluoride variation was also reported by [Sisay et al. \(2017\)](#).

Table 6.23 Kruskal-wallis summary table for Fluoride

Sites and seasons	Chi-square	df	n	Sig. level	Mean Rank
Urban sites in the dry season	24.83	4	50	.000	1.50 (NB)
Urban sites in the wet season	29.78	4	50	.000	1.50 (NB)
Rural sites in the dry season	8.53	3	50	.04	1.10 (KSH)
Rural sites in the wet season	1.70	3	50	.64	.60 (ALL)*

Source: Field work 2016

*Means all the sites had same mean rank, implying same level of contamination

In terms of seasonal variations, there was a statistically significant difference in contamination with the dry season having higher fluoride values than the wet season. This was done using Wilcoxon ranked test: $Z=1.59$, $p>.001$, with a very small effect size ($r=.11$). The median score decreased from the dry season (md=.80) to the wet season (md=.60). Seasonal variation was also reported by [Sisay et al. \(2017\)](#).

The Mann-Whitney U test for fluorides in improved and unimproved wells in the dry season show that there is no statistically significant difference in fluoride contamination between improved and unimproved wells. The unimproved wells had a higher median value, implying there were more contaminated than improved wells, though not statistically significant. In the wet season too, fluoride had no statistically significant difference in contamination between improved and unimproved wells. Both well categories had the same median scores. This tallies

with [Godfrey et al. \(2006\)](#) and ([Bain et al., 2014a](#))’s views that improved and unimproved sources are often equally contaminated.

The results show that both improved and unimproved wells were substantially contaminated. In some cases, contamination levels were the same, and this raises critiques of the JMP classification of improved and unimproved wells. The SDG targets are more comprehensive in the sense that they emphasise that water has to satisfy biological and chemical demands to be safely managed. This is not surprising as some studies such as that by [Graham and Polizzotto \(2013\)](#) suggested that the contamination of groundwater from pit latrines is dependent upon social factors such latrine use, latrine densities, maintenance and groundwater pumping. They further stressed that latrine type, design, materials and construction quality influence contamination containment and leaching from pit latrines. These factors could possibly have caused contamination in both well (improved/unimproved) categories.

An investigation into fluoride contamination between rural and urban wells in the dry season using Mann-Whitney U test revealed a statistically significant difference in fluoride contamination between rural and urban wells and the latter appeared to be more contaminated, though with small effect. Therefore, higher values are found in the urban areas, corresponding to higher mean rank as well. The higher contamination in the urban sites tally with the views of [Maheshwari \(2006\)](#).

Similarly, in the wet season, the test shows that there is a statistically significant difference (since .000 is less than .05) in fluoride contamination between rural and urban wells in the wet season. Higher values of fluoride were also obtainable in the urban areas, corresponding to mean rank. In this test, the effect size is large. Concerns of this nature have also been reported by [Liu et al. \(2012\)](#). The Mann-Whitney U summary is presented in Table 6.24.

Table 6.24 Mann-Whitney U Summary Table for Fluoride

Chloride	Md1, n	Md2, n	U	z	p	r
Improved and unimproved wells in dry season	Improved md=.80, n=65	Unimproved Md=1.0, n=35	1012	-.933	.35	.09
Improved and unimproved wells in wet season	Improved Md=.60, n=65	Unimproved Md=.60, n=35	1029	-.828	.41	.08
Urban and rural wells in the dry season	Urban Md=1.00, n=50	Rural Md=.60, n=50	875.5	-2.66	.008	.27
Urban and rural wells in wet season	Urban Md=1.2, n=50	Rural Md=.60, n=50	226.5	-7.45	.000	.75

Source: Field work 2016

6.5 Faecal Coliforms

6.5.1 Well-Latrine Distance

In the study sites, a compound made of blocks of houses would contain a well and a latrine facility with soak-away pit at the back or by the side in the case of urban areas while in the rural areas, a compound made of round houses or huts would have a well in the middle and a toilet facility by the corner. Separating distances between the sampled wells and latrine facilities were measured using a measuring tape in meters. From the measurements most of the wells were less than 30 meters away from the latrines. The urban areas had a mean separating distance of 13.17 meters while the rural areas had a mean separating distance of 18.71 meters. The total mean separating distance was 15.94 m (Table 6.25). This actually poses risks to groundwater contamination and could help to explain the heavy contamination with faecal coliforms in all the sampled wells, especially in the urban sites. The shorter separating distance in the urban areas could also help to explain the higher contamination. The statistics from the measured distances show that the distances ranged from 4.8 m to 39.0 meters. This means the minimum separating distance was 4.8 m and the maximum separating distance was 39.0 m. [Graham and Polizzotto \(2013\)](#); [Bain et al. \(2014b\)](#) raised concerns about links between latrine sources and groundwater point and advocated for use of international guidelines separating the facilities

which are between 10 and 75m. Although some authors reported that beyond 5 meters from pit latrines, there is a reduction in contamination ([Chidavaenzi et al., 2000](#); [Still and Nash, 2002](#); [Dzwairo et al., 2006](#)), many authors recommend separating distances between 15-30 meters ([Franceys et al., 1992](#); [Still and Nash, 2002](#); [Project, 2011](#); [Reed et al., 2013](#); [Back et al., 2018](#)). In the study sites, the total mean separating distance of 15.94 m and a standard deviation of 6.26 were obtained for sampled wells which show that the facilities are relatively close to each other. The statistics table is shown in Table 6.25.

Table 6.25 Total descriptive statistics for well-latrine distance

Descriptive Statistics									
	N	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Well-Latrine distance	100	4.8	39.0	15.941	6.2649	.774	.241	1.434	.478
Valid N (listwise)	100								

Source: Field work 2016

Table 6.26: Descriptive statistics for well-latrine distance for urban and rural sites

Descriptives								
Well-Latrine distance								
	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Rural	50	18.71	5.5569	.7859	17.129	20.287	8.6	39.0
Urban	50	13.17	5.7267	.8099	11.546	14.802	4.8	30.0
Total	100	15.94	6.2649	.6265	14.698	17.184	4.8	39.0

Source: Field work 2016

To make more meaning from the measurements, the separating distances were grouped into four groups: shortest (4 - 10 meters); Short (11 - 20 meters); Medium (21 - 30 meters) and

long (31 -40 meters) (Table 6.27). The separating distances between latrine and well water are also shown in the illustrations in Figure 6.5, Figure 6.6 and Figure 6.7.

Table 6.27 Well-Latrine distance

Well-LatrineDistance					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		2	2.0	2.0	2.0
	Shortest (4 - 10 meters)	21	21.0	21.0	100.0
	Short (11 - 20 meters)	60	60.0	60.0	62.0
	Medium (21 - 30 meters)	15	15.0	15.0	77.0
	Long (31 - 40 meters)	2	2.0	2.0	79.0
	Total	100	100.0	100.0	

Source: Field work 2016.

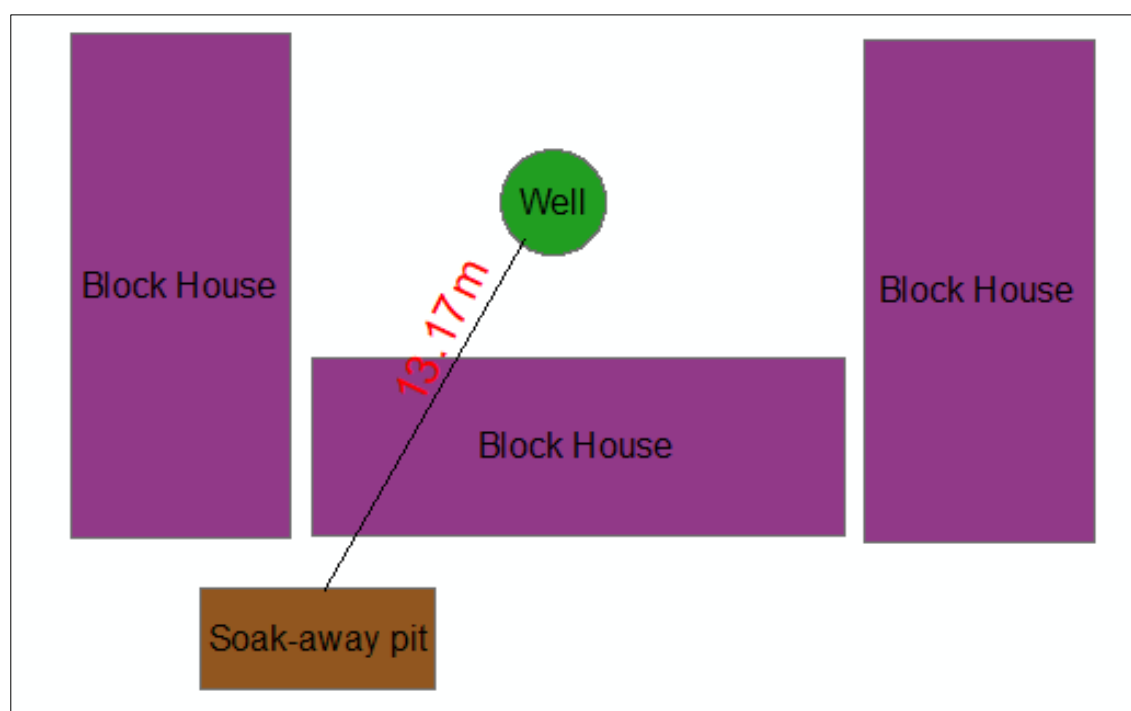


Figure 6.5: Well-latrine location in urban sites (Sketch not to scale)

Source: Field work 2016

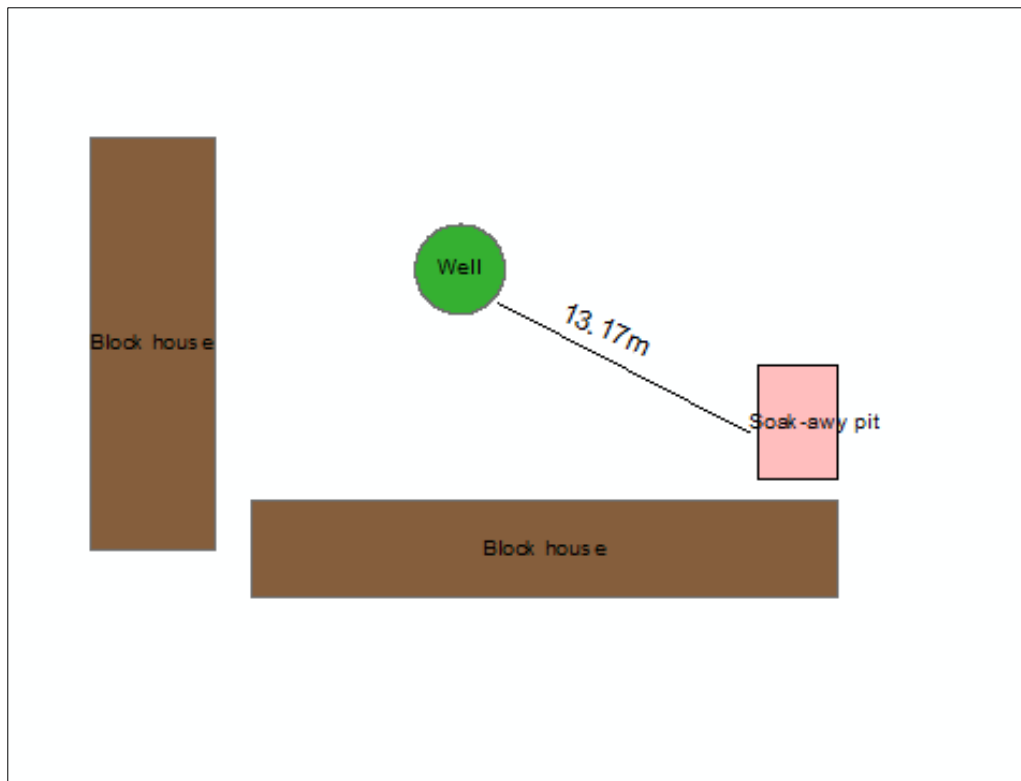


Figure 6.6: Another Well-Latrine Location Sample in urban sites (Sketch not to scale)
Source: Field work 2016

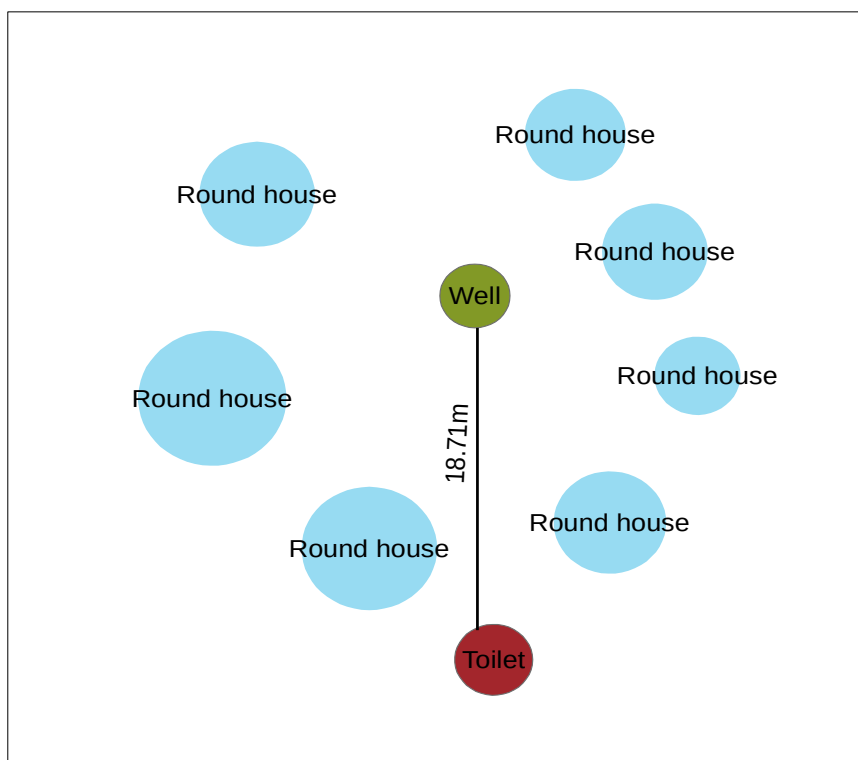


Figure 6.7: Well-latrine location in rural sites
Source: Field work 2016

6.5.2 Faecal Coliform test results

The petrifilms were used to test for faecal coliforms. The details are found in the methodology section (4.11.1). The tests show that both rural and urban sites in the dry and wet seasons were heavily contaminated. The results are shown in tables and figures detailing variations between dry/wet seasons, rural/urban, improved/unimproved categories in this section. At the enumeration of faecal coliforms, some colony counts do not have gas bubbles associated with the colony counts. These are counted as coliforms. Some of the colonies are associated with gas bubbles and are confirmed coliforms. The combination of coliform colonies with gas (confirmed faecal coliforms) and colonies without gas gives the total coliform counts (Petrifilm, 1999). Coliform detection is important in drinking water sources. Faecal coliforms can cause diseases like diarrhoea, typhoid fever and many others as they measure faecal indicator bacteria (Wade *et al.*, 2003; Lopez *et al.*, 2006; Montgomery and Elimelech, 2007; Isunju *et al.*, 2011b). Below are samples of how the coliforms tested. The data are presented as charts and tables.

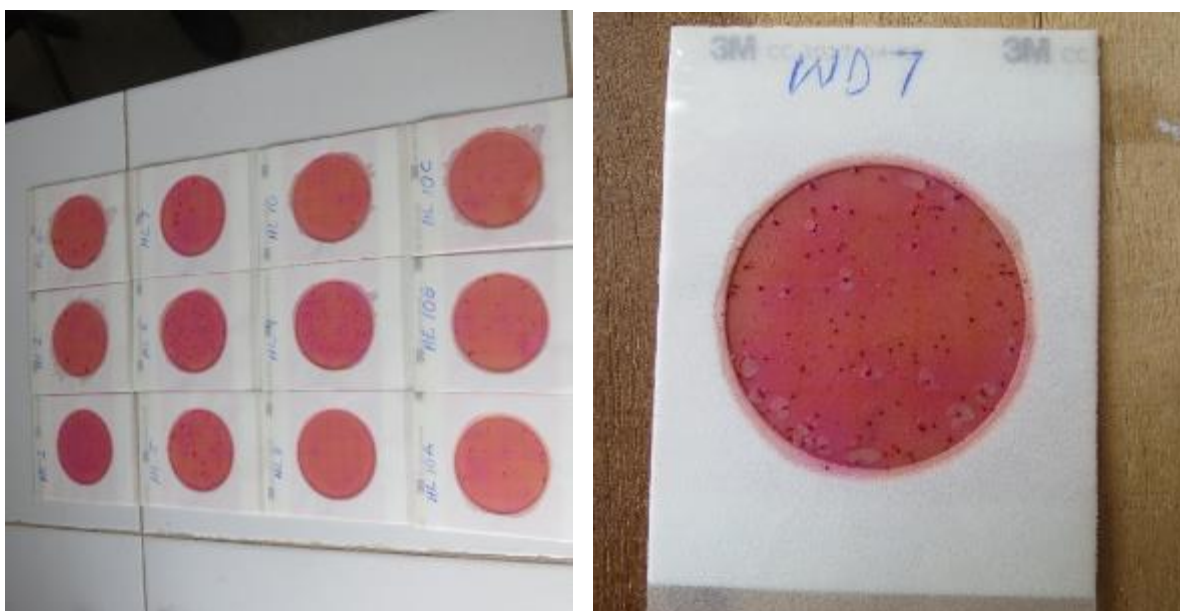


Plate 6.4 Labelled and incubated Coliform Count Plates.
Source: Fieldwork 2016

Table 6.28 Mean Dry and Wet Season Coliform without gas bubble values for Urban Sites

Season	Site	Mean	Standard Deviation
Dry	HL	43.00	18.67
Wet	HL	42.60	21.28
Dry	KS	TNTC	TNTC
Wet	KS	48.60	16.76
Dry	NB	TNTC	TNTC
Wet	NB	78.67	24.13
Dry	WD	TNTC	TNTC
Wet	WD	83.20	22.03
Dry	WK	49.00	19.70
Wet	WK	44.25	27.05

Source: Field work 2016

From Table 6.28, coliform counts on the count plates appeared to be higher in the dry than the wet season in most of the samples. For instance, many dry season samples had colonies that were too-numerous-to-count (TNTC). This means the colonies were numerous and too difficult to count and so were labelled as TNTC (Petrifilm, 1999). The TNTC therefore refers to where the counts are too many and counting is difficult (Petrifilm, 1999; Kiptum and Ndambuki, 2012). Banerjee (2011) reported that coliforms increased in the monsoon season in the sandy soil, with a maximum travel distance of 10 m from the pit. On the other hand, Chidavaenzi *et al.* (2000) found contamination higher in the dry season with transport distance of up to 20 meters from a pit. It is possible that in the dry season there is more contaminant transport due to hydraulic action with higher contamination levels than the wet season. Locations having higher contaminations were Wadata, Wurukum, North Bank and Kanshio where some TNTC samples were found. In such cases, the total colonies were reported as directed by the manufacturers (Chapter 4:). The lowest contaminated location was High Level. Much of Wadata, some parts of Wurukum and North Bank had dirty surroundings and so it was not surprising for the results to have shown high contamination. This conforms to the observation that waste and waste dumps can affect groundwater (Kassenga and Mbuligwe, 2009; Oyeku and Eludoyin, 2010; Akinbile and Yusoff, 2011).

Table 6.29 Mean Dry and Wet Season Coliform without gas bubbles values for Rural Sites

Site	Season	Mean	Standard deviation
AL	Wet	45.91	60.07
AL	Dry	TNTC	TNTC
DM	Wet	30.08	22.82
DM	Dry	TNTC	TNTC
KSH	Wet	29.83	23.64
KSH	Dry	TNTC	TNTC
ST	Wet	25.27	24.02
ST	Dry	TNTC	TNTC

Source: Field work 2016

From table Table 6.29 almost all the locations in the rural sites show some signs of heavy faecal contamination. The most notable were Dam and Secretariat areas where six samples in Dam and five samples each in Secretariat and Konshisha had faecal coliforms samples which were too-numerous-to-count denoted by TNTC as earlier mentioned. Relatively, Alemenyi was the least contaminated. In terms of seasonal variation, most of the heavily contaminated samples (TNTC) occurred in the dry season samples. Therefore, the dry season was characterised by more samples contaminated with faecal coliforms. Although many researchers such as [Wright \(1986\)](#); [Ouyang et al. \(2006\)](#); [Wu et al. \(2011\)](#) found that contamination with faecal coliform was higher in the wet than dry season, [Patz et al. \(2000\)](#) and [Lee et al. \(2004\)](#), have questioned whether studies reporting higher contamination in the wet season are consistently reporting higher contaminations throughout the season or whether they are reporting large contamination loading at the beginning of the wet season preceded by a dry period. [Kostyla et al. \(2015\)](#) reported that many studies reporting higher contamination in the wet season did not report the statistical significance making it difficult to know if the difference in contamination in the seasons were significant. It is therefore not unusual to have higher contamination in the dry season.

Table 6.30 Mean Dry and Wet season Coliform with gas bubbles values for Urban Sites

Season	Site	Mean	Standard Deviation
Dry	HL	31.78	18.95
Wet	HL	21.90	17.59
Dry	KS	TNTC	TNTC
Wet	KS	29.60	29.28
Dry	NB	TNTC	TNTC
Wet	NB	60.33	32.39
Dry	WD	TNTC	TNTC
Wet	WD	50.20	34.41
Dry	WK	25.67	13.02
Wet	WK	31.88	19.95

Source: Field work 2016

As earlier mentioned, the colony counts associated with gas bubbles on petrifilms are confirmed faecal coliforms. These were also enumerated separately to determine the extent of faecal coliform contamination. In terms of location, Wadata was the most contaminated site followed by Wurukum. The other heavily contaminated sites were North Bank and Kanshio. High Level was the least contaminated site. In terms of season, most of the higher contamination values occurred in the dry season. For instance, most of the TNTC bearing samples were the dry season ones. This may be due to the transportation of contaminants over longer distances in sandy soils in the dry season due to hydraulic action ([Chidavaenzi et al., 2000](#)).

Table 6.31 Mean Dry and Wet season Coliform with gas bubbles values for rural Sites

Site	Season	Mean	Standard deviation
AL	Dry	63.64	113.55
AL	Wet	17.18	10.03
DM	Dry	TNTC	TNTC
DM	Wet	23.92	20.06
KSH	Dry	TNTC	TNTC
KSH	Wet	32.67	30.75
ST	Dry	TNTC	TNTC
ST	Wet	23.81	27.90

Source: Field work 2016

In the rural sites, the most contaminated area was Dam where five samples out of twelve in the dry season had TNTC colonies on the petrifilms. This was followed by Konshisha and Secretariat with each having four samples with TNTC colonies on the petrifilms. Alemenyi was

relatively less contaminated. Seasonally, the dry season appeared to be more contaminated than the wet season as the TNTC sample bearing colonies were all obtained in the dry season. These results tally with those of [Pujari *et al.* \(2012\)](#) who found higher levels of faecal coliforms in summer (dry) than monsoon (wet) season. Similarly, [Chidavaenzi *et al.* \(2000\)](#) found higher contamination in the dry season. [Godfrey *et al.* \(2006\)](#) attributed higher contaminations in the dry season to usage rates.

Table 6.32 Mean Dry and Wet Season Total Coliform Counts for Urban Sites

Season	Site	Mean	Standard Deviation
Dry	HL	87.30	49.55
Wet	HL	124.50	202.54
Dry	KS	TNTC	TNTC
Wet	KS	78.20	36.90
Dry	NB	TNTC	TNTC
Wet	NB	165.10	87.37
Dry	WD	TNTC	TNTC
Wet	WD	133.40	22.42
Dry	WK	136.80	88.69
Wet	WK	108.90	78.28

Source: Field work 2016

The total coliform counts are summations of coliform colonies with gas bubbles and the ones without gas bubbles (Chapter 4:). Wadata showed more contamination as it had TNTC samples especially in the dry season. The second most heavily contaminated site was North Bank. Wurukum and Kanshio also had significant contamination with High Level being the least contaminated. Seasonally, the dry season was more contaminated than the wet season.

Table 6.33 Mean Dry and Wet Season Total Coliform (cfu) values for Rural Sites

Site	Season	Mean	Standard deviation
AL	Dry	TNTC	TNTC
AL	Wet	74.50	75.06
DM	Dry	TNTC	TNTC
DM	Wet	54.00	39.39
KSH	Dry	TNTC	TNTC
KSH	Wet	62.50	45.96
ST	Dry	TNTC	TNTC
ST	Wet	55.86	45.30

Source: Field work 2016

In the rural sites, the most contaminated site was Dam, followed by Konshisha and Secretariat with the same number of samples having TNTC plates. The least contaminated relatively was Alemenyi site. Again, the dry season showed more contamination with TNTC samples than the wet season.

Table 6.34 is based on low, high and very high coliform count classifications. The definition is as follows: 0-9 colony counts is considered low, 10-30 is considered as high and 30 and above is considered very high. A similar grouping was recommended by the manufacturers of petrifilms and [Seib \(2011\)](#); [Chuang \(2010\)](#); [Elisante and Muzuka \(2016\)](#) used similar classifications. Generally, it is easier and more convenient to use a classification to make more meaning of the data. In Table 6.34, the percentage calculations in each of all the categories are done on 100% basis. For instance, improved/unimproved, rural/urban are calculated on the basis of 100% each. This is done to make comparisons easily among the categories.

Table 6.34 is based on faecal coliform contamination measured as total coliforms in the dry season. The improved wells had 92.3% (43.1% urban and 49.2% rural) of total counts falling into the very high category compared with unimproved wells having 97.1% (51.4% urban and 45.7% rural) falling into the very high category. The unimproved wells could be more contaminated since they are sometimes not covered or protected, have low well heads above the ground and often have non-concrete casings ([Elisante and Muzuka, 2016](#)). The rural sites were more contaminated among the improved wells while the urban sites were more contaminated among unimproved wells. The unimproved wells were therefore slightly more highly contaminated. In urban areas, 94.5% (43.1% improved and 51.4% unimproved) of the samples fell into the very high category while in the rural sites, 94.9% (49.2% improved and 45.7% unimproved) of the wells fell into the very high category. The contamination in urban and rural sites were roughly the same. Based on these it can be said that both urban and rural

sites were heavily contaminated with respect to faecal coliform and the level of contamination is the same.

Table 6.34: Dry Season Coliform Counts based on Improved and Unimproved Categories.

Well Improved/unimproved	Counts Rate		Urban (%)	Rural (%)	Total (%)
Improved Well in dry season	Counts from low to High	Low	1.5	0.0	1.5
		High	3.1	3.1	6.2
		Very High	43.1	49.2	92.3
	Total		47.7	52.3	100.0
Unimproved Well in dry season	Counts from low to High	Low	0.0	0.0	0.0
		High	2.9	0.0	2.9
		Very High	51.4	45.7	97.1
	Total		54.3	45.7	100.0
Total	Counts from low to High	Low	1.0	1.0	1.0
		High	3.0	2.0	5.0
		Very High	46.0	48.0	94.0
	Total		50.0	50.0	100.0

Source: Field work 2016

The next table considers the wet season.

Table 6.35: Wet Season Coliform Counts Summary based on Rural/Urban and Well Improved/Unimproved Categories.

Well Improved/unimproved	Counts Rate		Urban (%)	Rural (%)	Total (%)
Well improved in wet season	Counts from Low to High	Low	0.0	3.1	3.1
		High	1.5	15.4	16.9
		Very High	46.2	33.8	80.0
	Total		47.7	52.3	100.0
Well unimproved in wet season	Counts from Low to High	Low	0.0	0.0	0.0
		High	2.9	14.3	17.1
		Very High	51.4	31.4	82.9
	Total		54.3	45.7	100.0
Total	Counts from Low to High	Low	0.0	2.0	2.0
		High	2.0	15.0	17.0
		Very High	48.0	33.0	81.0
	Total		50.0	50.0	100.0

Source: Field work 2016

From Table 6.35 which is based on wet season faecal coliform data, both urban and rural sites are heavily contaminated, with the urban areas being more heavily contaminated 97.6% (46.2% from improved wells and 51.4% from unimproved wells) than the rural areas 65% (33.8% improved and 31.4% unimproved). In terms of improved and unimproved well samples, they are both heavily contaminated although there are slightly more unimproved wells (82.8%: 51.4% urban and 31.4% rural) than improved wells (80%: 46.2% urban and 33.8% rural) that fell into the very high coliform count category. The finding of higher contamination in the urban sites tallies with the views of researchers such as [Barrett *et al.* \(2000\)](#); [Howard *et al.* \(2003b\)](#); [Nyenje *et al.* \(2010\)](#) and [Foppen and Kansiime \(2009\)](#) who noted that pollution loads in urban areas are increased due to high settlement density, number of people using the facilities and geological conditions. As Makurdi lies in a sandy area, it is affected by high contamination from sanitation facilities. For easy visualisation and comparison, the data are presented in a bar chart Figure 6.8.

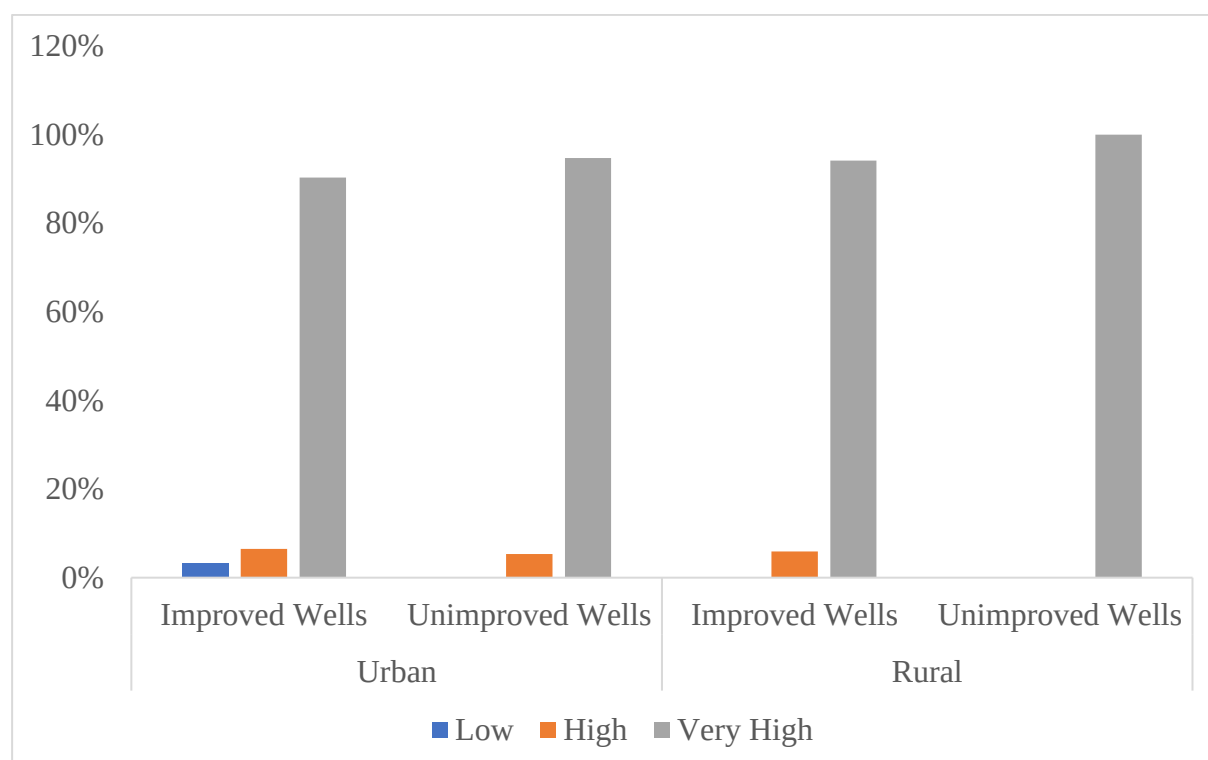


Figure 6.8 Total Coliform Counts for Dry Season on Improved/Unimproved and Urban/Rural basis

Source: Field work 2016

It can be seen from Figure 6.8 that the total coliform counts were very high for both rural and urban areas in the dry season, though slightly higher in the rural areas in the unimproved category (100%) compared with urban (95%) and also higher in the rural areas in the improved category (94%) compared with urban (90%). This could be due to high concentrations of contaminants in the dry season in the rural and urban areas. [Kiptum and Ndambuki \(2012\)](#) noted that the higher the number of well users, the higher the amount of water drawn from a well and the amount of water discharged into the latrines. As more water is drawn from wells, there is a hydraulic gradient between the well and latrine which induce water to flow into the wells and consequently create contamination. Therefore as more water is pulled from the wells, it could draw water around, including contaminated water from latrines and hence more contamination in the dry season. [Godfrey et al. \(2006\)](#) also reported that contamination from wells could be high in the dry season due to high usage rates by contaminating water in the withdrawal process.



Figure 6.9 Total Coliform Counts for Wet Season based on Improved/Unimproved and Urban/Rural

Source: Field work 2016

In the wet season, the contamination was also very high but not as high as in the dry season in the rural areas. There was higher contamination from unimproved wells category in the urban sites (95%) than the rural ones (69%) and also higher in improved wells in the urban sites (97%) compared to rural sites (65%). [Kostyla et al. \(2015\)](#) in their systematic review reported that most studies found greater contamination in the wet than dry season, as was also the case here in improved wells. The timings could also account for this. If samples are taken at heavier rainfall events, it could report higher contamination than at normal (non-extreme rainfall) conditions. Another difference is that the contamination was higher in the urban centres. This could be due to possibly more pollution loading in urban environments due to high population and high latrine usage ([Isunju et al., 2011a](#)) and movement of effluents in the wet season due to abundance of water and rising water table levels ([Kiptum and Ndambuki, 2012](#)).

6.5.3 Faecal Coliforms statistical analysis in the urban/rural sites and dry/wet seasons

[Kostyla et al. \(2015\)](#), in their systematic analysis of faecal coliform observed that some researchers did not report on the statistical significance in their research. In this report, an attempt is made to report on the statistical significance to give an idea on the extent of contamination. Though all the sites were contaminated, Wadata had higher faecal coliform records. In this section, attention is focused on comparing the level of faecal coliform contamination among the sites. To achieve this the Kruskal-Wallis test was employed. In this case, a comparison is made of contamination values among the different sites in urban and rural areas in the dry and wet seasons.

The results from the Kruskal-Wallis test show that the total coliform counts had the same distribution across the urban sites in the dry ($p=.74$), but not in the wet season ($p=.001$), in which case there was a significant difference with North Bank having higher contamination, also reflected in the mean rank. North Bank could be more contaminated due to the poor

environmental conditions in the area. Many authors such as [Oyeku and Eludoyin \(2010\)](#) and [Akinbile and Yusoff \(2011\)](#) have linked waste and waste dumps to groundwater contamination.

In the rural sites, both dry and wet season were not statistically significant in terms of faecal contamination, though Dam and Konshisha respectively had higher contamination as also shown in the mean rank with significant levels respectively ($p=.09$) and ($p=.89$). Dam was therefore the most heavily contaminated site. The Dam area has sandy soil which could facilitate contamination in the dry season accelerated by hydraulic action from water withdrawn from wells as earlier noted. Konshisha site was more heavily contaminated in the wet season. This could probably be explained by the fact that the site had more challenging sanitation facilities. During the semi-structured interviews, many respondents mentioned this. This could have accounted for the higher contamination ([Zingoni et al., 2005](#)).

Many researchers identified pit latrines to have accounted for faecal coliform in well water ([Still and Nash, 2002](#); [Zingoni et al., 2005](#); [Ley et al., 2006](#); [Dzwairo et al., 2006](#); [Ramakrishna, 2007](#); [Banerjee, 2011](#); [Pujari et al., 2012](#)). The higher median values signify higher contamination values corresponding to the locations that bear them. Statistically, it is presented in the summary table below.

Table 6.36: Kruskal-wallis Summary Table for Faecal coliform

Sites and seasons	Chi-square	df	n	Sig. level	Mean Rank
Urban sites in the dry season	1.97	4	50	.74	137.50 (WD)
Urban sites in the wet season	19.37	4	50	.001	145.00 (NB)
Rural sites in the dry season	6.57	3	50	.09	265.00 (DM)
Rural sites in the wet season	.64	3	50	.89	55.50 (KSH)

Source: Field work 2016

6.6 Distribution of Faecal Coliform Counts based on Improved/Unimproved Wells

The measurement of faecal coliforms in improved/unimproved wells is one of the objectives of the study. Faecal coliforms were measured as total coliform counts. Their origin is basically from human and animal faeces ([Nkhuwa et al., 2006](#); [Tukur and Amadi, 2014](#); [Nyenje et al.,](#)

2014; Lapworth *et al.*, 2017a; Martínez-Santos *et al.*, 2017b). Because of their negative impacts on human health, the WHO standard for it is 0cfu/100 ml of water (World Health Organisation, 2011). In all the study sites (urban and rural) and in both improved and unimproved wells, samples were heavily contaminated with faecal coliforms. This implies that the residents could face health risks. Data were collected on the coliform counts from improved and unimproved wells. Surprisingly, even improved wells showed a high level of contamination by coliforms. Generally, it is expected that improved water sources should be less contaminated than unimproved. However, Bonsor *et al.* (2014); Ewodo *et al.* (2009); Obiri-Danso *et al.* (2009); Lapworth *et al.* (2017a) reported that in a majority of cases, improved and unimproved (wells) are highly contaminated with faecal coliform with unacceptable limits. The dry season appeared to be more contaminated than the wet season. It is worth pointing out here that the total counts comprised of both counts with gas bubbles and ones without gas bubbles. The gas bubbles signify confirmed faecal coliforms as indicated in the 3M petrifilms interpretation guide. Figure 6.10 and Figure 6.11 present the data showing faecal coliform contamination for both dry and wet seasons.

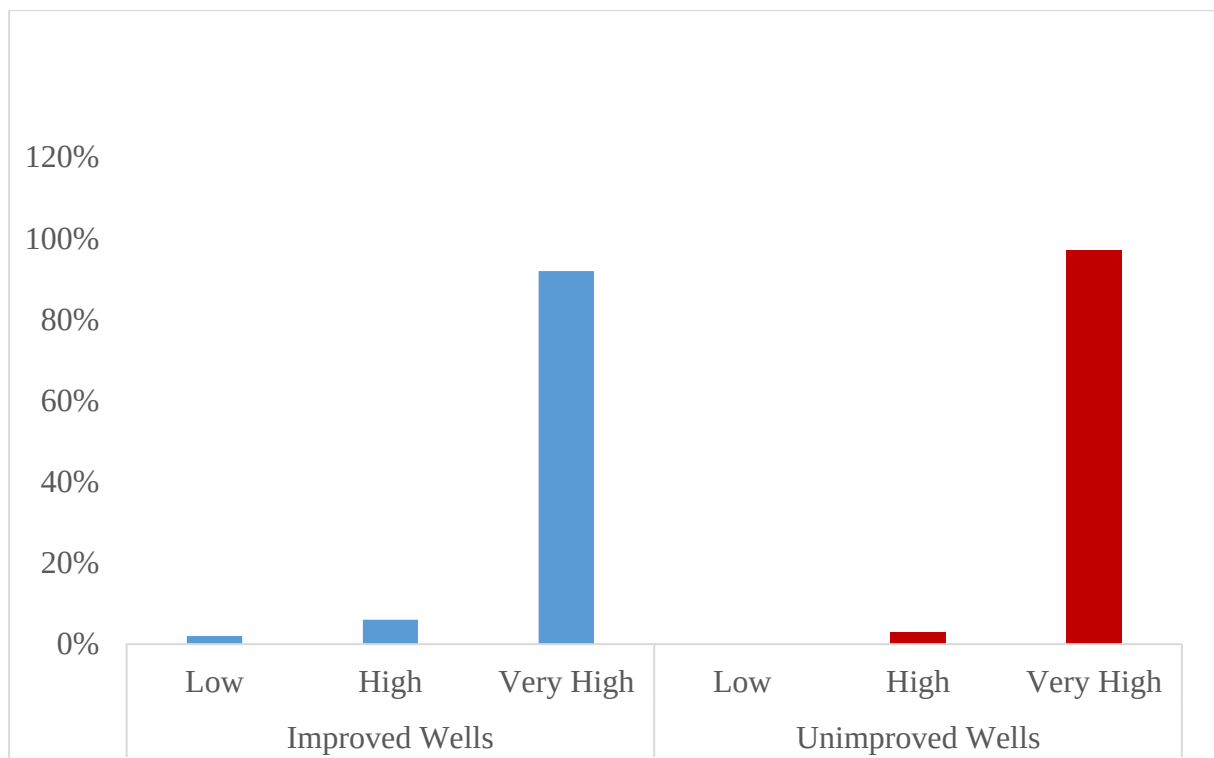


Figure 6.10 Dry Season Total Coliform Counts in Improved/Unimproved Wells
Source: Fieldwork 2016

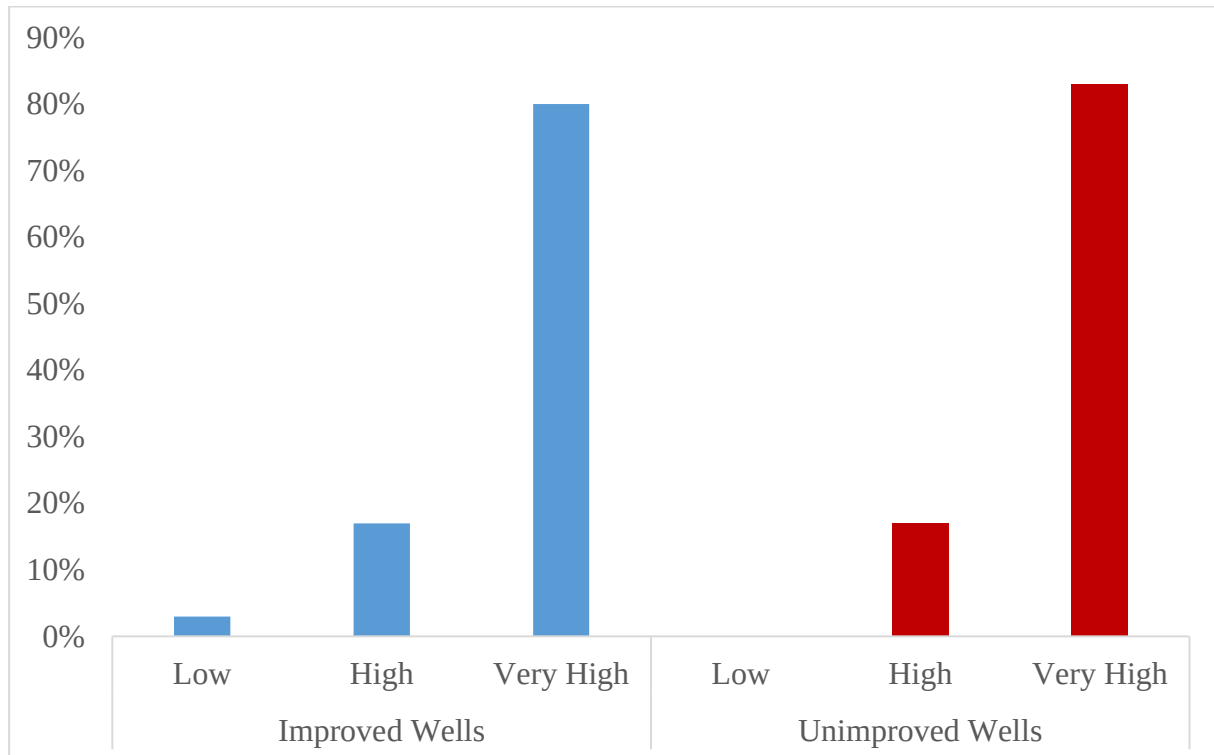


Figure 6.11 Wet Season Total Coliform Counts in Improved/Unimproved Wells
Source: Fieldwork 2016

It is clear from both Figure 6.10 and Figure 6.11 that even the improved wells were heavily contaminated by faecal coliforms. The unimproved wells appeared slightly more contaminated. The contamination appeared to be higher in the dry than the wet season. This is not surprising as some studies such as [Chidavaenzi *et al.* \(1997\)](#); [Tukur and Amadi \(2014\)](#) also found that contamination was higher in the dry than wet season. This could be due to hydraulic action in the dry season arising from many well users earlier mentioned.

6.6.1 Faecal Contamination Statistical results

In this section, attention is paid to statistical analyses of faecal contamination based on improved/unimproved in dry/wet seasons and rural/urban categories. Apart from the charts, statistical techniques were employed to compare contamination in improved and unimproved wells. Independent-samples Mann-Whitney U Tests were used to test for differences in faecal contamination between improved and unimproved wells in the dry and wet seasons. The Mann-Whitney U Test revealed no statistically significant difference in faecal coliforms in the improved and unimproved wells in the dry season ($p=.11$), although unimproved wells have a higher median value. That means unimproved wells were more contaminated, though, with no statistically significant difference. [Wright \(1986\)](#); [Palamuleni \(2002a\)](#); [Zingoni *et al.* \(2005\)](#); [Kulabako *et al.* \(2007\)](#); [Takem *et al.* \(2010\)](#) and [Sorensen *et al.* \(2015a\)](#) noted that contamination with faecal coliforms in improved water sources is much less than unimproved sources, similar to what is obtainable in this research in the wet season. In the wet season, there is a statistically significant difference in faecal contamination between improved and unimproved wells ($p=.01$). Unimproved wells were more contaminated than improved ones. This finding is similar to the research carried out by [Kiptum and Ndambuki \(2012\)](#) and [Elisante and Muzuka \(2016\)](#). It is not surprising that the unimproved wells were more contaminated in the wet season as open and unlined wells always have poorer water quality compared with lined or covered wells (improved) ([Godfrey *et al.*, 2006](#); [Sorensen *et al.*, 2015a](#)). The fact that even

improved wells were heavily contaminated means that the simple definitions of wells being improved or unimproved according to JMP criteria were not satisfactory. In time, such inconsistencies are likely to be addressed as part of SDG monitoring which will use water testing methods to confirm the absence of faecal contamination of water in definitions of safely managed water sources.

In terms of contamination between rural and urban wells in the dry season, the Mann-Whitney U Test show no difference in faecal coliform contamination between the two regions ($p=.10$). Both rural and urban areas have the same median score values ($md=104$). Since both urban and rural sites have pit latrines relatively near, this is not surprising ([Vinger *et al.*, 2012](#)). In the wet season, the test for contamination between rural and urban wells in the wet season revealed a statistically significant difference ($p=.01$ and since $.01$ is less than $.05$, the result is significant) in faecal contamination between rural and urban wells. That is, wells in urban areas had higher faecal coliform levels than in rural areas. In this test, the effect size is large. Contamination may be higher in urban than rural areas due to the pollution loading from more people using sanitation facilities and sandy soil conditions obtainable in the urban compared to the rural sites ([Foppen and Kansiime, 2009](#); [Nyenje *et al.*, 2010](#)) and possibly with the effect of higher water tables in the wet season ([Elisante and Muzuka, 2016](#)).

Table 6.37: Mann-Whitney U Summary Table for Faecal coliform

Faecal Coliform	Median1, n	Median2, n	U	z	p	r
Improved and unimproved wells in dry season	Improved md=85, n=65	Unimproved Md=112, n=35	914.5	-1.617	.11	.16
Improved and unimproved wells in wet season	Improved Md=66, n=65	Unimproved Md=119, n=35	797	-2.46	.01	.25
Urban and rural wells in the dry season	Urban Md=104, n=50	Rural Md=104, n=50	1015	-1.63	.10	.16
Urban and rural wells in wet season	Urban Md=105, n=50	Rural Md=43, n=50	586	-4.58	.000	.46

Source: Field work 2016

In terms of seasonal variation in faecal coliforms contamination between dry and wet seasons, there was a statistically significant difference in contamination between dry and wet seasons according to the Mann-Whitney U test. $Z=-4.62$, $p<.001$, with a medium effect size ($r=.33$). The median score on total counts decreased from the dry season ($md=94$) to the wet season ($md=73.5$). This is interpreted that there was higher contamination of faecal coliform in wells in the dry than the wet season.

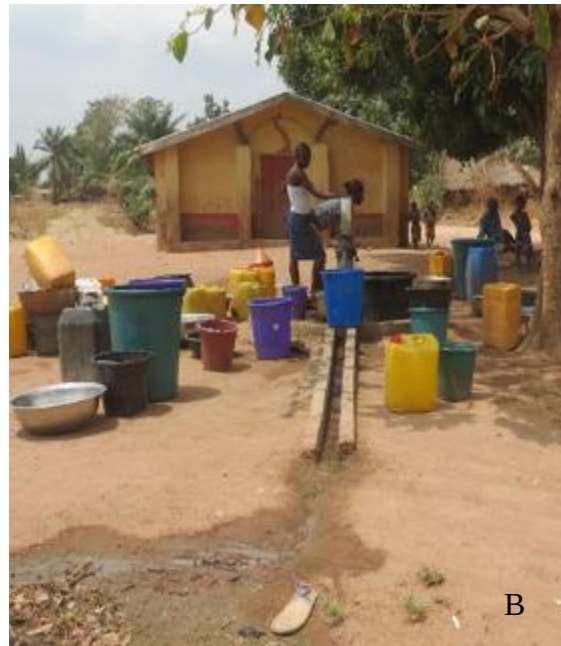
Many researchers such as [Kostyla *et al.* \(2015\)](#); [Wright *et al.* \(2013\)](#); [Moyo \(2013\)](#), found that faecal coliform contaminations were higher in the wet than dry season. However, this was contrary to these findings as the faecal coliforms appeared to be higher in the dry than the wet season. Similarly, other researchers such as [Chidavaenzi *et al.* \(1997\)](#), [Palamuleni \(2002a\)](#) [Kulabako *et al.* \(2007\)](#); [Tukur and Amadi \(2014\)](#) found that contamination levels were higher in the dry than wet season. [Godfrey *et al.* \(2006\)](#) also observed that contamination could be higher in the dry season due to pressure on fewer available water sources. A sample of different water sources in rural and urban areas is shown in Plate 6.5 and Plate 6.6.



Plate 6.5: An example of a compound with well
Source: Fieldwork 2016



A



B

Plate 6.6 Surface Water Supply (A) and borehole Water Supply in Dry in Tse-Agberagba
Source: Fieldwork 2016

6.7 Possible Relationship among well characteristics variable

From the literature, there have been some reports linking contamination with well characteristics. For instance, [Kiptum and Ndambuki \(2012\)](#) and [Elisante and Muzuka \(2016\)](#)

illustrated that the shorter the distance between wells and latrines or any contaminant source, the higher the contamination due to short transport distance. Although a few studies such as [Ahmed *et al.* \(2002\)](#); [Howard and Bartram \(2003a\)](#); [Howard *et al.* \(2003b\)](#) found no strong positive association between proximity of latrines and poor bacteriological water quality, many other studies such as [Zingoni *et al.* \(2005\)](#); [Banks *et al.* \(2002\)](#); [Girard and Hillaire-Marcel \(1997\)](#); [Mafa and Vogel \(2004\)](#); [Pujari *et al.* \(2012\)](#); [Tandia *et al.* \(1999\)](#); [Jacks *et al.* \(1999\)](#); [Back *et al.* \(2018\)](#) have linked proximity of latrines to wells to contamination. [Elisante and Muzuka \(2016\)](#) reported that coliform count contamination decreased with depth of wells with shallow wells being more contaminated than deep ones. In this research, an investigation was also made into the possible contributions of the well characteristics such as their distances from the latrines, their depths and number of users. To achieve this, correlation was employed to test for these characteristics. Correlation is used to describe the strength and direction of the linear relationship between two variables. It can be used on continuous variables and one dichotomous variable. In this test, Spearman correlation was used to test for relationships among variables of well characteristics to see if there is a correlation between the variables and the water contamination in the dry and wet seasons. This version of correlation was used because the data violated the rule of normality ([Pallant, 2016](#)).

The relationship between total coliform count and depth in the dry and wet seasons was investigated using spearman rho correlation. Preliminary analyses were performed to ensure no violation of assumptions. There was a positive correlation between the two variables in the dry season, $r = 0.75$, $n = 100$, $p > .001$, with shallower wells having less contamination. The user rates could account for this, as depth might not have influence. In the wet season there was a weak negative correlation between the two variables, $r = -.39$, $n = 100$, $p < .001$, with shallower wells having more contamination. In this analysis, it means when the well depth increases, contamination decreases and when well depth decreases, contamination increases with

shallower wells getting more contaminated than deeper wells. This is supported by the research carried out by [Elisante and Muzuka \(2016\)](#); [Banks *et al.* \(2002\)](#); [Kimani-Murage and Ngindu \(2007\)](#); [Isikwue *et al.* \(2011\)](#).

The relationship between faecal coliform and number of well users in the dry season was investigated using spearman rho correlation. Preliminary analyses were performed to ensure no violation of assumptions. There was a weak negative correlation between the two variables, $r = -0.89$, $n = 100$, $p > .001$, with less contamination with more well users. Again, the wet dry season could account for this as less water to likely create hydraulic gradient to increase contamination. In the wet season, there was a weak positive correlation between the two variables, $r = .19$, $n = 100$, $p > .001$, with more contamination with increased number of well users. In this case, increasing number of well users brings about an increase in faecal contamination levels and a decrease in the number of well users brings about a decrease in the faecal contamination levels. From the literature, [Barrett *et al.* \(1999\)](#) and [Nyenje *et al.* \(2010\)](#) noted that when many people use on-site sanitation facilities, there would be an increase in the pollution load. [Elisante and Muzuka \(2016\)](#) reported a rise in the water table in the wet season which accelerates contamination from pit latrines. [Kiptum and Ndambuki \(2012\)](#) reported that when many people draw water from wells, there is a hydraulic gradient which pulls water from the latrines and causes contamination.

The relationship between total coliform count and the well-latrine distance in the dry season was investigated using spearman rho correlation. Preliminary analyses were performed to ensure no violation of assumptions. There was a weak positive correlation between the two variables, $r = .02$, $n = 100$, $p > .001$, with increasing distance towards latrine, more contamination. This means contamination could also come from other latrine facilities from other compounds. Many researchers also reported faecal coliform contamination to be associated with latrine proximity ([Zingoni *et al.*, 2005](#); [Dzwairo *et al.*, 2006](#); [Verheyen *et al.*,](#)

2009b; Banerjee, 2011; Pujari *et al.*, 2012). In the wet season, there was a weak negative correlation between the two variables, $r = -0.18$, $n = 100$, $p > .001$, with more contamination with closeness to latrines. Negative correlation means as one value increases, the other one decreases. In this test, it means that as the distance from the well to the latrine increases, faecal contamination decreases and when the distance from the well decreases, faecal contamination increases. In other words, faecal contamination increases with decreasing distance away from the well, with wells closer to the latrine being associated with increased faecal contamination. The implication is that there are correlations among well-latrines distance, well depth and number of well users and faecal contamination of wells in the study sites. The correlation was low as indicated by low correlation values. However, Pallant (2016) noted that in sample sizes of 100 and above, a low correlation value might reach statistical significance. Therefore, well-latrines distance, well depth and the number of well users had some relationship with faecal contamination even though the correlation (ρ) value was less than .5. Based on Cohen (1988)'s suggestion a correlation has to reach a value of .5 to be considered strong.

6.8 Faecal coliform contamination and sediment type

Graham and Polizzotto (2013) noted that the contamination of microbes from pit latrines waste into wells depends on the environmental context of the area such as hydrological and soil conditions. Data was collected on the various sediment types in which the wells were found. The sediment types are clay, sand and sandstone. The Kruskal-Wallis Test was employed to test for the differences in contamination among the soil types. The results show that in the dry season, there was no difference in faecal coliform contamination among the sediment types. In the wet season, there was a statistically significant difference in contamination among the sediment types as reported below:

- Faecal coliform had a statistically significant difference in the wet season, between clay (n=73), sand (n=20) and sandstone (n=7), $p=.000$, Sandstone recorded a higher median score (md=148) than sand and clay, both with median of 113 and 52 respectively.
- In the dry season, faecal coliforms had no statistically significant difference in contamination levels across the soil types. Total coliform counts in clay is shown as (n=73), sand (n=20) and sandstone (n=7). Sandstone had a median value of 200 which is higher than clay and sand with median values respectively 96 and 77. This means the contamination was higher in sandstone bearing areas, followed by clayey soil bearing areas and lastly by sandy dominated areas.

The results obtained were influenced by the geology. For instance, [Moyo \(2013\)](#) also observed that geology affects water quality. He further asserted that well quality is bad in the wet season due to a rise in the water table, particularly in wells found in clayey soil. He explained that the wells in clayey soils tend to be contaminated due to defective fissures from clayey soils. All of the rural sites are located in clayey soils. This could also have some link with contamination in these areas as reported by [Moyo \(2013\)](#). Many researchers reported a relationship between contamination and hydrological conditions such as permeability of the aquifer ([Schijven and Hassanizadeh, 2000](#); [Gundry *et al.*, 2009](#); [Verheyen *et al.*, 2009b](#); [Charles *et al.*, 2009](#); [Taylor *et al.*, 2010](#))

6.9 Conclusions

This chapter has considered water quality analysis of 100 wells sampled in both dry and wet seasons totalling 200 samples. [Graham and Polizzotto \(2013\)](#) noted that in low income countries, many households depend on pit latrines due to their affordability. While many pit latrines lack a physical barrier, effluents from pit latrines can potentially leach to groundwater causing contamination, especially in unlined wells ([Isikwue *et al.*, 2011](#); [Kiptum and Ndambuki, 2012](#); [Sustainable Sanitation Alliance, 2018](#)). This could help explain heavy

contamination of wells in the study sites. There are many researchers who also raised concerns about groundwater contamination from pit latrines ([Dzwairo et al., 2006](#); [Kiptum and Ndambuki, 2012](#); [Nyenje et al., 2014](#); [Shivendra and Ramaraju, 2015](#); [Sorensen et al., 2016](#)). Based on the JMP criteria, a good number of the wells sampled fall into the improved category. However, the analyses suggest that a majority of these wells were contaminated with faecal coliforms. Although both improved and unimproved wells were heavily contaminated, the latter were more contaminated in line with observations in the literature such as [Wright \(1986\)](#); [Palamuleni \(2002a\)](#); [Zingoni et al. \(2005\)](#); [Kulabako et al. \(2007\)](#); [Takem et al. \(2010\)](#); [Sorensen et al. \(2015a\)](#) who note that improved wells are less contaminated than unimproved wells. The difference in my research was very small though. The fact that the improved wells were heavily contaminated raised concerns about the JMP's definition of 'improved' as noted by other reserachers ([Kvarnström et al., 2011](#); [Bain et al., 2014a](#)). Although the dry season did not show much variation in contamination levels between rural and urban areas, the wet season reveals significant differences such as higher coliform and nitrate contamination in the urban than rural areas. The high contamination levels could pose a health threat in the study areas as reported by [Montgomery et al. \(2009\)](#); [Utsev and Aho \(2012\)](#); [Ocheri and Ogwuche \(2012\)](#). The higher contamination in urban areas support other findings that the higher population in urban areas increases more nitrogen loading in latrines reflecting in higher contamination rates ([Isunju et al., 2011a](#)). The high nitrate values in the study sites suggest contamination from pit latrines as echoed by other reserachers ([Tandia et al., 1999](#); [Zingoni et al., 2005](#); [Vinger et al., 2012](#); [Graham and Polizzotto, 2013](#); [Wright et al., 2013](#)). The high chlorides from the study sites indicated contamination from pit latrine density which tallies with other findings elsewhere ([Verheyen et al., 2009a](#); [Wright et al., 2013](#); [Martínez-Santos et al., 2017b](#)).

Well depth, well-latrine distance and number of well users show some correlations as contributing to contamination levels, though with low correlation strength. [Zingoni et al.](#)

(2005); Banks *et al.* (2002); Girard and Hillaire-Marcel (1997); Mafa and Vogel (2004); Pujari *et al.* (2012); Tandia *et al.* (1999); Jacks *et al.* (1999) have linked proximity of latrines to well contamination. Although some studies such as Jimmy *et al.* (2013) in Sierra-Leone reported no statistical significance in well latrine distance, others such Dzwauro *et al.* (2006) in Zimbabwe, Chidavaenzi *et al.* (2000) also in Zimbabwe reported that coliform and nitrate concentrations increases with pit latrines proximity. Kimani-Murage and Ngindu (2007) reported of reduced coliforms after 15m from pit latrines. In the study sites, there are some shorter separating distances between well and latrines and this is reflected in higher contamination, especially in urban sites. From these, it is clear that separating distances from pit latrines and wells affect contamination levels. The impact of depth has also been raised (Isikwue *et al.*, 2011; Elisante and Muzuka, 2016) and numbers of well users (Kiptum and Ndambuki, 2012). The physical water parameters such as temperatures and pH were generally high. Jamieson *et al.* (2002) noted that pH and temperatures influence bacteria survival as high temperatures increase bacterial survival rate while a pH of 6-7 is optimum for bacteria survival. Overall, the water quality showed over 90% contamination in the faecal coliforms tested. Geology had some influence on contamination as such as sandstone areas having higher contamination as reported in the literature (Schijven and Hassanizadeh, 2000; Charles *et al.*, 2009; Gundry *et al.*, 2009; Verheyen *et al.*, 2009a; Taylor *et al.*, 2010; Moyo, 2013).

This marks the end of chapter six. The next chapter will focus on quantitative data analysis based mainly on the questionnaires administered on water and sanitation in Benue State.

Chapter 7: Quantitative Analysis of Water Supply and Sanitation in Benue State

7.1 Introduction

This chapter presents information collected mainly via the questionnaire survey which sought to gain insights into access to improved water and sanitation in rural and urban areas of Benue State. The quantitative data collected through the questionnaire is justifiable on the understanding that it would be a field-based quantitative follow up and confirmation of data analysed using the DHS data, which is also quantitative. Also, the study sought to replicate some of the JMP questions used in the DHS and the extent they echo the latter's data, in the field so the use of questionnaires was appropriate for this purpose. This would also help to address some of the specific questions raised following the DHS analysis in 5.13.1 and 5.13.2 quantitatively. This chapter follows from chapter six which dealt with water quality testing. The stakeholders' understandings of contamination, its causes, associated risks and other matters are covered in this chapter. The water and sanitation issues considered here are based on Joint Monitoring Programme (JMP) criteria. While JMP activities under the MDGs are considered (as the research involved them from the onset), efforts are made in this, as in the previous chapter, to align the research with SDG emphasis on 'safely managed' water and sanitation. The analysis considers demographic characteristics (section 7.2) followed by an overview of access to improved water (section 7.3), water treatment (7.4) and improved sanitation (7.5) in rural and urban areas of Benue state. Since the research enters the SDG era, information on handwashing in hygiene is also included (7.6.2).

7.2 Demographic Characteristics of Respondents

7.2.1 Breakdown of Respondents by Gender and Region

A total of 600 individuals completed the questionnaire survey and were evenly distributed between rural and urban sites. The survey was administered in four rural regions, Alemenyi,

Dam, Konshisha and Secretariat and five urban settlements: High Level, Kanshio, Wadata, North Bank and Wurukum. There was a total of 75 respondents in each rural area and 60 in each urban area. Although the importance of women's particular WASH needs is acknowledged (Rajagopal and Mathur, 2017), a desire to better understand gender variations in WASH-related concerns and perceptions of water and sanitation required a roughly even balance between male and female respondents. Also, as Sultana (2009a) points out, the impacts of poor water access on men is often under-reported so it was deemed important to capture their views as well as those of women in this study.

Overall, women made up 46.3% of respondents although there were slight spatial variations between sites and female respondents exceeded male respondents in Alemeniyi and Kanshio areas. In other areas, male respondents were more numerous but efforts to balance this had to be weighed against concerns about being seen to challenge cultural norms in the area which sometimes made it difficult to interview female instead of male household members. The breakdown of respondents by region and gender is shown in Table 7.1

Table 7.1: Breakdown of Respondents by Gender and region

Type of residence			Location									Total
			AL	DM	KSH	ST	HL	KS	WD	NB	WK	
Rural	Gender	F	43	32	21	43						139
		M	32	43	54	32						161
	Total		75	75	75	75						300
Urban	Gender	F					23	31	30	25	30	139
		M					37	29	30	35	30	161
	Total						60	60	60	60	60	300
Total	Gender	F	43	32	21	43	23	31	30	25	30	278
		M	32	43	54	32	37	29	30	35	30	322
	Total		75	75	75	75	60	60	60	60	60	600

Source: Fieldwork 2016

AL=Alemeniyi; DM=Dam; KSH=Konshisha; ST=Secretariat; HL=High Level; KS=Kanshio; WD=Wadata; NB=North Bank; WK=Wurukum; F=Female; M=Male.

7.2.2 Education

A study carried out by [Pande *et al.* \(2008\)](#) reported that households with access to clean water and good hygiene will not suffer from diarrhoea often. They also reported that the richer and better educated members of a population suffer less from diseases and secure water for their households regardless of where they live. The DHS data also supported the argument that better educated people had greater access to improved water and sanitation across the surveys. Therefore, education can have an important influence on water and sanitation access and is considered here for analysis. A good number of respondents are educated but women made up a lower proportion of those educated, especially in the rural areas. Educational attainment and gender are calculated at 100% each for rural and urban sites in the chart below to enable comparison by gender across rural and urban areas. The majority of respondents had been educated to secondary or tertiary level, although it is clear from the data that men tend to have received a higher level of education than women with 50% of male respondents being educated to tertiary level compared to 33% of women in the urban areas. In the rural areas 42% of men received tertiary education as against only 25% of women. In contrast while just 10% of women indicated that they had received no formal education the percentage for men was 3% in the urban areas while in the rural areas 10% of women reported having no formal education compared to 5% of men. The figures for rural and urban environments show a similar breakdown, although urban women were slightly more likely to have received a tertiary education (33%) than rural women (25%). This information is presented in Figure 7.1.

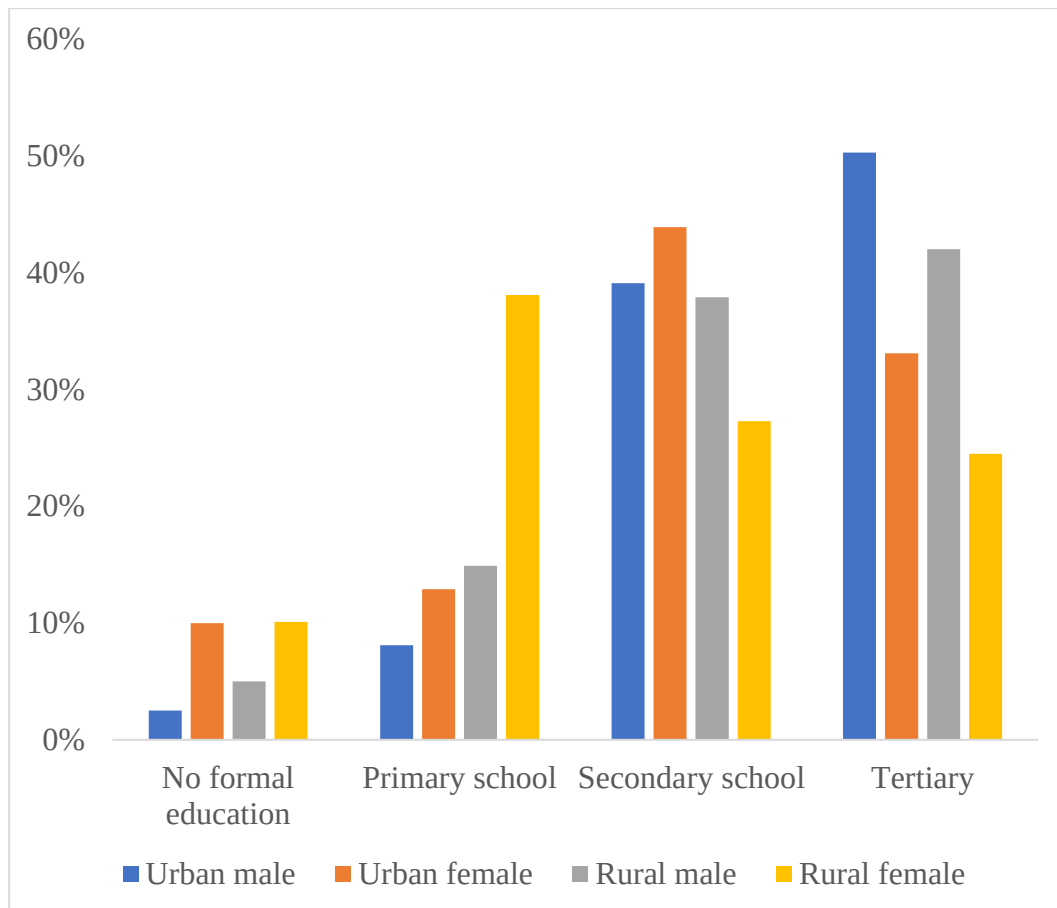


Figure 7.1 Educational Level of Respondents.
Source: Fieldwork 2016

7.2.3 Income

[Wright et al. \(2004a\)](#) noted that with continued population growth in many cities in Sub-Saharan Africa, utilities find it difficult to keep up with water supply. As this happens, water rationing sets in with residents forced to look for alternatives. Due to the shortage of potable water supply, the use of sachet or ‘pure’ water (water sold in 500ml sealed plastic bags) has become popular. As the demand for pure water rises, some poorly processed sachet water sellers sell water at cheaper prices to attract customers and undercut the registered producers who sell at higher prices. At this point, the low income earners face the risk of drinking contaminated water ([Stoler et al., 2012](#); [Stoler et al., 2015](#)). Therefore, people with lower incomes are disadvantaged when they have to buy water and other commodities. Also, in the semi-structured interview, a respondent at Benue State Water Board reported that since the government does

not provide water for everyone, the rich stand a better chance of providing safer water for themselves. A look is therefore taken at the income of the respondents. Figure 7.2 shows the broad distribution of income (monthly) for the survey respondents. It is clear from these data that the majority of women interviewed fall into the no income or very low-income category. Some 44% of urban females report no income compared with 30% of men in the urban area in the same category while in the rural areas the figures are 42% of women compared to 18 % of men. Although a significant number of male respondents (30% and 18% respectively for urban and rural areas) fall into the no-income category the number of men in higher income brackets exceeds that of women with 32% urban and 40% rural areas compared to only 17% and 19% for urban and rural women respectively. Significantly, income levels for women were very similar in both rural and urban areas but for men showed a number of differences. The most notable was the higher proportion of men (30%) reporting no income in the urban areas compared to 18% in the rural areas. The reason for this difference is not clear but it could reflect movement of non-income earners – most of whom are men - to urban centres in search of greener pastures.

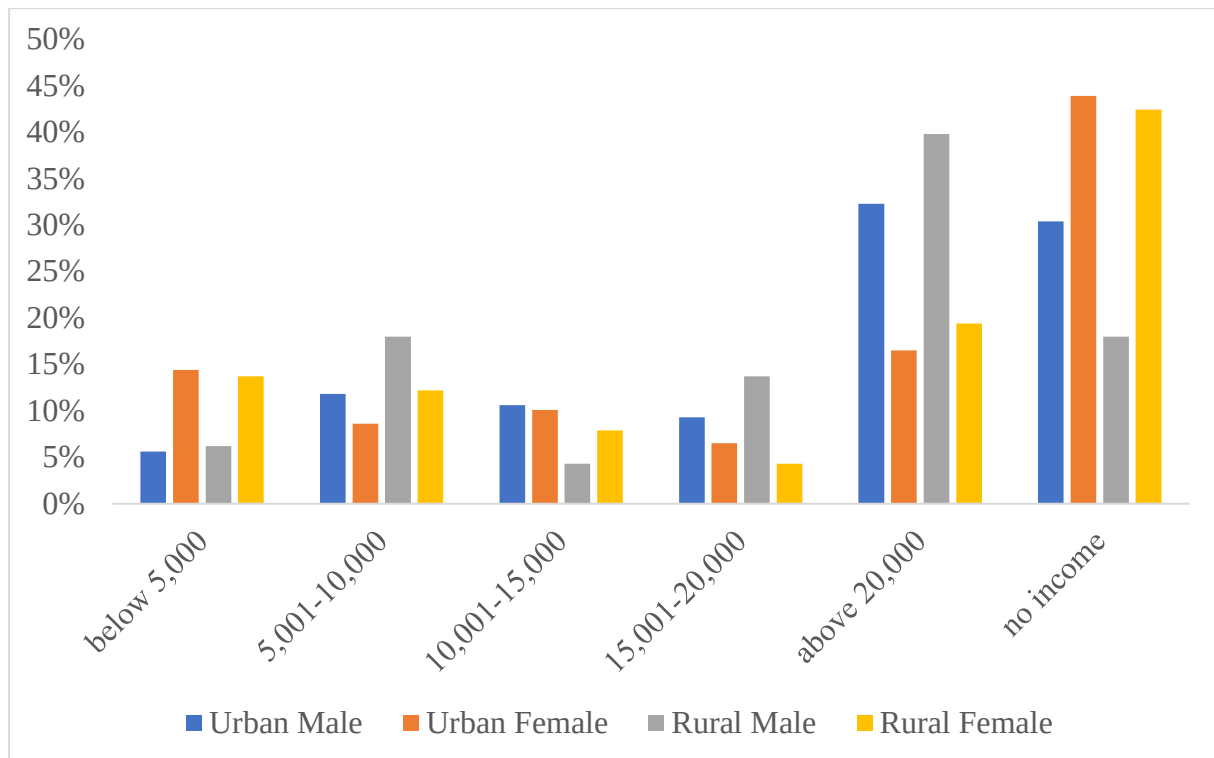


Figure 7.2 Income Level of Respondents
Source: Fieldwork 2016

7.2.4 Employment Status

Closely related to income is the employment status of people. Their employment status helps to shape their income which influences many things they demand. For instance [Pande *et al.* \(2008\)](#) found that richer people can secure good water for their households and consequently avoid water related diseases. The link between improved water access and economic base was also confirmed during the semi-structured interviews (Chapter 8:), establishing a solid conclusion. The employment status is not very high in the study sites as most people consider ‘employed’ to be working in a government job. In a study of access to health insurance by women in South Africa, [Kirigia *et al.* \(2005\)](#) reported that high income women had a higher likelihood of being insured, indicating how income (related to employment) affects many things people do. In the survey generally there is a low level of employment. For instance, 19% of rural respondents compared with 28% urban respondents were unemployed. If we include the ‘other’ category (which comprises mostly of students, retirees and other categories), there

would be more people in the unemployed category. The employed constitute 22% in the rural areas compared with 17% among the urban respondents. This is an indication of low employment in the urban sector even though it potentially has more capacity to engage people in employment than the rural sector. There is a sharp distinction in unemployment between urban areas (28%) compared with rural areas (19%). In rural areas, the 'other' category accounts for 20% compared with 16% in the urban areas. The reason for the high rate of 'unemployed' and 'others' could be due to migration into the urban centres by people looking for greener pastures, and the presence of students. This implies a high dependency ratio and pressure on water supply, sanitation and other facilities. This is explained by the fact that the non-working category members stay with relatives and friends who are working and depend on the latter, making dependency high on the few employed people and increasing pressure on resources. The general trend is that most students who stay with dependents do not necessarily live in student accommodation. In most cases they are full time students (not working part time). These are the particular categories this discussion relates to. The chart below shows details of employment status in the study sites. Again, it could be that some people might be under employed and feel they are not 'employed' and report as such.

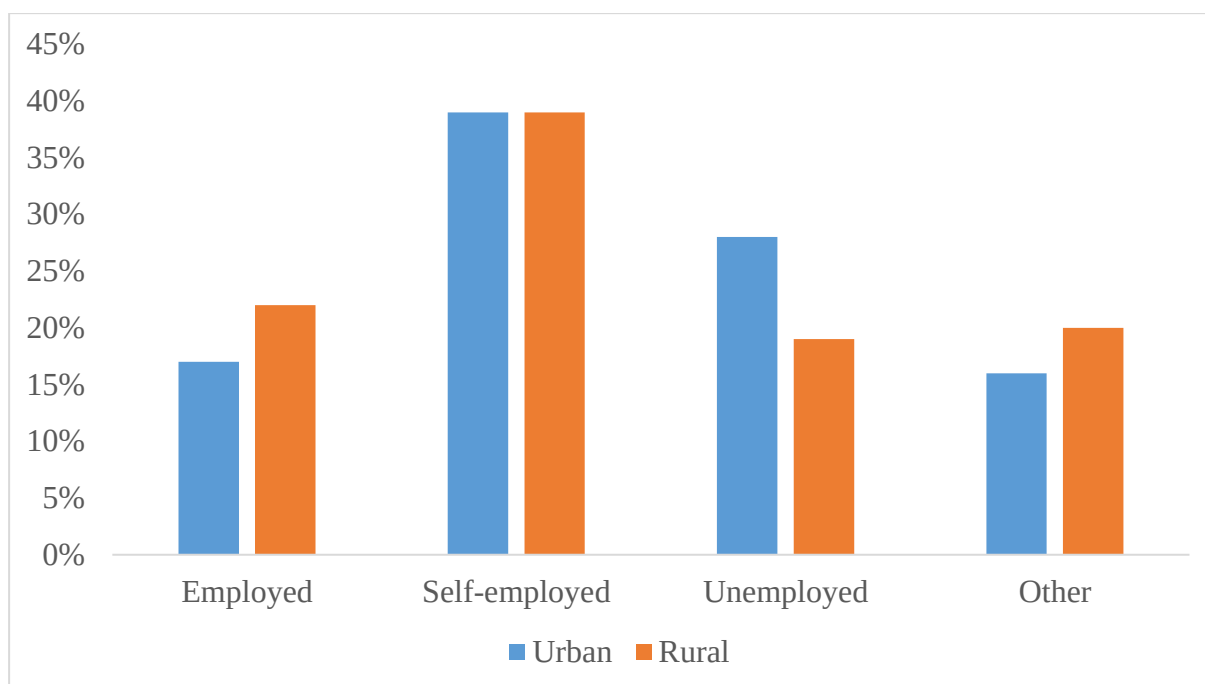


Figure 7.3 Employment Status in the Study Areas.

Source: Fieldwork 2016

The chart above provides information on employment levels in the study sites. The self-employed are more popular but the unemployed also have a significant proportion as can be seen from the graph.

7.3 Access to Improved Water Supply

This section looks at access to improved water supply in the study sites, to follow up from DHS water analysis. A background to the concepts are recapped and access based on various variables are considered in line with the DHS analyses. The findings from the field confirmed the DHS analyses.

7.3.1 Improved water access definitions based on MDGs and SDGs.

As mentioned in the introduction, JMP criteria were used in the questionnaire design to determine the types of sanitation and water supply systems respondents had access to and whether they fell into the JMP's 'improved' or 'unimproved' categories. Using the JMP's classification of improved and unimproved drinking water sources, the questionnaire data revealed that 62% of respondents had access to improved drinking water sources. Of this

number, 21% of urban respondents had improved drinking water compared to 41% of rural respondents. The main reason why the rural respondents had higher access to improved drinking water is that a good number of them drink water from boreholes and protected dug wells while many urban dwellers (24%) depend on sachet water for drinking which was not recognised as an improved source of drinking water by the JMP in the MDG era. This was justified by the JMP on the grounds that someone using sachet or bottled water for drinking but washing hands with unimproved water is not using an improved water source. Data were collected on sources of water for handwashing and cooking in households drinking sachet and bottled water. Observations in the field clearly showed that people do not use sachet water or bottled water for cooking and for washing hands. Also, although some people were using improved water sources according to JMP criteria, they were using unimproved water sources such as water from unprotected wells and surface water for cooking and hand washing. For instance, from the field data, 7% of respondents who use bottled or sachet water used water from unimproved sources for handwashing. Even among those that use improved water sources, it is not guaranteed that the sources are uncontaminated. [Bain et al. \(2012a\)](#) criticised the JMP's pronouncement of some water sources as improved and consequent announcement that the MDG water target was met in 2010. They argued that the JMP's use of 'improved' is an assessment of specific types of water sources rather than the quality of water they provide. They demonstrated that the Rapid Assessment of Drinking Water Quality (RADWQ) studies conducted in Nigeria found that boreholes were more compliant (86%) than piped supplies (77%). The authors therefore concluded that improved did not necessarily mean safe; a finding supported by data from this study and elaborated on in sections 6.6.

As noted in chapter two, the SDGs came into effect in September 2015. The monitoring of water and sanitation access under the SDGs makes use of a service ladder. The SDG ladders

are slightly different from those used for MDG monitoring. The current water service ladder from top to bottom comprises of:

**Safely managed* Drinking water from an improved water source which is located on premises, available when needed and free from faecal and priority contamination.

**Basic* Drinking water from an improved source provided collection time is not more than 30 minutes for a roundtrip including queuing.

**Limited* Drinking water from an improved source where collection time exceeds 30 minutes for a roundtrip, including queuing.

**Unimproved* Drinking water from an unprotected dug well or unprotected spring.

**Surface water* Drinking water directly from a river, dam, lake, pond, stream, canal or irrigation channel.

A key criterion here is the collection time for an improved water source which should be under 30 minutes. Questions on water collection times were included in the questionnaire used in this study and based on these criteria, the proportion of people (over 30%) in the study area with access to improved water would mostly fall into the limited category; especially in rural areas in the dry season (section 7.3.5).

7.3.2 Improved water access in the study areas

When the MDGs ended in 2015, only a handful of countries in Sub-Saharan Africa were able to halve the proportion of the population without access to safe drinking water. [Ndikumana and Pickbourn \(2017\)](#) observed that while education and health care have received attention from governments and donors, less attention is paid to water and sanitation in the allocation of aid, policy debates and even in the scholarly literature. [Howard and Bartram \(2005b\)](#) identified a

lack of financial resources and the low priority accorded to water and sanitation in developing countries.

In the DHS analysis earlier carried out, it was clear that access to potable water is poor in Nigeria as a whole and Benue State in particular. Some recent publications in Benue show that access to water is low with demand exceeding supply. For instance, in a study of potable water supply in Ugbokolo, Benue State, [Aper and Agbehi \(2011\)](#) reported that the water needs were not equally met with supply that is no community had enough water supply, with about 73% of household water needs not been available. The major water sources reported in Ugbokolo and Agberagba are streams, rainwater, wells, boreholes and water vendors ([Aper and Agbehi, 2011](#); [Utsev and Aho, 2012](#)).

An important question asked by JMP is the main drinking water for the household. In the questionnaire administered in Benue, respondents were asked to identify the major problems of the community. This was to give them liberty to air their views. From the responses received, the most important problem facing the community was water supply as 49% of rural respondents and 28% of urban respondents (77% of sample) saw the non-availability of potable water supply as the most serious community problem. Since respondents were asked about their general problems first, the responses can not be attributed to survey bias and in any case the responses were supported by field observations. Responses to this question also revealed that sanitation was considered a significant problem. The respondents who identified sanitation as an issue made up 16% while the remaining 7% identified other needs such as power supply, access roads and schools. Although only 16% reported sanitation as a problem, this could be an oversight on the part of respondents because when there is water scarcity, sanitation is also automatically affected. In terms of gender, there were no significant gender variations in responses, as concerns about access to water cut across gender and other demographic compositions. This place the problem of access to potable water supply in the study sites into

context. The main source of water for drinking available to the respondents in both urban and rural sites will now be considered. The main water sources were sachet water (42%) and tube well/borehole (19%) in the urban sites while protected well (51%) and tube well/borehole (32%) were the major water sources in the rural sites (Figure 7.4).

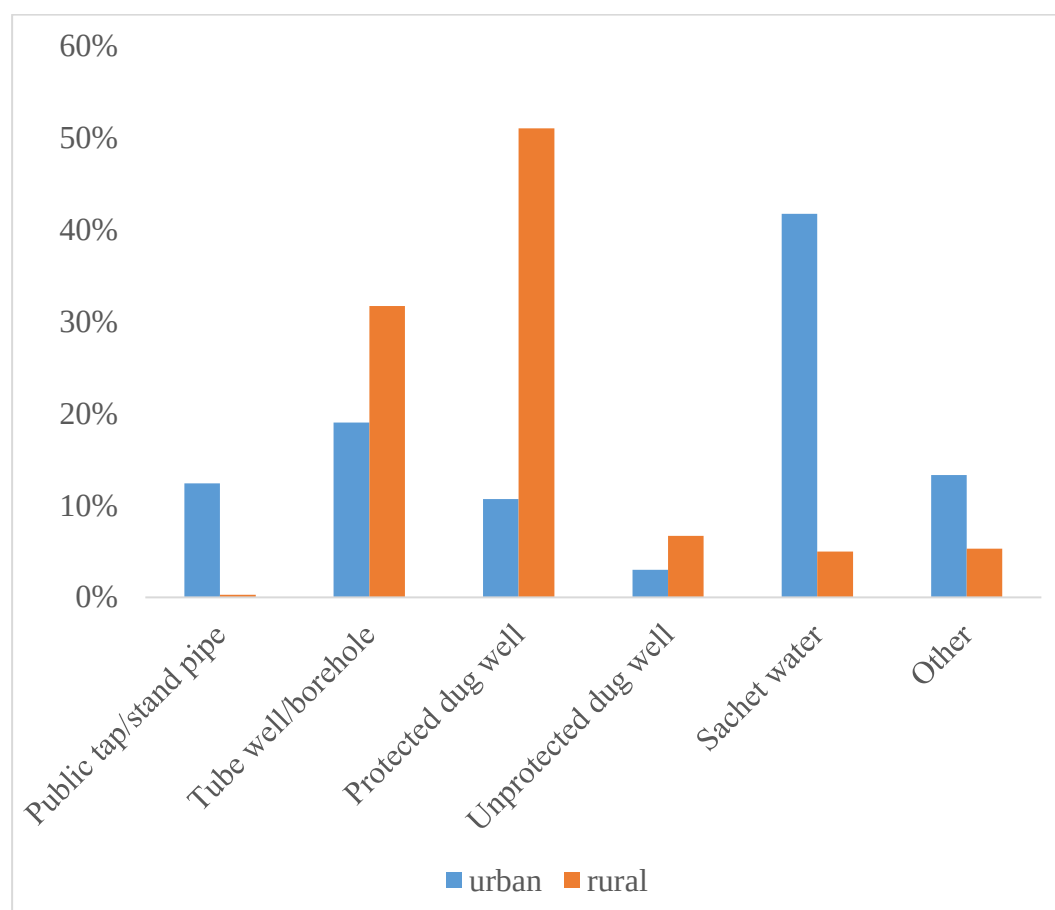


Figure 7.4 Main Sources of Drinking Water for Urban and Rural Sites
Source: Fieldwork 2016

The figure above shows details of drinking water sources in rural and urban sites. However, it should be noted that the figures provide an over-estimate of improved drinking water access in the study areas as houses with both wells and latrines were deliberately sampled for the research in order to investigate possible cross contamination. Households without wells in their compound were excluded from the sample frame and information on households that accessed their drinking water from other sources such as surface water were not captured. This accounts for differences in data obtained from this research and DHS data on improved drinking water for the region. Having clarified that, it can be established that access to improved water and

sanitation are low in the study sites as found from the DHS analysis. Again, some water sources are considered as improved simply based on JMP definitions. In reality, as discussed in chapter 6, some of the water sources classified as improved according to JMP criteria provide water of equal or lower quality than so-called ‘unimproved’ sources in terms of their microbial and chemical quality. This gives an exaggerated percentage of people having access to improved sources of drinking water.

In the dry season, there is a significant variation in water access between the rural and urban areas as rural respondents have to travel up to over four kilometres to get water from rivers/unprotected springs. Drinking water from unimproved sources has health risks like diarrhoea and other diseases (Esrey *et al.*, 1991; Waddington *et al.*, 2009; Snilstveit and Waddington, 2009; Clasen *et al.*, 2010; Cairncross *et al.*, 2010; Liu *et al.*, 2012). Although there are boreholes, they are insufficient in number and there are very long queues at the borehole water collection centres. Water scarcity compels people to store water which could become contaminated (Wright *et al.*, 2004b; Shields *et al.*, 2015).

While the JMP collects data on the main source of drinking water, there are other sources which people significantly depend on. For instance, in the rural sites, people take hours to get water from rivers/unprotected springs. These sources are not improved though local people sometimes drink water from protected wells (improved). Therefore, in such cases, questions of improved/unimproved vary according to the season. Some of the statistics give an overestimated access to improved water and sanitation and some of these concerns have been raised by other researchers (O'Hara *et al.*, 2008; Kvarnström *et al.*, 2011; Jewitt *et al.*, 2018). Issues associated with seasonal water access and the JMP's emphasis on the main drinking water supply are also captured in detail in the semi-structured interviews (Chapter 8:).

7.3.3 Education and access to Improved Water supply

From literature such as [Pande *et al.* \(2008\)](#) and [Kirigia *et al.* \(2005\)](#), educational level has an influence on access to improved water and other services. There appears to be a link between educational level and improved water access in the study sites with more highly educated respondents having higher access. As Figure 7.5 shows, 92% of respondents with tertiary education have access to improved water compared to 73% of secondary school graduates (Figure 7.5). Also, a chi-square test for independence was employed. This test is used to explore the relationship between two categorical variables, where each case can have two or more variables. In this case it is used to check if there is any association between educational attainment and access to improved water. It indicated that there is a significant association between education and improved water access, $X^2(44, n=600) = 92.73, p=.00$, Cramer's $V=.20$. The interpretation of this is that there is a significant association between educational attainment and improved water access although the size of this effect is small (.20).

Similarly, as would be expected, the use of unimproved water sources assumed a pattern with those educated to tertiary level having a lower percentage of unimproved drinking water supply usage. Here, 8% of tertiary respondents had access to unimproved water compared to 27% in the secondary school and 26% in the no formal education category. The tertiary category's use of unimproved water could probably be due to financial constraints making them to live in places that they would prefer not to.

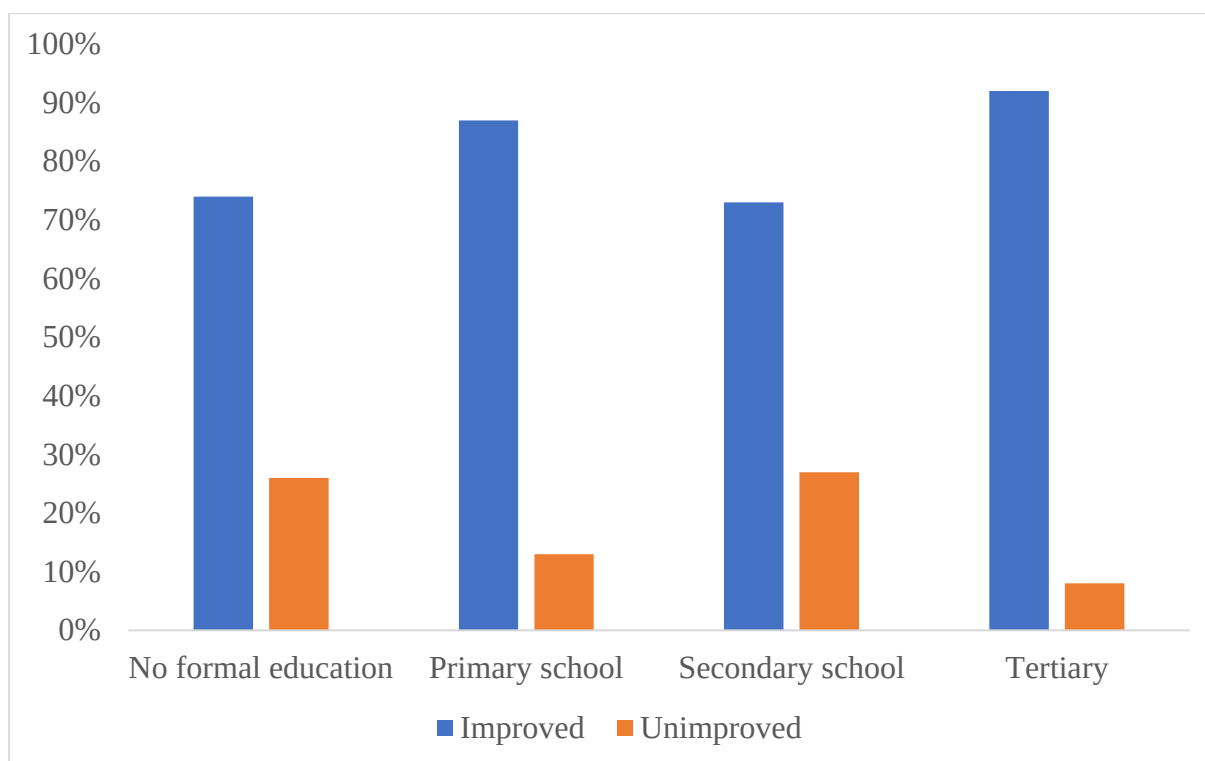


Figure 7.5 Access to improved and unimproved water by educational status

Source: Fieldwork 2016

7.3.4 Access to improved water and income level

[Wright et al. \(2016\)](#) found that households with low expenditure and use surface water are more exposed to contaminated water at the point of consumption. There is also a link between income levels and access to improved water with 89% of respondents in the higher income (above N20,000) having access to improved water compared to 84% of those with N15,001-N20,000 (see Figure 7.6). The 85% access by those with no income represent those who are dependents who live with the higher income earners. Generally, the fact is that those who have higher incomes can provide themselves with better water supplies like a tap or borehole: a finding confirmed in the semi-structured interview carried out at Benue State Water Board, Makurdi. (See Chapter 8:). Similarly, [Stoler et al. \(2012\)](#) and [Stoler et al. \(2015\)](#) noted that the higher income earners could afford to demand better water quality including sachet water and another form of water that can be bought. On the other hand, those with lower income levels have limited access to improved water sources as they are unable to get better water sources like tap

water, etc. However, in this case the data has not much tallied with this because of the simple definitions of protected wells as improved which are basic needs and common even to low income earners. The information on income and unimproved drinking water sources is presented in Figure 7.6

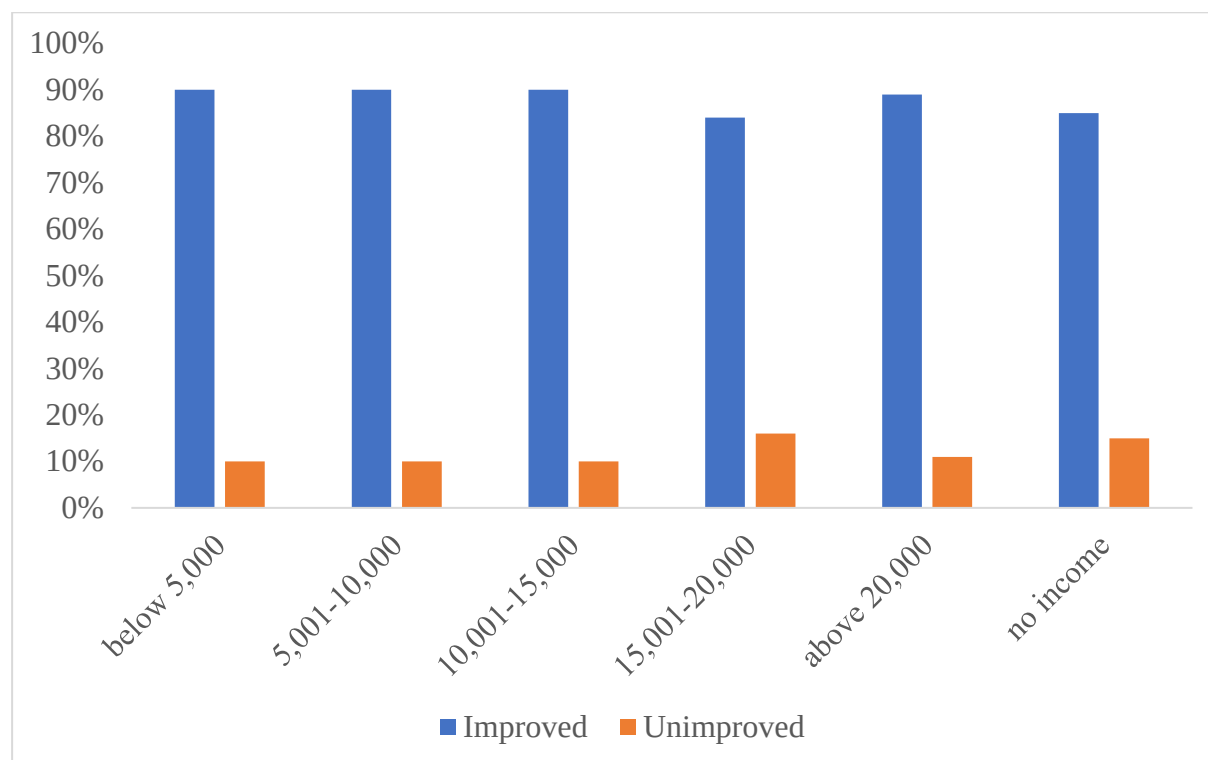


Figure 7.6 Access to Improved Water based on Income Level
Source: Fieldwork 2016

7.3.5 Round trip Duration for getting Drinking Water

One of the questions on the JMP WASH questionnaire module in relation to accessing sources of drinking water is ‘how long does it take to get there, get water, and come back?’ The rationale behind this is to find out if it takes more than 30 minutes to collect drinking water. According to the JMP Post 2015 Brochure (WHO/UNICEF 2015), “Several other factors, in addition to the quantity of water available and the time and distance to the source, affect the quality of access that a household has to drinking water. Such factors include the quality of the water delivered, the continuity of the drinking water service, the seasonal availability of water, and the affordability of the services”. The amount of time taken to haul water is very important

because significant time spent undertaking such activity can affect the ability of children to attend school whilst adults may suffer from time taken away from paid work and other activities (Montgomery and Elimelech, 2007). In the survey, over 50% of respondents took over 30 minutes to get the drinking water source in the rural areas. In the literature there are many issues reported that come with water scarcity such as conflicts (Utsev and Aho, 2012).

Water that takes over 30 minutes to collect is classed as 'limited' on the water ladder and safely managed water is far from being attained at the moment in the study areas. The target at the moment in Nigeria is to attain a 'basic' level of provision where improved water collection time is below 30 minutes.

Another important factor to consider is how water is made available to the people by the government as part of public utilities. It is the Government's responsibility to provide water to people as part of their duty to provide public utilities. The government agencies acknowledged this in the semi-structured interviews and noted that insufficient funds hinder them from fully carrying out this mandate (see Chapter 8:) To investigate respondents' views on this, they were asked about the activities of the government in terms of providing potable water. With reference to people's assessment of the water agencies, 49% of rural respondents and 39% of urban respondents expressed dissatisfaction with the water agencies because they were not being supplied potable water. Because of poor access to drinking water, many people (over 30% of respondents) - especially women and children in rural areas - travel over 30 minutes to get drinking water in the dry season. Only 2% of respondents in urban areas and 1% in the rural

areas confirmed getting a regular supply of water.

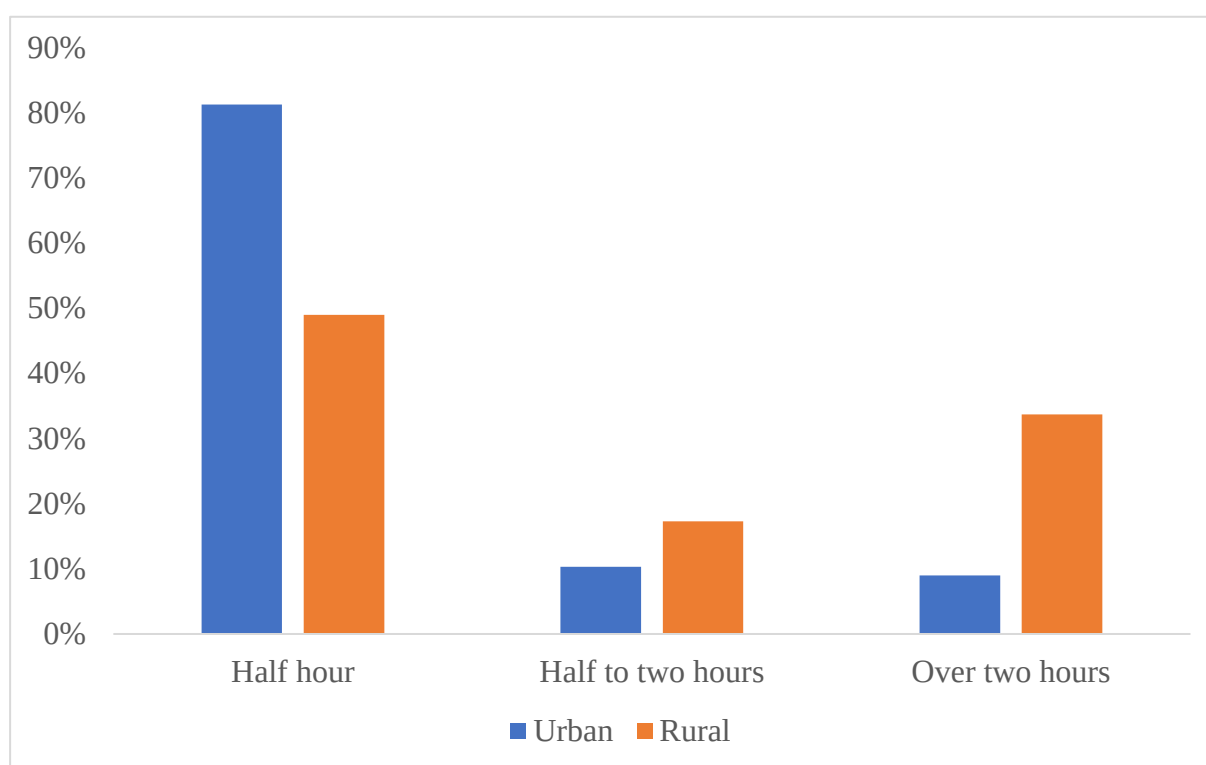


Figure 7.7 it can be seen that although 81% urban and 49% rural dwellers collect water within 30 minutes, there is a sharp contrast between urban and rural areas in terms of water haulage time in the dry season because rural respondents depend on water from the river/surface water and boreholes in the dry season which are sometimes far away. Again, due to the small number of boreholes, the waiting and queuing time is very long at the borehole points. On the other hand, urban people have more income (please refer to Figure 7.2) to purchase sachet water and pay water vendors who supply them with water from boreholes and taps and so they don't have to go far or wait long at boreholes to get water. But here too, there are times in the dry season when they spend over 30 minutes looking for water vendors with 10% of urban dwellers and 17% rural residents taking between half to two hours to collect water. But as mentioned earlier, during dry season peak periods, the water hauling round trip is far longer as 9% urban and 34% rural dwellers take over two hours to get water. In the dry season, 51% (17% taking half to two

hours and 34% taking over two hours) of rural residents take over 30 minutes to collect water. This information is presented in the chart below.

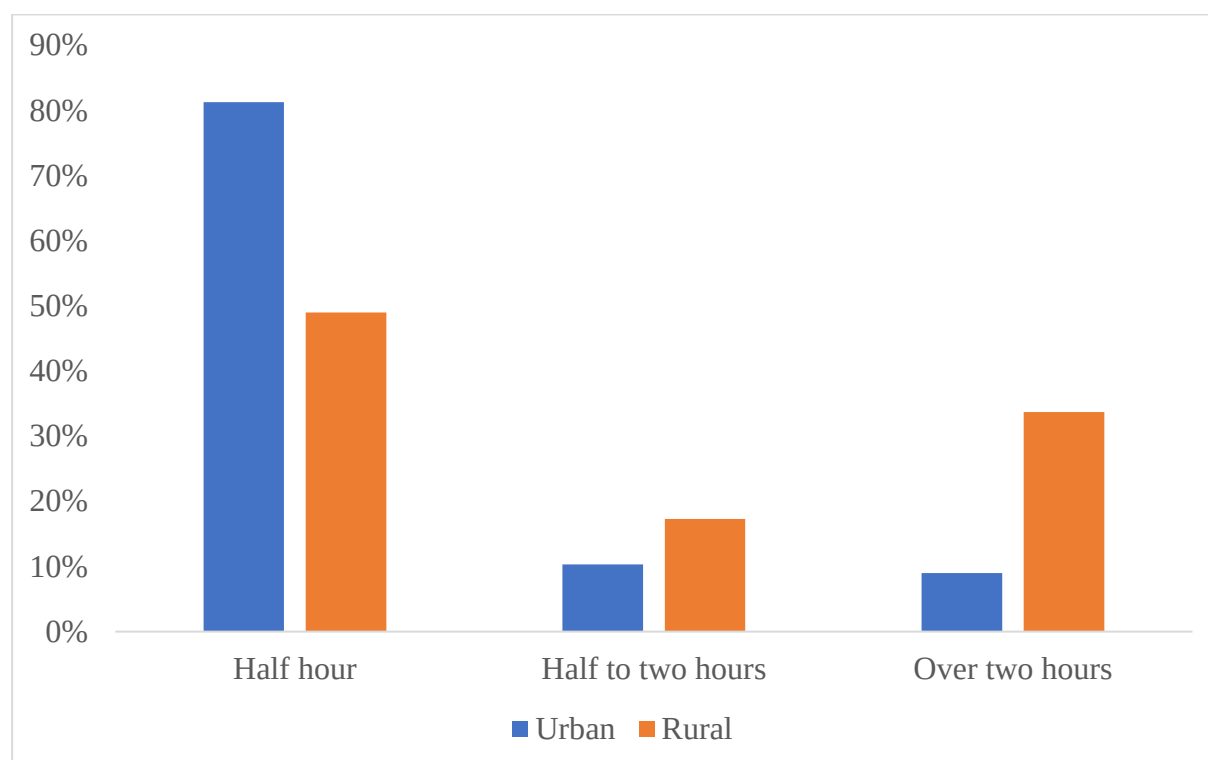


Figure 7.7 Drinking Water Round Trip for Rural and Urban sites
Source: Fieldwork 2016

While we have seen from the figure above that collection time is significantly more than 30 minutes especially in the rural areas, there are variations in who bears the burden of water collection. As water is collected from distant sources in the dry season in the rural areas, women and children carry more of the burden (Figure 7.8). Many researchers have observed issues with this. For instance, [Montgomery and Elimelech \(2007\)](#) and [Freeman *et al.* \(2012\)](#) observed that the time children take to search for water could take them out of school. Also, scarcity of water can stop women from growing vegetables and doing other trades. Long term diarrhoea has been linked with secondary health impacts such as malnutrition which are also linked to water scarcity ([Keusch *et al.*, 2006](#)). Issues of security especially for women and children during water haulage trips have also been raised ([Bapat and Agarwal, 2003](#)) and ([Talaat *et al.*, 2011](#)).

It is evident from the data presented in Figure 7.8 that over 50% of respondents in the rural areas take over 30 minutes to get drinking water spending an average of three hours in which

women account for 50% of those collecting water compared with 60% of men. Men are more involved in collecting water due to the long distance and heavy labour involved. In the 'over two hours' collection time, 41% of adult men and 33% adult women are involved. Female children under 15 (36%) and boys under 15 (33%) are involved. This situation is consistent across the rural settlements. Children are rarely involved in collecting water from distant water sources, but more at nearby sources and with more waiting time. In the urban areas, 78% women and 83% men are involved in water collection within 30 minutes. Over 30 minutes, 22% of adult women, 18% of adult men, 22% of young girls and 13% of young boys are involved in water collection (Figure 7.8). In the urban centres the time spent in getting water does not take as long as in rural areas as most respondents depend on water vendors or commute to boreholes or tap water sources that are not as distant as in rural areas. In the wet season, water hauling times tend to be shorter as most people use their wells in which case there is not much variation as to who collects the water and collection is not an issue. It is the dry season in the rural areas that is more problematic in collecting water.

The questionnaire survey took place in the dry season but not at the peak of this season, so some people were still able to draw water from their wells and their neighbours for drinking. At the peak of the dry season in March, when semi-structured interviews were conducted, most respondents' wells were dry and greater amounts of time were spent both hauling water and queuing at water collection sources such as boreholes and at the river as some wells in rural areas were dug by the riverbanks/unprotected springs for collecting water. The seasonality issue in collecting water was investigated in more detail in the semi-structured interviews (8.2.8) when generally people recounted that they reserve their 'hard earned water' for drinking and use water from the dam for other purposes such as handwashing and cooking. There is therefore a seasonal variation in the water hauling time and also in taste of the water as respondents complained of a salty taste to well water in the dry season. In the wet season, people use their

wells or neighbours' wells for drinking (because there is water in the wells and some people say their wells don't taste salty in the wet season) and use rainwater, which is harvested by keeping containers under zinc roofs. The JMP considers rainwater as an improved drinking water source. In terms of who fetches the water, women are mostly involved followed by men and female children under 15 years old. While there is little hauling time in the urban areas (mostly within half hour), the rural areas require more hauling time due to distance and/or waiting time. The 'over two-hour' category of hauling time is the most problematic and occurs in the dry season when the local wells are dried. Water chores are traditionally considered jobs for women while men do other tasks such as clearing and tilling the land, building houses, etc. Below is a chart relating to water haulage in urban and rural sites.

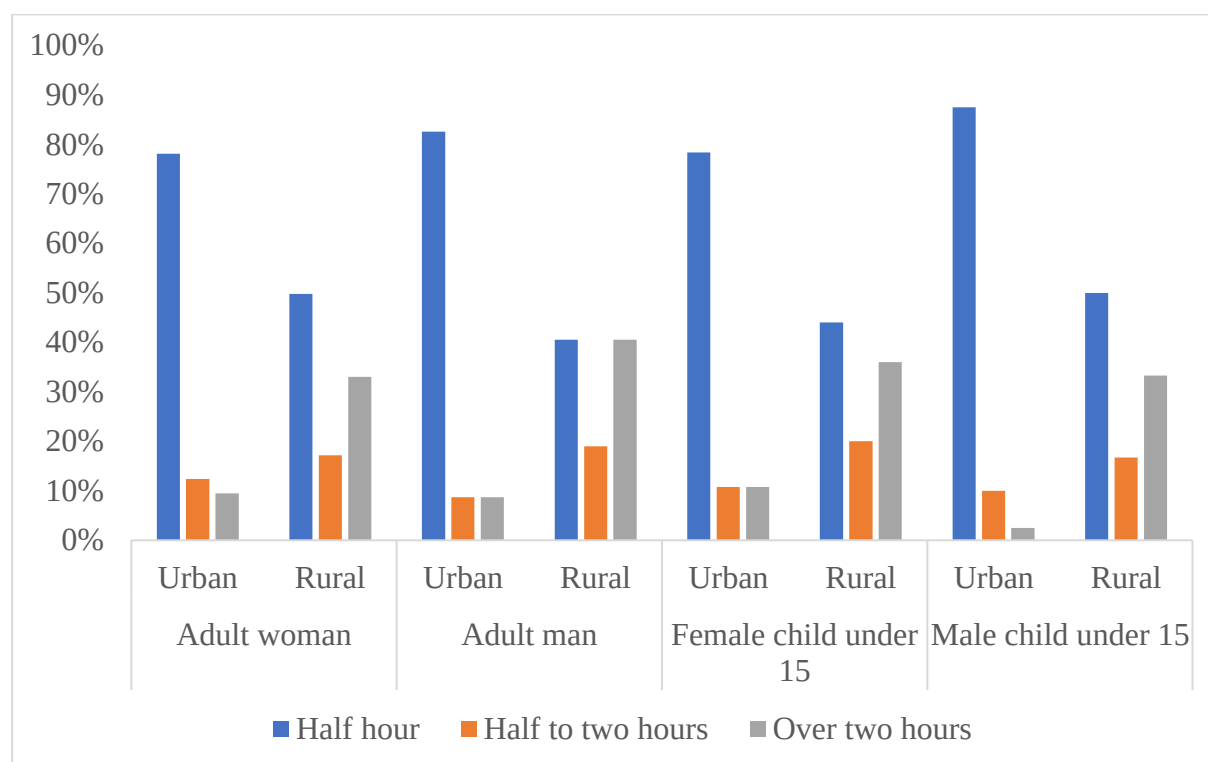


Figure 7.8 Water hauling time and those involved
Source: Fieldwork 2016

7.4 Water Treatment.

7.4.1 Status of Water Treatment in the Rural and Urban areas.

Godfrey *et al.* (2006); Bain *et al.* (2014b) and Wolf *et al.* (2014) noted that even water from improved sources is often of poor quality. This is also confirmed in my findings as can be seen in section 6.6. Water from piped systems in low- and medium-income settings are always discontinuous which can create problems in that non-continuously flowing water may allow infiltration and re-contaminate the water source or growth of micro-organisms could occur during storage. Apart from the health risks, non-continuous household water supplies could affect the water available for hygiene practices. Furthermore, many authors such as Wang and Hunter (2010) and Pickering and Davis (2012) noted that availability and distance to water sources have links with diarrhoea risks. Because of these risks, water treatment is important. As centralised treatment systems are no longer viable, decentralised approaches of household water treatment are encouraged (Montgomery and Elimelech, 2007).

As most people do not have access to centrally treated water supplies, water treatment should be of high importance as noted from the foregoing. The JMP WASH questions ask about water treatment ('What do you usually do to the water to make it safer to drink?') and this question was used in the questionnaire survey used in this study. Water treatment was found to be low in both urban and rural areas. Even those that treat water, especially in the rural areas, often treat it by 'straining through a cloth' which is not effective according to the JMP. Some people are aware of the risks of the water as they complain of not being satisfied with the quality of their drinking water. Semi-structured interviews indicated that urban respondents assume that the sachet water and borehole/tap water they get from water vendors are safe for drinking and therefore don't need treatment. The rural respondents appeared to have a higher percentage of water treatment, but as most of the treatments are limited to straining water through a cloth, these treatments are not very effective. We can conclusively say that water treatment is not high

in both urban and rural areas and a good number of people are not aware of the risks of contamination.

Tertiary educated people in the urban areas (65%) and rural areas (21%); secondary educated ones in the urban areas (73%) and rural areas (36%); and primary educated in the urban areas (71%) and rural areas (33%) do not treat their water. Many people who drink sachet reported not treating because it does not need treatment. In the group that treat their water tertiary educated in urban (35%) and rural (79%), secondary in urban (27%) and rural (64%), primary in urban (29%) and rural (68%) that treat their water. Water treatment was higher in the rural areas possibly because they were not much into sachet water usage as their urban counterparts and also because they were prone to water diseases, were more into water treatment. Data on water treatment by education is provided in Figure 7.9.

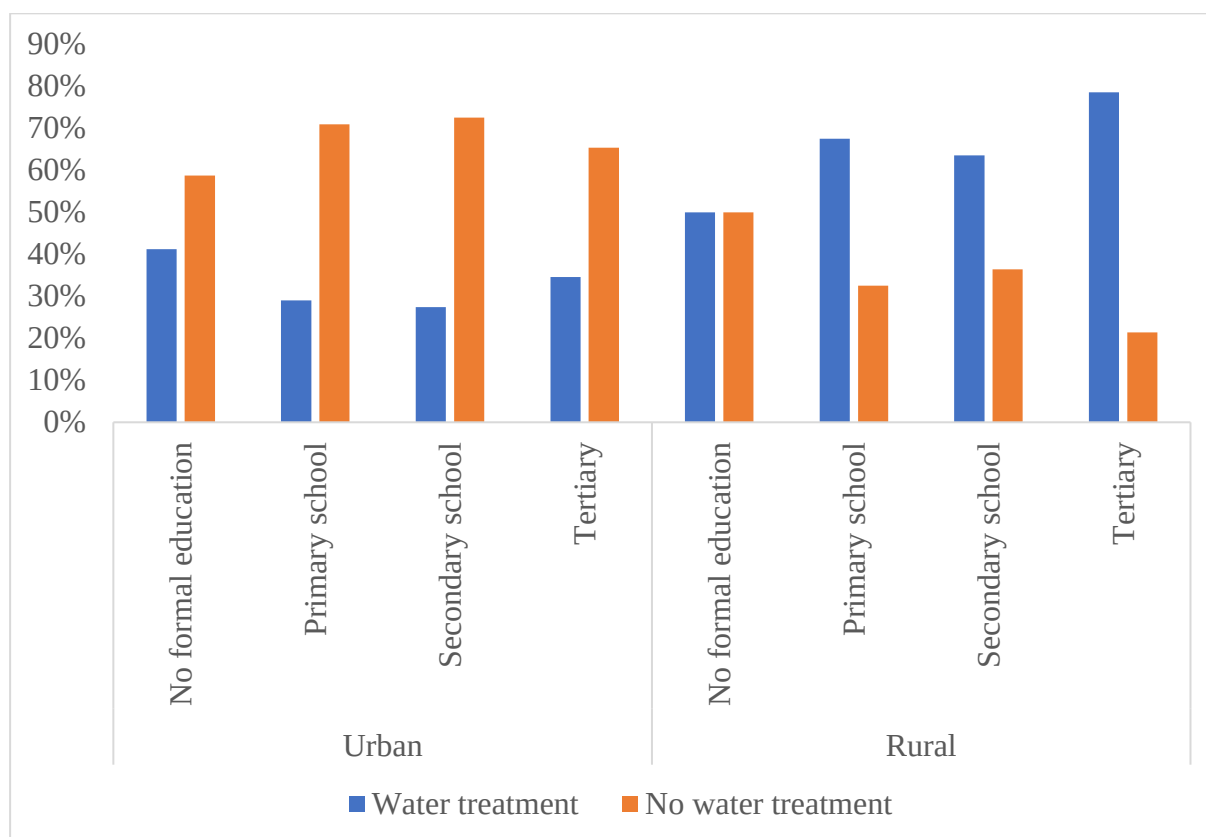


Figure 7.9 Water Treatment by Educational level

Source: Fieldwork 2016

As more educated people have higher access to improved water as reported by [Pande *et al.* \(2008\)](#), it could be expected that they would also be able to carry out good water treatment as the better educated would be more likely to have learnt about basic hygiene and clean water in school. In the fieldwork (during semi-structured interviews) many respondents reported having first received information about hygiene in school. However, it appears education has not helped much in this case. Even people who attended tertiary institutions reported straining their water through cloth as a form of treatment. This method is not sound according to the JMP. [Wolf *et al.* \(2014\)](#) reported that for household studies, filter interventions which also offer safe water storage such as ceramic filters bring about a significant reduction in diarrhoeal diseases but these are not common in the study sites. [Wolf *et al.* \(2014\)](#) also reported that a greater reduction in diarrhoea occurs from improving household water storage and combining the water intervention with hygiene education and/or improved sanitation rather than just through water interventions.

Treatment of water appears to relate to income as among the higher income group, 35% of rural respondents and 36% of urban respondents treat their water compared with 8% of rural and 5% of urban respondents in the low-income group who treat their water (Figure 7.10). There are cases of no water treatment among the higher income group. Again, partly the reason for not treating water may be the assumption that some drinking water sources such as sachet water (like bottled water), boreholes, etc. do not need treatment prior to drinking. These ‘non-needing treatment’ water sources are patronised by higher income groups. This was also highlighted in the semi structured interviews.

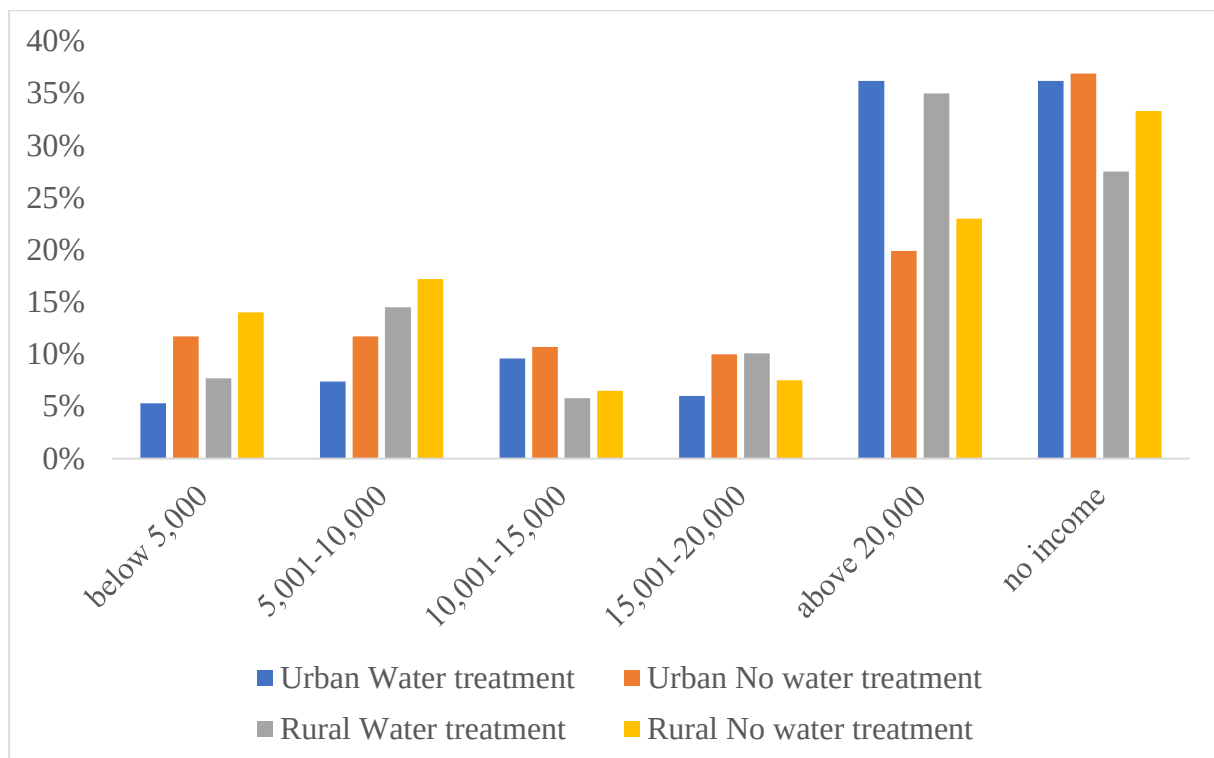


Figure 7.10 Water Treatment by Income level

Source: Fieldwork 2016

The fact that people treat even improved water attests to the fact that they are not sure of the safety or quality of the water sources. This tallies with the view of [Godfrey *et al.* \(2006\)](#) and [Bain *et al.* \(2012b\)](#) that improved does not necessarily mean safe. It is interesting to consider water treatment by source. Treatment of improved water was higher in the rural areas (87%) compared with 78% in the urban areas. Improved water sources were not treated by the urban people (88%) compared with the rural ones (90%). On the other hand, unimproved water sources were treated by 22% of the urban people and just 13% of the rural dwellers and not treated by 12% urban compared with 10% of rural dwellers. As earlier mentioned, urban people consume a lot of sachet water, which is recognised by consumers as treated and so needs no treatment. It is risky drinking some of the improved water sources without treatment and drinking unimproved sources without treatment as carried out by some urban and rural dwellers. Treatment by water sources (improved/unimproved) is shown in figures 7.11.

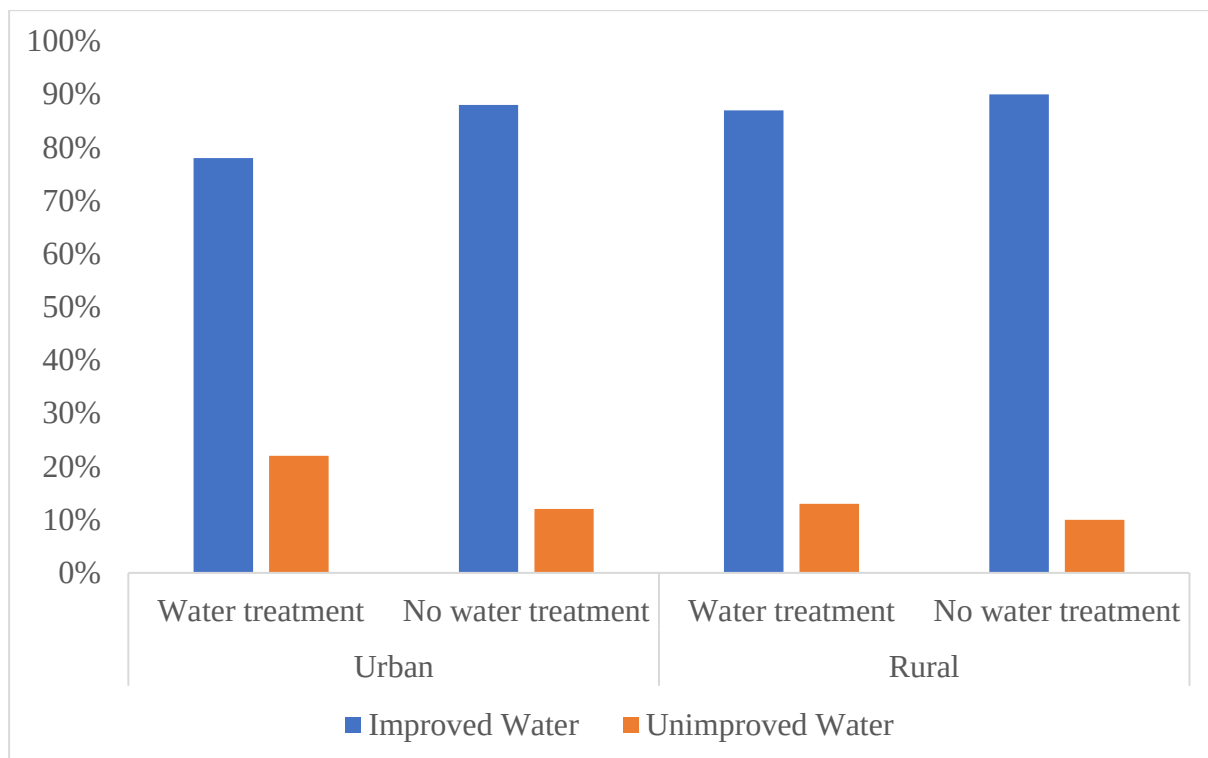


Figure 7.11 Treatment of Improved/unimproved Water Sources

Source: Fieldwork 2016

Wolf *et al.* (2014) reported the use of ceramic filters to have a substantial reduction on the incidence of diarrhoea diseases. This practice has been reported by many researchers with some estimates of reduction in diarrhoea such as (Brown *et al.* (2008a); Brown *et al.* (2009); Clasen *et al.* (2010); Clasen and Cairncross (2004); Clasen *et al.* (2004) and Preez *et al.* (2008). Therefore, filters should be more effective than straining water through cloth which is a common practice in the study sites. There was therefore not much difference in water treatment between improved and unimproved drinking water sources.

7.4.2 Health risks associated with drinking unimproved water sources.

Utsev and Aho (2012); Aper and Agbehi (2011); Maxwell *et al.* (2012) reported on water related diseases in Benue State. The incidence of water-related diseases was confirmed by respondents who reported that water related ailments affected them or their families. As mentioned earlier, access to improved water sources is low in the study areas, forcing people to drink water from unsafe sources and making them more susceptible to water related diseases.

In line with this, an attempt was made to find out if respondents or their family members had fallen ill in the last 12 months. The questionnaire showed that some people were affected. It can be seen from Figure 7.12 that a high proportion of illness is water related. This was confirmed at an interview with a staff member from the Benue Rural Water and Sanitation Agency (BERWASSA) who stated that most of the diseases in the state are water, sanitation and hygiene related. From Figure 7.12, it can be seen that 32% of rural respondents compared with 17% in urban areas reported that they or their family members had been affected with typhoid fever while 25% of rural respondents and 14% of their urban counterparts reported diarrhoea. Hepatitis, though affecting less than 4% in both rural and urban areas, was also reported but included with 'others' category. The 19% urban and 6% rural report of headaches could be from poisonous vehicular emission or something else, which is higher in urban areas. Generally rural people appear to be at higher risk, being evenly spread across the rural sites. This could be due to use of unsafe water sources and a limited treatment by straining drinking water through a cloth which is predominantly carried out in the rural areas. Also, rural people tend to be more at risk, partly because they have lower income and could not purchase the needed water treatment items, but also due to lower levels of education and awareness (Please refer to Figure 7.1 for education and Figure 7.2 for income). The information on diseases is presented in Figure 7.12.

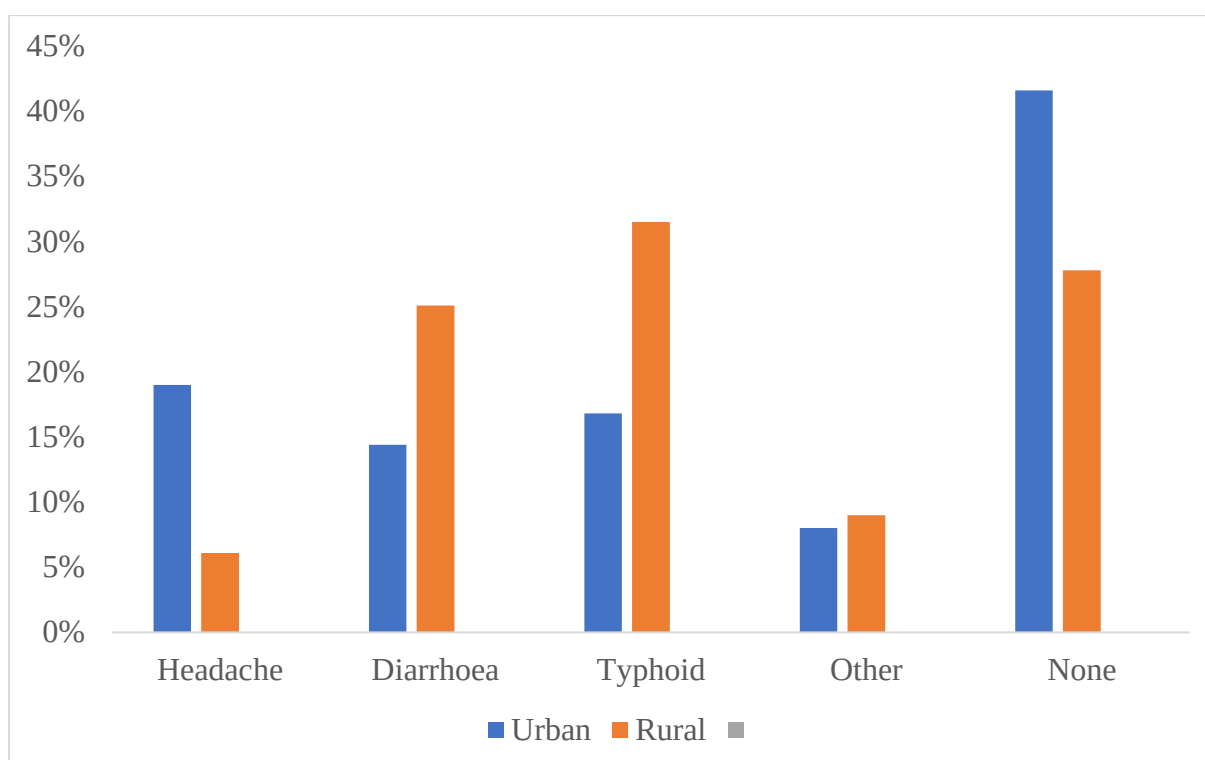


Figure 7.12 Diseases Suffered by Respondents

Source: Fieldwork 2016

7.4.3 Understanding good quality wells and drinking Water.

One of the objectives of the study was to explore stakeholders' understanding of water issues. Since well water is widely used in the study sites and forms an important part of the study, respondents were asked what they understand by a 'good well' and 'good drinking water quality'. The understanding of the respondents was that any protected or covered well is good. There was little mention of any contamination. This is in sharp contrast to reports of many researchers that covered or improved wells are not necessarily safe as reported by (Godfrey *et al.* (2006); Bain *et al.* (2012b); and Wright *et al.* (2016)). Although SDG monitoring has improved on earlier JMP approaches by considering the absence of faecal and chemical contamination, the old definitions remain in use for monitoring purposes as water testing is not yet widely practiced. In probing understanding of good quality well, respondents were asked, 'What makes a good quality water?' Many people described good water on aesthetic considerations. This tallies with the subjective or aesthetic assessment people give to water as described by Chapelle *et al.* (2009) in Chapter 2:. Despite these descriptions, there was limited

recognition that water regarded locally as good quality can still be contaminated. This shows there are quite poor levels of understanding about well water contamination amongst respondents that are likely to reflect the understandings of the broader population.

Good quality drinking water was perceived to be tasteless, colourless and odourless by 39% and 73% of respondents respectively in urban and rural areas while 24% of urban residents and 21% of rural respondents described good quality water as ‘clean water.’ 37% of urban respondents and 6% of rural ones consider treated/pure water as good quality water for drinking (Figure 7.13). This quantitative data was supplemented by qualitative data from semi-structured interviews, confirming the information and forming a strong evidence base.

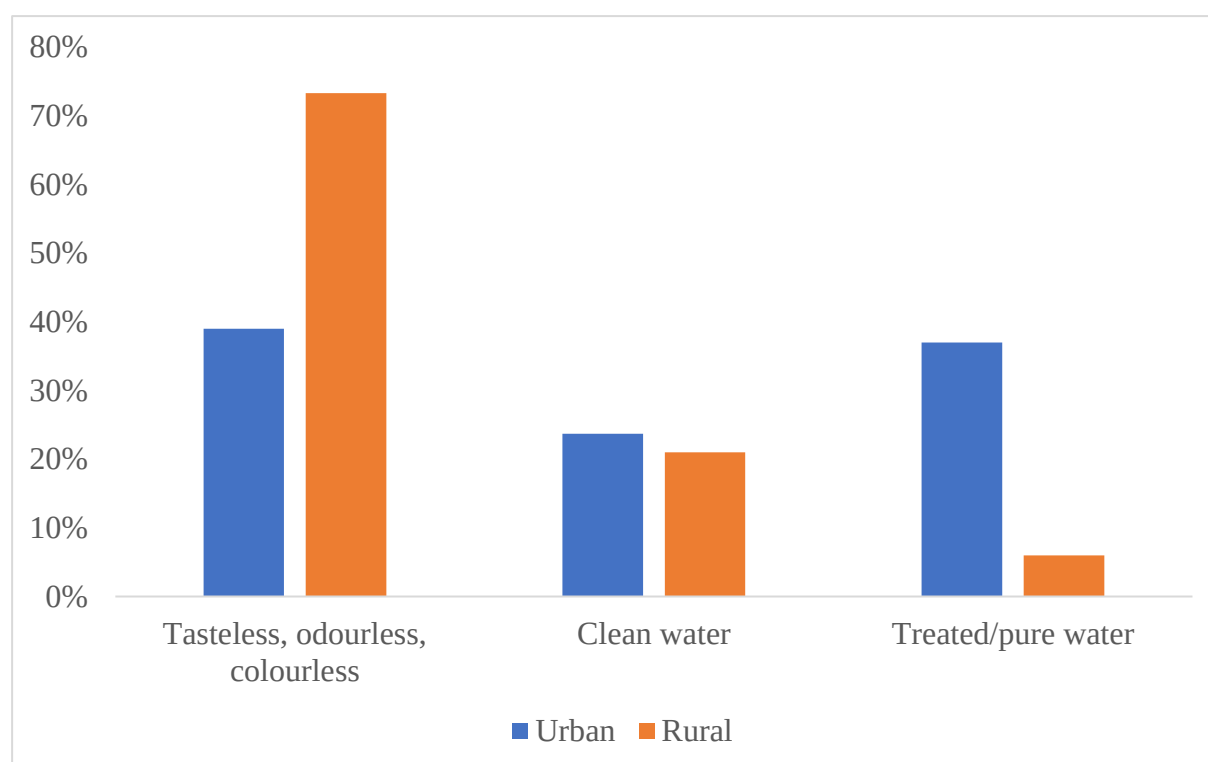


Figure 7.13 Good quality drinking water as perceived by respondents
Source: Fieldwork 2016

7.4.4 Awareness on Water Contamination Levels.

Odunsi (2018) reported that a human rights advocacy group, Socio-Economic Rights and Accountability Project (SERAP) demanded that the Minister of Water Resources should

explain “why Nigeria’s water and sanitation infrastructure has continued to deteriorate and millions of Nigerians resorting to drinking water from contaminated sources with deadly health consequences, despite the authorities claiming to have spent trillions of Naira of budgetary allocations on the sector since the return of democracy in 1999.” The report went further: “Millions of Nigerians (mostly children) lie sick, bodies ravaged by cholera, typhoid fever, dysentery among other diseases” ... “An estimated 194,000 Nigerian children under the age of five die annually from these preventable diseases.” It is clear that the problem of water contamination and the attendant consequences are not hidden, and many respondents were evidently aware of these issues. The questionnaire therefore sought to find out if the respondents were aware of the contamination of water sources in their environment. In particular, they were asked if they knew the causes of the diseases that affected them and/or their family members. Some 40% of urban and 66% of rural respondents identified poor WASH as a cause of diseases and 20% and 7% of the urban and rural respondents respectively identified mosquito bites and others as cause of sickness. There was therefore a fair understanding of diseases causes among the respondents, based on what the respondents reported as can be seen from the data presented in Figure 7.14. The rural people appear to be more aware of the fact that poor water could be the cause of diseases. This could be that the rural people were more affected by the water borne diseases (see section 7.4.2) and so their doctors/health workers could have educated them on the causes of the diseases. Information about awareness of the causes of diseases is found in Figure 7.14

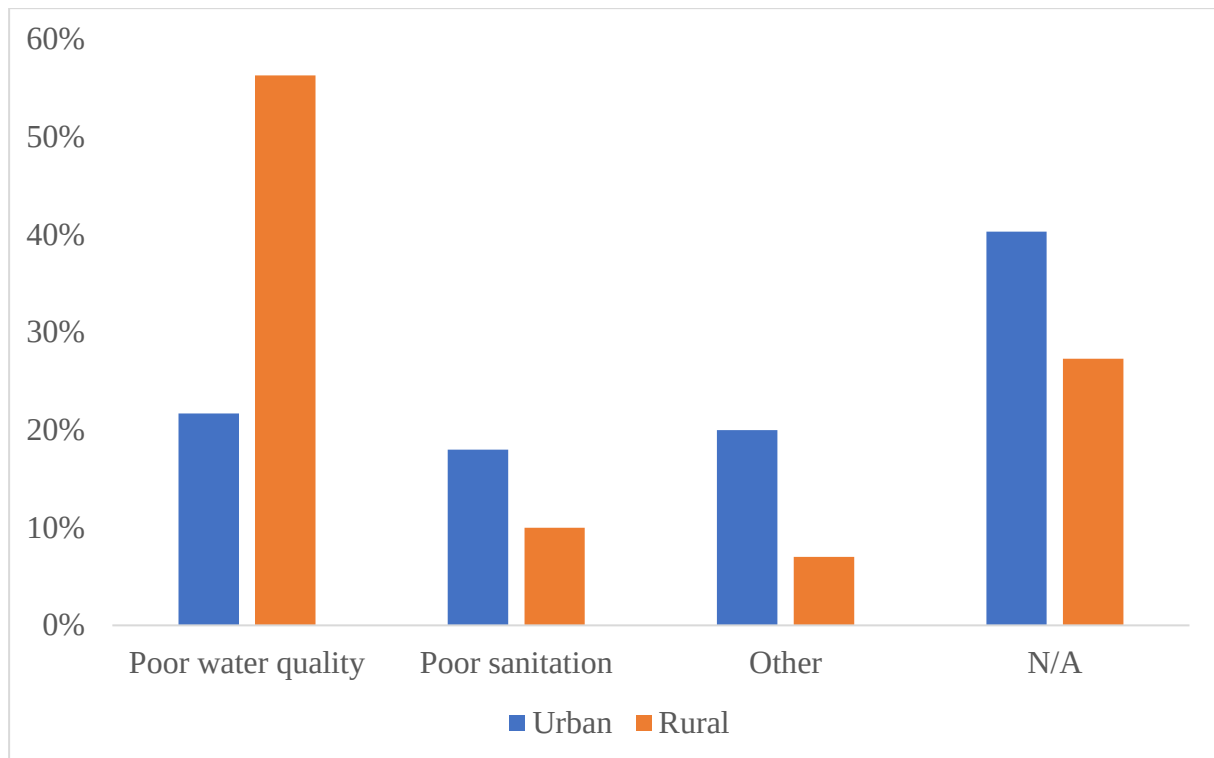


Figure 7.14 Awareness of causes of diseases by the respondents.
Source: Fieldwork 2016

7.4.5 Provision of potable water facilities by the government.

Odunsi (2018) reported that SERAP highlighted how “Successive governments have failed to improve affordability of water for millions of low-income Nigerians, thereby denying them access to water... This dearth of water also affects sanitation. The large number of broken down water facilities across the country has hindered effective water supply to the citizens.” In the pilot field interaction with Federal and State agencies involved in water and sanitation, these agencies reported having responsibilities in water and sanitation provision. While there is low coverage in the study areas, these agencies shoulder the responsibility of providing water. For their activities to be questioned by the human rights group is an indication that people are not satisfied with their performance. In order to obtain local perceptions on these issues, at the end of the survey, respondents were asked to suggest possible solutions to the problems they faced. Most of the respondents saw government provision of potable water as an important priority as shown in Figure 7.15. It highlights how 28% of urban and 54% of rural respondents view

unavailability of potable water supply as a major problem in the study areas that needs to be addressed. A few others (22% in urban and 9% in rural areas) reported that the use of improved sanitation and practice of hygiene would be helpful in minimising diseases. Therefore 50% of urban people and 63% of rural people suggested WASH related solution to their problems. That is why a majority are of the view that if improved water supply is available, most water related diseases would be minimised. The study shows that access to improved water is poor in both the rural and urban areas. The percentage of respondents with access to improved water is exaggerated due to some definitions by JMP as to what constitutes improved and unimproved drinking water sources (O'Hara *et al.*, 2008; Kvarnström *et al.*, 2011). For instance, covered/protected wells are considered as improved drinking water sources but as chapter 6 demonstrates, the water obtained from such sources is often contaminated. The government has not lived up to respondents' expectations with regard to providing potable water as part of their civic responsibility to provide public utilities. This is associated with health risks and respondents were of the view that if potable water is supplied, the situation would improve (Figure 7.15).

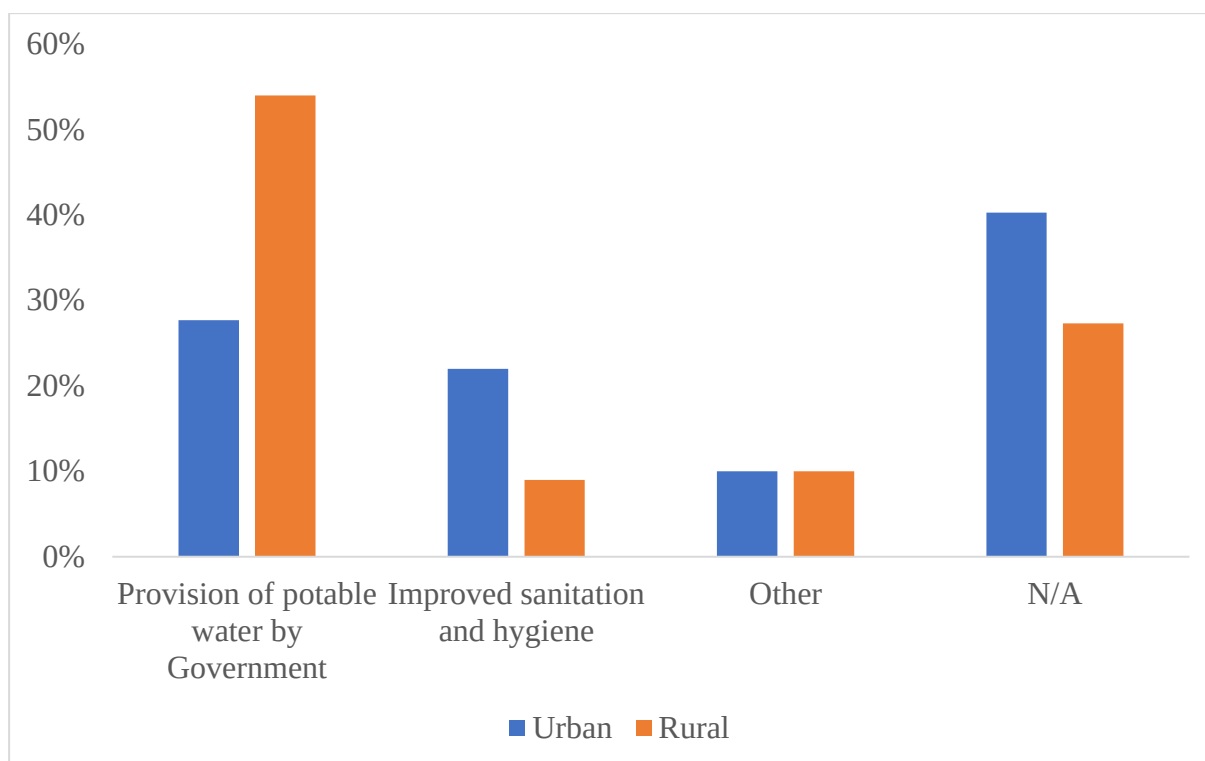


Figure 7.15 Respondents' Suggested Solution Strategies
Source: Fieldwork 2016

7.5 Sanitation

7.5.1 Improved Sanitation Definitions based on MDGs and SDGs.

As mentioned in the introduction, JMP criteria were included in the questionnaire design to get information on access to improved sanitation among other things. The JMP MDG definitions of improved/unimproved sanitation suggest that 'Facilities that hygienically separates human excreta from human contact are considered to be adequate'. The facilities that meet these requirements are termed 'improved' and those that do not are 'unimproved'. Examples of improved sanitation facilities include: Flush/pour flush to piped sewer system, septic tank, pit latrine, Ventilated Improved Pit (VIP) latrine, pit latrine with slab and composting toilet. According to the JMP, a response of "flush/pour flush to unknown place/not sure/DK where" is taken to indicate that the household sanitation facility is improved, as respondents might not know if their toilet is connected to a sewer or septic tank". The unimproved sources on the other hand include flush/pour flush to elsewhere, pit latrine without slab, bucket, hanging

toilet/hanging latrine, shared facilities of any type, no facilities or bush or field. To determine whether households use an adequate sanitation facility, the JMP question ‘What kind of toilet facility do members of your household usually use?’ is asked. This same question was used in the survey and the responses are summarised.

As for water, the MDGs for sanitation were transformed into the SDGs. Many countries including Nigeria did not meet the sanitation goal as reported by [Abubakar \(2017\)](#). While there has not been much change to the definition of improved/unimproved, the SDGs targets are more ambitious. ([World Health Organisation and United Nations Children's Fund, 2017a](#)). The sanitation related target 6.2 aims to: “achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations”. The sanitation system in Nigeria and the study sites is poor.

In light of this, the Punch Nigeria national newspaper online edition reported that WHO quoted a human rights group as expressing “serious concern that millions of Nigerians do not have access to clean and potable water and adequate sanitation.” The unavailability of water also affects sanitation, and this explains why flush toilets are sometimes problematic. Even some that have flush toilets are unable to use them due to the scarcity of water. In addition, the regulatory responsibilities that are supposed to go with sanitation are not carried out. Eighty one percent of urban dwellers use pour flush toilet facilities which is very similar to the situation in rural areas where the figure was 58% (with most flushing to septic tank or pit), while 18% and 15% respectively of urban and rural dwellers use pit latrines with slabs. Central sewer systems are non-existent in the study sites. Pit latrines without slabs were very rare among urban respondents but are more common in rural areas (25%). This is because many rural people do not have the resources to build better toilets and the soil conditions allow the construction of such toilets in contrast with the urban areas where they can easily collapse due to sandy soil

conditions. The figures for improved sanitation are not representative of the population as a whole as sampling was deliberately carried out in compounds with latrines and wells to investigate possible cross contamination between latrines and well water. Thus, other unimproved facilities like ‘no facilities or bush or field were not directly investigated in this survey and so the proportion of unimproved facilities being used is under-represented. It is also important to clarify here that all the sanitation facilities investigated in the study were ‘pour flush’ to pit and septic tanks as pit latrines were the target of the research and no ‘flush’ systems were identified in the sample. The pour flush and pit latrines with slab are improved sources while pit latrine with out slab and others are unimproved sanitation facilities.

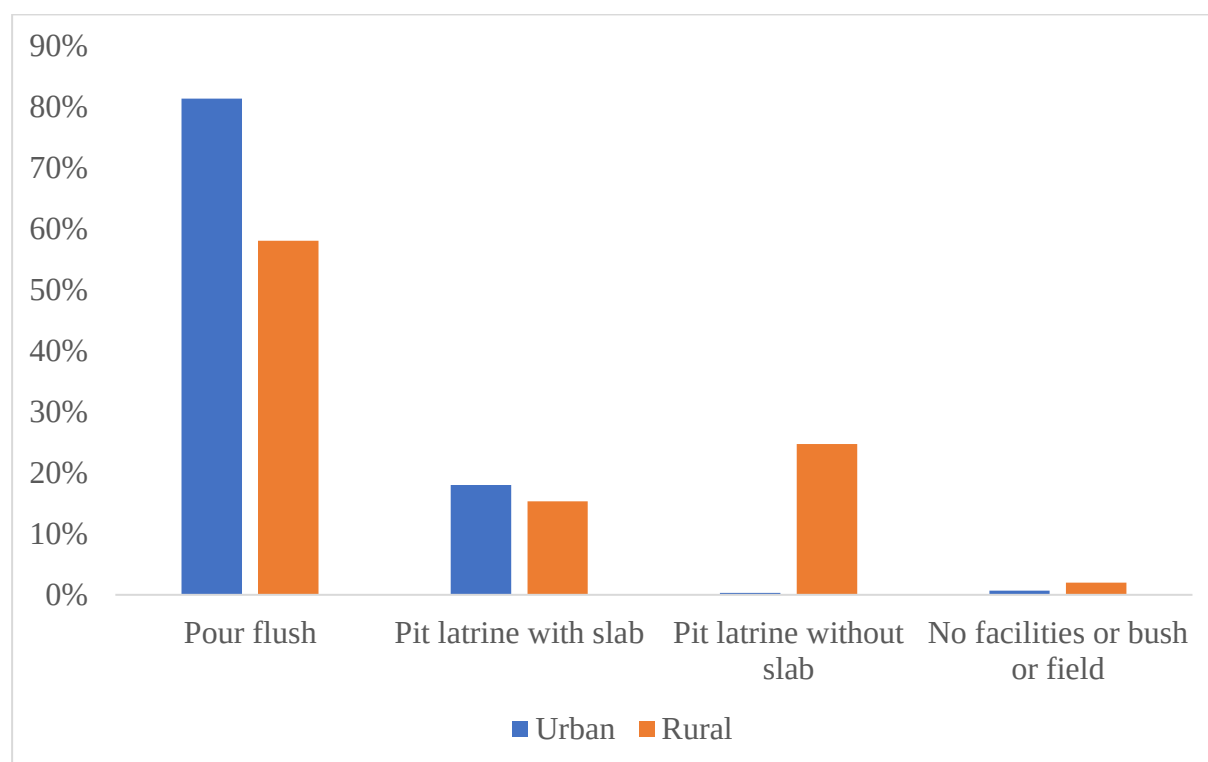


Figure 7.16 Household Toilet Facility
Source: Fieldwork 2016

Data were also collected on toilet facility based on educational level. These data are presented in Figure 7.17. [Abubakar \(2017\)](#) noted that the more educated people use better and improved toilet facilities than the less educated ones. This is confirmed in the studies as more educated people use better toilet facilities and less educated use less good and unimproved facilities. In

the urban areas apart from secondary school leavers having 3% access to unimproved facilities, all the groups had access to improved sanitation facilities. In the rural areas, tertiary educated people (82%) compared with 62% of those with primary education used improved sanitation facility. While access to unimproved is higher in among the primary school leavers (38%), the figure is less (18%) among those who attended tertiary school. None of the higher educated group used unimproved facilities in the urban sites (Figure 7.17). Further, a chi-square test of independence was used. As earlier mentioned, this test is used to explore the relationship between two categorical variables, where each case can have two or more variables. In this case it was used to check for association between educational attainment and access to improved toilet facilities. The test indicated a significant association between education and toilet facilities used, $X^2 (16, n=600) = 60.68, p=.00$, Cramer's $V=.16$. The interpretation of this is there is a significant association between educational attainment and improved toilet access. In other words, the level of access to improved toilet facilities is influenced by educational level. The effect size though is small (.16). In comparing urban and rural areas, there are differences as the uneducated in rural areas use unimproved facilities more than their urban counterparts. In summary, education influences access to improved sanitation facilities with the more educated having higher access to improved sanitation facilities than the uneducated ones.

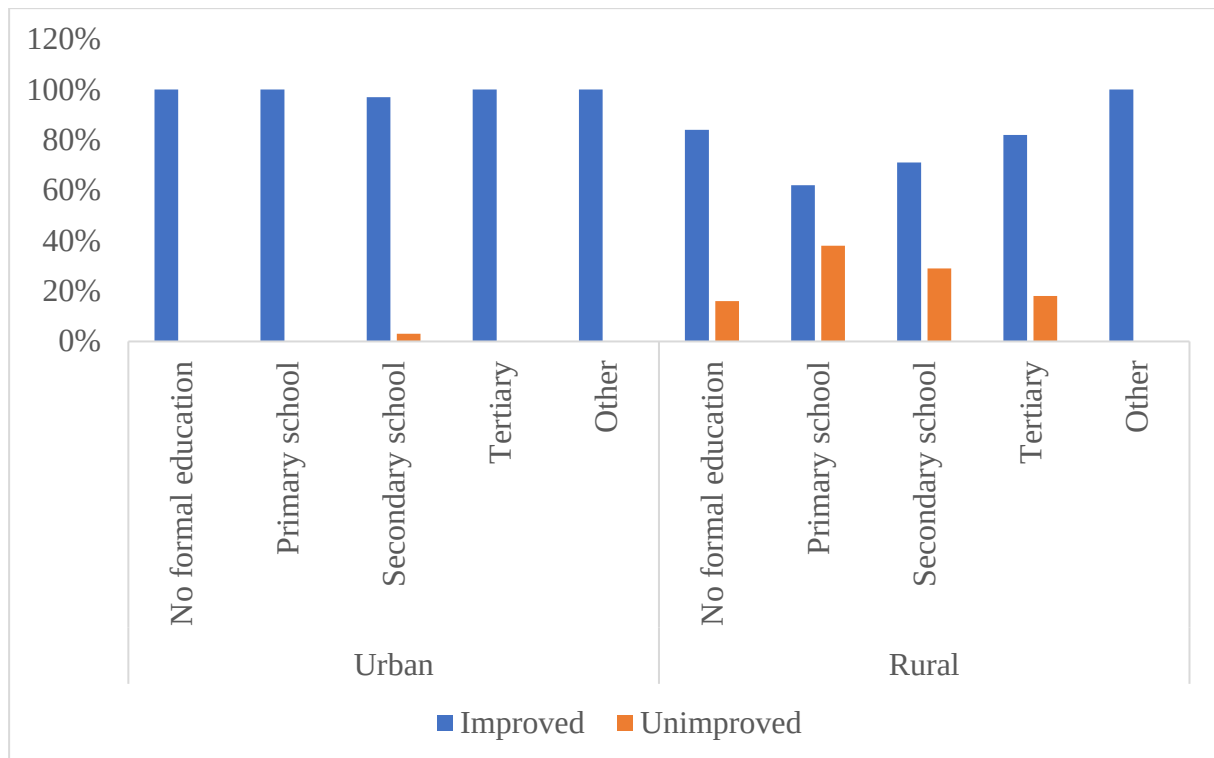


Figure 7.17 Household Toilet facility according to Educational level

Source: Fieldwork 2016

[Isunju et al. \(2011a\)](#) linked income to houses with good toilet facilities as some poor landlords could not provide the services. On the other hand, the poor tenants cannot afford to pay for expensive accommodation where the toilet facilities are better.

As shown in Figure 7.18, 98% of the higher income group (above N20,000) use improved sanitation facilities in the urban areas compared to 80% in the rural areas. Generally, the urban areas were advantageous in terms of improved sanitation as even the low income had access to improved facilities. In the rural areas, while 80% of the higher income had access to improved sanitation, lower income groups (N5,001-10,000) had access of 59%. While the higher income had access of 20% to unimproved sanitation facilities, those in the lower income group in the same rural category 41% access. Therefore, the urban areas have more advantages than their rural counterparts as the use of unimproved facilities were almost non-existent in the urban areas. The fact that 99% of ‘no income’ group had access to improved sanitation facilities could be explained by this group being made up of students and dependents staying with friends and

relatives in houses with improved sanitation facilities (Figure 7.19). The income level therefore determines the use of facilities to some extent. The next chart provides information on distribution of toilets by income.

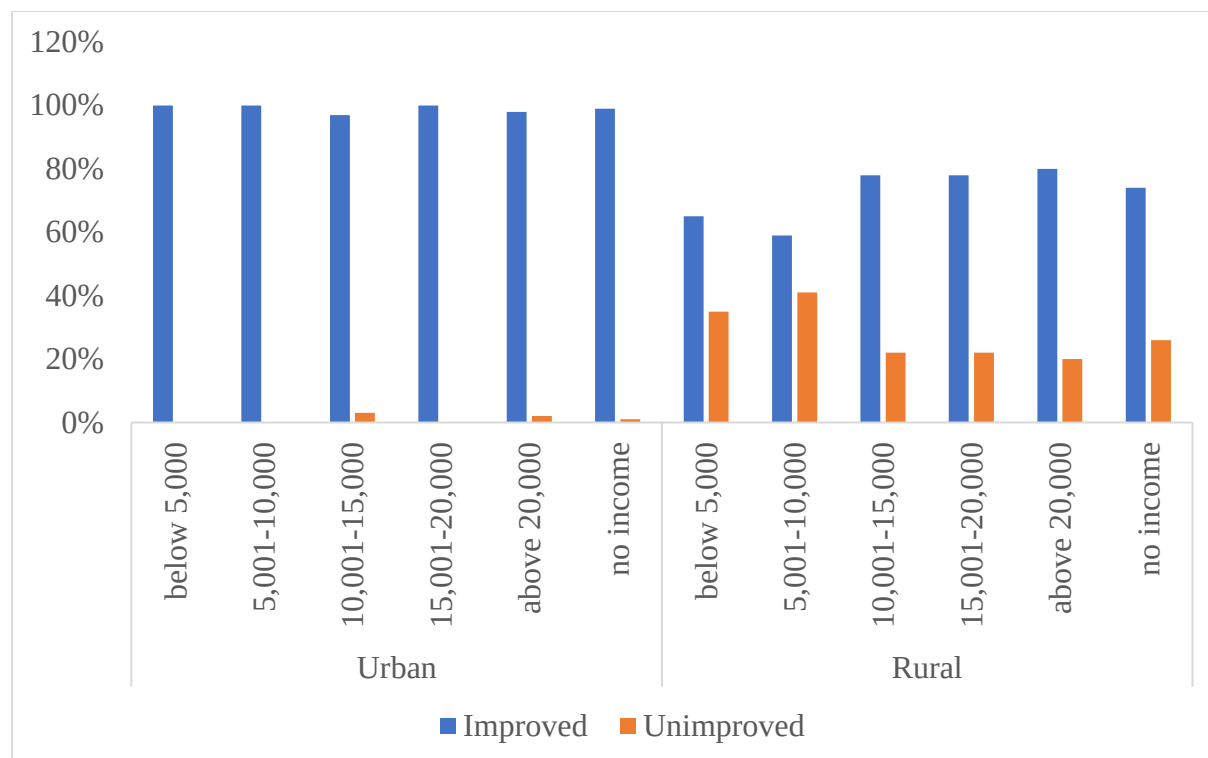


Figure 7.18 Household Toilet Facility based on Income level
Source: Fieldwork 2016

7.5.2 Toilet Sharing

Under MDG monitoring systems, the JMP does not consider shared toilet facilities as ‘improved’. In the SDGs, the use of shared facilities is classed as ‘limited’ on the sanitation ladder. [Ndikumana and Pickbourn \(2017\)](#) reported that in 2015, no country in SSA was able to meet the target of halving the population without access to safe sanitation. The [World Health Organisation and United Nations Children's Fund \(2015\)](#) reported that about 70% of the population do not have access to improved sanitation facilities. In terms of sharing [Isunju et al. \(2011a\)](#) reported the proportion of people sharing toilet facilities is higher in SSA than anywhere in the world. The authors also stated that sharing in urban areas is higher than in rural areas by more than three times. The concerns raised by the JMP over shared facilities are that

they can be unhygienic. [Isunju *et al.* \(2011a\)](#) reported more health risks in slums than less crowded areas. To capture data on sharing, the JMP core WASH questions ask: ‘Do you share this facility with other households?’ The essence of this question is to determine if a household uses an improved sanitation facility as shared facilities are considered limited. The concerns about shared facilities are that if a toilet facility is shared between many households, there is a greater possibility of faeces being found on the floor, walls and in other areas accessible to flies. The urban sharing status is higher because people migrate into urban centres for employment opportunities increasing the pressure on the limited resources. Also, with Makurdi being the state capital with access to higher and tertiary education facilities, it attracts a lot of students, which increases the proportion of shared facilities.

Another indication of access to improved sanitation is the number of people sharing the toilet. The JMP acknowledges that in urban areas and apartments, several households normally share a facility. For classification purposes I have grouped sharing categories into 1-3 households, 4-9 households, and 10 and above households sharing a facility.

The chart in Figure 7.19 shows that 49% rural dwellers compared to 21% of urban respondents use toilets shared between 1 and 3 households while 32% urban and 11% rural respondents use toilets shared between 4 and 9 households. Toilets shared with up to 10 or more other households were used by 47% of urban respondents and 40% of rural respondents. If the 4-9 group is merged with the 10 and more households group, then 79% of urban respondents and 51% of rural respondents use facilities shared by 4 or more households. Findings from the study areas echo results from the DHS data (see Chapter 5: section 5.10.3) which shows poor sanitation access in the study areas. The trends in Figure 7.19 show only low or high sharing status in the rural areas while the urban trends show increase in 1-3 households and 10 and over households’ categories. The reason for this could be that while sharing between 1-3 households is common in the rural sites, 4-9 households sharing a toilet is less common while scenarios of

10 and more households sharing a toilet tends to be found in big compounds being shared by many tenants where each tenant and their dependants form a household. Conversely in the urban areas, the sharing status is consistently high due to population concentration, with more medium income housing with compounds more occupied. In the urban situation, many households could be in a compound characterised by heavy sharing of sanitation facilities. The chart relating to sharing of sanitation facilities is presented in Figure 7.19.

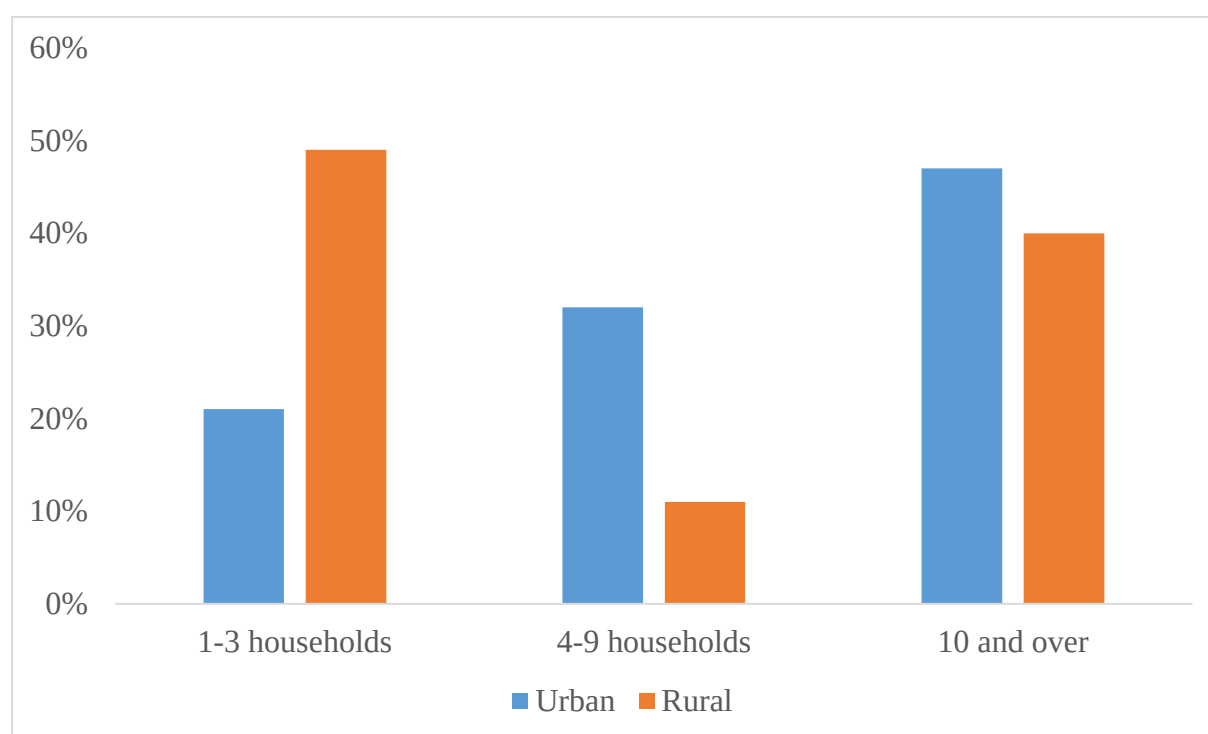


Figure 7.19 Number of households Sharing Toilets
Source: Fieldwork 2016

7.5.3 Toilet Sharing Status based on Educational Level.

Although [Abubakar \(2017\)](#) observed that more educated people use better sanitation facilities, data from the study indicates a different picture. This could better be explained by the forces of demand and supply as earlier noted by [Isunju *et al.* \(2011a\)](#). Education often has an influence on people's lifestyles, and this may include preferences for particular sanitation facilities and views on sharing toilet facilities. This is because they might have learnt about hygiene in school and should be generally exposed to knowledge about sanitation and hygiene related issues. However, this tendency may be limited by economic and employment circumstances that can

force more educated groups to adopt poorer sanitation facilities than they would like. For example, a well-educated, but jobless person cannot always afford accommodation with good sanitation facilities. In the study sites, the sharing status is higher in urban areas probably because of students and unemployed graduates and other dependents (Figure 7.20). It can be seen that those educated to tertiary (62%), secondary (71%) and primary level (77%) were sharing toilets in urban areas compared with 51% in tertiary, 71% in secondary and 62% in primary who share toilet facilities in the rural areas. Ordinarily one would expect a lower percentage of the higher-educated group in the sharing category, but as earlier mentioned, the influence of education could be limited in circumstances where economic factors and influences prevail.

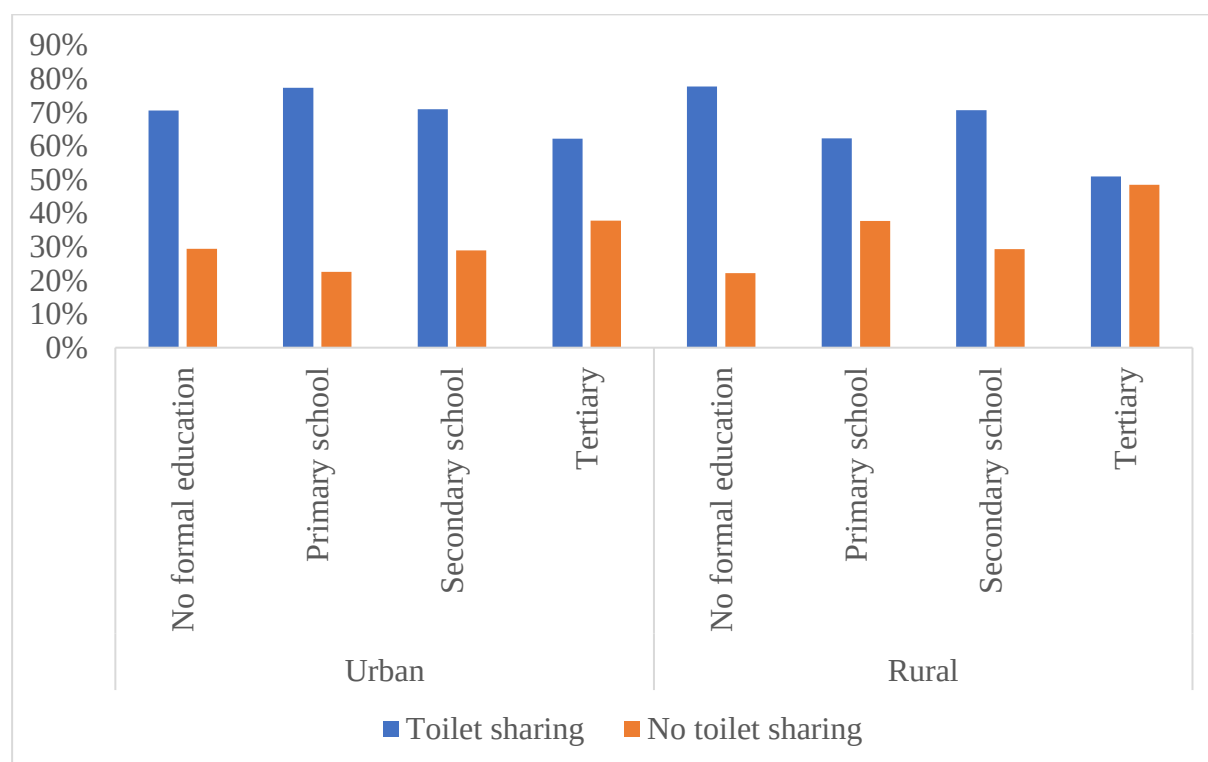


Figure 7.20 Toilet Sharing Based on Educational Level

Source: Fieldwork 2016

7.5.4 Toilet Facility Sharing and Income Level.

This demographic variable is very important as it has a strong influence on people's ability to demand goods and services. In relation to sanitation and hygiene, income determines one's ability to rent or own decent accommodation with standard facilities like water closets. In the

study sites, these data indicated that those with higher incomes were marginally more able to access better sanitation services. This was probably due to economic factors (Isunju *et al.* (2011a). Although there were some sorts of sharing of sanitation facilities across all income groups, it was slightly higher among the low-income earners, especially in the urban sites. For instance, the lower income group had 76% in sharing category in the urban areas compared with 72% in the rural areas. While the higher income in the rural areas (46%) were not sharing, the urban figure was 39% (Figure 7.21). The lower income category respondents were more involved in toilet sharing which is expected due to economic limitations associated with getting accommodation with better toilet facilities. Sharing of sanitation facilities was also higher in the urban areas due to population and economic pressures. This information is found in Figure 7.21.

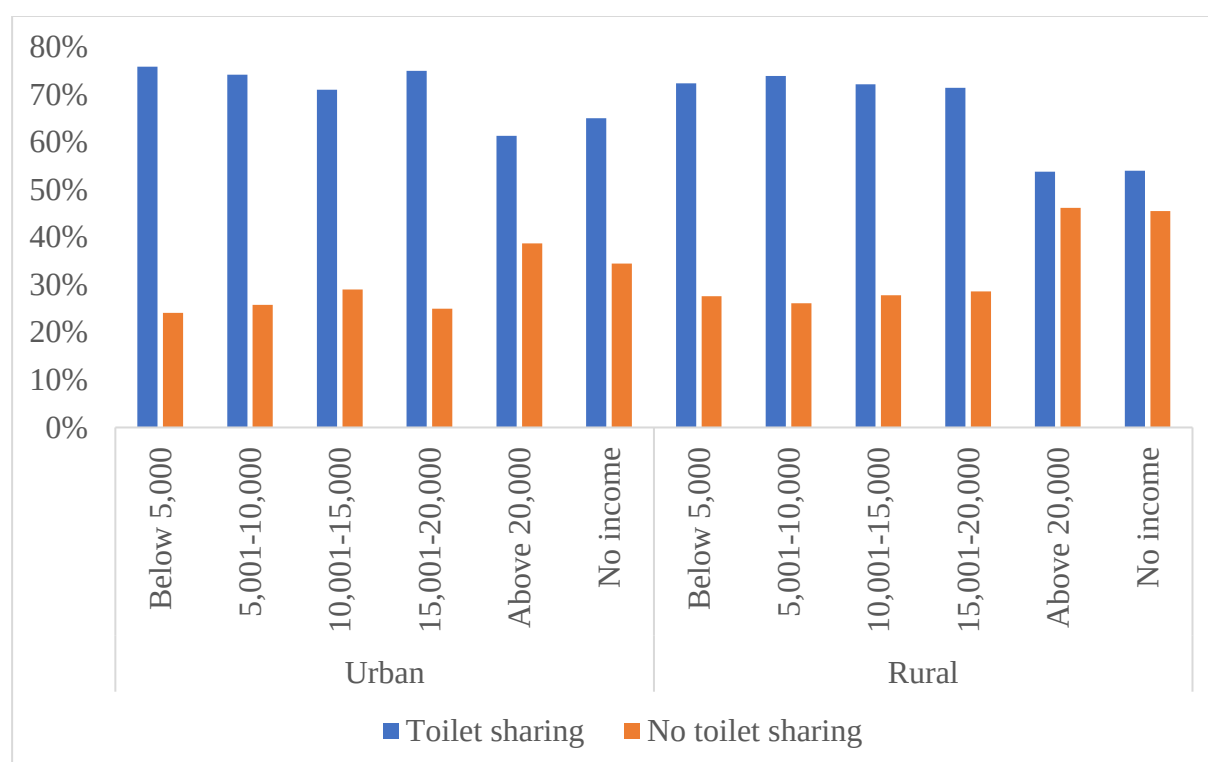


Figure 7.21 Toilet Sharing based on Income Level
Source: Fieldwork 2016

7.5.5 Toilet Sharing Status according to Educational level

Although educational level may be expected to be linked to improved sanitation access and toilet sharing status, this is not always achieved due to the economic implications mentioned above. For example, people who are unemployed and under employed may find it more difficult to afford accommodation with good sanitation facilities. Consequently, they may go for cheaper options in compounds that have many tenants with a limited number of toilet facilities, with resultant high toilet sharing status. This could possibly be the case in the study sites as higher educated people still have high toilet sharing status.

In the category of over 10 households sharing a facility, those with higher education accounted for 52% in urban areas compared with those with secondary education (44%). In the rural areas, 30% of secondary educated people shared compared to 48% of those with tertiary education in the over 10 households sharing category. There were only 31% and 36% respectively with tertiary education and secondary education falling into the toilet sharing category of between 4 and 9 households in the urban areas compared with 8% of those with tertiary education and 11% with secondary in the rural areas in the same category. Only 17% of the higher educated respondents and 20% of secondary school leavers fell into the category of persons sharing toilets facilities with between 1-3 households in the urban areas compared to 44% of those with tertiary education and 59% with secondary in the rural areas in the same category. As mentioned earlier, this is likely to reflect financial constraints, as cultural norms do not necessarily encourage toilet sharing.

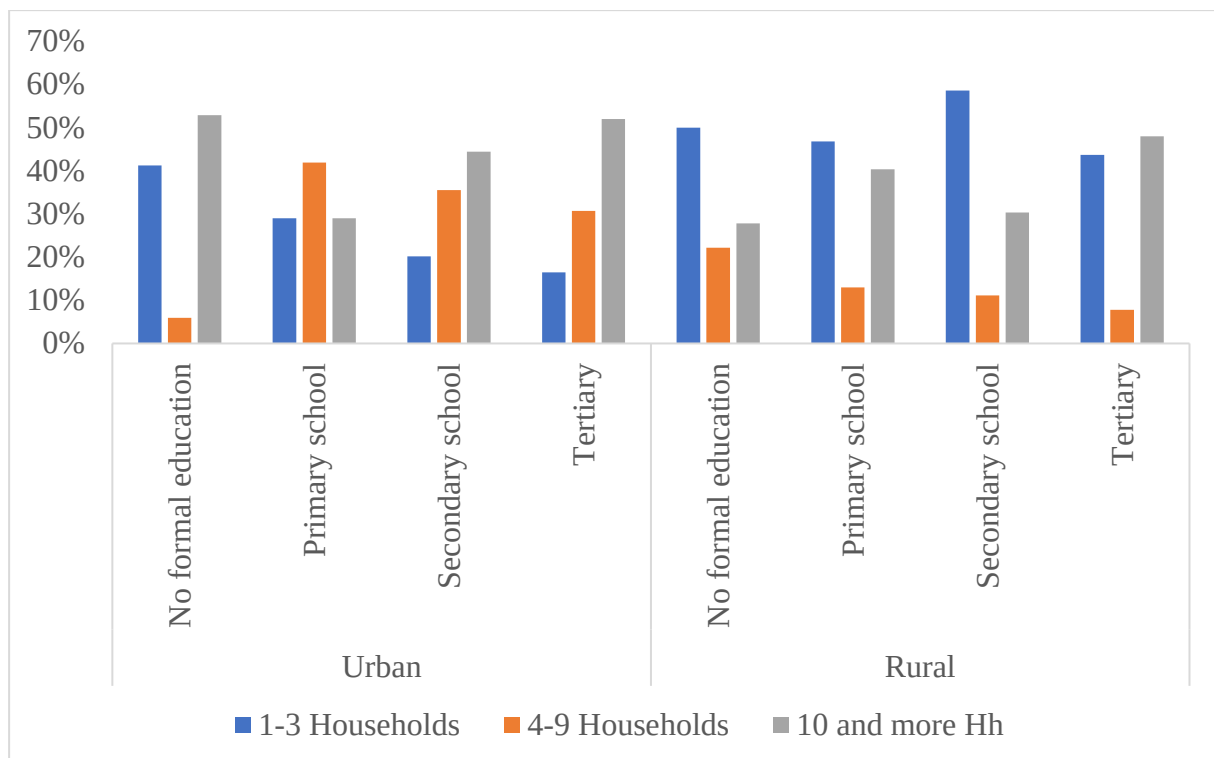


Figure 7.22 Toilet Sharing Status according to Educational level.
Source: Fieldwork 2016

7.5.6 Toilet Sharing Status and Income Level

The fact that high income earners still share could reflect their inability to afford accommodation with non-shared facilities (Pande *et al.*, 2008; Abubakar, 2017). Income level influences people's lifestyles. For instance, if someone has a good income, it is easier for them to rent or build a house without shared toilet facilities. That is why accommodation that does not have a shared toilet (called self-contained) are very much more expensive than compounds with shared toilets. In the questionnaire, many respondents expressed dissatisfaction with their toilets because they were shared with many households.

From Figure 7.23, it is clear that 51% of respondents from the no income group and 48% of those earning above N20, 000 share toilets with 10 and more households in the urban areas. 35% from the no income group and 28% of those with higher incomes share toilets with between 4 and 9 households while 24% with higher incomes and 14% from the no income group share toilets with between 1 and 3 households. In the rural areas 47% of those with higher

income share toilets with 10 or more households, compared with 45% of those with lower incomes. The higher income group falling into sharing between 1-3 households account for 45% and only 9% in the 4-9 households sharing category. The higher income earners share even more than the lower income earners. Generally, the toilet sharing status is higher in the urban than rural sites of the areas. The reason for this is not clear, but as already suggested, it may be due to financial constraints which leaves people unable to demand accommodation with better sanitation facilities. Information on income level with respect to toilet sharing is presented in Figure 7.23.

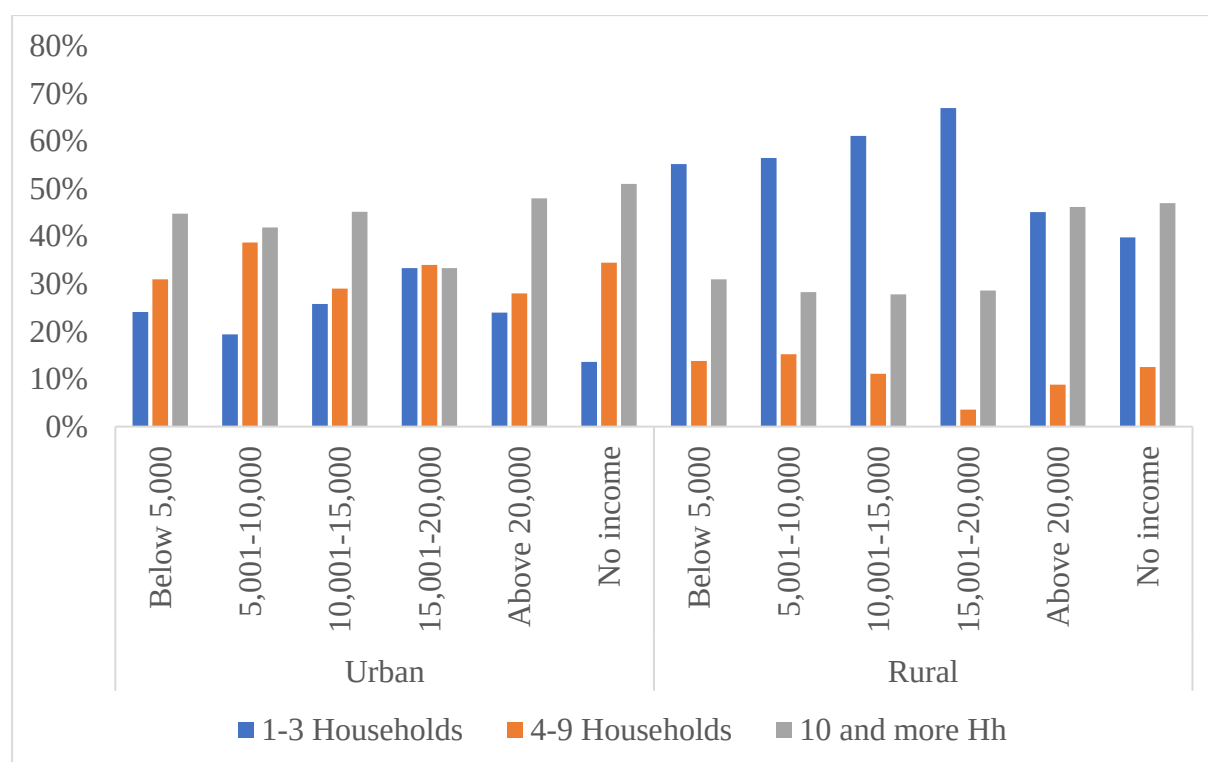


Figure 7.23 Toilet Sharing Status based on Income level
Source: Fieldwork 2016

7.5.7 Disposal of Children's faeces.

The JMP is also interested in how faeces of children are disposed of. This is important because it is easy for children's faeces to contaminate the immediate household environment. The JMP's recommended question on this topic is 'The last time (name of youngest child) passed stools, what was done to dispose of the stools?' and was used in the survey. Some people feel that

childrens' faeces could not be harmful (interview with BERWASSA March 2016) and would not bother to wash hands after cleaning a child and quoted: 'Some people think the child's faeces is not bad or whatever, but it is not like that so whether adult or child, if you come in contact with faeces, it is good for you to wash your hands before you eat.' Some people are constrained by a lack of water, an environmental constraint, sanitation facilities and some by a lack of knowledge about the health risks presented by faeces as noted by Dreibelbis *et al.* (2013a) and Dreibelbis *et al.* (2013b).

Based on these data it can be seen that amongst the survey population 40% of urban dwellers compared with 28% of rural dwellers reported they put or rinsed the stool into the toilet. This is an acceptable way of disposing of children's faeces according to JMP. 15% urban dwellers compared to 28% rural dwellers said the children used a toilet. Those in the rural areas who threw stools in the garbage or drain amounted to 19% compared to 15% in the urban areas. The results are shown in Figure 7.24.

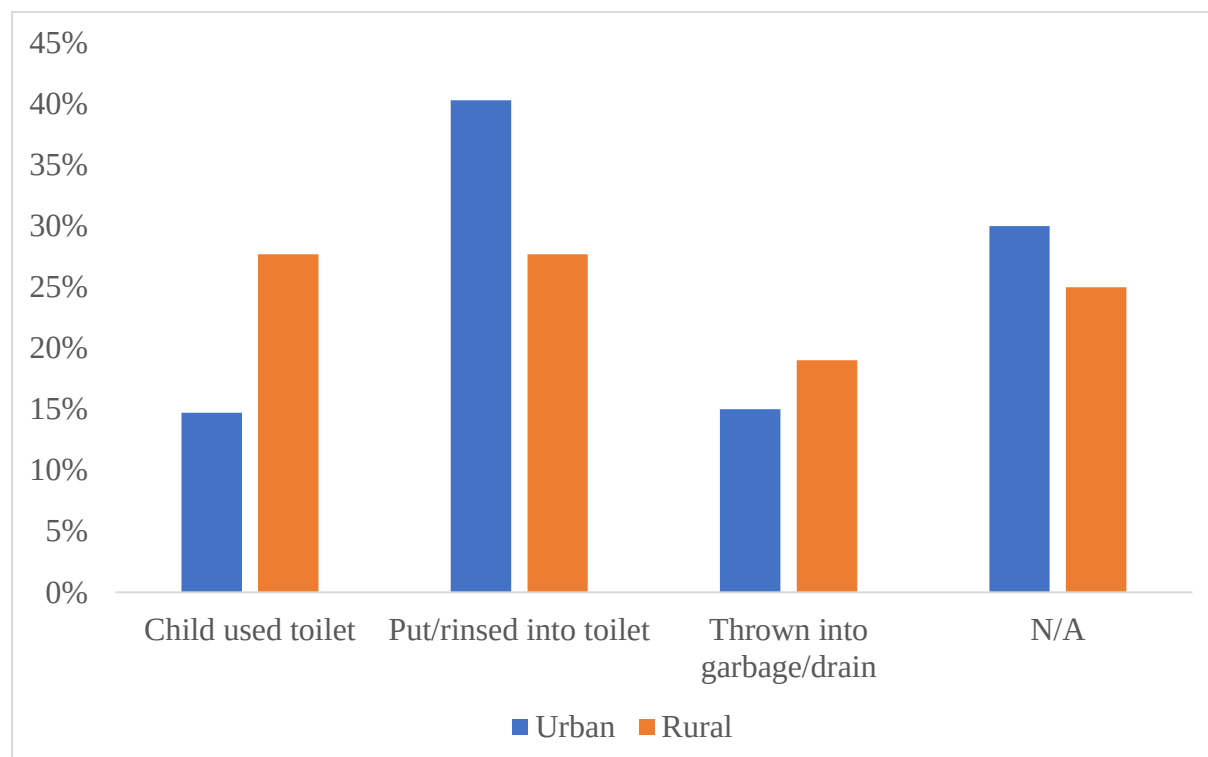


Figure 7.24 Child's Stool Disposal
Source: Fieldwork 2016

7.6 Environmental Awareness Matters

7.6.1 Understanding of risks of poor Environmental quality.

In Nigeria and Benue State the government and local people are fairly aware of the risks of poor environmental quality. That is why a good number of people feel dirty surroundings could be harmful in one way or the other. The government agencies also acknowledged these during interviews. Many researchers have linked waste to water contamination such as [Oyeku and Eludoyin \(2010\)](#); [Akinbile and Yusoff \(2011\)](#); [Longe and Balogun \(2010\)](#); [Balogun *et al.* \(2017\)](#) and so respondents were probed on this matter. Although this is not one of the JMP questions, understanding wider environmental risks forms part of the objectives of the study, so efforts were made to assess peoples' understanding of these. From the survey it appears people are aware of some risks associated with poor environmental conditions. According to these data, 82% of respondents in urban areas and 28% in rural areas agreed that poor environmental conditions could cause diseases while 65% of rural and 5% of urban dwellers reported that poor environmental conditions could harbour dangerous animals. These data show that the people are fairly aware of the problems associated with poor environmental conditions. Their responses are summarised in Figure 7.25.

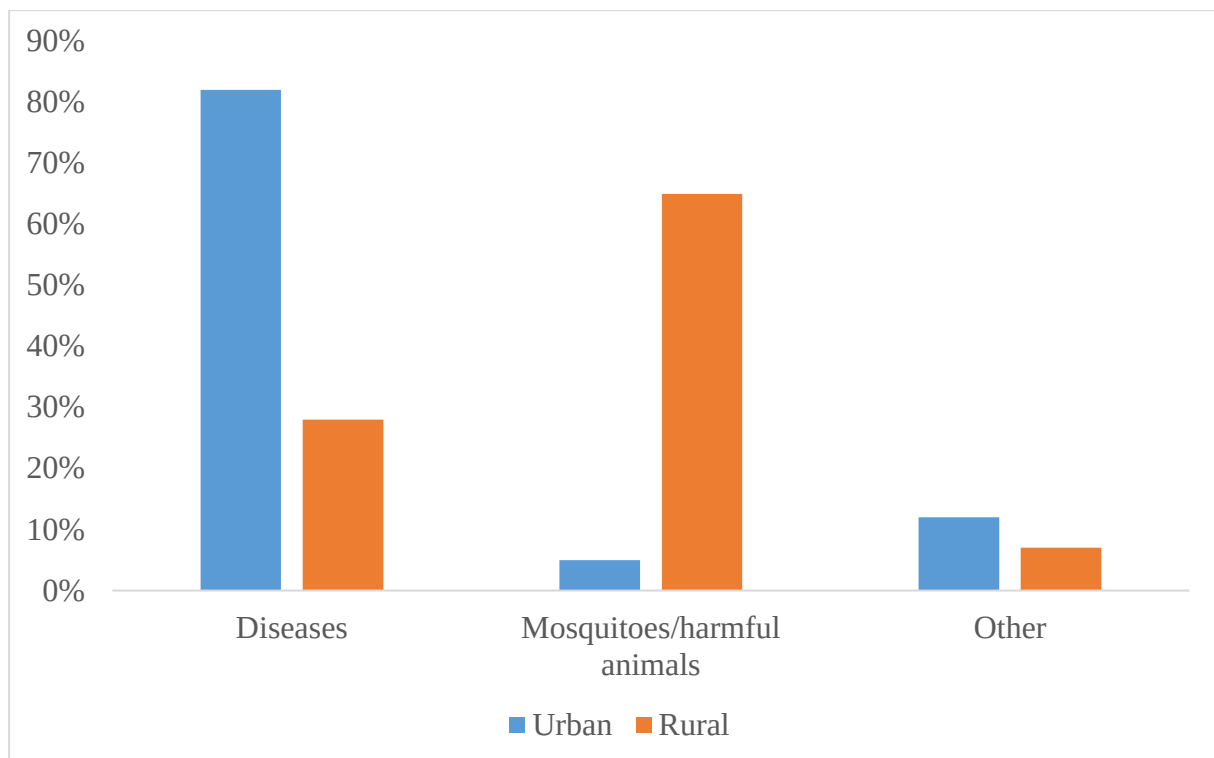


Figure 7.25 Examples of problems associated with poor Sanitation
Source: Fieldwork 2016

7.6.2 Hand washing at critical times.

Inclusion of hygiene in monitoring is one of the improvements made in the SDGs. In interventions seeking to reduce diarrhoea risks, many studies reported that handwashing with soap and water could reduce the risks in diarrhoea diseases by up to 27%. These authors include [Han and Hlaing \(1989\)](#); [Shahid *et al.* \(1996\)](#); [Luby *et al.* \(2006b\)](#) [Luby *et al.* \(2004b\)](#); [Luby *et al.* \(2004a\)](#); [Luby *et al.* \(2011\)](#); [Langford *et al.* \(2011\)](#); [Langford *et al.* \(2014\)](#); [Nicholson *et al.* \(2014\)](#)). Considering the importance of hygiene, the survey used in this research had also tried to get information on hygiene in the study sites in terms of hand washing after using the toilet. The respondents were indirectly asked if they had hand washing facilities and the frequency with which they use them. From the data, 53% and 47% of rural and urban respondents respectively reported washing their hands every time after using the toilet. 56% of urban and 44% of rural respondents reported not washing their hands after using the toilets as they responded that they didn't have hand washing facilities in the first place. In the semi-structured interviews too, many people reported not having handwashing facilities. It was suggested by

some of the people surveyed/interviewed that sensitisation was carried out in rural areas about hand washing: ‘It is until the coming of WASH that a lot of people became aware that it is necessary to wash hands after using the toilet.’ Interview with a female resident in Alemenyi: Rural March 2017. But this need repeating as some people don’t really observe hand washing protocols and some reported not having had any sensitization/education on hand washing. Many people who had had hygiene education said they got it in schools, so there is a need for more work on awareness creation, as the semi-structured interviews revealed that some people actually benefited from hygiene-related education thus: ‘When WASH came, they told us that these practices are not good and unhygienic. Now many people know that going to toilet without washing hands is risky.’ Interview with a female resident, Dam: Rural March 2017. [Darvesh et al. \(2017\)](#) also reported that hygiene education with soap provision helped in reducing the risks of diarrhoea diseases.

7.6.3 Government’s involvement in Sanitation activities.

In developing countries, governments are supposed to be responsible for water and sanitation and the inability of governments to provide water has resulted in poor coverage ([Howard and Bartram, 2005a](#); [Montgomery and Elimelech, 2007](#); [Isunju et al., 2011b](#)). Analysis of the DHS data for Benue state indicated that access to water and sanitation is poor. During the field survey, attempts were made to find out why sanitation access was poor, so respondents were asked to express their satisfaction with the agencies involved in sanitation matters. It was not expected by the respondents that the government build toilet facilities for households and compounds but there was a sense that government should provide an enabling environment for achieving sanitation generally such as the provision of water, evacuation and disposal of waste and regulations on sanitation matters. For example, in the semi-structured interviews some respondents suggested that government agencies should carry out inspections and should arrest and prosecute residents who don’t have toilets and who keep their environments dirty, etc (see

section 8.3.6). Their responses suggested that the government was not living up to their expectations in the area of providing infrastructure; particularly water regulations and enforcement. Many respondents expected that governments should have significant control in environmental matters because they have the power to regulate and build infrastructure and dispose of refuse, etc. A detailed interview with government agencies in charge of sanitation acknowledged this too. From Figure 7.26 it can be seen that 75% of urban respondents compared with 59% (summation of unsatisfied and very unsatisfied % responses) of rural respondents expressed their dissatisfaction with the government agencies. Of the urban respondents 25% (compared with of 41% of rural respondents) reported that they were satisfied. As a matter of fact, the government is supposed to play a leading role in regulation and enforcement on sanitation because the cost of these (such as central sewer system projects) are beyond the scope of individuals and the survey showed that the provision of such facilities is low in the study areas. The responses of the people are summarised below in Figure 7.26.

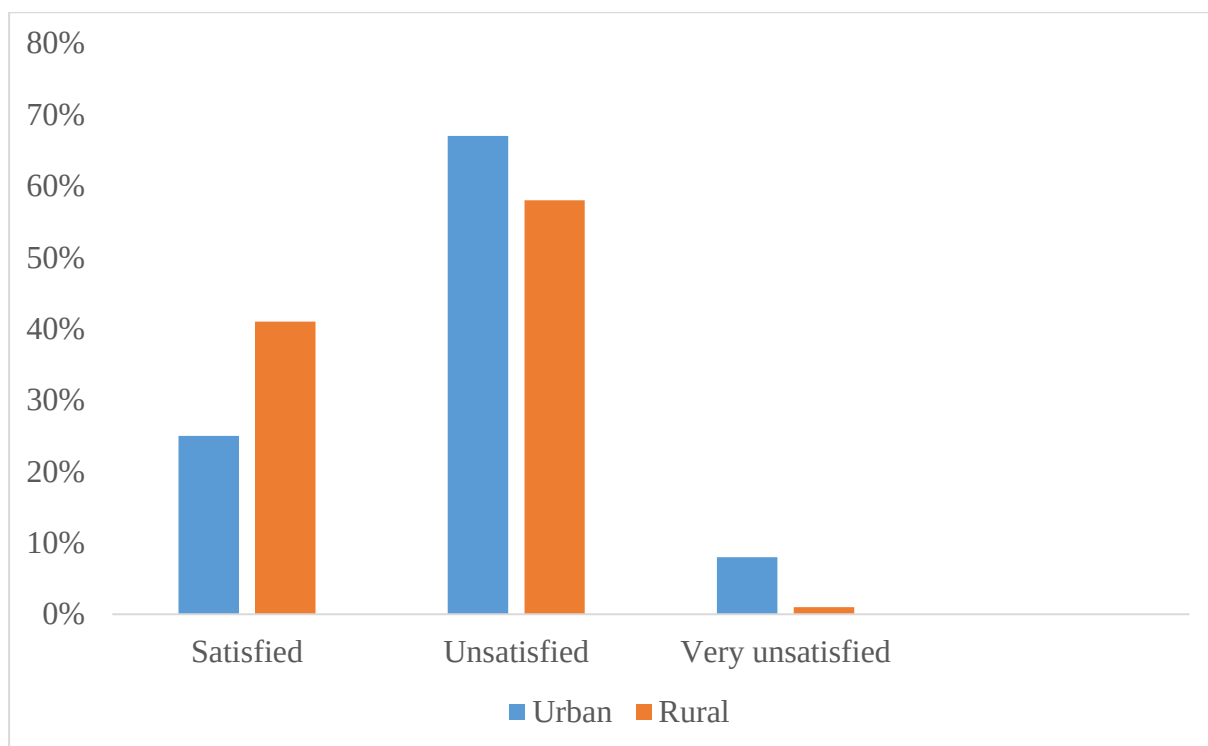


Figure 7.26 Respondents' Satisfaction with Government Agencies.
Source: Fieldwork 2016

7.7 Conclusions

The study shows that access to improved water and sanitation is poor in both rural and urban areas. The relatively higher percentage of access to improved water in this survey reflects the nature of the sampling strategy along with some ‘false’ definitions that indicate improved water sources but which in reality are not improved in most cases. [Bain *et al.* \(2012b\)](#) observed that ‘improved’ does not necessarily mean safe. This is similar to what [O'Hara *et al.* \(2008\)](#); [Kvarnström *et al.* \(2011\)](#) referred to when facilities that are unsafe are pronounced otherwise. [Christenson *et al.* \(2014\)](#) also questions the rationale for categorising rural sources as safer than urban ones when the former was found to be worse.

Although access to improved water was generally low, the urban areas had an advantage over the rural areas just as reported by other reserachers ([Bain *et al.*, 2012a](#); [World Health Organisation and United Nations Children's Fund, 2017a](#)). More educated and higher income groups had better access to both improved water and sanitation as noted by other reserachers ([Wright *et al.*, 2004a](#); [Pande *et al.*, 2008](#); [Stoler *et al.*, 2012](#); [Stoler *et al.*, 2015](#)).

The government has not lived up to the expectations of many respondents in providing potable water. Water treatment is poor, especially in the rural areas which creates health risks and health issues and echoes the views of other reserachers ([Utsev and Aho, 2012](#); [Idoko *et al.*, 2012](#); [Maxwell *et al.*, 2012](#); [Ocheri and Ogwuche, 2012](#)). Apart from health problems other issues such as burden of water collection on women and girls, missing school by children, stress, emotional problems etc. (stress, emotional problems, etc. were earlier mentioned in section 2.12.2) supported findings from the literature ([Doyle, 1995b](#); [Koppen, 1997](#); [Joshi and Fawcett, 2001](#); [Sultana, 2009b](#); [Devoto *et al.*, 2012](#); [Stevenson *et al.*, 2012a](#); [House *et al.*, 2014b](#); [Hirve *et al.*, 2015a](#); [Graham *et al.*, 2016](#); [Geere *et al.*, 2018](#)). Most respondents are of the view that if potable water is supplied by the government in the form of tap water, the situation would improve ([Aper and Agbehi, 2011](#)). Many reserachers, in opposing privatisation reported that

the public sector should care for the water and sanitation needs of the people (Stewart, 1991; Brendan, 1993; Ayodele, 1994; Adejumobi, 1999; Castro, 2007a; Castro, 2007b; Gutierrez, 2007a; Omoleke, 2010; Gelting *et al.*, 2013; Chang *et al.*, 2013). Despite these risks, a good number of people were unaware of contamination and described water by aesthetic characteristics (Chapelle *et al.*, 2009). The importance of water treatment, especially at point-of-use has been recommended by many authors such as Makutsa *et al.* (2001).

In terms of sanitation, most of the facilities are pour flush and are often not well constructed. In most cases, the toilets are separated between the squatting platform and pit/soak away by pipes, so that water is manually poured to push the faeces into the pit/soak away. The negative impacts of these sanitation systems were noted in water tests and other sanitary risks collaborating concerns reported in the literature (Lawrence *et al.*, 2001; Pedley *et al.*, 2004; Bain *et al.*, 2014a; Cho *et al.*, 2016; Lapworth *et al.*, 2017a; Martínez-Santos *et al.*, 2017b). Paterson *et al.* (2007) reported that decentralised small-bore sewerage which connect small homes are preferable as they are technically and economically suitable for low income areas, apparently in preference to the kind of toilet facilities obtainable in the study sites. There is high level of toilet sharing even among the highly educated and high income groups which could be explained by economic considerations (Isunju *et al.*, 2011a). A good number of the facilities in the study area are classed as unimproved based on JMP definitions. Although a high number of respondents dispose of children's faeces in the toilet which is an acceptable practice, some leave it in the open which can spread diseases. Although a good proportion of respondents have had hygiene education, more sensitisation is needed although it is well recognised (Schlegelmilch *et al.*, 2016) that education alone is unlikely to achieve full hygiene awareness.

Chapter 8: Qualitative Analysis of Water, Sanitation and Hygiene

8.1 Introduction

The last chapter presented water and sanitation data collected mainly through the questionnaire, focusing primarily on DHS questions as they echo DHS data as well as other issues. These are related to the objectives of the research and important issues in WASH. This chapter focuses on data obtained from the semi-structured interviews conducted with government agencies and individual households in the study sites to elucidate the water, sanitation and hygiene situation. The following questions that emerged from the DHS analysis reported in chapter five were investigated during the fieldwork:

- Why is access to improved water sources low in the survey years?
- Who has been in charge of developing water supply facilities?
- How effective are the stakeholders concerned in tackling water supply?
- Why is tap water access generally low (less than 10%) in all the survey years?
- Why has there been a high level of reliance on wells?
- Why has access to boreholes been low?
- Why has the use of rainwater been low in all the survey years?
- Why some respondents rely heavily on surface water as their major source of drinking water?
- Do the sources of water used vary seasonally?
- How aware are respondents of the risks presented by poor quality drinking water and have there been awareness campaigns to increase knowledge of these?
- What measures can be taken to address water supply problems?
- Why has sanitation not shown significant positive development over the years?
- What is the cause of poor sanitation and why is open defecation so widespread?

- Why has access to Ventilated Improved Pit (VIP) latrines been low in the survey years?
- Who has been in charge of developing these sanitation facilities?
- What are the perceptions of and actions promoting improved environmental quality?
- Have there been some public health campaigns on improved sanitation and hygiene?
- How effective are the stakeholders concerned in tackling sanitation?
- How could sanitation and hygiene be improved?

In order to explore these issues, interviews with households and government agencies were conducted using an Olympus digital voice recorder model WS-812 and the recorded interviews were transcribed and imported into Nvivo 11 Pro for Windows for analysis. After thematic coding, queries were run to retrieve the necessary information for analysis. The results are presented according to key themes linked to the research objectives. The themes integrating government agencies and individual respondents' views include roles of the various agencies in WASH, contamination awareness, water and sanitation access, water quality perception, knowledge and practice of hygiene, operational constraints and solution strategies. Quotations from respondents are used to illustrate their views as supporting evidence mostly in line with the follow up questions. For confidentiality, the respondents are only identified by their organisations' names in the case of government agencies and in the case of individual households, by their location name followed by their type of place of residence: urban or rural. For instance, a respondent from High Level location which is an urban site is identified as 'Interview with a married female in High Level: Urban'. In the household data presentation, attention is paid to urban and rural and gender categories to understand the basic differences between the sites.

8.2 Follow-up questions from DHS analysis on Water supply

In this section, field data relating to questions emerging from the DHS data analysis are presented.

8.2.1 Access to improved water and sanitation

This section provides some background information on access to water and sanitation in order to contextualise responses to questions arising from the DHS analysis (see sections 5.13.1 and 5.13.2) regarding issues concerning access to improved water and sanitation in urban and rural contexts. This helps to address the question, ‘why is access to improved water sources low in all the survey years?’

In Nigeria a large proportion of residents can be classed as having ‘limited service’ on the water ladder, especially in the dry season. In terms of sanitation too, many residents in the study sites fall within the limited service rung as most people share facilities with other households and the use of unimproved sanitation is widespread. It is clear from these data that the ‘safely managed’ rung on the water and sanitation ladders are likely to remain out of reach for many Benue residents for some time.

Water from dug wells constitutes an important drinking water source in the study sites. This claim is justified by the initial DHS analysis in which well water accounted for the highest patronage in all the survey years. Furthermore, [Utsev and Aho \(2012\)](#), identified dug wells as the highest water source available to residents of Tse-Agberagba and other locations in Benue State. The main purpose of collecting information about the main sources of drinking water is to determine if a household uses improved or unimproved water sources. Under JMP definitions of improved versus unimproved wells in the MDG era, covered or protected wells fell into the improved category while uncovered or unprotected wells were considered unimproved. These definitions were being used from 2000 to 2015. The concern here is that those wells defined as

improved were heavily contaminated as (Bain *et al.*, 2014a) noted that ‘improved’ does not necessarily mean safe. It is for reasons such as this that many authors advocate a decentralised approach involving household water treatment (Mintz *et al.*, 2001; Souter *et al.*, 2003; Wilderer, 2005; Elimelech, 2006).

According to JMP definitions, over 85% of the wells sampled in the study sites during field work in both rural and urban areas could be classed as improved drinking water sources. This is based on the grounds that the JMP classed protected or covered wells as improved and most of the wells sampled fell into the improved category based on this definition. It is worth pointing out here that since the research was mainly concerned with collecting data on dug wells (which were mostly classed as improved by the JMP as they were covered/protected), data on other unimproved sources of drinking water were not captured. However, based on targets and indicators used for the Sustainable Development Goals (SDGs), less than 20% have access to safely managed drinking water in the study sites. This is mainly based on the inclusion of criteria relating to water and sanitation availability, accessibility and quality. For clarity, “The new global SDGs indicator of population using ‘safely managed drinking water services’ is defined as an improved drinking water source, which is (i) located on premises (ii) available when needed, and (iii) compliant with faecal and priority chemical standards” (World Health Organisation and United Nations Children's Fund, 2017a). Based on these definitions, a good proportion of residents in the study areas fall within ‘basic’ category of the water ladder. In the dry season in the rural areas, ‘limited service’ is a more appropriate classification as collection time far exceeds 30 minutes. Some even fall into the unimproved category, taking water directly from rivers and dams.

Most of the people in the urban sites do not have access to tap water and use water from wells and rainwater in the wet season when there is rainfall. In the dry season, as water is scarce, most people purchase water from water vendors although the purity of the water is not guaranteed.

This raises issues with accessibility, availability and quality criteria for safely managed water. In the study sites, based on observations and quotes from respondents, it is clear that safely managed water status is far from being achieved.

While we see the condition of water supply in urban areas as poor, rural dwellers often face a worse situation as they don't have the money to buy water. This further collaborates the WHO's observation ([World Health Organisation and United Nations Children's Fund, 2017a](#)) that poor water access is especially prevalent in rural areas:

“There are big gaps in service between urban and rural areas. Two out of three people with safely managed drinking water and three out of five people with safely managed sanitation services live in urban areas. Of the 161 million people using untreated surface water (from lakes, rivers or irrigation channels), 150 million live in rural areas.” ([World Health Organisation, 2017](#)).

As earlier mentioned, the JMP criteria for availability under the SDGs demands that a household could be considered as using safely managed water services when an improved water source should be available when needed, being sufficient for the last week or being available for at least 12 hours per day. As this condition is not met, rural sites in the study areas could be considered as using a limited service since several hours are wasted daily looking for water. Echoing observations from the literature ([Koppen, 1997](#); [Touré, 1998](#); [Joshi and Fawcett, 2001](#)), several hours are lost each day for water collection in the rural areas in the dry season which could be used for other things.

Information on WASH was gathered in the interviews. In order to encourage household respondents to discuss what they perceived to be the most pressing issues facing them, they were asked to identify the major environmental problems facing them. Most identified the scarcity of potable water as their major problem, especially in rural areas in the dry season. In the rural sites in the wet season, well and rainwater are the major sources of drinking water while in the dry season, streams and boreholes are used but the latter are limited and have long

queues. A respondent in Secretariat area commented on the availability of water and time wasted thus:

“There is poor water supply and hence scarcity of water in this community and we suffer. When you go to a borehole, you cannot come back on time. Other things we have to do, we cannot do them because of looking for water.” (Interview with a married female resident in Secretariat: Rural, March 2017).

In the Konshisha zone, a similar report was made as a respondent observed:

“There is water supply in terms of boreholes but sometimes people fight there and spoil the borehole, so they guard and open it at intervals making the supply of water irregular. Sometimes your water finishes and when you go there, you are not able to get it immediately. Again, the boreholes are inadequate as they are not in many places.” (Interview with an adult male resident in Konshisha: Rural, March 2017).

These clearly show that potable water scarcity is a serious problem in the study sites, especially in the rural areas. This tallies with the DHS data analysis which was based on MDG-era JMP criteria. It found that improved water access was poor in the study sites in all the survey years. SDG targets 6.1 and 6.2 for drinking water, sanitation and hygiene are far more ambitious than the previous MDG target 7c which aimed to halve the proportion of population without water and sanitation by 2015. As the DHS data confirmed poor water access based on the MDGs, it is obvious that attaining a basic level of service in the SDG ladder is the immediate target in the study sites. The [World Health Organisation and United Nations Children's Fund \(2017a\)](#) update and SDG baselines reported that in Nigeria, the population attaining safely managed water was 20% while that attaining basic water facilities was estimated at 55%. On water scarcity and crisis, [Utsev and Aho \(2012\)](#) in their research on water shortage and health problems reported how water scarcity led to a communal conflict in Oju, Benue State in 2008 where a life was lost. In the quotation above too, the interviewee mentioned fights erupting at some borehole points. Many cases of conflicts over water have been reported elsewhere ([Kilgour and Hipel, 2005](#); [Levy and Sidel, 2011](#); [Molina et al., 2011](#); [Gleick, 2014](#); [Robins and](#)

Fergusson, 2014; Gorelick and Zheng, 2015; Givental and Meredith, 2016) which highlights the need for more attention to be focused on addressing water scarcity.

8.2.2 Potable Water Supply Responsibilities

This section considers whose responsibility it is to provide potable water and is linked to ‘Who has been in charge of developing water supply facilities?’ identified in 5.13.1. The roles of the organizations are considered to provide the background to their involvement in WASH. To achieve this, in addition to interviews with household members, four respondents from government agencies were interviewed and information on their roles and involvement in WASH is considered in this section. Kleemeier and Lockwood (2012) noted that WASH services often display poor sustainability in that they become dysfunctional after not having been used for a long time while Garriga *et al.* (2015); Giné Garriga *et al.* (2011) identified unclear roles at national, state and local levels as hindering the effective provision of water and sanitation services. The authors also identified the problem of inadequate financing as a contributing factor. Echoing this, in the study sites, there appear to be many organisations that have work associated with water supply, sanitation and hygiene yet their conflicting roles often present challenges. In Benue State, many agencies are involved in the provision of water and sanitation services. These include the Ministry of Water Resources, Benue State Water Board, Benue Rural Water and Sanitation Agency (BERWASSA) and Benue State Environmental Sanitation Authority. In this section, we try to identify and establish the roles of these organisations in Water, Sanitation and Hygiene (WASH).

According to the Benue Water Supply and Sanitation Strategic Framework WASH related agencies are supposed to carry out the functions outlined in Table 8.1.

Table 8.1: Activities of government agencies working in water and/or sanitation in Benue State

S/No	Responsible Institutions	Sector Activities
1	Ministry of Water Resources and Environment	Develop and promote proper policy formulation and review, planning, facilitation, co-ordination and collaboration with LGAs, ministries and agencies, for sustainable implementation of water supply and sanitation programme. Put in place regulatory measures to guide the Water Supply and Sanitation Sector.
2	Benue Rural Water and Sanitation Agency (BERWASSA)	Facilitate rural water supply & sanitation Provide technical support to WES (WASH) Promote hygiene in rural communities
3	Benue State Water Board (BSWB)	Provide adequate urban water supply and maintenance of facilities, quality assurance and control of urban water supply systems, setting of urban tariffs as well as data collection and analysis.
4	Benue State Environmental Sanitation Authority (BENSESA)	Enforce environmental sanitation and public health laws

Source: Benue State Water Supply and Sanitation Strategic Framework

During interviews with representatives from the various agencies, interviewees were asked about their roles/involvement in WASH activities as a means to establish that they have WASH related functions. BENSESA reported that they monitor water resources to ensure they meet the standards and monitor the environment to prevent contamination of water sources:

“The role of BENSESA in water supply and sanitation is to ensure quality monitoring that all the sources of water supply within the State are adequate, satisfy both biological and chemical demands and to ensure the sources are adequately protected against the factors that can lead to their pollution. The sanitation aspect of it is to ensure that we address all measures to ensure that overgrown grasses, those deleterious factors that can give rise to the protection of all water sources are taken into consideration and addressed appropriately so that our sources of water are free from contamination or pollution” (Interview with BENSESA March 2017).

The interviewee representative from the Benue State Rural Water and Sanitation Agency (BERWASSA) Makurdi reported that BERWASSA has responsibility for handling rural water supply and sanitation:

“As an agency, BERWASSA is about promoting rural sanitation through community-based approaches, particularly what we call Community Led Total Sanitation (CLTS) and provision of rural water supply by drilling of boreholes” (Interview with BERWASSA March 2017).

Just as stated in the WASH strategic framework, the interviewee from the Benue State Water Board, Makurdi reported that they carry out water supply and collect levies:

“The role of the water Board in water services is to construct and maintain water works, to collect fees and charges and to construct and manage any water works invested in the Board” (Interview with Water Board March 2017).

The interviewee from the Ministry of Water Resources, reported that they oversee water and sanitation:

“The ministry has departments, one of the departments overlooks water supply and sanitation” (Interview with BERWASSA March 2017).

Therefore, all the agencies mentioned had work associated with WASH. Therefore, the agencies have been in charge of developing the water supply facilities.

8.2.3 Effectiveness in tackling Water supply Responsibilities

This section addresses a follow up question from DHS analysis, ‘How effective are the stakeholders concerned in tackling water supply’? Echoing findings by ([Brendan, 1993](#); [Adejumobi, 1999](#); [Omoleke, 2010](#)), most household interviewees were of the view that it is the responsibility of the government to provide water although they felt that the government has not done well on this front. Comments from respondents about non-provision of water from the government support the claim of a ‘lack of political will’ raised in the literature ([Montgomery and Elimelech, 2007](#); [Montgomery *et al.*, 2009](#); [Isunju *et al.*, 2011a](#)).

“Water supply is very poor. The government has not provided any water to the community.” (Interview with a married female resident at Kanshio: Urban March 2017).

At Wadata site in the urban area, a respondent’s view on the problem of tap water is captured in the following quote:

“As I told you earlier, water supply is poor as we only get water either once or twice a week and it doesn’t exceed two to three hours and for the period of two to three months now, I saw them breaking some pipes around Bishop Murray...Kaduna Street upward to central mosque. There are holes they dug for more than one month ago and they did not cover it, they did not maintain it. I don’t know what is happening with the government.” (Interview with an adult male resident at Wadata: Urban, March 2017).

Even in the urban centres, people complain of no potable water supply and go as far expressing dissatisfaction with government activities. The note that tap water is not available is a dissatisfaction with government activities as this is the latter’s duty. A respondent from High Level in urban centre stated:

“No, it is only borehole as tap water doesn’t run in this our area.” (Interview with a married female resident at High Level: Urban, March 2017).

From the various roles of the agencies, there appear to be conflicts and duplication of roles with no sound coordination. For instance, while the Water Board constructs and maintains water works, their activities are limited to the state capital and do not reach the rural areas. This is surprising since the Board should have responsibility for the whole state and not just urban areas. BENSESA performs water and sanitation monitoring roles, but like the Water Board, it does not operate outside the state capital although its remit is to operate in the whole state. During the interview with BENSESA, it was mentioned that BENSESA is supposed to have zonal offices, but this has not actually been executed. BERWASSA now shoulders the responsibility of water and sanitation in the rural areas but water and sanitation monitoring – which comes under the remit of BENSESA – remains unattended to. The Ministry of Water Resources, which is supposed to make policy and coordinate water supply activities, is also involved in water provision in small towns and emergency situations and these are not fully executed. Therefore, there appear to be conflicts, role duplication and no proper coordination. The complexity of water and sanitation provision needs different strategies in different settings. There should be improved governance issues relating to institutions, their roles, regulations and

the capacity and commitment to implement agreed rules for continuous delivery of WASH services as noted by [Bartram and Cairncross \(2010\)](#) and [Calow *et al.* \(2013\)](#). Without these being carried out, many agencies get involved in the provision of water and sanitation services, but little coverage is being achieved. A look at the agencies' functions as stated by the WASH strategic framework, interviews with the agencies, observations in the field and formal and informal interviews suggest that the agencies have not lived up to their expectations.

The water supply facilities are supposed to be maintained by the state government as earlier mentioned in Chapter 2:. The government agencies have not denied this but complain of inadequate funds as a hinderence to their performance and ability to effectively discharge their duties. This also supports emphasis on a 'lack of political will' discussed in the WASH literature ([Howard and Bartram, 2005a](#); [Isunju *et al.*, 2011a](#); [News Agency of Nigeria, 2017](#)).

“Like I mentioned before, there is an agency in the state, which is supervised by this Ministry that is BERWASSA. Their coverage is the entire state, Benue State as a whole, rural communities and small towns. We are supposed to cover that but because of lack of funds, in fact their activities are more centred in areas where UNICEF and other donor agencies have given support.” (Interview with respondent from the Ministry of Water Resources, March 2017).

The BERWASSA representative reported similar problems:

“By enabling environment here, I mean putting the needed structures in place, providing funding, not the issue of the money being budgeted but never released, if money is budgeted for it should be released. If there is anything like counterpart that is to be contributed, let the government be doing it. It should not be an issue of government has earmarked so-so billions of Naira for counterpart and the counterparts are not forth coming.” (Interview with BERWASSA representative, March 2017).

On how the sanitation situation can be improved, the BERWASSA interviewee mentioned equipment and manpower shortage:

“The problems are about the equipment we have here, there are obsolete, they are down. a few hands in this area, the technical manpower is lacking. By the time there are good equipment, the manpower on ground, I think the sky will be our limit.” (Interview with BERWASSA, March 2017).

While the government has the responsibility for providing water, they are not able to effectively carry out this mandate. They reported funding, equipment and manpower to be main impediments to success.

8.2.4 Low tap water access and use of alternative sources

As detailed in chapter two, low access to tap water, especially among the poor, has been a key issue that raised arguments for water privatisation ([Serageldin, 1995](#); [Nickson and Franceys, 2003](#); [Winpenny, 2005](#); [Galil, 2006](#)). Key questions arising from the DHS analysis in 5.13.1 as well as from a study on water access in Benue State by [Maxwell et al. \(2012\)](#) relates to why tap water access is poor in the study sites, why water from wells increased significantly between 1999-2013 and why some respondents rely heavily on surface water as their major source of drinking water. Although respondents in the field sites stated a strong desire for tap water, many didn't have access to it and their comments echoed trends identified in the DHS survey data regarding a decline in tap water supply over time.

“Water supply is poor and so scarce here. Before now tap water used to run but it has stopped so it is only borehole water that one can find. Water supply therefore is not satisfactory”. (Interview with a married female resident at High Level: Urban, March 2017).

In another urban settlement it was reported that:

“Water supply in this area especially drinking water is not close as there are no taps here and the water from the wells is not good enough for drinking. Where we get tap water is very far.” (Interview with a married female resident at Wurukum: Urban, March 2017).

In the rural areas too, there is no tap water:

“We have potable water scarcity in this community, so the water supply is poor.” (Interview with a married female resident, Dam: Rural, March 2017).

A similar response came from another rural location:

“Water supply here is poor as we have serious potable water scarcity in this community, and we suffer a lot to get water even though it is a local government headquarters. There are just few places to get water here.” (Interview with a married female resident, Secretariat: Rural, March 2017).

Because of the non-availability of tap water, people have no option other than to use sources such as wells, rainwater and surface water even though they are not sure of their quality. This was reflected in the DHS which showed significant use of wells so the reasons behind the high levels of reliance on wells were explored in the interviews. One resident in Makurdi reported that since tap water is not available, they rely on hand dug wells which dry up seasonally, intensifying the difficulties they face accessing water. Even in the urban areas, well water is the main source for drinking for many people:

“The main source of drinking water is hand dug well. ” (Interview with a married female resident at High Level: Urban March 2017).

From another urban respondent in Wurukum, a response was:

“My community depends so much on natural water sources: the rainwater and the hand dug wells and a few boreholes that surround us. There is not much piped borne water so to say, in the locality.” (Interview with an adult male resident, Wurukum: Urban, March 2017).

A similar response was given by another resident at North Bank which is an urban site:

“Sincerely, I don’t get any water supply from the government. Since the economy is not even favourable to us, what we do is to use well and river water to drink. So, there is nothing like water supply from the government to us.” (Interview with a young male resident, North Bank: Urban, March 2017).

In North Bank, which is in urban centre, another resident reported their water source to be well and surface water thus:

“No, apart from the well and the river, there is no other water because the few people who have tap don’t allow others to use it”. (Interview with a young female resident, North Bank: Urban, March 2017).

Many people have wells as the main water source. As well water appears to be a main water source in the study sites, open wells which are unimproved are also common. It also suggests that people are limited economically to maintain their wells properly hence the abundance of open wells. It is also important to note that my sample only included respondents with wells in their compounds and this means more attention was focused on wells than other water sources. In a rural site of Secretariat, a respondent emphasised that well water was the only available source.

“My main drinking water source is well water.” (Interview with a married female resident at Secretariat: Rural March 2017).

“Water supply is poor in the community because we don’t have any other supply apart from well water.” (Interview with a married female resident, Secretariat: Rural, March 2017).

Many people drink water from both wells and rivers. This problematises the assumption that people drink water primarily from the ‘main source’ of drinking water reported by the JMP as in reality, they may drink equally from sources which could be unimproved and affected with water borne diseases. When discussing this, one respondent talked about the lack of a ‘favourable economy’ in the area implying they don’t have money to be buying water. A common practice is for urban dwellers to buy water for a range of different uses and with no guaranteed quality. Since water is a basic need and is always being used, continuous buying of the commodity places financial burdens on urban residents which raises concerns of affordability. If the water can only be obtained by purchase and the people do not have money to do this, then the situation akin to the water being inaccessible.

The responsible water agencies corroborated what the residents said as they were unable to connect many locations with tap water. It is the responsibility of the Water Board to connect tap water to main locations before individuals can connect them to their houses. According to

Water Board, the coverage of tap water is not sufficient as the Board has not connected tap water to some of the locations or areas.

“The uncovered places are areas under development because of the expansion of the town. We have limited areas where we have been operating. So, these new areas that are developing, we need to extend our pipelines to these areas. So, the major problem we have now is to extend the pipelines which have never reached these areas.” (Interview with Water Board, March 2017).

The Ministry of Water Resources also collaborated this:

“The Ministry is supposed to take care of both urban water supply and sanitation as well as rural and small towns. But in the past few years I have discovered that there is more attention on urban settlements. If we analyse that further, the state is made up about 70% of the population in either rural or small towns, while the 30% is in urban. If you look at the budgetary provision, more money has been allotted to the urban areas than small towns and rural settlements which are having the highest population.” (Interview with Ministry of Water Resources, March 2017).

The above statement by the Ministry of Water Resources has supported claims in the literature that there is lack of political will for water and sanitation as the budgetary allocations are not sustainable.

The representative from BENSESA stated:

“..... where I live there is even no pipe borne water. We rely completely on our hand dug wells. But by dry season which is in February/March, water distribution here drops because the water table drops. The problem of water supply becomes a serious issue in Makurdi town generally.” (Interview with BENSESA, March 2017).

As mentioned, because it depends on people’s ability to get borehole or wells, the poor which are more in number find it difficult to get boreholes, hence their limited number as also noted here:

“The government has not provided water for every individual. So, for those that are rich, they provide for themselves water facilities such as boreholes and then they have better latrines like the water closet. Now, for the poor,

because they don't have money, some of the people even if they afford latrine, it will be the traditional pit latrine that is still not sanitary enough. For hand washing, a lot of them water is their problem. They cannot afford toilet that uses water even if they can afford to have toilet, water becomes a problem.” (Interview with Ministry of Water Resources, March 2017).

8.2.5 Low access to boreholes

The DHS analysis revealed that access to boreholes had been low and the ‘why’ for this trend was explored in the field. The boreholes are privately owned with a few in the rural areas provided by the government/NGOs but are insufficient in numbers and since they are capital intensive, not many individuals can afford them. Consequently, they are few in number and this explains why access to boreholes has been low as reflected in the DHS surveys. This also explains why many people still use other unimproved water sources for drinking. The boreholes in the urban sites are provided by private individuals. The vendors then buy water from these private boreholes and sell to the public. Those who have money can buy this water while others, use alternative sources. In the rural sites, some places have boreholes provided by the government or donor agencies in partnership with the home governments. These are few in number and therefore insufficient. This section contains many quotations explaining borehole water access. In the Wadata, one woman reported:

“Water supply is not good because many of us are buying water. There is no water supply in our area. We buy water for drinking and for other purposes.” (Interview with a married female resident, Wadata: Urban, March 2017).

The above quote was supported by another urban resident from Kanshio:

“It is very poor. Government doesn't supply us water here. We depend on private boreholes.” (Interview with an adult male resident, Kanshio: Urban, March 2017).

Other residents in the rural sites responded similarly:

“Water supply is inadequate because the borehole is not enough.” (Interview with a married female resident, Konshisha: Rural, March 2017).

“The major problem we have here is potable water scarcity. Even our dug wells cannot sustain us. If we get a borehole, it could be better water as dug wells cannot solve the problem of water scarcity.” (Interview with a married female resident Konshisha: Rural, March 2017).

“We have boreholes here which are opened from time to time, but people are many and the boreholes are inadequate, so we appear to experience water scarcity.” (Interview with a married female resident, Alemenyi: Rural, March 2017).

Therefore, as mentioned in the last section, boreholes are capital intensive so not many people can afford them, hence their low patronage as reported in the DHS analysis. This was also confirmed in the field as can be seen from the earlier quotes.

8.2.6 Low use of rainwater

The DHS reported of low access to and use of rainwater as a source of drinking water. People expressed enthusiasm for harvesting rainwater, especially in rural areas but since it is seasonal, it would not be available in the dry season:

“Yes, I do drink rainwater, and borehole. But now, there is no rainwater but only the borehole that we drink.” (Interview with a married female resident, Konshisha: Rural March 2017).

In the Secretariat site, a respondent said:

“Yes, additional source of water we use is when rain falls, we collect rainwater from the zinc roof but when there is no rain it is the borehole water that we use.” (Interview with a married female resident, Secretariat: Rural) in March 2017).

Also, the DHS data was sometimes collected when it was not the rainy season so this source might not have been captured due to seasonal shifts in water use patterns (see 5.2). Harvested rainwater is collected and stored in big plastic containers, so people who do not have these facilities will find it difficult to store water to use for a long time. The equipment needed for

storing rainwater is also expensive which helps to account for low levels of rainwater use for drinking.

8.2.7 Why surface water is used

The question addressed here is, ‘Why do some respondents rely heavily on surface water as their major source of drinking water?’ The use of surface water increases seasonally because people cannot get alternatives especially in the rural areas. Also, they are not economically buoyant enough to purchase alternative water sources:

“The major problem here is a lack of potable water. Most of the families you see here are either drinking water from the river or from the well.” (Interview with a resident young male in North Bank: Urban in March 2017).

“I fetch water from the dam because I don’t have any other sources of getting water as my well dries up by that time.” (Interview with a married female resident at Alemenyi: Rural in March 2017).

Another respondent also spoke about use of surface water from Konshisha site thus:

“Yes, we normally collect from the stream, at times the borehole is congested with people and we decide to go to River Konshisha though it is quite a far distance.” Interview with a married female resident in Dam: Rural in March 2017).

These quotes echo what was reported in the literature regarding the use of surface sources by people with lower socio-economic status as they could not afford the upfront costs involved in piped connection in privatised water systems ([Adejumobi, 1999](#); [Bakker, 2005](#); [Goldman, 2007](#)).

8.2.8 Seasonality in the use of water sources

This section addresses the follow-up question, ‘Do the sources of water used vary seasonally?’

An additional issue related to water accessibility in the study area is seasonal variations in supply as already pointed out. While there are significant seasonal variations in potable water access, the DHS data did not capture this, pointing out some of the limitations of JMP

monitoring in the MDG era which the present study seeks to highlight. In the literature, the seasonality issue in water supply has been discussed. For instance, [Seifert-Dähnn *et al.* \(2017\)](#) maintained that people alternate drinking water sources mainly due to water scarcity during the dry season. Because of this, people whose main water supply is tap water may have to use surface water, hence having different water types in different seasons. Apart from the supply of water, [Seifert-Dähnn *et al.* \(2017\)](#) also noted that water quality also changes in different seasons. In their study in India, the authors reported that only 49% of households consumed drinking water that satisfied the criteria of no faecal coliform detection in 100ml samples during the post monsoon season. In the pre-monsoon season, the percentage dropped to 40% and lower to 36% during the monsoon season. In Nigeria, there are two distinct seasons: dry and wet. In the wet season, there is rainfall and people depend on natural water sources such as water from dug wells and rainwater harvesting. Since rainwater is only available in the rainy season, people who use it have to collect and keep as much as possible to use after the rainy season (that is for people who have containers). This leads to water stacking ([Jewitt *et al.*, 2018](#)). The importance of this lies in the fact that when rain is falling, people do not drink water from the well because they are drinking rainwater. Even though this is important and has strong seasonal connotations, the DHS data never captured this in the ‘main source’ of water for drinking question. This shortcoming is being addressed in this research. In the urban areas too, the seasonality issue has some influence. For instance, in High Level area, an interviewee noted:

“It is the dry season that water scarcity is most challenging when there is no rain but during rainy season especially for those that have big containers, they do collect rainwater and use it for a long time.” (Interview with a married female resident in High Level: Urban, March 2017).

In another location of the urban site, Kanshio area, a respondent pointed out:

“During rainy season, people would just harvest rainwater and drink so not many people go to the borehole to queue up. But during dry season when there is no rain, water supply is greatly affected, there is less water supply and a lot of people go to the borehole and the queue is very long and hence more time to get

the water.” (Interview with a married female resident in Kanshio: Urban, March 2017).

There is also pressure on the urban residents as most of the water used is purchased as highlighted by many residents in the urban sites. So, the urban dwellers buy a lot of water and the price sometimes rises in relation to the demand for the commodity. Their relief comes in the wet season. At this time rain falls and people make use of their wells and sometimes, rainwater is harvested for drinking. In some areas with tap water, it was reported that even tap water runs more in the wet season.

In the rural areas, the problem is more serious with long queues and many hours spent looking for water. Unlike the urban dwellers, few rural people buy water, probably due to financial limitations. Some quotations supporting this claim can be found below:

“During the rainy season our wells do have water and so we do not go far to the river looking for water. But during dry season it is difficult because our wells dry and there is insufficient water. We have to go far in search of water and the queueing time is long in addition to long distance.” (Interview with a married female resident in Dam: Rural, March 2017).

Another vivid picture of the situation was given by a resident from Konshisha area:

“During rainy season my well has water and I fetch it so we do not go far looking for water but during dry season it is difficult to get water so we go and fetch water from the dam, and the dam water is like a place for pigs to bathe but we fetch it and drink because we don’t have money. We do add alum to the water to clear and use it for cooking and drinking since we don’t have another source of water.” (Interview with a married female resident in Konshisha: Rural, March 2017).

The above quotes are a clear demonstration of how people shift between improved sources in the rainy season to unimproved water sources in the dry season. The [World Health Organisation and United Nations Children's Fund \(2017a\)](#) in its regional snap shot for Africa gave the percentage of the population using unimproved and surface water sources as 23% and 7% in rural and urban areas respectively in 2015. Based on the shifts in supply mentioned above, can we say the population quoted above uses improved or unimproved water as the main source?

Do the figures given by the JMP above take into consideration the seasonality issue? Answers on improved and unimproved water sources in Nigeria depend on the season in which there were surveyed. I would also observe that based on what was observed and collected in the field, the population accessing unimproved water sources is more than the figures given above, especially in the rural areas. The critical situation in the rural areas is also acknowledged by the JMP. For instance in the snap shot report the JMP noted, ‘435 million people in Africa lacked a basic drinking water service in 2015, 84% of whom live in rural areas’ ([World Health Organisation and United Nations Children's Fund, 2017a](#)). So, it is clear from the above that both urban and rural sites suffer from water shortages; especially in the dry season although the situation for rural dwellers’ is worse. The picture of water from the Dam mentioned in the above quotation is shown in Plate 8.2.



Plate 8.1: Water buying in Makurdi (a) and Borehole queues at Tse-Agberagba (b)
Source: Fieldwork 2016

Even water from improved but non-piped sources are often contaminated during collection, transport and household storage as pointed out by [Wright et al. \(2004b\)](#); [Rufener et al. \(2010\)](#). [Brown et al. \(2013\)](#) noted that even household with piped water in low- and medium-income settings have non-continuous water access which can cause water to enter through the stagnated

piped water to cause recontamination or in the process of storing water, some faecal growths could occur. This illustrates the extent to which rural people are disadvantaged when it comes to potable water access, especially in the dry season. Thus, the rural people suffer more regarding access to safely managed water as even basic services are not met, hence being at the bottom of the safely managed water ladder.

8.2.9 Awareness of water quality and exposure to awareness campaigns

This section is linked to the follow-up question, ‘How aware are respondents of the risks presented by poor quality drinking water and have there been awareness campaigns to increase knowledge of these?’ from the DHS analysis presented in chapter 5. In order to explore this, residents’ conceptions of good water quality in urban and rural areas were explored. Most of the residents understood good drinking water quality to be tasteless, colourless and odourless. Another important consideration the respondents had was about the water having a salty taste. Some of the perceptions are quoted here. This was from a resident at Wurukum area:

“I suppose that good drinking water quality should be clean, should be tasteless, should be colourless and it should not be salty at all.” (Interview with an adult male resident in Wurukum: Urban, March 2017).

From Wadata area, a respondent noted that:

“I think good drinking water quality is clean and without taste. That is what I would consider to be good quality water.” (Interview with a married female resident in Wadata: Urban, March 2017).

In the rural areas also, there is not much difference in the understanding of good drinking water quality. For instance, some respondents had the following to say:

“When the water is clean and tasteless, it is good drinking water quality.” (Interview with a married female resident in Secretariat: Rural, March 2017).

From Alemenyi, a respondent highlighted:

“When the water is clean and colourless, I consider it as good drinking water quality.” (Interview with a married female resident in Alemenyi: Rural, March 2017).

Therefore, in the rural areas too, people paid attention to the cleanliness of the water, a lack of a salty taste and no colour as good qualities for a water source. The critique of this understanding about good quality water for drinking stems from the fact that the quality of water is not necessarily guaranteed by its clean appearance or not having a salty taste. The sources of water mostly used in the study sites such as wells present health risks since there is no physical barrier between the stored excreta and groundwater (Van Ryneveld and Fourie, 1997; Rosa and Clasen, 2010). Also, as Bain *et al.* (2012b); Bain *et al.* (2014b) and Wolf *et al.* (2014) observed, even water from improved sources is frequently of poor quality. In light of this, Bain *et al.* (2012b); Bain *et al.* (2014a) and Wolf *et al.* (2014) advocated the use of filters which they noted to have benefits over improved and unimproved water sources.

In the water and sanitation questionnaire analysis (Chapter 7:), many people carried out some form of water treatment even among users of improved sources. For instance, 15% of urban and 34% of rural respondents reported treating water from improved sources. The fact that some people who use improved sources still attempted some form of treatment indicates that they are not convinced of the quality of water they are drinking. The assumption that water that appears clean to the naked eye is safe is misleading as it can be contaminated and cause health risks. For instance, in Kwara State in Nigeria, WHO reported a cholera outbreak in June 2017 with a total of 1558 suspected cases of cholera including 11 deaths. The report stated that a lack of access to clean drinking water and poor hygiene conditions were important risk contributory factors as noted by World Health Organisation (2017). An example of visibly poor water that can be seen with naked eye is shown in Plate 8.2. Some sources may look clean, but not safe for drinking.



Plate 8.2: Surface water at Tse-Agberagba (a), Sample of surface water at Tse-Agberagba(b)
Source: Fieldwork 2016

One of the key foci of the interviews was to ascertain whether respondents are aware of well water contamination or not. In the urban areas, about 60% of respondents were not aware of well water contamination as against just 25% not being aware of well water contamination in the rural areas. Surprisingly, 75% of rural dwellers appeared to have been aware of well water contamination while only 25% seemed not to be aware. Similarly, in the questionnaire data analysis in chapter seven, 16% of respondents in the urban study sites, compared to 31% of respondents in the rural sites attributed the cause of diseases to poor water supply and sanitation. This implies there is some contamination awareness. It is also surprising that the awareness seemed to be higher in the rural sites. Water treatment, educational level and being affected by water related diseases could have increased awareness not necessarily acquired by education campaigns. In spite of this awareness, more efforts could be made by agencies and NGOs to specifically address water treatment. [Darvesh *et al.* \(2017\)](#) noted that point-of-use water quality improvement interventions such as filtration could have up to 50% impact in reducing diarrhoea. Also, more attention needs to be given to sanitation in terms of education, legislation and enforcement.

In the urban sites during the semi-structured interviews, twelve out of twenty respondents interviewed noted that they were not aware of groundwater contamination. The other eight respondents reported being aware of well water contamination and one of them reported:

“Water that tastes salty or smell is not good. I think it is a problem in the ground that makes the water salty or smells. I also said earlier that sometimes toilets can contaminate the water. This is evidenced by the water being salty.” (Interview with a married female resident in Wurukum: Urban).

Although this respondent demonstrated some knowledge of contamination, most of the urban dwellers sampled appeared not to be aware of groundwater contamination in dug wells.

In the rural sites, most respondents reported being aware of well water contamination.

“Sometimes there are chemicals they inject a dead person before burial, when there is plenty of water in the ground as a result of rain, the chemicals can flow in the well and contaminate the water.” (Interview with a married female resident in Secretariat: Rural, March 2017).

Another succinct idea was given by a respondent in Konshisha area:

“Sometimes the wells we dug; other compounds have toilets like pit latrines. The flow of water from the toilets in some cases do contaminate the water from wells and make it unsuitable for drinking. In most cases these are not our own toilets, but neighbours’ and they do contaminate water when it rains and the water flow mixes rendering the water unfit for drinking.” (Interview with an adult male resident in Konshisha: Rural, March 2017).

The rural people generally were therefore more aware of groundwater contamination than the urban dwellers. As earlier mentioned, water treatment and education might increase awareness as some people reported knowing about WASH matters from school rather than education campaigns. It could also be due to the fact that since the rural dwellers appeared to be more at risk of drinking contaminated water, they could also be exposed to knowledge of possible contamination. Although some respondents (40% in the urban and 75% in the rural) demonstrated knowledge of contamination issues, some were unaware, and this poses some risks. Again, the people may know of some sort of contamination but not actually know a contaminated water source. Furthermore, the people may know a water source is not safe but

cannot treat or buy expensive safe water for drinking. So, knowledge in this case should be supported with provision of potable water or proper water treatment measures.

Following awareness on water quality, attention is paid to awareness campaigns. Echoing work indicating the positive impact of environmental education campaigns on water and sanitation (Ugbaja and Edet (2004); Anijaobi-Idem *et al.* (2015), the study investigated whether public education campaigns focused on drinking water took place in the study sites. Although a few in the rural areas reported having experienced WASH awareness campaigns, a majority reported a lack of exposure to education campaigns. When this issue was explored in interviews, the interviewee from the Water Board stated:

“Yes, we carry out public education on water supply. This is done more especially by educating the people through radio, television and the internet.”
(Interview with Water Board, March 2017).

Nevertheless, 60% of the urban respondents interviewed and 40% of the rural interviewees reported that they had not received any information or education about water quality.

Although representatives from the government agencies reported that they do carry out campaigns, more than 50% of interviewees reported no knowledge of this, so it appears that the government agencies need to do more work in terms of water provision and sensitization.

8.2.10 Water problem solutions

One of the follow up questions from DHS surveys was to identify measures to address water supply problems. Specifically, the question addressed here is, ‘What measures can be taken to address water supply problems? Interactions with urban respondents identified the provision of water by the government as the best option:

“I think the government should drill more boreholes or provide tap water for us and this will lessen the water scarcity problem.” (Interview with a married female resident at High Level: Urban, March 2017).

“If the Government could supply us with a tap, give us water direct from Water Board, like in Kanshio here, there is not any other water source apart from borehole. So, if they supply us with water, it would be very good.” (Interview with a married female resident at Kanshio: Urban, March 2017).

These views were also shared in the rural sites:

“The government should provide us more boreholes. WASH have attested to the fact that borehole water is the best. So, if the government provides us with boreholes, we would be sure that we are drinking good water and we will not have problems related to water.” (Interview with a married female resident at Dam: Rural, March 2017).

“Yes, our own is a cry that the government should come to our rescue so that we too can enjoy water supply. Otherwise we are suffering from getting potable water too much.” (Interview with a married female resident at Secretariat: Rural, March 2017).

As a government support measure, the Ministry of Water Resources advocated for more attention to water and sanitation by the government as a way forward:

“It is for government to give more attention to water and sanitation. All these problems we are discussing about, it is not as if government is not aware, government is aware. But the funding is not adequate.” (Interview with Ministry of Water Resources, March 2017).

The Water Board similarly observed:

“These are the basic areas of need: funding, steady power supply, adequate supply of water treatment chemicals and the need for manpower.” (Interview with Water Board, March 2017).

According to these agencies, if the problems of funding, manpower, equipment and actual implementation of budgetary allocations are implemented, water and sanitation would improve. The solution strategies mentioned by the agencies appear genuine and have been identified by other researchers in other areas as pointed out above. In addition to these, a sound managing, and accountability structure needs to be put in place.

The unanimous response by the people for government to intervene in water and sanitation tallies with observations in the literature that privatisation may not address the basic needs of

the poor in the society (Bayliss and Hall, 2002; Grusky, 2002; Hall *et al.*, 2002; Hall, 2003; Barlow and Clarke, 2017). In opposition to privatisation, many researchers are of the view that the problems facing the public sector should be addressed to improve them but privatisation might not be a solution to provision of social services as citizens would be in poverty while a few elites flourish (Stewart, 1991; Brendan, 1993; Ayodele, 1994; Adejumobi, 1999; Omoleke, 2010).

8.3 Follow-up questions from DHS analysis on Sanitation

Having considered water, particular attention in the following sections is paid to questions concerning access to sanitation raised in the DHS analysis.

8.3.1 Low access to improved sanitation

With regards to the low sanitation access and open defecation, respondents reported that it depends on people's financial ability to get access to good facilities. On the part of open defecation, weak legislation and enforcement were identified as the key cause. The specific follow up questions from DHS analysis considered here are 'Why has sanitation not shown significant positive development over the years?' and 'What is the cause of poor sanitation and why is open defecation so widespread?'

“The issue of water and sanitation is highly associated with poverty. Those who are richer tend to take care of their sanitation better than those that are poor...The role of government is to lead to develop policies and laws that will involve the general public because the general public has to know that this particular practice or that one will put their life and that of others at risk. So, government is supposed to involve the general public, both in rural and urban communities by development of policies and laws that will guide the water and sanitation sector.” (Interview with representative from the Ministry of Water Resources, March 2017).

The Ministry representative went further saying that:

“So, for those that are rich, they provide for themselves better latrines like the water closet. Now, for the poor, because they don't have money, some of

the people even if they afford latrine, it will be the traditional pit latrine that is still not sanitary enough. For hand washing, a lot of them water is their problem. They cannot afford toilets that use water even if they can afford to have them water becomes a problem.” (Interview with Ministry of Water Resources, March 2017).

Echoing work by [Harvey \(2008\)](#) people in the study sites also see indiscriminate waste dumping as a sanitation challenge. In particular, they view sanitation as extending beyond toilet facilities to encompass environmental conditions threatening health and wellbeing such as waste and waste dumps; especially in urban sites.

“The major problem is the refuse dump near us. When it rains, the stench is much and that brings plenty of mosquitoes disturbing us here.” (Interview with a young female resident, North Bank: Urban, March 2017).

In Wadata, a responded reported:

“The environment is also very dirty from improper waste disposal.” (Interview with a married female resident, Wadata: Urban, March 2017).

Kanshio urban site had similar response:

“The environment in my community is not too good especially as it concerns the waste products that are being thrown out. There is no good sanitary disposable equipment say good dustbins to put in waste products.” (Interview with a young female resident, Kanshio: Urban, March 2017).

Respondents in Wurukum area too complained of toilets:

“No good toilets are our major problems here.” (Interview with an adult male resident, Wurukum: Urban, March 2017).

In the rural sites, inadequate sanitation facilities are major challenges:

“One of our greatest challenges here is the issue of toilets as some people don’t have proper toilets and the government is not even helping matters.” (Interview with an adult male resident, Konshisha: Rural, March 2017)

“Also is the problem of good toilet facilities as some places do not even have toilets.” (Interview with a married female resident, Secretariat: Rural, March 2017).

In Dam site was also a response:

“We also have problem of refuse littering everywhere.” (Interview with a married female resident, Dam: Rural, March 2017).

Therefore, it is clear from the quotes that sanitation has been low over the years. This is due to the fact that these are provided by individuals and the facilities provided depends on the economic capabilities of those involved. Limited economic resources therefore account largely for the dominance of unimproved sanitation. Where government is involved by legislation and other logistics, the latter has not done this adequately. Because the legislation is weak, open defecation thrives. As there is also a poor waste disposal culture, the environmental sanitation conditions are generally poor. The question ‘Who has been in charge of developing these sanitation facilities?’ is answered here as private individuals have sanitation responsibility while the government regulates.

8.3.2 Low access to Ventilated Improved Pit (VIP) latrine and other improved sanitation facilities

The DHS trends revealed that access to improved facilities such as ventilated improved latrines (VIP), compost toilets and flush toilets was low in the study sites. The question arising from this analysis was ‘Why has access to Ventilated Improved Pit (VIP) latrines been low in the survey years?’ By extension, the question implies low access to other improved sanitation. Low access to flush toilets reflects the fact that people’s income could not support them as pointed out in the interview with government representatives. People therefore mostly used traditional pit toilets in the rural areas and pour-flush systems in the urban areas. VIP latrines are not common as they are expensive and cost issues arise as earlier mentioned. Also, respondents appeared to be unfamiliar with them because they described them as being similar to pit latrines. In an informal discussion, a respondent expressed concern that VIP latrines might not separate human faeces from human contact and may encourage contamination. These latrines are mostly used by primary schools in the study sites while pour flush were more widely used in urban

households and traditional pit latrines were more common in rural sites although some pour flush toilets were observed in these locations and a few houses have both pour-flush and traditional toilets for use during water scarcity:

“I have traditional pit latrine outside and pour-flush water system in the house.”
(Interview with a married female resident, Konshisha: Rural, March 2017).

Income levels were the key influence on sanitation system choices with poorer households often being unable to afford facilities like VIP, water closets and sewer systems. This was supported by a response from Ministry of Water Resources: “So for those that are rich, they provide for themselves water facilities such as boreholes and better latrines like the water closets. Now, for the poor, because they don’t have money, some of the people even if they afford latrine, it will be the traditional pit latrine that is still not sanitary enough.”

Generally, poor sanitation facilities have been linked to contamination with coliform, nitrate, chloride, ammonium and phosphate (Cidu *et al.*, 2003; Ugbaja and Edet, 2004; Taiwo *et al.*, 2011). With these sanitation facilities obtainable in the study sites, it is clear that such facilities pose some health threats. A similar situation was acknowledged in the field:

“The condition of the environment is not good. There are problems, there are wells and toilets (that are not good) sited in close position but we do drink it. It is not good, but we don’t have a choice.” (Interview with an adult male resident in Alemenyi: Rural, March 2017).

Plate 8.3 (a) and (b) show an example of shared and unimproved toilets respectively.



Plate 8.3: A compound with Toilet sharing in Makurdi (a) An unimproved Toilet in Tse-Agberagba (b)

Source: Fieldwork 2016

8.3.3 Sanitation and hygiene-related public health campaigns

One of the DHS questions for follow up in the field was ‘Have there been some public health campaigns on improved sanitation and hygiene?’ There have been some differing views on the usefulness of education in solving environmental problems. While some argue in opposition to education, a good number of people are of the view that environmental education is helpful. For instance in Ghana, [Napari and Cobbinah \(2014\)](#) in their study of environmental sanitation in Tamale, advocated for public education on environmental sanitation as one of the measures to minimise the problem of environmental sanitation. Due to many problems that poor or dirty environmental conditions can cause, in Nigeria and Benue State, the last Saturday of every month is set aside (called environmental sanitation days) for people to clean their surroundings. People are required to sanitise their locations for a period of time, say 7am to 10.00am before going out for their activities. During these sanitation hours movement is restricted to ensure compliance with sanitation regulations. In the past some task forces would go around to inspect this work and demand that every compound cleans their surroundings and possess a toilet

facility or face sanctions. [Anijaobi-Idem et al. \(2015\)](#) studied the influence of environmental awareness in Calabar, Nigeria and reported that it had positive significant relationship between environmental awareness and improvements in environmental sanitation in terms of cleanliness and refuse management. Environmental education is therefore helpful. Although 12 out of 20 rural respondents reported being aware of sanitation and hygiene campaigns, this was the case for less than half of the urban respondents. Nevertheless, interviews with government agencies indicated that they carry out sanitation campaigns:

“Yes, we carry out public education on sanitation particularly in the rural communities where we facilitate them to realise the problems of sanitation and hygiene that is surrounding them. So, the issue of personal hygiene in communities is getting forward. The only slag about it is that, because intervention is not in all the communities in the state, it is only in the SHAWN LGAs that intervention is going on. The rest of the communities in other local governments are still waiting to take their turn.” (Interview with a BERWASSA representative, March 2017)

On government’s role on sanitation and public health campaigns, the representative from the Ministry of Water Resources had this to say:

“As I told you, there is no law and no enforcement, but we have an agency here: BERWASSA which is charged with the responsibility of implementing water and sanitation plans and they carry enlightenment campaigns in villages where water facilities are to be sited. They advised where water could be sited and, in most cases, they prefer water facilities to be cited up gradient from potential contaminants sources.” (Interview with a representative Ministry of Water Resources, March 2017).

This indicates a potential need for demand-driven approaches to promoting sanitation uptake as there have been some criticisms in the literature such as [Jenkins and Sugden \(2006\)](#) that supply-driven interventions in sanitation such as subsidies on latrines construction have not yielded the desired results. The critics point out that such interventions are captured by the wealthy people and do not reach the poor; they are sometimes poorly designed or are culturally inappropriate as reported by [Jenkins and Sugden \(2006\)](#); [Jenkins and Scott \(2007\)](#); [Mara et al.](#)

(2010). Consequently, research and policy have moved to the ‘software’ or demand side of sanitation as low demand at the household level has been identified as contributing to the failure of sanitation initiatives (Evans, 2005; Jenkins and Sugden, 2006). With this in mind, BERWASSA has the mandate to promote rural sanitation using software approaches to end open defecation. The need for education and legislation has been collaborated by Harvey (2008). In light of this, BERWASSA stated:

“...we still emphasise the need for people to be mobilised to see the negative consequences that go with bad sanitation practices and take a lead in making a desire to change. If you bring a change from outside, it is not sustainable. But when the people resolve and take a communal decision to change, it is more sustainable.”.....“Key areas that have to do with people’s health in the community, people die due to lack of knowledge but as we go and facilitate the communities and they realise these and embrace, you see a lot of changes. When people are empowered and get out of water, sanitation and hygiene related diseases they become empowered economically and socially too.” (Interview with a BERWASSA representative, March 2017).

In terms of hygiene practices, hygiene promotion has been identified as the most cost effective health intervention as reported by Bank (2000). In the water and sanitation questionnaire survey, a few people appeared to be aware of sanitation-related health risks and carried out some basic hygiene practices.

8.3.4 Effectiveness of stakeholders in tackling sanitation problems

‘How effective are the stakeholders concerned in tackling sanitation?’ was another follow up question focused on respondents’ views regarding stakeholders’ effectiveness in tackling sanitation problems. In the study sites, people understand sanitation to not only include toilet facilities but also include general environmental cleanliness that promotes public health. In the urban areas, poor environmental conditions were major challenges. Such circumstances are capable of anthropogenic pollution including those linked to pit latrines especially nitrates (Faye *et al.*, 2004; Ugbaja and Edet, 2004; Tijani and Onodera, 2007; Goshu *et al.*, 2010; Orebiyi *et al.*, 2010; Goshu and Akoma, 2011; Vala *et al.*, 2011). Despite these threats, many

people are of the view that the authorities have not been performing well to address sanitation problems such as legislation and enforcing sanitation regulations:

“The environment in my community is not good due to indiscriminate waste dumps.” (Interview with a young female resident, North Bank: Urban, March 2017).

In the Kanshio area too:

“The condition of the environment is not good. They are no gutters, no good water and no place to dump refuse. These are the issues we have here.” (Interview with a married female resident, Kanshio: Rural, March 2017).

In the rural areas too, people reported of poor sanitary conditions which could have been improved by legislation and enforcement by the appropriate authorities:

“There are actually some problems here because the environment is not clean.” (Interview with a married female resident, Dam: Rural, March 2017).

Similarly, in Konshisha site:

“The condition of the environment is not good because agencies responsible for environmental issues are not doing their work and so people do things as they please them. If you like, you tidy your place, if you don’t, nobody cautions you.” (Interview with an adult male resident, Konshisha: Rural, March 2017).

While the household respondents reported of dirty environmental conditions, BENSESA, the responsible agency had a different view:

“But what is important is consistency and sustainability of the service which BENSESA has been doing very well.... so, the present government is managing and doing everything possible to ensure that waste management is sustained and that we have been doing very well.” (Interview with a representative of BENSESA, March 2017).

Therefore, in many cases, the households say one thing and the government agencies say something different. With observations of what is actually obtainable in the field, the household respondents’ views are not out of place.

From an investigation of government activities, it is clear that the agencies have not been very effective in carrying out their functions. Echoing findings from the literature, respondents in the study area, attributed key limitations in the provision for water and sanitation services to weak institutional arrangements. For instance [Braune and Xu \(2010\)](#) noted that many regions in SSA lack suitable approaches and efficient investment in groundwater resources planning and management. When asked to highlight the key impediments in providing water and sanitation services, most organisations mentioned underfunding as the root problem. The BERWASSA agency representative made mention of a shortage of technical staff and functional equipment while the representative from BENSESA raised the issue of a lack of reagents to collect and test water samples for effective monitoring and the non-availability of dumpsites. Interviewees from both the Benue State Water Board and the Ministry of Water Resources identified funding as the major problem, as with adequate funding, skilled manpower, reagents and even dumpsites can be acquired. However, how the available funds are managed is not clear and there are allegations of corruption. The Water Board collect some fees, but how the purchase of reagents has been a serious problem is not well understood and problems linked to management and accountability structures were also identified. Some of the problems that were tabled by the agencies are presented below:

“BENSESA does not supply water, we only monitor the supply and its distribution and of course the quality too. Firstly, we lack reagents for water samples collection and analysis. Secondly for sanitation purposes, we don’t have an adequate dumpsite. By the time all these things are provided, we will be able to address these problems adequately.” (Interview with BENSESA, March 2017).

One of the tasks of BERWASSA seeks to achieve is to promote rural sanitation by trying to end open defecation, but they are constrained in this regard by a shortage of manpower as ‘people are retiring others are dying without any new employment coming up. So, the lack of manpower is always there’

Another key problem for BERWASSA is obsolete equipment:

“The problems have been stated It is all about the equipment we have here, there are obsolete, they are down. The drillers that are here, after drilling one borehole, they spend money on it even more than what people pay to drill for them. These equipments need to be changed and ... the technical manpower is lacking ... By the time there are good equipment, the manpower on ground, I think the sky will be our limit” (Interview with BERWASSA, March 2017).

From the foregoing, it is clear that funding, human resources and equipment are identified as limiting factors to adequate water supply and sanitation services in the state. The issue of funding has been highlighted by many researchers as negatively affecting the performance of agencies involved in water and sanitation as noted by [Napari and Cobbinah \(2014\)](#) and [Utsev and Aho \(2012\)](#). [Saleth and Dinar \(2000\)](#) attributed the failure of authorities to provide acceptable water and sanitation to poorly invested resources and misaligned investments while [Radelet and Levine \(2008\)](#) associated this situation with some donor failings. The misplacement of priorities and limited resources in many cases cripple the provision of water and sanitation services. Other problems appearing to limit activities of water and sanitation provision include lack of skilled human resources, equipment, poor legislation and enforcement and poor government commitment in terms of providing policy.

8.3.5 Environmental Sanitation

Another follow-up question is, ‘What are the perceptions of and actions promoting improved environmental quality?’ As rightly observed by [Harvey \(2008\)](#), environmental sanitation encompasses not just excreta disposal and management, but solid waste management, drainage and hygiene practices. [Harvey \(2008\)](#) further highlighted that improved environmental sanitation has positive effects on many development indicators. The general condition around human habitats is therefore very important.

At the start of the householder interviews, respondents were asked to comment on the general conditions of the environment in their localities. According to studies by [Schneider \(2014\)](#) and the [Republic of Sierra Leone \(2014\)](#), environmental conditions around the wells should be

considered during well siting to identify potential hygiene issues such as the presence of free range animals, flood plains and proximity to other potential contaminant sources. Apart from being an eyesore, poor surrounding in terms of indiscriminate littering of the environment can easily contaminate water sources as noted by many researchers such as [Baabereyir \(2009\)](#). For instance in a cholera outbreak in Kwara State, Nigeria in July 2017, WHO reported that the outbreak of the epidemic was caused by poor sanitation conditions ([World Health Organisation and United Nations Children's Fund, 2017b](#)). As environmental sanitation is closely linked with drinking water sources, the respondents were asked to comment on the environmental conditions of their compounds and their responses were categorised into positive and negative dimensions. In general, most of the respondents maintained that the general condition of their environment was poor. This related particularly to general cleanliness. Refuse was present everywhere in the study sites. There also appears to be a decline and ineffective operation of national institutions for groundwater development and groundwater protection as reported by [Foster *et al.* \(2008\)](#). This is true in the study sites as groundwater resources are not professionally harnessed for use.

From the interviews, respondents were not convinced that their environmental conditions in terms of cleanliness and safety was satisfactory in both rural and urban sites. Similarly, in the semi-structured interviews in the urban areas, about 85% of the respondents opined that the environmental condition was not good in their localities.

While the agencies' representatives presented a positive image of their activities, many residents had different views. For instance, while the BENSESA agency talked about their consistency in evacuating waste as contained above, a resident in the heart of town (Wadata) stated:

“The environmental problem in our community is we are lacking the people to evacuate our dustbins away because we go far away and throw it away.” (Interview in with a married female resident in Wadata: urban, March 2017).

Another Wadata resident reported:

“The sanitation in my locality is poor’ with dirty gutters and foul-smelling gutters, leaking sanitary systems.” (Interview with a married female in Wadata: Urban, March 2017).

In the urban sites, for instance, one of the respondents in Wurukum area stated:

“The environment is very bad because it is so rough, it is dirty and smelling. The streets are bad and dirty.” (Interview with a married female resident in North Bank: Urban, March 2017).

In the rural areas, 80% of the respondents were not happy with their environmental conditions.

A similar response was given by another respondent in Konshisha zone who observed:

“The condition of the environment is not good because agencies responsible for environmental issues are not doing their work and so people do things as they please them.” (Interview with an adult male resident of Konshisha: Rural, March 2017).

Therefore, many of the respondents in both rural and urban areas observed that the condition of their environment was not good. It appears the urban areas were slightly more concerned about the condition of their environment than their rural counterparts. The reason probably could be that more refuse was being generated in the urban areas and collection and disposal were more challenging. The observations made in the field corroborated concerns raised by the respondents on the general conditions of their immediate environment. This could account in part for risks associated with the wells. During fieldwork, refuse was widespread in compounds and animals were freely roaming around some wells used for drinking and respondents in both urban and rural areas experience a range of other risks as illustrated in the quotes above.

Echoing findings by [Nyenje et al. \(2010\)](#), residents living near refuse dumps in developing countries are exposed to health hazards resulting from pollution of drinking water and soil. The flood that displaced 15,000 residents as reported by [Duru \(2017\)](#) on 26th August 2017 in

Makurdi, was reported by Vanguard National Newspaper to be partly accelerated by waste-blocked drainage channels. The flood also polluted water sources. Therefore, poor environmental sanitation conditions have a range of negative influence on drinking water sources.



Plate 8.4: A roadside rubbish at Tse-Agberagba (a) and a polluted drainage in Makurdi (b)
Source: Fieldwork 2016

Many studies such as [Oyeku and Eludoyin \(2010\)](#); [Akinbile and Yusoff \(2011\)](#); [Longe and Balogun \(2010\)](#); [Kassenga and Mbuligwe \(2009\)](#) have linked waste and waste dumps to groundwater contamination.

8.3.6 Suggestions to improve sanitation

Following on from the DHS analysis, attention was focused in the interviews on how sanitation can be improved. The DHS question being considered here reads: ‘How could the sanitation and hygiene situation be improved?’ Many residents suggested strict monitoring and sanctions:

“The government can take charge using the grassroots level to educate the people about sanitation and even employ stiffer penalties to check mate people’s activities because some people would not want to sanitise their places. Some people would dump refuse in any place they see. People should

be assembled at local government level to carry out house to house campaign. They should sound to the people the negative consequences of poor sanitation and I think this could be helpful.” (Interview with an adult male resident: Alemenyi: Rural March 2017).

“I think it is to bring in people that have sanitation knowledge so that they can help educate those that don’t have the requisite knowledge so that we can imbibe these sanitation practices and the problem will be solved automatically.” (Interview with a married female resident: Konshisha: Rural March 2017).

Other respondents shared similar views:

“When the government apply stiffer penalty people will improve the sanitation in their places.” (Interview with a young male resident: Dam: Rural March 2017).

“Yes, the sanitation problems can be solved by educating the masses in my area.” (Interview with an adult male resident: Secretariat: Rural, March 2017).

Another female urban resident saw provision of bins as important in tidying the environment:

“The government should also assist us by providing dust bin so that pure water sachets can be packed and drop into to make the town look cleaner than it is at the moment.” (Interview with a married female resident: High Level: Urban, March 2017).

Some respondents gave information on how sanitation issues were handled in the past:

“In those days, sometime in the 1970’s government had people who used to go around known as sanitary officers, enforcing sanitary laws. These days, we don’t have them so, no matter how you shout, if they are no people to go around and enforce these laws, what you are shouting would take time to be effective so I suggest that government should reintroduce sanitary officers to enforce sanitation laws and other voluntary organizations too can help the government to carry out campaigns on the need for us to have a clean environment, it will go a long way to improve our sanitary conditions.” (Interview with an adult male resident: High Level: Urban, March 2017).

“By taking good care of our streets and environment.” (Interview a married female resident: Wadata: Urban, March 2017).

“By knowledge of improved sanitation, most people would take caution on how they live their lives. And how to make sanitation is a very nice thing to

the community.” (Interview with a married female resident: Wurukum: Urban, March 2017).

Improved funding, equipment and waste management systems are other suggestions. BENSESA stated that the provision of dumpsites, reagents and equipment would improve their productivity. BERWASSA sees private sector participation, acquisition of manpower and equipment to be helpful to solve the problem. Responses from questionnaires, interactions with the residents and BENSESA suggested that environmental sanitation regulation and enforcement could help in addressing some environmental challenges. These are mostly supposed to be the responsibility of the government as they have the powers to fund, legislate and enforce sanitation regulations. The view that the government could better tackle the problem of water scarcity and sanitation was corroborated by local residents during the interviews as well as in the questionnaire administration. It is also reflected in the draft policy for water and sanitation in Benue State which clearly shows that the government would provide water and sanitation services for the masses. The agencies expressed their opinions and are quoted below:

BENSESA are of the view that acquisition of dumpsite and reagents could help as well as equipment for waste evacuation:

“The problem can be solved by firstly providing a dumpsite where we can move our waste straight from their area of generation to where they should be treated and then disposed of finally. Secondly to provide adequate reagents and upgrade our laboratory equipment so that we can be monitoring our water sources from time to time. Sanitation too, because for now we have limited equipment and vehicles but we are also believing that as the present government settles down, they will procure more vehicles and equipment for us to effectively cover the town and even create zonal offices to reflect the geo-political zones of the state, that is zone C with the headquarters at Otukpo, zone B in Gboko and zone A at Katsina-Ala. So that we will be able to massively and adequately address sanitation problems in the state generally.” (Interview with BENSESA, March 2017).

Private participation was suggested by BERWASSA representative. Having made some progress in software-based sanitation approaches, but facing impediments in terms of resource and manpower shortages, BERWASSA has proposed private participation and additional manpower in tackling water, sanitation and hygiene by lifting the embargo on employment as ways to improve upon the current situation:

“Yes, we had already mentioned the role of the government, but since the government cannot do everything alone, we have already acknowledged the fact that there are opportunities for private investors to delve into hygiene and sanitation issues... If I have my way, government should lift the embargo on employment, especially in these critical areas.” (Interview with BERWASSA, March 2017).

In their research [Napari and Cobbinah \(2014\)](#) noted that legislation and enforcement could check environmental sanitation abuses. For instance, if monitoring, legislation and enforcement are in place, people would be compelled to have their own toilets and littering of faeces around would be drastically reduced. This opinion also corroborated the views of respondents in the study sites both in the questionnaire data analysis and interviews. Respondents stated that government intervention could help improve access to WASH, as the agencies had challenges meeting up with these.

Since hygiene has been recognised as an important element in JMP monitoring, its knowledge and practice were explored in both urban and rural sites through semi-structured interviews. Many urban respondents reported carrying out one hygiene practice or the other. For instance, at High Level, a resident said:

“We wash our pots and plates, avoid keeping dirty environment by sweeping our surroundings clean and minimise littering the surroundings.” (Interview with a married female resident in High Level: Urban, March 2017).

At Wadata, a respondent stated:

“It’s about cleaning your home, toilets and keeping your cooking and drinking water clean. These are the basic things we do.” (Interview with a married female resident in Wadata: Urban, March 2017).

Similarly, in the rural sites, residents reported knowledge and practice of hygiene. For instance, from Alemenyi, a resident reported:

“Yes. For instance, I wash plates after food rather than keeping them. Stools of children are being removed immediately and washing of hands after with soap.” (Interview with a married female resident in Alemenyi: Rural, March 2017).

From Secretariat site, a respondent stated:

“When I wake up, I tell my wives to sweep the compound and ensure my toilet is clean.” (Interview with an adult male resident in Secretariat: Rural, March 2017).

The benefits of hygiene were also highlighted by [Wolf *et al.* \(2014\)](#) where they reported greater diarrhoea risk reduction from water intervention with hygiene education and/or improved sanitation than through the water intervention only. [World Health Organisation and United Nations Children's Fund \(2017a\)](#) also identified handwashing as a cheap and easy way to avoid catching diseases. Although some people responded that they practice hygiene, others do not, and more work is needed to sensitize the people. In the study sites, these could be achieved by using religious gatherings and the media.

As a basic and important hygiene task, handwashing practices were explored by asking the interviewees how they saw the importance of handwashing. Both the rural and urban residents spoke well about this.

In the urban sites, a respondent from Wadata observed:

“Handwashing is a very good thing. It keeps our children away from danger, especially germs. The children that are taught to wash hands before eating and the ones not taught, even in the same compound, you would see that this one is always sick, always dull while the other one is very okay. You would even see the difference there.” (Interview with an adult male resident in Wadata: Urban, March 2017).

From High Level also, a similar response was received:

“Washing of hands is a necessity, especially when you do some activity or walk for a long time, you should wash hands before eating. If you go to toilet, you should wash hands with soap and water before touching something else.” (Interview with an adult male resident in High Level: Urban, March 2017).

The rural sites also spoke well about handwashing. From Secretariat site a respondent highlighted:

“Yes, it is necessary to wash hands to be neat before using them. If you use your dirty hands and do something with it, especially food, you would have problem of contacting diseases.” (Interview with a married female resident in Secretariat: Rural, March 2017).

From Dam site a similar response was received thus:

“Hand washing is something very important. If you get food, it is not good to just start eating without first washing hands.” (Interview with a married female resident in Dam: Rural, March 2017).

From the foregoing, it is clear that the respondents seemed to have understood about handwashing. Even if they were not practising it, at least they could talk about it. In the questionnaire data analysis (Chapter 7:) urban respondents (30%) compared to their rural counterparts (34%) reported washing hands. While there are positive comments on handwashing, field observations noted that more work is needed in this area as some people interviewed seemed not to be practicing handwashing and physical observations collaborated this. The comments from media collaborate this view and should be encouraged. For instance, [Achuagu \(2017\)](#), a WASH coordinator commented about handwashing on handwashing day in Nigeria with the theme ‘Our Hands, Our Future’, the WASH coordinator for Enugu State in Nigeria stated: “Hand washing is the easiest way of preventing diseases and saving lives. So, it should be done at critical times especially before and after eating, after visiting toilets and hand shaking”. However, the barrier to achieving this is availability of potable water. While acknowledging this issue, the coordinator of WASH called on the relevant agencies to provide potable water to the people.

8.4 Conclusions

This chapter has looked at data collected through semi-structured interviews based on respondents' responses to a range of questions identified during the analysis of DHS data (see 5.13.1 and 5.13.2). It found that water and sanitation were the major problems identified by respondents. This is also supported by literature ([Onda *et al.*, 2014](#)), the DHS data and field observations. The water situation is considered followed by sanitation.

Access to water and sanitation were generally low in the study sites as found in the DHS data analysis. According to the SDGs, one of the requirements for a water source to be regarded as safely managed is to be 'free from faecal and priority chemical contamination'. The [World Health Organisation \(2017\)](#) stated that globally, at least 2 billion people use a drinking water source contaminated with faeces. The document also highlighted that contaminated water can cause diseases like diarrhoea, cholera, dysentery, typhoid and polio. The fact sheet further noted that contaminated drinking water is estimated to cause 502,000 deaths each year. Contamination from onsite sanitation have also been reported by many researchers ([Palamuleni, 2002a](#); [Nkhuwa *et al.*, 2006](#); [Kulabako *et al.*, 2007](#); [Lapworth *et al.*, 2017a](#); [Martínez-Santos *et al.*, 2017b](#)). The findings in the study sites revealed similar circumstances.

The government agencies interviewed were found to be ineffective in the discharge of their duties. They acknowledged their failure to provide water and sanitation and attributed the problems to poor funding, equipment and personnel in the semi-structured interviews. In the literature too, similar issues were identified ([Annamraju *et al.*, 2001](#); [Howard and Bartram, 2005a](#); [Montgomery and Elimelech, 2007](#); [Isunju *et al.*, 2011a](#)). People therefore resorted to the use of unimproved sources such as surface water as not many people had resources to drill boreholes. The limited income therefore accounted for low access to boreholes and pushed many people to drink surface water. The seasonality factor compelled the rural people to either spend hours waiting at few borehole points or trek long distances to the river to get surface

water in the dry season. The seasonality issue also affected access to rainwater as when the dry season sets in, people who used to drink rainwater are no longer able to do so because of no rain. The urban people mostly buy water from the vendors. Echoing reports from the literature that most people cannot afford piped connection compared to the water they buy from vendors though of questionable quality ([Adejumobi, 1999](#); [Bakker, 2005](#); [Goldman, 2007](#)).

Probably due to limited environmental education campaigns, peoples' perception of water quality is mostly based on aesthetic considerations. People in the study sites understood good water to be colourless, tasteless and without smell. This situation can result in rejecting water as being unsafe on aesthetic grounds and accepting water appearing to be aesthetically pleasant but having health risks ([Chapelle *et al.*, 2009](#)). Apart from aesthetic considerations, potable water must be free of pathogenic bacteria, suspended sediments, corrosion and harmfulness ([Mustafa and Yusuf, 1999](#)). Some people are aware of contamination, but others appear not, as they pay attention to aesthetic characteristics. This means more work has to be done in terms of providing water for the people and educating them about water quality. Even though some respondents/interviewees appear to be fairly aware of contamination, they might not know when the water is actually contaminated as they don't have the means of testing it. Again, even if the people know that a water source is not pure, they could not afford treatment or purchase of safe water which could be expensive ([World Health Organisation, 2017](#); [Punch, 2018](#)).

Well water is an important source in the study sites. [MacDonald *et al.* \(2012\)](#) stated that groundwater is the largest and most important water source in Africa. While a lot of people depend on groundwater in Africa and in Nigeria, this resource is at risk due to contamination. In light of this, [Lapworth *et al.* \(2017a\)](#) noted that the quality of groundwater resources in South Saharan Africa (SSA) is poor due to inadequate waste management which pose a health risk to users. In the same vein [Baabereyir \(2009\)](#) noted that urban sanitation, waste management provision and waste management systems across SSA are inadequate. While groundwater is

important, a lack of adequate management of household and industrial waste is a growing concern as reported by [Kassenga and Mbuligwe \(2009\)](#); [Oyeku and Eludoyin \(2010\)](#); [Akinbile and Yusoff \(2011\)](#); [Wang et al. \(2012\)](#). Poor waste management therefore leads to pollution of groundwater resources and consequently a threat to public health. This is even accelerated where extreme cases of rainfall can cause flooding and related disease outbreak ([McMichael et al., 2006](#); [Howard et al., 2016](#)). Concerns about groundwater contamination have also been raised by many researchers ([Mara, 2003](#); [Muruka et al., 2012](#)). It is in line with this that [Schneider \(2014\)](#) enumerated guidelines for siting wells relative to pit latrines and other potential contaminant sources (see Chapter 2:, section 2.15). Apart from diarrhoea, there are many ailments associated with inadequate water and sanitation such as intestinal infections, nutrition-related health issues and other environmental issues in the study echoing reports from literature such as [Korpe and Petri Jr \(2012\)](#); [Ziegelbauer et al. \(2012\)](#); [Dangour et al. \(2011\)](#); [Lin et al. \(2013\)](#).

As for measures to minimise water and sanitation problems, generally, respondents felt the government should help in the provision of water and sanitation services, help by education, legislation, enforcement and monitoring of sanitation regulations. This request is reasonable because apart from dug wells, people would not afford to provide tap water or boreholes, and this explain why they have low patronage in all the DHS survey years. Those who are rich could be able to drill boreholes and that means only the rich could afford potable water. Again, in Nigeria government is supposed to provide potable water to the citizens. It is the governments' civic responsibility to do so. Although there have been some arguments for water privatisation, many researchers see the public sector as better positioned to address water problem ([Ingram and Kessides, 1994](#); [Nickson et al., 1996](#); [Lobina, 2000](#); [Hall, 2001](#); [McIntosh, 2003](#); [Castro et al., 2003](#); [Gutierrez, 2007b](#)). A look at the draft water and sanitation policy for Benue State (Chapter 2:) also mentioned this responsibility there. The interview with government agencies

confirmed these, otherwise what are they established for and what are taxpayer's money used for?

As in the case of water, sanitation was also found to be low. As these were private concerns, only the economically buoyant people could afford good sanitation facilities. The common facilities were pour-flush in the urban and rural areas while traditional pit latrines were mainly in the rural areas. Ventilated Improved Pit latrines were also not common. Because of the low access to sanitation, open defecation was also being practiced in some places. Although the sampling strategy focused on wells and latrines, some open defecation was come across.

The [World Health Organisation and United Nations Children's Fund \(2017a\)](#) reports that 4.5 billion people worldwide lack access to safely managed sanitation services. In its snap shot for Africa, the JMP noted that '736 million people in Africa lacked a basic sanitation service in 2015, 234 million of whom practise open defecation' and estimated sanitation coverage in Nigeria as just over 35% ([World Health Organisation, 2017](#)). Sanitation remains one of Africa's public health challenges, with half of the population in SSA not having appropriate facilities ([Kamara *et al.*, 2017](#)).

It is in light of this that access to water and sanitation is reported to be one of Africa's public health challenges, with half of the population in SSA not having appropriate facilities ([Montgomery *et al.*, 2009](#); [Ndikumana and Pickbourn, 2017](#); [Kamara *et al.*, 2017](#)). In their research, [Graham and Polizzotto \(2013\)](#) estimated that 1.77 billion around the world use some form of latrine. [Graham and Polizzotto \(2013\)](#) further observed that while 48% use facilities classed as improved, the remainder use shared or unimproved facilities such as traditional latrines or pit latrines without slabs. Some people appear not to have knowledge and practice of hygiene. When some are unaware of hygiene matters, it implies they are left behind or

excluded and many researchers noted that WASH programmes should leave no one behind (Sweetman and Medland, 2017; Leder *et al.*, 2017).

The sanitation situation is not supposed to be low as it is. As rightly pointed out by Dr Tedros Adhanom Ghebreyesus, WHO Director-General “Safe water, sanitation and hygiene at home should not be a privilege of only those who are rich or live in urban centres” (World Health Organisation and United Nations Children's Fund, 2017a). Without adequate water supply, it would be difficult to achieve good sanitation and hygiene access as not only does it affect the potable water supply, but it also makes toilet flushing and handwashing difficult to be achieved.

As for the ways to improve sanitation, more commitment on the part of government was identified. Although areas such as education and health care have received attention from governments and donors, less attention is paid to water and sanitation, particularly in terms of allocation of funds, aid, policies and even in the scholarly literature (Ndikumana and Pickbourn, 2017). Consequently, in SSA, when the MDG era came to an end in 2015, only a few countries in the region succeeded in halving the proportion of people without access to safe drinking water while none were able to meet the sanitation target as reported by World Health Organisation and United Nations Children's Fund (2015). Still on sanitation problems solution strategies, the government agencies reported limited resources to have hindered effective discharge of their duties and also reported elsewhere (Howard and Bartram, 2005a; Montgomery and Elimelech, 2007; Isunju *et al.*, 2011a). Therefore, if the public sector problems are addressed properly, they can better deal with water and sanitation for the masses as supported by many researchers (Bardhan, 1997; Hawley, 2000; Uddin and Hopper, 2003; Estache and Fay, 2007; Witness, 2010; Bakre, 2011; Integrity, 2013; Andrews, 2013; Bakre and Lauwo, 2016; Lassou and Hopper, 2016). The public sector should therefore be in a better position to address water and sanitation concerns. This marks the end of chapter eight. The next chapter will summarise and present conclusions for the research.

Chapter 9: Conclusion

9.1 Introduction

The present study set out to investigate the impacts of pit latrines on groundwater quality in Benue State, Nigeria. Initially a desk-based study was carried out using the DHS data to get trends in access to water and sanitation. This helped in establishing the justification for carrying out the research and guiding the investigation. To proceed with the study, the following objectives were postulated:

1. To analyse DHS datasets from 1999-2013 to identify trends in access to water and sanitation in Nigeria and Benue State, by demographic variables and urban/rural categories.
2. To select, sample and test for faecal coliforms from well water samples from improved and unimproved wells that are situated in the same compounds as both improved and unimproved pit latrines in urban and rural areas of Benue state.
3. To collect baseline data on wells sampled including the nature of their location (rural/urban), construction type (improved/unimproved), ownership and usage (i.e. owned/used by a single family or shared and if so by how many people and animals) and distance between wells and pit latrines in the same compound.
4. To explore different stakeholders' understanding of well water contamination levels and causes and how these are perceived to vary in different types of wells in rural and urban areas of Benue state.

The first objective was addressed in Chapter 5: while the second and third objectives were addressed in Chapter 6: as part of the water quality testing. The fourth objective was addressed in Chapter 7: and Chapter 8: using mainly questionnaires and semi-structured interviews respectively. This chapter provides a summary and discussion of the major research findings. Sections 9.2 and 9.3 integrate findings from the water testing, questionnaire and semi-structured

interviews while section 9.4 presents recommendations from the study and section 9.5 highlights the key strengths and limitations of the research. This is followed by some concluding remarks in section 9.6 and the identification of issues for further research in section 9.7.

9.2 Trends in access to water and sanitation in urban and rural areas

9.2.1 Trends in access to improved water supply

Considering the normative dimensions of the new Sustainable Development Goals (SDG) 6, access to water and sanitation is low in the study area. For instance, in the DHS data sets analysed from 1999 to 2013, it was found that in Nigeria as a whole, access to improved water was low and tap water access declined from 25% in 1999 to 11% in 2013. Surface water usage was 24%, 22%, 21%, 16% and 16% in 1999, 2003, 2008, 2010 and 2013 respectively. The same DHS data analysis shows that in Benue State, surface water usage made up 48%, 45%, 44%, 44% and 34% of the samples respectively in 1999, 2003, 2008, 2010 and 2013. These data clearly tell us that access to water supply has been low in the years under review: a situation that has many implications for public health. The data tallied with what was obtainable in the field as respondents reported poor access to water and resorted to use of unimproved sources such as surface water. This is also supported by literature where sometimes the government give misleading figures showing exaggerated access to improved water ([Satterthwaite, 2003](#); [O'Hara *et al.*, 2008](#); [Kvarnström *et al.*, 2011](#)). The water quality testing in Chapter 6: showed a high level of well water contamination confirming poor water access as reported in the DHS. For instance, faecal coliforms results showed contamination of wells in both urban and rural areas in both dry and wet seasons. The contamination levels were higher in rural areas during the dry season while in the wet season, contamination was higher in the urban locations. The finding of higher water contamination in the rural area support the findings of [Christenson *et al.* \(2014\)](#) who challenged the assumption by SDGs that water quality is worse in urban than

rural areas. [Christenson *et al.* \(2014\)](#); [Bain *et al.* \(2014b\)](#) [Gunnarsdottir *et al.* \(2015\)](#) also challenged the urban bias and reported that lower access to improved water is recorded in the rural areas. The results from the physico-chemical parameters suggested possible contamination from pit latrines. For instance, [Lawrence *et al.* \(2001\)](#); [Fourie and Van Ryneveld \(1995\)](#) and [Pedley *et al.* \(2006\)](#) have linked nitrate to contamination from pit latrines which implies the contamination has attendant health risks. In the dry and wet seasons, nitrate was higher in urban than rural sites while temperature, conductivity, pH and fluoride had values that signal contamination as supported by [Jamieson *et al.* \(2002\)](#). As mentioned earlier, these are important since they indicate doubtful water quality and potentially raise health concerns. The water from both improved and unimproved sources was heavily contaminated, although unimproved sources were slightly more so. This finding matches with what has been reported in the literature as [Wright \(1986\)](#); [Palamuleni \(2002a\)](#); [Zingoni *et al.* \(2005\)](#); [Kulabako *et al.* \(2007\)](#); [Takem *et al.* \(2010\)](#) and [Sorensen *et al.* \(2015a\)](#) noted that contamination with faecal coliforms in improved water sources is less than unimproved sources. Although unimproved water sources often show higher contamination, there are cases where improved wells are contaminated above WHO limits. It is in line with this that [Bain *et al.* \(2014a\)](#) noted in their research that ‘improved’ does not necessarily imply free from contamination.

The cause of well water contamination is suspected to be as a result of water sources being contaminated by on-site sanitation systems as reported by many researchers such as [Still and Nash \(2002\)](#); [Dzwairo *et al.* \(2006\)](#) and [Banerjee \(2011\)](#). This confirms the report by [Agbonkhese and Edeh \(2018\)](#) in Vanguard Nigeria national newspaper online edition, on 22/3/18, quoting UNICEF to have said that it is a matter of regret that 69% of Nigerians lack access to safe water. UNICEF was also noted that based on the Multiple Indicator Cluster Survey (MICS) conducted in 2016/17, 40% of households did not have access to clean water sources, as Nigeria marks world water day. In the questionnaire survey (Chapter 7:) poor water

access was confirmed in the study sites, as the main source of drinking water for rural dwellers was protected dug wells (25%) while sachet water was the main drinking water source in the urban sites (21%). Apart from the main sources mentioned, other ones such as unprotected wells, surface water and rainwater were being used depending on the season considered. This confirms observations that groundwater resources in the form of shallow wells are common water sources (MacDonald *et al.*, 2012; Lapworth *et al.*, 2017b). Although well water is important, it is also vulnerable to contamination and drought (Mkandawire, 2008; Pritchard *et al.*, 2008; Wanke *et al.*, 2014; Machado and Bordalo, 2014; Okotto *et al.*, 2015; Liddle *et al.*, 2015; Lapworth *et al.*, 2017a). Tap water accounted for 4.8% of the sampled respondents in urban areas and was virtually non-existent in the rural sites. Echoing Pande *et al.* (2008) argument that wealthier people are better positioned to access clean water, some of the observed wealthier people drilled boreholes or drank bottled water which were beyond the reach of most people. Household interview respondents reported the failure of government to provide water for the masses. This was also acknowledged by the agencies. This failure is also acknowledged in the literature (Ducrot, 2017).

With regards to the urban and rural categories, the latter are most affected by poor water quality issues with the respondents that spent hours travelling several kilometres to get water from the river primarily coming from rural areas. This scenario echoes reports by both World Health Organisation (2017) and UNICEF (2015, cited in Ndikumana and Pickbourn (2017) which indicated that urban residents have higher access than their rural counterparts. This is supported by WHO report. According to WHO media centre new releases:

“There are big gaps in service between urban and rural areas. Two out of three people with safely managed drinking water and three out of five people with safely managed sanitation services live in urban areas. Of the 161 million people using untreated surface water (from lakes, rivers or irrigation channels), 150 million live in rural areas” (World Health Organisation, 2017).

The limitations in household supplies of tap water in developing and transition countries is partly explained by the problem of economies of scale. The remoteness of rural areas from the urban centres make timely operation and maintenance by staff from the central system difficult (Barde, 2017). Therefore, urban areas generally have more access to improved water and sanitation than their rural counterparts.

Again, rural people – especially women - in the study sites suffered for water (Sultana, 2009b) in the dry season where there were limited boreholes and there would be long queues, causing water collection roundtrips to take several hours. Alternatively, they also travel to far away locations to get water from streams. This is supported by observations from the literature that women have responsibility for water collection which involves them in fetching a lot water to meet the family needs and is often linked with attendant health problems (Geere *et al.*, 2010; Graham *et al.*, 2016; Geere *et al.*, 2018). This is true of the study sites as mostly women travel long distances carrying water on their heads. It is also reported that girls' water collection affect their school enrolment and women loose other opportunities such as growing and selling vegetables, getting more income, reduction in stress levels, etc. (Doyle, 1995a; Koppen, 1997; Touré, 1998; Joshi and Fawcett, 2001; Sultana, 2009b; van de Walle and Koolwal, 2010; Devoto *et al.*, 2012; Stevenson *et al.*, 2012b; Henley *et al.*, 2014; House *et al.*, 2014a; Hirve *et al.*, 2015a). Bhakta *et al.* (2017) noted that lack of water affects women at perimenopause as they need more water. Women's body needs demand for water use in order to address health needs which sometimes lead to discrimination and stigmatisation surrounded by different social norms (Say *et al.*, 2014; Carter *et al.*, 2017; Leahy *et al.*, 2017). As reported in the literature in Chapter 2:, economic and social capabilities limit women access to WASH services. Specifically, the problems of cost and affordability limit the access of rural women to WASH services and create problems for the poorest in both rural and urban areas (Briceno *et al.*, 2004; Estache and Fay, 2007; Thara, 2017; Button, 2017). In order to address these problems, many

authors advocate for WASH programmes to eliminate marginalisation and inequalities and women's involvement and empowerment in WASH (Radcliffe *et al.*, 2004; Sweetman and Medland, 2017; Leder *et al.*, 2017; Leahy *et al.*, 2017; Carter *et al.*, 2017; Hanson, 2017).

The urban dwellers mostly purchased water from vendors and boreholes in the dry season. Both urban and rural residents complained of not having water supply from the government and a scarcity of potable water was identified as the major community problem in both rural and urban areas. The fact that rural people travel far especially in the dry season to get water from rivers (unimproved sources) and urban people buy from water vendors shows the water sources could be exposed to contamination. Wright *et al.* (2004b) and Rufener *et al.* (2010) noted that even an improved water source can become contaminated in the process of collection, transport and storage. As people attempt to treat water even from improved sources indicate they are not sure of the quality of water they are using or at least suspect some kind of contamination.

Chidavaenzi *et al.* (1997) and Godfrey *et al.* (2006) attributed the higher contamination of water in the dry season to usage, as more use is made of wells in the dry season and hence contamination from hydraulic action and during water withdrawal. Both improved and unimproved wells were heavily contaminated. This casts doubt on the JMP's earlier definition of improved and unimproved sources which focuses on the nature of the water source which doesn't necessarily equate to the quality of the water available from that source (Bain *et al.*, 2014a). In the study sites, contamination levels were found to be high in both urban and rural areas.

The key reason why access to water has been low in the study sites has included a lack of political will to deal with the matter (Howard and Bartram, 2005a; Montgomery and Elimelech, 2007; Isunju *et al.*, 2011b), inadequate funding, (Howard and Bartram, 2005a) and management and technical limitations (Harvey and Reed, 2004). All these are likely to undermine efforts to

achieve the SDG 6 target to “achieve universal and equitable access to safe and affordable drinking-water for all” by 2030. With the present progress, it would be hard to achieve the targets. Literature also reported water scarcity to have resulted in many crises at local and international levels (Kilgour and Hipel, 2005; Levy and Sidel, 2011; Molina *et al.*, 2011; Gleick, 2014; Robins and Fergusson, 2014; Gorelick and Zheng, 2015; Givental and Meredith, 2016).

These trends in water access also show that people are exposed to health hazards from drinking unimproved water sources. In the literature, many authors reported that unimproved water consumption could affect people with diseases (Lopez *et al.*, 2006; Montgomery and Elimelech, 2007; Aper and Agbehi, 2011; Isunju *et al.*, 2011a; Utsev and Aho, 2012; Velleman *et al.*, 2014a). In light of this, UNICEF was quoted in the Vanguard newspaper to have said that “Diarrhoea remains the leading cause of death among children under five years of age in Nigeria..... Waterborne diseases is one of the major contributions to stunting” (Lopez *et al.*, 2006).

Water treatment was also found to be weak with the consequence of some water-borne diseases such as typhoid fever and cholera, being reported. While centralised systems of water system proved to be less effective, a household water treatment at point-of-use (POU) has been recommended (Mintz *et al.*, 2001; Sobsey *et al.*, 2002; Souter *et al.*, 2003; Wilderer, 2005; Elimelech, 2006; Chiller *et al.*, 2006; Rose *et al.*, 2006). However, this is difficult to achieve due to economic limitations as water treatment has some monetary costs. Agbonkhese and Edeh (2018); Luby *et al.* (2006a); Figueroa and Kincaid (2010) and Blum *et al.* (2014) have identified the cost of water treatment as a barrier to effecting diseases prevention practices. Generally, there appeared to be a link between income and access to improved water sources as the higher income earners had higher access to improved water than the poorer ones. Therefore, it appears

that access to improved or higher rungs on water and sanitation ladders have some socio-economic inter-relationships.

The results from my field water quality tests showed that even improved (protected) wells were heavily contaminated as equally pointed out by [Bennett *et al.* \(2018\)](#) and [Bain *et al.* \(2012b\)](#) that improved wells' water quality is not guaranteed. The improved wells obtainable in the study sites are traditional wells which in comparison with other water sources such as boreholes, are the most contaminated ([Wright, 1986](#); [Palamuleni, 2002a](#); [Zingoni *et al.*, 2005](#); [Kulabako *et al.*, 2007](#); [Ewodo *et al.*, 2009](#); [Obiri-Danso *et al.*, 2009](#); [Takem *et al.*, 2010](#); [Bonsor *et al.*, 2014](#); [Sorensen *et al.*, 2015a](#)). Consequently, people reported water-borne diseases such as typhoid, diarrhoea and hepatitis in the study sites. Similarly, many researchers such as [Godfrey *et al.* \(2006\)](#); [Ocheri and Ogwuche \(2012\)](#); [Utsev and Aho \(2012\)](#); [Zingoni *et al.* \(2005\)](#) and [Tandia *et al.* \(1999\)](#); [Vinger *et al.* \(2012\)](#) have observed that drinking water from unsafe sources can have health risks. This means the people are at risk of contracting water-borne diseases as also confirmed by some media reports. For instance, [News Agency of Nigeria \(2018\)](#) reported that 20 people were affected by cholera and two died in March 2018 in Bauchi State, Nigeria. The attack was linked to drinking poor water quality. This and other similar reports are evidence of risks from drinking poor water quality in the study areas and other similar places.

While the problem of access to potable water escalated in the study sites, respondents were of the view that government should provide potable water for the people. In the literature, this problem invited the debate that the private sector should step in ([Serageldin, 1995](#); [Rivera, 1996](#); [Franceys, 1997](#); [des Eaux, 1998](#); [Shirley, 2002](#); [Ochieng, 2002](#); [Kooy, 2003](#); [Bank, 2004](#); [Winpenny, 2005](#)). However, evidences from the literature show that privatisation had proved problematic in many places ([Bayliss and Hall, 2002](#); [Grusky, 2002](#); [Hall *et al.*, 2002](#); [Laurie and Crespo, 2002](#); [Hall, 2003](#); [Trawick, 2003](#); [Gutierrez, 2003](#); [McDonald and Ruiters, 2005](#); [Swyngedouw, 2005](#); [Barlow and Clarke, 2017](#)). Based on the critical analysis of the Nigerian

situation it is concluded that privatisation of water would not be a solution to the water problem in Nigeria [Stewart \(1991\)](#); [Ayodele \(1994\)](#); [Adejumobi \(1999\)](#); ([Hawley, 2000](#); [Uddin and Hopper, 2003](#); [Shiraz Rahaman *et al.*, 2007](#); [Stiglitz, 2008](#); [Witness, 2010](#); [Andrews, 2013](#); [Integrity, 2013](#); [Bakre and Lauwo, 2016](#); [Lassou and Hopper, 2016](#)) [Brendan \(1993\)](#); [Omoleke \(2010\)](#).

9.2.2 Trends in access to improved Sanitation.

In terms of sanitation, the rural population having improved access was 23% compared with the 40% of the population with access to improved sanitation in the urban areas. Although the urban areas have a slightly higher access to improved sanitation, the overall access was low in the study sites. Part of the reason for poor sanitation was reported to be as a result of weak legislation as some people have no proper toilets but were never apprehended as found in the interviews and confirmed in the literature ([Martínez-Santos *et al.*, 2017b](#)). The findings in the field revealed that the poor sanitation could have negative impacts on the health of the people in Benue State and Nigeria as a whole as supported by the DHS data. The risks of contamination identified in the study also challenge the JMP's definition of 'improved' water and sanitation and also their monitoring mechanisms. Many researchers also support the findings from the research about the health risks linked to water contamination. For instance, [News Agency of Nigeria \(2018\)](#); [Banerjee \(2011\)](#); [Chidavaenzi *et al.* \(1997\)](#); [Pujari *et al.* \(2012\)](#) and [Zingoni *et al.* \(2005\)](#) have linked the proliferation of pit latrines and open defecation to groundwater contamination with associated health risks.

This trend shows poor access to sanitation and supports WaterAid's report that Nigeria has 67% of 122,802,379 people without access to at least a basic sanitation as reported by [Banks *et al.* \(2002\)](#). There has been some decline in pit toilet use but we cannot say there is much improvement in sanitation. The decline could reflect that while the population has grown, the provision of toilets has not kept pace. Also considering the fact that open defecation was still

high reaching over 30% on average in the survey years, there is little improvement. While the reason for the increase in open defecation is not well known, it could be that there is a decline in toilet construction along with a rise in open defecation. The findings from the research support this, revealing that some people did not have sanitation facilities and many respondents reporting being unhappy with their sanitation services. The present research found and supported by literature that some sanitation facilities are not safe. For instance in the literature many authors report that human and animal faeces have been identified as the main source of pathogen contamination which contain microbes which emanate from pit latrines, septic tanks and open defecation (Nkhuwa *et al.*, 2006; Nyenje *et al.*, 2014; Lapworth *et al.*, 2017a; Martínez-Santos *et al.*, 2017b). Other health consequences of poor sanitation are highlighted by many authors such as WaterAid (2017b) and Montgomery and Elimelech (2007) along with non-health consequences Utsev and Aho (2012) and Isunju *et al.* (2011a).

Similar patterns to the DHS were confirmed in the questionnaire survey carried out (in Chapter 7:) where about 50% of urban respondents and 37% of rural respondents could be classed as using improved sanitation facilities. Also, trends from the field data revealed that based on the SDGs definition, in which shared toilet facilities are categorised as being limited sanitation facilities, only 16% of urban and 20% of rural respondents in the study sites could be classed as using safely managed sanitation facilities. Also, the level of access to improved sanitation facilities was influenced by education and income as higher educated and higher earning people had better access to improved facilities than the less educated and poor ones.

Jewitt (2011) noted that in Sub-Saharan Africa, the population of people using shared sanitation facilities is higher than in the rest of the world. Citing Ghana as an example she noted that in overcrowded areas, there is no room to build houses with facilities that are not shared. According to Isunju *et al.* (2011a), there are concerns about shared facilities as a facility that is shared and poorly maintained “can undercut the hygienic quality of the facility and discourage

people from using it. Such facilities pose health hazards by exposing people directly to human excreta” (World Health Organisation and United Nations Children's Fund, 2006). The World Health Organisation and United Nations Children's Fund (2006) observed that concerns over shared facilities also include the accessibility of such facilities in the day and the security of users in the night. Another implication of heavy toilet sharing is high nitrogen loading in the latrines relative to other areas under consideration as latrine density has been identified in accelerating groundwater contamination (Zingoni *et al.*, 2005; Okotto-Okotto *et al.*, 2015; Back *et al.*, 2018). Many respondents in the study sites appeared not to be satisfied or comfortable with sharing toilet facilities. Many expressed concerns that their toilets were being shared by many households. Some people seem to understand the risks associated with poor sanitation, including poor environmental sanitation to have caused diseases. Some people especially in the rural areas use unimproved sanitation facilities such as pit latrines without slabs because that is all they could afford. Semi-structured interviews further revealed that due to a scarcity of water in the dry season to flush and maintain water toilets, pit latrines were preferred. Regarding handwashing, over half of respondents reported to have been practising handwashing but often find this challenging due to limited water availability especially in the dry season. Although some people are unaware of the health impacts of not washing hands, the scarcity of water especially in the dry season impedes handwashing and is the bigger problem. There was little awareness on implications of poor sanitation on health. Findings from the research show that urban areas have higher access than rural areas and open defecation generally tends to be higher in rural areas as indicated by the WHO:

“Of the 4.5 billion people who do not have safely managed sanitation, 2.3 billion still do not have basic sanitation services. This includes 600 million people who share a toilet or latrine with other households, and 892 million people – mostly in rural areas – who defecate in the open. Due to population growth, open defecation is increasing in sub-Saharan Africa and Oceania” Isunju *et al.* (2011a).

Poor access to sanitation was also confirmed by government agencies in the semi-structured interviews as the Ministry of Water Resources admitted that sanitation was not accorded the priority it deserves and is therefore below expectation (25%). BERWASSA also collaborated this view in the semi-structured interviews emphasising that poor sanitation and hygiene has negative health impacts and act as major cause of diseases with open defecation still being practised in many places. Many residents interviewed also reported that sanitation was poor in their locations with dirty surroundings and health threatening sanitation facilities (Chapter 8:).

9.3 Factors in well water Contamination and its awareness in Urban and Rural areas

There are a range of possible drivers of groundwater contamination and knowledge of some of them could be helpful. To investigate this, the link between well characteristics such as well depth, well-latrine distance and number of well users and contamination levels were explored. For instance, [World Health Organisation \(2017\)](#); [Kiptum and Ndambuki \(2012\)](#); [Elisante and Muzuka \(2016\)](#); [Zingoni *et al.* \(2005\)](#); [Banerjee \(2011\)](#) found that wells closer to latrines were more contaminated than wells located farther away. This would have been due to shorter travel distance of water and effluents between latrines and wells especially where there is a gradient between the two facilities. Echoing findings by [Sangodoyin \(1993\)](#); [Vinger *et al.* \(2012\)](#); [Elisante and Muzuka \(2016\)](#) that well depth influenced contamination, shallow wells were found to be more contaminated than deep ones. This may reflect the rise of water table in the wet season and the shorter travel distance effluents had to move.

The number of well users was also found to influence contamination levels with more heavily used wells being more contaminated. This finding tallies with that of [Kiptum and Ndambuki \(2012\)](#); [Back *et al.* \(2018\)](#) who attributed the cause to hydraulic action between the well and latrine which make the former to draw water from the latter. In terms of soil properties, sandstone areas had more faecal coliform contamination levels than sandy and clayey soils. In the dry season, sandstone recorded higher contamination levels in chloride and faecal coliforms.

Echoing the work of authors such as [Taylor *et al.* \(2010\)](#); [Kiptum and Ndambuki \(2012\)](#) and [Moyo \(2013\)](#) geology influenced the level of contamination in the study sites.

Apart from toilet facilities, waste and waste dumps have potential to contaminate groundwater which many respondents in the study sites are not aware of. Awareness of groundwater contamination by waste dumps was evident among key WASH stakeholders and echoed findings from the literature ([Kassenga and Mbuligwe, 2009](#); [Oyeku and Eludoyin, 2010](#); [Longe and Balogun, 2010](#); [Akinbile and Yusoff, 2011](#)). Many residents also demonstrated some awareness of groundwater contamination in both urban and rural areas, with rural areas having more awareness. For instance, a respondent in a rural site reported that contamination could come from chemicals used to inject dead people before burial which could leak to groundwater during heavy rainfall and contaminate groundwater. Although some demonstration of contamination awareness was noted, not everyone was aware of contamination issues as some reported to be unaware. For instance, in the water and sanitation questionnaire survey (Chapter 7:), many respondents reported that good water quality is the one that is tasteless, colourless and odourless (19% urban, 37% rural); while others were of the opinion that clean water is good quality water (12% urban, 11% rural). Most people considered protected wells as sources of good water and the fact that most people look at water quality on the basis of aesthetics ([Chapelle *et al.*, 2009](#); [Graham and Polizzotto, 2013](#)) indicated that they have little knowledge or awareness of the health impacts of contamination. Since these are more of aesthetic descriptors rather than a recognition of the health threats associated with faecal contamination issues as water that is clean or tasteless, colourless, and odourless could still be contaminated ([Chapelle *et al.*, 2009](#)).

Although poor sanitation has some negative implications, due to financial difficulties, personnel, governance logistics and other policy issues, there are constraints towards providing water to the people. The authorities concerned admitted that provision of potable water is part

of their responsibilities. For instance, [Howard and Bartram \(2003b\)](#) identified lack of political will as a barrier to effective water and sanitation. Inadequate funding has been identified as another impediment ([Montgomery et al., 2009](#)). Management and other policy-related issues affect effective provision of water and sanitation services ([Isunju et al., 2011a](#)). [Rahman et al. \(2011\)](#); [Peletz et al. \(2016\)](#); [World Health Organisation \(2011\)](#); [Crocker and Bartram \(2014\)](#); [Mushi et al. \(2012\)](#) have noted that while there are regulatory structures that identify the responsibilities to be carried out, agencies in Sub-Saharan Africa have limited abilities to perform the functions, especially water testing which is expensive and involves many requirements such as equipment, consumables, transportation, training, etc. These were similar issues raised by the water agencies in water and sanitation provision.

9.4 Recommendations from the Study

The study focused on investigating the impacts of pit latrines on groundwater quality in Benue State, Nigeria and the following recommendations are put forward for improving access to improved water and sanitation in the study sites and similar areas in other places.

9.4.1 Access to improved water supply

The research did a desk-based study using DHS and the analysis of the data sets had shown that access to improved water was low in Nigeria as a whole and Benue State. The data sets have been a good way to have an idea of water and sanitation access. However, they could be improved to have a better understanding of water and sanitation issues. For instance, the water testing undertaken during this study highlights the limitations associated with existing definitions of improved/unimproved water and sanitation facilities by the JMP. Water sources classified as improved were often found to be contaminated. The JMP in the MDGs considered sharing of toilet facilities unimproved. Although there are concerns about sharing of toilet facilities, the definition would have depended on how the facilities are managed. These two issues are however being considered in the SDGs by definitions of improved being specifically

linked to non-contaminated water and the classification of shared toilet facilities into limited rung on the sanitation ladder (rather than being considered out rightly unimproved).

In collecting data on water and sanitation, the DHS's focus on the main source of drinking water was found to be misleading as data from the study sites indicate that seasonal changes were often accompanied by a change in the water supply source with people often being compelled by water scarcity to switch to unimproved sources; a situation unlikely to be captured in questions focused on the 'main' water supply. In order to address this, it would be helpful to include questions that elicit information on seasonal shifts in water access and use. The inclusion of such questions in DHS surveys could help to improve and enhance understanding of seasonal issues affecting water and sanitation access and hygiene. The JMP monitors water without seasonal consideration and this should be improved. My research tested water in both dry and wet seasons. Many authors such as [Wright *et al.* \(2014\)](#); [Bain *et al.* \(2012b\)](#); [Kostyla *et al.* \(2015\)](#) have raised concerns about one season sampling. Therefore, the seasonal water quality testing under different well characteristics is another way this research adds to current water testing approaches.

Many researchers such as [Barde \(2017\)](#); [Isham and Kähkönen \(2002\)](#); [Madrigal *et al.* \(2011\)](#); [Marks and Davis \(2012\)](#); [Prokopy \(2004\)](#); [Prokopy \(2005\)](#) and [Prokopy \(2009\)](#) reported that participatory and demand-driven approaches are more sustainable as the locals contribute money or labour to projects and consequently their maintenance. Therefore, adoption of participatory approaches could help towards sustainability and improvement in the WASH sector.

Since most of the water samples were tested to be contaminated, point-of-use treatment should be carried out before water consumption. This would minimise chances of contamination after treatment.

To solve potable water supply and attendant problems, the government should provide water for the citizens as also supported by [Stewart \(1991\)](#); [Ayodele \(1994\)](#); [Adejumobi \(1999\)](#); ([Hawley, 2000](#); [Uddin and Hopper, 2003](#); [Shiraz Rahaman *et al.*, 2007](#); [Stiglitz, 2008](#); [Witness, 2010](#); [Andrews, 2013](#); [Integrity, 2013](#); [Bakre and Lauwo, 2016](#); [Lassou and Hopper, 2016](#)) [Brendan \(1993\)](#); [Omoleke \(2010\)](#). Public water supply by the government could be more affordable.

9.4.2 Access to improved sanitation

Private participation and behaviour change, including Community-led Total Sanitation (CLTS) could be helpful to address the poor sanitation and open defecation as gathered from the respondents. Since the findings from the research (questionnaires and semi-structured interviews) found that some people did not have sanitation facilities, and some respondents also emphasised this, CLTS could be a good way to improve sanitation and end open defecation (OD) and should be strengthened in the study areas as also emphasised by BERWASSA. The success of CLTS have been reported elsewhere ([Robinson, 2006](#); [Evans *et al.*, 2009](#); [Peal *et al.*, 2010](#); [Baker and Ensink, 2012](#); [Lawrence *et al.*, 2016](#)).

As access to improved sanitation is low with some households using traditional toilets (known to contaminate groundwater) based on the study findings, the VIP latrines are recommended since they allow odours to escape, prevent flies from entering and when sealed, prevent groundwater contamination as reported by [Bartram *et al.* \(2012\)](#); [Lawrence *et al.* \(2016\)](#).

As a cost-effective measure, the study also recommends urine diversion toilets. This is important as central sewer systems might be difficult to achieve within the short term. This technology is popular in China and now spreading to other parts of the world ([Montgomery and Elimelech, 2007](#)). [Langergraber and Muellegger \(2005\)](#); [Jenkins and Curtis \(2005\)](#); [Montgomery and Elimelech \(2007\)](#) have reported that urine diversion toilets use urine and

faeces as fertilizers and minimise groundwater pollution by onsite sanitation systems. This could be adopted in the study area and other places.

9.4.3 Well water contamination awareness

Some respondents in the questionnaire survey appeared to understand about contamination levels (28% in the rural and 11% urban), but a good number of the respondents did not. In the rural areas where water scarcity is high in the dry season, people would just drink any water available. To minimise drinking of contaminated water, it is recommended that private participation especially with NGOs could work with the local community for education as explained in the CLTS above and this could be helpful. The public could also demand that the authorities account for huge budget allocations they have collected as human rights group questioned the minister of water resources earlier mentioned. This could check corrupt practices plaguing the WASH and other sectors ([Howard and Bartram, 2005a](#); [Isunju et al., 2011a](#)).

WASH campaigns are recommended to advise against use of unprotected wells; free roaming of animals around drinking water sources; and closeness of latrine to well water sources. As there was a link between well depth and contamination, there are benefits of sinking deeper wells in minimising contamination from pit latrines and these could be disseminated as noted by [WaterAid \(2011\)](#). It is recommended that pit latrines should not be built in thin rocky soils ([Nicholas et al.](#), cited in [Vinger et al. \(2012\)](#)). In fractured media, effluents could move faster than expected and hence groundwater contamination ([Taylor et al., 2004](#); [Harvey, 2007](#)). ([Graham and Polizzotto, 2013](#)) recommends analysis of infiltration and direction of groundwater flow, develop lined or raised pit latrines to minimise pollution and to adopt integrated approach involving geo-technology and hydrogeology to deal with sanitation problems.

Strict regulations and enforcement could be helpful. There should be strict regulation and enforcement against open defecation. Closely related to this is the issue of indiscriminate dumping of waste in the study sites. Apart from having some indirect impact to water resources by infiltration and run-off, they are an eye sore. The impacts of waste and waste dumps on groundwater have been reported ([Kassenga and Mbuligwe, 2009](#); [Oyeku and Eludoyin, 2010](#); [Longe and Balogun, 2010](#); [Akinbile and Yusoff, 2011](#)). At present there seems to be non-existent or weak laws to curb indiscriminate littering and open defecation and general environmental protection. For instance, in the North Bank area, some people do not have soak-aways in their homes and they channel pipes from their toilets straight into the channel that drains into River Benue where some people get the water for drinking. In the field work, the Water Board mentioned that the abattoir had been polluting the local water sources and that they were never sanctioned.

9.5 Strengths and Limitations of the Research

In this section, a brief reflection on the research is made. A look is taken at the strengths and limitations of the research. Some areas needing further research are also explored.

9.5.1 Strengths of the Study

One of the strengths of the study is its mixed methods approach. In other words, the research used different methods to collect data such as water quality testing, questionnaires, semi-structured interviews, observations and documentary sources. This was helpful in the sense that one method complemented the others. For instance, observation helped me to actually see the water and sanitation situation in the state. I was able to see people queue at some borehole points in the rural sites in search for water. The interviews also helped me to get more information on the situations from the stakeholders concerned. The questionnaire data made it possible to get responses from a lot of respondents thereby generating quantitative data, while interviews enabled in-depth investigations. By this, some methods helped to check and confirm

or refute what other sources produced. For instance, while the Water Board created an impression that 60% of the town was covered with tap water supply, the respondents in the questionnaire and interviews did not support the Water Board's claim. Also, while BENSESA painted a picture that they are doing very well, my observations and the respondents' views were used to check what BENSESA was saying. For instance, a respondent in Wadata and some locations stated that they have not seen someone evacuate their waste for a long time. The method therefore helped to investigate the problem from various angles to determine the actual situation on ground.

The field work was conducted in both the dry and wet seasons which are the seasons in Nigeria with distinct characteristics. By doing so, I was able to see the impact of the dry season on water scarcity and how people depend significantly on natural water sources like rivers for drinking and other purposes. Studies on water and sanitation were best captured in the two existing seasons in the study sites. This made the details surrounding the issues easier to understand.

My familiarity with the study sites was an added advantage. Apart from being familiar with the study sites, I understand the culture and language of the people which made field work smoother than would have otherwise been. The people did not see me as a security threat and cooperated for the field work to be successful.

9.5.2 Limitations of the Study

While the research went well, some limitations can be highlighted. One such limitation was the number of questionnaires administered. A total of 600 questionnaires were administered (300 each in urban and rural areas). A larger sample size would have captured more respondents. However, due to limited resources available, this sample size was employed. The triangulation of the research made it possible to supplement the data with other methods such as interviews, observations and documented sources, thereby helping to mitigate this limitation. Nitrite was

not tested in the field as initially planned due to a lack of reagents and the difficulty of obtaining them in the study sites. This limited the test parameters planned.

Due to the design of the research, data were collected mainly on wells and latrines in the same compounds to investigate possible cross-contamination between well and latrines. By this design, other water and sanitation information was cut from the study which may have led to important information being missed from compounds that didn't display these characteristics. Furthermore, language barriers may have caused some data loss as although I speak English and Tiv very well, some information from the rural sites were obtained in the local language and translated in English. It is possible that some information and meanings from the respondents could have been lost in the process of translation.

9.6 Concluding Remarks

The research found that access to water and sanitation has been poor in Nigeria, North Central region and Benue State from the DHS analysis. Having analysed these as a desk-based study, a detailed investigation into the problem found similar patterns to those indicated in the DHS analysis. Water and sanitation access were more limited in rural areas, especially in the dry season as people spent many hours looking for water at borehole points and travelling for several hours to get water from streams. It is obvious that without good water supply systems, sanitation can also be affected as water is needed for flushing and cleaning. Sanitation systems were also poor as many households used unimproved sanitation facilities. Also, most households share toilet facilities, a practice considered unimproved by the MDGs JMP and limited based on SDGs sanitation ladder. The higher income and more educated households had higher access to improved water and sanitation services. In each of the situations, urban sites had advantage over the rural ones.

Water sources from both rural and urban areas, and from improved and unimproved sources were contaminated by faecal coliforms. Physico-chemical parameters were also found to be contaminated. The fact that water-borne diseases affected many people in the study sites is an indication that people have not been drinking safe water sources. The well characteristics such as their construction, number of users, and the closeness of wells to latrines were risk factors that had a link with well water contamination. While some people and government agencies understand the level of contamination, some people seem not to be aware as they only considered aesthetic characteristics.

Provision of potable water by the government and NGOs, legislation and enforcement on water and sanitation by the government, empowerment of the agencies involved in water and sanitation services by staffing, funding and other logistics, more education of the masses on water and sanitation matters could help by addressing problems of commitment, funding and corruption to minimise these problems.

9.7 Suggested areas for further research

This research investigated the impact of pit latrines on groundwater quality in Benue State, Nigeria. The situation of water and sanitation has been explored by DHS analysis and detailed fieldwork on water, sanitation and some elements of hygiene were carried out in the study sites. The water samples were tested, and some contributing factors explored as well as contamination issues.

However, some issues were not fully investigated and need more research. This research investigated contamination of groundwater sources. It is possible some form of contamination could also come from surface sources such as containers used, etc. which could be investigated (Ducrot, 2017). Again, hygiene in schools should be studied as this area has some positive or negative influence on children depending on how they are exposed to the situation. This issue

is also being targeted under SDG 6. Water testing will form part of DHS monitoring under SDG 6 and more research could be carried out on these. As my findings reveal significant trends in seasonal contamination, it is argued and advocated that seasonality should be reflected in water testing. Financing of water and sanitation as well as possible funding sources could be investigated as this constitutes a serious impediment to achieving water and sanitation targets. This could be achieved by using demand-driven and participatory approaches where the residents and NGOs participate by contributing money or labour for maintenance of WASH infrastructure which would increase their sustainability ([Mansuri and Rao, 2004](#); [Godfrey *et al.*, 2006](#); [Whittington *et al.*, 2009](#); [Kleemeier and Lockwood, 2012](#); [Shaheed *et al.*, 2014](#)). Finally, research is needed to get data or give an idea of amount of faeces generated in urban centres. This can be done using tools such as 'Faecal Flow Diagrams' which could be employed for planning and other purposes. As data is provided, more planning and strategies to deal with sanitation matters can be better handled. This has been done in other places such as India and could help in the study area and elsewhere.

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Appendix 1: Household Survey Questionnaire

Dear Respondent,

I am doing a PhD in Environmental Geography, in the School of Geography, University of Nottingham, United Kingdom. I am carrying out a research on water supply and sanitation in Benue state. This questionnaire survey is designed to collect data for the study. It would be highly appreciated if you could please complete the questionnaire. The research is purely for academic purposes and all responses will be anonymised and treated confidentially.

Thank you very much for your time.

Stephen Aondoakaa.

Section A: Demographic Characteristics

1. Location.....Urban/Rural.....

2. Gender (a) Male (b) Female

3. What is your employment status? (a) Employed (b) Self-employed (c) Unemployed (d) Other

4. What is your highest educational level? (a) No formal education (b) Primary School (c) Secondary school (d) tertiary (e) Other (please specify)
.....

5. What is your monthly income? (a) Below N5, 000 (b) N5, 001-N10, 000 (c) N10, 001-N15, 000

(d) N15, 001-N20, 000 (e) Above N20, 000 (f) No income

6. What are the pressing needs for your household? Please rank these on a scale of 1-4(1-lowest and 4-highest

7. On a scale of 1-4, (1-lowest and 4-highest) please rank the seriousness of the following problems facing your household. (a) Power supply access (b) Potable water access (c) Access roads (d) Good sanitation (e) Good school access (f) Good health services access.

8. What are the most important problems facing your community?
Answer.....

Section B: Water Supply

9. What is the main source of drinking water for members of your household?

(a) Piped water into dwelling >Q12 (b) Piped water to yard/plot>Q12 (c) Public tap/standpipe >Q10 (d) Tube well/borehole >Q10 (e) Protected dug well >Q10 (f) Unprotected dug well>Q10 (g) Protected spring >Q10 (h) Unprotected spring >Q10 (i) Rainwater collection >Q10 (j) Bottled water >Q9A (k) Cart with small tank/drum >Q10 (l) Tanker-truck>Q10 (m) Surface water (river, dam, lake, pond, stream, canal, irrigation channels) >Q10 (n) Sachet water >Q9A (o) Other (specify) >Q10

9A. What is the main source of water used by your household for other purposes such as cooking and handwashing? a) Piped water into dwelling >Q12 (b) Piped water to yard/plot>Q12 (c) Public tap/stand pipe(d) Tube well/borehole (e) Protected dug well (f) Unprotected dug well (g) Protected spring (h) Unprotected spring (i) Rainwater collection (j) Bottled water (k) Cart with small tank/drum (l) Tanker-truck(m) Surface water (river, dam, lake, pond, stream, canal, irrigation channels) (n) Sachet water (o) Other (specify)

10. How long does it take to go there, get the drinking water, and come back? (a) Number of minutes.....>Q11 (b) Water on premises >Q12 (c) Don't know >Q11.

11. Who usually goes to this source, to fetch the water for your household? Probe: is this person under age 15? What sex? Circle the code that best describes this person. (a) Adult woman >Q12 (b) Adult man >Q12 (c) Female child (under 15 years) >Q12 (d) Male child (under 15) >Q12 (e) Don't know >Q12.

12. Do you treat your water in any way to make it safer to drink? (a) Yes >Q13. (b) No >Q14 (c) Don't know >Q14.

13. What do you usually do to the water to make it safer to drink? Anything else? Record all items mentioned. (a) Boil >Q14 (b) Add bleach/chlorine >Q14 (c) Strain it through a cloth >Q14 (d) Use a water filter (Ceramic, sand, composite, etc.) >Q14 (e) Solar disinfection >Q14 (f) Let it stand and settle >Q14 (g) Other (specify).....>Q14 (h) Don't know >Q14

14. What are the 'other' sources of drinking water for members of your household?

(a) Piped water into dwelling (b) Piped water to yard/plot (c) Public tap/stand pipe (d) Tube well/borehole (e) Protected dug well (f) Unprotected dug well (g) Protected spring (h) Unprotected spring (i) Rainwater collection (j) Bottled water (k) Cart with small tank/drum (l) Tanker-truck
(m) Surface water (river, dam, lake, pond, stream, canal, irrigation channels) (n) Sachet water
(o) Other (specify).....

15. What is the main source of water for cooking for members of your household? (a) Piped water into dwelling (b) Piped water to yard/plot (c) Public tap/stand pipe (d) Tube well/borehole (e) Protected dug well (f) Unprotected dug well (g) Protected spring (h) Unprotected spring (i) Rainwater collection (j) Bottled water (k) Cart with small tank/drum (l) Tanker-truck (m) Surface water (river, dam, lake, pond, stream, canal, irrigation channels) (n) Sachet water (o) Other (specify).....

16. What are the other sources of water for cooking for members of your household?

(a) Piped water into dwelling (b) Piped water to yard/plot (c) Public tap/stand pipe (d) Tube well/borehole (e) Protected dug well (f) Unprotected dug well (g) Protected spring (h) Unprotected spring (i) Rainwater collection (j) Bottled water (k) Cart with small tank/drum (l) Tanker-truck
(m) Surface water (river, dam, lake, pond, stream, canal, irrigation channels) (n) Sachet water
(o) Other (specify)

17. What makes a good quality well? Answer.....

18. What do you understand by ‘good quality drinking water?’ In other words, what are the key factors that makes ‘good quality water’ for drinking?.....

19. How are you satisfied with the quality of your drinking water?

(a) Very satisfied (b) Satisfied (c) unsatisfied (d) Very unsatisfied.

Please give a reason for your answer

20. Do you have information/awareness on water cleanliness? (a) Yes (b) No

If yes, by whom? (a) Government agency (b) NGO (c) Schools (d) Others.....

21. Have you or your family ever suffered or suspected any health problems linked to your drinking water? (a) Yes (b) No (c) Don't know

If yes, please provide details.....

22. How satisfied are you with the agencies involved in water supply provision?

(a) Very satisfied (b) Satisfied (c) Unsatisfied (d) Very unsatisfied. (e) Don't know

Please give a reason for your answer

23. Are there any regulations by the government on water supply in place? (a) Yes (b) No (c) Don't know

If yes, what are these? Answer.....

24. If so, how enforceable are there? (a) Highly enforceable (b) Enforceable (c) Not enforceable (d) Don't know

25. What do you think are the most important influences on changing how people access water and what they use different water sources for? Answer.....

Section C: Sanitation

26. What kind of toilet facility do members of your household usually use? If "flush" or "pour flush" probe: Where does it flush to? (a) Flush/pour flush to: (i) piped sewer system (ii) septic tank (iii) pit latrine (iv) elsewhere (v) unknown place/not sure/don't know where (b) Ventilated improved pit latrine (VIP) (c) Pit latrine with slab (d) Pit latrine without slab/open pit (e) Composting toilet

(f) Bucket (g) Hanging toilet/hanging latrine (h) No facilities or bush or field (i) Other (specify).

27. Which other toilet facility do your household members use? (a) Flush/pour flush to: (i) piped sewer system (ii) septic tank (iii) pit latrine (iv) elsewhere (v) unknown place/not sure/don't know where (b) Ventilated improved pit latrine (VIP) (c) Pit latrine with slab (d) Pit latrine without slab/open pit (e) Composting toilet (f) Bucket (g) Hanging toilet/hanging latrine (h) No facilities or bush or field (i) Other (specify)

28. Do you share this facility with other households? (a) Yes >Q29 (b) No >Q30.

29. How many households use this toilet facility? (a) (How many other households share this toilet? Can any member of the public use this toilet?) (b) Don't know

30. The last time [name of youngest child] passed stools, what was done to dispose of the stools?
(a) Child used toilet/latrine (b) Put/rinsed into toilet or latrine (c) Put/rinsed into drain or ditch
(d) Thrown into garbage (e) Buried (f) Left in the open (g) Other (specify)
.....(h)Don't know

31. Do you have soap and water washing facility in or near your sanitation facility? (a) Yes >Q32 (b) No >Q33.

32. How often do you use this facility? (a) Every time (b) Sometimes (c) Not at all (d) Don't know

33. Do you have soap and water washing facility in or near food preparation area? (a) Yes >Q34 (b) No >Q35.

34. How often do you use this facility? (a) Every time (b) Sometimes (c) not at all (d) Don't know

35. Have you been educated/given campaign on sanitation or hygiene issues?

(a) Yes >Q36 (b) No >Q37 (c) Don't know >Q37

36. If yes, by whom? (a) Government agency (b) NGO (c) School (d) Other (Specify).....

37. Do you have sanitation regulations by the government in place? (a) Yes (b) No >Q39 (c) Don't

Know >Q39

If yes, what are they? Answer.....

38. If so, how enforceable are they? (a) Highly enforceable (b) Enforceable (c) Not enforceable (d) Don't know

39. How likely do you think it is, that poor sanitation can cause problems? (a) Very likely (b) likely (c) Not likely (d) very unlikely.

If you think poor sanitation can cause problems, what are these?

40. What do you consider to be a good quality sanitation (toilet) facility?
Answer.....

41. How satisfied are you with the quality of your toilet facility? (a) Very Satisfied (b) Satisfied
(c) Unsatisfied (d) Very unsatisfied

Please give reason(s) for your answer.....

42. How would you rank environmental sanitation in your community? (a) Excellent (b) Good
(c) Okay (d) Poor (e) Extremely poor

43. Have you done anything to improve sanitation for your household? (a) Yes (b) No

If yes, please give reason(s) for your answer.....

44. How satisfied are you with the agencies involved in sanitation?

(a) Very Satisfied (b) Satisfied (c) Unsatisfied (d) Very unsatisfied

45. What do you think are the most important influences on changing sanitation behaviour?
Answer.....

46. Have you or a member of your household suffered from the following over the last 12 months? (a) Headache (b) Diarrhoea (c) Typhoid fever (d) Influenza (e) Hepatitis (f) Other..... (g) None

47. If yes, what do you think the cause might be?.....

48. What do you think can be done to solve or minimise the problem based on your answer above?.....

Appendix 2: Letter of Introduction for Interview with Government agencies

Dear Sir,

Request for interview

I am a PhD student at the University of Nottingham, United Kingdom. I am carrying out a research on water supply and sanitation in Benue state.

As a stakeholder, your views and inputs are very important in this study. It will therefore be highly appreciated if you can please avail yourself for interview at the date, time and venue most convenient to you. The information collected will be used purely for research purposes and all information you give will be anonymised and confidentially handled.

Please find attached a copy of the interview appointment and complete it.

Thank you very much for your time.

Stephen Aondoakaa

Phone: +2348033025677/+2348026699402

Email: lgxsca@nottingham.ac.uk.

Appointment for interview

Name of officer Institution

Position/Rank Contact number

Preferred date for interview Time Venue.....

Appendix 3: Interview Guides for Government Agencies

1. What is the name of your organisation? Location
2. What is your role in water supply and or sanitation?
3. Are you adequately resourced to discharge your duties in terms of funds, logistics and personnel?
4. Would you say there is adequate commitment to water and sanitation management in the town?
5. What are the main environmental and health problems? (Please rank the answers on a scale 1 (lowest) to 5 (highest))
6. On what problems or issues do you focus mainly?
7. Are you able to enforce regulations on water and sanitation?
8. Do you regulate the siting of sanitation and water facilities?
9. Which areas do you service?
10. What considerations influence the level or quality of service to provide in an area?
11. Is your organisation aware of health impacts of poor water and sanitation?
12. Do you carry out public education on water and sanitation?
13. How best can the information be disseminated to the people?
14. Have you put any plans in place about water and sanitation?
15. If yes, what plans have you put in place to eradicate this problem?
16. How will you achieve these plans and policies? (a) economic (b) social (c) cultural
17. What do you think should be the role of government, private organisation and individuals in tackling water supply and sanitation problem?
18. How would you describe the water supply and sanitation situation in this community?
19. How best do you think water supply and or sanitation problem can be solved?
20. What are the problems faced by your organisation in providing good water supply and sanitation?
21. Any other comments?

Appendix 4: Participants' Consent Form

School of Geography
University of Nottingham

Participant Consent Form

Investigating the Impacts of pit latrines on Groundwater Quality in Benue State, Nigeria.

In signing this consent form, I confirm that:

I have read the Participant Information Sheet and the nature and purpose of the research project has been explained to me.

Yes

No

I have had the opportunity to ask questions.

Yes

No

I understand the purpose of the research project and my involvement in it.

Yes

No

I understand that my participation is voluntary, and I may withdraw from the research project at any stage, without having to give any reason and withdrawing will not penalise or disadvantage me in any way.

Yes

No

I understand that while information gained during the study may be published, any information I provide is confidential (with one exception – see below), and that no information that could lead to the identification of any individual will be disclosed in any reports on the project, or to any other party. No identifiable personal data will be published. *[If other arrangements have been agreed in relation to identification of research participants (e.g. in a focus group) this point will require amendment to accurately reflect those arrangements]*

Yes

No

I understand that the researcher may be required to report to the authorities any significant harm to a child/young person (up to the age of 18 years) that he/she becomes aware of during the research. I agree that such harm may violate the principle of confidentiality.

Yes

No

I agree that extracts from the interview may be anonymously quoted in any report or publication arising from the research *[Omit if quotes not being used]*

Yes

No

I understand that the interview will be recorded using audiotape/electronic voice recorder/video recorder *[Amend/delete as applicable]*

Yes

No

I understand that data will be securely stored

Yes

No

I understand that I may contact the researcher *[or supervisor]* if I require further information about the research, and that I may contact the Research Ethics

Yes

No

Officer of the School of Geography, University of Nottingham, if I wish to make a complaint relating to my involvement in the research.

I agree to take part in the above research project.

Yes	No

_____ Participant's name (BLOCK CAPITAL)	_____ Participant's signature	_____ Date
_____ Researcher's name (BLOCK CAPITAL)	_____ Researcher's signature	_____ Date

Appendix 5: Household semi-structured interview guides

Number.....Date.....

Time (Start) (End) Venue

1. What do you perceive to be the condition of the environment in your community?
2. What do you think to be the major environmental problems of your community?
3. If you are to think of tackling any environmental problems in your community, which ones will be your priorities?
4. Please could you tell me the main source of drinking water for members of your household?
(If well is not mentioned, also include questions 19-25 for well specific questions.)
5. How long does it take to go there, get the drinking water, and come back?
6. Does the time spent collecting water vary by season?
7. If yes, how?
8. Who usually goes to this source to fetch the water for your household?
9. Is water always available when needed? (Or are there some seasonal or daily interruptions to availability?)
10. Do you use additional sources of drinking water?
11. If no, go to 12. If yes,
 - What sort of sources?
 - Where are they located?
 - How long does the round trip take for water collection from these sources?
 - Who collects water from them?
 - When do they use these sources?
 - Why do they use these sources?
12. Do you treat your water in any way to make it safer to drink? If no, go 15.
13. What do you usually do to the water to make it safer to drink?

14. Could you tell me why you treat the water?
15. Do you think you should treat the water?
16. What is the main source of water used by your household for other purposes such as bathing/handwashing and handwashing?
17. Do you use additional sources of cooking/bathing/handwashing water?
18. If no, go to 19. If yes,
- What sort of sources?
 - Where are they located?
 - How long does the round trip take for water collection from these sources?
 - Who collects water from them?
 - When do they use these sources?
 - Why do they use these sources?

Well water use questions

19. Do you use the water from your well for drinking?
20. If no, why are you not using the well water for drinking?
21. Do you treat your well water in any way to make it safer to drink? If no, go to 24.
22. What do you usually do to the well water to make it safer to drink?
23. Could you tell me why you treat the water from your well?
24. Do you think you should treat the well water?
25. Do you use the water from your well for cooking?

Other questions not specific on well water use

26. What makes a good quality well?
27. Do you share this water source with other people?
28. Do animals take water from these same sources or move around the source?
29. What key factors make good drinking water quality?

30. What can you say about water supply in your community?
31. Are you aware of groundwater contamination in your community?
32. If yes, are you aware of possible sources of groundwater contamination in your community?
33. Have you received any information or education about water supply from any source?
34. Do you think access to knowledge; information and education about improved water supply could be helpful?
35. Suggest ways by which poor water supply can best be solved or improved in your community.
36. What kind of toilet facility do members of your household usually use?
37. Do any members of the household use other facilities (or open defecation)?
38. If no, go to q 39. If yes
- What sort of facilities?
 - Who uses them?
 - Why do they use them?
 - Are they used at particular times (day/week/year)?
39. Do you share this facility with other households?
40. If so, how many households use this toilet facility?
41. The last time (name of youngest child) passed stools, what was done to dispose of the stools?
42. How do you perceive the quality of sanitation in your locality?
43. What do you think to be the implications of your answer to the question above on your community?
44. Have you received any information or education about sanitation or hygiene?
45. If yes, from where?
46. Do you think access to knowledge; information and education about improved sanitation can be of any help in your community?

47. How do you think information about sanitation could be best shared in your community?
48. Suggest ways by which sanitation problem(s) can best be solved or improved in your community.
49. Please can you tell me about the hygiene practices you carry out?
50. How do you see the importance of handwashing?
51. In what circumstances is hand washing with soap or ashes necessary?
52. What do you think can be done to make people practice handwashing?
53. Any other comments?

Appendix 6: DHS Water supply questions with options

1999	2003	2008	2010	2013
1 What is the main source of drinking water for members of your household?	1 What is the main source of drinking water for members of your household?	1 What is the main source of drinking water for members of your household?	1 What is the main source of drinking water for members of your household?	1 What is the main source of drinking water for members of your household?
*piped into residence/yard/plot	*Piped into dwelling	*Piped into dwelling	*Piped into dwelling	*Piped into dwelling
*public tap	*Piped into yard/plot	*Piped to yard/plot	*Piped to yard/plot	*Piped to yard/plot
*well in residence/yard/plot	*Public tap	*Public tap/standpipe	*Public tap/standpipe	*Public tap/standpipe
*public well	*Open well in dwelling	*Tube well or borehole	*Tube well or borehole	*Tube well or borehole
*Spring	*Open well in yard/plot	*Protected well	*Hand pump, protected well	*protected well
*river/stream	*Open public well	*Unprotected well	*Unprotected well	*Unprotected well
*pond/lake	*Protected well/borehole in dwelling	*Protected spring	*Protected spring	*Protected spring
*dam	*Protected well/borehole in yard/plot	*Unprotected spring	*Unprotected spring	*Unprotected spring
*Rainwater	*Protected public well/borehole	*Rainwater	*Rainwater	*Rainwater
*Tanker (Truck)	*Spring	*Tanker Truck	*Tanker Truck	*Tanker Truck
*Tanker Vendor	*River/stream	*Cart with small tank	*Cart with small tank	*Cart with small tank

*Bottled Water	*Pond/lake	*River/dam/lake/ Pond/stream/canal	*Surface water/river/lake / stream	*Surface water/river/lake / stream
*Borehole	*Dam	*Bottled water	*Bottled water	*Bottled water
*Other	*Rainwater	*Other	*Water sachets (pure water)	-
	*Tanker truck		*Other	*Other
	*Bottled water			
	*Other			
2 How long does it take you to get there, get water and come back?	2 How long does it take you to get there, get water and come back?	2 What is the main source of water used by your household for other purposes such as cooking and hand washing?	There is no second question on water supply.	2 Where is that water source located?
*Minutes *On premises	*Minutes *On premises	*Piped into dwell to yard/plot *pub. Tap/standpipe *tube well or borehole *protected well *unprotected well *protected spring *unprotected spring *Rainwater *Tanker truck		*In own dwelling *In own yard/ plot *Elsewhere

		*cart with small tank *surface water (river/dam/ Lake/pond/stream /canal/irrigation Channel *other		
3. There is no third question on water	3. There is no third question on water	3. Where is that water source located?	3. There is no third question on water	3. How long does it take you to get the water?

Appendix 7: Report of Pilot Survey on Agencies involved in Water and Sanitation in Nigeria

There was a brief interaction with agencies that are stakeholders in water supply and sanitation in Nigeria. The interaction was to scope the research and identify areas of interaction during the main fieldwork exercise. The report is therefore made from interaction with the following bodies.

Federal Ministry of Water Resources

This is the main regulatory body on water and sanitation in Nigeria. Although it is the main regulatory body, it collaborates with other Ministries and agencies, e.g. Federal Ministries of Environment, Health, Housing and Urban development, etc. Its water policy is summarised in the Nigeria Standards for Drinking Water Quality. In the area of water quality, it monitors groundwater quality by using monitoring points called sampling points. Boreholes and protected dug wells are tested. Water produced by water works is also monitored and tested. Samples are taken at intake (where water is taken to treatment point) called raw water, at treatment and then at the distribution line to know if there are contaminants. We also monitor surface water-major rivers, dams, irrigation sites. Samples are taken and tested for arsenic, fluoride, carbon load, etc. For drinking water, we test for parameters related to health while for surface water, we carry out test for main parameters. These water samples are tested to see that they comply with water quality standards. There are six water quality laboratories that are operational located in Kano, Gombe, Minna, Akure Lagos and Enugu. They are used by state water boards, individuals, etc. The analyses are done with a fee. But if one has a reagent, there will be no charge.

We got financial support from Africa Development Bank (ADB) to set out the programmes. We work with UNICEF, WHO. Others are state water boards, Rural Water Supply and Sanitation Agency (RUWASA).

In the area of sanitation, they have National, state and local government steering committees on sanitation to work at these respective levels. (This is contained in the Federal Republic of Nigeria: Federal Ministry of Water Resources National Water Sanitation Policy November 2004 Final Draft). Sanitation is concerned with liquid waste as regards to water contamination to both surface and groundwater-bacteriological, chemical and physical contamination. The national water research institute in Kaduna has data and research works done.

The Water, Sanitation and Hygiene (WASH) programme is being coordinated by Federal Ministry of Water Resources. The ministry is mainly for policy formulation while the actual implementation is done by state agencies, local governments and other institutions. The ministry is mainly for supervision and planning policies and guidelines. There is national rural water supply and sanitation policy and Joint Monitoring Platform (JMP) which is a joint monitoring platform by WHO and UNICEF.

Federal Ministry of Environment

The ministry has many component units. The aspect that concerns water and sanitation is in the area of environmental health and sanitation which looks at environmental sanitation, environmental health assessment, food hygiene and safety, sanitary complaints and inspection of premises, vector control, abattoir and market sanitation and solid waste management.

World Health Organisation (WHO)

During the interaction with the body, they maintained that their main role is to set standard for drinking water quality. This is to ensure that the water people are drinking fall within the safety standards to protect the people. Details of these are found on WHO website.

United Nations Children Fund (UNICEF)

This is a non-governmental organisation that works for the welfare of children. UNICEF's mission in Nigeria is to help governments at all levels, organisations, communities and families provide every child with education, health equality and protection. According to UNICEF the Water, Sanitation and Hygiene (WASH) programme aims to create safe water sources and sanitary facilities in communities and schools and provide hygiene education. Water, hygiene and sanitation ensure optimal child health and survival and also boost school attendance rates – especially girls (<http://www.unicef.org/nigeria/wash.html>). They work at the grass roots, carrying out various projects to help children. During the visit, they maintained that Abuja was the coordination office and referred me to Makurdi where they have many of their activities. They maintained that most of their activities are done through Benue Rural Water Supply and Sanitation Agency (BERWASSA). At Benue they have projects in many Local Governments like Konshisha, Tarka, Oju, etc. For instance, in one of the local governments in Benue state, a project known as community-led total sanitation where Betty Torkwase Ikyaator and her team are “triggering” Nigerian communities one by one to stop defecating in the open is being carried out and children are healthier for their efforts.

They have been going around some villages and seeing people living in unhygienic conditions and practicing open defecation. They have been educating and encouraging people to stop open defecation and there have been good responses in construction toilets. Some people have started practising simple hygiene like washing hands after defecation. This has yielded some results but with more than 45 million Nigerians still defecating in the open, according to the 2011 Multiple Indicator Survey, she knows there is still much triggering to be done.

WaterAid

This is a non-governmental organisation working in Nigeria to improve safe water supply and sanitation. According to water aid report, inadequate access to safe drinking water and improved sanitation is a major challenge in Nigeria. So far, Nigeria is far from meeting the MDG goals 75% coverage for safe drinking water and 63% coverage for basic sanitation by the year 2015. The latest joint monitoring programme report place sanitation coverage in the country at 32% national, 36% in urban and 28% rural. The national bureau of statistics place sanitation coverage at 51.6% and 58.9% coverage for water. The unhygienic practices and lack of sanitation facilities has been contributing to infant mortality. Lack of improved toilets with hand washing facilities in schools also affect children.

Available specific sanitation data for Nigeria from waterAid point that:

- At least 103 million people out of the 151.2 million population of Nigeria do not have access to sanitation. People without access to sanitation practice open defecation and other unsafe means of disposing their faeces.
- Of the 48.2 million people who have access to sanitation, 62.5% of their facilities are unimproved. These include traditional pit latrines and other sanitation facilities whose use expose them to health hazards and have the tendency to contaminate groundwater and to cause harm.
- Lack of sanitation seriously affect the number of children particularly girls that are able to enrol and finish school.
- Lack of improved sanitation facilities is the major cause of high mortality and morbidity rates which are related to diseases such as cholera, scabies, typhoid fever, malaria, trachoma and ringworm.
- An investment of \$1(145 Naira) yields between \$7-\$9(N1015-N1305) in other benefits both directly and indirectly.

According to WHO/UNICEF JMP 2010, access to sanitation by states was as follows:

% of populati. using improved sanitation facilities	No of states	percenta ge	States
Less than 10	3	8	Bayelsa (6,4%); Oyo (8.8%); Taraba (9.6%)
10-30	18	49	Kwara (10.4%) Cross River (12.2%); Ogun (14.6%); Ebonyi (15.4%); Osun (16.0%); Benue (16.3%); Plateau (17%); Ondo (17.5%); Ekiti (18.0%); Kogi (19.7%); Enugu (20.5%); Jigawa (22.2%); Bauchi (22.5%); Rivers (22.7%); Delta (25%); Adamawa (25.3%); Niger (26.1%); Lagos (25.3%).
30-50	12	32	Borno (30.1%); Yobe (31.4%); zamfara (31.4%); Kaduna (33.4%); Edo (34.5%); FCT (40.5%); Kebbi (41.7%); Nassarawa (42.1%); Akwa Ibom (45.3%); Abia (45.4%); Anambra (47.6%); Gombe (48.1%).
50-70	4	11	Katsina (52.6%); Imo (55.8%); Sokoto (60.7%); Kano (67.9%)
Total	37	100	

Source: Access to sanitation by states (WHO/UNICEF JMP 2010).

On waterAid website (www.wateraid.org/ng/what-we-do/the-crisis/statistics) are the following information:

*63.2 million people in Nigeria don't have access to safe drinking water.

*over 111 million people don't have access to adequate sanitation in Nigeria, two-thirds of the population.

*over 97,000 children die every year from diarrhoea caused by unsafe water and poor sanitation.

*Over 66 million Nigerians have no choice but to get water from wherever they can.

*where there is no safe and clean place to go to toilet, people are exposed to disease, lack of privacy and indignity.

*hand washing alone could cut the risk of diarrhoea almost in half saving hundreds of lives every day.

Benue State Ministry of Water Resources

This is mainly a regulatory body and it also monitors water quality from all sources to ensure compliance with safety standards. It also carries out supervisory roles mostly on BERWASSA, water board and contractors.

Benue State Rural Water and Sanitation Agency (BERWASSA)

Interaction was carried out with this body on 18/12/2013. This body takes responsibility for provision of water supply and sanitation monitoring in the rural areas of the state. The agency regulates water quality by regulating siting of boreholes upstreams of latrines and distance of about 30 metres apart and people are advised to site latrines away from drinking water sources. Water quality monitoring and surveillance is done by looking at risks around water points like is a latrine upstream? Are animals near it? Cleanliness and hygiene of water drawing bucket? Is the well concreted, lined or covered?

Rural people are provided with simple bacteriological test kits like hydrogen sulphide(H_2S) and trained to use it. People are also trained on bio-sand infiltration and solar disinfection when transporting water.

The major actors are state government which created BERWASSA. It gets support from donor agencies like UNICEF, DFID, WaterAid, and intervention from global sanitation funds.

Some projects include Water Sanitation and Hygiene project (WASH), implemented between 2002-2009 which piloted water and sanitation in selected communities to see the success before widening it. About 21 communities were selected in five local government areas. They were provided with boreholes and latrines in schools and at community level, latrine construction were subsidized by providing people with cement, mould, gravel, and sand and trained to build pit latrines and cover it with lid. From year 2000 to date, we are implementing the Sanitation, Hygiene and Water in Nigeria (SHAWN) project. This came as an improvement upon WASH which made most communities placed emphasis on water and ignoring sanitation. But SHAWN places much emphasis on sanitation and hygiene and water aspect as complementary to sanitation and hygiene. SHAWN is covering four local government areas of Oju, Ogbadibo, Konshisha and Tarka. The projects are ongoing with field workers implementing the hygiene

and sanitation improvement and strategies. There are water testing kits in every local government that has the project.

Benue State Sanitation Agency (BENSESA)

While Benue Rural Water and Sanitation Agency (BERWASSA) take care of water supply and sanitation in the rural areas, the Benue Sanitation Agency has its focus in the urban areas of Benue State. They take care of environmental sanitation and monitoring of water quality. They test their water samples at Federal Environmental Protection Agency laboratory located close to them. They regulate the siting of pit latrines and other sanitation systems with respect to water sources in urban areas. BENSESA works on solid and liquid waste in raw state mainly by collection and disposal in open dumps without treatment.

Conclusion

The interaction was carried out with these agencies to scope the research. The exercise identified areas to interact more at the fieldwork. Most of the agencies visited expressed willingness to cooperate and collaborate during the fieldwork.