

Does Source Sanitation affect Water Quality?

ABSTRACT

In order to correlate sanitation around water source with the quality of water from the source this study was conducted a cross-sectional study on 15 boreholes in 5 political wards using quantitative method of data collection. The Field survey was carried out in selected wards of Sabongari Local Government Area (LGA) of Kaduna State, Nigeria, while the laboratory analysis was carried out at the Department of Water Resources and Environmental Engineering between February and March, 2017. All functional boreholes in each of the five selected wards within Sabon gari LGA that served as communal source of water supply were included. A total of 15 boreholes (3 from each ward) were studied for water quality and surrounding sanitation. The physicochemical and microbiological analysis of water samples collected from the respective boreholes were carried out using standard methods and the results were compared to the Nigerian Standard for Drinking Water Quality and the WHO standards for conformity or otherwise while a checklist was used to assess the surrounding sanitation. The total score of both the water quality and sanitation were categorized respectively as poor, fair and good. A t-test was carried out using STATA/SE 13.1 Statistical Software to correlate the surrounding sanitation with the water quality. The confidence interval for the mean difference between water quality and sanitation (0.2384 – 1.3616) and the *P*-value (*P* = .0086) suggest that there is a relationship between the sanitation and the quality of water. As efforts are being made to increase access to clean water especially in developing economies like Nigeria, serious attention need to be given to the sanitation of the surroundings of the water source to prevent compromise of the water quality.

Keywords: Borehole, Physicochemical characteristics, Sanitation, Water quality, Zaria

1. INTRODUCTION

Clearly spelt out in the post-2015 Sustainable Development Goals (SDGs) is the call for universal access to clean water and sanitation by 2030 [1] yet the attainment of this goal still remains a major challenge for sub-Saharan Africa [2,3]. This is largely due to financial limitations on the part of the Governments within the regions to provide this amenity declared as a basic human right by a consensus of world governing bodies [4].

While efforts are being made by governments at various levels to meet the water needs of the people even with the limited resources, a majority of the populace still have to cater for their water needs at their respective household level. These personal efforts for household supply include wells and boreholes while others depend on direct consumption of surface water where available. While much effort is currently being made to increase the access to clean water both by governments and individuals, the efforts in the direction of sanitation seem not be commensurate. This is reflected among other indices by the poor sanitation around the water source. For instance, a careful observation at the surrounding of some boreholes especially around the northern part of Nigeria, are refuse dumps and other kinds of activities that have tendencies of introducing impurities to the water.

Previous researches have assessed the physicochemical and microbiological characteristics of water from various sources, the influence of drinking water quality on health and other aspects of human concerns as well as the public perception about drinking water from boreholes but studies on the assessment of the sanitation condition of the water source surrounding on the quality of water from that source seem to be non-existent [4–12]. It therefore becomes imperative for researches such as this to be carried out to establish whether the sanitation of the surrounding of the water source have any effect on the quality of water from that source.

2. MATERIAL AND METHODS

2.1 Study Area

The study was conducted in Sabon gari local government area of Kaduna state of Nigeria. The LGA lies between Latitude $11^{\circ} 5' N$ and $11^{\circ} 16' N$, and Longitude $7^{\circ} 34' E$ and $7^{\circ} 47' E$. The LGA consists also of 11 political wards. The wards are Samaru, Jama'a, Bassawa, Hanwa, Dogarawa, Chikagi, Muchia, Zabbi, Jushi, Angwa gabas and Bomo. The map of study area is shown in Fig. 1.

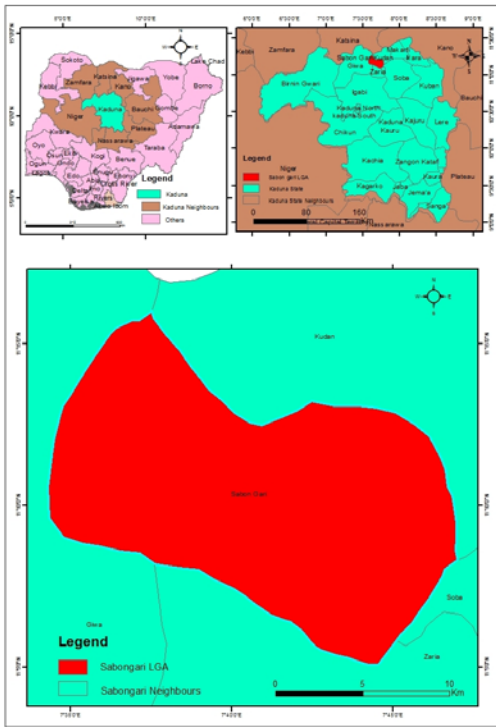


Fig. 1: Map of Study Area

2.2 Study Design

This study was a cross-sectional study on 15 boreholes across 5 political wards using quantitative method of data collection.

2.3 Inclusion and Exclusion Criteria

53 The study population included all functional boreholes in each of the five selected wards
54 within Sabon gari LGA that serve as communal source of water supply. Boreholes that were
55 not functioning at the time of the research as well as boreholes and wells that served only
56 individual households were excluded.

57 **2.4 Sampling Technique**

58 A multi-level sampling technique was used in this study. The first level involved the
59 purposive selection of five (5) wards (Bassawa, Chikaji, Dogarawa, Jama'a and Samaru)
60 based on accessibility and security concerns. The second level involved the selection of the
61 boreholes based on the inclusion and exclusion criteria earlier stated. Based on this three (3)
62 boreholes in each of the wards making a total of 15 were selected for the study.

63 **2.5 Preparation for Data Collection**

64 Reconnaissance visits were made to the District Heads of the respective communities to
65 intimate them on the research and solicit for their support. The assessment of the water
66 sources for inclusion or exclusion was done during these visits. Sterile sample collection
67 bottles were prepared for collection of samples for analysis in the laboratory. Three
68 undergraduate students were trained as research assistants for field enumeration. The
69 checklist for assessment of water source sanitation was pretested in the course of the visits.
70 All the required reagents and media for the physicochemical and microbiological analysis
71 were prepared before the commencement of the sample/data collection.

72 **2.6 Data Collection Instruments and Data Collection**

73 **2.6.1 Assessment of Water Source Sanitation**

74 A pre-designed checklist was used to assess the sanitation condition of the selected
75 boreholes. The checklist contained five parameters for assessing the sanitation. The
76 parameters were all positive with a "yes" having a score of "1" and a "No" having a score of
77 "0". The total score for each borehole was used to classify the sanitation as 1=Poor (40%),
78 2=Fair (60%) and 3=Good (80%).

79 **2.6.2 Physicochemical and Microbiological Analysis**

80 The water samples for the analysis were collected in sterile bottles and labeled appropriately
81 before transferring them to the laboratory below a temperature of 4 °C for analysis. Standard
82 internationally approved techniques for analysis of water quality described previously in
83 Hassan *et al.* [8] were adopted in this study with slight variations in the models of the
84 instruments used. The analyses were carried out at the Environmental Engineering
85 Laboratory of the Department of Water Resources and Environmental Engineering, Ahmadu
86 Bello University, Zaria, Nigeria. Standard laboratory result sheets were used to record the
87 results of the physicochemical and microbiological analysis. The results of the parameters
88 were compared with the Nigeria Standard for Drinking Water Quality (NSDWQ) [13] and the
89 World Health Organization Standard for drinking water quality [14]. The results of the
90 parameters that conform to the limits were labeled "yes" with a score of "1" while those that
91 fail to meet the standards were labeled "No" with a score of "0". The water quality was
92 classified based on the total score as follows: Poor ($\leq 60\%$) ranked 1, Fair ($>60\%$ but $\leq 70\%$)
93 ranked 2 and Good ($>70\%$) ranked 3.

94

95 2.7 Data Analysis

96 STATA/SE version 13.1 statistical software was to carry out the analysis of data. Paired t-
97 test was carried assess the relationship between the sanitation of the water source and the
98 quality of water. A 95% confidence level was used and $P \leq 0.05$ was considered statistically
99 significant.

100

101 3. RESULTS AND DISCUSSION

102

103 A total of 15 functional boreholes were identified across the five political wards of Bassawa,
104 Chikaji, Dogarawa, Jama'a and Samaru. The results of the physicochemical and
105 microbiological analysis are presented in Table 1 and 2. The results show that the BOD of all
106 the samples tested did not conform to the acceptable limits. Although BOD limits were not
107 specified in both NSDWQ and WHO standards, BOD of zero is generally accepted in
108 drinking water. BOD is undesirable in drinking water as it is indicative of the presence of
109 organic contaminants in water. Although the BOD values for all the samples were not so
110 high, it still makes the water objectionable. All the samples analyzed had a colour of 5 NSA
111 which is far less than the 15 NSA limit specified by both NSDWQ and WHO. Only 33.33% of
112 the samples conformed to the hardness limit of 150 mg/l specified with Dogarawa1 having
113 the least value of 10.1 mg/l. the conformity of the remaining 67.67 % could be attributable to
114 the geological characteristics of the area which is not within the scope of this study. All the
115 samples conformed to the limits of 5 NTU for turbidity while 86.67 % conformed to the limit
116 for Total Dissolved solids. Meanwhile, 66.67 % of all the samples fell within the specified 6.5
117 – 8.5 range, all samples passed the nitrate test. Although, nitrate is not the only indicator of
118 faecal contamination in water as there could be other anthropogenic sources, these results
119 could be a possible indication that no faecal contamination has taken place [8]. Similar
120 studies conducted in other regions of Nigeria found the nitrate level to be above the specified
121 limits contrary to the results obtained herein [8,15-16]. The respective authors inferred
122 possible faecal contamination probably via infiltration from nearby pit latrines. The absence
123 of pit latrines within 30 meters radius of all the boreholes assessed in the present study
124 could be a possible reason for the results obtained. The Temperature of 80% of the samples
125 was above the ambient temperature of 25 °C at the time of the study. The percentage of
126 samples that conformed to the limits for electrical conductivity and total coliforms were 86.67
127 % and 46.67% respectively. The below average conformity of the Total coliforms should be
128 taken with seriousness as it is indicative of probable faecal contamination which probably
129 was introduced in the course of the activities around the borehole. This seems to contradict
130 the nitrate results but could only be a reflection of the variations in the degree of
131 contamination. Comparing the total coliforms obtained herein with a related study in Kenya
132 [17], the results obtained in the present study were closer to the recommended limits. The
133 sources of water and the activities around them could be possible reasons for the disparities.
134 In the overall quality analysis, 13.33 % of the samples had good qualities while 60 % and
135 26.67 % had fair and poor qualities respectively. However, the study could not assess other
136 chemical contaminants of health importance as only indicative parameters required for
137 probable correlation of quality with sanitation around sources were examined. These
138 indicative parameters were selected based on the recommendations of the Nigerian
139 Standard for drinking water quality [13].

140

Table 1: Physicochemical and Microbiological Characteristics of the Water Samples

Sample	Bod (mg/L)	Colour (NSA)	Hardness (mg/l)	Turbidity (NTU)	Total Dissolved Solids (mg/l)	Chloride (mg/l)	pH	Nitrate (mg/l)	Temp (°C)	Electrical conductivity (μ S/cm)	Total coliforms (Cfu/100ml)	Quality
Chikaji1	0.2	5	262.6	0.863	80.8	12.5	8.68	0	34	165.1	0×10^3	Good
Chikaji2	0.7	5	1080.7	0.965	336	13.5	7.66	1.2	33	694	0×10^3	Fair
Chikaji3	0.9	5	2111	0.372	362	17.5	7.56	0	33	727	1×10^3	Poor
Samaru1	1.3	5	302.02	1.68	600.3	118	7.4	0	24	1225	2×10^3	Poor
Samaru2	2.2	5	132.3	0.454	455	115.6	7.3	2.1	25	949	1×10^3	Fair
Samaru3	0.5	5	301.2	0.412	315.6	50.8	7.5	3.2	24	630	2×10^3	Poor
Dogarawa1	0.3	5	10.1	0.278	92.8	21.99	9.06	2.4	29	188.4	2×10^3	Fair
Dogarawa2	0.2	5	80.8	0.724	110.4	27.49	8.82	5.3	28	223.8	1×10^3	Good
Dogarawa3	2.3	5	262.62	2	68.6	14.99	8.83	1.6	29	136	1×10^3	Fair
Bassawa1	1.8	5	151.5	0.863	118.8	22.99	8.31	0	29	244	2×10^3	Fair
Bassawa2	1.5	5	80.8	0.868	151	42.48	8.22	1.3	28	304	2×10^3	Fair
Bassawa3	1.8	5	383.83	0.454	693	61.48	8.1	3.6	28	1357	2×10^3	Poor
Jama'a1	0.9	5	151.51	0.169	123.1	17.9	8.56	1.3	28	244	1×10^3	Fair
Jama'a2	0.7	5	212.11	0.789	303	29.49	8.44	4.3	28	151	2×10^3	Fair
Jama'a3	0.2	5	141.41	0.734	80.1	11.49	8.47	0	29	165.1	2×10^3	Fair
NSDWQ	0	15	150	5	500	250	6.5- 8.5	50	25	1000	1×10^3	
WHO	0	15	150	5	500	250	6.5- 8.5	50	25	2500	1×10^3	

144 **Table 2: Physicochemical and Microbiological Characteristics of the Water samples**

Characteristics	Frequency	Percentage
BOD		
Yes	0	0
No	15	100
Colour		
Yes	15	100
No	0	0
Hardness		
Yes	5	33.33
No	10	66.67
Turbidity		
Yes	13	86.67
No	12	13.33
Chloride		
Yes	15	100
No	0	0
pH		
Yes	10	66.67
No	5	33.33
Nitrate		
Yes	15	100
No	0	0
Temperature		
Yes	3	20
No	12	80
Electrical Conductivity		
Yes	13	86.67
No	2	13.33
Total Coliforms		
Yes	7	46.67
No	8	53.33

145
146 Similarly, the results of the assessment of the sanitation condition around the boreholes are
147 presented in Table 3 and 4. All the water samples were clean in their appearance.
148 Meanwhile, refuse dumpsites were found around 26.67 % of the boreholes. More so,
149 washing activities were found around about 33 % of the boreholes. None of the boreholes
150 had drainage around it while only about 13 % had clean surrounding. Based on the weights
151 allocated for these observations, about 7 % had good sanitation while 40 % and 53 % had
152 fair and poor sanitations respectively.

153
154
155
156

157 **Table 3: Results of the Assessment of Sanitation around Water Source**

Samples	Drinking water is clean	No dump site around water source	No washing around water source	The source is properly drained	The source surrounding is clean
Chikaji1	Yes	Yes	Yes	No	Yes
Chikaji2	Yes	Yes	No	No	No
Chikaji3	Yes	No	Yes	No	No
Samaru1	Yes	Yes	No	No	No
Samaru2	Yes	Yes	No	No	No
Samaru3	Yes	No	Yes	No	Yes
Dogarawa1	Yes	Yes	Yes	No	No
Dogarawa2	Yes	Yes	Yes	No	No
Dogarawa3	Yes	Yes	No	No	No
Bassawa1	Yes	No	Yes	No	No
Bassawa2	Yes	No	Yes	No	No
Bassawa3	Yes	Yes	Yes	No	No
Jama'a1	Yes	Yes	No	No	No
Jama'a2	Yes	Yes	Yes	No	No
Jama'a3	Yes	Yes	Yes	No	No

158
159 **Table 4: Sanitation Characteristics of the Water Sources**

Characteristics	Frequency	Percentage
Drinking water is clean		
Yes	0	0
No	15	100
No refuse dumpsite around Source		
Yes	11	73.33
No	4	26.67
No washing at the source		
Yes	10	66.67
No	5	33.33
Drainage at the source		
Yes	0	0
No	15	100

160
161 Furthermore, the results of the t-test to examine whether or not the quality of water has a
162 relationship with the sanitation are presented in Table 5.

163
164 **Table 5: Relationship between the water source sanitation and water quality**

Variable	Obs.	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]
Water quality	15	2.33	0.1869	0.7237	1.9325 – 2.7341
Sanitation	15	1.53	0.1652	0.6399	1.1790 – 1.8877
Difference	15	0.80	0.2619	1.0142	0.2384 – 1.3616

t = 3.0551

P = .0086

165 The confidence interval for the mean difference between water quality and sanitation does
166 not include zero which suggests a relationship between them. This is further buttressed by

the small *P*-value ($p = .0086$). This implies that there is actually a relationship between the water quality and the source sanitation.

4. CONCLUSION

The results obtained in this study have shown evidence of a relationship between the quality of water from the boreholes studied and the conditions of sanitation around the boreholes. It is therefore very important for policy makers to pay attention to maintaining good sanitation around water sources as they have the capability of compromising the water quality. As efforts are being made to increase access to clean water especially in developing economies like Nigeria, serious attention need to be given to the sanitation of the surroundings of the water source to prevent compromise of the water quality.

COMPETING INTERESTS

None

REFERENCES

1. United Nations. Transforming our World: The 2030 Agenda for Sustainable Development. New York: United Nations; 2015.
2. Ndikumana L, Pickbourn L. The impact of foreign aid allocation on access to social services in sub-Saharan Africa: the case of water and sanitation. *World Development*. 2017 Feb 28;90:104-14.
3. Roche R, Bain R, Cumming O. A long way to go—Estimates of combined water, sanitation and hygiene coverage for 25 sub-Saharan African countries. *PloS one*. 2017 Feb 9;12(2):e0171783.
4. Kamara JK, Galukande M, Maeda F, Luboga S, Renzaho A. Understanding the Challenges of Improving Sanitation and Hygiene Outcomes in a Community Based Intervention: A Cross-Sectional Study in Rural Tanzania. *International Journal of Environmental Research and Public Health*. 2017 Jun 5;14(6):602-17.
5. Dearden KA, Brennan AT, Behrman JR, Schott W, Crookston BT, Humphries DL, Penny ME, Fernald LC. Does household access to improved water and sanitation in infancy and childhood predict better vocabulary test performance in Ethiopian, Indian, Peruvian and Vietnamese cohort studies?. *BMJ open*. 2017 Mar 1;7(3):e013201.
6. Delaire C, Peletz R, Kumpel E, Kisiangani J, Bain R, Khush R. How Much Will It Cost To Monitor Microbial Drinking Water Quality in Sub-Saharan Africa?. *Environmental Science & Technology*. 2017 May 12;51(11):5869-78.
7. Hamaidi-Chergui F, Errahmani MB, Debib A, Hamaidi MS. Bacteriological analysis and public perception about drinking water of boreholes in Arib (Ain Defla, Algeria). *Journal of Fundamental and Applied Sciences*. 2016;8(2):542-51.

- 217 8. Hassan AS, Bashir D, Hayatu JM, Mohammed IU. The influence of drinking water
218 quality on health and food security in Taraba State, Nigeria. *European Journal of Earth and*
219 *Environment* 2016;3(2):1–16.
- 220
- 221 9. Mgbemena NM. Physicochemical and bacteriological analysis of borehole waters in
222 Owerri North LGA, Imo State, Nigeria. *Journal of Chemical Society of Nigeria*. 2017 Feb
223 10;41(1):99-104.
- 224
- 225 10. Kumpel E, Peletz R, Bonham M, Khush R. Assessing Drinking Water Quality and
226 Water Safety Management in Sub-Saharan Africa Using Regulated Monitoring Data.
227 *Environmental science & technology*. 2016 Sep 28;50(20):10869-76.
- 228
- 229 11. Peletz R, Kumpel E, Bonham M, Rahman Z, Khush R. To what extent is drinking
230 water tested in sub-Saharan Africa? A comparative analysis of regulated water quality
231 monitoring. *International journal of environmental research and public health*. 2016 Mar
232 2;13(3):275.
- 233
- 234 12. Kumpel E, Cock-Esteb A, Duret M, de Waal D, Khush R. Seasonal variation in
235 drinking and domestic water sources and quality in Port Harcourt, Nigeria. *The American*
236 *journal of tropical medicine and hygiene*. 2017 Feb 8;96(2):437-45.
- 237
- 238 13. Standard Organizations of Nigeria. *Nigeria Standard for Drinking Water Quality*
239 *(NSDWQ)*, Lagos: Standards Organizations of Nigeria: NIS 554: 2007,
- 240 14. World Health Organization (WHO). *Guidelines for Drinking Water Quality-*
241 *Recommendations*, 3rd Ed. Geneva: 1:2004
- 242 15. Erah PO, Akujieze CN. The Quality of Groundwater in Benin City: A baseline study
243 on inorganic chemicals and microbial contaminants of health importance in boreholes and
244 open wells. *Tropical Journal of Pharmaceutical Research*. 2002;1(2):75-82.
- 245
- 246 16. Nwuba RI, Philips AO. Assessment of Hydrological Properties and Proximate Impact
247 of Septic Tank Leachate on Well-water Quality in Two Residential Areas in Ibadan, South-
248 western Nigeria. *British Journal of Applied Science and Technology*. 2015;10(6):1-18.
- 249
- 250 17. Douglas K, Mwangi J. Microbial Assessment of Water Used by the Residents of
251 Kabianga in Kericho, Kenya from the Different Sources. *British Microbiology Research*
252 *Journal*. 2016;16(6):1-8.