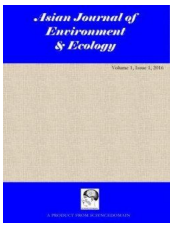

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Does Source Sanitation Affect Water Quality?

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Authors' contributions

This is a collaborative study carried by all the aforementioned authors. Authors SBI and MIA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author FBW managed the analyses of the study while author OOO managed the literature searches as well as the data collection phase of the study. All authors read and approved the final manuscript.

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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

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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, 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 effects of 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. MATERIALS 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° 5' N and 11° 16' N, and Longitude 7° 34' E and 7° 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.

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

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

2.4 Sampling Technique

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

2.5 Preparation for Data Collection

Reconnaissance visits were made to the District Heads of the respective communities to intimate them on the research and solicit for their support. The assessment of the water sources for

inclusion or exclusion was done during these visits. Sterile sample collection bottles were prepared for collection of samples for analysis in the laboratory. Three undergraduate students were trained as research assistants for field enumeration. The checklist for assessment of water source sanitation was pretested in the course of the visits. All the required reagents and media for the physicochemical and microbiological analysis were prepared before the commencement of the sample/data collection.

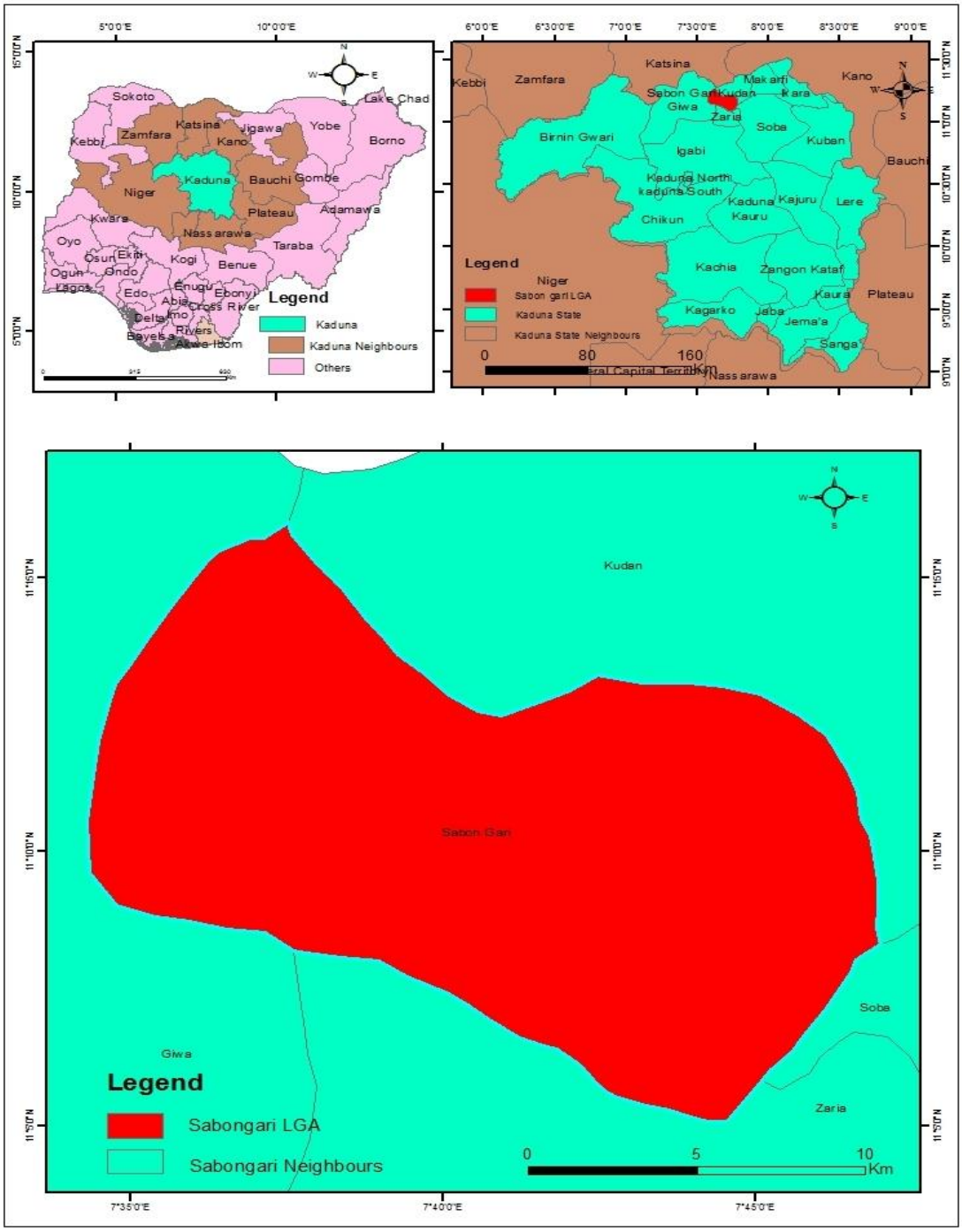

Fig. 1. Map of Study Area

2.6 Data Collection Instruments and Data Collection

2.6.1 Assessment of water source sanitation

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

2.6.2 Physicochemical and microbiological analysis

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

2.7 Data Analysis

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

3. RESULTS AND DISCUSSION

A total of 15 functional boreholes were identified across the five political wards of Bassawa, Chikaji, Dogarawa, Jama'a and Samaru. The results of the physicochemical and microbiological analysis are presented in Table 1 and 2. The results show that the BOD of all the samples tested did not conform to the acceptable limits. Although BOD limits were not specified in both NSDWQ and WHO standards, BOD of zero is generally accepted in drinking water. BOD is undesirable in drinking water as it is indicative of the presence of organic contaminants in water. Although the BOD values for all the samples were not so high, it still makes the water objectionable. All the samples analyzed had a colour of 5 NSA which is far less than the 15 NSA limit specified by both NSDWQ and WHO. Only 33.33% of the samples conformed to the hardness limit of 150 mg/l specified with Dogarawa1 having the least value of 10.1 mg/l. The conformity of the remaining 67.67% could be attributable to the geological characteristics of the area which is not within the scope of this study. All the samples conformed to the limits of 5 NTU for turbidity while 86.67% conformed to the limit for Total Dissolved solids. Meanwhile, 66.67% of all the samples fell within the specified 6.5 – 8.5 range, all samples passed the nitrate test. Although, nitrate is not the only indicator of feacal contamination in water as there could be other anthropogenic sources, these results could be a possible indication that no feacal contamination has taken place [8]. Similar studies conducted in other regions of Nigeria found the nitrate level to be above the specified limits contrary to the results obtained herein [8,15-16]. The respective authors inferred possible feacal contamination probably via infiltration from nearby pit latrines. The absence of pit latrines within 30 meters radius of all the boreholes assessed in the present study could be a possible reason for the results obtained. The Temperature of 80% of the samples was above the ambient temperature of 25°C at the time of the study. The percentage of samples that conformed to the limits for electrical conductivity and total coliforms were 86.67% and 46.67% respectively. The below average conformity of the Total coliforms should be taken with seriousness as it is indicative of probable feacal contamination which probably was introduced in the course of the activities around the borehole. This seems to contradict the nitrate results but could only be a reflection of the variations in the degree of contamination. Comparing the total coliforms obtained herein with a related study in Kenya [17], the results obtained in the present study were closer to the recommended limits. The sources of water and

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 (µS/cm)	Total coliforms (Cfu/100 ml)	Quality
Chikaji1	0.2	5	262.6	0.863	80.8	12.5	8.68	0	34	165.1	$0x10^3$	Good
Chikaji2	0.7	5	1080.7	0.965	336	13.5	7.66	1.2	33	694	$0x10^3$	Fair
Chikaji3	0.9	5	2111	0.372	362	17.5	7.56.	0	33	727	$1x10^3$	Poor
Samaru1	1.3	5	302.02	1.68	600.3	118	7.4	0	24	1225	$2x10^3$	Poor
Samaru2	2.2	5	132.3	0.454	455	115.6	7.3	2.1	25	949	$1x10^3$	Fair
Samaru3	0.5	5	301.2	0.412	315.6	50.8	7.5	3.2	24	630	$2 x10^3$	Poor
Dogarawa1	0.3	5	10.1	0.278	92.8	21.99	9.06	2.4	29	188.4	$2 x10^3$	Fair
Dogarawa2	0.2	5	80.8	0.724	110.4	27.49	8.82	5.3	28	223.8	$1x10^3$	Good
Dogarawa3	2.3	5	262.62	2	68.6	14.99	8.83	1.6	29	136	$1x10^3$	Fair
Bassawa1	1.8	5	151.5	0.863	118.8	22.99	8.31	0	29	244	$2 x10^3$	Fair
Bassawa2	1.5	5	80.8	0.868	151	42.48	8.22	1.3	28	304	$2 x10^3$	Fair
Bassawa3	1.8	5	383.83	0.454	693	61.48	8.1	3.6	28	1357	$2x10^3$	Poor
Jama'a1	0.9	5	151.51	0.169	123.1	17.9	8.56	1.3	28	244	$1 x10^3$	Fair
Jama'a2	0.7	5	212.11	0.789	303	29.49	8.44	4.3	28	151	$2 x10^3$	Fair
Jama'a3	0.2	5	141.41	0.734	80.1	11.49	8.47	0	29	165.1	$2 x10^3$	Fair
NSDWQ	0	15	150	5	500	250	6.5-8.5	50	25	1000	$1 x10^3$	
WHO	0	15	150	5	500	250	6.5-8.5	50	25	2500	$1 x10^3$	

the activities around them could be possible reasons for the disparities. In the overall quality analysis, 13.33% of the samples had good qualities while 60% and 26.67% had fair and poor qualities respectively. However, the study could not assess other chemical contaminants of health importance as only indicative parameters required for probable correlation of quality with sanitation around sources were examined. These indicative parameters were selected based on the recommendations of the Nigerian Standard for drinking water quality [13].

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

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

The confidence interval for the mean difference between water quality and sanitation does 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.

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

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

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

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

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

Authors have declared that no competing interests exist.

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