A COMPARISON OF THE IMPACT OF HUMAN ACTIVITIES ON BIOLOGICAL GROUNDWATER PARAMETER BETWEEN NORTH AND SOUTH OF KADUNA METROPOLIS

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ABSTRACT
Groundwater is a major source of water supply in urban centers like Kaduna Metropolis, where pipe borne water is not reliable in terms of availability and quality. This has necessitated the inhabitants of Kaduna Metropolis to seek for groundwater as an alternative. However human activities have resulted in the depletion of groundwater of this area. This study compares the impact of human activities on biological groundwater quality between North and South of Kaduna Metropolis. Fifty groundwater samples, comprising 30 from North and 20 from South (29 boreholes (motorized and hand pump) and 21 hand dug wells) were analysed for faecal and total coliform using membrane filter technique in accordance with America Public Health Association standard procedure. Result indicated that 60% and 70% of the groundwater in the South and North respectively is contaminated in faecal and total coliform. The coliform count (cfu/100ml) in the water samples ranges between zero to "too numerous to count". Coliform contamination is high in areas with poor sanitation and in locations where groundwater sources are installed close to toilet facilities as seen in the results. Hence, it is recommended that appropriate measures be taken to treat the groundwater by disinfection and boiling before drinking.

KEYWORDS: *Groundwater, Microbiological analysis, Human activities, Pollution, Kaduna South and North*

1. INTRODUCTION

Water is essential to sustain human life, animals and plants (Patil and Patil, 2010). This is because water is the major solvent in which many of the body's proteins and other substances are dissolved. It enables many metabolic activities of the body to take place (Davis, 2005). Water is essential for food production, domestic and industrial uses, tourism and cultural purposes. Water also helps in sustaining the earth's ecosystem (Mark et al. 2002). Groundwater is of major importance and is intensively exploited for private, domestic and industrial uses. According to Ajibade *et al,* (2011), 90% of the population in Nigeria depends largely on hand dug wells and boreholes. Rapid growth in urban population, industrial, commercial and agricultural developments result in ground water pollution. Groundwater is vulnerable to a variety of threats, including overuse and contamination. Nigeria is also facing the problem of water quality degradation. However, the severity of groundwater pollution is more prominent in

urban centers like Kaduna where industrialization and commercial activities are on the increase. Jatau *et al* (2006) assessed the quality of surface and groundwater in some parts of Kaduna Metropolis and noted that the groundwater was slightly acidic, high in iron, nitrate and faecal coliform which was attributed to leachate from wastes and dumpsites. In a similar study, Egbulem (2003) used faecal coliform and faecal streptococcus indicator to assess the microbial quality of groundwater from hand dug wells in Mando and Kawo areas of Kaduna and found that the wells were all contaminated which was attributed to increased human and industrial activities. This paper is aimed at assessing the impact of urbanization on bacteriological quality of groundwater in Kaduna Metropolis, which is an important drinking water parameter.

2. MATERIALS AND METHODS

2.1 The Study Area

Kaduna Metropolis is located in the Northwest geopolitical zone of Nigeria. It lies between latitudes 10°N and 11°N, and between longitudes 7°E and 8°E, and at an altitude of 645m above sea level. Kaduna is characterized by two distinct seasons in the year: the dry season and the rainy season. The dry season runs from late October to March and is characterized by cold and dry conditions with the 'harmattan' wind that blow from north-east to south-west. The rainy season runs from April to early October and is characterized by warm and humid conditions with winds blowing from the south-west to north-east. The average monthly temperature for the city is between 26°C and 34°C (Bununu *et al.,* 2015). The State shares geographical boundaries with Katsina and Zamfara States to the North, Plateau and Bauchi States to the East, Nasarawa State and the Federal Capital Territory to the South, Niger State to the West, and Kano State to the Northeast. Kaduna State occupies an area of 48,473.25 km^2 with a human population of over 6 million according to census figures of 2006. Presently, the population in Kaduna Metropolis is estimated to be around 1.3 million and is comprised of four local government areas namely, Kaduna North, Kaduna South, Igabi and Chikun local governments. Figure 1 shows the map of the study area, (Kaduna Metropolis).

Figure2: Map of study area. Source: (Kaduna Street Metro map, 2014)

2.2 Sampling Locations

Figure 2 shows the groundwater sampling locations. The locations were chosen after a preliminary survey in order to identify the sampling locations representative sampling of the studied area. Kaduna Metropolis was divided into two (2) segments (South and North) with Leventis Round about as the reference point (Centre).

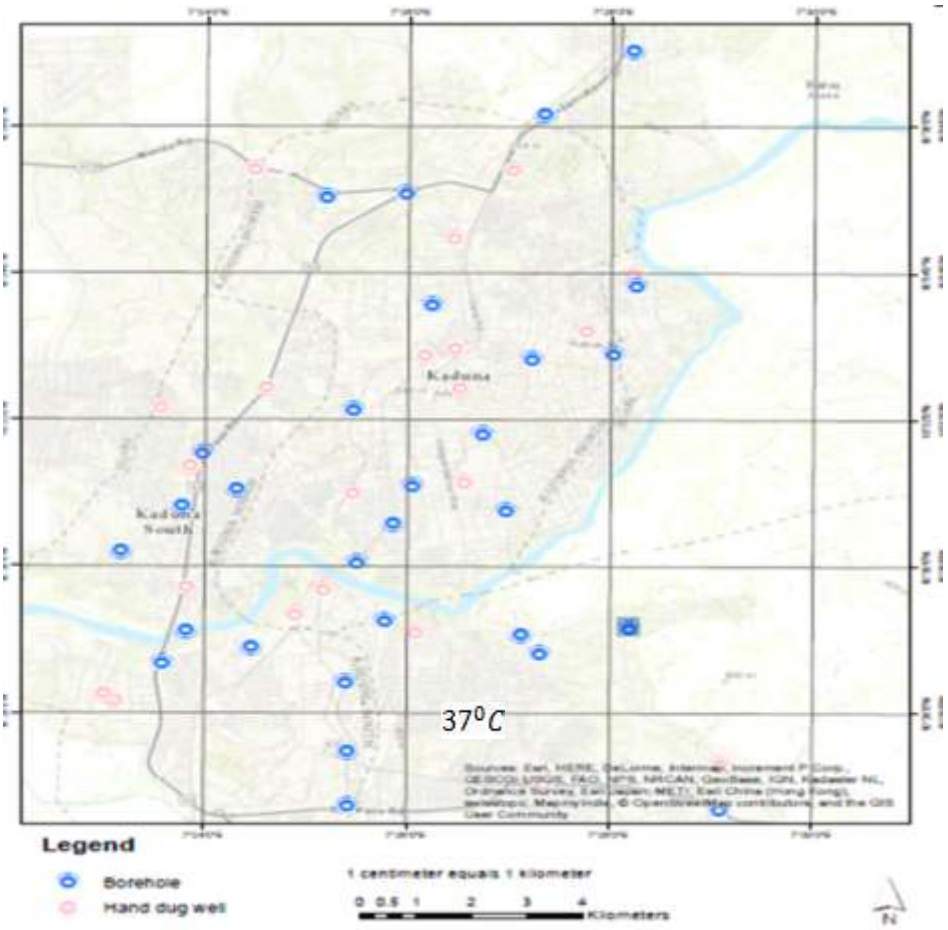

Figure 1.1: GPS location of the sampling locations

2.3 Sampling Procedure

A total of fifty (50) groundwater samples were collected at a radial distance of 2.1 km covering the populated area, commercial, industrial, agricultural, schools and religious areas so as to obtain a good representation within the Kaduna Metropolis. The geographical coordinates of the sampling points were also taken using GPS 76 GARMIN. Twenty one (21) samples were collected from hand-dug wells and twenty nine (29) samples from boreholes. The samples were stored in sampling kits at 4°C and transported to the National Water Resources Institute's for laboratory analysis.

2.4 Microbiological Analysis

The membrane filtration technique was employed in the microbiological analysis for both faecal and total coliform. The test was carried out in accordance with the Standard methods for the examination of water and wastewater (APHA, 1998).The lids were removed and all yellow colonies counted irrespective of size count. Sometimes hand lens was used when necessary. The colonies were counted within a few minutes of removal from the incubator. Colonies that are not yellow such as pink and transparent colonies were ignored. The process was repeated for the other

incubator. Once the yellow colonies have been determined for each incubator, assuming that 100 ml of sample was filtered, this value equals the number of coliforms per 100 ml, bearing in mind that samples incubated at 44°C are faecal (thermo tolerant) coliforms, whilst those incubated at 37°C are total coliforms. The results were recorded as colony forming unit per 100 ml (cfu/100 ml) and presented in Table 1.

3. RESULT AND DISCUSSIONS

3.1 Faecal Coliform and Total Coliform Contamination in Kaduna North

Table 1 present result of bacteriological parameters of groundwater in Kaduna North. The results were compared with the maximum permissible limit given by the Nigerian standard for drinking water quality (NSDWQ) and the WHO drinking water guideline.

Table 1: Bacteriological qualityfor samples in Kaduna North

S/N	Locations	Faecal Coliform (CFU/100 ml)	Total Coliform (CFU/100 ml)
1	AnguwarSarki (HDW)	4	10
2	ECWADcc Ali Akilu Rd (BH)	1	60
3	Kano Road(HDW)	8	71
4	Kankara Road Kawo (HDW)	0	TNTC
5	AnguwarGwari (HDW)	0	TNTC
6	NDC (BH)	4	7
7	Rigachukun (BH)	0	10
8	AnguwarMaisamariMalali (HDW)	TNTC	TNTC
9	Malali Primary School (BH)	11	TNTC
10	Zamani College (BH)	20	TNTC
11	Sultan Road (BH)	TNTC	TNTC
12	AnguwarRimi Village (BH)	0	0
13	Alkali Road (HDW)	TNTC	TNTC
14	MagajinGari (BH)	2	9
15	Constitution Road (BH)	0	18
16	College Road (BH)	0	3
17	Defence Road (HDW)	12	25
18	Mando Central Park (BH)	0	4
19	FarinGida (BH)	0	2
20	NECCO (HDW)	6	18
21	Badiko (HDW)	4	126
22	AnguwarSanusi (HDW)	TNTC	TNTC
23	Arewa (BH)	5	13
24	Railway Rigasa (HDW)	8	19
25	Yankifi (BH)	2	8
26	MakeraRigasa (BH)	20	26
27	KarshenKwalta (HDW)	6	19
28	Shanono (BH)	17	61
29	Mashi (HDW)	47	110
30	AnguwarSanusi (HDW)	TNTC	TNTC
	WHO Guideline Value (2006)	0	10
	NSDWQ Maximum Allowable Limit (2007)	0	10

Note: HDW: Hand dug well, BH: Bore hole, TNTC: Too numerous to count

The faecal coliform and total coliform values ranged from zero to "too numerous to count" (TNTC). Twenty two samples (out of 30) had faecal coliform values greater than the recommended WHO and the NSDWQ while 21 samples (out of 30) had total coliform values greater than or equal to 10 cfu/100 ml representing non compliance with NSDWQ and WHO guidelines which indicate contamination bacteriologically. These locations are areas where the distance between septic facilities and groundwater sources are not maintained at the required standard distance of at least 30 m. Human activities within these locations result in the deterioration of groundwater as observed during sampling. Pollution of these water sources might be as a result of poor sanitation practices within and around the environment where samples were collected. Leachate from toilet or sanitary drainage facilities, located few metres away from the groundwater sources, may also be sources of contamination. Potentially pathogenic bacteria may be transmitted through human excreta where open defecation is practiced and transported into unprotected wells during storm water runoff. Figure 3.1 and Figure 3.2 show graphical representation for feacal and total coliform respectively.

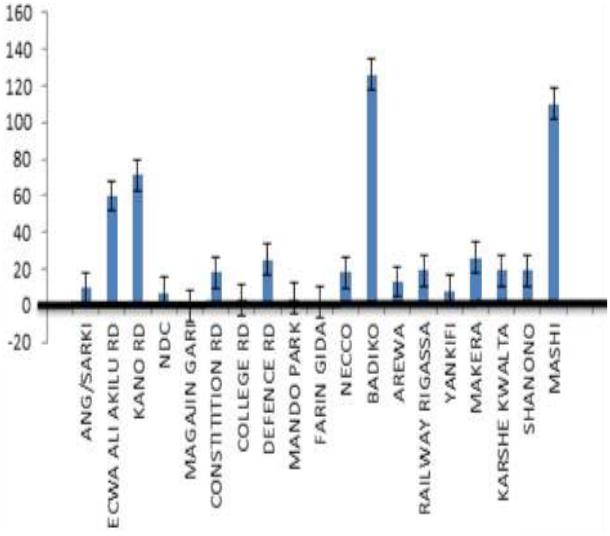

Figure 3.1: A comparison of faecal coliform in Kaduna North with NSDWQ MAL

From Figure 3.1, the bars above the thick black line passing through the abscissa, are locations whose faecal values are above the NSDWQ (0 CFU/100 ml), while those on the black thick line are within the NSDWQ MAL as seen in Figure 3.1. Areas not captured (as shown in Table 1) on the graph have faecal coliform values, too numerous to count (TNTC) and are not applicable.

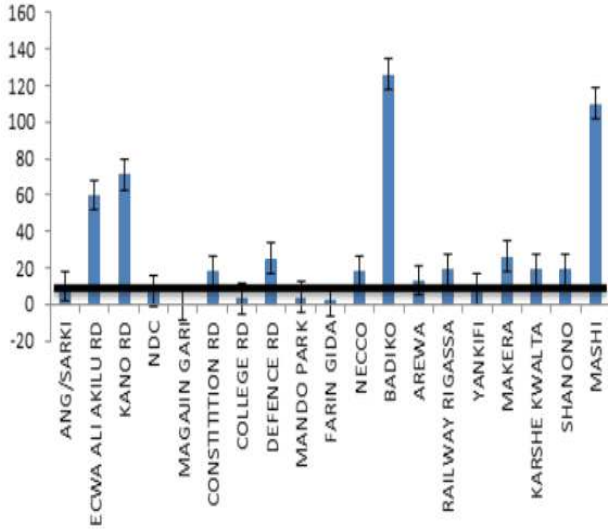

Figure 3.2: A comparison of total coliform in Kaduna North with NSDWQ MAL

From Figure 3.2, the bars above the thick black line parallel to the abscissa, are locations whose total coliform values are above the NSDWQ (10 CFU/100 ml), while those below the black thick line are within the NSDWQ MAL as seen in Figure 3.2. Areas not captured (as shown in Table 1) on the graph have total coliform values, too numerous to count (TNTC) and are not applicable.

3.2 Faecal Coliform and Total Contamination for Kaduna South

Table 2 present result of bacteriological quality of groundwater in Kaduna South. The results were compared with the maximum permissible limit given by the Nigerian standard for drinking water quality (NSDWQ) and the WHO drinking water guidelines.

Table 2: Bacteriological parameters for samples in Kaduna South

S/N	Locations	Faecal Coliform (CFU/100	TotalColiform (CFU/100 ml)
1	Kakuri (BH)	0	7
2	Jega Road (HDW)	1	18
3	Command Road (BH)	0	3
4	Sabo Market (HDW)	TNTC	TNTC
5	Kamazo (HDW)	10	TNTC
6	Barnawa (BH)	0	5
7	Narayi (BH)	6	9
8	Karji (BH)	13	22
9	Refinery Road Kaduna (BH)	8	TNTC
10	Textile Quarters (HDW)	5	TNTC
11	United Quarters (BH)	6	150
12	Nasarawa Village (HDW)	20	92
13	Breweries (BH)	2	6
14	L.E.A Nasarawa (BH)	0	7
15	Nocaco Road (BH)	0	4
16	KurmiMashi (HDW)	8	70
17	Tudun Wada (BH)	2	10
18	Kabala West (BH)	1	10
19	Kaduna Royal Hotel (BH)	0	8
20	AnguwarMu'azu (HDW)	11	102
	WHO Guideline Value (2006)	0	10
	NSDWQ Maximum Allowable Limit (2007)	0	10

Note: *HDW: Hand dug well, BH: Bore hole, TNTC: Too numerous to count*

The faecal coliform and total coliform values ranged from zero to "too numerous to count" (TNTC). Fourteen samples (out of 20) had faecal coliform values of greater than 0 cfu/100 ml which is above the WHO and the NSDWQ indicating contamination bacteriologically. These locations are areas where the distance between septic facilities and groundwater sources are not maintained at the required standard distance of at least 30 m. On the other hand, 10 samples (out of 20) had total coliform values greater than or equal to 10 cfu/100 ml which did not conform to WHO and NSDWQ standards. Human activities within these locations might have resulted in the deterioration of groundwater as observed during sampling. Figure 3.3 and Figure 3.4 show graphical representation for feacal and total coliform respectively.

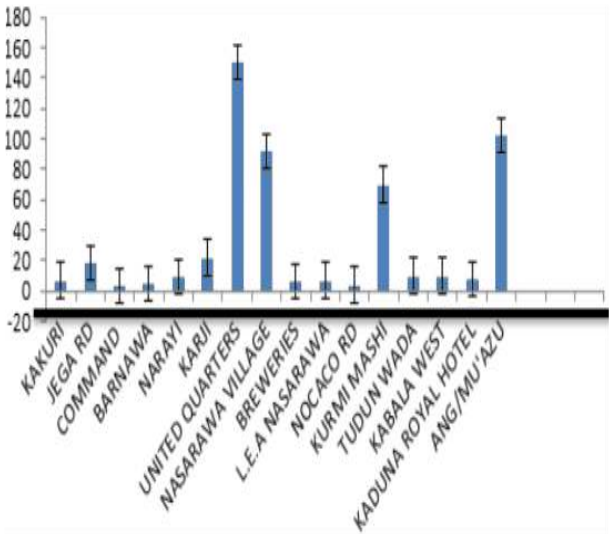

Figure 3.3: A comparison of faecal coliform in Kaduna South with NSDWQ MAL

From Figure 3.3, the bars above the thick black line passing through the abscissa, are locations whose faecal values are above the NSDWQ (0 CFU/100 ml), while those on the black thick line are within the NSDWQ MAL as seen in Figure 3.3. Areas not captured (as shown in Table 2) on the graph have faecal coliform values, too numerous to count (TNTC) and are not applicable.

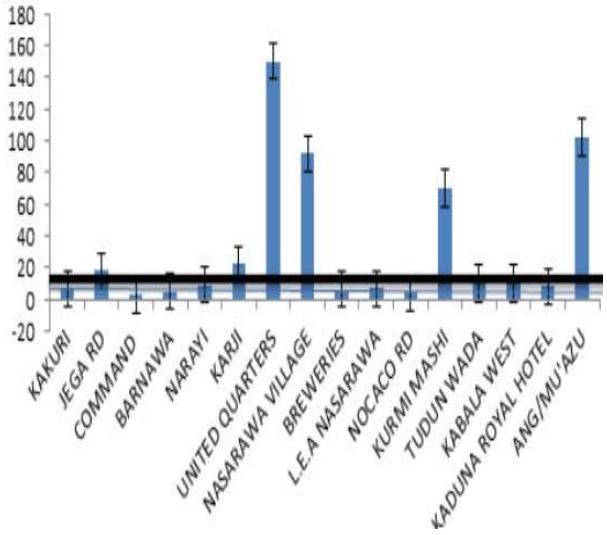

Figure 3.4: A comparison of total coliform in Kaduna South with NSDWQ MAL

From Figure 3.4, the bars above the thick black line parallel to the abscissa, are locations whose total coliform values are above the NSDWQ (10 CFU/100 ml), while those below the black thick line are within the NSDWQ MAL as seen in Figure 3.4. Areas not captured (as shown in Table 2) on the graph have total coliform values, too numerous to count (TNTC) and are not applicable.

3.3 Discussions

During the course of the work, it was observed that over 60% of residential buildings have their ground water constructed at an average distance of 12m away from toilet and other septic facilities. This is not in compliance with the recommended spacing distance of 30m, as recommended by Environmental Protection Agency (EPA), hence may also be responsible for these contaminations. Sampling locations which are spaced at least 30m between toilet and groundwater source, conformed to both WHO and NSDWQ recommended values of 10 cfu/100 ml and 0 cfu/100 ml for total and faecal coliform respectively. Pollution of these water sources might also be as a result of poor sanitation practices within and around the environment where samples were collected. Also leachate from toilet or sanitary drainage facilities, located few metres away from the groundwater sources, might also be one of the sources of contamination. Faecal bacteria may be transmitted through human excreta where open defecation is practiced as in the case of L.E.A Malali and transported into unprotected wells during storm water runoff. From the result of coliform analysis, it is obvious that an average of 73% and 70% feacal coliform and TC contamination respectively was noticed in groundwater sample in Kaduna North while 70% and 50% feacal coliform and TC contamination respectively was observed in groundwater samples in Kaduna South indicating higher contamination in northern Kaduna. The groundwater in the affected areas will not be fit for drinking without disinfection as this may pose water borne diseases such as cholera, typhoid, diarrhea, gastroenteritis, etc

CONCLUSIONS

Based on the study carried out, it can be concluded that 73 % and 70% of the groundwater in Kaduna North and South respectively did not conform to the standard set by WHO and NSDWQ in terms of faecal coliform, while 70% and 50% of the samples in Kaduna North and South respectively did not conform to the standard set by WHO and NSDWQ in terms of TC. Sampling locations which are spaced at least 30m between toilet and groundwater source conformed to both WHO and NSDWQ recommended values of 10 cfu/100 ml and 0 cfu/100 ml for TC and faecal coliform respectively. It is recommended that continuous groundwater monitoring be carried out to monitor chances of further deterioration. Land use activities capable of polluting groundwater should be properly regulated to safe guide its quality. Indiscriminate dumping of wastes into water course should be prevented and the environment should be kept free of

stagnant waters and animal/human defecation. Lining of hand-dug wells may also help reduce the rate of pollution. Finally, appropriate measures should be taken to treat the groundwater by way of disinfection and boiling before drinking.

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