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Analysis of Some Biological Parameters of Selected Open-Wells in Southern Senatorial Zone of Kaduna State, Nigeria

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Abstract

This research is aimed at determining the level of Biological contamination of the water of wells in southern Kaduna. The purpose of this research is to help the people of the study area to understand how to use these wells sustainably, and also provide information to organizations like WHO, UNICEF and UNDP that are concerned with water quality in improving and monitoring performance to enable better planning and management at the national level. This was achieved by determining the bacteriological characteristics of the water of the wells. The sample was taken from five Local Government in the area using a base map to select the Local Government where the water sample was collected using American Standard procedure of sample water collection. The laboratory analysis revealed a significant level of biological contamination as well as differences in the concentration level of the biological contamination within the study area and the World Health Organization Standard of 2014. The study revealed that the Study area is under the stress of biological contamination which may lead to water-borne diseases due to coliforms and pathogenic bacteria, therefore treatment of the contaminated water, proper sitting of well and public enlightenment were recommended.

Keywords: Water, Quality, Biological, Contamination, Wells

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Background to the Study

Water is the world's most abundant natural resource and it is in constant circulation. About 71% of the earth's surface is cover by water, mostly in oceans and other large water bodies, with 1.6% of the water below ground (underground) in aquifers and 0.001% in the air as vapour, clouds and precipitation. Over 97% of the total water supply is contained in the oceans and other saline bodies of water and is not readily usable for most purposes. Of the remaining 3%, a little over 2% is tied up in ice caps and glaciers (about 12.4%), 0.62% was found in groundwater supplies, the surface water like lakes and rivers cover about 0.019%. (Hussein, Okoro, Adeniyi, Omollo, Jondiko & Bhekumusa, 2012).

Water comprises about 70 to 90% of the weight of the living organism. It is a dispersion medium for all biochemical reactions which constitutes the living process and takes part in many of these reactions. Without water, life cannot survive. It is absolutely essential to life, not only human but all life, plant and animal. (Hussein et al. 2012). Water quality refers to the chemical, physical, biological, and radiological characteristics of water (Diersing, 2009). It is a measure of the condition of water relative to the requirements of one or more biotic species and or to any human need or purpose (Johnson, Ambrose, Bassett, Bowen, Crummey, Isaacson, Johnson, Lamb, Saul, and Winter-Nelson 1997). It is most frequently used by reference to a set of standards against which compliance, generally achieved through treatment of the water, can be assessed. The most common standards used to assess water quality relate to health of ecosystems, safety of human contact, and drinking water. (Johnson et al 1997).

Therefore, the quality of water is of vital concern for mankind since it is directly linked with human welfare. Groundwater is believed to be comparatively much clean and free from pollution than surface water. However, indiscriminate discharge of industrial effluents, domestic sewage and solid waste dump cause groundwater to become polluted and creates health problems (Patil & Patil, 2010). There are various ways in which groundwater is contaminated, amongst which are; the use of fertilizer in farming (Okpokwasili, Azubuike & Ebah, 2013).

The practice of physical and chemical analyses of water samples and the exclusion of microbial/bacteriological analysis is unacceptable in all ramifications (Amadi, 2009). The bacteriological quality of most drinking water in many rural areas in Sub-Sahara Africa is worrisome. Interestingly, water-borne diseases like typhoid fever, amoebic and bacillary dysentery, cholera, and diarrhea, as well as food and equipment damages, caused by bacteria's (Sanusi, Hassan, Abbas & Kura 2017; Amadi, Olasehinde, Okosun, Okoye, Okunlola, Alkali, & Dan-Hassan, 2012). For most communities, the most secure source of safe drinking water is pipe-borne water from municipal water treatment plants. Often, most water treatment facilities do not deliver or fail to meet the water requirements of the served community; due to corruption, lack of maintenance or increased population. The scarcity of piped water has made communities find alternative sources of water: groundwater sources being a ready source. Wells are a common groundwater source readily explored to meet community water requirement or make up the shortfall (Imoobe & Koye 2010).

Wells are categorized based on the nature of construction: open dug wells are generally considered the worst type of groundwater sources in terms of faecal contamination and bacteriological analysis. Dug wells with windlass or hand pumped or mechanically pumped well are generally regarded to be less prone to contamination (UNESCO 2006). WHO (2011) assert that open or poorly covered well heads pose the commonest risk to well-water quality; the possibility of the water being contaminated is further increased by the use of inappropriate water-lifting devices by consumers.

The commonest physical defects leading to faecal contamination of dug wells are associated with damage to, or lack of, a concrete plinth, and with breaks in the parapet wall and in the drainage channel (UNESCO 2006). The most serious source of pollution of well water is contamination by human waste from latrines and septic tanks resulting in increased levels of microorganisms, including pathogens. Other likely sources of contamination include runoffs, agrochemicals such as pesticides and nitrates used on farmlands and industrial effluents. Contamination of well water due to under seepage has reported in the Niger Delta area of Nigeria (Ibe & Agbamu, 1999). Seepage from effluent bearing surface water would readily contaminate wells located close to the surface water.

In the Tunisian side of the Mediterranean Coast, contamination of El Melah Lagoon water with Pb and Cd has been attributed to industrial effluent (Ruiz et al., 2006). In Ethiopia, levels of Cd, Cr and Zn water sample from wells exceeding recommended limits was attributed to industrial effluents along Akaki River, which is polluted with untreated sewage and industrial effluent (Prabu, 2009). Contamination of soil and sediments around Iture Estuary in Ghana with Pb and Cd has been attributed to waste carried by the Sorowie and Kakum Rivers, which flow through a rapidly industrialized central region (Fianko, Osae, Adomako, Adotey D. K. & Serfor. A. Y. 2007). In Nigeria, petroleum extraction is one of the major causes of heavy metals contamination around the coastal area. High concentrations of Pb and Cd were recorded in the Warri River following dredging of an oil well access canal (Ohimain, Jonathan & Abah, 2008).

Groundwater is a preferred source of water because of its high quality with respect to portability and the minimum treatment requirement. For individual homes, they find well water attractive because of its more desirable chemical characteristics and reliability. In general, the importance of groundwater for the existence of human society cannot be overemphasised. Hence, there is always a need for the protection and management of groundwater quality. With respect to the above-mentioned groundwater quality, this study aims at carrying out qualitative analysis of Biological parameters of selected groundwater in Southern Kaduna Senatorial Zone.

Study Area

The study area is located between Latitude 9o 08 ′N and 10o 04′ N and Longitude 7o 15′E and 70 50′E (Chori, 2003). It is bounded in the North by Kajuru and Chikun, in the South it is bounded by the Federal Capital Territory (FCT) and Nassarawa State. In the west, it is bounded by Niger State in the East it is bounded by Lere and Kubau Local Government while at the Southeast it is bounded by Plateau State (see fig.1.)

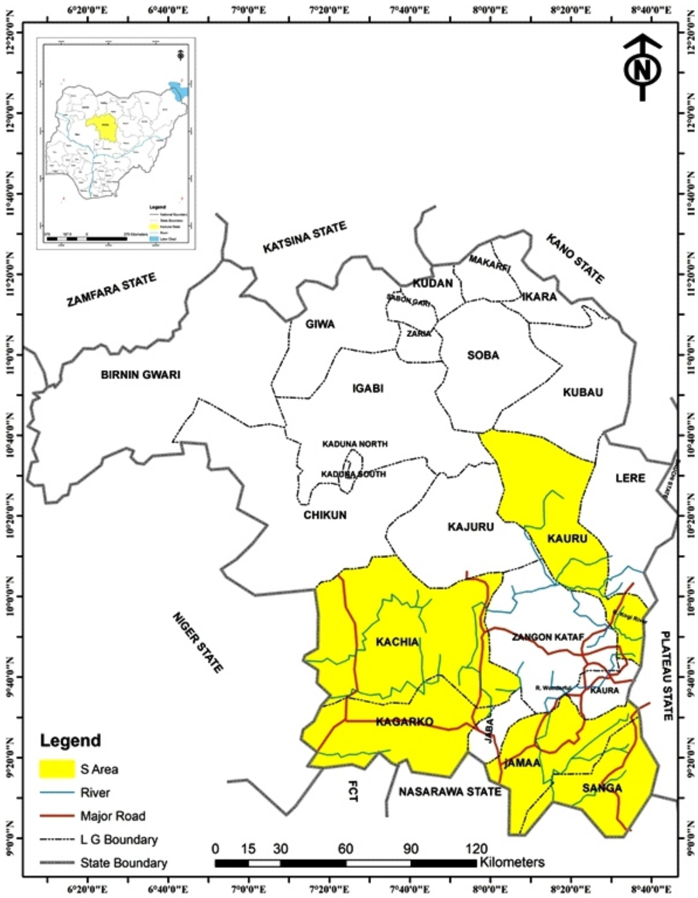

Fig. 1: Study area
Source: Adopted from Google Earth 2018.

Southern Kaduna has a population of 2.3 million (National Population Commission (NPC) 2006) and consists of eight Local Governments namely; Jema'a, Jaba, Kauru, Kaura, Zango-Kataf, Kagarko, Kachia and Sanga. Adara, Bajju, Ham, Atyap, Oegworok and Anghan are the majority of tribal groups in the region (Ishaya and Abaje 2008). The area has two distinct seasons according to Koppen classification, is found under AW climate types. The dry season lasts from November to Mid-April while the rainy reason, which is cold, starts from mid-April, reached its peak in August and in October. The mean annual rainfall within the region ranges between 1,800- 2,000mm, with Kagoro, Kafanchan town and Gidan-waya having the highest amount due to the mountainous nature of the areas. The mean monthly temperature is about 250c while the relative humidity is about 62% during the rainy season. (Abaje & Giwa 2007).

The Region extends from the tropical grassland known as the Guinea Savannah at the extreme South to Sudan Savannah toward the North. Vegetation is thick and grasses about 3.6 meters tall with big trees, which grow shorter as one approaches the Sudan Savannah. River Kaduna is a major river that flows through southern Kaduna and has its source in the highlands around the Jos Plateau. It is however fed by many tributaries and in turn runs into River Niger (Abaje & Giwa 2007).

Materials and Methods

Selection of the Sampling Site

The water samples were taken at the peak of the dry season in March as this mark the period of maximum utilization or dependency on well water in the area. Open dug well were involved in the study and three wells were selected each from the five (see fig.2) local Government. Fifteen (15) samples were collected for bacteriological analysis. A strong thread was attached to the neck of each sterile bottle and gently released into the well; the opened bottle was allowed to sink below the water and was pulled up after observing there were no bubbles from the bottle. The bottle was gently raised out of the well without allowing the bottle to touch the sides of the wells. The caps were carefully replaced and the samples were transported in ice bag to the laboratory for analysis.

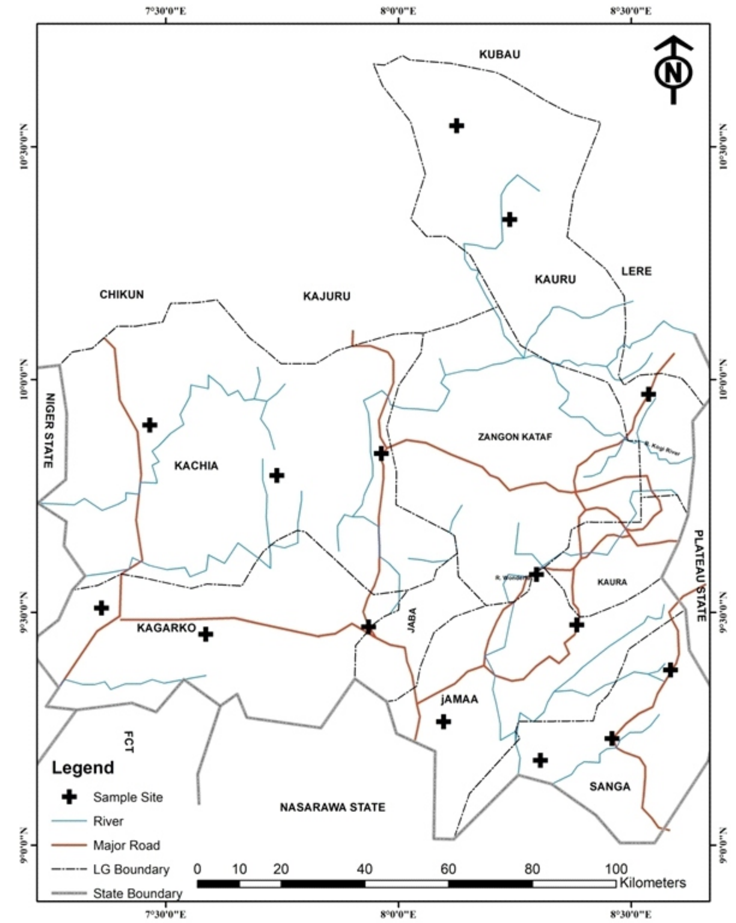

Fig. 2: Sampling site
Source: Adopted from Google Earth Map 2018

Treatment of Water Samples

The water samples were transported to the laboratory of the National Water Resources Institute Mando Kaduna, in plastic containers. The plastic containers were not fully filled up to allowed space for microbial interactions and were used for the biological parameters analysis. The samples were preserved by cooling to 40c and addition of tetra-oxo-sulphate VI acid (H2SO4) before Analysis. The samples were tested for Coliform, Escherichia coli, using the American Public Health Association (2005) methods for wastewater examination 21st Edition.

Total Coliform and Escherichia Coli: Membrane filtration was employed in the tests for total and Escherichia coli. Water samples were appropriately diluted, filtered, inoculated and incubated at 370C for total coliforms. For Escherichia coli, 100ml of the water samples was filtered, inoculated and incubated at 44.50C. Plates which had characteristics yellow colonies after 24 hours resuscitation and incubation in each case were selected and the colonies counted and calculated as follows:

Cfu/100ml = No. of colonies counted/Vol. of samples filtered x 100.

Results

The data were presented in tables and subjected to descriptive statistics and Chi-square analysis in order to identified areas with significant differences.

Table 1: Biological Parameters

S/N0	L.G.A	LOCATION	POSITION	WELL DEPTH. (m)	TOTAL COLIFORM (cfu/100ml)	ESCHERICHIA COLI (cfu/100ml)
1	S A N	SGA	Lat.9^{0}24’ 24” Long.8^{0}34’31”	11.4	11	1
2	G A	SGB	Lat.9^{0}25’38” Long.8^{0}33’51”	15.58	30	45
3		SGC	Lat.9^{0}28’4” Long.8^{0}34’5”	6.61	50	40
4	K A U	KRA	Lat.9^{0}58’5” Long. 8^{0}32.14”	11	34	40
5	R U	KRB	Lat.9^{0}55’ Long.8^{0} 30’33”	8.7	10	0
6		KRC	Lat.9^{0}53’14” Long.8^{0}29’33”	7.5	45	35
7	K A	KCA	Lat.9^{0}52’20” Long.8^{0}02’4”	7.21	10	2
8	C H	KCB	Lat.9^{0}50’28” Long.7^{0}57’47”	8.20	8	0
9	I A	KCC	Lat.9^{0}40’43” Long.7^{0}57’05”	9.20	42	35

10	K A	KGA	Lat.$9^0$32’51” Long.$7^0$55’28”	8.2	30	44
11	G A	KGB	Lat.$9^0$28’17” Long.$7^0$54’22”	8.22	27	29
12	R O	KGC	Lat.$9^0$28’07” Long.7056’09’ ’	13.8	0	0
13	J A	JMA	Lat.$9^0$28’30” Long.$8^0$29’57”	10.4	10	0
14	M A’ A	JMB	Lat.$9^0$28’23” Long. $8^0$22’59”	13.4	13	1
15		JMC	Lat.$9^0$36’50” Long.$8^0$18’56”	6.20	9	0

Source: Author's fieldwork 2018.

Figure 2 and Table 1 above showed a significant biological contamination within the study area as the study reveals that, Total Coliform is having the highest concentration of 50cfu/100 at location SGC (Ungwan Bera) Sanga local government followed by location KRC (Bakin Kogi) Kauru Local government of 45cfu/100 while location KGC (Kurmin-Jibrin) Kagarko Local government showed a complete absence of Total Coliform in similar Locations KRB (kikureni), location KCB (Kasan Kamantan), location KGC (Kurmin - Jibrin) and location JMC (Kafanchan town) shows a complete absence of Escherichia Coli while location KGA (Kenyi), SGC (Ungwan Bera), KRA (Damakasuwa) and KCC (Kurmin-Gwaza) shows a significant presence of Escherichia Coli with the following concentration 4cfu/100, 40cfu/100, 40cfu/100 35cfu/100 respectively.

Ekiye and Lou (2010) monitored the level of physiochemical and Biological contamination of underground water in industrial cities in Nigeria and discovered variation in the concentration of the chemical and Biological parameters of the sampled water, some were above the standard required by WHO and some below.

Akoteyon and Soladoye (2011) used multivariate analysis to assess the groundwater quality of Eti-Osa in Lagos Nigeria and they found out that, the Groundwater is not free from Microbial contamination and they attributed it to environmental influences.

Table2: Descriptive analysis of the laboratory result for Biological Parameters.

S/No.	Parameters	Range	Mean	Std. Deviation	Coefficient of Variation
1	Total Coliform	0-50	21.93	15.79	249.49
2	Escherichia Coli	0-45	18.13	19.87	394.70

Source: Author's fieldwork 2018

Table 2 revealed that water from the wells fall short of the WHO (2016) recommended guideline standard for drinking water as the Total Coliform and Escherichia Coli mean values concentration ranges between 0-50 and0-45 respectively. WHO required that water intended for drinking should not contain any pathogen or microorganism's indicative of faecal contamination. Almost all the water samples examined contained Total coliform (*E. coli*) and high population of Escherichia bacteria, which is consisted with WHO (2004) report that open dug wells are contaminated, with levels of at least 100 faecal coliforms per 100 ml. This is not necessarily a result of the well site but a reflection of the human activities taking place around the catchment of the wells. The unrigged nature of the wells makes contamination by seepage from the soil more likely. The WHO (2014) recommends that wells are ringed and provided with an apron around the head to minimize contamination.

Table 3: Chi-square Test on Concentration levels of Tested Variables and the World Health Organization (WHO).

Sources of Variation	N	df	Calculated value	Tabulated value	Decision
Bacteriological	2	1	554.38	3.841	H_O Rejected

Source: Author's Field Work, 2018.

On testing the concentration levels of the variables and that of World Health Organization (WHO), inferential statistics of chi-square (Table 3) was used to test the hypothesis and the result shows that the chi-square calculated value for the biological parameters are greater than the tabulated value as such the null is thereby rejected. This is in agreement with McJunkin (1982). Who compared water quality and Human Health in the United States using the WHO standard for water quality and discovered compliance to the standard.

Discussion of Results and Findings

The research findings revealed the presence of bacteria, which are used as indicators of contamination of the water by water-borne organism that could potentially cause diseases. For instance, the results of the research conducted for coliforms shows that faecal coliforms were detected in all the water samples tested except the water samples from Kurmin-Jibrin in Kagarko Local Government Area. This, however, suggests that water in all the wells that revealed the presence of coliforms are potential for causing water-borne diseases if not well treated before use.

Escherichia coli was not detected at five locations namely; Bakin-Kogi (KRB), Kasan-Kamantan (KCB), Kurmin-Jibrin (KGC), and Kanufi (JMA) in Kauru, Kachia, Kagarko and Jama'a Local Government Area respectively. The remaining locations revealed the presence of Escherichia Coli in different concentration with Fadan Karshi (SGB) having the highest concentration of 45cfu/100ml followed by Kenyi, 44cfu/100ml, with Gidan-Waya (JMB) having the least concentration of 1cfu/100ml in Sanga, Kagarko and Jama'a local Government respectively. The World Health Organization (WHO) standard for safe drinking water is that such water should be 0cfu/l00ml of coliform and Escherichia coli.

The presence of Escherichia coliform in most of the samples indicates faecal contamination. This contamination may be due to several factors such as the sanitary habit of well owners and users. Uncovered wells also stand the risk of contamination in this way. In most cases, practices such as washing of clothes, household utensils, various materials and objects are done close to the wells. The washing of these items are hygienic but when the washed dirt is poured on the ground, close to the well it becomes unsanitary. Shallow wells are susceptible to contamination by surface and soil microorganisms (Frind, Molson, and Rudolph, 2006). Pollution of water from wells may also be attributed to the deliberate discharge of sewage effluents while some wells may have been contaminated from its inception by the uncleanness of the diggers. Buried corpses in the locality may also affect water purity.

High coliform number in wells in this study could be because of the presence of lizards, frogs which are usually found near the wells as coliforms have been isolated from their intestine (Frind, et al, 2006). Most wells had cockroaches living inside the tunnels. Other factors affecting contamination of wells may be structural defects of the well which may allow seepage of pollutants from nearby sewage into wells (Jagucki, Jurgens, Burow, & Eberts, 2009). Where wastewater can drain down through macrospores such as root channels, rodent burrows and structural voids, the groundwater may become significantly polluted with faecal coliforms and streptococci (Kauffman, & Chapelle, 2010).

Conclusion

The assessment of well carried out in Southern Kaduna Senatorial Zones of Kaduna State showed that the use of well can alleviate water problem in the rural areas and even in urban areas both in the dry and rainy season in Nigeria because it can give appreciable quantity of water. The analysis of the findings of this study, it was discovered that well water is of low quality. The water quality is low particularly with respect to faecal contamination with both total coliform and faecal coliform count. This is evidence that the groundwater from the hand-dug wells may be in contact with human (animal) faeces. This is linked to the poor sanitary situation in the area and the proximity of the hand dug wells to the pit-latrines/soak ways and dumpsites in the area. To enhance the water quality of the study area more mechanized methods of well construction and water extraction is necessary. Septic tank and household wastes should be sited or deposited far away from the wells.

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