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Investigating Human Health Implications of Surface and Ground Water Consumption in the Sokoto-Rima Floodplain, Sokoto, North-west Nigeria

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Abstract: This research investigated the surface and ground water quality in the Sokoto-Rima floodplain and determined the human health implications of consuming it. Five sample points were selected systematically, and at each sample point, three samples were taken each from ground (tube well), and surface (river) water. The surface water was taken from the river Rima at hundred meters interval, and the sampling was repeated after 20days. Thus a total of 30 samples (1^{st} batch-15 and 2^{nd} batch-15) were collected. Data obtained from laboratory were tested for correlation (Pearson correlation) and the difference (paired t-test) between surface and ground water. Results showed that positive correlation exist in pH, Biochemical Oxygen Demand (BOD), Total Dissolve Solid (TDS), Total Suspended Solid (TSS), Nitrate (NO_3^-), Sulphate (SO_4^{2-}), while negative correlation in Dissolved Oxygen (DO), Chloride (Cl^-), Phosphate (PO_4^{3-}) and Potassium (K^+). Result also showed that the mean difference of pH, BOD, PO_4^{3-} and K^+ are significant at $p<0.01$ (2-tailed) and Cl^- is significant at $p< 0.05$ (2-tailed). TDS, Cl, PO_4, NO_3, SO_4 and K are within the WHO and NESREA standards, while, DO, BOD and TSS (in NESREA) are above the standards. The Most Probable Number (MPN) method was used to find the number of coliforms, and Isolate method was used to identify the name of the coliforms found in each sample area. Result showed that in surface water *Citrobacter freundii* was found in all the study area except in Boye and *Escherichia coli* were only found in Boye. While, in groundwater *Escherichia coli* was found in two sample areas. The study therefore, concludes that the quality of the surface and ground water in the area is a determinant of the soil characteristics and has a positive relationship with the health characteristics of the surrounding communities. The research also concludes that surface and groundwater in the study area are not safe for human consumption unless proper water treatment and sanitation is done.

Keywords: Surface and Groundwater, Physicochemical Characteristics, Microbial, water quality, pollution

INTRODUCTION

Fresh water is a finite resource, essential for agriculture, industry and even human existence. Without fresh water of adequate quantity and quality, sustainable development will not be possible [1]. Fresh water resource deterioration is now a global problem and is increasing at a faster rate [2]. Discharge of toxic chemicals, over pumping of aquifer and contamination of water bodies with substances that promote algae growth are some of the major causes of water quality deterioration [3].

The composition of surface and groundwater is dependent on natural factors (geological, topographical, meteorological, hydrological and biological) in the drainage basin and varies with seasonal difference in runoff volumes, weather conditions and water levels [3, 4].

Groundwater is generally less vulnerable to contamination and pollution when compared to surface water bodies [5, 6]. Also, according to Ojutiku *et al.* [7], groundwater is believed to be comparatively much cleaner and free from pollution than surface water. Groundwater can also be contaminated by naturally occurring sources like the annual flood in the study area. Pollution of groundwater due to industrial effluents, agricultural activities and municipal waste in water bodies is another major concern in many cities in Nigeria [3]. Agricultural activities have also been reported to affect the quality of ground and surface water, which is the major economic activity in the Sokoto-Rima floodplain [8]. Groundwater is a major source of supplemental irrigation water. The most potential groundwater reservoirs lie in the alluvial formations of major rivers [9].

Pollutants to surface and groundwater used for drinking can cause many chronic and life threatening diseases in humans. Many common water pollutants cause side effects in humans such as damage to the central nervous system, the development of various cancers, reproduction disorders, and liver damage to name a few [10].

About 25% of the human body is made up of solid matter while the remaining 75% is water. Therefore, if our bodies are not continuously supplied with water, they become dehydrated.

Access to safe water supply has indeed become a nightmare in Nigeria, about 90 million people are without access to safe drinking water and 130,000 under five Nigerian children die annually from preventable waterborne diseases. Some states in Nigeria are predominantly rural with over 65% of the population living in rural areas [11]. According to UNICEF [12] about 400 children under the age of five die daily due to diarrhea-related diseases in Nigeria as a result of the consumption of contaminated water.

People living along the Sokoto-Rima floodplain in Wamakko L.G.A of Sokoto, Nigeria are using water from both river and shallow wells for domestic purposes such as drinking, cooking and washing. This can lead to diseases, because of poor method of water treatment and sanitation.

> *"Access to safe water is a fundamental human need and, therefore, a basic human right. Contaminated water jeopardizes both the physical and social health of all people. It is an affront to human dignity." -Kofi Annan, UN Secretary-General*

The aim of this research is to investigate the human health implications of surface and ground water consumption in the Sokoto-Rima Floodplain.

The objectives are: To find out the physicochemical characteristics of surface and ground water, to compare the physicochemical characteristics with the WHO and NESREA standards, and to examine the microbial organisms in both surface and ground water.

STUDY AREA

The Sokoto-Rima basin is located in the northwest of Nigeria between latitudes 10˚04′-13˚57′N and longitudes 3˚35′-8˚14′E. The basin covers a catchment area of about 131,600km^2, which is about 14% of Nigeria's landmass [13]. Three physiographic units are found in the basin namely: the uplands or high plains of the east and south east, the Sokoto plains of the north and the center, and lastly the lowlands of the Rima Valley and the Niger River [14]. Urban Sokoto is located on the Sokoto plains which are a monotonous lowlands derived from softer sedimentary rocks with an average height of 300m. The wet season is from June to October; rainfall starts late and ends early with mean annual rainfall ranging between 500mm to 900mm [15]. Sokoto is located in the Sudan Savannah bioclimatic zone, with daily mean temperature of 36˚C [16].

This is an area where the basement complex is overlain by the Illumidan Sedimentary Basin which consists of many groups including the Wurno, Kalambaina and Gundumi formations. The Sokoto Rima floodplain is situated to the north of the town, and it effectively prevents growth of the city in that direction. The confluence of the Sokoto-Rima is found close to Kalambaina area where the Rima river catches the Sokoto river, the letter being its major tributary [17].

Wamakko L.G.A is located between Latitudes 12.93 and 13.229ºN, Longitude 5.04 and 5.127ºE, and it is about 226 meters above the sea level and covers an area of 697km² with a population of 179,619; NPC, 2006.

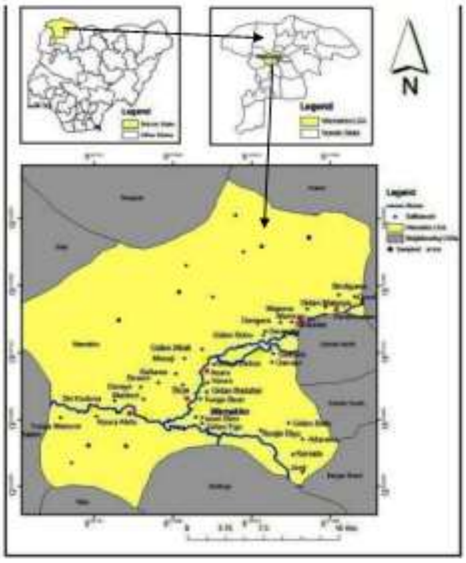

Fig-1: Wamakko L.G.A, Sokoto State, Nigeria showing the study area
Source: Arc Map, Department of Geography UDUS, 2017

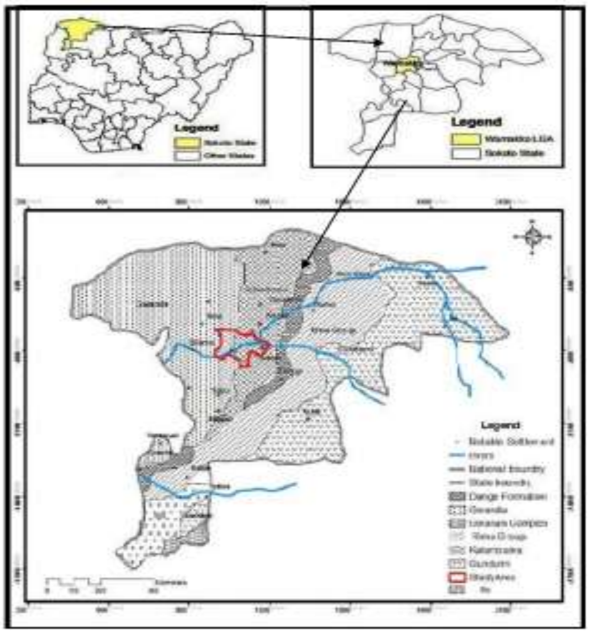

Fig-2: Geology of Sokoto State showing the study area
Source: UDUS GIS LAB, 2016

METHODS

Water Sampling

Five sample points were selected systematically along river Rima and in each sample point, three samples were taken each from ground (tube well) and surface (river) water. The surface water was taken from the river at hundred meters interval, and the sampling was repeated after 20days for quality assurance. A total of 30 samples (first batch-15 and second batch-15) were taken and contained in clean rubber bottles, and taken to the laboratory.

Fig-3: Long tube well

Fig-4: Short tube well

Fig-5: Protected tube well

Fig-6: Human activities

Water Analyses

Water samples collected were taken to the laboratory and tested for the following parameters: pH was measured using a pH meter, nitrate (NO_3) by kjeldhler method, phosphate (PO_4,) and sulphate (SO_4)by spectrophotometer, chloride (Cl) by titration method, Dissolved Oxygen (DO) by iodometric titration method, Total Dissolved Solids (TDS) by glass fibre filter method, Total Suspended Solids (TSS) by filter paper method, Biochemical Oxygen demand (BOD) by incubation bottles and potassium by flame photometer [18].

Microbial Analysis

The water samples collected were taken to the laboratory and tested for microbial. The Most Probable Number (MPN) method was used to find the number of coliforms and Isolate method was used to identify the name of the coliforms found in each sample area and presented in table 3

RESULTS AND DISCUSSION

Table 1 indicates that TDS, Cl, PO_4, NO_3, SO_4 and K^+ are within the WHO and NESREA level and the means range between 1.7-7.2 mg/l, 0.0-7.6 mg/l, 0.1-0.2 mg/l, 0.7-1.6 mg/l, 234.7-304.7 mg/l and 0.9-2.1 mg/l respectively. While, DO, BOD and TSS (in NESREA), are above the standard. In pH, some means are below and some are within the WHO and NESREA standard, the mean range between 5.8-7.1

Table 2 shows that the mean difference of pH, BOD, PO_4, and K are statistically significant at $p< 0.01$ (2-tailed), while Cl is significant at $p< 0.05$ (2-tailed). The correlation is positive between surface and groundwater in ph, BOD, TDS, TSS, NO_3, and SO_4. Correlation is negative in DO, Cl, PO_4, and K. this indicates that, there is a strong relationship between pollutants in surface and groundwater in the flood plain.

The reason of positive correlations and significant differences between surface and groundwater is because of the alluvial soils is thick and does not allow infiltration of minerals to take place easily, this lead to the accumulation of minerals in the floodplain.

Table 3 shows that in surface water *Citrobacter freundii* was found in all the study area except in Boye and *Escherichia coli* were only found in Boye. While, *Escherichia coli* was the majority in the ground water.

Diseases caused by bacteria, viruses and protozoa are the most common health hazards associated with untreated drinking and recreational waters. The main sources of these microbial contaminants in waste water are human and animal wastes [19-21]. These contain a wide variety of viruses, bacteria, and protozoa that may get washed into drinking water supplies or receiving water bodies [22].

Microbial pathogens are considered to be critical factors contributing to numerous waterborne outbreaks. Infectious diseases can be spread through contaminated water. Some of these water borne diseases are *Typhoid, Cholera, Paratyphoid Fever, Dysentery, Amoebiasis and Malaria.* From this research various coliforms were identified in the table 3.

Table 1: Mean and Standard Deviation of physiochemical parameters of Sokoto-Rima floodplain

Sampling Points	Sampling Stations	pH	DO (mg/l)	BOD (mg/l)	TDS (mg/l)	TSS (mg/l)	Cl^- (mg/l)	PO_4^{3-} (mg/l)	NO_3^- (mg/l)	SO_4^{2-} (mg/l)	K^+ (mg/l)
Kwalkwalawa	SW	6.6 ± 0.1	7.1± 1.1	20.1 ± 1.4	7.2 ± 2.5	5.8 ± 0.3	0.8 ± 0.2	0.2 ± 0.0	1.1± 0.1	274.0 ± 1.7	1.9 ± 0.1
	GW	5.8 ± 0.8	6.8 ± 0.8	24.4 ± 2.4	5.0 ± 0.9	3.8 ± 0.8	4.5 ± 0.1	0.1 ± 0.0	0.7± 0.1	304.7 ± 0.6	1.6 ± 0.0
Marmaro	SW	6.7 ± 0.1	5.7 ± 2.0	16.7 ± 3.6	5.3 ± 0.6	3.3 ± 0.3	1.1 ± 0.3	0.2 ± 0.0	1.0 ± 0.1	265.7± 1.5	2.0 ± 0.1
	GW	6.0 ± 0.0	6.6 ± 0.3	23.5 ± 2.1	1.8 ± 0.8	2.7 ± 0.3	7.6 ± 3.3	0.1 ± 0.0	1.4 ± 0.2	242.3 ± 3.1	1.6 ± 0.2
Asare	SW	6.8 ± 0.0	7.4 ± 2.3	16.8 ± 3.9	5.2 ± 0.8	5.2 ± 0.3	1.1 ± 0.1	0.2 ± 0.0	1.2 ± 0.2	234.7 ± 2.5	2.1 ± 0.1
	GW	6.2 ± 0.1	6.3 ±0.7	18.2 ± 2.1	2.8 ± 0.3	2.2 ± 0.3	1.7 ± 0.2	0.1 ± 0.0	0.9 ± 0.2	257.3 ± 0.6	0.9 ± 0.1
Boya	SW	6.7 ± 0.0	7.1 ± 1.3	14.7 ± 1.3	3.2 ± 0.6	2.3 ± 0.6	1.4 ± 0.3	0.2 ± 0.0	1.6 ± 0.2	237.3 ± 0.6	2.0 ± 0.0
	GW	6.5 ± 0.1	5.8 ± 2.0	21.4 ± 1.6	6.3 ± 0.3	4.8 ± 0.3	0.0 ± 0.0	0.1 ± 0.0	1.6 ± 0.1	248.3 ± 2.1	1.8 ± 0.1
Kaura Abdu	SW	7.1 ± 0.1	7.1 ± 0.6	23.4 ± 1.7	2.2 ± 0.3	1.2 ± 0.3	1.1± 0.1	0.2 ± 0.0	0.9 ± 0.1	252.3 ± 0.6	2.0 ± 0.1
	GW	6.5 ± 0.1	5.8 ± 0.8	23.0 ± 5.7	1.7 ± 0.3	1.3 ± 1.0	1.9 ± 0.7	0.1 ± 0.0	1.2 ± 0.1	247.7 ± 0.6	1.5 ± 0.1
WHO		6.5-8.5	7.5	10	1	10	-	5	10	500	-
NESREA		6.5-8.5	4.0	6.0	-	0.75	350	3.5	40	500	50

SW: Surface Water
GW: Ground Water

Table 2: Paired test and Correlation between surface and ground water

	Significant	Correlation
SWpH – GWpH	.000**	.571
SWDO – GWDO	.215	-.385
SWBOD – GWBOD	.006**	.233
SWTDS – GWTDS	.135	.174
SWTSS – GWTSS	.281	.185
SWCL – GWCL	.024*	-.328
SW PO_4– GW PO_4	.000**	-.171
SWK – GWK	.000**	-.296
$SWNO_3$– $GWNO_3$	.937	.446
$SWSO_4$– $GWSO_4$	.185	.539

*The mean is significant difference at $p< 0.05$ (2-tailed)
**The mean is significant difference at $p< 0.01$ (2-tailed)

Table 3: Coliforms found in the Sokoto-Rima Floodplain Sokoto, Nigeria

Sample points	**Surface water Confirmed Spp**	**Groundwater Confirmed Spp**
Kwalkwalawa	*Citrobacter freundii & Entrobacter aeorgene*	*Escherichia coli*
Marmaro	*Entrobacter aeorgene & Citrobacter freundii*	*Entrobacter aeorgene*
Asare	*Citrobacter freundii*	*scherichia coli*
Boye	*Escherichia coli & Entrobacter aeorgene*	*Citrobacter freundii*
Kaura Abdu	*Citrobacter freundii*	*Citrobacter freundii*

CONCLUSION

This research showed that six out of ten parameters tested in both surface and ground water (TDS, Cl, PO_4, NO_3, SO_4 and K) are within the WHO and NESREA standards. While, DO, BOD and TSS (in NESREA), are above the standard. The mean differences between surface and groundwater are statistically significant and there is a strong relationship between surface and groundwater pollutants. Also, results showed that coliforms in the surface water *Citrobacter freundii* was found in all the study area except in Boye and *Escherichia coli* were only found in Boye. While, in ground water *Escherichia coli* was found in two sample areas. The research concludes that surface and groundwater in the study area are not safe for human consumption unless proper water treatment and sanitation was done.

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