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PHYSICO-CHEMICAL PROPERTIES AND MICROBIAL SCREENING OF WATER SAMPLES FROM LIKOSI AREA OF OGUN STATE, NIGERIA

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ABSTRACT

Physico-chemical analyses were carried out on water samples from Likosi (a densely populated area) in Sagamu, Ogun State, Nigeria, to determine the level of heavy metals such as cobalt, copper, nickel, lead and cadmium in ten water samples. The heavy metals were determined using atomic absorption spectrophotometer (AAS). The results obtained showed that lead, nickel and cobalt were of desirable levels in all the samples with the exception of the latter in Sample 3. Copper was also in normal range except in Sample 1 while cadmium was below detection limit only in Samples 4 to 10. The microbial screening revealed that Sample 2 which is Well water has the highest microbial load. Also, bacteria like *Shigella dysenteriae and Staphylococcus aureus* were confirmed in all the samples. The pH values ranged between 5.20 and 5.98. conductivity values were between 57 and 109 µs⁄cm, Total dissolve solid values ranged from 41.00 to 64.34 mg⁄l, Total hardness values ranged from 14.11 to 31.02 mg⁄l, Turbidity values ranged from 0.9 to 1.34 NTU. All the physicochemical properties were below the permissible limit by WHO, (2017). Continuous monitoring of the quality of water sources in Likosi is recommended to prevent diseases and improve quality of life.

Key Words: Likosi Area, bore-hole water, physicochemical analysis, water pollution, water quality

INTRODUCTION

Water is one of the most important and abundant natural resources in which all living organisms on the earth depends for their normal survival and growth [1]. Different types of harmful contaminants find their ways into the water and make it unsuitable and unsafe for both drinking and domestic purposes. This is as a result of increased human population, industrialization, agricultural practices and manmade activities.

Therefore, it is necessary that the quality of drinking water should be evaluated at regular intervals, because continuous use of contaminated water causes the spread of varieties of water borne diseases [2].

The use of water by man, plants and animals is universal and that without it there can be no life. In homes, whether in the city or rural, potable water within the environment is vital for cleanliness and health. Water having secured first priority amongst man's needs, is also the life-blood of most industries including: pharmaceuticals, manufacturing, generation of electric power, transportation, and recreation. The demand for water is increasing rapidly with the growing population thereby creating acute shortage of both surface and underground waters in many localities. Water supply systems and drinking water inaccessibility in developing countries is a global concern that calls for immediate action. Globally, about 900 billion peoples still remain without access to improved sources of water. Similarly, about 2.6 billion have no access to any form of improved sanitation services [3]. The majority of these persons are in Asia (20%) and sub-Saharan Africa (42%) [4]. Consequently, people in developing countries especially children below five years die every year from diseases associated with lack of access to safe drinking-water, inadequate sanitation and poor hygiene. Providing quality drinking water to all citizens will serve as the breaking point of poverty alleviation in most developing countries, especially in Africa, where substantial amounts of national budgets are used to treat preventable waterborne diseases [5].

The availability of good quality water is an indispensable feature for preventing diseases and improving quality of life. Natural water contains different types of impurities which are introduced into aquatic system by different ways such as weathering of rocks and leaching of soils, dissolution of aerosol particles from the atmosphere and from several human activities including mining and other activities from processing industries [6].

Contamination of water bodies has increasingly become an issue of serious environmental concern. Contaminants such as bacteria, heavy metals, nitrates and salts have polluted water supplies as a result of inadequate treatment and disposal of waste from humans and livestock, agricultural activities, industrial discharges and over-use of limited water resources [7].

Environmental pollution is a major problem worldwide particularly that involving heavy metals (HMs) and pathogenic bacteria. There appears to be a micro environmental link between HMs and bacteria as research has reported that HMs have been found at increasing levels within bacterial environments [8]. Metals like copper (Cu), iron (Fe), manganese (Mn), nickel (Ni) and zinc (Zn) are essential micronutrients in bacterial metabolism where they are involved in redox processes and stabilize molecules through electrostatic interactions. In addition, they are co-factors in enzymatic reactions and regulate osmotic balance [9, 10]. Essential metals are also involved in the expression of genes and stabilize DNA structure [11].

However, a physiological role by HMs like cadmium and lead is not known as they are toxic to bacterial cells, even at low concentration [12]. A heavy metal is any metallic element that has a relatively high density and is toxic or poisonous even at low concentrations. Heavy metals exist as natural constituents of the earth crust and are persistent environmental contaminants, because they cannot be degraded or destroyed [13]. Whilst these elements occur naturally, they are often bound up in inert compounds. However, their concentrations have increased several-fold as a result of anthropogenic activities [14]. Human exposure to harmful heavy metals can occur in many ways, ranging from the consumption of contaminated food, exposure to air-borne particles, and contact or consumption of contaminated water and accumulate over a period of time [14]. Humans are exposed to these metals from numerous sources, including contaminated air, water, soil and food [15].

Water related diseases can often be attributed to exposure to elevated heavy metal concentrations of both organic and inorganic contaminants. Many of these compounds exist naturally, but their concentration has increased as a result of anthropogenic activities [16].This study aims to determine heavy metals (cadmium, cobalt, copper, nickel and lead) in water sources such as hand-pump wells and hand-dug wells in Likosi area of Ogun State, Nigeria, correlate the level of these heavy metals with the permissible limit stated by the World Health Organization (WHO), assess the physicochemical properties of the water samples and determine the microbial load of ground water in Likosi area of Ogun State, Nigeria.

MATERIALS AND METHODS

All reagents were of analytical grade. Standard stock solutions of metals (1.0000 mg/dm3 as nitrate salts in 0.5 mol/dm3 nitric acid) were obtained from Merck. Standard solutions were prepared by appropriate dilution of stock standards with deionized water.

SAMPLE COLLECTION AND ANALYSIS

The samples were collected at Likosi, a community near Ogijo along Ikorodu road. Likosi is situated in Sagamu LGA, Ogun State, Nigeria. Its geographical coordinates are 6˚ 46’0” North, 3˚ 32’ 0” East. The community is an industrialized environment. Borehole water is the major source of drinking water for domestic and other uses in the community. Wells are very scarce in Likosi community because the water table is far from the ground surface. The entire boreholes in the community are privately owned and are situated at different places in the community where 9 sampling points were selected and used for the study.

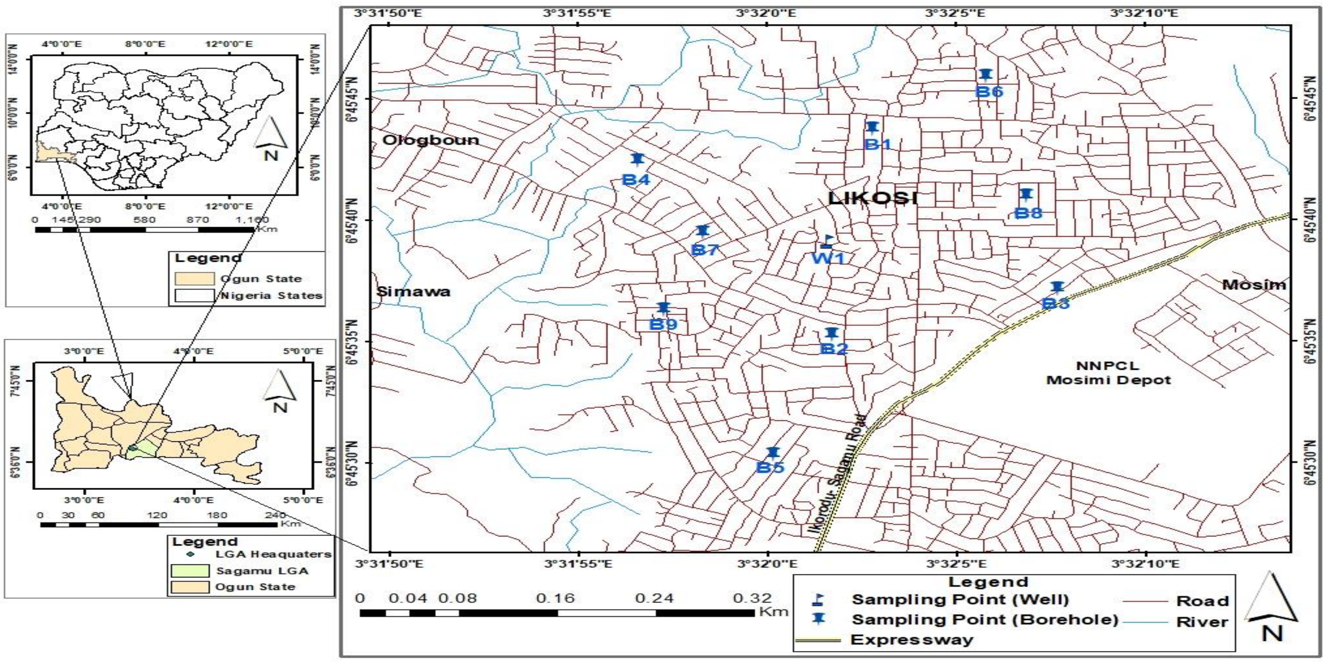

Fig. 1: Map of study area and sampling sites in Likosi

The borehole water had all been pumped and stored in overhead poly-tanks prior to the collection for the investigations. Samples of the water for the laboratory investigations were collected according to the American Public Health Association [17]. Sampling guidelines and the standard operating procedures were adopted for the examination of water and wastewater samples. A total of 10 water samples were collected from 9 different boreholes and 1 sample was collected from a Well. The water samples were collected aseptically into sterile 600 ml polyethene plastic amber bottles. Each collected borehole water sample was labeled S1-S10 with the temporal code number and transported to Federal Institute of Industrial Research, Oshodi, Lagos, Nigeria for analysis.

The physicochemical properties of the water samples were determined according to methods by the American Society of Testing and Materials (ASTM) International. The physicochemical properties determined include pH, conductivity, turbidity, total dissolved solid and total hardness.

The water samples were digested by using nitric acid. Exactly 10ml of 1:1 HNO_3 was added to the water sample, mixed and covered with a watch glass. The sample was heated to 95^{o}C and reflux for 10 to

15 minutes without boiling. Digests as obtained was stored for no longer than 24 h at a temperature of about 8 ºC prior to AAS analysis.

The heavy metal concentration was estimated using novAA - 800 F - Atomic Absorption Spectrometer after acid digestion. Sodium and potassium were determined with Sedico- AFP-100 - Flame Photometer using direct aspiration method [17].

Microbiological screening, gram staining, oxidase test and catalase test were conducted on all the water samples according to standard methods.

RESULTS AND DISCUSSION

GENERATION OF CALIBRATION CURVE

After serial dilution of the stock samples, the different calibrations were fed into the Atomic Absorption Spectrophotometer (AAS) as standard samples and their absorbance were recorded. These were used by the AAS to generate a suitable calibration curve as presented in Table 1.

Table 1: Absorbance of Stock Sample Solution

	Cu (ppm)	Pb (ppm)	Co (ppm)	Ni (ppm)	Cd (ppm)
Sample 1	4.7606	0.0037	0.0003	ND	0.0608
Sample 2	0.2041	ND	ND	0.1138	0.0532
Sample 3	0.2041	ND	0.0052	ND	0.0429
Sample 4	0.0365	ND	0.0021	ND	0.0031
Sample 5	0.0056	ND	0.0018	ND	ND
Sample 6	0.3116	ND	ND	ND	0.0087
Sample 7	0.1853	0.0014	ND	ND	0.0084
Sample 8	ND	ND	0.0045	0.0021	0.0037
Sample 9	0.0331	ND	ND	ND	0.0077
Sample 10	ND	0.0004	ND	0.0047	0.0018
WHO Detection Limit	2.0	0.05	0.05	0.20	0.005

% =Percentage, Kcal=Kilocalorie, Cfu/ml =Colony forming unit per Millilitre, ND=Not detected, mg/kg =Milligram per Kilogram, µg/kg =Microgram per kilogram, ppm =part per million, mV=Millivolt, cm/sec=centimeter per Second g/cm^3=Gram per centimeter cube.

PHYSICOCHEMICAL PROPERTIES

The results in Table 2 show the physicochemical properties of water sources in Likosi, a developing community near Ogijo along Ikorodu road, Sagamu LGA, Ogun State, Nigeria, compared with the World Health Organization [18] standard for drinking water. The water samples were clear and colourless. This corroborates with the very low values of the total dissolved solids, total hardness and turbidity values (0.9 – 1.34 NTU) compared to the permissible limit of 10 NTU which indicated that there were little or no particle suspensions that could give an apparent colour to the analyzed samples.

The values of the total dissolved solids and total hardness shown in Table 2 ranged at 41.00 – 64.34 mg/l and 14.11 – 31.02 mg/L respectively. When compared with the permissible limits of 500 and 300 mg/L of total dissolved and total hardness, these values indicated that the water samples do not contain noticeable dissolved solids and residues as they were below the allowable limits of the World Health Organisation standard which could be due averagely lesser trading, construction and automobile activities around Likosi area.

All the water samples (S1 to S10) were slightly acidic with pH ranging from 5.20 to 5.98 when compared with the permissible limit of 6.5 – 8.5 which may be characteristic of mild contamination by some hydrolyzing salts. There were variations in the pH values across the ten sample points due to changes in the values of CO_2, carbonate, and bicarbonate in water. The lower values of pH may cause tuberculosis. Higher values as observed in this present study may produce incrustation, sediment, deposition, and some difficulties in chlorination for disinfections of water.

Conductivity values for all the ten (10) water samples were lower than the WHO permissible limit of 300 µs/cm. Electrical conductivity is the measure of water capacity to convey electric current. Electrical conductivity of water is directly proportional to its dissolved mineral matter content. The source of conductivity may be an abundance of dissolved salts and other mineral discharges inthe Wells and boreholes. Conductivity values for all the ten (10) water samples ranged from 57 µs/cm which is lowest in Sample 2 to 109 µs/cm, being highest, in Sample 9.

Table 2: Physicochemical Properties of Water Samples

Samples	pH @ 25ºC	Conductivity (µs/cm)	Total Dissolved Solid (mg/L)	Total Hardness (mg/L)	Turbidity (NTU)
Sample1	5.33 ± 0.3*	102 ± 11.2*	62.72 ± 2.5*	24.15 ± 1.7*	1.34 ± 0.03*
Sample 2	5.98 ± 0.4	57 ± 5.1*	41.00 ± 1.9*	22.11 ± 2.9*	1.05 ± 0.05*
Sample 3	5.51 ± 0.1	90 ± 8.6*	49.88 ± 4.3*	31.02 ± 2.2*	0.9 ± 0.01*
Sample 4	5.20 ± 0.5*	109 ± 12.3*	64.34 ± 3.7*	27.26 ± 2.7*	1.7 ± 0.02*
Sample 5	5.53 ± 0.2	91 ± 7.5*	49.01 ± 4.8*	24.10 ± 1.3*	1.1 ± 0.03*
Sample 6	5.93 ± 0.5	58 ± 3.1*	42.86 ± 2.9*	22.51 ± 1.8*	0.9 ± 0.05*
Sample 7	5.86 ± 0.6	69 ± 5.3*	45.23 ± 1.6*	29.04 ± 1.7*	0.9 ± 0.01*
Sample 8	5.64 ± 0.2	82 ± 6.0*	41.38 ± 3.9*	27.23 ± 2.1*	1.1 ± 0.03*
Sample 9	5.92 ± 0.1	61 ± 4.1*	51.36 ± 2.5*	29.23 ± 1.1*	1.4 ± 0.04*
Samsple10	5.48 ± 0.4*	92 ± 5.6*	50.00 ± 1.9*	14.11 ± 1.5*	1.1 ± 0.02*
WHO permissible limits	6.5 – 8.5	300	500	300	10

% =Percentage, Kcal=Kilocalorie, Cfu/ml=Colony forming unit per Millilitre. ND=Not detected, mg/kg =Milligram per Kilogram, µg/kg= Microgram per kilogram, ppm=part per million, mV=Millivolt, cm/sec=centimeter per Second, g/cm$^{3=}$ Gram per centimeter cube, µs/cm= micro simen per centimeter, NTU=Nephelometric Turbidity Unit, * - Significantly lower than the WHO permissible limits at $P < 0.05$, ** - Significantly higher than the WHO permissible limits at $P < 0.05$

Table 3 shows the heavy metal concentrations of borehole water sources in Likosi, a developing community near Ogijo along Ikorodu road, Sagamu LGA, Ogun State, Nigeria.

Table 3: Heavy Metal Content of Water Samples

Samples	Cadmium (mg/L)	Copper (mg/L)	Nickel (mg/L)	Lead (mg/L)	Cobalt (mg/L)
Sample1	0.0608 ± 0.0001*	4.7606 ± 0.220**	ND	0.0037 ± 0.0001*	0.0003 ± 0.00*
Sample 2	0.0532 ± 0.0004*	0.2041 ± 0.003*	0.1138 ± 0.001*	ND	ND
Sample 3	0.04290 ± 0.0002*	0.2041 ± 0.002*	ND	ND	0.0052 ± 0.0002*
Sample 4	0.0031 ± 0.0001*	0.0365 ± 0.0005*	ND	ND	0.0021 ± 0.0001*
Sample 5	ND	0.0056 ± 0.0001*	ND	ND	0.0018 ± 0.0001*
Sample 6	0.0087 ± 0.0002*	0.3116 ± 0.006*	ND	ND	ND
Sample 7	0.0084 ± 0.0003*	0.1853 ± 0.002*	ND	0.0014 ± 0.0001*	ND
Sample 8	0.0037 ± 0.0001*	ND	0.00021± 0.00*	ND	0.0045 ± 0.0002*
Sample 9	0.0077 ± 0.0002*	0.0331 ± 0.0003*	ND	ND	ND

Samsple10	0.0018 ± 0.0001*	ND	0.0047 ± 0.00*	0.0004 ± 0.00*	ND
WHO permissible Limits	0.05	2.00	0.20	0.05	0.05

ND=Not detected, mg/l =Milligram per Litre, * - Significantly lower than the WHO permissible limits at $P < 0.05$, ** - Significantly higher than the WHO permissible limits at $P < 0.05$

Table 4: Total Bacteria Load of Micro Organism Isolated from Water Samples

Water samples	Total bacteria load
Sample 1	38.00 ± 3.2
Sample 2	122.00 ± 13.6
Sample 3	15. ± 2.7
Sample 4	67.00± 6.8
Sample 5	6.00 ± 1.1
Sample 6	2.00 ± 0.2
Sample 7	18.00 ± 2.9
Sample 8	84.00 ± 5.9
Sample 9	34.00 ± 2.7
Sample 10	15.00 ± 1.9

Table 5: Biochemical Analysis of the Isolates

Water samples	Gram staining	Catalase test	Oxidase test	Micro organism confirmed
Sample 1	-ve	+ve	-ve	*Shigelladysenteriae*
Sample 2	+ve	+ve	-ve	*Staphylococcus aureus*
Sample 3	+ve	+ve	-ve	*Staphylococcus aureus*
	-ve	+ve	-ve	*Shigelladysenteriae*
Sample 4	+ve	+ve	-ve	*Staphylococcus aureus*
Sample 5	+ve	+ve	-ve	*Staphylococcus aureus*
	-ve	+ve	-ve	*Shigelladysenteriae*
Sample 6	+ve	+ve	-ve	*Staphylococcus aureus*
	-ve	+ve	-ve	*Klebsiella pneumonia*
Sample 7	-ve	+ve	-ve	*Shigelladysenteriae*

Sample 8	+ve	+ve	-ve	*Staphylococcus aureus*
	-ve	+ve	-ve	*Shigelladysenteriae*
Sample 9	+ve	+ve	-ve	*Staphylococcus aureus*
	-ve /	+ve	-ve	*Shigelladysenteriae*
Sample 10	+ve	+ve	-ve	*Staphylococcus aureus*
	-ve	+ve	-ve	*Shigelladysenteriae*

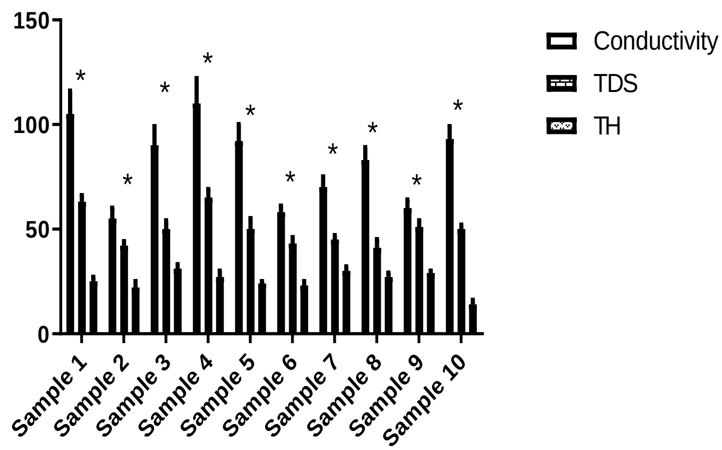

Figure 2: Physicochemical analysis (Conductivity, Total Dissolved Solid, Total Hardness) of Water Samples From Likosi Area of Sagamu

WHP Std (Conductivity- 300 µs/cm; TDS- 500 mg/l; TH- 300 mg/l

*WHO Std- World Health Organization Permissible limit, * - Significantly lower than the WHO permissible limits at P < 0.05, Conductivity (µs/cm), TDS- Total Dissolved Solid (mg/l), TH- Total Hardness (mg/l)*

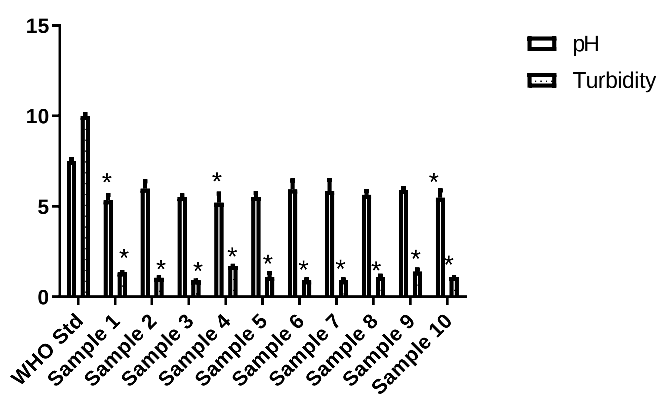

Figure 3: Physicochemical Analysis (pH and Tubidity) of water sample from Lukosi area of Sagamu

*WHO Std- World Health Organization Permissible limit, Turbidity - Nephelometric turbidity unit (NTU), * - Significantly lower than the WHO permissible limits at P < 0.05,* The observed concentrations of Pb, Co, Cd, Ni, and Cu in the water samples were compared with the recommended limits as established by WHO in 2022 to assess the levels of contamination in the water samples [18]. In all the samples, levels of lead and nickel were observed to be the lowest while the level of cadmium was the highest. Cadmium was detected in nine samples, Copper was detected in eight water samples, Cobalt was detected in six water samples, while lead and nickel were detected in three water samples. Heavy metals have been widely acknowledged to have deleterious effect on human beings. Humans are exposed to these metals for numerous sources, including contaminated air, water, soil and food [15]. Water related diseases can often be attributed to exposure to elevated heavy metal concentrations of both organic and inorganic contaminants. WHO have set the maximum permissible level of toxic metals in drinking water.

COPPER

Copper has the highest value in Sample one which was 4.7606 mg/l, 2041 mg/l, Sample four was 0.0365 mg/l, Sample five was 0.0056 mg/l, Sample seven was 0.1853 mg/l, Sample nine was 0.0331 mg/l. copper was not detected in Samples eight and ten. The permissible limit by WHO for copper is 2 mg⁄l. From this study, only Sample one exceeded WHO permissible limit which may be as a result of auto body rust, engine parts, bearing wear and brake emissions from automobile outlets around the borehole.In an appropriate limit, copper is an essential micronutrient which functions as a biocatalyst. It is required for body pigmentation in addition to Iron, maintains a healthy central nervous system, prevents anaemia and interrelated with the function of zinc and Iron in the body [19]. Long-term exposure to copper can cause irritation of the nose, mouth and eyes and it causes headaches, stomachaches, dizziness, vomiting and diarrhea. Intentionally high uptakes of copper may cause liver and kidney damage and even death.

CADMIUM

Cadmium has the highest values in Samples one to three which are respectively 0.0608 mg/l, 0.0532 mg/l, 0.0429 mg/l. Cadmium was not detected in Sample five. The WHO permissible limit for cadmium is 0.01 mg⁄l. From this study Samples one to three exceeded WHO permissible limits. Other samples were lower than WHO permissible limit.

Cadmium is a non-essential element in food and natural waters and it accumulates principally in kidney and liver [20,21]. Human uptake of cadmium takes place mainly through food. Foodstuffs that are rich in cadmium can greatly increase the cadmium concentration in human bodies. Examples are liver, mushrooms, shellfish, mussels, cocoa powder and dried seaweed. An exposure to significantly higher cadmium levels occurs when people smoke. Tobacco smoke transports cadmium into the lungs. Blood will transport it through the rest of the body where it can increase effects by potentiating cadmium that is already present from cadmium-rich food. Cadmium and its compounds are classified as Group 1 carcinogens for humans by the international Agency for Research on Cancer [22]. Other health effects that can be caused by cadmium are: diarrhea, stomach pains and severe vomiting, bone fracture, reproductive failure and possibly even infertility, damage to the central nervous system, damage to the immune system, psychological disorders, possibly DNA damage or cancer development.

NICKEL

Nickel was not detected in Sample one, three, four, five, six, seven and nine. Nickel values in Sample two, eight and ten are 0.1138 mg/l, 0.0021 mg/l and 0.0047 mg/l respectively. WHO permissible limit for Nickel is 0.2mg/l. From this study, all the samples were lower than WHO permissible limit. Nickel is required in minute quantities for body as it is mostly present in the pancreas and hence plays an important role in the production of Insulin. Its deficiency results in disorder of the liver. Nickel also plays some roles in body functions including enzymatic functions. It occurs naturally in plants than in animal's flesh. Humans may be exposed to nickel by breathing air, drinking water, eating food or smoking cigarettes. Skin contact with nickel-contaminated soil or water may also result in nickel exposure. In small quantities nickel is essential, but when the uptake is too high it can be a danger to human health. An uptake of large quantities of nickel has the following consequences: higher chances of development of lung cancer, nose cancer, larynx cancer and prostate cancer, sickness and dizziness after exposure to nickel gas, lung embolism, respiratory failure, birth defects, asthma and chronic bronchitis, allergic reactions such as skin rashes, mainly from jewelry and heart disorders.

COBALT

Cobalt was not detected in Samples two, six, seven nine and ten. The highest value was detected in Sample three which is 0.0052 mg/l, Sample one 0.0003 mg/l, Sample four 0.0021 mg/l, Sample five 0.0018 mg/l andSample eight 0.0045 mg/l. WHO permissible limit for cobalt is 0.05mg/l. From this study all the sample are lower than WHO permissible limit.Cobalt is beneficial for humans because it is a part of vitamin B_{12}, which is essential for human health. Cobalt is used to treat anemia with pregnant women, as it stimulates the production of red blood cells. The total daily intake of cobalt is variable and may be as much as 1 mg, but almost all will pass through the body unabsorbed, except that in vitamin $B_{12.}$

However, too high concentrations of cobalt may damage human health. Breathing high concentrations of cobalt through air may cause lung effects, such as asthma and pneumonia. This mainly occurs with people that work with cobalt. When plants grow on contaminated soils they will accumulate very small particles of cobalt, especially in the parts of the plant we eat, such as fruits and seeds. Soils near mining and smelting facilities may contain very high amounts of cobalt. Uptake by humans through eating plants can cause health effects such as vomiting and nausea, vision problems, heart problems, thyroid damage [23].

LEAD

Lead was not detected in Samples two, three, four, five, six, eight and nine, Lead values in Samples one, seven and ten are 0.037 mg/l, 0.014 mg/l, 0.0004 mg/l respectively. WHO permissible limit for lead is 0.0 5 mg/l. From this study all the samples were lower than WHO permissible limit.

Lead can enter (drinking) water through corrosion of pipes. This is more likely to happen when the water is slightly acidic. That is why public water treatment systems are now required to carry out pH-adjustments in water that will serve for drinking purposes. The rise and fall in exposure to airborne lead from the combustion of tetraethyl lead in gasoline during the 20th century has been linked with historical increase and decrease in crime levels, a hypothesis which is not universally accepted [24]. Lead fulfils no essential function in the human body, it can merely do harm after uptake from food, air or water. Lead can cause several unwanted effects, such as: disruption of the biosynthesis of haemoglobin and anaemia, rise in blood pressure, kidney damage, miscarriages and subtle abortions, disruption of nervous systems, brain damage, declined fertility of men through sperm damage, diminished learning abilities of children, behavioural disruptions of children, such as aggression, impulsive behavior and hyperactivity etc.

CONCLUSION

This study assessed the parameters like pH, conductivity, total dissolved solid, turbidity, hardness, cobalt, copper, nickel, chromium and lead in borehole and Well water around Likosi area. On the basis of the heavy metals investigated and detected it was observed that water samples were not contaminated with nickel, lead and cobalt as their levels were lower than World Health Organization [17] permissible limit. Some physicochemical parameters were below detection limit indicating better quality of the ground waters around Likosi area. From this study, Samples 1, 2 and 3 are not safe for drinking, domestic and pharmaceutical purpose because they were contaminated with copper and cadmium. Coliform bacteria were absent in the water samples and this indicates that the water samples were not contaminated with fecal material.

RECOMMENDATION

Continuous monitoring of the quality of water sources in Likosi area of Ogun State is recommended to improve quality of life and prevent diseases.

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