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Assessment of Heavy Metals Leaching in Groundwater of Industrial Areas of Nigeria

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ABSTRACT

Pollution of ground water with heavy metals from industrial activities has caused a major threat to human life exposing man to series of diseases, crippling disability and death. This study was carried out to determine the concentration of heavy metals leaching into groundwater from the industrial activities and to assess their long term effect on life of the people and the resultant aquifer. The study was carried out at 10 different locations which are all located in Ikeja industrial areas. The water samples collected were subjected to physical, chemical, heavy metal and bacteriological analysis in order to determine their level of pollution. Samples were prepared according to the standard methods using atomic absorption spectrophotometry for heavy metals determination. The result of the analysis shows that heavy metals in water samples had an average pH mean value of 5.20 indicating the acidity of the water sampled, while the average electrical conductivity, temperature and total acidity of were 0.64µs/cm $29.70^{o}C$ and 29.60 respectively. The average mean concentration of the chemical and heavy metals were 0.132 mg/l, 0.040 mg/l, 0.279 mg/l, 0.148 mg/l, 0.026 mg/l, 0.0055 mg/l, 0.00266 mg/l and 0.0097 mg/l for calcium, magnesium, sodium, potassium, iron, cadmium, lead, and chromium respectively. The parameters analysed were at varying concentrations in the groundwater with parameters such as nitrate, phosphate, and pH exceeding the World Health Organization (W.H.O) standard, it was observed that the sample collected from Neimeth pharmaceuticals exceeded the permissible level for iron and lead having the value of 0.0391mg/l and 0.0627mg/l, while most of the water samples analysed falls within the permissible limit in accordance with the WHO standards. Adequate care must be taken for further prevention and handling of chemical discharges from industries. The need for the treatment of the groundwater and control of human activities in the area to prevent further contamination must also be put be in place.

Introduction

Water is the most indispensable resources that we have on the planet earth, it is a renewable resource accounting for 60% of the total body weight of an average adult being and 75% of a new born infant (Lamikanra, 1990). Surface and ground water are two separate entities requiring ever increasing need for management, Depletion of surface and ground water for public consumption, industrial, commercial and residential areas is caused by over pumping. Aquifers near water streams that are over pumped have been known to deplete surface water sources and ground water.

The term “heavy metals” refers to any metallic element that has a relatively high density and is toxic or poisonous even at low concentration (Lenntech, 2004). “Heavy metals” is a general collective term, which applies to the group of metals and metalloids with atomic density greater than 4 g/cm or 5 times or more, greater than water as acribed by Duruibe et. al. 2007 definition. However, being a heavy metal has little to do with density but concerns chemical properties. Heavy metals include lead (Pb), cadmium (Cd), zinc (Zn), silver (Ag), chromium (Cr), mercury (Hg), arsenic (As), copper (Cu) iron (Fe), and the platinum group elements. A pollutant is any substance in the environment, which causes objectionable effects, impairing the welfare of the environment, reducing the quality of life and may eventually cause death. Such a substance has to be present in the environment beyond a set or tolerance limit, which could be either a desirable or acceptable limit. Hence, environmental pollution is the presence of a pollutant in the environment; air, water and soil, which may be poisonous or toxic and will cause harm to living things in the polluted environment.

Review

Leaching can be defined as “the dissolution of metals, solids, and chemicals into drinking water” (Symons et. al., 2000). Leaching can result in elevated levels of metals, organic contaminants, or asbestos in water consumed at the tap.

However, despite its abundance, good quality drinking water is not readily available to man. Unavailability of good quality drinking water is wide spread and this has serious health implications. Adekunle et. al., 2004 reaffirmed that the availability and accessibility of fresh clean water is a key to sustainable development and an essential element in health, food production and reduction of poverty. However, an estimated 1.2 billion people around the world lack access to safe water and close to 2.5 billion persons are not provided with adequate sanitation (Third World Water Forum on Water, 2003). In developing nations of the world alone, 30% and 80% of all death and diseases respectively are related to drinking water (Dada and Ntukekpo, 1997). In 1988 a study funded by the National

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Endownment for the Humanities (NEH) investigated the interconnections among water supply and wastewater and solid waste collection and disposal in the United States and considered the broader intellectual context in which these services were devised and implemented to meet water demand. The resulting book, *The Sanitary City*, examined the development and implementation of these three services (Melosi, 2000). The NEH study and earlier research by Melosi, 1980 raised questions about the nature of the urban environment and the correlation between decisions to use certain kinds of " technologies of sanitation" and the prevailing public health and environmental views that inform those decisions. Though, by implication to the Federal Ministry of Health statistics, only about 30% of Nigerians have access to portable water while the United Nations estimated that about 1.2 billion people all over the world lack access to portable water (Oyeku *et. al.*, 2001; Ajewole, 2005).

To achieve such standards raw water is subjected to purification processes that range from simple long term storage to enable sedimentation of some suspended solids to aeration, coagulation, flocculation, filtration and disinfection among other treatments (Ajewole, 2005). The implication therefore, is that any drinking water sold to the public must be made wholesome and must meet WHO standards (Oyeku et. al., 2001). Unfortunately, the quality of water sold to the public in many places in Nigeria may not be said to be wholesome (Mendie, 2004). Given the economic difficulties of sustaining operations, however, a cost-effective waste/water reclamation system is critically important (Ojekunle et.al., 2009).

Every year, thousands of cholera cases causing many human fatalities are said to occur in Nigeria. In addition, it has been confirmed in the country that water-related diarrhea is the most prevalent disease among the population after malaria, prompting the need for safe drinking (Njoku & Osinlu, 2007).

Consequently, a number of small scale industries are packaging and marketing factory-filled sachet drinking water, popularly called "pure water", that many consider a safer source of potable water (Dodoo *et. al.*, 2006).

The proliferation of drinking water products raises the question as to whether they are hygienically produced, especially when the poor sanitary environment is coupled with irregular monitoring of portable water producers by regulating agencies is taken into account (Adekunle et. al., 2004; Obiri-Danso et. al., 2003; Agada, 1998). According to the Institute of Public Health Analyst (IPAN), 50% of the "pure water" sold in the streets of Lagos may not be fit for human consumption (Osibanjo et al., 2000). The possibility that the same situation may be applicable to other cities in the country prompted this work. Some heavy metals have bio-importance as trace elements but, the bio toxic effects of many of them in human biochemistry are of great concern. Hence, there is the need for proper understanding of the conditions, such as the concentrations and oxidation states, which make them harmful, and how bio toxicity occurs. It is also important to know their sources, leaching processes, chemical conversions and their modes of deposition to pollute the environment, which essentially supports lives. Literature sources point to the fact that these metals are released into the environment by both natural and anthropogenic sources, especially mining and industrial activities, and automobile exhausts (for lead). They leach into underground waters, moving along water pathways and eventually depositing in the aquifer, or are washed away by run-off into surface waters thereby resulting in water and subsequently soil pollution. Poisoning and toxicity in animals occur frequently through exchange and co-ordination mechanisms. When ingested, they combine with the body's biomolecules, like proteins and enzymes to form stable bio-toxic compounds, thereby mutilating their structures and hindering them from the bio reactions of their functions. Industrial products that are used in homes, and which have been produced with heavy metals are sources of human exposure to such heavy metals. McCluggage, 1991 investigated that the exposure of mercury is through disinfectants (like mercurochrome), antifungal agents, toiletries, creams and organo-metallics; cadmium exposure is through nickel/cadmium batteries and artist paints; lead is exposed or contacted through wine bottle wraps, mirror coatings, batteries, old paints and tiles and linolein amongst others. Infants are more susceptible to the endangering effects of exposure to heavy metals. The bio-toxic effects of heavy metals refer to the harmful effects of heavy metals to the body when consumed above the bio-recommended limits. Although individual metals exhibit specific signs of their toxicity, the following have been reported as general signs associated with cadmium, lead, arsenic, mercury, zinc, copper and aluminium poisoning: gastrointestinal (GI) disorders, diarrhoea, stomatitis, tremor, hemoglobinuria causing a rust–red colour to stool, ataxia, paralysis, vomiting and convulsion, depression, and pneumonia when volatile vapours and fumes are inhaled (McCluggage, 1991). The nature of effects could be toxic (acute, chronic or sub-chronic), neurotoxic, carcinogenic, mutagenic or teratogenic. Heavy metal exposure occurs significantly by occupational exposure. Workers of the mining and production of cadmium, chromium, lead, mercury, gold and silver have been reported to be thus exposed; also inhabitants around industrial sites of heavy metal mining and processing, are exposed through air by suspended particulate matters (SPM) (Heyer, 1985; USDOL, 2004; Ogwuegbu and Muhanga, 2005).

Soil Characteristics affecting Leaching

Variable factors may contribute to high incidence of heavy leaching in the and these factor include; organic matter, soil texture, soil structure and soil water content while the site characteristic affecting leaching also include; depth to groundwater, type of bedrock and slope of the area.

Materials And Methods

Water samples was collected in ten industries in Ikeja industrial area environs (Mokland Hotel, Nigerite, PHCN Oba-Akran, Berger Paint, Wahum Nigeria Ltd, Guinness Company, Mobil Filling Station, Seven-Up Bottling Company, Vita-Biotics Ikeja, and Niemeth Pharmaceutical Company) with a 5L white clean plastic kegs for physical and chemical analysis, sample kegs were labelled with the location, time of collection, name of industry, the industries were labelled 1 to 10. The plastic kegs used in sample collection were rinsed with distilled water and water samples after the taps in the industries are allowed to run for about 5 minutes before samples are collected. After sample collection the water collected are transferred to the laboratory for various analyses as shown in table 1 below.

Results And Discussions

The samples were analysed using the Duncan multiple range (difference in mean) and ANOVA (Correlation of different variable). All the water sampled were colourless, odourless and tasteless (See table 3). The presence of colour, odour and taste in potable water is objectionable to the consumer. The Mean pH of all water sampled was 7.04 with range of 6.00-8.00 which all fell within the range of 6.5-8.5 specified by WHO (2011) as shown in table 2. According to the pH values obtained, majority were in the trend of slightly alkaline. Therefore, the water samples were unlikely to cause health problems such as acidosis (Asamoah and Amorin, 2011).

Table 1. Methods of Various Parameters Analysis

PARAMETERS	EQUIPMENT USED
Dissolved oxygen	Dissolved oxygen meter
Temperature	Thermometer
PH	PH meter
Electrical conductivity	EC meter
Total dissolved solids	TDS meter
Total alkalinity/total acidity	Titration method
Total hardness	Titration method
Chloride	Titration method
Sulphate	Spectrophotometer
Nitrate	Spectrophotometer
Phosphate	Spectrophotometer
water digestion	Water heater
Silver	AAS
Calcium	AAS
Manganese	AAS
Magnesium	AAS
Lead	AAS
Cadmium	AAS
Potassium	AAS
Chromium	AAS
Sodium	AAS
Nickel	AAS
Iron	AAS

Table 2a. Physical and Chemical Parameters Guidelines by WHO, SON and European Union

Parameters	W.H.O Guideline value	S.O.N Max. permitted level	European Union Parametric value
Colour	ND	15 TCU	Inoffensive
Odour	ND	Unobjectionable	Inoffensive
Taste	ND	Unobjectionable	Inoffensive
Temperature (^oC)	ND	Ambient	ND
pH	6.5 – 8.5	6.5 – 8.5	$\geq$ 6.5 and $\leq$ 9.5
DS (mg/l)	1200	500	ND
Elec. Cond.(µS/cm)	ND	1000	ND
HCO_3^- (mg/l)	ND	ND	ND
SO_4^{2-} (mg/l)	250	100	250
NO_3^-(mg/l)	10	5	5
DO (mg/l)	2	2	2
Cl^- (mg/l)	250	250	250
PO_4^{3-} (mg/l)	ND	ND	ND
K^+(mg/l)	ND	ND	ND
Na^+ (mg/l)	200	200	200
Hardness (mg/l)	200	150	ND
Total Acidity mg/l	100	100	100
Total Acidity	100	100	100

Table 2b. Guideline in drinking water by the World Health Organisation (WHO) and National Agency for Food Drugs Administration and Control (NAFDAC), Nigeria

Heavy Metal	Max. acceptable conc. (WHO)	Max. acceptable conc. (NAFDAC)
Zinc	5 mg/l	5 mg/l
Arsenic	0.01 mg/l	0.0 mg/l
Manganese	0.5 mg/l	0.5 mg/l
Magnesium	50 mg/l	30 mg/l
ron	0.30 mg/l	0.30mg/l
alcium	50 mg/l	50 mg/l
Nickel	0.02 mg/l	0.02 mg/l
Cadmiun	0.003 mg/l	0.0 mg/l
Lead	0.01 mg/l	0.0 mg/l
Silver	0.0 mg/l	0.0 mg/l
Mercury	0.001 mg/l	0.0 mg/l

Table 3. Statistical Analysis Result of the Mean Values of Temperature, pH, Conductivity and Total Suspended Solids.

Samples	Temperature (^{o}C)	pH	Conductivity (µS/cm at 25^{o}C)	Total Suspended Solids (mg/l)
1	29.50^{a}	6.00^{a}	40.0^{a}	6.00^{b}
2	29.50^{a}	6.40^{a}	42.0^{a}	5.00^{b}
3	29.40^{a}	6.60^{a}	41.0^{a}	4.00^{b}
4	29.50^{a}	6.80^{a}	36.0^{a}	4.00^{b}
5	29.60^{a}	6.90^{a}	30.0^{a}	5.00^{b}
6	29.50^{a}	6.80^{a}	42.0^{a}	6.00^{b}
7	29.50^{a}	6.90^{a}	39.0^{a}	4.00^{b}
8	29.30^{a}	8.00^{a}	41.0^{a}	0.00^{a}
9	29.40^{a}	8.00^{a}	50.0^{a}	0.00^{a}
10	29.60^{a}	8.00^{a}	42.0^{a}	12.00^{c}
Average	29.48	7.04	40.3	4.60
F- Value	0.11^{ns}	1.022^{ns}	0.404^{ns}	20.078*

Mean values with different superscript letter(s) within each column differ significantly ($p<0.05$)

Table 4: Statistical Analysis to the Results of the Mean Values of Total Acidity, Alkalinity, Hardness and Chloride

Sample	Total Acidity (mg/l)	Total alkalinity (mg/l)	Total hardness (mg/l)	Chloride (mg/l)
1	40/00^{b}	20.00^{d}	32.00^{e}	26.00^{d}
2	6.00^{f}	20.00^{d}	44.00^{c}	59.00^{a}
3	16.00^{c}	25.00^{c}	4.00^{c}	43.00^{c}
4	8.00^{ef}	20.00^{d}	4.50^{a}	26.00^{d}
5	11.00^{d}	10.00^{f}	38.00^{d}	18.00^{e}
6	12.00^{d}	25.00^{c}	82.00^{b}	51.00^{b}
7	12.00^{d}	15.00^{e}	98.00^{a}	44.00^{c}
8	63.00^{a}	63.00^{a}	0.00^{g}	0.00^{f}
9	10.00^{de}	33.00^{b}	0.00^{g}	0.00^{f}
10	18.00^{c}	25.00^{c}	0.00^{g}	0.00^{f}
Average	19.60	25.60	30.25	26.70
F-value	441.879	221.600	3227	774.404
	Ns	*	*	*

Mean values with different superscript letter(s) within each column differ significantly ($p<0.05$)

Table 5. Statistical Analysis Results of the Mean Values of Nitrate, Phosphate, Sulphate and Dissolved Oxygen.

Samples	Nitrate mg/l	Phosphate mg/l	Sulphate mg/l	Dissolved oxygen mg/l
1	13.30^{c}	7.00^{a}	8.00^{cd}	4.47^{b}
2	5.90a	1.12^{bc}	8.00^{cd}	4.54^{a}
3	16.80^{b}	0.54^{cd}	4.00^{e}	3.31^{g}
4	2.40^{g}	0.62^{cd}	8.00^{cd}	6.93^{c}
5	10.10^{b}	0.98^{bcd}	23.00^{a}	4.17^{d}
6	13.30^{d}	1.36^{b}	14.00^{b}	3.57^{f}
7	37.70^{a}	0.57^{cd}	10.00^{c}	3.30^{g}
8	2.40^{g}	1.56^{b}	7.00^{d}	3.91^{e}
9	3.10^{f}	0.45^{d}	2.00^{e}	4.44^{c}
10	0.70^{h}	0.67^{d}	8.00^{cd}	2.64^{h}
Average	9.86	1.48	9.20	3.87
f-value	10160*	111.690*	53.263*	7898

Mean values with different superscript letter(s) within each column differ significantly ($p<0.05$)

Table 6. Statistical Analysis Result of the Mean Values of Calcium, Magnesium, Sodium, Potassium, manganese, iron and nickel.

Samples	Calcium	Magnesium	Sodium	Potassium	Manganese	Iron	Nickel
1	0.1442^{d}	0.0367^{b}	0.0507^{a}	0.2154^{c}	0.0054^{b}	0.0010^{j}	0.0008^{b}
2	0.02181^{i}	0.0434^{b}	0.2969^{d}	0.0697^{d}	0.0099^{a}	0.0148^{c}	0.0015^{a}
3	0.4390^{f}	0.0039^{b}	2.2927^{e}	0.0591^{e}	0.0000^{f}	0.0051^{g}	0.0014^{a}
4	0.0064i	0.0029^{h}	0.2187^{g}	0.0250i	0.00000^{f}	0.0075^{f}	0.0006^{c}
5	0.1797^{c}	0.0432^{b}	0.4096^{b}	0.5027^{a}	0.0025^{d}	0.0100^{d}	0.0000^{d}
6	0.4269^{a}	0.2061^{a}	0.3641^{c}	0.4685^{b}	0.0015^{e}	0.0031^{i}	0.0000^{d}
7	0.3602^{b}	0.0469^{b}	0.2714^{f}	0.0412^{h}	0.0033^{c}	0.0079^{e}	0.0000^{d}
8	0.0693^{e}	0.0079^{h}	0.1071^{j}	0.0449^{g}	0.0000^{f}	0.0391^{b}	0.0000^{d}
9	0.0433^{g}	0.0053^{b}	1.1891^{h}	0.0027^{j}	0.0000^{f}	0.0045^{h}	0.0000^{d}
10	0.0339^{h}	0.0080^{b}	0.1396^{i}	0.0536^{f}	0.0000^{f}	0.0176^{a}	0.0000^{d}
F-value	5.511 x 10^{6}	1.565	2.087 x 10^{6}	8.066 x 10^{6}	6.366 x 10^{6}	4.509 x 10^{5}	160.048
P of sample		Ns	*	*	*	*	*

Mean values with different superscript letter(s) within each column differ significantly ($p<0.05$) * Significant ($P<0.05$) Ns = not significant($P<0.05$)

Table 7. Statistical Analysis Result of the Mean Values of Silver, Cadmium, Lead

Samples	Silver mg/l	Cadmium mg/l	Lead mg/l	Chromium mg/l
1	0.0000^{c}	0.0001^{d}	0.0000^{d}	0.0050^{g}
2	0.0000^{c}	0.0005^{b}	0.0032^{b}	0.0041^{i}
3	0.0000^{c}	0.0002^{cd}	0.0000^{d}	0.0074^{f}
4	0.0000^{c}	0.0003^{bcd}	0.0000^{d}	0.0115^{b}
5	0.0000^{c}	0.0004^{bc}	0.0000^{d}	0.0088^{e}
6	0.0000^{c}	0.0002^{cd}	0.0006^{c}	0.0100^{d}
7	0.0000^{c}	0.0002^{cd}	0.0000^{d}	0.0101^{d}
8	0.0000^{c}	0.0034^{a}	0.0627^{a}	0.0091^{e}
9	0.0000^{c}	0.0001^{d}	0.0000^{d}	0.0108^{c}
10	0.0002^{a}	0.0001^{d}	0.0000^{d}	0.0203^{a}
f-value	6.8333	235.523	1.882 x 105	526.693
p of sample	*	*	*	*

Mean values with different superscript letter(s) within each column differ significantly ($p<0.05$)

Table 8. Statistical Analysis Result of the Mean Values of Total Plate Count, Total Coliform Count and the result of Feacal Coliform.

Samples	Total Plate Count cfu/ml	Total Coliform Count cfu/ml	Faecal Coliform
1	60.00^{bcd}	15.00^{d}	-ve
2	10.00^{d}	7.00^{de}	+ve
3	30.00^{cd}	0.00^{e}	-ve
4	80.00^{bc}	49.00^{b}	+ve
5	100.00^{b}	23.00^{c}	-ve
6	1000.00^{a}	240.00^{a}	-ve
7	20.00^{d}	240.00^{a}	+ve
8	1.00^{d}	0.00^{e}	+ve
9	10.00^{d}	0.00^{e}	+ve
10	20.00^{d}	0.00^{e}	-ve
Average	133.10	57.40	Not detected
F -value	279.902*	558.539*	Not detected

Mean values with different superscript letter(s) within each column differ significantly ($p<0.05$)

However, pH played a significant role in determining the bacterial population growth and diversity in sachet water. Increases in the observed pH, could be attributed to the production of basic metabolic waste products by increasing bacterial population. In their review, Prescott et al. (1999) stated that microorganisms frequently change the pH of their own habitat by producing acidic or basic metabolic waste products.

The values ranged of temperature from table 3 were recorded to be 29.40 to 29.60^{o}C of all the ten water samples. The temperature values obtained throughout the study locations fall within the optimal growth range for mesophilic bacteria including human pathogens. Prescott et al. (1999) reported 20-45^{o}C as optimal growth temperature for mesophilic microorganisms. According to WHO report (1996), the microbiological characteristics of drinking water are related to temperature through its effects on water-treatment processes and its effects on both growth and survival of microorganisms. Consequently, growth of microorganisms is enhanced by warm water conditions and could lead to the development of unpleasant tastes and odours.

Conductivity values as express in table 3 depicts the amount of dissolved solids in the groundwater sampled with an average value of 40.3 µS/cm at 25^{o}C and a range values of 30-50 µS/cm at 25^{o}C. Conductivity of the water samples were found to be within the permissible standard recommended (1000 µS/cm at 25^{o}C) by WHO and SON. Although may be high with attended increase in value over time.

The total suspended solid as expressed in table 3 is higher in location 10 and virtually not detectable in location 8 and 9 and also varied significantly amongst the samples as the values obtained were different which may be the nature of the soil material, rock formation and method of borehole construction.

All the ten locations sampled with respect to the physical parameters are within the permissible limit of SON, WHO and European Union and all the values with exception to Total Suspended Solid shows no significant variation or difference amongst samples measured.

Among the water samples in the ten locations, location 2 has the highest chloride values of 59 mg/l while it was detected in locations 8, 9, 10 as indicated on table 4. We can established certain relationship between chloride and total hardness hence the more the chloride the more the total hardness (see location 7, 8, 9, and 10), it is established that the values of both chloride and total hardness are within the permissible limit of WHO, (See table 4). The values also showed significant difference in the range of means for both total hardness and chloride contents. Chloride ions are non-cumulative toxins, an excess amount of which, if taken over a period of time, can constitute a health hazard. WHO (2011) recommended 250 mg/L as the maximum chloride ion level allowable in drinking water. It is believed that higher concentration of chloride ions may result in taste problems. High level of chloride is known to impart taste to portable water particularly when sodium is the predominant cation (APHA, 2005). Apparently the level of residual chloride observed in the samples used for this study was not high enough to impact on the taste of the samples, since there was no salty or objectionable taste identified in any of the water samples.

Also as established in table 4 above, locations 6 and 7 had the highest (82 mg/l and 98 mg/l) of total hardness expressed as $CaCO_3$ while location 8, 9, and 10 had the least total hardness (0.0 mg/l each). However, the level of total hardness in all the groundwater evaluated for the period of investigation is within the range of total hardness (100 mg/L) recommended by WHO and NAFDAC. According to APHA (2005), calcium contributes appreciably to total hardness but in this study, all locations had a relatively low total hardness when compared with the level in other site.

Among the samples investigated location 2, 5, 1, 3 and 7 recorded progressive values of Nitrite (5.90, 10.10, 13.30, 16.80 and 37.70 mg/l) which are greater than the WHO permissible limit of 5.0 mg/l, while the values also have significant difference in the range of the means (see table 5). Also from Table 5 above, the values of nitrate ranged from 0.70-37.70 mg/L with a mean of 9.86 mg/l exceeding the WHO permissible standard. Decrease in nitrate values in some locations could be attributed to their utilization by microorganisms for growth and reproduction (Prescott et. al., 1999)

The values of Phosphate recorded shows significant difference in the range of means and four of the locations sample recorded values greater than one i.e locations 2, 6, 8 and 1 with values of 1.12, 1.36, 1.56 and 7.00 mg/l which exceeded the WHO permissible standard. The values of Sulphate and DO though having values which were all significantly different in their range of means were all within the acceptable limit of WHO standard for drinking water. The values of DO is not too significant with respect to human welfare, it lack may make water taste flat while excess sulphate have significant health implication to man and the environment.

The level of total iron ions in the water samples location ranged, from 0.0010-0.0176 mg/l, sodium ions ranged from 0-0507-.1.1891 mg/l. According to table 6 above, these values were below the maximum limit of 0.30 mg/L for total iron and 200 mg/L for sodium ions recommended by WHO (2011). High level of sodium can lead to a high Na/K and Na/total cation ratio which may be of great concern from the perspective of human pathology (NRC, 1989; APHA, 2005).

Table 6 also express the level of calcium, magnesium, potassium, manganese, and nickel in the water samples location which ranged from 0.0064-0.4269 mg/l, 0.002-0.2061 mg/l, 0.0027-0.5027, 0.000-0.0099 and 0.0000-0.0015 mg/l respectively. These values were below the maximum limit recommended by WHO (2011). No evidence of adverse health effects specifically attributable to calcium and magnesium in drinking water has been established. However, excess calcium and magnesium ions make water hard (Tay, 2007). The water samples were characterized by low mean calcium and magnesium ion concentrations from all sampled locations. National Research Council (NRC, 1989) noted that calcium is one of the essential dietary minerals that drinking water usually supplies.

The chemical characteristics of all the locations of water evaluated were within the range of standard values recommended for chloride, total hardness, phosphate, sulphate, iron, potassium, sodium and calcium by WHO and NAFDAC with exception of nitrate which exceeded the permissible limit of WHO and NAFDAC standard for drinking water. The implication of this result is that the processors of this water obtain raw water from chemically good sources and adopt standard operating procedures for chemical water treatment.

The levels of other anions, phosphate, nitrate and sulphate in all the brands of water evaluated met the recommended standards for portable water also there were variations in the levels of the cations; iron, potassium, sodium and calcium in the different locations of water evaluated. The results from table 7 of the samples in locations of water samples indicated that the concentration of selected metals present (Lead, Cadmium, Chromium, Manganese) were at concentrations below the WHO limits and had little or no significance importance except in location 8 where cadmium and lead were found to be 0.0034mg/l and 0.0627 mg/l as against the 0.003 mg/l and 0.01 mg/l respectively exceeding WHO limits. Other metals (Zinc, Copper, Aluminium, Manganese, Nickel, Cobalt, Arsenic, Mercury and Silver) were below the detectable limits of the metals.

Total coliform bacteria were detected in 50% of the water analyzed within all the locations investigated as depicted on table 8 above. However, they were not detected in locations 3, 8, 9 and 10. Coliform bacteria and tested positive for faecal coliform 50% of the ten locations, i.e., locations 2, 4, 7, 8, and 9. Indicator organisms loose viability in freshwater environment with time (WHO, 2001).

Total coliforms are widely used as indicators of the general sanitary quality of treated drinking water while faecal coliforms give a much closer indication of faecal pollution (Ashbolt et. al, 2001). WHO limit is that none should be detected. Unlike total and faecal coliform counts did not increase in samples locations tested. Among the criteria for indicator organisms, Prescott et al. (1999) stated that indicator bacterium should not reproduce in the contaminated water and produce an inflated value.

Two of the locations (location 5 and 6) water samples analyzed did exceed WHO limit of 100 cfu/ml for total aerobic coliform bacteria. Although all sample locations study are groundwater from borehole source and it thus confirms the result of an earlier study by Okoli et al., (2005), indicating that the boreholes are heavily contaminated with faecal matter. Feacal contamination of drinking water has very serious health implications (Banwart, 2004). The source of these contaminations could be attributed to the deliberate and indiscriminate littering of human and animal waste in adjoining bushes to the borehole sites.

Conclusion

Heavy metals are important in many respects to man, especially in the manufacturing of certain important products of human use, such as accumulators (Pb), mercury- arch lamps and thermometers (Hg), utensils (Al) and a wide range of other products (Yaw, 1990; McCluggage, 1991). But the bio toxic effects, when unduly exposed to them could be potentially life threatening hence, cannot be neglected. While these metals are in many ways Indispensable, good precaution and adequate occupational hygiene should be taken in handling them. Although heavy metal poisoning could be clinically diagnosed and medically treated, the best option is to prevent heavy metal pollution and the subsequent human poisoning.

Industrial and commercial activities occasioned by economic imperatives of the society has also contributed in no small measures to the discharge and/or emission of poisonous gases, heavy metals and chemicals into the environment which ultimately have found its way into both the surface and ground water with its attendant deleterious effect on the health of humans.

The analytical results revealed that prolonged storage caused an increase in pH. The presence of dissolved oxygen coupled with availability of organic material and nutrients aided continuous and rapid proliferation of bacteria in location water samples tested over time.

It was evident from the study that the groundwater water sampled in Ikeja Metropolis study met the recommended standards for physical and chemical qualities except for the pH and the Nitrite but about 50% of the locations water investigated were microbiologically unwholesome as 50% water samples analzed were contaminated by coliform bacteria. It is therefore necessary for groundwater water i.e., borehole or whichever way it is abstracted be properly treated and handled to meet the WHO standard for drinking water. Since microbiological quality of water is a hidden attribute that impact seriously on public health, it is pertinent that the activities of regulatory agencies be intensified to ensure compliance with standard to avert public health hazards.

Reference

Adekunle, L.V., Sridhar, M.K.C., Ajayi, A.A., Oluwade, P.A. and Olawuyi, J.F. (2004) An assessment of the health and social economic implications of sachet water in Ibadan, Nigeria: A public health challenge. Afr. J. Biochem. Res., 7: 5-8.

Agada, O.A., 1998. Result of baseline studies on water supply and sanitation conducted by Federal Ministry of Water Resources and Rural Development, Nigeria: UNICEF assisted National Water Supply and Sanitation Monitoring Programme-An Overview.FGN-UNICEF WEB Review Meeting, pp: 1-14.

Ajewole, I.A., 2005. Water an Overview, Food Forum, A Publication of the Nigerian Institute of Food Science and Technology, 4(1): 15 Dada, A. and Ntukekpo, D.S., 1997. Pure Water: How Safe? Ultimate Water Technology and Environment, 1(3): 8 – 11.

Dodoo, D.K.; Quagraine, E.K.; Okai-Sam, F.; Kambo, D.J. and Headley, J.V., 2006. Quality of “sachet” waters in the Cape Coast municipality of Ghana. J. Environ. Sc. Health: Part A, 41: 329-342.

Duruibe, J. O., Ogwuegbu, M. O. C and Egwurugwu, J. N (2007) Heavy metal pollution and human biotoxic effects. International Journal of Physical Sciences Vol. 2 (5), pp. 112-118, May, 2007 Available online at http://www.academicjournals.org/IJPS ISSN 1992 - 1950 © 2007 Academic Journals.

Heyer, N.J (1985). Neurological Disorder in Three Aluminium Smelter Workers, Arch. Intern. Med. 145(11): 1972-1975.

Lamikanra, A., Ogundaini, A.O and Ogungbamilla, F.O (1990) Antibacterial constituents of Alchornia cordifolia leaves. Phytotherapy Research 4,198-200 Lenntech Water Treatment and Air Purification (2004). Water Treatment, Published by Lenntech, Rotterdamseweg, Netherlands (www.excelwater.com/thp/filters/Water-Purification.htm).

McCluggage D (1991). Heavy Metal Poisoning, NCS Magazine, Published by The Bird Hospital, CO, U.S.A. (www.cockatiels.org/articles/Diseases/metals.html).

Melosi, M.V., 1980. Environmental Crisis in the City: The Relationship Between Industrialization and Pollution. Pollution and Reform in American Cities, 1870-1930, University of Texas Press, Austin Melosi, M.V., 2000. The Sanitary City: Urban Infrastructure in America From Colonial Times to the Present. The Johns Hopkins University Press, Baltimore.

Mendie, U., 2004. Cyclical Growth of Contaminants in Drinking Water Packaged in Polythene Bags. Nigerian Journal of Pharmacy 40: 398 – 399.

Njoku, G and Osondu, A., 2007. New Standard for Drinking Water Quality in Nigeria to Ensure the Safety of Drinking Water and Protect Public Health. http://www.unicef.org/Nigeria/wash-2165.html.

Obiri-Danso, K. A.; Okore-Hanson and Jones K., 2003. The microbiological quality of drinking water sold on the streets in Kumasi, Ghana. Lett. Appl. Microbiol., 37: 334-339.

Oladipo I. C.; Onyenike, I.C.; and Adebiyi, A. O., 2009. Microbiological analysis of some vended sachet water in Ogbomoso, Nigeria. African J of Food Sci., 3(12): 406 – 412.

Ogwuegbu MOC, Muhanga W (2005). Investigation of Lead Concentration in the Blood of People in the Copperbelt Province of Zambia, J. Environ. (1): 66 – 75.

Olusheyi, Z. O.; Lin, Z.; Ruopu, L.; Xin, T.; Wenming, L.; and Hamza, I. B., 2009. Ameliorating Water Crises Through Sustainable Wastewater Reuse in Hengshui, China. American Water Works Association Vol 101:10 (71-79).

Omalu, I.C.J.; Eze, G.C.; Olayemi, I.K.; Gbesi, S.; Adeniran, L.A.; Ayanwale, A.V.; Mohammed, A.Z.; and Chukwuemeka, V., 2010. Contamination of Sachet Water in Nigeria: Assessment and Health Impact. Online J of Health and Allied Sci., 9 (1): 1 – 3.

Osibanjo, O.; Ajayi, S.; Adebiyi, F. and Akinyanju, P., 2000. Public Analysis Reporting System as Applied to Environmental Issues. IPAN News, A Publication of the Institute of Public Analysts 1(3):10.

Oyeku, O.M.; Omowumi, O.T.; Kupoluyi, C.F. and Toye, E.O., 2001. Wholesomeness Studies of Water Produced and Sold in Plastic Sachets (Pure Water) in Lagos Metropolis. Nigerian Food Journal,19:63– 69.

Rutz, D., 1996. Pure water vending machines may not be so pure. CNN: Food & Health, May 2.

Symons, James M., L. C. Bradley, T. C. Cleveland, 2000. The Drinking Water Dictionary.AWWA, Denver, CO.

Third World Water Forum on Water, 2003. Blockade, Myth, Illusions in Development and Cooperation. Tokyo, Japan, Vol. 30.

United States Department of Labor (2004). Occupational Safety and Health Administration (OSHA); Safety and Health Topics: Heavy metals, USDOL Publication, Washington, D.C. (www.osha.gov/SLTC/metalsheavy/index.html).

Warburton, D. W.; Dodds, K. L.; Burke, R.; Johnston, M. A and Laffey P. J., 1992. A review of the microbiological quality of bottled water sold in Canada between 1981 and 1989. Can. J. Microbiol., 38:12-19.WHO, 2011.Guidelines for Drinking-Water Quality.Word Health Organisation, Geneva, Switzerland.