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Research Article

Comparative Assessment of Trace and Heavy Metals in Available Drinking Water From Different Sources in the Centre of Lagos and off Town (Ikorodu LGA) of Lagos State, Nigeria

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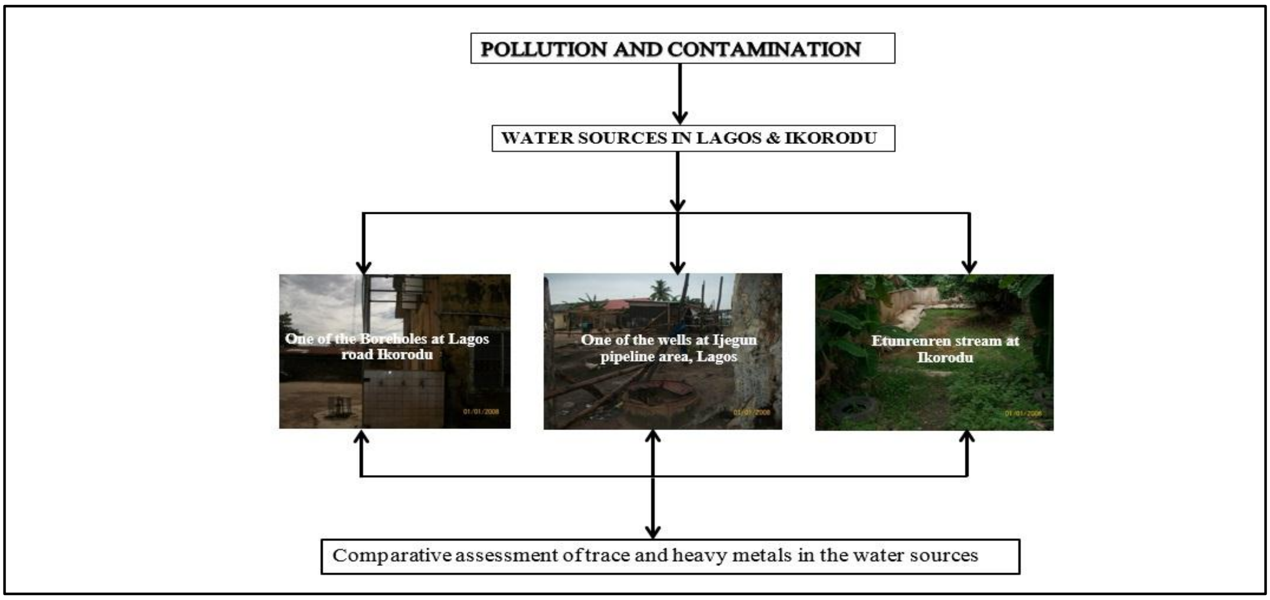
ABSTRACT

The analysis of heavy metals in drinking water from different sources in Lagos state, Nigeria were determined with a view of comparing the effects of level of Industrialization, population density and urbanization on the water quality in the centre of Lagos and off town of Lagos (Ikorodu LGA, a relatively less Industrialized and less Urbanized town of Lagos state) as a case study. The different sources of drinking water considered were wells, boreholes, surface water and tap water. In each of Lagos and Ikorodu. The heavy metals were analysed; Pb, Cd, Cu, Fe, Cr, Zn, Na, Ni, Mg and Ca using Atomic Absorption Spectrophotometer (Perkin-Elmer 305B model with air-acetylene flame). The results show that Pb, Ni, and Mg values exceeded the permissible limits set by WHO, EU and NIS for all the samples from all the sources in all study area while Fe has values above the standards set by all the regulatory bodies in Ikorodu boreholes (*i.e.* 1.804 mg/L) but all other sources as well as all Lagos samples have values of Fe within the permissible limits (0.2-0.3 mg/L) and this could be traced to the geology of the area. Cu, Zn, Na, Cr, and Ca all have higher values in Lagos centre samples than in Ikorodu samples but are all within the permissible limits. Cd was not detected in any of the samples at all.

GRAPHICAL ABSTRACT



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Introduction

Water is one of the most vital natural resources necessary for the existence of life. In most urban cities in various countries such as Nigeria, it is the duty of the government to provide potable water. Most often the responsibility is not adequately discharged, causing the inhabitant of those cities to look elsewhere to meet their water needs. The alternative may be unwholesome [1].

Drinking water or potable water is water of sufficiently high quality that it can be consumed or used without risk of immediate or long term harm. In most developed countries, the water supplied to households, commerce and industry is all of drinking water standard.

Water covers about 70% of the earth crust; hence it is the most abundant substance on the earth surface. This is because the sources of surface water such as rivers, lakes, streams, oceans, sea, and wetlands are found in abundance on this planet.

Water is colourless, odourless and tasteless in its pure form and has a boiling point of 100 °C and freezing point of 0 °C. It has the ability to exist in three different phases - solid, liquid and gases. Liquid water consists of a continuous network of randomly connected hydrogen bonds which form a liquid.

Surface water is water in a liquid form which always flows downwards usually, on mountain slopes. The quality of river water depends on the feeding source of the river which includes surface runoff, water of glaciers, underground water, swamp, rain, treated sewage, water of industrial enterprises and polluted area. Surface water is a basic natural resources essential to man for his various and intense agricultural and industrial activities.

Groundwater has long served as a source of drinking water and it is still very important today. The development of ground water has provided great socio-economic benefits to humanity. Globally, groundwater is estimated to provide about 50% of current drinking water supplies. As groundwater is isolated from the surface, most people take it for granted that groundwater should be relatively pure and free from pollutants. Although most ground waters are still of high quality, at some locations, it is becoming increasingly difficult to maintain the purity of groundwater. One of the major sources of pollution of groundwater is by saltwater intrusions. Others include seepages from underground storage tanks, oil wells, septic tanks, landfills and agricultural leaching [2].

Groundwater is a reliable source of water supply, because it is often unpolluted due to restricted movement of pollutants in the soil profile. However, shallow and permeable water table aquifers are most susceptible to contamination [3]. The potential of such water to harbour microbial pathogens and cause illness is well documented for both developed and developing countries [4]. Introduction of pollutants into the natural water occur directly through point source (septic tanks, disposal sites *etc.*) near the ground water or indirectly through non-point source when already polluted water in the area enters into the freshwater body by lateral or side movement.

Water pollution results in transmission of infectious diseases. The implications of waterborne bacteria and virus infection include polio, hepatitis, cholera, diarrhoea, typhoid *etc.* [5] but nitrate contamination is very severe. Thus, contamination of drinking water from any source is of primary importance due to the danger and risk of water diseases. In 1997, the World Health Organization (WHO) reported that 40% of deaths in developing nations occur due to infections from water related diseases and an estimated 500 million cases of diarrhea, occurs every year in children below 5 years in parts of Asia, Africa and Latin America.

Water that has good drinking quality is of basic importance to human physiology and human's continued existence relies very much on its availability [6]. The standard for drinking water can be attributed to two main criteria, namely: The presence of objectionable taste, odour and colour and the presence of substances with adverse physiological effects. However, most of the groundwater from most sources is therefore unfit for immediate consumption without some sort of treatment. The extent of treatment needed therefore is determined by the quality of the raw water source [7,13]. Therefore, water has to meet certain physical, chemical and microbiological standards, that is, it must be free from diseases producing micro-organisms and chemical substances, perilous to health before it can be termed potable.

Though, much of the Land mass of Lagos state are covered by water, getting a clean drinking water poses a major challenge. It is almost impossible to get drinking water from the large volume of surface water found in Lagos. This is largely due to salinity of the water bodies and also pollution by anthropogenic activities. Rivers, lakes and other water bodies serve as a cheap source of effluent disposal by most industries especially in the developing nation [8].

Although access to safe and consistent drinking water is imperative for a healthy population, surface water may be contaminated by pesticides by agricultural, household and industrial application [9]. As a result of immense industrialization and high population growth, groundwater is heavily relied on in Lagos metropolis to serve as an alternative source of water where surface water is seriously polluted. The continued reliance on ground water has resulted in its decline in quantity and quality.

Contamination of drinking water supplies by industrial waste is as a result of various types of industrial processes and disposal practices. Industries which use large amount of water in their processes (like steam production, as solvent for washing purposes, as a coolant for rinsing, waste disposal practices and for finishing operations *etc.*) including chemical manufacturing, steel plants, battery industries, metal processes, textile manufacturers, tanneries *etc.* [10].

The presence of detergent phosphate pollution has also been noticed in the source of water supply in Lagos Metropolis. This has played a significant role in stimulating the explosive growth of algae in the water in the area. There are reports that most oil terminals and gasoline stations in Lagos lack effluent treatment plants and as a consequence, the oil gains access to groundwater in the area [11].

The aim of this work is to investigate in totality the quality of water consumed in Lagos and its surroundings bearing in mind the population and high pollution in this area. The work will embrace the three possible sources of drinking water at Lagos metropolis like boreholes, well-waters and river/stream. A comparative study of these sources will be carried out in respect of central Lagos and Ikorodu LGA which is somehow outskirt to the main metropolis in Lagos state. The result obtained in this work would throw light to the nature of water being consumed in one of the most populated city in Nigeria. The Off-Lagos metropolitan result would also indicate the possible degree of pollution or of the contaminated water. Such result could also give an insight to the possible steps to take in order to improve water quality where standards were not met.

Experimental

Analysis of trace and heavy metals

Site description

Lagos State is one of the states in the south-western Nigeria, boarded in the south by the Atlantic Ocean, in the north and east by Ogun state and in the west by Republic of Benin. It occupies an area of about 3,577 sq. km with a population of about 14 million. About 80-85% of the industries in Nigeria are located in Lagos state and 80% of the population resides in the metropolitan (central) Lagos, making the state the most urbanized in Nigeria [12].

Ikorodu is one of the largest Local Government Areas, but outskirt from the main Lagos city in Lagos state. Ikorodu town is one of the twenty (20) local governments in Lagos State. The local government is located between longitude 4° 12' and 4° 47' E and latitude 7° 15' and 7° 36'N. It shares part of its boundary with Ogun State. The area falls within the high forest region whereas the drier Northwestern part is attributed to the vegetation growth of the Guinea Savannah [13]. Ikorodu here is less developed and less industrialized.

Sampling and sample collection

FOR lagos centre

Sample A; pooled well water–collected from 7 areas *i.e.,* Baruwa Ayobo, Abulegba dumpsite surroundings, Olusosun-ojota, Ilupeju industrial area, Solus dumpsite LASU-Igando road, Surulere LG swampy areas, Ijegun pipeline environs.

Sample B; pooled borehole water-collected from Baruwa-Ayobo, Abulegba dumpsite surroundings, Olusosun-Ojota dumpsite, Ilupeju industrial area, solus dumpsite LASU–Igando road, Surulere swampy areas, Ijegun pipeline environs.

Sample C; tap water- obtained from Ketu area, Baruwa-Ayobo, Abulegba surroundings, Ojota, Surulere LGA, Ijegun-Ikotun area, Ikeja.

For lagos offtown (ikorodu)

Sample A; pooled well water-collected from 7 different areas *i.e.,* Owode, Ogolonto, Fasheun estate, Orile Idera, Etunrenren road, CAC/Lagos road, Majidun.

Sample B; pooled borehole water–obtained from Owode, Ogolonto, Fasheun estate, Orile Idera, Etunrenren road, CAC/Lagos road, Majidun.

Sample C; surface water–obtained from 'etunrenren' streams.

Samples were preserved and digested. The heavy metals were analysed using Atomic Absorption Spectrophotometer (Perkin-Elmer 305B model with air-acetylene flame).

Stringent precautions were taken for quality assurance, and all the reagents used were of analytical grade. All the containers used for the sampling were thoroughly washed. Plastic bottles were used for the collection of samples for determination of metals. All materials that came in contact with the samples and sample containers were thoroughly washed and rinsed with 1:1 nitric acid and then with distilled water. 5mL concentrated nitric acid was added per litre of samples at the time of collection, to minimize adsorption of metals onto the container walls [14].

The samples were all stored in the refrigerator throughout the period prior to analysis.

Results and discussion

The results of the heavy metal concentrations obtained from the Assessment of Drinking water quality from the centre and off town (Ikorodu) of Lagos state are presented in Table 1. Table 2 show the World Health Organization, European Union and Nigerian Industrial Standards for Potable water while Tables 3 presented the Mean values of the entire Lagos centre samples as well as the mean values for the entire Ikorodu drinking water samples from the various sources for Trace metals concentrations.

Figures 1-4 present the Bar charts showing the mean heavy metals concentrations in the samples from the various sources for the two areas studied *i.e.,* Lagos centre and Ikorodu, all in comparison with the permissible limits.

Table 1. Heavy Metals Concentrations of the six samples. Values are mean of three replicate values

Heavy metals (mg/L)	1A (mg/L)	1B (mg/L)	1C (mg/L)	2A (mg/L)	2B (mg/L)	2C (mg/L)
Pb	0.116±0.03	0.121±0.015	0.099±0.006	0.098±0.005	0.140±0.012	0.102±0.001
Cd	ND	ND	ND	ND	ND	ND
Cu	0.027±0.004	0.064±0.002	0.047±0.003	0.027±0.003	0.051±0.002	0.060±0.007
Fe	0.151±0.021	0.171±0.019	0.139±0.013	0.096±0.008	1.804±0.420	0.146±0.031
Cr	0.026±0.003	0.021±0.004	0.009±0.0002	0.01±0.001	0.011±0.001	0.016±0.004
Zn	0.311±0.02	0.111±0.01	0.41±0.025	0.213±0.015	0.328±0.039	0.270±0.05
Na	42.0±5.2	46.0±3.9	68.0±4.8	16.0±3.0	49.0±7.0	24.0±4.0
Ni	0.721±0.041	0.814±0.038	0.951±0.066	0.953±0.068	0.814±0.025	1.021±0.13
Mg	6.41±0.42	4.95±0.35	7.49±0.61	7.49±0.70	2.62±0.20	7.49±0.33
Ca	17.60±1.31	13.60±1.20	8.82±0.61	8.82±0.49	7.20±0.44	8.82±0.31

Note: ND= Not detected

Table 2. WHO, EU and NIS (Nigerian Industrial Standards) for drinking water (Trace Metal Concentrations)

Heavy Metals Concentrations	Wholimits (mg/L)	European unionlimits (mg/L)	Nigerian Ind. Standards (mg/L)
Pb	0.01	0.01	0.01
Cd	0.003	0.005	0.003
Cu	2	2	1
Fe	0.3	0.2	0.3
Cr	0.05	0.05	0.05
Zn	3	NA	3
Na	200	200	200
Ni	0.02	0.02	0.02
Mg	20-125	20-125	0.2
Ca	75	NA	NA

Note: Pb -- Lead, Cd -- Cadnium, Cu -- Copper, Fe -- Iron, Cr – Chromium, Zn – Zinc, Na – Sodium, Ni -- Nickel, Mg – Magnesium

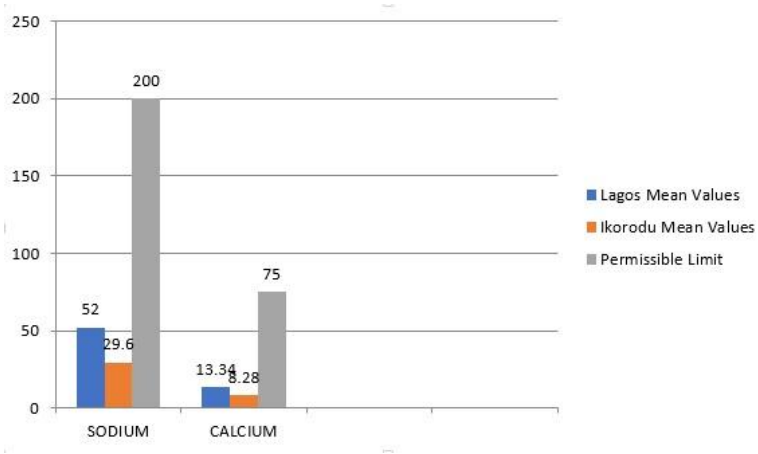


Figure 1. Bar charts showing mean heavy metal concentrations of water from different sources in comparison with the permissible limits for sodium and calcium

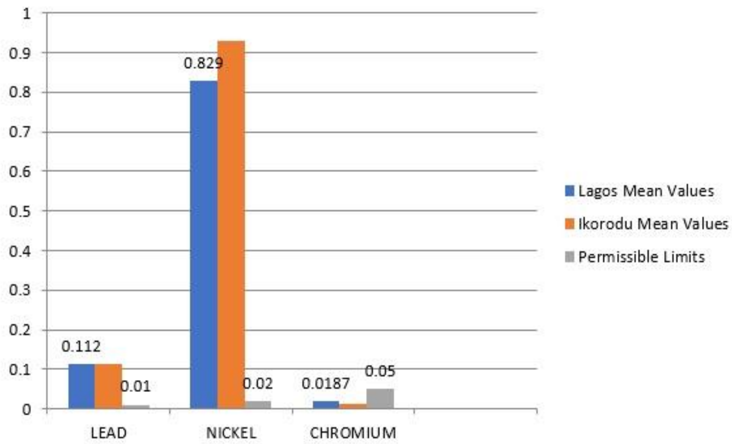


Figure 2. Bar charts showing mean heavy metal concentrations of water from different sources in comparison with the permissible limits for Pb, Ni and Cr

Lead is one of the poisonous trace elements often found in polluted natural waters. From the result obtained in Table 1, the value of lead ranged from 0.098 mg/L for 1C (Lagos tap water) to 0.140 mg/L for 2B (Ikorodu borehole water), with an average value of 0.112±0.011 mg/L for Lagos drinking water and 0.113±0.013 mg/L for Ikorodu drinking water sources (Table 3). A permissible standard limit of 0.01 mg/L was set by WHO, EU and Nigerian standards for potable water (Table 2). All the values for the various sources of drinking water in the two areas studied exceeded the limits (Figure 2), which is indicative of non-suitability of these waters for drinking purposes without treatments.

Lead gets into the surface and ground water through municipal wastes, mining activities, plumbing, paint residue, burning of coal and leaded gasoline *etc.* It causes anaemia, kidney diseases, cancer, interferes with vitamin D metabolism, affect mental development in infants, toxic to the central and peripheral nervous systems [15-17].

Cadmium is also another trace element of serious environmental concern, if present in a significant concentration. Cadmium was not detected in any of the samples. Cadmium value above the mandatory limit of 0.003 mg/L is known to be toxic to the kidney, causes high blood pressure, destroys testicular tissue and red blood cells [16,17]. Cadmium is usually found in effluents from industries producing batteries, phosphate fertilizers, mining and other inorganic products.

Copper is considered an essential element for human nutrition, since it is required in many enzymatic reactions.

The results for copper varied between 0.027 mg/L for (1A and 2A) and 0.064 mg/L for 1B (Table 1) with a mean value of 0.046±0.019

mg/L for Lagos centre water samples and 0.046± 0.017 mg/L for Ikorodu samples (Table 3). This shows that irrespective of industrialization, the two areas have common soil and water origin and content with respect to copper ion. The permissible limits set by WHO, EU and NIS (2007) includes 2.0, 2.0 and 1.0 mg/L respectively (Table 2). However, these values were not exceeded by the results obtained for the copper ion. More so, values above the permissible limits can cause gastro intestinal disorder.

Iron has no serious health impact [17], but iron values are objectionable for other domestic purposes and plumbing fixtures.

The result obtained for Iron (Fe) ranged from 0.096 mg/L for 1C (Lagos tap water) to I.804 mg/L for 2B (Ikorodu borehole water) (Table 1), with a mean value of 0.54±0.016 mg/L for samples from Lagos centre and 0.682±0.97mg/L for samples from Ikorodu (Table 3). The WHO, EU and NIS stipulated standards for iron in portable water is 0.3, 0.2 and 0.3 mg/L respectively (Table 2). The values obtained from the two cities are all within the limits (Figure 3) except for sample 2B (Borehole representative sample from Ikorodu) with a value of 1.804 mg/L. The geology of the areas could probably be the source of iron in the water from such boreholes [18].

Iron values greater than 0.3 mg/L can damage fabric, paper and corrode the inner walls of high pressure boilers [11].

Calcium is interrelated with magnesium and total hardness. An important source of calcium is dissolution of small quantities of carbonate compounds from industries [19]. Calcium concentrations varied from 7.20 mg/L for 2B (Ikorodu borehole water) to 17.60 mg/L for 1A (Lagos wells) (Table 1) with an average value of 13.34±4.40 mg/L for Lagos centre samples and an average value of 8.280±0.94 mg/L for Ikorodu water samples (Table 3), showing higher presence in Lagos water sources. The permissible standards given by WHO is 75 mg/L. The results obtained are lower than the limits, hence suitable for drinking purposes with respect to calcium.

Water containing high calcium is not suitable for washing, bathing and in boilers and also linked to the formation of concretion in the body and may cause gastro intestinal diseases and stone formations [20].

Magnesium is a beneficial metal but toxic at high concentrations, cause hardness and exert a cathartic and diuretic action [14]. The concentrations of magnesium in this study vary from 2.62 mg/L for 2B to 7.49 mg/L for (all of 1C, 2A and 2C) Table 1) with an average value of 6.28±1.28 mg/L and 5.86±2.81 mg/L for Lagos centre water sources and Ikorodu water sources respectively (Table 3). There is no recent guideline by WHO and EU, but Nigeria Industrial Standards gave a desirable limit of 0.2 mg/L Table 2, Figure 4). All the values obtained are however, above the limit, implying that the water is unfit.

The availability of magnesium in natural water is not uniformly distributed; it is also influenced by human activities on the environment [21]. The sources of magnesium in the hydrosphere are dolomite in sedimentary rocks and serpentines and tremolites in metamorphic rock [22]. Excess of calcium and magnesium contents in water will give rise to poor lathering and deterioration of clothes [23].

Chromium is a trace heavy metal usually found in surface and ground water occasionally Sources of chromium includes discharges from steel and pulp mills; erosion of natural deposits *etc.*, chromium concentrations ranged from 0.009 mg/L for 2C (Ikorodu stream) to 0.026 mg/L for 1A (Lagos well water) (Table 1) with mean value of 0.0187±0.009 mg/L for Lagos metropolitan drinking water and 0.012±0.003 mg/L for Ikorodu drinking water sources (Table 3). The permissible limit of chromium is 0.05 mg/L by WHO, EU and Nigeria Industrial Standards (2007) (Table 2, Figuer 2).

The concentration was higher in Lagos centre, but all the values are still within the permissible limit. Ingestion of water with chromium concentration above 0.05mg/L can cause cancer, Allergic dermatitis [17].

Zinc is another trace element needed in the body in very trace amounts. Many of the Zinc salts are highly soluble. Zinc concentration varied between 0.111 mg/L for 1B (Lagos borehole water) and 0.410 mg/L for 1C (Lagos tap water) (Table 1). The mean values of 0.277±0.152 mg/L and 0.270± 0.058 mg/L was obtained for Lagos drinking water sources and Ikorodu drinking water sources respectively (Table 3). WHO and Nigerian Industrial Standards for drinking water both have the permissible limit of 0.3 mg/L for zinc (Table 2).

Excess zinc concentration in the body accumulates in the body. Although zinc is not a human carcinogen, but excessive intake of zinc through contaminated food chain could lead to vomiting, dehydration, abdominal pain, lethargy and dizziness [24].

Sodium occurs as a major cation in water samples. It is of vital importance to the body. The concentration of sodium in the study area ranged from 16.0 mg for 2A (Ikorodu well water) to 68.0 mg for 1C (Lagos tap water) (Table 1) with the mean value of 52.0±14.0mg for Lagos centre water samples and mean value of 30.0±17.0 mg/L for Ikorodu water samples (Table 3). More industrialized and populous Lagos metropolis (centre) has higher values than Ikorodu areas.

Sodium has permissible limits for drinking water given by WHO, EU and NIS as 200 mg/L (Table 2, Figure 1). The levels of sodium are therefore within the acceptable limits for all the samples. Excess levels of sodium in any water sample could be linked to saline water intrusions, discharge of domestic and Industrial effluents on to the ground or water bodies [20].

Nickel has low toxicity comparable to zinc, manganese and chromium; it does not accumulate in tissues. The WHO, EU and Nigeria Industrial standards all stipulated permissible limits of 0.02 mg/L (Table 2).

However, from these study Nickel concentrations ranged from 0.721 mg/L for 1A (Lagos well water) to 1.021 mg/L for 2C (Ikorodu stream) (Table 1), with a mean value of 0.829±0.116 mg/L for Lagos centre drinking water sources and a mean value of 0.929±0.106 mg/L for Ikorodu drinking water sources (Table 3, Figure 2). These values exceeded the limits stipulated by all the regulatory bodies, indicating Nickel pollution. It is generally observed that there is higher concentration of Nickel in Ikorodu different drinking water sources including exceptionally high value recorded for 2C (Ikorodu stream). This may be associated with leachates from dumpsites which have existed for decades within the thick forest in the vicinity of the 'etunrenren' stream in Ikorodu.

Table 3. Mean values for the entire Lagos centre and entire Ikorodu samples (heavy metals parameters)

Heavy Metals Concentrations	1 (Mean lagos values) (mg/L)	2(Mean ikorodu values) (mg/L)	Permissible limits (mg/L)
Pb	0.112±0.011	0.113±0.013	0.01
Cd	ND	ND	0.003
Cu	0.046±0.019	0.046±0.017	2.0
Fe	0.154±0.016	0.682±0.97	0.3
Cr	0.0187±0.009	0.012±0.003	0.05
Zn	0.277±0.152	0.270±0.058	3.0
Na	52.00±14.00	29.90±17.00	200
Ni	0.829±0.116	0.929±0.106	0.02
Mg	6.283±1.275	5.867±2.812	0.2
Ca	13.34±4.40	8.280 ± 0.94	75

Figure 3. Bar charts showing mean heavy metal concentrations of water from different sources in comparison with the permissible limits for copper and iron

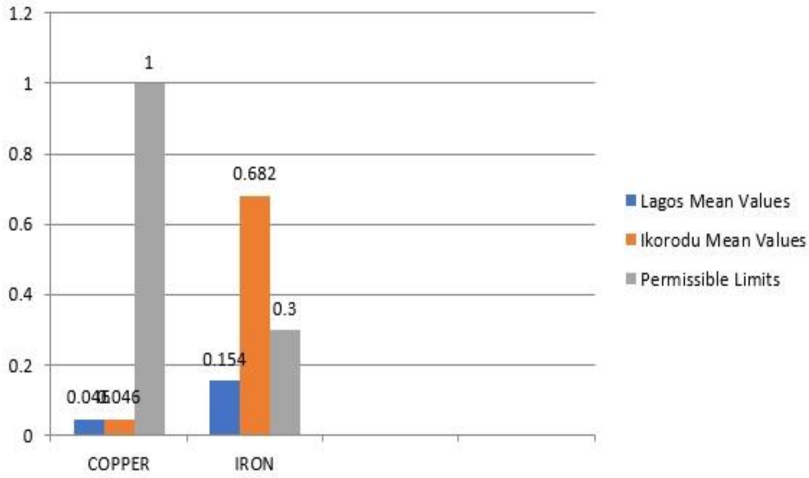
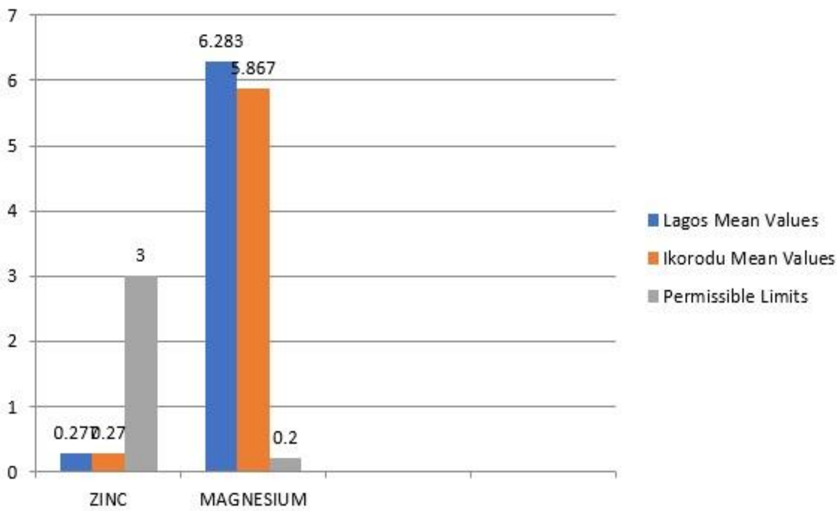


Figure 4. Bar charts showing mean heavy metal concentrations of water from different sources in comparison with the permissible limits for zinc and magnesium



Conclusion

The heavy metals presence showed that Lead, Nickel and Magnesium values exceeded the WHO, NIS and EU standards for all the representative samples for both areas of study which makes the water unfit for drinking. The value of Iron for Ikorodu sample exceeded the limits set by all the regulatory bodies but have value within the permissible limits for Lagos centre samples. This could be caused by factors such as geology of the place, iron peels and rusts from bailers used in fetching the water, rusted pipe channels for the bore holes which are not cared for, etc.

Cadmium was not detected in any of the whole sample. Cu, Cr, Zn, Na, and Ca all have values within the acceptable limits.

Bar charts were also used to depict the relationship between heavy metal values with the standard permissible limits.

Recommendations

The use of the surface water at Ikorodu "etunrenren" stream for drinking and other domestic purposes should be stopped, because of the high extent of pollution as discovered from this study except if adequate treatment is carried out before use.

Regular monitoring of the wells/boreholes (groundwater) and the quality of all other drinking water sources should be practiced since these supplies are used for washing, drinking, cooking and irrigation purposes.

Indiscriminate and unhealthy disposal practices should be abolished as well as introduction of modern techniques of waste disposal.

Regular treatment of water as to meet up to standards should be practiced to avoid water borne diseases. Appropriate treatment techniques/ methods should be taught to the people since in most cases wells and boreholes when pumped out are not treated in any form at all, or when treatment is attempted, it is arbitrary, involving random dosage of such chemicals as alums, sodium chloride, lime and hypochlorite.

Awareness should be created among the people on the possible danger of polluted water consumption and the associated diseases if not treated.

Drinking Water Quality Surveillance Agency should increase the frequency of sampling for drinking water facilities considering the ever-increasing population in Lagos state as a whole since such periodic monitoring of water quality will ensure future sustainability.

Further studies should be carried out on the level of the physicochemical parameters, Microbial parameters and Heavy metals concentration in more areas and from different sources. This will serve as baseline data and determine the source of future groundwater pollution.

- ❖ Industries should adequately treat their effluents before discharge to the environment and nearby surface water bodies.
- ❖ Dumpsites should be sited away from residential areas.
- ❖ Well and boreholes should be sited away at least 30 meters from soak away.
- ❖ A proper landfill site should be designed to minimize the adverse effects associated with solid waste disposal.
- ❖ The government should enact and enforce environmental laws to protect the different drinking water sources from vulnerable practices that could lead to pollution.

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References

[1]. C.O.B. Okoye, B.K. Adeleke, *Environ. Manage. Health*, **1991**, *2*, 13-14.

[2]. O.G. Adewuyi, O.U. Oputu, M.A. Opasina, *J. Water Res. Protect.*, **2010**, *2*, 849-853.

[3]. D.W. Moody, *North Carolina Cooperat. Extens. Services*, **1996**, 441-444.

[4]. J. Wright, S. Grungy, R. Conroy, *Trod. Med. Health*, **2004**, *8*, 106-177.

[5]. M. Kukkula, P. Arsila, L. Klossner, L. Marnuale, C.H. Bonsdorff, P. Jaatinen, *Scandinavian Infect. Dis.*, **1997**, *29*, 415-418.

[6]. A Lamikanra, *Essential Microbiology for Students and Practitioner of pharmacy, Medicine and Microbiology*, Amkra Books, Lagos, p 406.

[7]. R. Macreal, R.K. Robinson, M.J. Saddler, *Encyclopedia of Food Science Tech. and Nutrition*, **1993**, Academic Press Publisher London, p 1073-1077.

[8]. K. Iwuozor, E. Gold, *Adv. J. Chem. A*, **2018**, *1*, 66-78.

[9]. M. Baghban, A. Rezaian, E. Hashemi, *Adv. J. Chem. A*, **2008**, *1*, 79-85.

[10]. K. David, K. Brad, *Water Pollution Society*, **1998**, New York Academic Press.

[11]. U.U Egereonu, E. Odumegwu, *J. Chem. Soc. Nig.*, **2006**, *31*, 168-175.

[12]. E.O Longe, A. Williams, *Iranian Environ. Health Sci. Eng.*, **2006**, *3*, 163-174.

[13]. J.O. Adewuyi, C.J Mbuk, *J. Geology Mining Res.*, **2011**, *3,* 161-168.
{14]. ALPHA, Standard Methods for Examination of Water and Waste Water American Public Health Assoc. 16th edition, **1995**, Washington D.C., p 23-29.
[15]. U.U. Egereonu, C.I Osuzu, *J. Chem. Soc. Nig.*, **2005**, *30*, 2.
[16]. C.C Ogbuneke, BSc. Project Dept. of Science Lab. Tech. FUT owerri, **2007**, p 6-38.
[17]. NIS: Nig. Standards for drinking water quality, **2007**, p 5.
[18]. P.A.C. Amadi, T. Morrison, Understanding Water, **2001**, de Gryte and Co. Berlin, p 225.
[19]. A. Geetha, P.N Palanisamy, P. Sivakumar, M. Sujatha, *E-J. Chem.,* **2008**, *5*, 696-705.
[20]. M. George, A.G. Umadevi, P. Dharmalingam, J.P. Abraham, M. Rajagopalan, D.A Balakrishnan, P.P Harridasan, P.M Pillai, *E-J. Chem.*, **2010**, *7,* 903-914.
[21]. S. Ishaya, I.B. Abaje, *Hydrology J.*, **2009**, *10*, 52-67.
[22]. A.C. Twort, T.R. Dickson, Elementary Water Engineering, **1994**, John Willey and sons.
[23]. C. Pragathiswaran, G. Paruthiral, P. Prakash, P. Jeya, K. Suganandam, *Ecol. Environ. Conservat.*, **2008**, *14,* 605-608.
[24]. ATSDR, Toxicological profile for zinc US Dept. of Health and Human Sciences, **1994**, 205-88-0608.
[25]. A. Ahmed, A. Ali, A. Ghazy, *Adv. J. Chem. A*, **2019**, *2*, 79-93.
[26]. M. Abdel Aal, A. Ahmed, H. Abdel Rahman, S. Kandil, *Adv. J. Chem. A,* **2018**, *1*, 86-95.

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