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Quality assessment of groundwater in the vicinity of dumpsites in Ifo and Lagos, Southwestern Nigeria

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ABSRTACT

Groundwater samples were collected from the vicinity of major dump sites namely, Oke Afa refuse dump site in Isolo, Lagos State and Oju irin dump site in Ifo, Ogun State, with the aim of aim of assessing the physicochemical impacts of two refuse dump sites on quality of groundwater in the two major cities in western part of Nigeria. Levels of various physico-chemical parameters investigated include Total dissolved solids (TDS), Alkalinity, pH, Electrical conductivity (EC), and Hardness. Anions: Cal^-, SO_4^{2-}, NO_3^-, PO_4^{3-} were also determined, using standard analytical methods. Trace metals: Pb, Cd, Fe, Cu Zn Mg and Na were equally determined using Flame Atomic Absorption Spectrophotometer (Buck scientific 210VGP model). Concentration of Pb, Fe and Cd found in Isolo study area are higher than WHO health based guideline values, indicating possible impact of landfill on the groundwater quality. This raises the question of toxicities of these elements, hence threat to man. Most of the nutritive metals analysed (Na, Zn, and Cu) in Isolo samples maintained strong positive correlation with r values ≥ 0.8 showing that they probably have common source, unlike Ifo water samples that had all the metals analysed found within the WHO standards for drinking water. Ifo groundwater is soft with pH within the WHO acceptable range for drinking water while Isolo water is moderately hard, acidic in nature; hence require further treatment for it to be potable.

Keywords: Groundwater, Aquifer, Dump sites, Isolo, Ifo, Spectrophotometer.

INTRODUCTION

Factors such as low capital cost, required for the development of groundwater resources, convenient availability "close" to where water is needed and its natural quality (adequate for potable needs with little or no treatment) are influencing many developed and developing nations, in changing to sub- surface source of water, for both domestic and industrial purposes[1].

Knowing quality status of groundwater is as important as to its quantity, for it helps in determining the suitability of water for various purposes. Variation of groundwater quality in any area is a function of physicochemical quality parameters which are greatly influenced by geological formations and anthropogenic activities of the area [2]. Studies have shown that, impact assessment of various possible pollution sources on the quality of groundwater, have been receiving major attention both in the past and present [3], [4], [5], and [6]. Various major sources of pollution in groundwater include leachate from municipal refuse dumpsite, industrial discharge (liquid waste), domestic waste, salt water intrusion, application of agricultural chemicals, Oil spillage and pipeline vandalisation and geological formations. These sources generate pollutants ranging from heavy metals, N-species, Chlorinated hydrocarbon, phenols, cyanides, pesticides, major inorganic species and bacteria [7].

The rising population in Nigeria of about 140 million ([8], [9] is like without knowledge of proper waste disposal, going by the way wastes are dumped recklessly without any environmental regards in major cities of many states in Nigeria including Lagos and Ogun state. The waste authorities do not help the situation either for not putting in place a proper waste disposal scheme [10].

In most dump sites across the cities, wastes collected are burnt in the open and ashes abandoned at the site .The practise of burning, destroy the organic component, oxidise metal, thereby enriching the ashes left behind in metal. The leachates from these dump site percolate the soil and pollute the aquifer in the surrounding areas. The use of decaying wastes (domestic or industrial) from dump site to reclaim land, is another common practise particularly among the local residents, hence a considerable amount of waste is dumped haphazardly within the residential areas. Landfills have been identified as one of the major threats to groundwater resources [11]. In these refuse dumpsites, solid wastes gradually release its initial interstitial water and some of its decomposition by-products into aquifer, through the waste deposit. Such leachates contain innumerable organic and inorganic compounds. These wastes generate pollutants, majorly Cl^- and N^- species. Odukoya et al., [12] also pointed out that Leachate from these dump sites constitute major source of heavy metal pollutant to both soil and aquatic environment. Nitrates are known for strong solubility in water. They are very mobile in the soil and are rarely retained in it. Nitrates through rain, easily percolate into underground water table [13].

Toxicological studies have revealed the health implication of high level of NO_3^-. Toxicity comes from the natural reduction nitrate to nitrites by gastric enzymes. This, according to Boumediene et al., [14] is a serious disturbance of the system exchange: blood-oxygen the methemoglobinemy, a blue baby syndrome, and in the long run, to the formation of nitrosamines, which can supposedly produce carcinogenic cells in adults. It also causes gastric carcinomas.

Studies have also confirmed that heavy metals can adversely affect mental and neurological functions as well as altering metabolic processes in human body system. Heavy metals could also induce impairment and dysfunction in blood, cardiovascular, endocrine, immune, reproductive and urinary system [15]. Pb is known at elevated level, to affect intellectual performance in children and impairment of cognitive development in adults [16], [17. Cadmium can cause kidney damage, impair skeletal and reproductive system and other health related problems [18].

Access to potable water supplies (Government sources) in major cities across the country has been ever- increasingly difficult. More than 70% of the population lack access to improved water sources[19], hence, populace would only but rely on hand dug shallow wells and some few bore holes (deep well) with motorised pump.

The trend of uncontrolled and haphazard construction of groundwater facilities particularly shallow wells in the residential area with refuse sites such as Isolo dump site in Lagos state, and Ifo, Ogun State is of great health concern , as this may contribute significantly to adverse impact of the aquifer as a result of overdependence and over abstraction with attendant negative effects. This paper is aimed at assessing the possible impact of two dump sites on quality of groundwater in Lagos city and Ifo, Ogun state, western Nigeria. The data produced therein, can serve as a base line for further findings as well as helping the environmental agencies in formulating useful and necessary policies towards the betterment of our environment.

MATERIALS AND METHODS

Study Areas

(a) Isolo town lies between latitude 6^{o} 32′N and 6^{o} 33′N with longitude 3^{o}20′E in Isolo Local Government Area of Lagos State. It houses about three and half- decades old Oke-Afa dump site, which was recently closed down for commercial dumping due to expiration of age (30 years). The dump site is still been managed by Lagos State waste management Authority (LAWMA). It is bounded by Oke –Afa canal.

(b) Ifo town is located on 6^{o} 49′N and 3^{o}12′E in Ogun state. It is a sleepy town, fully residential with an abandoned age long Oju irin refuse dump site .The Oju irin dump site is on the high way that leads to Abeokuta, the state capital.

Samples and sampling techniques.

Twenty (20) active wells each in the two study areas were sampled during the dry season (January and March) and rain season (July and September) in 2008 in a way to ensure true representation of the study area.

Samples were drawn with the aid of locally made plastic drawer which has been prewashed with acid and soaked in deionised water. Two types of sampling plastic bottles were used: 1.5 L for physico-chemical parameters and 0.75 L for metal analyses [20]. The plastic bottle were previously washed and soaked overnight with 5% HNO_3 solution [21]. 0.75 L sample for metal analyses was acidified with 1.5 ml concentrated HNO_3 (analar), after which samples were transported to laboratory and kept at $4^{o}C$ till the time of analyses. Blanks were taken and treated as sample.

Physico – chemical analyses.

The water chemical analysis was done using standard analytical methods for water analysis [20]. Labile parameters such as, temperature, pH, and electrical conductivity (EC) were determined at the time of sampling on the field.

The pH of the sample was measured with a pH meter (pHEP HANNA 98107) that has been previously calibrated with buffer solutions and electrical conductivity was measured with a conductivity meter (Hitachi 2180) calibrated with potassium chloride solution.

Total solid (TS) was determined gravimetrically by evaporating a known volume of water sample to dryness in a pre- weighed crucible on a steam bath at 105^{o}C. Sulphate (SO_4^{2-}) was determined by a turbidimetric method. 20 mL of the buffer solution (made from magnesium chloride, sodium acetate, potassium nitrate, and acetic acid), and a spoonful of barium chloride crystal were added to a known volume of the sample and stirred on a magnetic stirrer for one minute. The barium sulphate turbidity was then measured with a UV-visible spectrometer (Spectronic 20 Milton) at 420 nm. Alkalinity was determined by titrating a known volume of water sample with 0.10 M HCl. Chloride (Cl^-) ,was analyzed by titration of a known volume of water sample with standardized 0.014 N mercuric (II) nitrate solution.

Phosphate (PO_4^{3-}) was determined colorimetrically by ascorbic acid-molybdenum blue method [20]. NO_3^- was determined by Phenoldisulphunic acid method [22].
Heavy metal was determined by digesting a known volume of water sample with HNO_3 (analytical grade). The digested sample was filtered into a 50 ml standard flask, made up to mark with distilled-deionized water and stored in a nitric acid prewashed polyethylene bottle in the refrigerator prior to the instrumental analysis. The water extracts were analyzed for metals (Pb, Cd, Fe, Zn, Na, Mg and Cu) by atomic absorption spectrometer. Each sample was analyzed in duplicate, so as to ascertain the validity of the method and the average of the results reported.
General laboratory quality assurance measures were observed to prevent sample contamination and instrumental errors.

RESULTS AND DISCUSSION

Table1.0 shows the mean values of physico-chemical parameters analysed as compared with World Health Organisation [23] standards and Federal ministry of Environment, Nigeria [24] Table 2.0 shows the concentration of anions in the two study areas and their comparism with some guideline values while the levels of heavy metals analysed were shown in Table 3.0. Tables 4.0 and 5.0 show correlation coefficient of trace metals in Isolo and Ifo groundwater samples respectively

Table 1.0: Physicochemical results of groundwater samples from both study areas

Quality Parameters	IFO (Ogun State)				ISOLO (Lagos State)				WHO	FME
	Range	Mean	S.D	CV	Range	Mean	S.D	CV		
pH	4.68- 7.34	6.67	0.07	1.04	4.30-6.60	5.68	1.05	18.49	6.5 -8.5	6.5 -8.5
Temperature ^{o} c	27.00-29.00	28.75	1.28	4.52	24.00-27.00	26.00	0.50	1.92	_	_
Alkalinity mg/L	10.01-80.10	66.36	1.28	1.92	1.98-378.10	135.48	20.09	14.83	_	_
Acidity mg/L	11.20-181.25	74.53	21.4	28.71	7.20-156.60	71.83	12.09	16.83	_	_
Hardness mg/L	23.45-334.04	54.76	5.25	9.58	44.24-210.14	97.10	48.21	49.64	500	_
TDS mg/L	181.00-901.57	408.95	90.17	22.04	92.00-512.00	474.25	60.30	19.18	1000	500
TSS mg/L	11.00-13.70	20.68	0.83	4.01	162.70-546.21	361.91	120.82	33.38	_	_
Conductivity(mS/cm					0.29- 2.45	1.01	0.89	24.42	1.4	_

SD --- Standard Deviation, CV--- Coefficient of Variation, WHO --- World Health Organisation, FME ---- Federal Ministry of Environment

The pH value of samples analysed ranged from 4.30 to 6.60 with the mean value of 5.68$\pm$0.21 in Isolo, Lagos while that of Ifo ranged from 4.68 to7.34 with the mean value of 6.67 $\pm$0.07. This indicates that the groundwater under review is acidic in nature, though the average value of the Ifo still fall within the acceptable range of 6.50 – 8.50 by W.H.O. The acidity is probably as a result of large volume of CO_2 in the atmosphere, an indication of high population, and industrialisation in Lagos site as compared with Ifo, Ogun State. The situation is worrisome, when considering the health implication of acidic water. It makes the body prone to ulcer, the chronic state which can lead to further perforation of intestinal tissues.

The mean value of hardness of groundwater in Isolo is 97.10 $\pm$ 48.21 mg/L, while that of Ifo is 54.76 $\pm$ 5.25 mg/L .This puts the Isolo water in moderately hard class and Ifo groundwater in soft class going by the classification of hardness of water [24]. The geological formation of the study area could have contributed to the high value of hardness [25]. Except for the acidity, all other quality parameter analysed for both study areas are higher in Isolo (Lagos) than Ifo (Ogun State). This may be attributed to the impact of volume of refuse (waste) generated in the two areas, which is a function of population. The mean values of Total dissolved solids in both study areas are relatively high, reflecting the level of solution ions in the groundwater under review. However the mean value of total suspended solids in Isolo is significantly higher than that of Ifo (Table 1.0), an observation that could be as a result of the fact that some of these residential areas in Lagos are actually on reclaimed land, using refuse. Hence the volume of non soluble material generated from wells dug in such areas could not be compared with the natural geology like Ifo in Ogun state.

The levels of all the anions investigated were higher in the Isolo groundwater compared to the Ifo site. The trend of anions found in the areas under review, $Cl^- >> SO_4^{2-} > NO_3^- > PO_4^{3-}$, is similar to that of Tamil Nadu, India study [2].

Table 2.0: Levels of anions concentration (mg/L) in groundwater sample from both study areas

Quality Parameters	IFO (Ogun State)	ISOLO (Lagos State)	WHO	FME
NO_3^-	0.27 + 0.10	2.44 + 0.69	45	10
SO_4^{2-}	26.81 + 0.14	8.27 + 3.92	400	500
PO_4^{3-}	0.124 + 0.001	0.36 + 0.52	_	5
Cl^-	71.61 + 11.29	162.07 + 92.78	250	250

W H O --- World Health Organisation, F M E ---- Federal Ministry of Environment

The Nitrate level of the two study areas ranged from 0.001 to 0.634 mg/L with mean value of 0.268 mg/L for Ifo while that of Isolo ranged from 0.807 to 3.656 mg/L with mean value of 2.44$\pm$0.69 mg / L. The sources of nitrate in groundwater include discharge of domestic waste, leachates from dump sites and run off from agricultural areas where there is intensive use of chemicals and organic substance (organic manure). The low level of this anion in Ifo may not be unconnected with possible occurrence of denitrification by Nitrosomonas and varying heterotrophic organisms.

The mean values from this study is lower compared with some international standards (Table 2.0), this is similar to the result by Ikem [4] on quality of groundwater around Oworonshoki dump site, in Lagos. The presence of nitrates particularly when its occurrence is above WHO standard 0.50 mg/L in drinking water is a threat to man. Toxicity of nitrate comes from the natural reduction to nitrites by gastric enzymes in human system. Nitrates present in great quantities in drinking water can cause serious illnesses for the consumer, particularly methemoglobinemy in children, nursing infants and nitrosamine in adults [14] .

The sulphates mean values of the study area are 8.27 $\pm$ 3.92 mg / L for isolo and 26.81$\pm$ 0.14 mg / L for Ifo .These values shows that the under groundwater under review are free from possible sulphate toxicity which include gastrointestinal irritation . The results from this study are lower than result obtained by Ikem [4], but however, higher than the results reported by Laluraj [26] ,Niger Delta Studies [27] [28] .The low level of sulphate could be as a result of microbial action capable of reducing SO_4^{2-} to S^- leading to depletion of sulphate in study areas. The sources of SO_4^{2-} in the areas under review could be geological nature of the soil because interlocation of clays, sands and salt could encourage dissolution of sulphide such as pyrite from inter stratified matters by percolating water to produce $SO4^{2=}$ water [28]. This may possibly account for the higher SO_4^{2-} level in Ifo when compared with Isolo, in Lagos.

Chloride is an important quality parameter that affects the aesthetic property of water including taste and renders it unsuitable for drinking purpose if present in high concentration. The chloride concentrations in Ifo areas ranged from 28.99 to 157.95 with mean values of 71.61 $\pm$ 11.29 mg / L while that of Isolo is ranged from 21.24 to314.37 with mean value of 162.07 $\pm$ 92.78 mg /. Although both values from this study are on lower side considering WHO maximum limit of 250 mg / L, there are about 30 % of the sampling locations that are higher than WHO limit. This point to the acute chloride toxicity from the dump sites in the study area. Going by [29] and [30], 40.00 and 50.00 mg/L chloride level respectively were used as indication of salt water intrusion couple with the fact that ground water with Cl- content greater than 100mg/L is classified as zone of diffusion. This would suggest that less than 6% of the ground water samples studied is free from possible salt intrusion.

However other possible sources of high Cl- (> 50mg/L) include seepage from septic tank and domestic effluent particularly in the residential areas, since NaCl is a common article of diet and passes through digestive system [20].

The phosphate values of the ground water investigated ranged from 0.001 to 0.382 with mean values of 0.124 $\pm$ 0.001 mg / L for Ifo while for Isolo, it ranged from 0.218 to 0.406 with mean value of 0.36 $\pm$ 0.52 mg / L. These are still below the WHO maximum allowable limit of 5.0mg /L. This indicates that the detergent pollutant is very low even in the land fill sample. The results obtained from this study are lower than that reported values for Lebanon Basin [31]. These observations are similar to Ibadan study but different from that of Lagos study both by [4]. Common sources such as sewage, and municipal solid waste leachates as well as run off from fertilizer use have been reported [31].

The trace metals analysed in the groundwater samples show that the toxic metals: Pb, Cd and Fe were found in either or both study areas, particularly in Isolo, with mean level higher than the WHO allowable limits. This raises a number of toxicity issues. The mean concentration of Pb in Isolo, Lagos is 0.003 ± 0.001 mg / L against the WHO maximum limit of 0.001mg / L of Lead in drinking water, but lower than 0.02 mg/L limits set by Canadian [32]and European economic communities (EEC) . Lead (Pb) is used principally in the manufacturing of lead acid battery and alloys. It gets into the environment through waste water or solid waste disposal. Due to the phasing- out of extensive use of lead anti-knock and lubricating agent in petrol, there is a decline in the concentration of Pb in air and food. The Lead intake from drinking water constitutes a greater proportion of total intake. Lead is generally toxic and it accumulates in kidney and skeleton. Infant, children up to the age 6 years and pregnant women are most susceptible to its adverse effects. Inhibition of activity of d-amino laevulinic dehydrase, affecting the intelligence quotient in infant, renal tumour and carcinogenicity in adults are some other side effects [23]. Lead was not detected in Ifo study area. Statistically, lead shows very strong positive and moderate correlation with Fe and Mg respectively. This suggests a common source to the heavy metals in the samples analysed.

The level of cadmium in the samples as shown in the result is also of health concern. Cd was not detected in Ifo samples while it has a mean value of 0.005 ± 0.01 mg / L in Isolo groundwater samples. This value is higher than WHO limit of 0.003 mg / L. The possible source of Cd metal in the groundwater analysed include industrial effluent and Solid waste dumped, particularly by dry cell batteries companies. Food and smoking are the main sources of Cd to man. High concentration of Cd leads to cancer of kidney, development of hypertension and some vascular diseases. It also inhibits enzyme such as ATP and amylase.

Table 3.0: Comparism of results of heavy metals (mg/L) in groundwater sample from both study areas with WHO (2006) FME (1991) and USEPA (2003) standards for drinking water

Quality Parameters	IFO (Ogun State)	ISOLO (Lagos State)	WHO	FME	USEPA
Pb	ND	0.003 ± 0.001	0.001		0.001
Fe	0.16 ± 0.19	2.06 ± 2.27	0.3	_	
Cu	0.005 ± 0.03	0.12 ± 0.02	2.0		1.3
Cd	_	0.005 ± 0.01	0.003		0.005
Zn	0.03 ± 0.02	2.43 ± 0.14	3.0		5.0
Na	76.37 ± 31.07	308.78 ± 39.92	200	_	
Mg	7.87 ± 4.21	19.24 ± 4.72	0.5	_	

The low level of all metals analysed in Ifo samples as compared with Isolo could be functions of population, rate of waste generation and more importantly the age of the dump sites, consequently, the mean value of Fe in Ifo is 0.158 ± 0.19mg /L, while that of Isolo in Lagos is 2.06 ± 2.27mg / L. The level of concentration of Fe in Lagos is higher than that of WHO limit of 0.3mg / L. The element Iron is the most abundant element in Earth crust. The breakdown of casing and pump often lead to unnecessary high level of iron “red water”. Other major sources of iron include nature of rock which houses the groundwater particularly the igneous rock, leachates from refuse dump, industrial waste, and seepage from septic tank. Amadi et al. [33] pointed out that pH is an important factor that could influence the solubility and resultant concentration of iron. The geology of the area could also be additional source of the element iron [27. Iron is an

essential element in human nutrient; it helps in formation of haemoglobin. It also helps during pregnancy and lactation. However the toxicological study has established a link between accidental exposure and iron overload and idiopathic hemochromatosis as well as excess dietary iron [34].
Other metals determined are sodium, magnesium, copper and zinc. These metals are of nutritional importance to life, so they are referred to as essential metals as they help in various metabolic activities in the body system. The mean values of sodium, magnesium, copper and zinc in Ifo groundwater samples analysed are 76.37 $\pm$ 31.07, 7.87 $\pm$ 4.21, 0.005 $\pm$ 0.03 and 0.03 $\pm$ 0.02 respectively while that of Isolo samples are 308.78 $\pm$ 39.92, 19.24 $\pm$ 4.72, 0.12 $\pm$ 0.02 and 2.43 $\pm$ 0.14 respectively. The magnesium values obtained are however lower than the Lebanon studies as well as Niger Delta studies. Leachate from the dump site remains the major source of these metals in the sub surface water. However these minerals (Na and Mg) are probably derived also from chemical weathering of feldspars as micas which are some of the minerals characterizing the rocks of plain sands. The cations Na^+, Ca^{2+} and $Mg^{2+}$are among the species that are constantly involved in cations exchange process and interactions with the aquifer materials [35]. The hardness of water is often caused by calcium and magnesium and is usually indicated by precipitation of soap scum which affect the public acceptability.

Table 4.0: Correlation coefficient of trace metals in Isolo groundwater samples

	Pb	Na	Mg	Zn	Cu	Fe
Pb	1.00	-0.8	0.40	-0.56	-0.57	0.80
Na		1.00	-0.14	0.9	0.9	-0.5
Mg			1.00	-0.13	0.3	0.22
Zn				1.00	0.8	-0.08
Cu					1.00	-0.31
Fe						1.00

Table 5.0: Correlation coefficient of trace metals in Ifo groundwater samples

	Na	Mg	Zn	Cu	Fe
Na	1.00	0.38	-0.23	-0.16	-0.23
Mg		1.00	-0.8	0.37	-0.37
Zn			1.00	-0.23	0.11
Cu				1.00	0.19
Fe					1.00

There are strong positive correlation between Na and Zn, Na and Cu as well as Zn and Cu in Isolo, Lagos with r values of 0.9, 0.9 and 0.8 respectively, as shown in Table 4.0. This shows that there is a common source of these elements in study area. Contrarily, Table 5.0 confirms the uncommon sources of metals analysed in Ifo study area going by the r values.

CONCLUSION

The study assessed groundwater quality from vicinity of dumpsite on both Ifo, Ogun state and Isolo, in Lagos state. The quality parameters tested were Physical qualities including HCO_3^- ,hardness,electrical conductivity, pH, TDS,TSS and temperature ;Anions such as Cl^- ,SO_4^{2-} ,NO_3^- and PO_4^{3-} as well as trace metals : Pb, Fe, Cu, Cd, Zn, Na and Mg. The Isolo water is moderately hard, acidic in nature, hence require further treatment for it to be potable, while pH of Ifo soft groundwater still fall within the WHO acceptable range of 6.5- 8.5 for drinking water. Except for the concentration of sulphate which is higher in Ifo study area probably due to the nature of geological formation, all other anions were found higher in Isolo study area. Most of the nutritive metals analysed maintained strong positive correlation, showing that they probably have common source. Generally, most of the quality parameters tested was found within the international water quality standards, showing almost no impact of the dump site particularly the Ifo landfill. Continuous groundwater quality monitoring in these two study areas is recommended.

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