EVALUATION OF GROUNDWATER QUALITY USING CONTAMINATION INDEX IN PARTS OF ALIMOSHO, LAGOS - NIGERIA.

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Abstract
15 groundwater water samples were collected around 3 landfill sites in Igando,Lagos-Nigeria. Sample were analyzed for 7 heavy metals including Iron, Copper, Cadmium, Manganese, Lead, Zinc and Chromium using standard method.The results show that the concentration of heavy metals ranged between nd-55.18 mg L□1. Zinc recorded the highest mean concentration of 18.12 mg L□1 followed by Manganese (2.89 mg L□1) while Chromium recorded the lowest mean value of 0.02mg L□1 in the study area. The computed contaminated index ranged between 15.4-432.06.The highest contamination value was recorded at location G_5 followed by G_2 while location G_9 recorded the lowest contamination value in the study area.It was concluded that contamination level is high.Cadmium accounted for about 23.3% for the contamination of groundwater quality deterioration while Lead and Copper accounts for 19.3 and 8.8% respectively.The study recommended treatment, proper maintenance and compliance to the specification of lanfill according to the world standard.

Key words: *Contamination index; Groundwater; Heavy metal; Igando; Water quality; WHO standard*

1. Introduction

Groundwater is the major source of drinking and other domestic water uses in Igando. It is the most reliable source of drinking water supply in the community. Groundwater has long been utilized as a readily accessible and stable source of water supply for domestic, industrial and agricultural use throughout the world [8]. Rapid urbanization, improper waste disposal and landfill, excessive application of fertilizers and unsanitary conditions has threatened groundwater quality and consequently human health in many parts of the world by naturally occurring pollutants and anthropogenic pollutants [8].

Contamination of groundwater with heavy metals (i.e., zinc, copper, chromium, nickel, cadmium, lead and mercury) could come from several sources, including industrial discharges from chemical and metallurgic factories or leakage from landfills [8]. In most developing countries, landfills are the primary means of Municipal Solid Waste (MSW) disposal because they offer dumping high quantities of MSW at low economical costs in comparison to other disposal methods such as incineration. However, landfill leachates produced from MSW landfill sites are generally heavily contaminated and consist of complex leachates that are difficult to deal with [19].

Leachates are characterized by high concentration of organic matter (biodegradable and non-biodegradable), ammonia nitrogen, heavy metals and chlorinated organic and inorganic salts [18]. Leachate can contaminate groundwater where landfills are not provided with liners. According to [18] [9], the characteristics of leachates depend on the waste composition, amount of precipitation, site hydrology and waste compaction, cover design and interaction of leachate with the environment and landfill design and operation.

Therefore, considering the increase in demand for fresh water due to rapid population growth and accelerated pace of industrialization, it becomes imperative to regularly monitor the operations of landfill vis-a-vis the quality of groundwater and to device ways and means of protecting it [16].The study evaluates groundwater quality of Igando-Lagos, Nigeria using contamination index as a tool for assessing environmental condition of the study area

2.The study area

The study area is situated within Alimosho LGA of Lagos - Nigeria. It is located approximately between latitude 6^o31 0' N to 6°31 30'N and longitude 3°15 0'E to 3°15 30'E. It occupies an area of about 25.1sq.km (Fig.1).River Owo demarcates the area from Ado-Odo/Ota LG of Ogun state .Towards its east are Ifako- Ijaiye, Agege and Ikeja LGAs of Lagos state. Oshodi/Isolo, Amuwo-Odofin and Ojo LGAs of the state bound it in the southern part. The climate is characterized by two distinct seasons, a dry season between November and March and wet season between April and October. Annual precipitation is about 2000mm and serves as the major source of groundwater recharge [11].

Temperatures ranged between 28-33°C.The soil is composed of red and sandy-clay (laterite).The vegetation is composed of swamp forest and coastal plants. The geology is underlain by inter-bedded sands, gravelly sands, silts and clay. The hydrology is dominated by River Owo and its tributaries (River Abesan, River Oponu and River Illo).They drain into the Ologe lagoon. The population is about 1,277,714 people with a density of about 6,899 people per km^2 [14] [13].The sources of water supply in the area include pipe borne water through the Lagos Water Corporation (LWC), boreholes and hand dug wells by private individual. Due to erratic power supply and the unwillingness of the people to pay and because the people believed water supply should be free of charge. Hence majority of the inhabitants has resorted to digging boreholes/hand dug wells as sources of water supply for drinking and other domestic uses.

Major land uses in the area includes, residential, industrial, commercial, agricultural and landfill. As a result of increasing rise in population and high rate of waste generation in the state, the Lagos Waste Management Authority (LAWMA) constructed 3 landfills between 1996 and 2009.Out of these landfills; only two are operational in the study area while the remaining one has been abandoned.The landfills were designed with the capacity of about 469,202.50 tonnes of waste from the entire state with lifespan of about 5-6 years [10]. However, despite the expiration of their lifespan; some of the landfills are still been operated.

The operation of the landfills in Igando has greatly impacted on the groundwater quality of the study area. It is pertinent to note that before now; most of the wells that were constructed in the area were useful for various purposes including drinking. However, since the establishment of the landfills in the area, most of the wells are no longer usable due to leachates contamination. This situation poses great threat to majority of the people who depend on groundwater for their daily water supply needs.

3.MATERIALS AND METHODS

Several methods for water quality evaluation such as fuzzy mathematics, membership degree, factor analysis, gray modeling and analytic hierarchy process. However, these methods can not clearly express the water pollutant categories and one will not be able to explain whether the parameters involved in the evaluation meet the requirements of functional areas. The development and application of index method for water quality assessment exist in literature [20].

Water Quality Index method (WQI) provide the mechanism for presenting a cumulatively derived numerical expression defining a certain level of water quality. One of the major advantages of WQI is that, it incorporates data from multiple water quality parameters into a mathematical equation that rates the health of water quality with number [23]. It is widely used in the world due to its capability of full expression of the water quality information and is one of the most effective tools and important parameters for the evaluation and management of groundwater quality for the concerned citizens and policy makers all over the world. Studies abound in literature on groundwater contamination. Such work include, [3] [6] [4][2]. They all concluded that there is need to monitor water quality on regular basis. This is because the increase in concentration of trace metals in potable water will increase the threat to man's health and life.

The quality of groundwater can be assessed with the use or calculation of environmental factors and indices, which include a wide range of parameters. Such factors may become valuable tool for the assessment of environmental condition of an area. According to [3], contamination index (C_d) may be considered as such if the measured concentration of parameters and the upper permissible levels of a contaminant is taken into account. According to [3], contamination index is defined as Eq. 1 and 2:

$$Cd = \sum_{i=I}^{n} Cfi \quad (1)$$

$$Cfi = \frac{CA_{i-1}}{CN} \quad (2)$$

where, C_d= contamination index; C_{fi}=contamination factor of the i-th component, C_{Ai} = analytical value of the i-th component and C_{Ni}=upper permissible concentration of the i-th component according to [22].Contamination index (C_d) is calculated individually for each water sample, as a sum of the contaminant factors of single component that exceed the maximum contaminant levels [17]. Hence, contamination index summarized the combinational effects of several quality parameters, that may have harmful consequences to human health/the environment. The value scale for contamination index consists of 3 ranges; $Cd< 1$ (low contamination), $1 < C_d < 3$ (medium contamination) and $C_d > 3$ (high contamination) [6].

In this study, fifteen (15) groundwater samples were collected around 3 landfills from the study area during dry season using random sampling technique. Dry season was chosen because dilution rate will be low and depth to groundwater table will have declined [21]. Samples were analyzed for heavy metals including (Iron, Lead, Manganese, Copper, Chromium, Cadmium and Zinc). The parameters were selected because municipal landfill leachates are highly concentrated and contain heavy metals such as cadmium, chromium, copper, lead, nickel, zinc among others [5] [15]. The standard methods for the examination of water and wastewater quality was adopted for the laboratory analysis [1].

Samples were collected in a 1.5 L polyethylene bottles after rinsing with the water being sampled and were properly sealed and labeled. The samples were stored in cooler containing ice cubes and transferred to Chemistry Department, University of Lagos, Akoka for laboratory analysis within 24hours from the time of sample collection to avoid errors that may be introduce due to environmental factors. Global Positioning System (GPS) was used to take the co-ordinates readings of the sampling locations and were plotted using ArcMap 9.3 software.

The heavy metals constituents in groundwater (Zinc, Lead, Cadmium, Iron, Manganese, Copper and Chromium) were analyzed using Atomic Absorption Spectrophotometry (AAS) method and the concentration of each parameter was read directly at their specific wavelength.

4.RESULTS AND DISCUSSION

The level of the detected heavy metal constituents in groundwater samples (Table 1) shows that in all the sampling locations, Iron exceeded the WHO standard limit in 7 locations (i.e., $G_{5\text{-}6,8 \text{ and } 10\text{-}12}$).Copper was found to be above the maximum permissible limit of WHO standard in only 5 locations (i.e., $G_{5,8,\ 10\text{-}11 \text{ and } 15}$).

Cadmium exceeded the WHO standard limit in all the sampling locations while Manganese was found to be above the maximum permissible limit of WHO standard in 8 sampling locations (i.e.$G_{2\text{-}5,\ 8,\ 10 \text{ and } 14\text{-}15}$). Lead and Zinc were found to be above the WHO standard limit in all the sampling locations except at $G_{2,\ 5,\ 8,\ 10}$ and $G_{1,\ 3,\ 4 \text{ and } 14}$ respectively. It was discovered that Chromium was found to be within the WHO standard limit in all the sampling locations.

Table 2 presents the statistics of heavy metal constituents in groundwater of the study area. The result shows that the mean concentration of the examined parameters (Iron, Copper, Cadmium, Manganese, Lead, Zinc and Chromium) ranged between 0.00-10.16, 0.02-8.71, 0.02-0.32, 0.04-30.00, 0.00-3.14, 1.40-55.18 and 0.00-0.04 mg L^{-1}) respectively. Among the examined heavy metal constituents, Zinc has the highest mean (18.12 mg L^{-1}) followed by Manganese (2.89 mg L^{-1}) while Chromium remained the least (0.02 mg L^{-1}). Also, Zinc recorded the highest standard deviation (17.30 mg L^{-1}).

This was followed by Manganese (7.68 mg L^{-1}) while Chromium recorded the least value of (0.01mg L^{-1}).The computed contamination index(Table 3) for the sampling locations shows that location G_5 has the highest contamination index as a result of the presence of Fe, Cu, Cd, Mn, Pb and Zn being the contamination parameters. This was followed by location G_2 with the presence of Cd, Mn, Pb and Zn as the contamination parameters while location G_9 recorded the lowest value of contamination index with the presence of Cd and Zn as the contamination parameters (Fig. 2).

Further, the World Health Organization (WHO) standard limit for drinking water quality adopted to adjudge the suitability of groundwater for human drinking in the study area showed that all the parameters examined with the exception of Chromium were found to be above the maximum permissible limit for drinking water standard.

High iron level noticed in water samples is characteristic of groundwater in Lagos environs which is due to the local geology [15].Studies have also shown that excessive dissolved iron and manganese concentrations in groundwater result in taste and precipitation problems.Heavy doses of chromium salts even though are rapidly eliminated from human body, could corrode the intestinal tract (WHO, 2004). Similarly,heavy metals such as lead, cadmium, chromium and copper have also been reported at excessive levels in groundwater in parts of the state due to landfill operations [15].

Concentration of heavy metals in landfill is generally higher at earlier stages because of higher metal solubility due to low pH caused by production of organic acids [9]. Asa result of decrease in pH at later stages, a decrease in metal solubility occurs resulting in rapid decrease in concentration of heavy metals except lead because lead is known to produce very heavy complex compound with humic acids [9].

Lead is a naturally occurring heavy metal. The presence of Pb in water and food can result in health effects including neurological damage, reduced IQ, anemia, and nerve disorders, among others [7].Chromium is a naturally occurring heavy metal that is commonly used in industrial processes.The presence of Chromium in water and food can result to gastrointestinal, respiratory, and immune systems, as well as reproductive and developmental problems [7].

5.CONCLUSION

The present study evaluated 15 groundwater samples using random sampling technique from 15 locations around landfills in Igando-Lagos, Nigeria during dry season. Samples were analyzed for heavy metals including (Iron, Lead, Manganese, Copper, Chromium, Cadmium and Zinc) according to standard method. The sampling locations were plotted using ArcMap 9.3 software. The quality of groundwater samples of the study area was assessed based on contamination index (i.e., factors of single component that exceed the maximum permissible concentration of water quality parameter according to WHO standard).The adopted WHO standard showed that only Chromium was found to be within the maximum permissible limit of drinking water quality in the study area. The computed contaminated index ranged between 15.4-432.06.The highest contamination index value was recorded at location G_5while location G_9 recorded the lowest contamination value in the study area.

Further analysis revealed that Cadmium accounted for about 23.3% of the contamination of groundwater quality in the study area while Lead and Copper accounted for 19.3 and 8.8% respectively.The study recommended thorough treatment, proper landfill design and operation, the use of liners, adequate maintenance and strict adherence to world standard of landfill operation. It was also recommended that, industrial effluent should be treated before it is been discharged unto the land surface. This will safeguard the health of the people especially those that depend on groundwater source for drinking purpose.

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Table 1: Level of detected heavy metal constituents in groundwater samples

Sampling location	Fe	Cu	Cd	Mn	Pb	Zn	Cr
G1	0.05	0.20	0.130	0.10	ND	1.40	ND
G2	0.11	0.40	0.190	2.40	1.7	8.60	0.02
G3	ND	0.10	0.190	0.80	ND	4.20	0.04
G4	0.15	0.50	0.150	0.30	ND	2.40	0.01
G5	2.39	7.34	0.220	5.89	3.14	18.20	ND
G6	0.68	0.27	0.050	0.08	0.07	12.70	0.03
G7	0.15	0.06	0.130	0.04	0.02	5.74	0.01
G8	10.16	8.71	0.080	0.26	0.15	55.18	0.02
G9	0.06	0.02	0.040	0.04	0.01	8.64	ND
G10	8.07	6.92	0.120	0.22	0.11	49.65	0.03
G11	2.76	2.36	0.020	0.09	0.08	29.82	0.01
G12	0.89	0.54	0.020	0.07	0.04	25.61	0.03
G13	0.12	0.08	0.130	0.09	0.03	10.42	0.02
G14	0.08	0.04	0.320	3.00	0.02	4.10	ND
G15	1.52	3.64	0.210	30.00	0.10	35.19	0.01
WHO Std.	0.3	2.00	0.003	0.20	0.01	5.00	0.05

All parameters are measured in mg/L; ND-Not detected, WHO-World Health Organization

Table 2: Statistics of Heavy metal constituents in groundwater samples

Parameters	Range	Mean ±SD
Iron(mg/L)	0.0-10.16	1.81±3.12
Copper	0.02-8.71	2.08±3.08
Cadmium (mg/L)	0.02-0.32	0.13±0.08
Manganese (mg/L)	0.04-30.0	2.89±7.68
Lead (mg/L)	0.0-3.14	0.36±0.88
Zinc (mg/L)	1.40-55.18	18.12±17.30
Chromium (mg/L)	0.0-0.04	0.02±0.01

SD: Standard Deviation

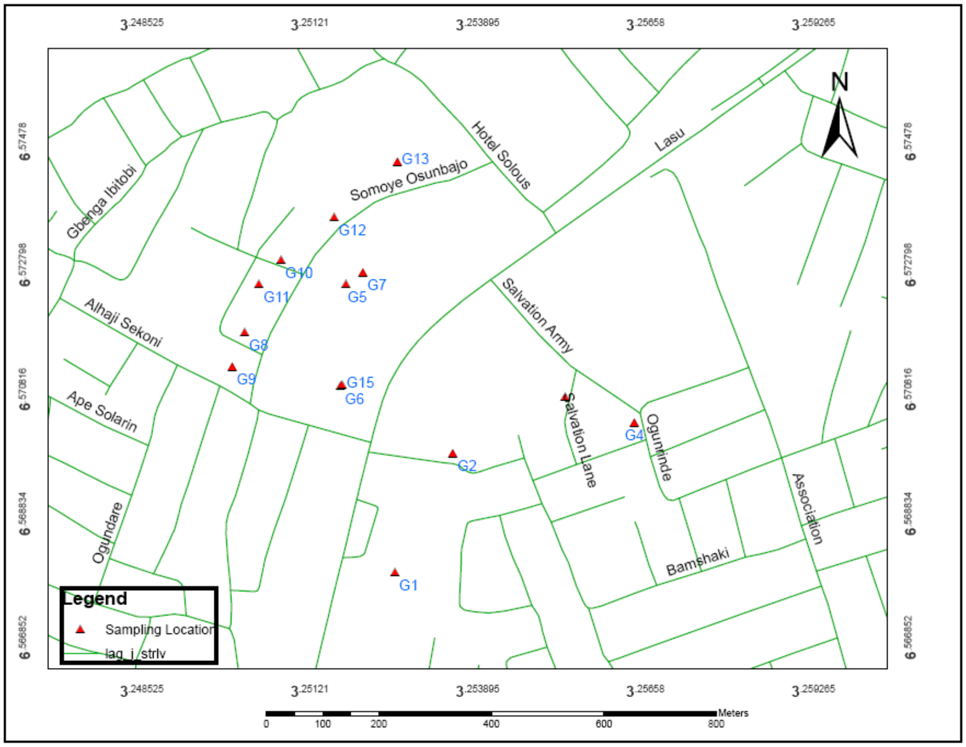

Fig.1: Sampling locations

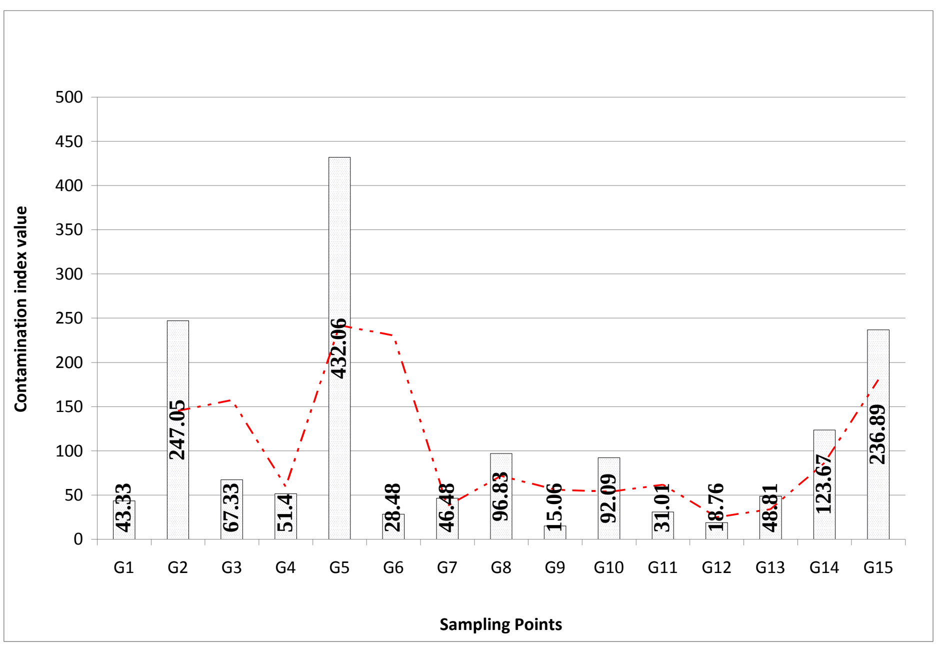

Fig. 2:Computed contamination index for the sampling locations