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Assessment of the Effects of Heavy Metals from Dumpsite Leachates on Groundwater Quality: A Case Study of Oyo Town, Nigeria

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Abstract— This work assessed the impact of heavy metals from a functional waste dumpsite leachates on the groundwater integrity in the vicinity of the waste dumpsite located in Akunlemu/Ogeese community in Oyo town. Soil samples were collected from six different locations on the dumpsite at the surface at different location on the dumpsite. Six different groundwater samples were collected at various distances from the dumpsite. All the samples were examined for zinc, lead, copper, iron, cadmium and manganese. The levels of concentration of the heavy metals in the groundwater samples were compared with the WHO (World Health Organization) standard to check if their concentration is higher than the permissible limit or lower in the standard laid down. The result of the groundwater samples analysis indicates that the average concentrations of the heavy metals in the groundwater samples follows the trend Fe>Mn>Pb>Cu>Zn>Cd. Also for the leachates collected, the result shows the average concentration of heavy metals in the soil samples to follow the trend Fe>Zn>Cu>Mn>Pb>Cd but there was a scarcity of guideline for soil of closed dumpsites for the purpose of comparison.

Index Terms— groundwater, heavy metals, leachates, pollution.

1 Introduction

The sustenance of life depend greatly on water therefore the demand for potable water increases continually in line with world population growth. Recently, many African cities have undergone unprecedented growth in population through migration from rural areas which has led to the growth of cities into sprawling "mega-cities" with large areas of unplanned sub-standard housing with few services. The unplanned expansion of such cities leads to a serious pollution threat to the groundwater supplies as lack of organized domestic waste disposal and uncontrolled industrial and commercial activity add to the pollution threat [1].

Due to the population explosion and urbanization and industrialization, groundwater has been the most threatened because most of human activities revolve around the use of water for both domestic and industrial uses.

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Increase in population has led to increased generation of waste and reduced area of land for disposal as people now encroach on land which should be meant for waste disposal as was the practice before the population explosion hence, these waste are not well handled and not properly treated before disposal leading to the generation of toxic fluids in form of leachates which flows to the nearest water course. It has been discovered that the cause of the low quality of groundwater is as a result of the leachates entering into the soil which is then absorbed by the water body.

Landfills are one of the sources of groundwater and soil pollution due to the production of Leachate and transportation of the contamination to farther points in the ecosystem [2]. The contaminations of soil, water and air with heavy metals even at low concentrations are known to have potential impact on environment and human health. These metals also pose a long-term risk to groundwater and ecosystem in general [3]. Therefore, this research work is aimed to assess the dumpsite and its impact on the groundwater within the vicinity of the dumpsite. This work will provide basis for further actions to be taken on the closed dumpsite which justifies the reason for the work. Different researchers have worked on the impact of landfill Leachate on the surface and groundwater quality [4].

2 STUDY AREA

The study area is situated in the Akunlemu/Ogeese, a suburb in the Oyo Township, under the jurisdiction of Oyo East Local Government Area in Oyo state. This area is selected because of the rate of pollution on groundwater resulting from the interference of various dumpsites located at various point in the local Government Area. The area of this study lies approximately within longitude 3.93^0N and latitude 6.93^0E and it lies in the humid tropical zone climate, having two seasons which are the dry and wet seasons (Figure 1). The annual rainfall is between 1200mm – 1300mm, average annual temperature is 32 ^{0}C and relative humidity of 70% [5].

The study area is located around a dumpsite which is surrounded by majorly residential buildings, a mini marketplace, a filling station and a metal parts scrap center which contributes to the nature of waste being dumped on the dumpsite and pollution discharge. Most of these residential buildings have no sewage disposal system hence human waste and faeces are deposited on this dumpsite alongside other industrial waste being carried from different parts of the town to be disposed at this particular dumpsite. Most of the hands dug well in this area were neither lined nor had a properly constructed base or cover. Some are simply covered with planks and rusted metal sheets. Some of the solid waste found on the site includes: scrap metals materials, garbage, paper, nylon, rubber, cartons, and cans, domestic refuse and waste materials etc. The wastes are deposited in this landfill without being treated, posing environmental risk to life in the area and the entire population directly or indirectly.

3 METHODOLOGY

In an effort to study the extent of the groundwater contamination, 6 hand dug well samples were selected in the vicinity of the dumpsite at different distances from the dumpsite. The water samples collected are kept in 50 cl bottles which has been pretreated and sterilized with trioxonitrate (v) acid. The water samples were also acidified after collection into the bottles, this is done to keep the pH low and to prevent precipitation of the heavy metals and also to keep bacterial activity low. Soil samples from the surface of the dumpsite was also collected and kept in a sterilized nylon sachet, six samples of the soil was taken from different point on the dumpsite. The collection of the soil is necessary because soil samples represent an excellent media to monitor heavy metal pollution resulting from anthropogenic activities.

3.1 Analysis of water and soil samples

All the water samples and the soil samples collected were analyzed for selected heavy metals according to international standards and procedures. For the determination of the concentration of heavy metals, concentration of Fe, Zn, Cu, Pb, Mn and Cd were determined using Atomic Absorption Spectrometer (AAS, model 210/211 VGP). The data collected from the result of the analysis were statistically analyzed using the Excel Microsoft software. This program was used to represent the data collected graphically. The site specification for the collection of the water samples is shown in Table 1.

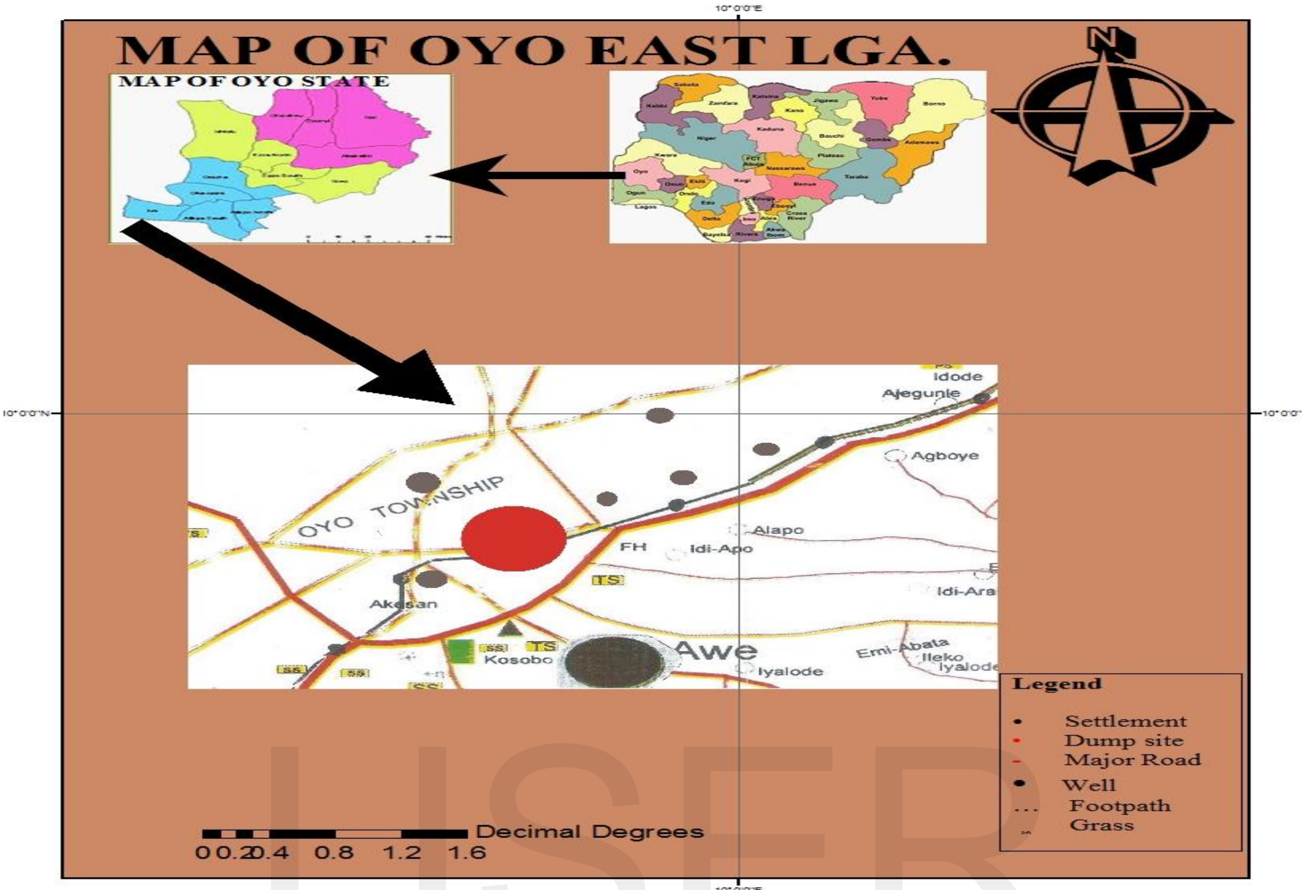

Fig. 1: Location Map of the study area

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Table 1: Site specification for the samples

Sample code	Sampling location	Distance from Dumpsite (m)	Depth (ft.)	Coordinates
GW 1	Dumpsite	15	_	(9.914^{o}N, 8.095^{O}E
GW 2	Residential	45	18 (5 m)	(10.328^{O}N,9.206^{O}E)
GW 3	Residential	124	90 (27 m)	(10.554^{O}N,9.667^{O}E)
GW 4	Commercial	Approx.200	90 (27 m)	(11.213^{O}N,9.526^{O}E)
GW 5	Commercial	Approx.426	95 (29 m)	(10.865^{O}N,10.176^{O}E)
GW 6	Commercial	Approx. 480	92 (28 m)	(10.723^{O}N,10.211^{O}E)

4 RESULTS AND DISCUSSION

The summary of the results for the heavy metal concentration in the groundwater samples collected at different distances from the dumpsite is shown in Table 2. The result of the analysis showed the presence of potentially toxic metals in the water samples and there is no clear trend in the way the values vary from well to well. The result from the analysis is viewed in line with the WHO standard for heavy metal in ground water and it shows that the concentrations of some of the metals analyzed falls below the desirable standard while above three of the metals ranges above the set standard and just about one of the metals is just within the stipulated range set by the WHO standards.

4.1 Result from soil sample analysis

The summary of the results for the heavy metal concentration in the soil samples collected at different locations on the dumpsite is shown in Table 3. The result of the analysis showed the presence of potentially toxic metals in the soil samples and there is no clear trend in the way the values vary from location to location.

4.2 Analysis of the results

The results obtained from the groundwater samples analysis were processed using Excel Microsoft package (2010). The graphs indicate the level of concentration of each of the heavy metals in the groundwater samples. The concentration of the heavy metals characteristics in the dumpsite soil and groundwater samples were presented in Tables 2 and 3 respectively. The results of the groundwater samples and soil samples in comparison with the WHO standard for groundwater quality indicate a high level of heavy metals contamination, a some are within the WHO permissible limit, some are below and some are higher than the permissible limit. The range of concentration (mg/L) were 0.793 - 0.847 (Cu), 0.004 - 0.006 (Zn), 0.001- 0.007(Cd), 0.031-0.44(Pb), 0.03- 6.6(Mn), 0.44 -13.90 (Fe) as shown in Figures 2 to 7. However the concentration of copper, iron and manganese were above the highest desirable limit of WHO which is stated to be 0.5 mg/l, 1.0 mg/l and 0.4 mg/l respectively. Zinc and cadmium are found to be below the permissible limit and the maximum desirable limit of 1.0 mg/l and 3.0 mg/l for zinc and 0.003mg/l and 0.03 mg/l for cadmium while lead (Pb) is just within the permissible and desirable limit of the WHO standard. This observation suggests high possibility of toxicity of the heavy metals in the dumpsite. Also it could be inferred that the presence of these heavy metals at toxic levels are responsible for the coloration of some of the water samples collected very close to the dumpsite.

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Table 2: Heavy metal ion concentration in mg/l in the ground water samples

Sample codes	Distance from dumpsite (m)	Pb (mg/l)	Cd (mg/l)	Mn (mg/l)	Fe (mg/l)	Cu (mg/l)	Zn (mg/l)
GW 1	15	0.235	0.001	6.61	13.90	0.841	0.004
GW 2	45	0.187	0.001	0.03	0.53	0.811	0.004
GW 3	124	0.031	0.001	0.27	2.50	0.847	0.043
GW 4	221	0.140	0.007	0.04	0.59	0.817	0.001
GW 5	426	0.408	0.001	0.26	1.23	0.825	0.003
GW 6	480	0.445	0.001	0.08	0.35	0.793	0.004

Table 3: Heavy metal ion concentration in mg/kg in the soil samples

Sample codes	Pb (mg/kg)	Cd (mg/kg)	Mn (mg/kg)	Fe (mg/kg)	Cu (mg/kg)	Zn (mg/kg)
SS 1	3.40	0.25	335.50	23700.00	39.4	152.5
SS 2	415.00	17.00	1220.00	109000.00	2112.5	50.95
SS 3	56.20	0.70	511.00	22825.00	47.6	127.0
SS 4	34.15	0.95	182.00	12625.00	20.5	56.0
SS 5	1330.00	11.95	1280.00	290500.00	3045.0	6107.5
SS 6	557.00	31.95	1010.00	232500.00	2062.5	5577.5
Average	399.29	10.47	756.42	115191.67	1221.25	2011.91

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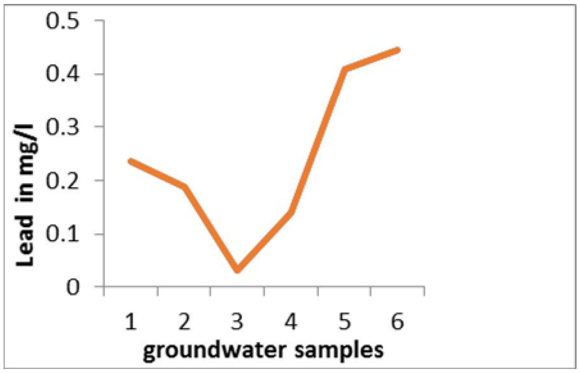

Fig. 2: Lead (Pb) in the groundwater samples

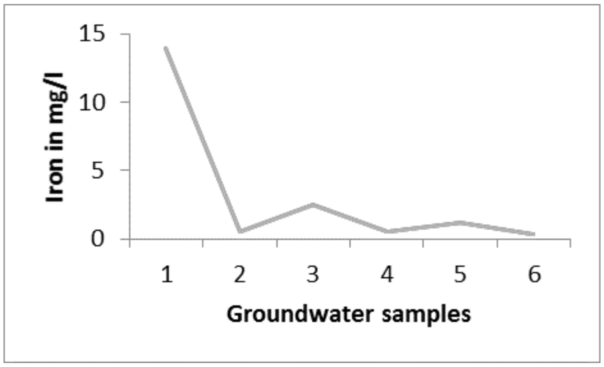

Fig. 5: Iron (Fe) in the groundwater samples

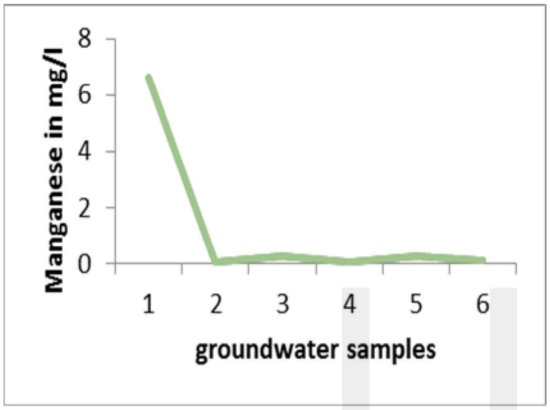

Fig. 3: Manganese (Mn) in the groundwater samples

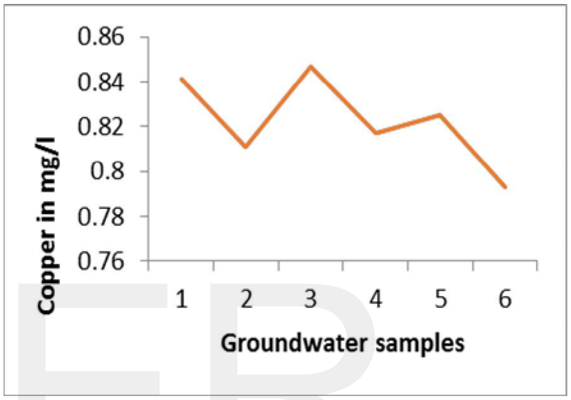

Fig. 6: Copper (Cu) in the groundwater samples

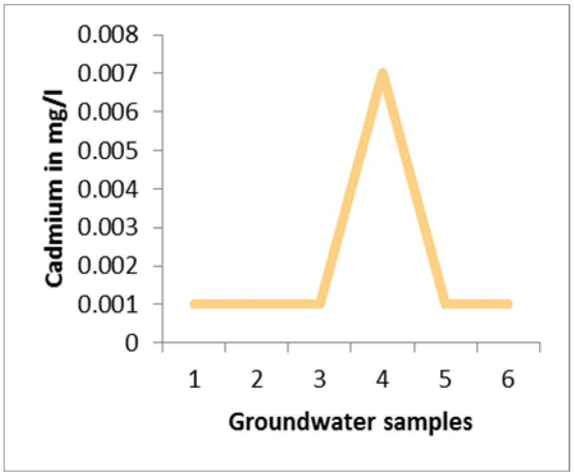

Fig. 4: Cadmium (Cd) in the groundwater samples

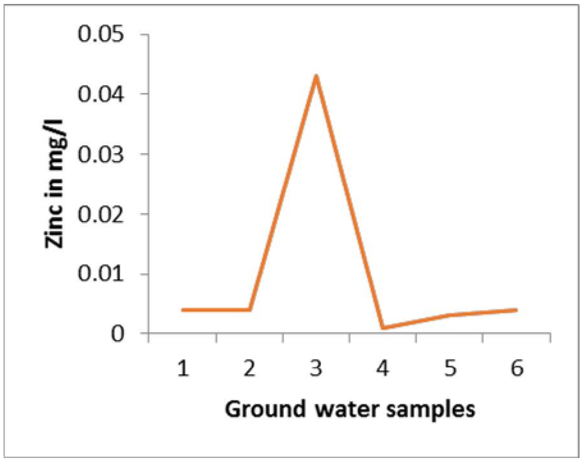

Fig. 7: Zinc (Zn) in the groundwater samples

5 CONCLUSION

From the results obtained, it could be inferred that materials been dumped on the dumpsite has systematically polluted the soil and groundwater in the vicinity of the dumpsite. Wells with a fairly high amount of these heavy metals in the study area indicates a level of pollution in these wells due to the effects of dissolved solids from the dumpsite. It was also inferred from the study that the wastewater from the dumpsite soils constitutes potential source of heavy metals contamination. This may hence constitute environmental and health challenges in the long-term. Therefore, degradation of the soil with heavy metals confirms the sanitary risk related to the contamination of the hand dug wells in the area. Hence, dumping of industrial waste and accumulation of heavy metals are considered one of the greatest hazard of dumpsite from the study.

Acknowledgment

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