Assessment of the Effect of Leachate on Groundwater Quality around Lapite Dumpsite in Ibadan, Southwestern Nigeria

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***Abstract*— This study assessed the effect of leachate generated by Lapite dumpsite on groundwater quality of the sites around it. Fourteen (14) groundwater and one (1) leachate samples were collected and analysed for cations, anions, heavy metals and water physical parameters. The result of this study indicated that concentrations; cations (Na^+, K^+, Mg^{2+}, and Ca^{2+}), anions (NO_3^-, Cl^-, HCO_3^-, and SO_4^{2-}) and physical parameters (pH, temperature (^oC), total dissolved solid (mg/l) and electrical conductivity (us/cm) measured for all the water samples outside the boundary of the dumpsite fall within the range provided by WHO (2003) for drinking water. Reverse is the case for the leachate, stream and well water samples, collected at the entrance of the site. Heavy metals present except chromium and cadmium did not fall within the range provided by WHO (2004). This may be attributed to the effect of leachate from the dumpsite. This suggested that the groundwater around the site is still safe for human consumption and therefore suitable for engineering constructions. Although the heavy metals such as lead and iron present in the water should be treated. The water in the well at the entrance of the site is not safe for drinking and therefore all the groundwater within the compound of the site might have been contaminated and hence not safe for human consumption and engineering constructions.**

Keywords*— *leachate; dumpsite; groundwater; Lapite; engineering constructions

I. INTRODUCTION

Water is a very important commodity to human existence. In fact, all living being directly or indirectly depends on water for their sustenance [1]. This justifies the saying “water: you no get enemy”. As important as water is to life, it is rendered useless once it gets contaminated. Several researches have established different sources of water contamination [2,3]. There are different sources of water and among the main source of pure and reliable water is groundwater [4]. Groundwater is the water that is found below ground surface.

Leachate, a toxic liquid generated when pollutant get dissolved in water, has been reported by different authors as a major source of groundwater pollution [5,6]. One of the main sources of this leachate is dumpsite or landfill. The leachate generated from dumpsite has been a major threat to groundwater system. It has rendered a lot of water stored by nature for human existence useless [5]. As far back as 1965, not so many people were conscious of the fact that water passing through solid waste in a sanitary landfill would become highly contaminated. This water generally known as leachate was never a matter of concern until when cases of water pollution was noted, and that leachate can cause harm [7]. According to [7], many contaminants generated by sanitary landfill could migrate laterally and vertically if no barrier is created against it. Once this leachate is able to leak out of the landfill system, nobody could determine the extent it could travel after some years. As this leaches through the soil, it gets in contact with groundwater and poses a severe threat on its quality.

[8] had the earliest organized publication on leachate from domestic landfill sites. In his report, the contamination of groundwater was due to leachate migrating from refuse slurry located about 500 meters from groundwater wells. According to [9], the leachate composition affects groundwater chemistry as it percolates through the soil horizon to the subsurface groundwater aquifers. In their study of Ruseifa landfill

between 1992 and 2006, there was an increase in salinity from 650 to 788 mg/l and an increase in the other inorganic constituents; the concentration of Cl increased from 4.8 to 332 mg/l; and SO_4 from 0.59 to 56 mg/l. This suggests that, chemistry of the groundwater is affected by the landfill.

Inasmuch as right to water cannot be exchanged for anything and contaminated water is contagious to human living, therefore efforts must be intensified to prevent available water from been contaminated. Investigation must be sourced, evaluated and developed to establish that our groundwater does not get contaminated. The extent leachate generated through a dumpsite in an environment has gone to contaminate groundwater around it must be a matter of concern. This research work is hence aimed to investigate the effects of Lapite dumpsite on groundwater quality of the sites around it.

II. Description of the Study Area

The Lapite dumpsite is located near Lapite village between the old and the newly constructed Oyo-Ibadan expressway, Akinyele Local Government Area of Ibadan, Southwestern Nigeria (Plate 1.0). It lies within 70 33^{I} N and 70 35^{I} N and longitude 30 54^{I}E and 30 56^{I}E (Fig.1). The dumpsite receives solid wastes generated within Ibadan environs on daily basis. There is no provision for subsurface drainage system to collect the leachate as it flows out of the system. Therefore, the leachate could go directly to the groundwater. The waste dumped into this site comprises of industrial and domestic wastes. The disposal method practiced at Lapite dumpsite is known as the sandwich method in which the solid waste is dumped and followed directly by at least 30 cm of compacted earth material [10]. The site has been in existence for the past 18 years and it has land coverage of approximately 20 hectares surrounded by residential, commercial and industrial setups. The site is secured with block fence. It is accessible by tarred roads (Oyo-Ibadan old expressway) and some minor paths around the fence of the site.

Plate 1: Pictorial representation of Lapite dump site section

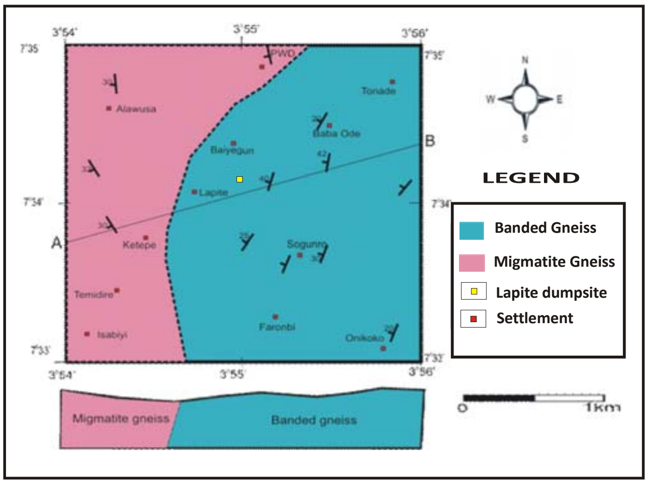

Figure 1: Geographical and geological map of the study area

Source: Oguntayo (2013)

III. Hydrogeology and Geology of the Study Area

Two principal climatic seasons can be distinguished easily in this area. This is influenced by two major air masses controlling the seasons; the dry season which is usually from November to March and the wet season which starts from April and ends in October, with a short dry spell in August. Average annual precipitation is put at about 1,316mm and serves as a major source of groundwater recharge [11]. The water table could fluctuate in response to the seasonality of the rainfall.

The geology of the study area is within the basement complex rocks of southwestern, Nigeria (Fig. 1) - [12]. The dumpsite is underlain by banded gneiss and is concealed in most parts of the site. The rock is medium to coarse grained in texture. It is light grey (leucocratic) in colour. Alternations of bands of light and dark colored minerals define a clear banding. Common structures such as minor folds and joints were observed in the rock; also intrusions observed in the rock are concordant and discordant quartz and pegmatite veins. Within the vicinity of Lapite waste dumpsite, the orientation and strike of joints and fracture occur mainly in the NNE- SSW direction. The lithology log of the area reveals two basic soils clay and sand deposits which is underlain by inter-bedded sands, gravelly sands, silts, and clays. The sub-surface is made up of semi-permeable to impermeable material.

IV. Groundwater Sample Collection, Test and Analysis

Fourteen (14) water samples and one leachate sample were used for this study. The wells were located along four profiles around the dumpsite, labeled P1 – P4, starting from 120m away from the dumpsite's fence and at interval of 40m (Fig. 2). Four wells each were dugged below groundwater table along profile 1 and 2 (downslope) while two each were located at profile 3 and 4 (upslope regions) making 12 dugged wells. One existing well (at the entrance of the site) and one stream water sample at about 1000m away from the site were sampled. One leachate sample was also collected from the centre of the dumpsite. The groundwater samples were collected in 60 ml bottle for cations test (2 drops of nitric acid were added for stabilization) and 1 liter bottle for chemical analysis of the anions, and heavy metals was taken. The stream, existing well and leachate were labeled STW, WW and LE respectively. The sensitive physical parameters such as total dissolved solid (TDS), Electrical conductivity (EC), temperature and pH were determined on the field using portable digital conductivity, thermometer and pH meters. The analyses of the chemical constituents of the water samples were carried out at the ACME water laboratory in Canada.

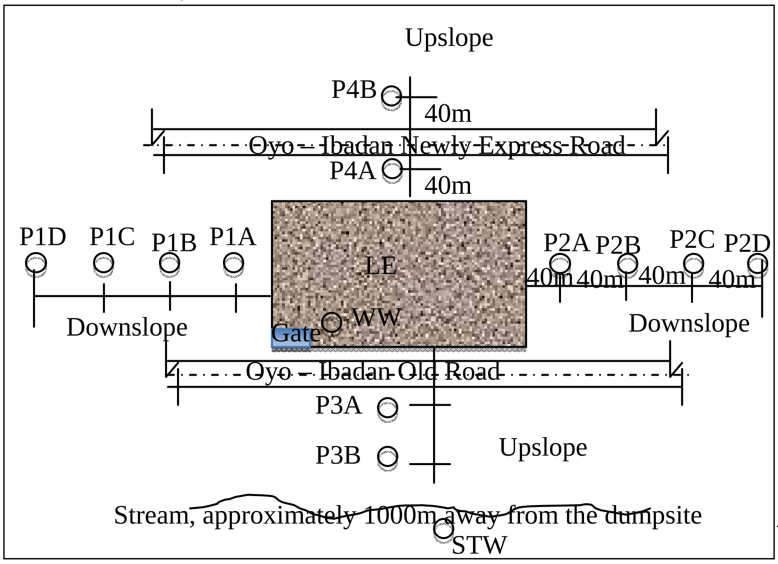

Figure 2: Geographical and geological map of the study area

V. Results and Discussion

A. *Physical Parameters of Water Samples from site around Lapite Dumpsite*

Table 1 consists of the physical properties of water samples collected within and around the dumpsite. From the table the pH value of the water ranges from 5.2 to 6.6. The electrical conductivity (EC) of the water ranges from 241.09 - 1321.43 us/cm while total dissolved solid (TDS) and temperature ranges from 150.21 - 826.11mg/l and 12.1 - 27.2^{o}C respectively. Majority of the pH values fall within the acceptable boundary of [13] for drinkable water. Also, majority of the electrical conductivity values (EC) fall below the standard. The same thing is applicable to TDS. Temperature ranges was not specified by [13]. Nevertheless, water from the leachate obtained at the center of the site has the highest TDS value (726.22mg/l), EC (1118.09us/cm) and lowest pH value. This was followed by well water (WW) obtained from the well at the entrance to the dumpsite and water sample (STW) collected from the flowing stream at the downslope of the site. TDS, EC and pH values of leachate and well water WW fall outside WHO's standard (WHO, 2003). The pH values are lower.

Table 1.0: Physical properties of water samples in and around Lapite dumpsite

Profile	Physical Parameters			
	Temp(^{o}C)	TDS (mg/l)	EC (us/cm)	p^{H}
WW	27.1	726.22	1118.09	5.4
P1A	27.1	321.22	501.99	6.6
P1B	27.2	256.21	399.36	6.5
P1C	27.1	221.22	344.76	6.5
P1D	27	181.22	282.01	6.5
STW	27.01	322.1	505.22	6.3
LE	27.1	826.11	1321.43	5.2
P2A	27	335.51	522.62	6.6
P2B	27.1	271.22	422.78	6.5
P2C	27.2	231.55	360.15	6.5
P2D	27	197.22	309.99	6.5
P3A	27.2	155.11	241.09	6.6
P3B	12.1	150.21	299.53	6.5
P4A	27.2	155.11	241.09	6.5
P4B	12.1	150.21	299.53	6.5
Range	12.1-27.2	150.21-826.11	241.09-1321.43	5.2-6.6
WHO (2003)	-	500	1000	6.5-8.5

B. *Chemical Properties of the Water Samples: Cations, Anions and Heavy metals*

Cations, anions and heavy metals detected in the water samples collected from the site are presented in Tables 2 and 3. The ion concentration of sodium ranges from 12.11 mg/l -50.21mg/l while that of potassium and magnesium range from 3.09mg/l - 25.07mg/l and 10.88 mg/l - 29.99mg/l respectively. Concentration of calcium ranges from 12.1mg/l - 27.2mg/l. All the ions indicated a concentration that falls within allowable and maximum permissible level standard of [14] except sodium and nitrate ions in the leachate and well water samples. According to the table, leachate followed by the well and stream water have the highest concentration of cations and anions.

For the anions, nitrate concentration ranges from 6.78mg/l-75.66mg/l, while that of chlorine ion, bicarbonate and sulphate ion concentrations range from 115.03mg/l - 320.01mg/l, 67.88mg/l - 276.11mg/l and 115.45 - 378.05mg/l respectively (Table 2). All the parameters (anions) range was below AL and MPL for all the water samples collected.

The following heavy metals: Lead (Pb), Zinc (Zn), Nickel (Ni), Chromium (Cr), Iron (Fe), and Manganese (Mn) were evaluated in the water samples collected (Table 2). The table indicates that the concentration of Fe ranges from 0.29mg/l - 3.22mg/l while that of Zn ranges from 0.43mg/l - 4.01mg/l. The concentrations of Cu, Pb, Ni, Mn Cd, Cr and Co range from 0.22mg/l-4.12 mg/l, 0.23mg/l - 4.09mg/l, 0.04mg/l - 1.51mg/l, 0.03mg/l - 1.48mg/l, 0.89mg/l - 9.87mg/l, 3.87mg/l-25.66mg/l and 3.48mg/l - 26.21mg/l respectively. Leachate followed by well and stream water assumed a higher concentrations in all the metals examined. According to Table 2, comparison of the result of the heavy metal examined with the WHO's standard of 2004 indicates that concentration of Fe in all the water samples fall within the range or slightly above WHO's standard except for leachate and well water samples. The same is applicable to all other metals measured except Cr and Cd. Higher concentrations of Chromium and Candieum were found in all the water samples. All the values were above the stipulated value of 0.05mg/l of chromium and 0.003 mg/l of Candieum in drinking water quality [4].

According to the result of this study, since the physical parameters of the water around the dumpsite falls within the range of drinkable water [13], the leachate generated by the dumpsite is yet to significantly affect the groundwater around the site [15]. Therefore, the water around the site can still be considered suitable for drinking and engineering construction. Nevertheless, it cannot certainly be concluded that the water can be used for industrial purpose because of the traces of the heavy metal detected in it. The case is otherwise for water within the dumpsite. Lower value of pH of the water indicates that the water is more acidic and it could easily attack steel rod if used to produce reinforced concrete [16].

The result of cations and anions also indicates that the water outside the dumpsite begin from 120m from the fence of the site could be used for drinking purpose but reverse is the case for groundwater within the site boundary [13]. This suggests that the effect of the leachate from the dumpsite on the groundwater around it is yet to be significant outside the boundary of the site (say, the first 40m away).

The value of cation (K^+) and anion (NO_3^-) concentrations that is above AL in the leachate collected from the centre of the site and the well water at the entrance of the site may be connected to the leaching of decomposed waste within the dumpsite [17].

TABLE 2: CHEMICAL PROPERTIES OF WATER SAMPLES IN AND AROUND LAPITE DUMPSITE (HEAVY METALS)

Profile	Heavy Metals							
	Fe (mg/l)	Zn(mg/l)	Cu(mg/l)	Pb(mg/l)	Ni(mg/l)	Mn(mg/l)	Cd(mg/l)	Cr(mg/l)
WW	2.58	3.48	3.55	3.51	1.38	1.31	8.13	20.11
P1A	0.38	0.58	0.46	0.45	0.12	0.11	2.9	8.26
P1B	0.35	0.5	0.4	0.38	0.11	0.05	2.91	7.7
P1C	0.33	0.44	0.25	0.26	0.08	0.04	2.04	6.21
P1D	0.31	0.43	0.22	0.23	0.06	0.03	1.98	6.57
STW	0.35	0.65	0.41	0.42	0.23	0.31	7.56	8.98
LE	3.22	4.01	4.12	4.09	1.51	1.48	9.87	25.66
P2A	0.39	0.61	0.47	0.5	0.12	0.12	2.91	7.36
P2B	0.36	0.54	0.45	0.48	0.12	0.11	2.89	7.13
P2C	0.32	0.52	0.44	0.47	0.11	0.1	2.04	7.12
P2D	0.31	0.51	0.43	0.47	0.1	0.1	2.04	7.11
P3A	0.31	0.44	0.33	0.32	0.05	0.09	1.18	4.72
P3B	0.29	0.44	0.32	0.31	0.04	0.09	0.92	3.87
P4A	0.32	0.43	0.34	0.33	0.06	0.08	1.2	5.78
P4B	0.31	0.44	0.33	0.32	0.05	0.07	0.89	3.89
Range	0.29-3.22	0.43-4.01	0.22-4.12	0.23-4.09	0.04-1.51	0.03-1.48	0.89-9.87	3.87-25.66
WHO 2004	0.3	3	1	0.01	0.05	0.1	0.003	0.05

VI CONCLUSION

Based on the results of physical and chemical properties analysis of the water samples collected within and around the dumpsite, it was concluded that;

1. The groundwater within the dumpsite has been contaminated by the leachate

2. The groundwater outside the dumpsite fence (boundary) is yet to be significantly contaminated

3. The groundwater around the site is safe for drinking and civil engineering construction.

VII RECOMMENDATIONS

Based on various findings during this study, the following recommendations were made:

1. Further study should be made in the next few years to reconfirm the state of the groundwater around the dumpsite.

2. It is recommended that the site should be converted to modern engineered landfill to create a barrier between the leachate generated by the site and the natural resources within its vicinity.

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