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A Comprehensive Evaluation of Contaminants in Soils in the Vicinity of the Three Soluos Dumpsites in Igando Area of Lagos State, Nigeria

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Abstract:

The disposal of solid wastes in landfill sites results in land pollution, this work was carried out to comprehensively evaluate the level of contaminants in soil within the vicinity of Soluos dumpsites in Igando area of Lagos State, Nigeria, at different depth. Six different locations, four separate locations and six different locations were identified using Global Positioning System (GPS) in the vicinity of Soluos 1, 2 and 3 dumpsites respectively. In each of the locations, soil samples were collected at the surface downward at a regular interval of 4.5 m until the aquifer is reached. The soil samples were dried, sieved and treated with extracting solution (0.05N HCl + 0.024N H_2SO_4). The resulting solution was filtered and diluted with 50 ml of the extracting solution. The treated samples were subjected to analysis of physicochemical parameters, heavy metals like lead, cadmium, copper, nickel, iron, chromium and magnesium and microbiological parameters like coliform and E coli using standard methods for examination of water and waste water by American Public Health Association. The results of the analysis revealed that in Soluos 1 and 2, most of the parameters investigated decreased in concentrations in the soil as the depth increases from the surface downward but in Soluos 3, non all the locations studied followed this trend. For example, in BH 1 (Soluos 3), the range of potassium, phonol and sodium was less than 1 percent while total iron, calcium and copper varied bewteen 36.74 and 1227.17 mg/L, between 192.19 and 1457.84 mg/L and between 0.9 and 22.46 mg/L respectively. Lead, chromium, nickel, fluoride and sulphate were not detected in BH 1 to 6 but were detected in BH 7 to 9 (Soluos 1). In BH 13 TO 16 (Soluos 2), the lead, nickel and boron ranged between less than 0.005 and 0.155 mg/L, between 0.001 and 0.006 mg/L and between less than 0.005 and 0.36 mg/L respectively. The percolation of contaminants through soil depends on the adsorption power of the soil and soil in the same vicinity may have different percolation rates and adsorption power.

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1. Introduction

Land pollution is the contamination of soil which makes the soil unfit for human and natural activities. It is also the deterioration of the earth surface and soil as a result of human activities. Soil contamination is caused by the presence of xenobiotic (human made) chemicals or other alteration in the natural soil environment. It is typically caused by industrial activity, agricultural chemicals or improper disposal of waste [1]. Soil contamination due to leachates from dumpsites is a threat to soil as a result mobilization and transport of organic, inorganic and biological pollutants from many sources such as spillage, land application and waste disposal practice is a well-recognized problem [2]. The concern over soil contamination stem from health risk and from direct contact with the contaminated soil.

Soil waste disposals represent a significant source of contaminants released into the environment [3–8]. The precipitation that falls into landfill, coupled with any disposed liquid waste, results in the extraction of water soluble compounds and particulate matter of the waste and subsequent formation of leachate. As a result of the migration of these leachates, soil do become contaminated especially with heavy metals such as cadmium, chromium, lead, copper, iron, zinc and manganese and this contamination of soil by heavy metals lead to a serious problems because they cannot be biodegraded [8].

Some researchers have worked on the impact of leachates from landfill sites on soil within the vicinity of the landfill sites [9-19]. It is obvious from the available literature that in Nigeria (Lagos State inclusive) there is a lack of comprehensive study which evaluates the level of pollution at different depth in the soil within the vicinity of the dumpsite due to migration of leachates from the dumpsites. Therefore the aim and objective of this study is to comprehensively evaluate the level of contaminants in soil within the vicinity of three dumpsites in Igando area of Lagos State, Nigeria, at different depth. This work will provide basis for further work to be done on modeling the break through concentrations of contaminants in the soil within the vicinity of Soluos dumpsites which justifies the work. it is imperative that the level of contamination in the soil within the vicinity of the dumpsites is evaluated at different depth is carried out in order to make available fundamental soil data base which can be used by Geologists, Environmental engineers, Chemical engineers, Scientists and other users of such materials who might work on soil within the vicinity of dumpsites which further justifies this work.

2. Study Area

Soluos community is situated at Ikotun/Igando Local Council Development area of Alimosho Local Government in Lagos State, Nigeria. Three dumpsites are located in the Soluos community known as Soluos 1 (Closed), Soluos 2 and Soluos 3 (open). Soluos 1 covers about 7.8 hectares of land, Soluos 2 covers approximately 3.2 hectares of land while Soluos 3 covers about 5 hectares of land [20]. The Soluos dumpsites are surrounded by commercial and industrial set up as well as clustered human settlement. The dumpsite has witnessed rehabilitation which comprised reclamation of land, construction of accessible road for case tipping, spreading and compaction of waste since inception [21]. The wastes in Soluos dumpsites are of different types, ranging from organic to inorganic, hazardous and non-hazardous. The waste stream is made up of domestic, market, commercial, industrial and institutional origins [21]. Soluos 1 and 2 started operation in 1994 and 1996 respectively while Soluos 3 started operation in 2006. The Soluos dumpsites are non-engineered landfill with a huge heap of waste. Trucks from different parts of Alimosho area of Lagos State collect and bring wastes to these sites and dump them in irregular fashion.

The wastes are dumped without separation but the rag pickers who constitute the informal sector rummage through the waste, help in segregating them by collecting the plastic and other valuable items and sell them to the recycling industries. The typical views of Soluos 1, 2 and 3 dumpsites are shown in Figures 1, 2 and 3, respectively.

Figure 1: A typical view of Soluos 1 dumpsite in Igando area of Alimosho Local Government of Lagos State, Nigeria

Figure 2: A typical view of Soluos 2 dumpsite in Igando area of Alimosho Local Government of Lagos State, Nigeria

Figure 3: A typical view of Soluos 3 dumpsite in Igando area of Alimosho Local Government of Lagos State, Nigeria

3. Methodology

3.1. Position of the Dug Locations

Six different boreholes (BH) were dug within the vicinity of Soluos 1 dumpsites, four different boreholes were dug around the vicinity of Soluos 2 dumpsites and six different boreholes were also dug within the vicinity Soluos 3 dumpsites in the month of August 2014. The positions of all the dug boreholes were carried out using Global Positioning System (GPS) in order to identify the positions universally. The coordinate list in Minna data of the dug locations in the vicinity of Soluos dumpsites is presented in Table 1 while the depth dug in each location around the vicinity of Soluos dumpsites is shown in Table 2.

Table 1: Coordinates list of the boreholes in Minna Datum

Borehole	Eastings (Meter)	Northings (Meter)	Orthometric Heights (Meter)
BH 1	528001.270	725659.533	35.173
BH 2	527866.697	725528.750	34.540
BH 3	527874.639	725581.834	34.879
BH 4	527883.005	725600.306	35.035
BH 5	528118.000	725652.000	38.098
BH 6	528192.584	725584.061	34.698
BH 7	528110.278	726137.063	37.982
BH 8	528164.000	726145.000	38.269
BH 9	528166.767	726345.164	38.302
BH 10	528032.334	726199.452	37.630
BH 11	528223.586	726344.494	36.393
BH 12	528258.606	726302.929	36.519
BH 13	528023.000	726261.000	37.265
BH 14	527973.288	726202.786	37.435
BH 15	527870.063	726416.404	36.286
BH 16	527780.610	726250.378	34.539

Table 2: Depth of the boreholes dug in the vicinity of Soluos dumpsites

Dumpsite	Locations	Depth (m)
Soluos 3	BH 1	45.00
	BH 2	45.00
	BH 3	45.00
	BH 4	45.50
	BH 5	45.00
	BH 6	45.00
Soluos 1	BH 7	41.00
	BH 8	35.00
	BH 9	41.00
	BH 10	35.00
	BH 11	45.50
	BH 12	41.00
Soluos 2	BH 13	41.00
	BH 14	58.00
	BH 15	58.00
	BH 16	45.50

3.2. Sampling of Soil Samples

At BH 1, soil sample was collected at the surface (0 m) using 1 litre plastic bottle which had been cleaned by soaking in 10 percent nitric acid and rinsed with distilled water. BH 1 was then dug within 6 inches diameter up to a depth of 4.5 m and soil sample was taken as this depth using 1 litre plastic bottle that had been treated. BH 1 was dug further and soil samples were collected at interval of 4.5 m using treated bottle until the aquifer was reached in the saturated zone of the underground. The same was done for BH 2–16.

3.3. Analysis of Soil Samples

The soil samples were first air dried overnight in an oven at 32^0C. The dried samples were mechanically ground and sieved through 200 mesh size sieve to remove large debris, gravel sized materials and plant roots. Five grams of each sieved samples was placed in an Erlenmeyer flask and 2.5 ml of extracting solution (0.05N HCl + 0.024 H_2S0_4) was added after which the mixture was placed in a mechanical shaker for 15 minutes. The resulting solution was filtered through whatmann filter paper into a 50 ml volumetric flask and diluted to 50 ml with the extracting solution. The treated samples were analysed for parameters revealed in section 4.0, according to the standard method for the examination of water and wastewater by APHA, 2005 [22].

4. Results and Discussions

Figure 1 shows concentrations of calcium against depth for BH 1 (Soluos 3) while Figure 2 shows a graph of concentrations of ammoniacal nitrogen against depth for BH 12 (Soluos 1). A graph of concentrations of nitrate against depth for BH 15 (Soluos 2) is depicted in Figure 3.

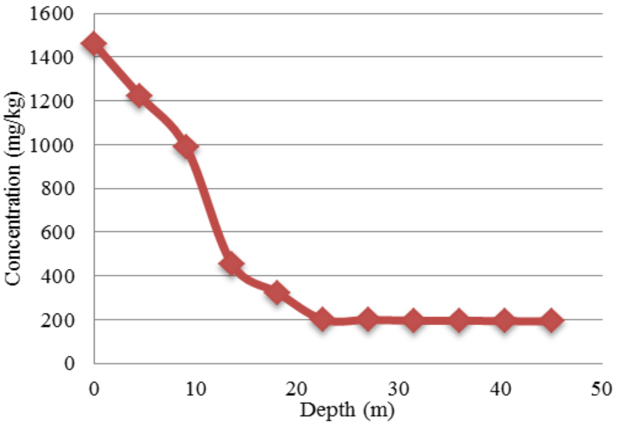

Figure 4: A graph of concentrations of calcium against depth for BH 1 (Soluos 3)

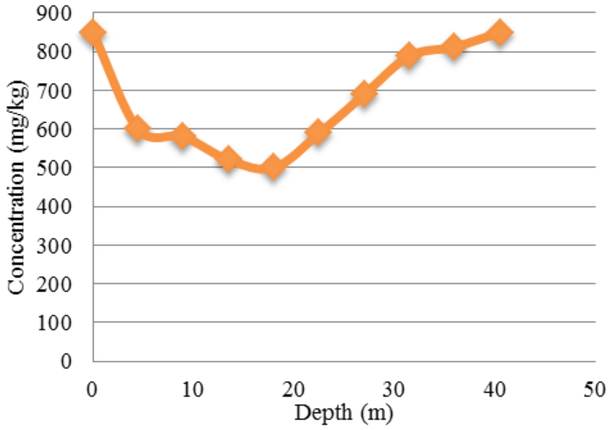

Figure 5: A graph of concentrations of ammoniacal nitrogen against depth for BH 12 (Soluos 1)

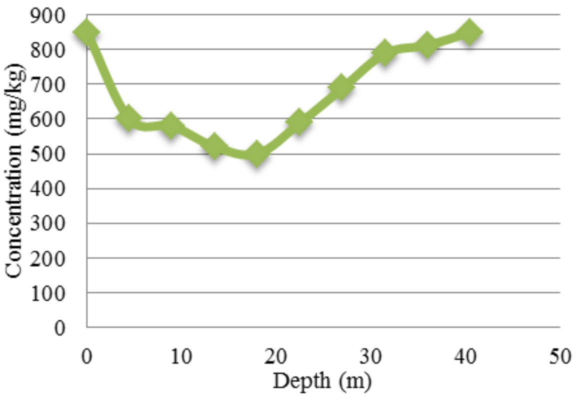

Figure 6: A graph of concentrations of nitrate against depth for BH 15 (Soluos 2)

In Figure 1, the concentrations of calcium decreased as the depth increased until a depth of 20 m and remained virtually constant as the depth increased. The inversely proportional relationship between the concentrations of calcium and depth until the depth of 20 m clearly revealed that the soil in this ranged had adsorption power and natural attenuation may occur in the region. However, after the depth of 20 m, the constant values of concentrations indicated that the soil matrix after 20 m lacked adsorption power and natural attenuation is not taking place.

Figures 2 and 3 have the same trend. The concentrations of pollutants decreased as the depth increased to a point of 20 m after which the concentrations started increasing as the depth increases. The inverse proportional relationship between the concentrations of pollutants and depth may be attributed to the adsorption power and natural attenuation within the soil matrix in this region. However, the direct proportional relationship between concentrations of pollutants and depth is a pointer that some pollutants were present in the soil of BH 12 and 15 after the depth of 20 m which were not from dumpsite leachates. These pollutants joined with the ones from the dumpsite leachates and this made the concentrations to increase as the depth increases. It is also possible that the soil matrix in this region lacked adsorption power and natural attenuation may not be occurring.

In BH 1, the pH of the soil from surface till subsoil layer in the aquifer ranged between 6.34 and 7.21 while the chloride content varied between 0.76 and 1.23 percent. Sulphate, lead chromium, cadmium, nickel and fluoride were not detected in the soil layers in BH1. Total phosphate ranged between 29.14 and 131.94 mg/L while the ammoniacal nitrogen and nitrate varied between 16.48 and 25.20 mg/L and between 5.73 and 73.92 mg/L respectively in the soil layers. The range of potassium, phonol and sodium was less than 1 percent while total iron, calcium and copper varied between 36.74 and 1227.17 mg/L, between192.19 and 1457.84 mg/L and between 0.9 and 22.46 mg/L. The coliforms and Ecoli in the BH1 soil layers is 0 Cfu/ml while the boron content ranged between 1.32 and 5.98 mg/L.

In BH 2, the pH in the soil layers varied between 6.67 and 7.12 which are also in the range of soil layers in location A. Chloride and total phosphate ranged between 0.77 and 1.02 percent and between 30.67 and 69.22 mg/L respectively. Sulphate, lead, chromium, cadmium, nickel and fluoride were not detected. Ammoniacal nitrogen, nitrate and silica ranged between 23 and 31.26 mg/L, between 6 and 54.76 mg/L and between 39 and 51.7 mg/L respectively. The level of coliform and Ecoli was 0 Cfu/ml while boron and copper and phenol varied between 1.33 and 4.59 mg/L, between not detected and 5.85 mg/L and between not detected and 0.7, respectively. Phenol was not detected at the point of 13.5 m, 22.5 and 36.5 m. Potassium and sodium content ranged between 0.02 and 0.57.11 percent and between 0.1 and 0.73 percent respectively while the iron content was high ranging between 21.88 and 3,646.32 mg/L.

In location BH 3, lead, chromium, cadmium, sulphate and fluoride were not detected which follow the pattern in location B. Coliform and Ecoli level was 0 Cfu/ml which again is the case as in location B. The pH ranged between 6.67 and 7.15 which can be compared relatively to location A and location B. Iron and calcium content were very high ranging between 20.89 and 1551.75 mg/L and between 110.45 and 1,879.82 mg/L. The high ranges of iron and calcium also manifested in locations B and C. Nitrate, silica and magnesium ranged between 22.19 and 430.23 mg/L, between 29.78 and 50.27 mg/L and between 36.71 to and 548.15 mg/L respectively. Phenol and boron varied between 0.19 and 0.56mg/L and between 0.13 and 3.94 mg/L respectively.

In locations 4 to 6, lead, chromium, cadmium, nickel and fluoride were not detected. The level of coliform and Ecoli was 0 Cfu/ml in the three boreholes. The pH in locatons 4 to 6, ranged between 6.56 and 7.21. The chloride, total phosphate and ammoniacal nitrogen ranged between 0.56 and 2.01 percent, between 32.77 and 134.24 mg/L and between 16.45 and 32.81 mg/L in BH 4 to 6 respectively. The level of phenol concentration was less than 1mg/L which revealed that less phenolic compounds are being dumped in Soluos 3. The iron and calcium level were still very high ranging between 27 and 5,049.70 mg/L and between 187.45 and 1,803 mg/L respectively in locations BH 4 to 6. The high level of iron and calcium were also in line with the high level in BH 1 to 3. This point to the likelihood of dumping high iron and calcium compounds in Soluos 3 dumpsite. The high level of calcium may also be attributed to carbonate-based minerals such as calcite and dolomite. The concentration profiles of parameters do not have regular tread in BH 4 to 6, which is also the case in BH 1 to 3.

In BH 7 to 9, the level of fluoride, chromium and nickel were less than 0.01 mg/L while sulphate content was less than 0.5 mg/L. Lead and cadmium concentration varied between less than 0.001 and 9.6 mg/L and between 0.015 and 0.18 mg/L respectively. Lead, chromium, nickel, fluoride and sulphate were not detected in BH 1 to 6 but were detected in BH 7 to 9. This indicates that much of hazardous and industrial wastes were being dumped in Soluos 1 than Soluos 3. The coliforms and Ecoli ranged between and 60 Cfu/ml and between 0 and 32 Cfu/ml respectively in locations BH 10 to 12. The level of coliforms and Ecoli was 0 Cfu/ml in locations A to I which was entirely different in locations J to L. Iron and calcium maintain the lead among all parameters ranging between 789 and 7958.17 mg/L and between 303 and 6,688.81 mg/L respectively which was also noticed in BH 1 to 9.

In BH 13 to 16, the lead, nickel and boron ranged between less than 0.005 and 0.155 mg/L, between 0.001 and 0.006 mg/L and between less than 0.005 and 0.36 mg/L respectively. Iron and calcium exhibited a very high concentration ranging between 1600 and 16,350mg/L and between 12.024 and 148.30 mg/L respectively in BH 3 to 16. This high concentration was also observed in BH 1 to 12which implies all the dumpsites in Soluos are receiving materials contain much of iron and calcium. The concentrations of potassium and sodium were within the range of less than 1 percent which happened to be the lowest in all the locations investigated within the vicinity of Soluos dumpsites.

In the vicinity of Soluos 3, the concentrations of parameters investigated such as boron, copper, total phosphate, nitrate, magnesium, total iron, calcium, ammonical nitrogen and phenol decrease as the depth increases from the surface downward in BH 1, 3, 4 and 6. In BH 2 and 5, the reverse is the case. This means that the soil samples in BH 1, 3, 4 and 6have adsorption power than the soil samples in BH 2 and 5. This is an indication that the parameters investigated will contaminant the groundwater faster in BH 2 and 5 than BH 1, 3, 4 and 5. This has also revealed that soil samples in the same vicinity may have different adsorption power which makes the rate of percolation differs. In the vicinity of Soluos 1, the concentrations of aforementioned parameters decrease as the depth increases from the surface downward in BH 7 to 12. This is revealed that the adsorption power of soil samples in the vicinity of Soluos 1 follow the same tread. Moreover, in the vicinity of Soluos 2, the concentrations of the parameters investigated in the soil samples decrease as the depth increases from the surface downward which means that the contaminants are adsorbed by the soil as the contaminants percolate through the subsoil.

5. Conclusion

The levels of contaminants in soil within the vicinity of three dumpsites in Igando area of Lagos State, Nigeria, at different depth have been studied comprehensively. The physicochemical parameters, heavy metals and microbiological parameters of the soil samples within the vicinity of the three dumpsites were evaluated. The disposals of solid wastes in the three Soluos dumpsites have impacted on the soil within the vicinity of the Soluos dumpsites. In locations BH 1–BH 16, most of the parameters investigated decreased in concentrations in the soil as the depth increases from the surface downward. It was revealed that the percolation of contaminants through soil depends on the adsorption power of the soil. This work has shown that soil in the same vicinity may have different percolation rate and adsorption power.

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