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Physicochemical and Heavy Metals Characteristics of Soil from Three Major Dumpsites in Ilorin Metrpolis, North Central Nigeria

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ABSTRACT: Impact of waste disposal and management is a worldwide phenomenon leading to health impact most especially in underdeveloped and developing world. This study was undertaken to assess the major contaminants in some municipal waste disposal sites and the prospective impact to the surrounding domestic water supply source as well as the impact on the health of the people in the city. This is carried out by studying various physico-chemical parameters of soil which were collected from three municipal dump locations namely; Ita-Amodu, Sawmill garage and Kuntu areas in Ilorin metropolis, Kwara State Nigeria. The geochemistry of the dumpsites were studied with respect to important parameters such as pH, electrical conductivity, temperature, sulphates, chlorides, nitrates, moisture content, organic matter and heavy metals having the following constituents present in its composition- *Cadmium (Cd), Lead (Pb), Zinc (Zn), Iron (Fe), and Copper (Cu)*. The study revealed that the three different soils samples: "(A) Ita-Amodu", "(B) Sawmill Garage", and "(C) Kuntu") have pH of 7.1, 7.2 and 6.8, respectively. Temperature of 24.2, 26.4, and 28.0 ºC, Organic matter compositions of 0.95%, 0.73%, and 1.14%. The Moisture contents were 3.93%, 2.89%, and 3.48% respectively. The chloride contents of the samples was found to be 31.76 mg/L, 48.98 mg/L, and 91.63 mg/L, while nitrates were found to be 0.10 mg/L, 0.06, mg/L and 0.23 mg/L, with a sulphate values of 1.96 mg/L, 2.35 mg/L, and 2.14 mg/L. The conductivities were 1.79 µs/cm, 2.23 µs/cm, and 1.15 µs/cm respectively. Heavy metal analysis from the waste soil were found to contained copper (Cu) - 0.03 mg/L, 0.028 mg/L, and 0.031 mg/L, zinc (Zn) - 0.04, mg/L 0.009 mg/L, and 0.066 mg/L), cadmium (Cd) - 0.516 mg/L, 0.62, mg/L and 0.048 mg/L), Lead (Pb) - 0.063 mg/L, 0.07 mg/L, and 0.056 mg/L), and iron (Fe) - 0.518 mg/L, 0.62 mg/L, and 0.190 mg/L.

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Anthropogenic activities within a society generate large quantities of wastes problems for disposal. Improper disposal leads to unhygienic conditions which further leads to diseases spreading. The municipal solid waste (MSW) is heterogeneous in nature and contains paper, plastic, metal, glass, ash and compostable matter. In addition, other substances like scrap materials, waste papers, dead animals, improperly discarded chemicals, paints, hazardous hospital waste and agricultural residue are also categorized under MSW (Lauber, 2005). This solid waste disposal pose a serious health risk and concerns to the environment, as well as burning of these solid wastes creates heavy smoke and dust pollution. On inhalation, this results in various respiratory problems among the habitats (The Indian Express, Pune 2006). According to Anikwe and Nwobodo (2001), municipal wastes increase the nitrogen, pH, cation exchange capacity, percentage base saturation and organic matter.

Organic waste can provide nutrients for increased plant growth, and such positive effect will likely encourage continued land application of these wastes (Anikwe and Nwobodo, 2001; Nyles and Ray 1999). However excessive waste in soil may increase heavy metal concentration in the soil and underground water. Heavy metals may have harmful effects on soils, crop and human health (Nyle and Ray 1999; Smith et al., 1996). Consequently, the management of our environment and control of discharge of waste products from anthropogenic activities is of high interest to researchers, regulatory bodies, environmental advisory agencies and policy-makers all over the world. Rapid urbanization, industrialization and population growth have been the major causes of stress on the environment leading to

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problems like human health problems, eutrophication and fish death, coral reef destruction, biodiversity loss, ozone layer depletion and climatic changes (Bay et al., 2003; Sadiq, 2002).

Determination of adverse effects of various elements upon human health and our ecosystem has been gaining momentum recently. Hence, there is a presumption that sound scientific data base is needed to define maximum exposure levels of specific chemical compounds of health implications (Fortner and Wittman, 1983). Ilorin is the state capital of Kwara-State, Nigeria it is an industrial and commercial center of the state with a population of over 4 million people to have generates the major deposits of both domestic and industrial waste in the state. These waste products are dumped in landfill untreated, posing environmental risks to life in the areas as shown in figure 1. Landfill is a practice adopted as a substitute to ocean outfall of sewage, domestic and industrial waste, after the outlawing and termination of the latter due to its effects on the lives in the ocean.

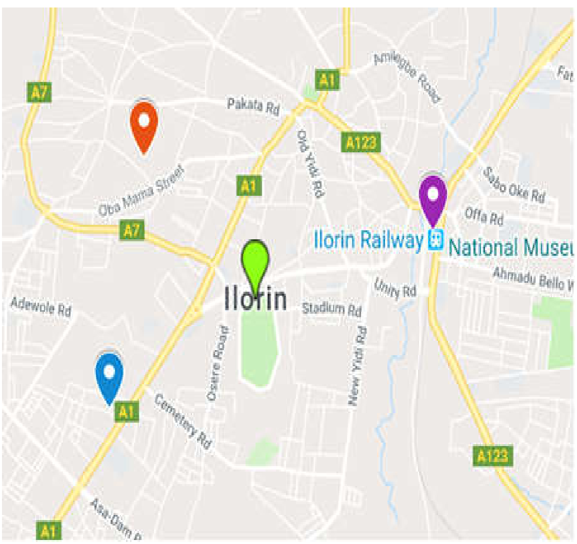

Fig 1 `: Map of sampled area

MATERIALS AND METHOD

Sample Collections: The soil-sample was taken from dumpsite located at Ita-Amodu, Sawmill garage and Kuntu areas, which are interior parts of Ilorin metropolis in Ilorin West Local Government, Kwara State, Nigeria. All the reagents used are of analytical grade.

Physicochemical Analysis: The physico-chemical parameters determined from the samples are Moisture content (Dhyan et al., 1999), Temperature, Organic matter, Conductivity, pH, Chlorides, Sulphates, Nitrates, Heavy Metal analysis, detection and analysis of heavy metals ions such as Cu, Zn, Cd, Pb and Fe from the soil samples was carried out by standard procedure recommended by Ademoroti, 1996.

RESULTS AND DISCUSSION

The result of physicochemical properties of the leachate samples is presented in Table 1. The analysis of the samples collected reveals some level of compliance with regulated standards and the significant deviations were equally noticed.

Table 1: Physicochemical parameters of different soil sample

Parameters	Soil Samples		
	A	B	C
pH	7.10	7.21	6.80
Conductivity (*$\mu S/cm^{-1}$*)	1.79	2.23	1.15
Moisture content (*%*)	3.93	2.89	3.48
Organic Matter (*%*)	0.95	0.73	1.14
Temperature (*^oC*)	24.2	26.4	28.0
Chlorides (*mg/L*)	31.76	48.98	91.63
Sulphates (*mg/L*)	1.96	2.35	2.14
Nitrates (*mg/L*)	0.10.	0.06	0.23

pH: pH has a scale of value ranging from 1 to 14 where a solution from pH 1-6.9 is considered acidic and a solution from PH 7.1 – 14 is alkaline while 7 is a neutral pH (Convingto A.K. 1985). The pH of the samples was 7.10, 7.21 and 6.8 respectively. These were found to be favorable as pH of water around 4.0 – 4.5 has been reported to be dangerous for human life (ACS 1969). pH which is at par with others reported in the literature (Abu-Rukah and Al-Kafahi, 2001; Keimowitz, 2005; Futta *et al.,* 1997). This agrees with the postulate that the pH of leachate increases with landfill age (Futta *et al.,* 1997) which is probably due to the fact that leachates have, to a large extent, witnessed washing-away by rainfall or percolated over time into the soil. However, the pH distribution of soil affects the availability, retention and mobility of metals with increasing pH (Itanna, 1998; Bhattacharya et al., 2002). The pH levels that are acidic tend to have an increased micronutrient solubility and mobility as well as increased heavy metal concentration in the soil, thus rendering the soil unsuitable for waste land filling. And the value falls with the range by WHO; 6.5 – 8.5. Elevated pH values can indicate potential losses of nitrate and subsequent water contamination. The tendency for soil acidification can suggest insufficient use of ammonia fertilizers and increased leaching losses (Smith and Doran 2006)

The organic matter: Is the reservoirs of essential and non-essential elements for plants growth and developments, hence increased organic matter may increase soil productivity (Anikwe and Nwobodo 2002) The organic matter of the samples were found to be0.95, 0.73 and 1.14%. The relative organic matter of the soil samples may be attributed to the decay of the dump waste. The organic matter values were recorded to be 0.95, 0.73 and 1.14%. The lower organic matter value was reported from the sample B and higher organic matter value was reported from the sample C. The higher organic matter content may be due to decaying of plant

Moisture content: This is the soil water holding capacity and it's essential to the evaluation of regional soil water balance (SWHC, 2005). The moisture content of the samples were reported to be 3.93, 2.89 and 3.48% respectively, which correlate with the result reported in the physicochemical analysis of soil from Chorwad Hehsil-Bhusawal (Narkhede *el al.,* 2011). Soil water content in air dried samples and saturated wet samples are given in table1 Soil texture greatly influences water availability. The sandy soil can quickly be recharged with soil moisture but is unable to hold as much water as the soils with heavier textures. As texture becomes heavier, the wilting point increases because fine soils with narrow pore spacing hold water more tightly than soils with wide pore spacing (SRNF, 2007). The texture of soil on the basis of water holding capacity was found to be Loam sandy

*Electrical conductivity***:** is used to estimate the soluble salt concentration in soil, and is commonly used as a measure of salinity. Soil with EC below 400 $\mu Scm^{-1}$are considered marginally or non-saline, while soils above 800 µS/cm are considered severely saline. Electrical conductivity at dumpsite C was lowest (1.15 μScm^{-1}) while it was highest at site B (2.23 μScm^{-1}). This indicates that at site C movement of charge particles are more than other two sites which is a good indicator for the growth of plants. The electrical conductivity at adjoining areas was higher than dumpsites (Table 1). The EC result obtain correlates with that of (Tripathi and Misra, 2012)

Chloride ion: concentrations of soil samples are given in table 1. The chloride concentration ranges from 31.76, 48.98 and 91.63mg/kg of the soil. These results are slightly below the optimal concentration range of chlorides in most crops is between 1.0 to 100 mg Cl /kg dry matter (Marschner, 1995). The negative effects of higher chloride ion concentrations on crops are common in coastal areas. The amount of chloride found in plants varies with habitat because both the external chloride concentration and the balance of other available anions influence the content

Sulphate: (SO_4^{2-}) values are observed from 1.96, 2.23 and 2.14 mg/l for the soil samples. Lower sulphate values were recorded in the sample A and higher sulphate value was recorded in the sample B. It may be due to the addition fertilizers during the plantation of crop and sowing of seeds.

Heavy Metal Concentration: Heavy metals are elements having some atomic weight between 63.54 and 200.59, and a specific gravity greater than 4 (Kennish, 1992). Although trace amount of some heavy metals are required by living organisms, any excess amount of these metals can be detrimental to the organisms (Berti and Jacobs, 1996). Metals also have a high affinity for humic acids, organic clays, and oxides coated with organic matter (Elliot et al., 1986; Connel and Miller, 1984). The solubility of the metals in soils and groundwater is predominantly controlled by pH (Baker and Walker, 1990; McNeil and Waring, 1992; Henry, 2000), amount of metal and cation exchange capacity (Martinez and Motto, 2000), organic carbon content (Elliot et al., 1986) and the oxidation state of mineral components as well as the redox potential of the system (Connell and Miller, 1984). Oygard et al. (2007) also observed that the heavy metals leached from the landfill are usually found in the form of free cation, dissolved organic compound complex, particulate and colloid. Most of these heavy metals from the surface layer of an open dumpsite usually creeps into the bottom layer of the dumpsite where anaerobic condition prevails (He et al., 2006; Bozkurt et al., 2000; Matensson et al., 1999; Flyhammar, 1998). The results of the heavy metal investigation in the landfill (Table- 2) show Cd and Fe to be the most predominant metals in the landfill (0.516, 0.620 and 0.048 mg/L; 0.518, 0.620 and 0.190mg/l), while Zn concentration was the lowest (0.04, 0.009 and 0.066mg/L) while Cu and Pb were found in considerable amounts in each of the soil samples (0.03, 0.028 and 0.031; 0.063, 0.07 and 0.056mg/L) respectively. Pb, Cd and Zn are from anthropogenic sources because of their high correlation with measures of organic matter and their high correlation with each other (Table 2).

Table 2: Concentration of metals (mg/kg) for soils in selected dumpsites in Ilorin metropolis Kwara State, Nigeria

Heavy metals	Soil Samples			
	*PL	A	B	C
Copper	2.0	0.030	0.028	0.031
Zinc	3.0	0.040	0.009	0.066
Cadmium	0.003	0.516	0.620	0.048
Lead	0.01	0.063	0.070	0.056
Iron	0.005	0.518	0.620	0.190

**PL =permissible limits, mg/kg*

Although metals are essential, at higher concentrations they become toxic and present different problems to soil microorganisms, because they cause oxidative stress by formation of free radicals. They can also replace essential metals in pigments or enzymes, thus disrupting their function (Henry, 2000) and may render the land unsuitable for plant growth and destroy the biodiversity.

Conclusion: This study indicates the level of contamination at the municipal waste dumpsites and explores the relationship between ranges of quantitative variables. The dumpsites were found to be heavily contaminated with heavy metals. Thus, open dumping of waste should be discouraged and proper monitoring and remediation plan is needed to reduce the chances of ground water pollution by leaching of contaminants. Presence of organic matter in dumpsite indicates that these soils have composting potential. The study provides indication of contamination at such open dumpsites and thus will be helpful in making any remediation plan for these contaminated sites. Artificial reclamation with mature soil is recommended for these sites.

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