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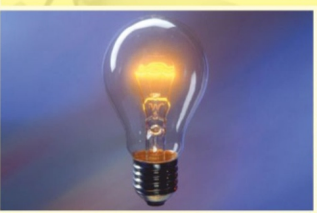
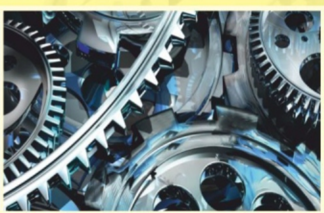


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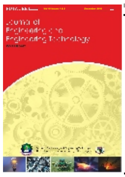

Journal of Engineering and Engineering Technology

Soil Quality Analysis for Dumpsite Environment in a University Community in Nigeria

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Waste; Soil; Pollution; Management; University; Nigeria

A B S T R A C T

Physicochemical analyses were carried out on soil samples from four different waste dumpsites in the Federal University of Technology Akure (FUTA), Nigeria to ascertain the effects of the refuse dumpsites on soil and groundwater qualities. Dumpsite locations are Physics Laboratory (PHY), Post Graduate Hostel (PG), School of Earth and Mineral Science (SEMS) and Staff Quarters (STQ). Soil samples collected at distances 0 (dumpsite), 10 and 20 m intervals away from the dumpsite were analyzed and at depths 10, 20 and 30 cm. Parameters determined include pH, Electrical Conductivity (EC), Magnesium (Mg), Calcium (Ca), Sodium (Na), Phosphorus (P), Nitrogen (N), Potassium (K), Organic Carbon (OC), Organic Matter (OM) and heavy metals such as Copper (Cu) and Lead (Pb) and subjected to relevant statistical analysis. Most of the parameters analyzed indicated pollution and were below the Food and Agricultural Organization (FAO) limits. P and Mg concentrations ranged from 1.19 to 1.25mg/kg and 3.17 to 13.61mg/kg respectively which indicated pollution. Out of heavy metals analyzed, Cu was 1.75mg/kg and Pb was not detected. Statistical analysis indicated significant differences at 95% level. The result showed that the soil samples were mildly polluted and therefore not suitable for crop production.

1. Introduction

Challenges associated with improper waste management and disposal has assumed a frightening dimension with its attendant effects on the environment, health and well being of people hence, approaching it holistically is a non negotiable alternative for a healthy and sustainable living (Ahmad et al., 2013). Population growth and economic development lead to enormous amounts of solid waste generation by the dwellers of the urban areas (Verge and Rowe, 2013) while urban Municipal Solid Waste (MSW) is usually generated from human settlements, small industries and commercial activities (Singh et al., 2011). Soil contamination through waste discharges, particularly hazardous wastes, is a worldwide phenomenon and carries different metals which are then transferred to plants by different ways (Akinbile and Yusoff, 2012). The contamination of soil by heavy metal can cause adverse effects on human health, animals and soil productivity (Smith et al., 1996) and depending on the tendency of the contaminants, they end up either in water held in the soil or leached to the underground water. Contaminants like Cd, Cu, Ni, Pb and Zn can alter the soil chemistry and have an impact on the organisms and plants depending on the soil for nutrition (Voutsa et al., 1996).

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In developing countries such as Nigeria, open dumpsites are common practice due to the low budget for waste disposal and lack of political will. A good amount of the city garbage is dumped in low lying areas which poses serious threat to groundwater resources and soil (Akinbile, 2012; Agamuthu and Fauziah, 2011). Many studies show evidence of seriousness of hazards caused by open waste dumping ultimately affecting the plant life on the planet leading towards an irreversible erosion trend unless the present land use pattern is checked (Phil-Eze, 2010). Solid waste pollutants serve as an external force affecting the physicochemical characteristics of soil ultimately contributing towards the poor production of vegetation (Christensen et al., 2014).

Nigeria is generally faced with rapid deterioration of environmental conditions due to the conventional system of collection and dumping of solid wastes. Therefore, waste management has become a major concern in cities. Little efforts have been made in order to improve the waste collection and disposal facilities. The present study therefore was conducted to determine the effect of the refuse dumpsites on a predominantly productive agricultural soil quality in the Federal University of Technology Akure Ondo State, Nigeria.

2.0 Materials and Methods

2.1 *Description of the Study Area*

The study area consists of four different locations of refuse dumpsite situated in Federal University of Technology Akure (FUTA) in Ondo State and it is located in southwestern Nigeria. Akure, capital city of Ondo state of Nigeria located between latitude 9°17'N and longitude 5°18'E and latitude 7°58'0'S and longitude 8°46'0'W. FUTA is one of the four specialized federal Universities of technology established by the Federal Government of Nigeria in 1981 to undertake training of technologists and engineers in order to meet the manpower development of the production sector of the country. Staff and students' population rose from 250 in 1981 to over 20,000 and due to population increase over the years, considerable pressure has been put on waste management structures in place since the inception of the University making indiscriminate dumping of refuse an inevitable option. This is despite several efforts put in place by the University administration to de centralize waste collection at strategic locations on campus.

2.2 *Soil Sampling and Analysis*

Soil samples were collected from four different waste dumpsites randomly located within FUTA environment. The locations include dumpsites behind Physics department laboratory (PHY), Post Graduate Students' Hostel (PG), School of Earth and Mineral Science building (SEMS) and Staff Quarters residence (STQ) as shown in Figures 1a to d. 100±0.5g of representative samples were collected at three different aligned locations of 10 m intervals from the refuse dump with each location having three samples at various distances of 0, 10m and 20m away from the dumpsite. Samples were collected at 10, 20 and 30 cm depths from each sampling point per location following standard procedure of auger method. The following constituents were analyzed in the soil samples taken from the respective locations, the pH, organic content (OC), Nitrogen (N), Phosphorus (P), Calcium (Ca), Magnesium (Mg), Copper(Cu), Lead (Pb), Sodium (Na) and Potassium (K) and particle size analysis using standard laboratory procedures. Similarly, soil porosity, moisture content, water holding capacity were also determined both by in-situ and laboratory measurements using standard procedures and as adopted by Akinbile et al., 2016a: Akinbile 2012.

2.3 *Statistical analysis of Data*

Data analysis was carried out using the Statistical Package for Social Sciences (SPSS) software, Descriptive analyses and Analysis of variance (ANOVA version 16) , least square significance (LSS) and Duncan multiple range test (DMRT) and regression analysis at significance level of ($P<0.05$).

3.0 Results and discussions

3.1 *Soil Physical Properties*

Tables1 show the physical properties and Table 2 the chemical properties of the soil analyzed at different locations within FUTA community. From Table 1 and using the USDA textural class triangle for soil classification, the soil was found to be sandy clay loam for all the locations. The mean values for sand in all the locations are 48.33 ± 7.02, 44.00 ± 3, 34.33 ± 3.06 and 35.66 ± 2.65 % while the average moisture content are 33.31 ± 0.68, 24.64 ± 2.22, 28.15 ± 1.31 and 29.12 ± 1.28 % for PHY, PG, SEMS and STQ respectively. Similar observations were noticed in the trends of water holding capacity (WHC), porosity and bulk density which connotes deviation from the ideal constituents due to pollution occasioned by the effect of indiscriminate waste disposal and management.

This has impaired significantly the use of soils from the four locations for productive agricultural activities such as in cropping and the observation is similar to the ones made by Ibitoye (2001). WHC was high for PHY and STQ when compared to other locations and this could be as a result of high organic matter content within the soil samples in those locations. From Table 1, there was no significant difference between PG and SEMS, SEMS and STQ but PGD was significantly different from STQ and PHY was significantly different from others. The level of significance between the four different locations could be attributed to the wastes compositions, the soil structure, method of waste disposal and management. The depletion of nutrients in the soils was evident from the level of moisture content in the four locations which typify active activity of microorganisms and high organic matter content (Han et al., 2015). Mean porosity values were 35.80 ± 1.27, 28.13 ± 1.37, 30.48 ± 2.30 and 32.80 ± 2.75% in all the locations. PG and SEMS, have no significant different between each other but are significantly different from PHY and PG at a significant level of $P < 0.05$ (Table 1).

The moisture content (MC) at locations SEMS and STQ have no significant difference between them but are significantly different from PHY and PG at a significant level of $P < 0.05$ and this decreases with increasing distance away from refuse dumpsite. This agreed with the findings of Moura et al., (2009); Zhang et al., (2007), Silva and Kay (1997). Bulk density ranged between 0.97-1.56g/cm^3 in the four locations which agreed with findings of Akinbile et al., 2016a and b and assessing the levels of significance, it was observed that PG and SEMS have no significant difference between them but are significantly different from PHY and Staff quarters (Table 1). The mean values of the twelve chemical parameters of the soil in four different locations within FUTA campus were herewith presented in Table 2. For each of the location, the pH values increased with increased distance from the .

waste dump. This could be as a result of high exchangeable bases content around the refuse dump (Akinbile, 2012) The major effects of soil acidification on plants include; reduction in supply of nutrients supply, increased concentrations of metal ions in solution, especially of Aluminum, and including those of manganese, copper, zinc which may be toxic, nitrogen fixation by legumes may be reduced unless the Rhizobium strain is acid-tolerant (Dorraji et.al.,2010). Organic Matter (OM) mean value was 4.43 ± 0.85, 2.30 ± 0.02, 3.95 ± 0.09 and 5.24 ± 0.13% for the four locations respectively. High organic matter discovered around wastes dump favours increased MC, WHC and permeability (Ibitoye, 2001). The frequent addition of easily decomposable organic residues caused the synthesis of complex organic compounds that bind soil particles into structural units called aggregates. These aggregates help to maintain a loose open, granular condition. Water is then able to enter and percolate downward through the soil with pollutant (Shepherd et al., 2002 and Ibitoye, 2001). The organic matter content in PHY and STQ were considerably large and this could be as a result of the type of refuse wastes on those soils.

OC mean values were 3.11 ± 0.02, 1.33 ± 0.01, 2.28 ± 0.06 and 2.96 ± 0.13% for PHY, PG, SEMS and STQ respectively. PHY has the highest OC value and this could be as a result of the type of refuse dumpsites in the location and were significantly different from each other (Shepherd et al., 2002).

Table 1: Physical properties of soils from the four different locations

	LOCATIONS			
PARAMETERS	**PHY**	**PG**	**SEMS**	**STQ**
MC	33.31 ± 0.68^{c}	24.64 ± 2.22^{a}	28.15 ± 1.31^{b}	29.12 ± 1.28^{b}
WHC	43.99 ± 0.68^{c}	34.98 ± 2.22^{a}	37.18 ± 1.31^{ab}	39.17 ± 1.28^{b}
Porosity	35.8 ± 1.27^{c}	28.13 ± 1.73^{a}	30.48 ± 2.3^{ab}	32.8 ± 2.75^{bc}
Bulk density	0.97 ± 0.02^{a}	1.56 ± 0.13^{c}	1.47 ± 0.07^{c}	1.16 ± 0.05^{b}
Sand	48.33 ± 7.02^{b}	44.0 ± 3^{a}	34.33 ± 3.06^{a}	35.66 ± 2.65^{a}
Clay	28.34 ± 4.58^{a}	28.67 ± 2.52^{a}	35.33 ± 1.53^{b}	30.67 ± 3.51^{ab}
Silt	23.33 ± 6.11^{a}	27.33 ± 1.15^{ab}	30.34 ± 1.73^{b}	33.67 ± 1.53^{b}

Mean in a given row with the same letter were not significantly different at P< 0.05. Note: All units in % except where otherwise stated; bulk density (BD) in g/cm^3; WHC – Water Holding Capacity; MC - Moisture Content

Table 2: Chemical properties of soils from four different locations

		LOCATIONS			
PARAMETERS	**FAO**	**PHY**	**PGD**	**SEMS**	**STQ**
pH	6.5-8.5	6.7 ± 0.1^{a}	7.37 ± 0.06^{c}	7.17 ± 0.06^{b}	7.13 ± 0.06^{b}
OC		3.11 ± 0.02^{d}	1.33 ± 0.01^{a}	2.28 ± 0.06^{b}	2.96 ± 0.13^{c}
OM	3	4.43 ± 0.85^{bc}	2.3 ± 0.02^{a}	3.95 ± 0.09^{b}	5.24 ± 0.13^{c}
EC	300-500	86.00 ± 1.00^{ab}	85.00 ± 1.00^{a}	88.33 ± 1.15^{bc}	89.33 ± 2.52^{c}
Nitrogen	0.1-2.0	0.94 ± 0.09^{bc}	1.07 ± 0.08^{c}	0.82 ± 0.03^{b}	0.63 ± 0.11^{a}
Phosphorus	10-20	7.93 ± 0.03^{c}	3.17 ± 0.02^{a}	13.61 ± 0.01^{d}	5.66 ± 0.1^{b}
Potassium	0.3-0.5	19.2 ± 0.2^{c}	11.38 ± 0.03^{b}	8.24 ± 0.23^{a}	14.35 ± 0.05^{d}
Sodium	0.3-0.5	8.32 ± 0.08^{b}	11.19 ± 0.02^{c}	7.73 ± 0.06^{a}	12.06 ± 0.17^{d}
Calcium	10-50	7.49 ± 0.01^{a}	7.9 ± 0.13^{b}	20.89 ± 0.11^{c}	22.3 ± 0.26^{d}
Magnesium	<5	1.19 ± 0.02^{a}	1.23 ± 0.05^{a}	1.2 ± 0.09^{a}	1.25 ± 0.06^{a}
Copper	<2	1.75 ± 0.1^{d}	0.34 ± 0.01^{c}	0.19 ± 0.02^{b}	ND
Lead	<0.001	ND	ND	ND	ND

Mean in a given row with the same letter were not significantly different at P< 0.05.
Note: All units in mg/kg except where otherwise stated; ND – Not detected; pH is dimensionless, organic carbon (OC), organic matter (OM) and Nitrogen are in %; Electrical conductivity (EC) is in µs/cm.

The mean values of Nitrogen were 0.94 ± 0.09, 1.07 ± 0.08, 0.82 ± 0.03 and 0.63 ± 0.11% for PHY, PG, SEMS and STQ respectively (Table 2). The Nitrogen values for PHY, PG, SEMS and STQ were all higher than the FAO standards value. Nitrogen values decreased with the increase in distance away from the wastes dumpsite as observed with other parameters in all the four locations which showed no significant difference between PHY and SEMS and PHY and PG but are significantly different from STQ.

Nitrogen is important as a building block in the formation of protein which is usually a major component of the protoplasm and nucleus. Nitrogen supply is important in carbohydrate utilization. When there is an acute shortage of nitrogen, carbohydrate is deposited in vegetative cells resulting in a thickened cell wall. Nitrogen also governs the utilization of K, P and other constituents (Smith et al., 1996). Excess nitrogen will increase the bulk of forage crops and can delay ripening in cereals and leave the crop susceptible to fungal attack. Shortage of nitrogen can be seen by a yellow colour of the foliage combined with lack of growth.

Available phosphorus ranged between 3.91 and 13.61mg/kg. It decreased with increase in distance away from the respective dumpsites. Phosphorus values are in the range of 7 to 20mg/kg (FAO standards) except for PG and STQ. Low values of available phosphorus showed that there is no constituent of domestic wastes such as soaps, and detergents present in the refuse dumpsites. Comparing their significance levels, it showed that there was significant difference between each of the locations. Exchangeable parameters such as Potassium (K), Sodium (Na), Calcium (Ca) and Magnesium (Mg) values ranged from 8.24 ± 0.23 to19.20 ± 0.20 mg/kg, 7.73 ± 0.06 to 12.06 ± 0.17 mg/kg, 7.49 ± 0.01 to 22.30 ± 0.26 mg/kg and 1.19 ± 0.02 to 1.25 ± 0.06 mg/kg respectively (Table 2). It was evident that the exchangeable bases were very high compared to FAO standards with the exception of Calcium at PHY and PG locations having 7.49 ± 0.01 mg/kg and 7.9 ± 0.13 mg/kg respectively (Table 2).

It also showed that K, Na and Ca have significant difference between each of the locations except for Mg which showed no significant difference between the soil samples in all the four locations. The presence of heavy metals such as Cu with mean ranging from 0.34 ± 0.01 to 1.75 ± 0.10 mg/kg and it reduced with increase in distance away from the dumpsites. Cu was not detected in STQ and this could be attributed to the fact that there were no toxic wastes deposited in the location (Akinbile et al., 2012). It was also observed that there was no significant difference in Cu between the four locations. Pb which is also a heavy metal was not detected in any of the locations (Table 2) and this could be attributed to the fact that there was no toxic wastes dump in all the four locations. Toxic wastes could contain iron ore, decomposing dead battery cells and other toxic substances.

4. Conclusion

The study revealed that the concentration of refuse wastes in the four study areas (PHY, PG, SEMS and STQ) has systematically decreased some important soil nutrients over time. The effect of such wastes as determined from the study declined away from the refuse source. It means that the contamination of the soil was more dependent on the proximity to the refuse dumpsites. The consequences are numerous and showed that there is indeed a proper and decisive approach in correct wastes management and disposal practises within the University which has direct impact on peoples' health within the community and productivity.

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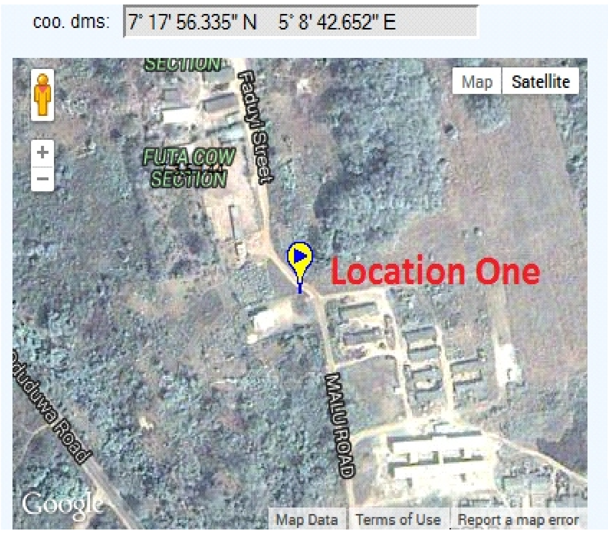

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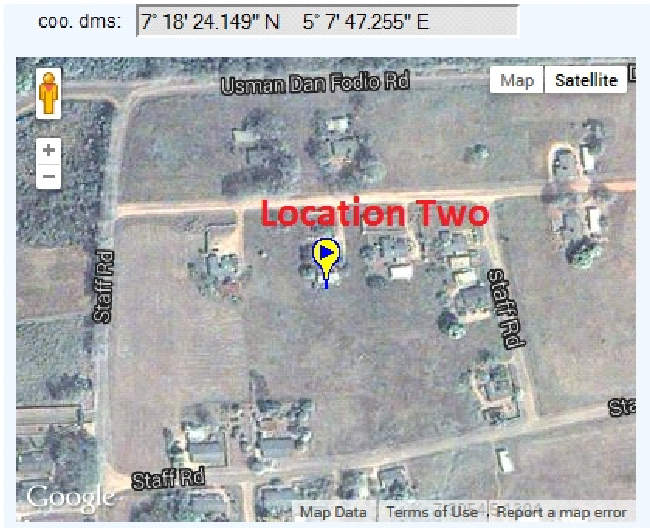

Figure 1b: Sampling location two near the senior staff quarters (Source: Google Earth, 2014)

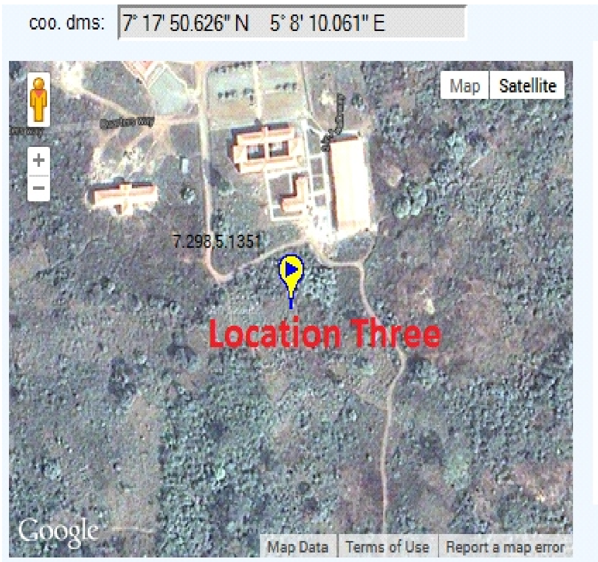

Figure 1c: Sampling location three close to 2 in 1 walkway, SEMS Extension (Source: Google Earth, 2014)

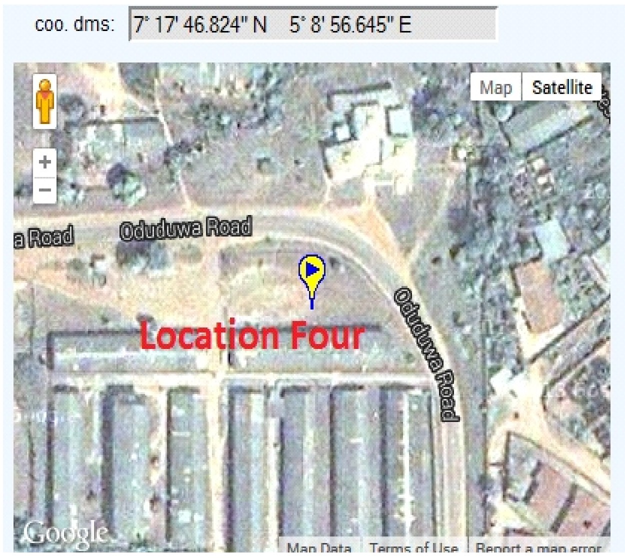

Figure 1d: Sampling location four near the university health center (Source: Google Earth, 2014)