Original Article

INVESTIGATING SOIL CONTAMINATION IN IHIAGWA FARMLANDS DUE TO WASTE DISPOSAL NEAR OWERRI, NIGERIA

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Abstract: This study investigates the impact of waste disposal on the physicochemical quality of soil from farmlands near a dumpsite in Umuchima, Ihiagwa, located in Owerri West, Imo State, Nigeria. Soil samples were systematically collected from three different locations at two depths (0–15 cm and 15–30 cm) to evaluate variations in soil properties resulting from proximity to waste disposal. Key parameters analyzed include pH, bulk density, nitrate, nitrate nitrogen, phosphate, total chloride, sulphate, and electrical conductivity. Results indicate that the soil pH ranged from 4.9 to 6.9, suggesting a more acidic environment in soils near the dumpsite compared to control sites. Bulk density values were relatively consistent (1.18–1.33 g/cm³), indicating similar compaction across sites. Chemical analysis revealed elevated levels of nitrate (36.00–48.10 mg/kg), nitrate nitrogen (8.25–12.95 mg/kg), phosphate (9.30–36.00 mg/kg), total chloride (983.95–2368.77 mg/kg), and sulphate (0.00–15.00 mg/kg) in soils closer to the dumpsite. Electrical conductivity ranged from 98.0 to 212 µS/cm, reflecting increased ionic concentration near the waste disposal area. While the waste had no notable effect on the soil's textural classification, the altered chemical properties point to significant contamination, potentially affecting soil health and agricultural productivity. These findings underscore the urgent need for sustainable waste management strategies to protect soil resources in peri-urban agricultural zones.

Keywords: Waste Disposal, Physicochemical properties, Farmland soil

1. Introduction

The menace of environmental pollution has been haunting the human world since early times and is still growing due to excessive growth in developing countries.

Nigeria is generally faced with rapid deterioration of environmental conditions due to the conventional system of collection and dumping of solid wastes. Therefore urban waste management has become a major concern in cities. Little efforts have been made in order to improve the waste collection and disposal facilities. This has some grave consequences ranging from deterioration of soil quality to reduced plant diversity. During rainfall, open dump site becomes saturated with water and out of runoff Contaminated water, carries pollutant (organic compounds and heavy metals) into the farm.

In developing countries open dumpsites are common, due to the low budget for waste disposal and non-availability of trained manpower. Open dumping of Municipal solid waste is a common practice in Umuchima, Ihiagwa. It also poses serious threat to groundwater resources and soil.

The contamination of soil by heavy metal can cause adverse effects on human health, animals and soil productivity *(Smith et al., 1996)*. Metals cause physiological disorders in soils as absorption through root system consequently retards plant growth and deprives it of vigour *(Moustakas et al., 1994).*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 *(Shaylor et al., 2009).*

Diversity of vegetation is directly influenced by soil characteristics. 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 physico-chemical characteristics of soil ultimately contributing towards the poor production of vegetation *(Papageorgiou, 2006).* It is depriving our ecosystem of the natural balance and bear result beyond any repair. Assessment of soil pollution becomes difficult when contaminants belong to different sources and their products are variably distributed *(Partha et al., 2011).* Chemical properties of soil serve as main reason of vegetation changes (*Neave et al., 1994).* Soil is a crucial component of urban environments and its management is the key to its quality open dumping of wastes, Soil pH generally has a major contribution in metal bioavailability, toxicity and leaching capability into the surrounding areas (*Chimuka et al., 2005).* The organic matter content, pH, conductivity, and available heavy metals on open dump sites are greatly affected by the quantity of wastes dumped. However, large amount of these metals are released into the soil as a result of increased anthropogenic activities such as agricultural practices, industrial activities, energy consumption and wastes disposal methods, thus leading to the contamination of soil *(Ebong et al., 2007).*

0.2. Materials and Methods

2.1 Description of study area The study area fall within the Cartesian coordinates of latitude: 5°24’0 N”, longitude: 7°1’0E”.

The geology of the area is predominantly composed of coastal plain sand.

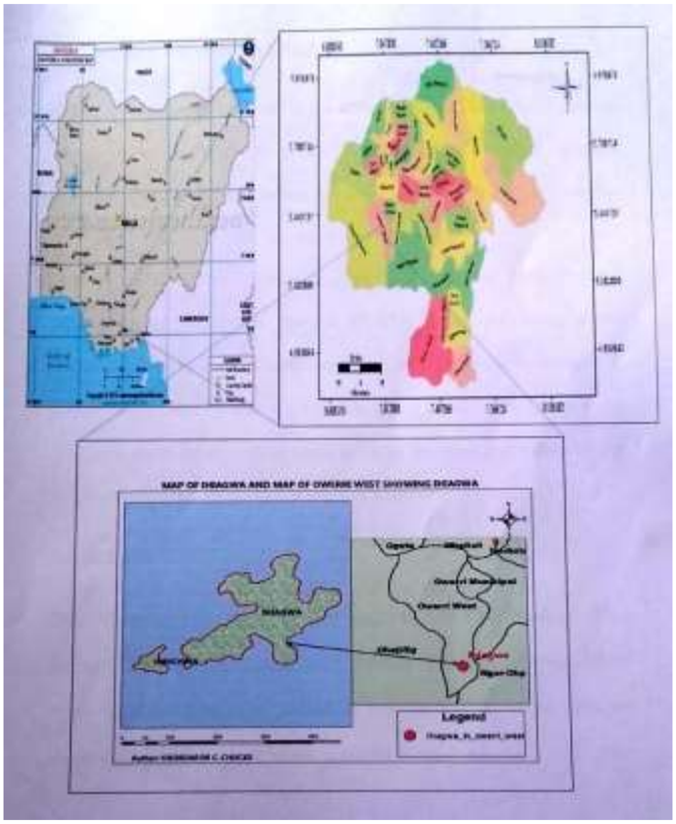

Fig 1. Location of the study area

The study area fall within the subequatorial climate region of Nigeria with a total rainfall varying from 1,500mm to 2,200mm (60 to 80 inches). The area under study experience two major season the rainy of wet and the dry seasons. The rainy season last from March to October while the dry Season starts in November and end in February. Humid tropical weathering of the sediments especially the carbonate is pronounce under this climate region. The rainy season is marked with heavy rainfall, thunderstorms, lighting water infiltration and percolation, leaching and sometimes flooding. The rainy season is divided into peaks. The first peak last from April to July while the second last from September to October. The dry season is divided into the cold dry season (harmattan) and the hot dry season.

The mean annual atmospheric temperature within the study area is about 28^{0}c maximally. It is usually at its peak from February-April toward the end of dry season but hardly exceeds 3^{0}c. The mean annual pressure range from 1010 millibars 1012.9 millibars. Average daily pressure value at mean sea level (MSL) is about 109mb- 10mb during the dry season.

The geology and topography of the area of studied have some influence on the drainage characteristics.

2.2 Collection of sample

Soil samples were collected from three different farm lands near the dumpsite tagged farm one (1) and farm two (2) in Umuchima using a soil Auger at a depth of 0-15cm for sample A and 15-30 cm for sample B respectively while the third sample used as the control sample was collected from Federal University of Technology Owerri (FUTO) farm land using a soil Auger at a depth of 0-15cm for sample A and 15-30 cm for sample B. Geographical coordinates of all the sampling points were taken using a Global positioning system bags, properly labelled and taken to the laboratory within 24 hours for various analyses.

2.3 SOIL LABORATORY ANALYSIS

2.3.1 pH and conductivity determination (ELECTROMETRIC METHOD)

The pH of the sample were determine using a Jewniary digital pH meter in a sample to water ratio of 1:10 that is twenty grams (20g) of each sample will be weighed in a beaker. Then two hundred millilitre (200ml) of distilled water be added to it. The pH electrode was dipped into the solution also conductivity electrode was dipped too, to read the conductivity.

2.3.2 Nitrate

It has to be extracted using Ammonium chloride (NH_4Cl) solution by adding 250ml of Ammonium chloride to ten (10) grams of the sample. It should be shaken for one (1) hour and filter, then can be used the determination using the cadmium reduction method.

2.3.3 Sulphate

The soil was extracted with water at a soil water ratio of 1:5 and the soil water mixture was heated on a hot plate for 30 minute. The sieved extracted sulphate is then reacted with sulphate reagent to form and insoluble barium salt which produces turbidity in test sample. The degree of turbidity is proportional to the sulphate level in the soil sample and is determined using the multi- parameter photometer.

2.3.4 Phosphate

Phosphate is extracted using 0 sample of sodium bicarbonate at soil water ratio of 1:2:25. The extracted phosphate is reagent/ Ammonium molybdate under reducing condition in acidic solution to form a blue cultured complex. The intensity of the blue coloration is proportional to the phosphate level in the soil is determined by Amino acid method. The phosphate is then determined in the sample by using multi- parameter photometer.

2.3.5 Sulphate (TURBIDIMETRIC METHOD)

Principle

(a) Sulphate ion react with barium ion, forming a turbidal suspension of insoluble barium sulphate. The scatter of light caused by this suspension is an indication of the sulphate concentration in the sample. Measurement are carried out on a spectrophotometer using a wave length of 550m

2.3.6 Total Chloride:(MOHR'S METHOD)

(b) Principle:

(c) The mohr method employs silver nitrate as titrant and potassium chromate as the end point indicator. The chloride ion present in the water/ waste water, soil sample is precipitated as white silver chloride

(d) $Ag^+ + Cl^- = AgCl$

(e) As the chloride ion in the water sample is being wholly precipitated, any addition of silver nitrate solution will lead to a level at which the solubility product of silver chromate is exceeded and it begins to form a reddish brown precipitate.

(f) $2Ag^+ + CrO_4^- = Ag_2CrO_4$ (Reddish – Brown)

(g) This is taken as the end poin

2.3.7 Bulk Density (Disturbed samples, pF 3.4 and 4.2)

The moisture content at Pf 3.4 (2.5 bar sunction) is determine with the 5- bar pressure plate extractor and at 15 bar extractor.

3.0 Results

The result of the soil analysis done, showed the variation that exists between soil from farmland close to dumpsite and soil from farmland without the presence of dumpsite. The content of the soil parameter varied in the different sample, which help to determine the actual effect of dumping municipal refuse close to a farmland.

Table 3.1: Selected Chemical Properties of Soil from FUTO Farmland (Control site) without presence of dumpsite.

Parameter	**Soil Depth (cm)**	
	0-15	15-30
PH	8.2	5.2
Bulk density, g/cm^3	1.29	1.25
Nitrate, mg/kg No_3^-	26.05	47.70
Nitrate-Nitrogen, mg/kg NO_3^-N	5.90	12.35
Phosphate, mg/kgPO_4^{3-}	42.40	31.40
Phosphate, mg/kg P	13.80	10.20
Total Chloride, mg/kg Cl^-	1257.27	947.51
Sulphate, mg/kgSO_4^{2-}	10.00	10.00
Conductivity	102.00	84.401

Table 3.2: Selected Chemical Properties of Soil from Farmland One (F1) close to the dumpsite.

Parameter	**Soil Depth (cm)**	
	0-15 (F1A)	15-30 (F1B)
PH	6.9	5.2
Bulk density, g/cm^3	1.18	1.21
Nitrate, mg/kg No_3^-	36.00	57.30
Nitrate-Nitrogen, mg/kg NO_3^-N	8.25	12.95
Phosphate, mg/kgPO_4^{3-}	36.00	33.6
Phosphate, mg/kg P	10.80	11.00
Total Chloride, mg/kg Cl^-	1975.06	983.95
Sulphate, mg/kgSO_4^{2-}	15.00	5.00
Conductivity	106.00	98.00

Table 3.3: Selected Chemical Properties of Soil from Farmland Two (F2) close to the dumpsite.

Parameter	**Soil Depth (cm)**	
	0-15 (F2A)	15-30 (F2B)
PH	6.2	4.9
Bulk density, g/cm^3	1.33	1.25
Nitrate, mg/kg NO_3^-	49.25	48.10
Nitrate-Nitrogen, mg/kg NO_3^-N	11.10	10.85
Phosphate, mg/kgPO_4^{3-}	35.00	9.30
Phosphate, mg/kg P	11.40	3.00
Total Chloride, mg/kg Cl^-	2368.77	1220.83
Sulphate, mg/kgSO_4^{2-}	5.00	0.00
Conductivity	212.00	139.00

Table 3.4 showing a mean concentration of parameter analyse

Parameter	Polluted farm Mean ± SE	Futo Farm Mean ± SE
pH	5.8±0.398	6.7±1.875
Bulk Density	1.243±0.028	1.27±0.014
Nitrate	47.66±3.805	36.88±7.65
Nitrate-Nitrogen	10.79±0.8373	9.125±2.28
Phosphate	28.475±5.578	36.9±3.889
Phosphate mg/kgP	9.05±1.758	12±1.273
Total chloride	1637.15±279.45	1102.39±109.52
Sulphate	6.25±2.232	10±0.00
Conductivity	**138.75±22.498**	**93.2±6.22**

4.0 Discussion

4.1 pH

The pH of the soil from the polluted site ranged from 4.9 to 6.9 with a mean concentration of 5.8±0.398. Which is lower than the control farm with a range of 5.2 to 8.2 and a mean concentration of 6.7±1.875. *Weiss (1974)* recognise that strongly alkaline soil are unsuitable for waste dump site. A pH of 6.5 is the best general purpose pH for farming allowing wide range of plant to grow, except lime hating plant (Royal horticulture society, 2016). The soil 5.2 is not very acidic, but the pH range of 8.2 is quite alkaline. The soil below 4.9 at farmland two (F2) at depth of 15-30cm is very acidic, at such pH levels, they tend to be an increased micro nutrient solubility and mobility, as well as heavy metals concentration in the soil (*Kumar, 1987)* **4.2 Bulk Density**

The total range of the bulk Density of polluted site was`1.18g/cm³ to 1.33g/cm³ with a mean of 1.243±0.028 while that of the control is ranged from 1.25 to 1.29 with a mean concentration of 1.27±0.014. An ideal bulk density was shown in table 4.1.

TABLE 4.1. GENERAL RELATIONSHIP OF SOIL BULK DENSITY TO ROOT GROWTH BASE ON SOIL TEXTURE (*Arshad et al, 1996)*

Soil texture	Ideal bulk density for plant growth (g/cm³)	Bulk Density that restrict root growth
Sandy	<1.60	>1.80
Silty	<1.40	>1.65
Clayey	<1.10	>1.47

High bulk density is an indicator of low soil porosity and soil compaction, it may cause restriction of growth and poor movement of water in the soil (Arshad *et al*, 1996). It is generally desirable to have soil with low bulk density (<1.5 g/cm³) *(Hunt and Gilkes, 1992).*

4.3 Nitrate (mg/kg NO_3)
The concentration of nitrate in the polluted soil sample ranging from 36.0 mg/kg NO_3 to 48.10 mg/kg NO_3 with a mean concentration of 47.66±3.805 is higher when compare with that of the control site whose range was 26.05 to 54.70 and mean concentration of 36.88±7.65.

4.4 Nitrate –Nitrogen (mg/kg NO_3^-N)
Nitrate- nitrogen (NO_3^-N) is most commonly measured in standard soil tests because it is the primary form of nitrogen available to trees and therefore, an indication of nitrogen soil fertility.

Table 4.2 A guild line for evaluating NO_3^-N soil fertility *(Allan and Fulton, 2010)*

Fertility	Ppm	Ibs /acre²
Low	<10	<36
Medium	10 -20	36 -72
High	20 -30	72 – 108
Excessive	>30	>108

Form the table it indicate that nitrate nitrogen content is low in fertility in F1 and F2 which ranges from 8.25 at F1A to 12.95 F1B mean of 10.79±0.8373 when compare to the control site with a range value of 5.90 to 12.35 and a mean concentration of 9.125±2.28.

4.5 Phosphate (mg/kgPO_4^{3-}).
From control farm land (Futo Farm) the phosphate ranged from 42.4mg/kg at depth of 0-15cm at pH value of 8.2 to a depth of 15-30cm it is 31.4mg/kg at a pH of 5.2 with a mean concentration of 36.9±3.889 because precipitation of phosphorus as slightly soluble calcium phosphate occur in calcareous soil with pH values around 8.0. Under acid conditions, phosphorus is precipitated as Fe or Al phosphate of low solubility maximum availability of phosphorus generally occurs in a pH range of 6.0 to 7.0. This is one of the beneficial effect of liming acid soil. Maintaining a soil pH in the range also favour the presence of $H_2PO_4^-$ Ions which are more readily absorbed by the plant than HPO_4^+ ions, which occur at pH values above
7.0, therefor At F1A the phosphate content of is 36.4mg/kg at a pH of 6.9 and at F1B it is 33.6mg/kg at a pH of 5.2 and in F2A the phosphate content is 35.0 mg/kg at a pH of 6.2 and in F2B it is 9.30 mg/kg at a pH of 4.9 as shown from the table above and is fairly acidic when compare with the control farm.

4.6 Phosphate (mg/kg p)
From control farm land (FUTO Farm) the phosphate is ranged from 13.80mg/kg at depth of 0-15cm at pH value of 8.2 to a depth of 15-30cm it is 10.2mg/kg at a pH of 5.2 and a mean and SEM value of 12±1.273 when compare to the value F1A the phosphate content of is 10.8mg/kg at a pH of 6.9 and at F1B it is 11.00mg/kg at a pH of 5.2 and in F2A the phosphate content is 11.40 mg/kg at a pH of 6.2 and in F2B it is 3.00 mg/kg at a pH of 4.9 as shown from the table above is fairly acidic when compare to the control farm.

4.7 Total Chloride (mg/kg Cl^-)
The total chloride concentration of the polluted soil sample is ranged from 983.95 mg/kg Cl^- to 2368.77 mg/kg Cl^- with a mean concentration of 1637.15±279.45. The sample collected close to dumpsite was lower than those from the control site which ranged from 1247.27 to 947.51 with mean concentration of 1102.39.74±109.52. This is clear indication that the waste dump has affected the quality of the crops grown around the area.

4.8 Sulphate (mg/kg So_4^{2-})
The sulphate concentration of the polluted soil sample ranged from 0.00 mg/kg So_4^{2-} to 15.00 mg/kg So_4^{2-} with a mean concentration of 6.25±2.232 respectively. The sample collected close from dumpsite varied from the control farm land that ranged from 0.00 to 10.00 with a mean of 10±0.00.

4.9 Conductivity

The conductivity of the sample ranged from 98.0 to 212.00 with a mean concentration of 138.75±22.498 collected from a farm close to a dumpsite was higher than those from the control site which ranged from 13.80 to 10.20 with a mean value of 93.2±6.222.

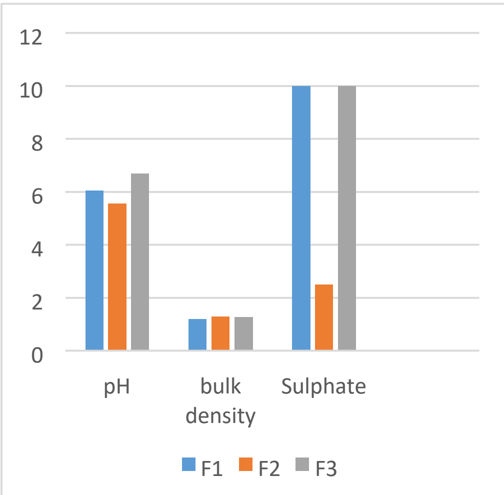

Fig4.0.A Bar chart showing a mean concentration of the pH, Bulk density and Sulphate

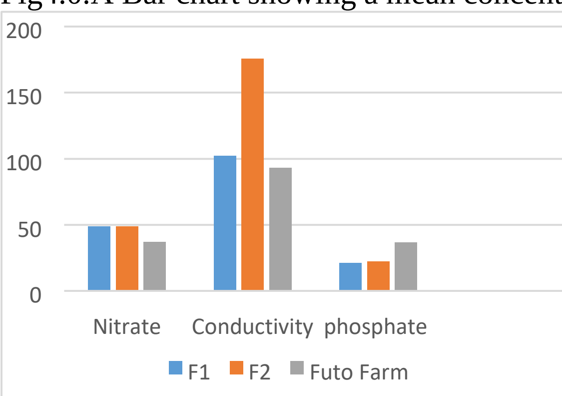

Fig4.1.A Bar chart showing a mean concentration of the Nitrate, Conductivity and Phosphate

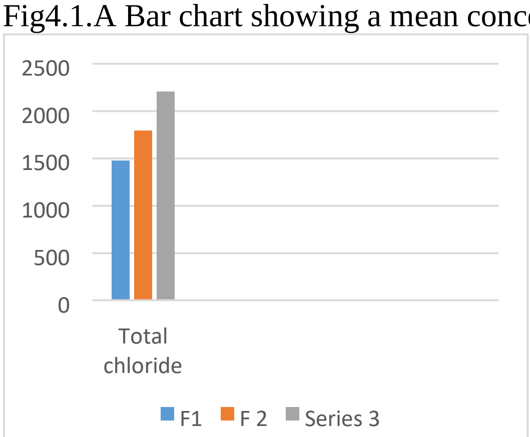

Fig4.2.A Bar chart showing a mean concentration of the Total chloride

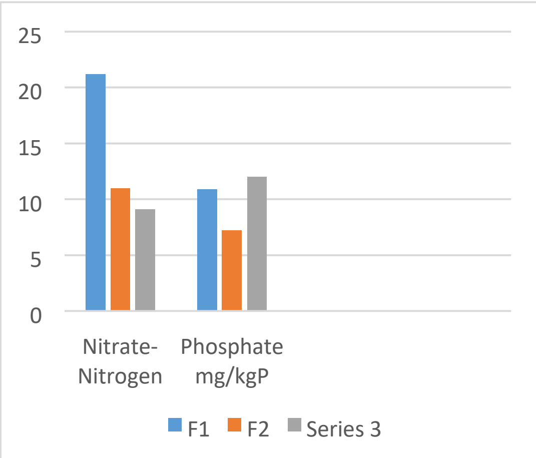

Fig4.2.A Bar chart showing a mean concentration of the Nitrate and Phosphate mg/kgP

Comparison was made with the mean concentration of the parameter analyse from (figure 4) it was indicated that the pH of the various farm was lower than the pH of the control farm, the Bulk density of F1 is lower than the control farm while that of F2 is higher however the phosphate, Nitrate and total chloride concentration is lower than that of the control site while the conductivity is higher than the control farm.

5.0 CONCLUSION

The results obtained from this study showed that:

The pH value was acidic in the farmland close to the dumpsite than in the farmland away from the dumpsite, it was also found that the Bulk density was negligible when compare to the control site.

Nitrate concentration was also reported from the finding to be higher than the control site while that of Nitrate Nitrogen than to be lower in fertility. The phosphate concentration value was acidic in the polluted site when compare with the unpolluted site.

Sulphate concentration in polluted site varied slightly from the unpolluted site and conductivity was less than that of the unpolluted site. Hence there is need for understanding of the impacts of dumping waste on soil physicochemical characteristics. Knowledge of such study would help in sound agricultural practice, Solid waste dumpsite should be created by relevant authority, and these site should be far away from a farmland. By doing this, strict environmental laws and regulation should be put in place for anyone who breaks the law, by this, people would be careful in the way and manner they dump waste. There should be provision of adequate disposal facilities by government authority and agencies to each residential area/household to aid proper refuse collection and effective disposal.

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