Global Research in Environment and Sustainability
October 2023, Vol. 1, No. 8, pp. 31-39.

Soil Contamination and Sustainability of Open Market in Ihiagwa, Imo State, Nigeria

Iheriohanma, C. C, Nwachukwu, M. A., Ejiogu, C. C., Uyo, C. N., Iwuji, M. C., Nmecha, I. M., Onwuagba, C. G., and Esomonu, I.

1. Department of Environmental Management, Federal University of Technology, Owerri, Nigeria

Abstract:
The open market system presently adopted in Ihiagwa and across sub-Sahara Africa without proper management of market waste is causing serious concern to environmentalists and society. The case of Ihiagwa is peculiar, due to the high population density resulting from the presence of three big Federal institutions within and around Ihiagwa. In this study, three (3) soil samples were collected from 0-20 cm depth following the direction of natural drainage obtained by drainage analysis. Inversion resistivity measurement conducted showed subsurface lithology to the depth of the water table as shallow (11m) which indicates highly vulnerable. The soil samples were subjected to physiochemical and metal content analysis using standard analytical techniques. The physiochemical analysis of the soil samples revealed organic matter (OM), nitrogen concentration, phosphate, potassium and sodium (Na) to be above the FAO permissible limit, and significant levels of Pb, Zn, Cu and Iron giving a mean of 3.11mg/100g. Soil pollution load index (PLI) is >1 which indicates pollution. The overall analysis strongly confirms that the open market system in Ihiagwa is not environmentally friendly and not a sustainable practice in the area. The lack of waste management and population pressure has subjected the market to serious environmental stress calling for alternative markets such as establishing private shopping malls and plazas in the area.

Keywords: Open Market, Waste Dumping, Environmental Degradation, Soil Pollution, Sustainability.

INTRODUCTION

The ripple effect associated with waste dumping in Nigeria is underemphasized. According to Ozoh et al., (2021), indiscriminate waste dumping in most urban regions of Nigeria is heavily noted in market areas. These include wastes from several food products sold in such markets, animal wastes, human wastes and equipment wastes. Food poisoning, traffic congestion, aesthetic degradation, reduction in quality of life, and blockage of drainages are some of the problems caused by the lack of efficient waste management practices in these areas (Nwigwe, 2008). Studies conducted by Nwachukwu et al., (2010), also revealed a significant contamination of shallow wells (37 to 67 m deep) from the Owerri west flank of the Imo River basin of Nigeria due to indiscriminate dumping of waste close to urban settlements, lack of good toilet facilities, and transit grazing of cattle.

Solid waste disposal is treated with levity in Nigeria, which may be attributed to the low level of appropriate waste disposal sensitization amongst the public. The nonchalant attitude of people in Nigerian cities towards the health implications of indiscriminate waste disposal has posed a serious challenge to the adoption of modern waste disposal strategies in these areas (Afangideh et al., 2012). The refuse dumps remain in the surroundings of sellers for a long time, decomposing with strong stench, blocking the roads, leaching into groundwater systems and preventing ease of movement in and out of the market. In many nations of the world today, people, industries and local governments have polluted rivers, streams, and lakes through dumping of waste materials (Ogunbameru and Rotimi, 2006). Consequently, the dumping of refuse on the land leads to environmental pollution in the form of air, water and land pollution. This is because land pollution in the form of refuse and sewage produces an offensive odor and an ugly sight. This affects the oxygen from the air and perhaps accounts for one reason why air pollution according to the European Public Health Alliance (EPHA, 2009) is one of the most common forms of pollution throughout the world. Again, poor refuse and sewage disposal contaminates the well through dirty flowing water and pollutes the water with which meals are prepared in market restaurants and the water intake of individuals. The heaps of dirt further prevent the flow of water into other wells thus discouraging the digging of additional wells and making available water unsafe for drinking.

The lack of adequate management of refuse dumps which has contributed to the increasing pollution of the environment is still a clog in the wheel of environmental development in Owerri-west Local Government Area of Imo State (Taiwo and Ajayi, 2013). (Ugorji et al., 2020) reports open dumping of waste as the main waste disposal method, which is not only a source of environmental pollution but has become less adaptable in a town where land is becoming scarce due to population increase and high demand for physical development. The consequences of which are evident in stench and offensive smell, dirtiness of the environment and disease infestation. These pollute the air people breathe and adversely affect their health. Also, the source of water supply which is mostly wells in the market which are also polluted with the water that flows in from dirty drainages and water from animal dung are used to cook foods in the market which most of the marketer eat in their restaurants. All these can predispose marketers and their wards to waterborne diseases like typhoid, dysentery, diarrhea, cholera and other physical discomforts such as stench and aesthetic deprivation. It is against this backdrop that the study seeks to examine the impact of waste dumping on soil properties in the Ihiagwa market, Owerri West Local Government Area of Imo state.

MATERIALS AND METHODS

Study Area

Ihiagwa, situated in the Owerri West Local Government Area of Imo State, Nigeria, is a town located to the south of Owerri, the state's capital, at a distance of 12 km (7.5 mi) with a land area of 44,904 m² and a population of more than 20,000 (Nwachukwu *et al*., 2012a). It consists of eight distinct villages: Umuelem, Umuchima, Mboke, Nkaramochie, Iriamogu, Aku/Umuokwo, Ibuzo, and Umuezeawula. Ihiagwa has been split into two self-governing communities: Ihiagwa Ancient Kingdom (Chimelem), encompassing Umuelem and Umuchima; and Dindi-Ihiagwa, including the remaining six villages.

Ihiagwa is a community hosting the Federal University of Technology Owerri (FUTO) and in close proximity with two other Federal institutions located at its neighboring communities Nekede and Obinze precisely. The three Federal establishments are situated in close proximity, resulting in shared neighboring or host communities. These two institutions collectively accommodate a growing student population of over 35,000 individuals and a staff contingent exceeding 6,000 individuals (Nwachukwu *et al*., 2012a). This expanding population of students and employees is placing considerable strain on the host and nearby communities due to increased urbanization and improper waste management strategies (Nwachukwu *et al*., 2012a). A significant portion of students reside off-campus, while a substantial number of staff members seek lodging in the vicinity due to the considerable distance between the institutions and the city of Owerri or Owerri urban center. The surrounding area comprises four sizable communities: Ihiagwa, with an approximate population of 23,000; Nekede, with around 20,000 residents; Eziobodo, hosting about 10,000 people; and Obinze, with a population of roughly 15,000 individuals (Nwachukwu *et al*., 2012a).

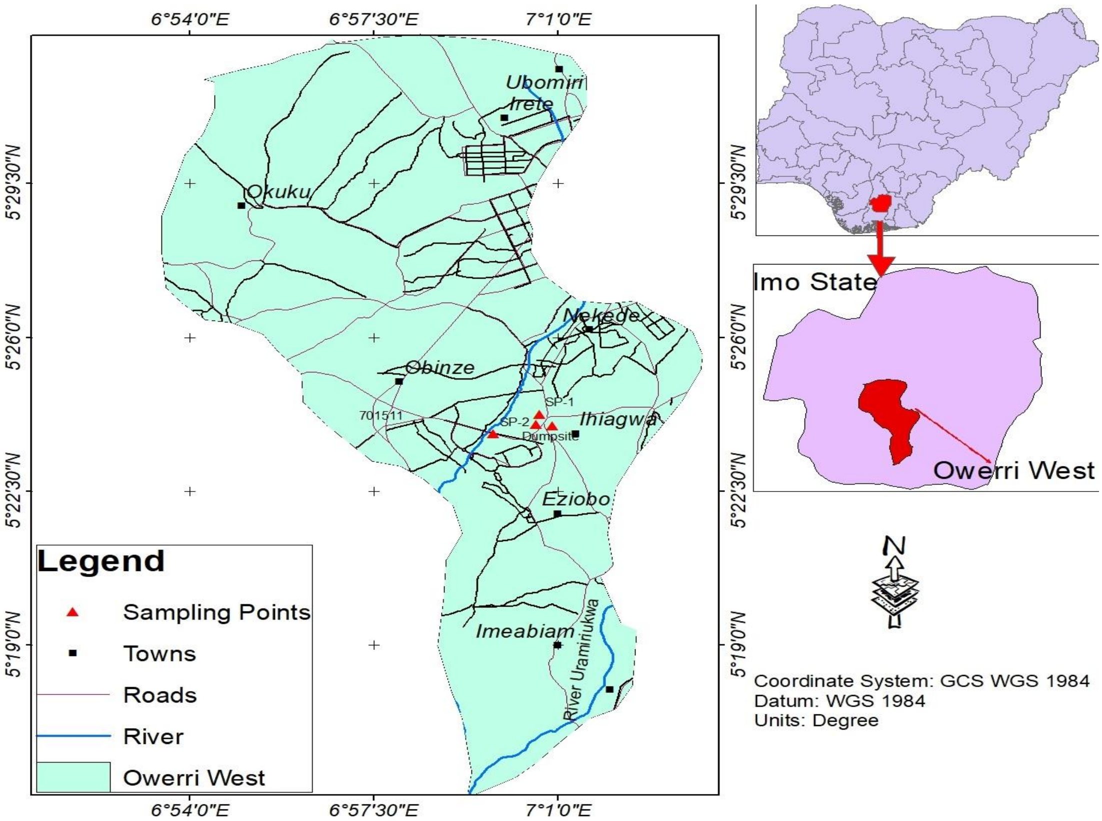

Fig. 1: Study Area Showing Sampling Points

Collection of Samples

Soil samples were collected from a total of three different locations using a hand auger from a depth of 15mm down the soil profile in an all the location and mixed to form a single sample method known as the composite method. This method of soil collection was done for the three different locations (market square, health center and Nkaramoche) in Ihiagwa. The soil samples were put inside a well labeled polythene bag for easy identification and sent to the laboratory for the required physiochemical analyses. The soil samples were air dried and stored at room temperature for laboratory analysis. The physiochemical parameters analyzed were; pH, % organic carbon, % organic matter, % nitrogen, available P, exchangeable acidity, exchangeable calcium, exchangeable Mg, exchangeable potassium, Magnesium, exchangeable Sodium, Iron, Copper, Zinc, % sand, % silt and % clay.

Determination of Parameters

The soil pH was carried out using a Glass-electrode pH meter. This was determined by preparing 1:2.5 soil to water ratio. 20g of air-dry soil was weighed into a 50ml beaker. 20ml of distilled water was added and allowed for 30 minutes. The mixture was stirred occasionally using a glass rod. Electrodes of the pH meter were inserted into the partly settled suspension and the pH was measured and reported as pH in water. The pH meter was calibrated with pH 7.0 and pH 4.0 buffer before use. The same procedure was carried out on 0.01 M $CaCl_2$ at 1:1 ratio of soil solution and 1N KCl ratio 1:2.5 soil to solution ratio.

The organic carbon was determined using the Walkley-Black method. Soil samples were weighed out in duplicates and transferred to 250ml Erlenmeyer flask. 10ml of 1N $K_2Cr_2O_7$ solution was pipetted into each flask and swirled gently to disperse the soil. 20ml concentration of H_2SO_4 was rapidly added using an automatic pipette. The flask was swirled until soil and reagent are mixed and allowed to stand for 30 minutes. 100ml of distilled water was added, 3-4 drops of indicator were added and titrated with 0.5N ferrous sulfate solution. The solution changes to dark green. Ferrous sulfate drops were added until the colour changed from blue to red. This formula was used to calculate:

$$\text{\% Organic C in soil (air dry basis)} = \frac{(\text{me } K_2Cr_2O_7 - \text{me } FeSO_4) \times 0.003 \times 100 \times (f)}{\text{g of air-dry soil}}$$

Correction factor, f = 1.33
me = normality of solution x ml of solution used
% Organic matter in soil = % Org. C x 1.729

The total nitrogen was determined using Regular Macro-Kjeldahl Method. 10g of soil sample was weighed in a dry 500ml Macro-Kjeldahl flask. 20ml of distilled water was added, stirred and allowed to stand for 30 minutes. 1 tablet of mercury catalyst and 10g of K_2SO_4 was added. Also, 30ml of concentrated H_2SO_4 was added through an automatic pipette. The mixture was boiled for 5 hours. The flask was allowed to cool and 100ml of water was added to the flask. The sand residue was washed with 50ml of distilled water four times and transferred into the same flask. 50ml H_2BO_3 indicator solution was added into a 500ml Erlenmeyer flask. The 750ml kjeldahl flask was attached to the distilled apparatus and 150ml of 10N NaOH poured through the distillation flask to commence distillation. The condenser was cooled below 30°C. 0.01N standard HCl was titrated using 25ml burette at 0.1ml intervals. The colour changed from green to pink. The %N content in soil was then calculated.

For available phosphorus (P), 5ml aliquot of the soil extract was pipetted (Olsen extracts) into 25ml volumetric flask and 10ml of distilled water was added. 4ml of reagent was added to make up to volume distilled water. The colour was allowed to develop for 15 minutes and the P content in solution was determined on a spectrophotometer at 882 mμ.

For Exchangeable Potassium (K), Sodium (Na) and Calcium (Ca), a flame photometer was set up and instrument calibrated using standard solutions. The meter was set at zero while aspiring distilled water of blank solution. The meter reading was set at 100% E (emission) while aspiring the top concentration of standards. The % E reading was recorded at intermediate standard solution and plotting standard curve on linear graph paper. The % E reading was recorded checking 0 and 100% E reading with blank and top standard after every 10 to 20 sample determinations. The concentration of the element in sample solution was read from the standard curve and K, Na and Ca contents in soil was calculated.

For Magnesium (Mg), Copper (Cu), Zinc (Zn) and Calcium (Ca), The Perkin-Elmer Model instrument was set according to the PE 403 Atomic Absorption Spectrometer. The concentration readout was standardized using the standard solutions of the element tested and the concentration of the element in sample solution was read.

Contamination Factor and Pollution Load Index

To assess the level of contamination in the soil, the contamination factors (Cf) and pollution load index (PLI) are calculated and computed using (Esshaimi *et al.*, 2012; Forstner and Calmano 1993) presented in equation 1 and 2.

$$CF = C_{\text{heavy metal}}/C_{\text{background}} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

$$PLI = (C_f1 * C_f2 * C_f3 \ldots\ldots..Cfn)^{1/n} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Where CF is the ratio obtained by dividing the concentration of each metal in the soil by the background value (Eq. 1) and n is the number of metals considered in the study.

Statistical Analysis

Statistical analysis of the data was by a TWO-WAY analysis of variance (ANOVA) without replication with an alpha value of p<0.05 for significance. Related Parameters (Heavy metals and physiochemical) were categorized, and then analysed to show significant degree of differences between the sample sites.

RESULT AND DISCUSSION

Table 1: Physiochemical Parameters of Soil Samples

PARAMETER	UNIT	SAMPLE 1	SAMPLE 2	SAMPLE 3	Mean	FAO
Coordinates		**$5^0 24^1 13^{11}$N $7^0 0^1 45^{11}$E**	**$5^0 24^1 9^{11}$N $7^0 0^1 39^{11}$E**	**$5^0 24^1 24^{11}$N $7^0 15^{11}$E**		
PH in water (1:25)		7.40	7.99	5.73	7.04	6.5-8.5
% Organic Matter		5.528	3.307	2.201	3.67	3
EC	us/cm	305	301	220	275.33	300-500
% Nitrogen		2.348	1.170	0.226	1.248	0.1-2.0
Available P	(Ppm p/g)	20.93	21.07	12.04	18.01	10-20
K	mg/100g	8.37	6.08	5.39	6.61	0.3-0.5
Na	mg/100g	5.27	5.65	7.14	6.02	0.3-0.5
Fe	mg/100g	3.425	3.117	2.788	3.11	0.05
Mn	mg/100g	2.855	2.763	2.429	2.68	NS
Cu	mg/100g	2.831	2.415	1.328	2.19	2
Zn	mg/100g	2.174	1.768	1.565	1.83	8.6
Mg	mg/100g	4.05	1.10	0.36	1.83	NS
Pb	Mg/100g	0.002	0.001	0	0.001	0.001
Exchangeable acidity	(cmol/kg)	5.16	0.60	1.12	2.29	NS
Exchangeable Ca		30.60	20.60	4.00	18.4	10-50
Exchangeable Mg		3.05	0.36	1.10	1.50	<5
Exchangeable K	(mg/100g)		0	0	0	
Exchangeable Na			0	0	0	
% sand		97.66	95.68	87.68	93.67	
% silt		2.0	2.00	8.00	4.00	
% clay		0.32	2.32	4.32	2.32	

EC= Electrical conductivity, K = Potassium, Na = Sodium, Fe = Iron, Mn = Manganese, Cu = Copper, Zn = Zinc, Mg = Magnesium, Ca = Calcium, Pb = Lead, FAO= Food and Agricultural Organization

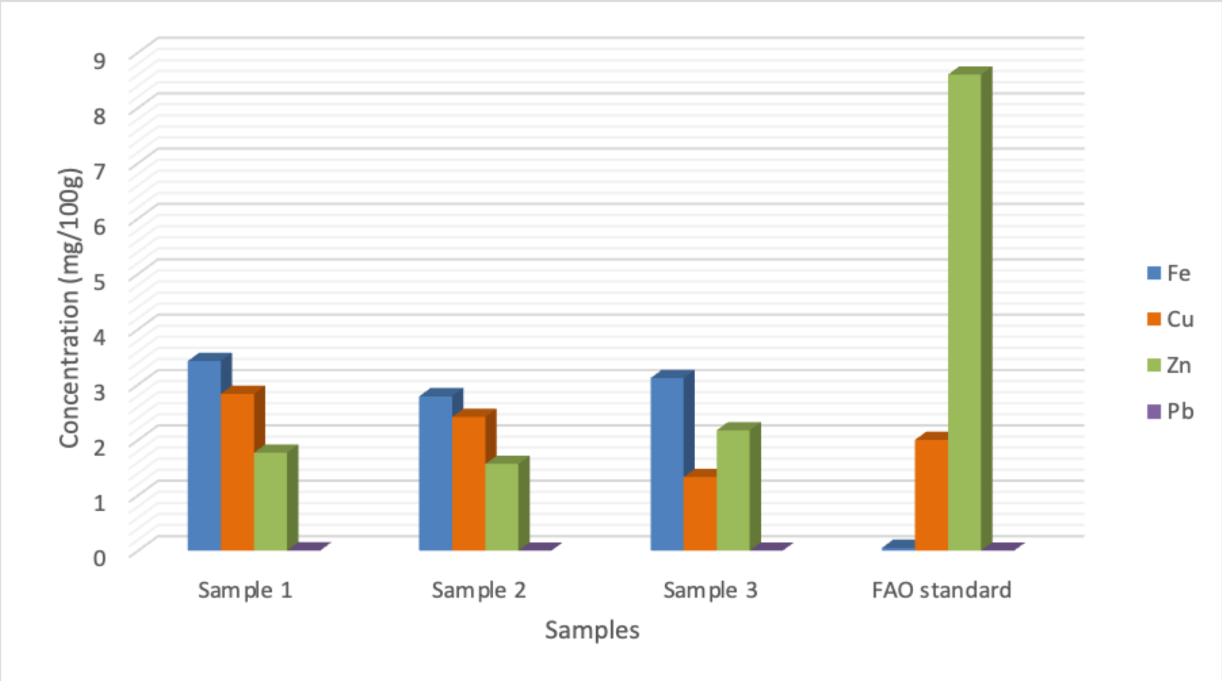

Figure 2: Heavy Metal Levels of Soil Samples Collected

Geophysical Result

The result acquired from the field was presented using the apparent resistivity values which was gotten from the automatic analysis of raw data gotten from the study area using the Advanced Geosciences Incorporation (AGI) ID software.

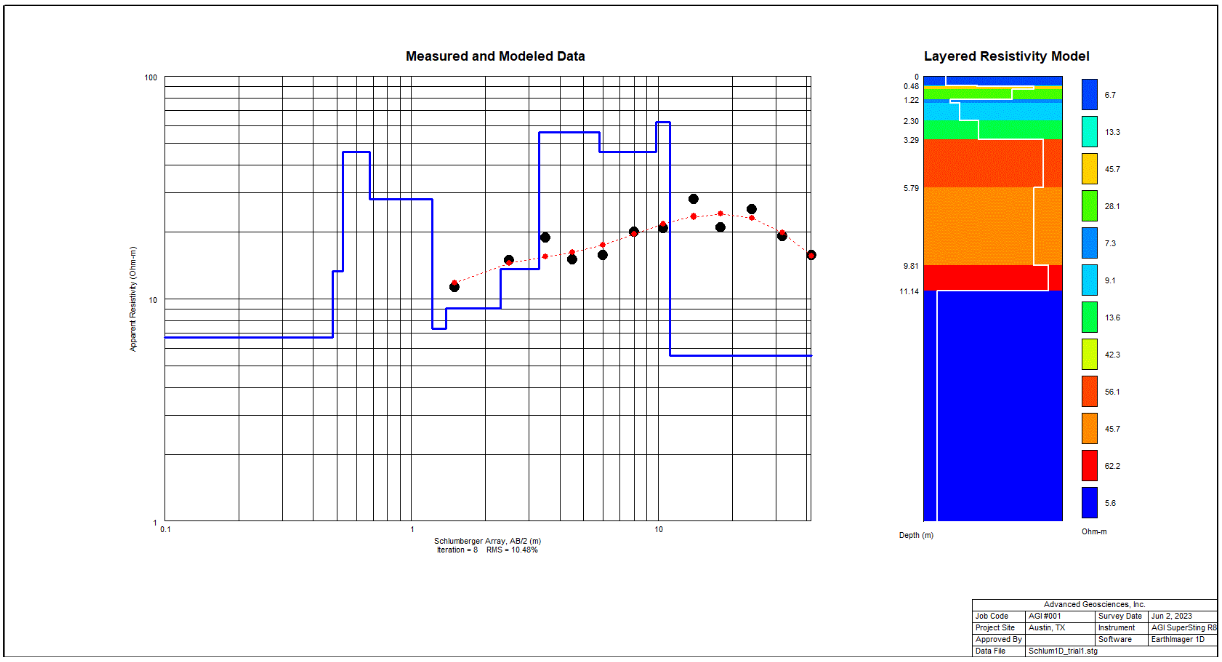

Fig 3: VES Model Result for Ihiagwa Market

Table 2: VES Analytical Result in Constrained Lithological Layers

Layer	Ohm-m	Depth (m)	Colour	Lithology
1	45.70	0.677	Brown	Topsoil (sandy)
2	7.34	1.382	Blue	Subsoil
3	42.25	3.300	Green	Subsoil
4	56.11	5.794	Red	Red earth
5	45.75	9.811	Orange	Silty sand
6	62.23	11.141	Light red	Siltstone
7	5.58		Blue	Saturated Aquifer unit

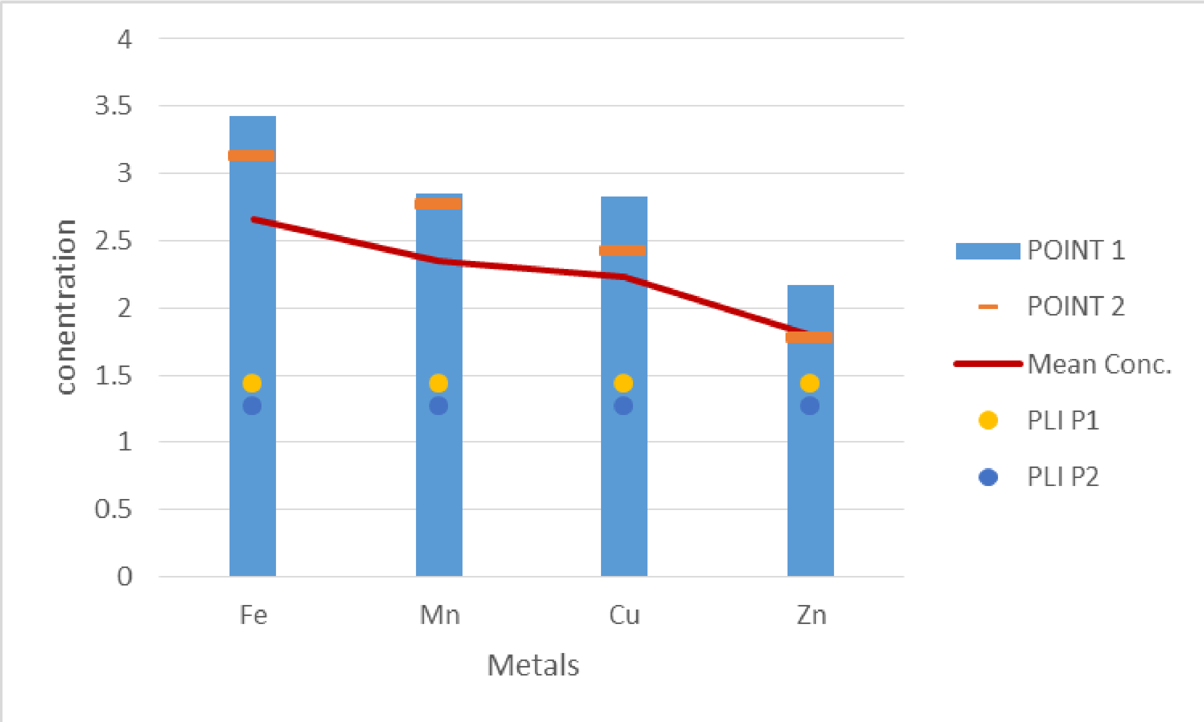

Fig 3.3: variability chart for PLI

Table 3: metal analysis and pollution load index

Metals	Point 1	CF point 1	PLI P1	Point 2	CF point 2	PLI P2	mean conc.	Point 3
Fe	3.425	1.228	1.438	3.117	1.118	1.272	2.66	2.788
Mn	2.855	1.175	1.438	2.763	1.138	1.272	2.352	2.429
Cu	2.831	2.132	1.438	2.415	1.819	1.272	2.228	1.328
Zn	2.174	1.389	1.438	1.768	1.130	1.272	1.793	1.565

The Ihiagwa market waste dumpsite contains various kinds of wastes from the environment and waste disposals; these are mainly organic wastes and food packaging materials. Result of Physiochemical and heavy metal analysis of the soil (Table 3.1) showed that the pH of the soil samples was below the permissible limit of 6.5 to 8.5 at sample 3 with a pH of 5.73, while sample 1 and 2 were within the permissible limits with a pH of 7.40 and 7.99 respectively. Organic natter (OM) was also above the FAO permissible limit of <3 at sample 1 and 2 with an OM of 5.528 and 3.307 respectively, while sample 3 recorded a 2.201 OM. Electrical conductivity (EC) of the samples ranged from 220µs/cm to 305µs/cm which was within the FAO permissible limit of 300-500µs/cm. Nitrogen concentrations in the soil ranged from 0.226% to 2.348% with sample 1 slightly above the FAO permissible limit of 0.1-2.0%. Available Phosphorus ranged from 12.04ppm/g to 21.07ppm/g with sample 1 and 2 above the FAO permissible limit of 10-20ppm/g. Potassium levels were all above the FAO permissible limit of 0.3-0.5mg/100g with the three samples reaching 8.37mg/100g, 6.08mg/100g, and 5.39mg/100gsd. High K concentrations in the soil solution inhibit Mg uptake and may induce Mg deficiency in plants (Trankner *et al*., 2018). Na levels were also higher than the FAO permissible limits of 0.3mg/100g – 0.5mg/100g for the three locations with 5.27mg/100g, 5.65mg/100g, and 7.14mg/100g for samples 1, 2 and 3 respectively. Root exposure to high sodium concentrations causes wilted foliage and stunted plant growth, which would impact negatively on the crop plants of the area.

Soil analysis conducted revealed the levels of various heavy metals in the soil such as Pb, Zn, Mn, Cu, and Fe in the Ihiagwa market waste dumpsite as shown in the result (Table 1). The levels of lead (Pb) in the soil were above the FAO and FME permissible standards with sample 1 at 0.002mg/100g, and sample 2 at 0.001mg/100g. Statistical analysis conducted for heavy metals on all samples showed significant levels of Pb with $p < 0.01$. The magnesium concentration of the soil was within the FAO and FME permissible limits of <5mg/100g. Zinc in the soil samples ranges from 1.565 mg/100g to 2.174mg/100g with an average mean of 1.835 mg/kg which were within the (FME, 2006) permissible limit of 5.00 mg/kg. The concentration of Cu contained in the three different soil samples ranges from 1.328mg/100g - 2.831mg/100g which were all above the FAO and FME permissible limits of <2mg/100g. Iron concentration in the soil samples is from 2.788mg/100g to 3.425mg/100g with a mean average of 3.11mg/100g. All the soil samples contain higher concentrations of iron when compared to the (FME, 2006) permissible limit of 1.00mg/100g which is a problem as Iron is toxic when it accumulates to high levels.

CONCLUSION

The investigation of the environmental impacts of waste dumping on soil and in Ihiagwa market has revealed that waste accumulated due to the improper waste dumping as disposal method affects the soil quality and is capable of altering the composition of the environment. The heavy metal pollution level in the study area can be linked to the indiscriminate dumping of waste in the area as the metal pollution is not of natural decomposition.

The environmental quality assessment in this study is based on a comparative analysis of soil. Based on soil contamination and pollution index, open market degrades the environment and therefore establishment of open markets without proper environmental management approaches should be discouraged. The pollution index load values also showed significant pollution level in determining the heavy metal concentration. This indicates presence of heavy metal pollution in the soil of the study area. This causes deterioration of the soil quality attributed to the dumping of waste directly on the soil surface as contaminates easily penetrate and contaminate the soil posing potential risk on the soil.

The physiochemical analysis results obtained from the soil sample revealed organic matter, nitrogen concentration, phosphorus, potassium and sodium were above the FAO permissible limit. Soil analysis conducted also revealed presence of heavy metals in the soil such as lead, zinc, magnesium, copper and iron.

The result obtained from the analysis has revealed the presence of different contaminates in the study area which contributes to environmental problems associated with improper waste disposal method and waste management. This confirms that the practice of open market system without waste management system is not environmentally friendly and not a sustainable practice and as such poses potential risk to soil.

REFERENCES

Afangideh, A.I., Joseph, K.U. and Atu, J.E. (2012). Attitude of urban dwellers to waste disposal and management in Calabar, Nigeria. European Journal of Sustainable Development, 1(1): 22-34.

EPHA, European Public Health Alliance (2009) Air, Water Pollution and Health Effects. https://epha.org/category/website-transfer/attic/old-environment/air-water pollution-and-health-effects/

FME, Federal Ministry of Environment (2006) National Policy Guidelines on Food Sanitation. *Federal Ministry of Environment*

Forstner, U, Ahlf, W, Calmano, W (1993). Sediment quality objectives and criteria development in Germany. *Water Sci. Tech*., 28(8-9) (1993) 307-316.

Mouhsine, Esshaimi, Ouazzani, Naaila, Avila, Marta, Perez, Gustavo, Valiente, Manuel and Mandi, Laila. (2012). Heavy Metal Contamination of Soils and Water Resources Kettara Abandoned Mine. *American Journal of Environmental Sciences*. 8. 253-261. 10.3844/ajessp.2012.253.261.

Nwachukwu, M. A., Feng, H., & Alinnor, J. (2010). Assessment of heavy metal pollution in soil and their implications within and around mechanic villages. *International Journal of Environmental Science & Technology*, *7*, 347-358.

Nwachukwu, M. A., Ohuawunwa, C., Nwachukwu, I., & Nnorom, U. (2012a). Sustainable water supply from boreholes in neighborhood communities besieged by off-campus students. Int. J. Water Res. Environ. Eng, 4(11), 352-362.

Nwigwe, N. (2008): Problems and Prospects of Refuse Disposal in Nigerian Urban Centres. International Journal of Natural and Applied Sciences, 4 (3): 98-107.

Ogunbameru, K. and Rotimi, W. (2006). Man, and His Social Environment: A Textbook of Sociology, Spectrum Books Limited, Ibadan, Nigeria.

Ozoh, Augustine, Longe, Blessing, Akpe, Victor and Cock, Ian. (2021). Indiscriminate Solid Waste Disposal and Problems with Water-Polluted Urban Cities in Africa. Coastal Zone Management Journal. 24. 1000005.

Taiwo, P. A and Ajayi, J. O. (2013). Environmental Pollution in Urban Market: The Case of Bodija Market Ibadan, Nigeria. *Environmental Pollution*, 3(13).

Tankner, M, Tavakol, E, and Jakli, B (2018). Functioning of potassium and magnesium in photosynthesis, photosynthate translocation and photoprotection. *Physiol. Plant*. 163, 414-431. Doi: 10.1111/ppl.12747

Ugorji, H. I, Onwujiariri C. M, Nkwocha E. E (2020). Solis Waste Generation and Disposal in Owerri Municipality, Imo State, Nigeria. *International Journal of Scientific Engineering and Science.* Vol 4(7) pp67-73