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EFFECTS OF WASTE DUMPSITE ON SOIL PHYSICO-CHEMICAL PARAMETERS AND PERI-URBAN AGRICULTURE IN BENIN CITY, NIGERIA

J. L. IGBEN[1] and C. A. IHAYERE[2]

[1,2]Department of Environmental Management and Toxicology, Western Delta University, Oghara, Delta State, Nigeria
Corresponding Author: E-mail: joma_igben@yahoo.com . Tel.:234 803 403 7691

Abstract
This study examines the effects of waste dumpsites on the physical and chemical properties of soil and its indirect impact on peri-urban agriculture potentials in outer limit of Benin City, Nigeria within the framework of Population-Environment (P-E) inter-relationship. It aims to analyse the physical and chemical variables of soils as impacted by dumpsites and ascertain its suitability for arable farming. A total of four (4) soil samples were collected around the sampled dumpsite at 20m interval. Ten physico-chemical parameters: soil particle size, pH, electrical conductivity (EC), moisture content, organic carbon, phosphorus (P), potassium (K), sodium (Na), magnesium (Mg) and calcium (Ca) were analysed. The spatial variation in these parameters was tested using the One-way Analysis of Variance (ANOVA). The study revealed that there was a significant spatial variation ($F= 0.065$, $df=3; 44$, $p<0.5$) in physico-chemical properties as a result of waste dumpsite. However, the organic content of the soils around dumpsite was enhanced as a result of decayed materials; thus, boosting agriculture potentials. The study recommends that efforts should be made to control the size of dumpsite periodically in order to make more land, which is usually in short supply due to urban encroachment available for agriculture.

Keywords: Peri-urban agriculture, waste dumpsites, soil pollution, population-environment linkage,

INTRODUCTION

Urban areas are dominated by secondary and tertiary occupations such as such as manufacturing, construction, mining, electricity, power and gas, transportation and communication, trade, finance, personal and domestic business and government services. However, there exist at their periphery a few primary activities such as farming, livestock and horticulture, in areas yet to be annexed by rapid urban growth. Peri-urban primary occupations such as farming involve the cultivation of crops and rearing of animals at the outer limits or outskirts of urban settlements. Products of this type of farming include vegetables and domestic animals such as goats, pigs and poultry products, which are sold in the urban markets. According to Igben and Itabita (2020), agricultural activities comprise human and physical aspects. While the former constitutes the agricultural labour force or farmers, the latter is the physical or environmental condition including soils, crops grown and animals reared. Therefore, soil is a critical component of successful agriculture and is the main source of nutrients required by crops (Valera, 1977). Agricultural production in per-urban areas is affected by waste dumpsites found mostly at the outskirts of major cities in Nigeria, Benin City inclusive; thus, competing for space with agriculture.

Waste is a relative term that is used to describe any liquid, soluble solid and movable substance that is no longer useful to the immediate owner and therefore disposable. Its relativity is dependent on its usefulness to the individual or persons; hence, Das (1992) cited in Joshi and Joshi (2009) asserted that waste is a resource at the wrong place, time and concentration. They include municipal waste, garbage, industrial waste, domestic waste, military waste and mining waste. Furthermore, they have been classified into hazardous and non-hazardous waste based on its effects on the environment. Non-hazardous waste does not pose any serious problem to environment and health of the population while hazardous waste, because of their physical, chemical or biological composition pose dangers to the environment and therefore requires special handling or disposal procedure to avoid risk to human health or other adverse effects on the environment (Akpofure, 2009). Various types of waste are usually generated from the households that constitute the population of any area being it urban or rural, depending on the nature of economic activities of the people. In other words, the type and volume of waste generated by households is influenced by their level of the socio-economic advancement as people consume the available resources and produce waste.

Urban waste, also known as refuse, which comprises garbage, plastics, metals, fibre, paper, glasses, tin-containers, fuel residues etc. has been identified as one of the major sources of soil pollution all over the world (Joshi and Joshi, 2009). The effect is more severe around dumpsites as they impede the capacity of the soil to function as a miniature ecosystem to support plants and animals, resist erosion and reduce negative impacts on associated air and water resources. According to Essien and Hanson (2013), dumping the waste on soil is one means which the soil quality is degraded. The interaction of these wastes with water (snow, rain) produces toxic filtrate water that flows through soil pores and can reach aquifers. Therefore, dumpsites pollute the soil by altering the physical and chemical constituents of the natural soil in a manner that disrupts the soils food web, reduce the soil's biodiversity and productivity (Akpofure, 2009).

The impact of municipal or urban waste dumpsite on soil properties was the focus of Agbeshie *et al* (2020) study. The study evaluated heavy metal contamination around waste dumpsites and determines the risk of heavy metal pollution and physiochemical properties of soil samples in Suyani, Ghana. Samples for the study were collected from a depth of 0-30cm within three demarcated zones of the dumpsites; namely, top-site, dumpsite and down-site. Physiochemical properties and heavy metals (e.g. Lead, Zinc and Cadmium) were analysed. The study revealed that soil at the dumpsite were heavily contaminated with Fe >30mgkg^{-1} as opposed to less than 0.55mg kg^{-1} for the remaining heavy metals (As, Cd, Pb and Zn). Similarly, Mouhoun-Chouaki *et al* (2019) study of the impact of municipal solid waste (MSW) on some soil physico-chemical properties in Ain-El-Hamman, Algeria indicated that MSW enhances the organic matter content of soils by 4.53% and increased heavy metal content, which indicated a clear level of pollution.

Ajibade *et al* (2021) studied the influence of uncontrolled deposition of municipal solid waste (MSW) on the physico-chemical properties of four selected dumpsites on the physico-chemical properties of soils in Akure, Nigeria. The soil samples used for the study were collected at a depth of 0-10, 10-20, and 20m at 20m distance from dumpsites. The variables measured include pH, total organic matter, carbon and soil particle size. Results show that samples were predominantly acidic (4.12 – 6.73) with values ranging from 0.17 – 4.14 and 0.02 to 3.15 for organic matter and organic carbon respectively. An indication that dumping has effects on soil the physico-chemical properties.

Furthermore, pH values increased with increased distance from the waste dump and soil quality impairment 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. However, High organic matter discovered around wastes dump favours increased moisture content (MC), water holding capacity (WHC) and permeability (Ibitoye, 2001). Available phosphorus decreased with increase in distance away from the respective dumpsites. The Food and Agricultural Organisation (FAO) standard value for phosphorus ranges of 7 to 20mg/kg.

Most of the studies on waste dumpsites dwell on their effects on the physical and chemical characteristics of the soil with little or no attention paid to peri-urban agriculture; hence, this study examines the effects of dumpsites on the physical and chemical properties of soil in urban fringes of the study area vis-a-vis farming. Therefore, the study is aimed to (i) analyse the physical and chemical variables of soils at specific interval around a selected dumpsite in the study area and (ii) ascertain the suitability of soils for peri-urban agriculture. The study is predicated on the hypothesis that there was no significant spatial variation in the physical and chemical properties of soil around waste dumpsite in the study area

The theoretical framework of this study is one of the numerous theories of Population – Environment (P-E) linkages: namely. Pressure – State – Response Model, proposed by Harrison and Pearce (2001). The model, in its original form indicates that population pressure on the physical environment, which may be in form of a particular human activity, such as urbanisation, causes impact on the environment. The level of pressure or impact is determined by population size, consumption and level of resource use and waste output these generate. The pressures lead to environmental degradation and depletion. The responses to this state of the environment are scarcity, loss of amenities, and hazards, which are in forms of feedbacks. Filters, which include science, monitoring, political, legal, market and property systems set the overall conditions for the operation of other parameters.

Lastly, the society responds to these consequences of population pressure and subsequent degradation of the physical environment are in forms of price shift, changes in behaviour, culture and technology and resource management. Other responses are policy measures, regulations, taxation subsidy and so on.

In applying the model to this study, urbanization and consequent population increase lead to increased generation of a variety of wastes, both solid, liquid and gaseous, and consequent emergence of legal and illegal waste dumpsites; thus, resulting in environmental degradation. The degraded environment particularly at the urban fringes reduces land for peri-urban agricultural activities. The demand for the products of this type of agriculture by urban dwellers may result in the high prices for agricultural products.

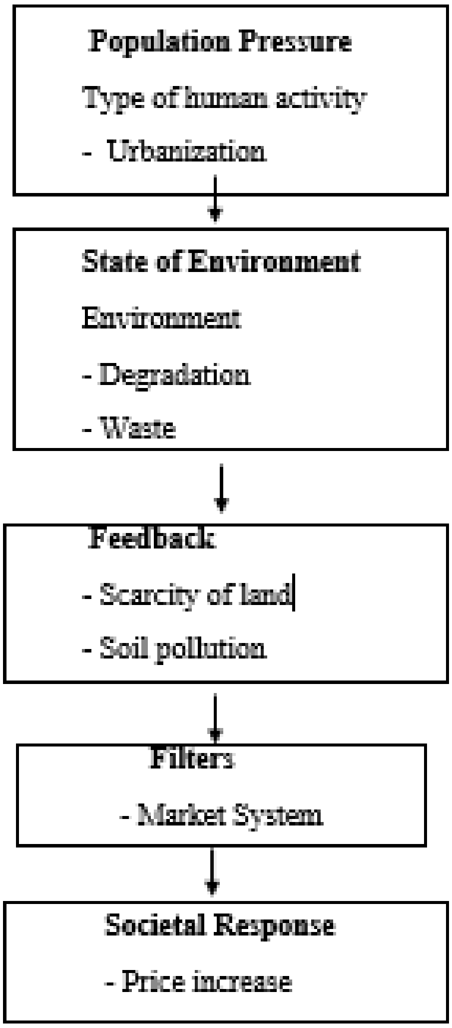

Figure 1: Effects of Waste Dumpsites on Soils and Peri-urban Agriculture. Adapted and modified from Harrison and Pearce (2001)

MATERIALS AND METHOD

Study Area

Benin City is the capital of Edo State, Nigeria. It is located roughly between longitude 5°34’E to 5°44’E and latitude 06°19’North to 6°21’ North over an estimated area of about 1,204km^2.The size of the city is due to territorial annexation of neighbouring settlements which together constitute three political division or local government areas (LGAs); namely, Egor, Oredo and Ikpoba-Okha. Its average elevation above sea level is 77.8m and is underlain by the Benin formation, which is also known as the sedimentary formation of the Miocene-Pleistocene-age (Odemerho, 1988). The city is located in the humid tropical rainforest belt of Nigeria and is underlain by sedimentary sequence of the Niger Delta sedimentary province. Consequently, the soils are mostly ferruginous ultisols, which are acidic red soils made up of sand, clayey sand and discontinuous clay sequence (Ibrahim and Ikhajiagbe, 2020). On the Koppen’s climatic classification, Benin City belongs to Af category (Igun and Igben, 2018).

The population of the city according to the 1991 national population census was 762,717 persons (NPC,1991) and a projected population of 2.0 million by 2020 at 2.7% growth rate (Igun and Igben, 2018). The rapidly increasing population of the city has resulted in the emergence of unauthorized dumpsites in public, open and unrestricted area within and outskirts of the city. These dumpsites contain mixture of both organic and inorganic waste materials, such as food wastes, papers, cardboards, metals, tins, glass, ceramics, battery wastes, textile rags, plastics, sewage night-soils and other miscellaneous materials such as bricks, ash, fine dust, rubber etc

Sample Collection

The soil samples were collected from a dumpsite located within Ekosodin village at the outskirts of Benin City, Edo State, Nigeria. A total of four (4) samples were collected around the dumpsite at 20m interval, scooping to about 10cm depth. After bulky inorganic objects such as cloth, plastic, glass, rubber, and metal had been sorted out manually, the soil samples were air dried and ground to pass through a 2mm sieve and kept in sterile polythene bags.

Laboratory Analysis

The physio-chemical parameters of soil samples analysed include soil size, pH, moisture content, Electrical conductivity (EC), organic carbon, phosphorus (P), potassium (K), sodium (Na), magnesium (Mg) and calcium (Ca).

Soil Particle Size Analysis

Particle size analysis was determined according to the method of Bouyoucos (1962) and Olayinka *et al*. (2017). In doing this, 50 g of the soil sample was soaked overnight with 50 ml of cogon solution. The mixture was then transferred into a 1000 ml measuring cylinder and was made up to mark. The mixture was shaken and left for 40 seconds and the hydrometer was dipped into it to determine the sandy content while the clay and silt was determined after 3 hours' interval (for the mixture to settle down) through the same process. The temperatures were then recorded simultaneously. % sand, % clay and % silt was calculated as follows

Where, H_1 and H_2 are hydrometer readings at 40 seconds and 3 hours respectively at corresponding temperature readings T_1 and T_2:

$$\% \text{ Sand} = 100 - (H_1 + 0.2\,(T_1 - 68) - 2.0)^2$$

$$\% \text{ Clay} = (H_2 + 0.2\,(T_2 - 68) - 2.0)^2$$

$$\% \text{ Silt} = 100 - (\% \text{ Sand} + \% \text{ Clay})$$

Determination of pH

The pH of the soil samples was determined according to Bamgbose *et al.* (2000). 10 grams of the air-dried sample were weighed into 100 ml beaker and 20 ml of distilled water was added. The mixture was allowed to stand for 30minutes with occasional stirring with glass rod. The electrode of calibrated pH meter (Horiba pH meter D-51) was inserted into the partially settled suspension, and the pH of the soil was measured.

Moisture Content

The moisture content of the soil was determined according to the method described by Anderson and Ingram (1989). In doing this, 1gram of the soil sample was placed in a clean dry crucible of known mass. The mass of the container and soil were determined (W2) using an analytical balance (OHAUS Advance AR 3130 Model). The crucible was placed in an oven maintained at 110 ± 5^o C for 4 hours to obtain a constant weight (W1). The measurement was done induplicate. % Moisture was calculated as follows: % Moisture = (W 2 – W1)/Sample weight; Where W2= weight of crucible + weight of sample before oven dry.

Nutrient Constituents

Nutrient Constituents; namely, organic carbon, Potassium (K), Calcium (Ca), Magnesium (Mg), Phosphorus (P), Sodium (Na), were analysed using standard laboratory procedures.

Organic carbon measurement was carried out by the method of Kalembasa and Jenkinson (1973). Total nitrogen assay was carried out by the Kjeldahl method as described by Bremner and Mulvaney (1982). Available phosphorus was determined by the method described by I.I.T.A. (1979) and Olsen and Sommers (1982).

Exchangeable Cations Determination

About 100 ml of concentrated ammonium acetate was added to a10 g measurement of air-dried soil and shaken for 30mins.The preparation was then filtered and taken to the flame analyser for reading. Calcium, Sodium and Potassium were read on the flame photometer. Readings for Magnesium was obtained from a further titration with sodium EDTA as flame photometers cannot be used.

Electrical conductivity

The electrical conductivity (EC) is used to measure the ability of an aqueous solution to carry an electric current. The EC was determined using a conductivity cell containing a platinized electrode and following APHA 2510B (2005).

Organic Carbon

Organic carbon reflects organic matter (the decomposed carbon in a material. The organic carbon content of soils was determined by the Walkey-Black and digestion method as described by Anderson and Ingram (1989). About 1 gram of soil sample was placed into a block digester tube (sample weight) and added 5 ml of potassium dichromate solution and 7.5 ml of concentrated H_2SO_4. The tube was placed in a pre-heated block at 145-155^o C for30 minutes, then removed and allowed to cool. The digest was quantitatively transferred into a 100ml conical flask and then added 0.3 ml of O-phenanthrene-ferrous complex (ferroin) indicator solution, then stirred and mixed properly using magnetic stirrer. The digest was titrated with ferrous ammonium sulphate solution with end point indicating a change from greenish to brown coloration. The organic carbon content expressed in percentage as follows was based on 77% recovery factor according to Olayinka *et al*. (2017).

$$\% \text{ Organic Content} = \frac{N(T-B)}{W} \times 0.390,$$

Where N = Normality of KMnO4; T =Volume of $KMnO_4$ used in titration of soil; B = Volume of $KMnO_4$ used in titration of blank; and W= Weight of soil in gram

Data Analysis

The process of data analysis was facilitated by the use of the Statistical Package for Social Sciences (SPSS version 23). The hypothesis that there was no significant spatial variation in the physical and chemical properties of soil around waste dumpsite in the study area was tested using the One-way Analysis of Variance (ANOVA). In doing this, the spatial distribution of the various parameters listed for study around the dumpsite at designated interval were compared.

RESULTS AND DISCUSSION

The results of the laboratory analyses of the physical and chemical characteristics of soil samples is presented in Table 1

Table 1: Physicochemical parameters of soil samples from dumpsite

Soil Parameters	0 m	20 m	40 m	60 m
pH	6.00	7.30	6.50	5.90
% Moisture Content	18.50	21.00	25.70	24.50
EC (dSm^{-1})	0.55	0.64	0.67	0.50
% Organic Carbon	3.87	2.40	2.00	1.54
Potassium (K)	9.65	15.80	20.22	21.90
Calcium (Ca)	7.50	13.00	17.50	17.00
Magnesium (Mg)	1.23	1.26	1.25	1.29
Phosphorus (P)	12.67	9.20	5.66	4.50
Sodium (Na)	7.70	11.67	12.70	16.35
		Granulometry		
% Sand	54.27	59.30	54.50	56.50
% Clay	20.23	25.45	25.00	20.40
% Silt	25.50	15.25	20.50	23.10

Key: The unit of K, Ca, Mg, P and Na in mg/kg

Table 1 shows that the pH of the soil samples ranged from 5.90 to 7.30 and varies with distance from the dumpsite. While % moisture content ranged from 18.50 to 25.70. Electrical conductivity ranged from 0.50 to 0.67 (dSm^{-1}). % Organic carbon range decreased from3.87 to 1.54 from the dumpsite, indicating that soils pollution decreases from dumpsites. This finding is supported by Chouaki *et al* (2019) study which indicated that MSW enhances the organic matter content of soils by 4.53% and increased heavy metal content, which indicated a clear level of pollution. Similarly, this finding is in line with Ajibade *et al* (2021) study which revealed that that dumping has effects on soil physico-chemical properties. Exchangeable bases; namely, Potassium (K), Calcium (Ca), Magnesium (Mg), Phosphorus (P) and Sodium (Na) (in mg/kg) ranged from 9.65 to 21.9; 7.50 to 17.0; 1. 23 to 1.29; 4.50 to12.67 and 7.70 to 16.35 respectively. All the soil samples examined in this study were sandy, with % sand ranging from 54.27 to 59.30, while % clay and % silt ranged from 20.23 to 25.45 and 15.25 to 25.50 respectively.

However, the organic content of the soils around dumpsite was enhanced as a result of decayed materials; thus, boosting agriculture This finding corroborates previous studies by Mouhoun-Chouaki *et al* (2019), Ibitoye (2001) and Ideriah *et al* (2010). For instance, Ibitoye (2001) study showed that high organic matter around wastes dumps favours increased moisture content, water holding capacity (WHC) and permeability. Also, Ideriah *et al* (2010) study indicated that dumpsites are rich in organic matter, which is the source of nitrogen and phosphorus that enhances soil fertility and promote plant growth.

To test the null hypothesis that there is no significant spatial variation in the physical and chemical properties of soil around waste dumpsite in the study area, the One-way Analysis of Variance (ANOVA) was used. The result as presented in table 2 shows an F-value of 0.65 which was significant at 0.05 level of confidence. Consequently, the null hypothesis is rejected and the alternative accepted. Therefore, there is significant spatial variation in the physico-chemical parameters of soils around dumpsite in the study area.

Table 2: Spatial Analysis of Soil Physical and Chemical Properties

ANOVA

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	43.076	3	14.359	.065	.978
Within Groups	9748.475	44	221.556		
Total	9791.551	47			

Though there is significant spatial variation in the physical and chemical parameters of soils around waste dumpsites, they do not inhibit agriculture activities as the organic content of the soils around dumpsite was enhanced as a result of decayed materials; thus, boosting agriculture. However, the presence of non-degradable solid materials such as pieces of broken bottles, plastics, iron, leather products etc. in the soil may pose a threat to effective cultivation. Therefore, the major threat is in the uncontrolled spatial spread of dumpsites.

CONCLUSION

This paper considered the spatial variation of selected physical and chemical variables of soils around a waste dump and its suitability for agriculture in the outer limit of Benin City within the population-environment inter-relationship. It revealed that the waste impacted on physico-chemical properties such as soil size, pH, Electrical conductivity (EC), moisture content, phosphorus (P), potassium (K), sodium (Na), magnesium (Mg), calcium (Ca) and organic carbon. However, the organic content of the soils around dumpsite was enhanced as a result of decayed materials; thus, boosting agriculture around dumpsites.

Following from the above, the study recommends that efforts should be made to control the size of dumpsite periodically in order to make more land, which is usually in short supply due to urban encroachment on available land at the outskirts

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