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PHYSIOCHEMICAL PROPERTIES OF SOIL AS INFLUENCED BY MUNICIPAL DUMPSITES AT IKWUANO, ABIA STATE, NIGERIA

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Abstract: Waste dumping has increasingly become an agricultural add aesthetic problem to rural communities. In Abia state, most of these dumpsites are rarely evacuated as these dumpsites are abandoned for new ones when filled and the soils treated as unfarmable . The wastes decompose and alter the physiochemical stability of the soils. This study investigated the effects of wastes on the physiochemical properties of soils in some dumpsites in Ikwuano Local Government Area of Abia State (Amawom, Umuokwo and Umugbalu) and their results compared with that of the soils from control sites located 100m away from the dumpsites. The results showed increase in organic carbon content of the soils in the dumpsites recorded at 2.6% – 2.7% against 0.77% - 1.25% in the control sites , increased organic matter content of more than 300% and increased moisture content of 24.33% - 37.7% against 10.73% - 11.13% from the control sites. There was a decrease in porosity and bulk densities.
Keywords: dumpsites, organic matter, physiochemical, porosity, wastes

1. INTRODUCTION

Recent increase in community expectations for enhanced environmental standards has greatly increased the awareness of the environmental impacts of careless dumping of wastes. (Michael-Agwuoke & Ekpete, 2013). However, as rural and "sub-urban" communities gear towards collective and more controlled forms of waste management with the use of community dumpsites, the effects of these wastes on the soil are mostly ignored. Even though these dumpsites are meant to be emptied regularly, lack of funding of environmental agencies as listed by (Ezerie, Nwabuko , Enyinnaya , & Babington, 2017) pose a major threat as these dumpsites mostly gets overfilled and subsequently abandoned by the community for a new site. When precipitation infiltrates through these dumped wastes, they leach the constituents of the decomposed part of the waste and on their way down contaminate the subsurface soils with the organic and inorganic solutes. (Jeyapreya & Saseetharan , 2010)Soil quality, in agriculture, is mostly hinged on soil fertility. According to (El-ramady, et al., 2014), fertility, while being a fundamental feature of an agricultural soil, measures the long-term ability of the soil to sustain satisfactory crop growth. Nitrogen (N), Phosphorous (P) and Potassium (K) were listed as the primary soil macro-nutrients by (Jones & Olson-Rutz, 2016) because of how common their deficiencies are compared to the secondary macro-nutrients Calcium (Ca), Magnesium (Mg) and Sulphur (S) and the micro nutrients Boron (B), Chlorine (Cl), Copper (Cu), Iron (Fe), Manganese (Mn), Molybdenum (Mo), Nickel (Ni) and Zinc (Zn).In Ikwuano Local Government Area, for example, there are three major dump sites located at Umuokpo, Umugbalu and Amawom communities. These areas are usually littered with decayed wastes due to the inefficiencies of the disposal agency in the state. These litter (majorly from household wastes) affect the soil hosting the dumpsite. More worrisome is the trend of abandoning a waste site when the community feels it has become "over-littered" for a fresh site. These abandoned sites are most times left to waste as most people believe they are destroyed with litter and not farmable, a belief that is mostly incorrect.While investigating the effects of municipal, rice mill and timber wastes on some selected soil properties in Abakiliki, South Easter Nigeria, (Njoku, 2015), observed that the soils from the waste sites had lower bulk densities, higher porosities, higher moisture contents, higher values of Pb, Cu and Cd compared to the "Non-dumpsite" areas which were used as control. Furthermore, their results also showed varying values for soil properties with respect to the type of waste in the dumpsite. Similarly, (Badmus, et al.,2014) in their research observed that the average pH, Organic matter (%OM), Organic carbon (%OC) and Electrical conductivity (EC) of the soils from the dumpsites they investigated were higher than that of the soils from the control sites. The accumulation of heavy metals in soil and maize plant in the vicinity of two government approved dumpsites in Benin, Edo state, Nigeria was investigated by (Oladejo, et al., 2017) and they observed that there were higher accumulations of Zn, Cu, Cd, Pb and Cr in the dumpsite soils than in the control soils and thus concluded that the dumpsites pose serious human and ecological risks.

Investigations into the geo-accumulation and contamination status of some selected municipal solid waste sites in Gombe state, Nigeria by (Sulaiman, et al., 2018), revealed the mean concentrations (mg/kg) of the metals found in the soil to range from (0.02 - 2.20) Cd, (105.68 - 301.16) Fe, (0.65 - 2.16) Cr, (40.87 - 100.08) Mn, (1.09 - 5.01) (4.09 - 24.05) Cu, Ni, (50.05 - 101.0) Zn and (2.01 - 9.05) Pb for dumpsites soil and (105.68) Fe, (0.65) Cr, (0.02) Cd, (4.09) Cu, (1.09) Ni, (40.87) Mn, (50.05) Zn and (2.01) Pb for control soil sample. Apart from Cd which was higher than the 0.8mg/kg standard set by the World Health Organisation (WHO) and Department of Petroleum Resources (DPR), the other studied metals were all within the set limits by DPR. A similar investigation conducted by (Anake, et al., 2009) in municipal waste sites with high paper and food scraps concentrations in Kano and Kaduna states showed ranges of metal concentrations (mg/kg) to be (0.30-49.8)Cd, (5.76-13.9)Cr, (0.39-19.1)Ni and (42.6-96.62)Pb. The soils from the Kano dumpsites were observed to be averagely the most polluted with concentrations of Cd,Pb and Cr in 50 -100% soil samples collected higher than the statutory standards given by the regulatory agencies.

The results from these researches show that the presence of wastes on soil alter the composition, physical and chemical properties of the soil. This research, therefore, is aimed at studying the alterations(if any) due to the dumping of municipal wastes on soils in Umuokpo, Umugbalu and Amawom communities of Ikwuano Local Government Area in comparison with soils from reserve areas within the same geographic location.

2. MATERIALS AND METHODS

— Site Description

The samples for the study were taken from three major municipal dumpsites at Umuokpo, Umugbalu and Amawom, all in Ikwuano Local Government Area, Abia State The project area had a humid tropical climate, with marked wet and dry seasons. The raining season usually lasts for eight months from March to October and the dry season starts from November to February. The average annual rainfall for Ikwuano ranges from 1512.2mm to 2731.4mm within 22 years period (Agroclimate, 1996) from NRCRI Umudike. The raining season has its peak occurrence in July and September with a break in August. The average annual temperature of Umudike is 26.7°C while the average annual evaporation (Pitcher) is 2.63ml and the average annual sunshine in hours is 4.7 hours. The geology of the study area is sedimentary to the formation of coastal plain sand. Land is used for arable crop production.

— Materials for Sample Collection

The materials used for sample collections were soil auger, trowel, spade, masking tape, hand gloves, safety shoe, respirator, coverall etc.

— Soil Analysis

≡ Sample collection

The soil samples were collected randomly at depths of 0-10cm, 10-20cm and 20-30cm (with emphasis on plant root zone area) with a soil auger for physicochemical analysis at three different locations mentioned above. The control soil samples were collected at the same depths at a distance of 100m from the dumpsites. The samples were labelled AMAW, UMUO and UMUG for the samples from the dumpsites in Amawom, Umuokpo and Umugbalu respectively and Samples AMAW-C, UMUO-C, UMUG-C for the control sites. The total samples collected are thus Samples $AMAW^{1,2,3}$, $UMUO^{1,2,3}$, $UMUG^{1,2,3}$ with corresponding control samples $AMAW\text{-}C^{1,2,3}$, $UMUO\text{-}C^{1,2,3}$, $UMUG\text{-}C^{1,2,3}$ respectively.

≡ Soil Physical Characterisation

The samples collected were characterised in terms of soil texture, bulk density, porosity, hydraulic conductivity etc. at the Soil and Water Laboratory of MOUAU.

a) **Moisture content**

The gravimetric moisture content θ in % was determined using the following formula:

$$\theta = \frac{m_f - m_d}{m_d} \times 100 \qquad (1)$$

where, m_f – mass of the wet soil sample, m_d – mass of the dry soil sample (after drying at 105°C)(Voroney, 2019)

b) **Bulk density**

The (dry) bulk density ρ_d was calculated using:

$$\rho_d = \frac{m_d}{V} \qquad (2)$$

where m_d and V have the same values as in equation 1 (Cooper , 2016)

c) **Porosity**

This was calculated with the formula:

$$\text{Porosity} = 1 - \left(\frac{\text{Bulk density}}{\text{Particle density}}\right) \qquad (5)$$

This was calculated with the assumption of 2.65g/cm^3 value for particle density

d) **Soil textural classification determination**

Hydrometer method was used to determine the percentage sand, silt and clay of the soil samples. The results read in a textural triangle.

The stem of the hydrometer reads directly in grams of the soil/ liter of suspension. To correct the hydrometer reading for temperature, 0.36g/litre was added for every 1^0C above 20 ^{0}C and 0.36g/litre was subtracted for every 1^0C below 20 ^{0}C.

≡ **Soil chemical properties**

a) Soil ph - This was measured as described by Smith and Smith (1998) using a model 3020pH meter.
b) Organic carbon-This organic compound was determined using method described by (Nelson and Sommers, 1996) and the result of organic carbon was multiplied by 1.724 to determine the organic matter content.
c) Total available Phosphorous - This was determined using Bray II method (Olsen and Sommers, 1982).
d) Total Nitrogen - This was determined using kjeidal digestion and Technicon/Auts analyzer methods.
e) Potassium - Potassium was determined using flame photometer.
f) (Mg^+ and ca^+) - Ethane diamine tetracetic acid (EDTA) titration metod was used for the Mg^+ and ca^+ hardness.
g) Metallic ions - The heavy metals were analyzed using Atomic Absorption Spectrophotometer, while sodium will be determined using photometer.


Figure 1. Amawom dumpsite


Figure 2. Umugbalu dumpsite


Figure 3. Umuokwo dumpsite

3. RESULTS AND DISCUSSION

From Table 1, it can be seen that the moisture contents (MC) of the three dumpsites are significantly higher than the ones for the control sites. With percentage average moisture contents of 37.7, 30.17 and 24.33 for AMAW, UMUO and UMUG against 11.13, 13.7 and 10.73 for AMAW-C, UMUO-C and UMUG-C, the increase in moisture contents in the dump sites is as high as 238%. The moisture content values from the control sites are close to the average value of 16.6 recorded by (Nebonta,2018) while characterizing soils in Michael Okpara University, Umudike which falls in the same local government area with the study sites. However, in comparison with the average values recorded by (Njoku, 2015) for municipal, rice mill and timber waste sites in Abakiliki which were 35.49, 23.49 and 32.09 respectively, the values from the dumpsites is in range. The increase in moisture content for the soils at the dumpsites can be attributed to leachates from the wastes continuously washed down by rainfall into the soil.

Table 1: Physical characterization of the soils at the dumpsites and at the control sites.

Location	Sample No	M. C %	B.D g/cm^3	POROSITY %	% SAND	% SILT	% CLAY	TEX CLASS
AMAW	1	40.0	1.22	39.0	89.00	4.40	9.60	SAND
	2	40.0	1.12	44.0	91.00	2.40	6.60	SAND
	3	33.3	1.20	40.0	87.00	5.40	7.60	LS
AMAW-C	1	10.0	1.48	43.9	89.00	1.40	9.60	SAND
	2	16.67	1.50	42.3	87.00	3.40	9.60	LS
	3	6.67	1.48	43.1	91.00	1.40	7.60	SAND
UMUO	1	33.3	1.35	32.5	49.00	33.40	17.60	L
	2	28.6	1.33	39.5	79.00	12.40	8.60	LS
	3	28.6	1.34	36.2	83.00	10.40	6.60	LS
UMUO-C	1	12.5	1.40	37.8	85.00	5.40	9.60	LS
	2	14.3	1.42	37.2	89.00	3.40	7.60	S
	3	14.3	1.44	36.0	67.00	15.40	17.60	SL
UMUG	1	28.6	1.36	32.0	81.00	9.40	9.60	LS
	2	22.2	1.34	33.0	89.00	1.40	9.60	S
	3	22.2	1.35	32.5	87.00	6.40	6.60	LS
UMUG-C	1	10.0	1.39	44.0	81.00	9.40	9.60	LS
	2	11.1	1.38	44.8	83.00	7.40	9.60	LS
	3	11.1	1.40	44.0	81.00	7.40	11.60	SL

B.D – soil bulk density, MC – Soil moisture content

The average values of bulk density for the soils at the dumpsites ranges from 1.18-1.35g/cm³ against 1.39-1.49g/cm³ for the control sites with AMAW and AMAW-C having the highest bulk densities. Similarly, the porosity of the soils at the dumpsites ranges from 32.5-41% against 37-44.27% for the soils from the control site. The (USDA,2008) recommends bulk densities below 1.4 g/cm3 for sandy loam soils to permit plant growth and bulk densities above 1.8 to restrict root growth. Consequently, the bulk densities of the dumpsites soils (AMAW, UMUO and UMUG) will permit root growth even. Also, the significant decrease in bulk density of the soils in the dumpsites(when compared to the soils from the control sites) can be attributed to the decomposed wastes on the soils as they over time move and settle in the soil thereby adding to the bulkiness of the soil. This same reason can also be attributed to the lower porosity values of the soils at the dumpsites. However, comparing the bulk density and porosity values from Table 1 with the average values recorded by (Adindu, et al.,2013) as 1.6g/cm³ and 38% for bulk density and porosity for soils at the Poultry Block in Michael Okpara University of Agriculture which is within the same area as the experimental sites, it is obvious that even with the effect of the wastes, the bulk densities and porosities of the soils at the dumpsites are still within the normal range for soils in that area. The soils from the dumpsites and the control sites are classified as mostly sandy loam soils with a greater predominance of sand than silt and clay, this classification is in agreement with other soil textural classifications performed around the area , an example of which is the soil characterization by (Enejete & Ifenkwe , 2012) which gave the soil textural class for soil samples collected from the western farm in Michael Okpara University, Umudike to be Sand(67.72%), Silt(20.46) and Clay (11.82).

Table 2: Results of the Chemical properties of the soil at the Experimental sites.

Parameters	AMAWOM						UMUOKWO						UMUGBALU					
	DUMPSITE			CONTROL			DUMPSITE			CONTROL			DUMPSITE			CONTROL		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Ph	7.30	7.10	7.30	6.30	6.10	5.60	7.70	7.90	7.75	5.20	5.82	5.80	5.70	7.70	7.80	5.00	6.20	5.40
P (mg/kg)	55.0	52.7	46.5	5.50	18.7	13.7	67.4	48.00	55.3	12.8	9.90	10.0	65.2	60.1	53.5	27.6	20.5	33.1
% N	0.28	0.29	0.22	0.042	0.07	0.056	0.31	0.28	0.32	0.06	0.06	0.04	0.28	0.31	0.27	0.098	0.084	0.140
% OC	2.36	2.99	2.44	0.233	0.85	0.621	2.36	2.17	2.56	0.58	0.43	0.43	2.90	2.80	2.40	1.24	0.93	1.58
% OM	4.06	5.15	4.21	0.40	1.47	1.07	4.06	3.75	4.42	1.00	0.74	0.74	5.02	4.85	4.21	2.14	1.61	2.73
Na (Cmol kg^{-1})	0.25	0.26	0.24	0.200	0.15	0.183	0.31	0.32	0.22	0.11	0.11	0.12	0.25	0.24	0.38	0.10	0.10	0.13
Ca(Cmol kg^{-1})	32.0	34.4	56.0	8.00	8.40	7.20	27.4	23.6	40.0	7.60	8.00	6.00	12.0	34.0	15.2	6.80	7.60	8.00
Mg (Cmol kg^{-1})	18.0	11.6	17.2	2.80	3.60	4.00	12.0	8.00	18.0	4.00	3.20	4.00	7.20	15.6	6.80	4.00	1.60	3.60
K(Cmol kg^{-1})	0.13	0.15	0.16	0.126	0.12	0.148	0.13	0.15	0.14	0.10	0.17	0.11	0.10	0.11	0.24	0.11	0.10	0.10
EA(Cmol kg^{-1})	0.48	0.64	0.64	0.56	0.40	0.64	0.72	0.64	0.56	0.72	0.56	0.48	0.72	0.64	0.56	0.56	0.56	0.40
ECEC (Cmol kg^{-1})	50.9	47.0	74.2	11.69	12.7	12.15	40.4	32.7	58.9	12.5	12.1	10.7	20.2	50.6	23.0	11.6	9.97	12.2
% BS	99.1	98.6	99.1	95.18	96.8	94.72	98.2	98.1	99.1	981	98.1	99.1	96.5	98.7	97.6	95.2	94.4	96.7

P – phosphorous , N- Nitrogen , OC – Organic carbon, OM – Organic matter, Na- Sodium, ca- calcium, Mg – Magnesium, K – Potassium, EA – Exchangeable Acidity, ECEC- Effective Cation Exchange Capacity.

The organic carbon contents in all the dumpsites were observed to be higher than those from the control sites. The average percentage organic carbon contents for AMAW, UMUO and UMUG samples were 2.60, 2.36 and 2.70 respectively while those of AMAW-C, UMUO-C and UMUG-C were 0.77, 0.48 and 1.25, respectively. These values translate to the structural stability of the soils as the soils from the dumpsites are observed to have high organic carbon and thus better structural stability than the soils at the control sites. Similarly, the organic matter content (OM) for the soils from the dumpsites were observed to be more than 300% higher than that of the control sites. This, understandably is due to the accumulation of decomposed litter from the wastes in the soil beneath it. As compared with the average organic carbon in municipal solid waste dumpsite in Kano and Kaduna State as published by (Anake et al, 2009) which are 1.57 ± 0.48% to 1.66 ± 0.19%. It can be observed that the organic carbon in the dumpsites in Ikwuano LGA of Abia state is close to the value for the soils in Kano and Kaduna states. The difference can be attributed to the high proportion of sand at the dumpsites.

From the result of the chemical property test gotten from the samples in Table 2, the soil pH in Umuokwo dumpsite was increasingly high in the samples compared with those from the other two dumpsites. The average pH for Umuokwo dump site was 7.78 in comparison with Amawom and Umugbalu which have average pH of 7.23 and 7.07 respectively. In comparison with the study at Kano and Kaduna State dumpsite as published by (Anake et al, 2009), the mean pH of soil for the four dumpsites in the two states ranged from 7.23 ±0.17 to 7.75 ±0.47 and also close to the pH range from the dumpsites in Ikwuano LGA. Therefore, the pH level across the dumpsites indicates that they are normal to saline and thus, falls between optimum pH ranges for most plants.

Also, the nitrogen content at the dump sites were determined to be in the range of 0.28 for Amawom, 0.30 for Umuokwo and 0.29 for Umugbalu. From the result determined from the study in the physicochemical characteristics of soil in Port Harcourt as published by (Obianefo et al, 2017), the total nitrogen in the dumpsites soils ranged from 0.4 to 0.6 was found to be higher as compared to the nitrogen content at dumpsites in Ikwuano LGA of Abia state. This might have been due to the composition of the wastes which have were mainly from agricultural and farmyard sources.

Table 3: Statistical Analysis of selected Physiochemical properties of the soils.

Parameter	Unit	Dumpsite	Control	F	Sig.
Moisture content	%	30.7 ± 6.5	11.8 ± 2.9	62.1	0.00
Bulk Density	g/cm³	1.29 ± 0.08	1.43 ± 0.05	19.0	0.00
Porosity	%	36.5 ± 4.3	41.3 ± 0.004	7.0	0.17
pH	-	7.3 ± 0.68	5.7 ± 0.45	36.7	0.00
O C	%	2.55 ± 0.27	6.76 ± 0.43	109.7	0.00
OM	%	4.42 ± 0.48	1.32 ± 0.74	108.8	0.00
N	Cmol/kg	0.02 ± 0.009	0.07 ± 0.03	222.7	0.00
K	Cmol/kg	0.132 ± 0.23	0.118 ± 0.22	1.6	0.217
Na	Cmol/kg	0.27 ± 0.052	0.136 ± 0.034	44.97	0.00
Ca	Cmol/kg	30.48 ± 13.25	7.5 ± 0.74	26.9	0.00
Mg	Cmol/kg	12.7 ± 4.7	3.4 ± 0.08	34.7	0.00
P	Cmol/kg	55.97 ± 7.1	16.87 ± 8.99	104.7	0.00
ECEC	µs/cm	44.2 ± 17.24	11.73 ± 0.88	31.87	0.00

The results were subjected to Analysis of Variance (Anova).

The moisture content of all the dumpsites ranged from 30.7 ± 6.5% and 11.8 ± 2.9 % in the control. The moisture content (MC) at the three locations have no significant difference between them at a (significant level of $P < 0.05$) .This agreed with the findings of (Moura et al., 2009)

Bulk density with a range of 1.29 ± 0.08 in the dumpsite and 1.43 ± 0.05 in the control has no significant difference and Porosity which ranges from 36.5 ± 4.3 in the dumpsite and 41.3 ± 0.004 in the control has a significant difference of 0.17. Both bulk density and porosity 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 three locations for productive agricultural activities such as in cropping and the observation is similar to the ones made by (Ibitoye, 2001). The PH ranges from 7.3 ± 0.68 in the dumpsite and 5.7 ± 0.45 in the control has no significant difference. It was observed that there were no significant difference in organic carbon, organic minerals, sodium, calcium, magnesium, available nitrogen, total phosphorous but potassium has a significant difference of 0.217.

The result from Table 4.3: which is the statistical analysis of Physiochemical properties of soils from the dumpsites and the control reveals that only porosity and potassium has a significant difference at significant level $P< 0.05\%$ and it goes further to show that the soil in the dump site is farmable.

4. CONCLUSION

The physiochemical tests conducted on the soil samples from the dumpsites in Amawom, Umuokwo and Umugbalu areas of Ikwuano local government Area of Abia state as compared with that of the control samples taken from soils at a minimum distance of 100m from the dumpsites revealed an increase in moisture content (MC) with slight decrease in bulk densities (BD) and Porosity as well as increase in organic carbon (OC) and organic matter (OM). The statistical analysis also showed significant differences for Porosity and Potassium contents of the soils only.

Although, these results fall within the range of the standards stipulated by (USDA, 2008), the effects of the prolonged decomposition of wastes on these soils and the consequent deposition and transport of leachates and organic matter on the soils are evident.

Even though, the physiochemical test results of the samples from the dumpsites shows the soils currently benefiting largely from the wastes, the effects of prolonged dumping of wastes on these soils should not be disregarded. Hence, it is recommended that the government through its waste disposal agencies should ensure frequent evacuation of the wastes to prevent degradation of the soil.

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