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Assessment of Soil Moisture Characteristics as Influenced by Agro-industrial Waste Dumpsite in Ikwuano L. G. A. Abia State

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Abstract

A study was carried out to investigate the moisture characteristics of soils exposed to agro-industrial waste sites of palm oil mill effluent (POME) and cassava mill effluent (CME). Soil samples were collected from the sites using core sampler, a spacing of 5m apart was adopted between sampling points and a total of nine samples were collected from each site with control samples collected 100m away from the sampling points. Soil properties analyzed include, bulk density (BD), porosity (P_t), saturated hydraulic conductivity (Ksat), available water content (AWC), field capacity (FC) and permanent wilting point. Results revealed that agro industrial wastes (POME and CME) influenced moisture characteristics of soils of the studied sites. POME had the highest values for AWC (27.02%), FC (32.33%), Ksat (50.52cm^3/hr) with the lowest BD (1.29g/cm^3) than the control site while CME showed lower values for AWC (14.96%), FC (20.15%), Ksat (19.54cm^3/hr) with higher BD (1.70g/cm^3) than the control sites. The high BD due to CME waste generally lowered the overall moisture characteristic of the CME site. Thus, it was ascertained that CME lowered the moisture characteristics of the site.

Key words: Agro-industry, Available water content, Moisture Characteristics, Wastes, Ikwuano, Dumped site

1.0 Introduction

Soil is a natural media that supplies the physical and chemical environment in the production of crops (Ogbodo, 2013). In the period of industrialization, a lot of wastes are being produced from industrial, commercial, domestic or mining activities, and these wastes are being dumped on the soil and may have a positive or negative impact on soil properties (Otoko *et al*., 2016). According to FAO (2019), food industries show high generation of waste which result to environmental pollution, climate change and economic development decline. Some agro industrial wastes can serve as amendments for improving soil quality and health (Mandel *et al*., 2016), by significantly increasing organic carbon content of soil thereby enhancing aeration, soil tilth, microbial activities, pH, cation exchange capacity, (Erana *et al*., 2019) as well as improve water holding capacity (Raju *et al*.,2016). The moisture content of the soil is the quantity of water available in soil (Nwagwu *et al*., 2018), influences the stability of aggregates, structure, particle size distribution and land use system (Fu *et al*., 2000). Some researchers (Eneje and Innocent, 2012; killi *et al*., 2014; Tabassum *et al*., 2015) have noted that soils amended with industrial waste have enhanced soil physical properties. These changes in soil properties can influence soil attributes related to improved structure that facilitated porous soil that allows permeation of air and water (more infiltration), aeration and drainage (Rakha *et al*., 2018; De_Silva *et al*., 2023) which generally increase available water content of the soil.

With the emerging challenges involving conservative use of soil for greater productivity which are associated with fertility loss, degradation and quality decline, it is necessary to evaluate soil moisture characteristics because it has a great influenced on the physiochemical properties of soil. Thus, a sound system should be developed for managing agro industrial waste being deposited on soil. This study will provide baseline information on moisture characteristics of soils exposed to agro industrial dumped sites of cassava mill effluent (CME) and palm oil mill effluent (POME) to ensure sustainable use of land resource. The objective of this study is to evaluate the moisture characteristics of soils exposed to agro industrial waste sites.

2.0 Materials and Methods

2.1 Study Area

The study lies between Latitude $5^0$16’ to $5^0$28’N and Longitude of $7^0$32’ to $7^0$36’E in Ikwuano local government area, Abia state. Soils are derived from coastal plain sand. The study area has a humid tropical environment, with annual rainfall of about 2250mm (NIMET, 2015) and temperature varying between 21 – 31 ^{0}C. Farming activity is the major occupation in the area with dominant trees and arable crops

2.2 Field Study

Two agro industrial sites were identified for sample collection. These sites were palm oil mill effluent (POME) and cassava mill effluent (CME) sites, a total of nine sampling points were marked with a spacing of 5m between sampling point for each of the waste sites using core samples. Controls were collected 100m away from the waste site. The collected soil samples were taken to the laboratory for analysis.

2.3 Laboratory Analysis

Moisture Characteristics: Field Capacity, (FC) and Permanent Wilting Point, (PWP) were determined using the estimation method describe by Mbagwu, (1991). Available Water Content (AWC) was deduced from Field Capacity, (FC) and Permanent Wilting Point, (PWP) (Romano and Santin, 2002), Bulk density was determined by Anderson and Ingram (1993) method. Total porosity was calculated from bulk density data assuming a particle density is 2.65kg/m^3 for mineral soil, saturated hydraulic conductivity (K_{sat}) was determined using the constant head method proposed by stolte (1997)., Darcy’s equation for vertical flow of liquids, as explained by Young (2001). Particle size analysis was determined using the hydrometer method as describe by Gee and Bauder (1986).

2.4 Experimental Design

Data collected from the laboratory analysis were analyzed using Analyses of Variance (ANOVA) in Randomized Complete Block Design (RCBD) and significant treatment means were separated using Fishers least significant difference (FLSD) at 5% probability levels.

3.0 Results and Discussion

3.1 Particle Size Distribution

The particle size analysis results which indicated the percentage of sand, silt and clay are presented in Table 3.1. Surface soils of the studied sites were dominated by sand fractions. The highest sand content of the soil could be due to unconsolidated sand deposit formed over land (Asawalam *et al.,* 2009; Chukwu *et al.,* 2013). Akamigbo and Ukaegbu, (2003) noted that geology of an area with coastal plain sand are characterized by sandy soils above a wide expanse of land. The agro industrial sites of POME and CME showed a significantly ($P<0.05$) higher percentage of sand and lower percentage of silt and clay than controls (POME-Con and CME-Con). Constant disturbance on soil arising from effluent discharge must have altered the textural composition of the dumpsites. The soil under the effluent sites also had higher sand fraction and low clay content, and may have weak cohesive and adhesive forces that result to low soil aggregation potential that leads to slaking (Babalola and Obi, 1981). The agro industrial sites (POME and CME) had a textural class of loamy sand (LS) and sandy loam (SL).

Table 3.1: Particle size distribution of studied soils

TREATMENT	SAND g/kg	SILT g/kg	CLAY g/kg	TEXTURAL CLASS
POMEs	817.1	60.7	122.2	LS
POME-CON	728.0	94.0	180.0	SL
CMEs	833.3	62.2	104.5	LS
CME-CON	795.3	82.8	121.9	LS
$FLSD_{(0.05)}$	0.609	0.34	0.45	

Key- ERO = Erosion site, ERO-CON = Erosion Control, POME = Palm oil mill effluent site, POME-CON = Palm oil mill effluent control, CMEs = Cassava mill effluent site, CME-CON = Cassava mill effluent control.

3.2 Moisture Characteristics of the Soils

The soil moisture characteristics such as moisture content (MC), field Capacity (FC), available water content (AWC) and permanent wilting point (PWP) of soil studied are shown in Table 3.2. The POME site showed a significantly ($p_{<0.05}$) higher soil moisture content at FC (32.33%) and AWC (27.02%). This result observed might support plant growth than the control site. The following researchers (Chinyere *et* al., (2018); Nta *et al.,* (2020); Nwachukwu *et* al., (2018) and Okwute and Isu, (2007)) obtained similar results. The higher moisture content recorded in POME site may be attributed to the organic materials contained in the effluents which add organic matter, supplies large surface area for adsorption and retention of water (Materachera and Mkhabela, 2001). Nwogwu *et al.* (2018) stated that soil moisture is the amount of water stored in the soil. The quantity of water present in soil is mostly dependent on some soil properties such as soil structure, texture and organic matter (Ogban and Ibitt, 2018). According to Bek-Nielsen *et al.*, (1999) and Okwute and Isu, (2007) the high moisture found in POME dumpsite could be due to the cellulose fruits debris and unrecovered oil (which during decomposition leads to higher organic matter) in the site which leads to more water retention than when compared to non POME site. At FC and AWC, CME control site had a significant ($P<0.05$) higher value than the CME dumpsite but showed no significant difference in PWP. This indicates that the CME control site retained more water at FC with more water absorbed by plant root and lesser tendency to experience moisture stress compared to CME dumpsite. The POME dumpsite showed lower BD (1.29g/cm^3) and was significantly different from the control (1.50g/cm^3) at $P<0.05$. The low BD recorded in POME dumpsite could be as a result of organic materials found in the effluent may have increased the organic matter content of the soil which lowers the BD of POME dumpsite. Kumark *et al.* (2020) noted that BD is dependent on organic matter and BD controls porosity (Athira *et al.*, 2019) which enables the capacity of pore spaces to exchange air and water in the soil (Kara and Baykara, 2014), facilitating water retention, fluid flow and water transmission (Rawls *et al.*, 1998). The low BD in POME dumpsite led to a higher porosity (51.08%) and better Ksat (50.52cm^3/hr) which enables good conductor of air, nutrient and water into the soil than the POME control. Kumar *et al.* (2020), noted that increased level of organic matter can lead to a greater pore spaces with the immediate result that water infiltrates more readily and can be held in the soil. The CME dumpsite showed a very high BD (1.70g/cm^3), and was significantly different from the control (1.42g/cm^3) at $P<0.05$, which indicates high soil strength and less moisture content in soil. The total porosity and Ksat were also significantly ($P<0.05$) lower than the CME-control site. According to Rengasamy *et al.* (1984), reduction in macro-porosity can increase strength of a soil, lowers its infiltration rate and hydraulic conductivity.

Table 3.2: Moisture characteristics of the studied soils

TREATMENT	**MC %**	**FC %**	**AWC %**	**PWP %**	**P_t %**	**BD g/cm^3**	**Ksat Cm$^{3/}$hr**
POME	43.24	32.33	27.02	5.30	51.08	1.29	50.52
POME-CON	38.82	26.68	21.77	4.48	43.39	1.50	38.40
CME	30.61	20.15	14.96	5.18	35.84	1.70	19.54
CME-CON	41.93	34.79	29.79	5.00	46.41	1.42	44.51
$FLSD_{(0.05)}$	2.43	1.92	1.93	0.18	3.37	0.09	2.00

Key- POME = Palm oil mill effluent site, POME-CON = Palm oil mill effluent control, CMEs = Cassava mill effluent site, CME-CON = Cassava mill effluent control, MC= Moisture content, FC=field capacity, AWC=Available water content, PWP=permanent wilting point, BD=bulk density and P_t= porosity.

Table 3.3: Pearson correlation matrix of some hydrological properties

	FC	AWC	BD	Ksat
FC	-			
AWC	0.995**	-		
BD	-0.722**	-0.739**	-	
Ksat	0.769**	0.770**	-0.817**	-

Key: FC= field capacity, AWC= available water content, BD= bulk density Ksat= saturated hydraulic conductivity

AWC showed a significantly ($P<0.01$) positive correlation with FC and Ksat and negative correlation with BD indicating that the higher the rate at which water enters the soil, the higher the availability with lesser tendency for the soil to compact. According to Rawls *et al*. (1998), BD influences the retention of water, its flow and transmission in the soil. Hydraulic conductivity helps in predicting the water movement and its retention pathways through the soil profile (Keller *et al.*, 2012; Quin *et al*., 2014)

4.0 Conclusion and Recommendation

The continuous deposition of agro industrial wastes on the studied soils has led to major changes in soil moisture characteristics. The POME dumpsite showed better moisture content at FC, AWC, Ksat and lower BD than the control. CME dumpsite suffered a great loss of moisture (FC and AWC, Ksat) with high BD which restricted water movement, its availability and overall moisture content. AWC, FC and Ksat showed a negative relationship with BD. Cassava mill effluent should undergo proper treatment before being deposited on the soil, in order to lower the tendency of clogging soil pores.

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