

ASSESSMENT OF THE STRUCTURAL AND CHEMICAL PROPERTIES OF AGRO-INDUSTRIAL SITE IN ABIA STATE

Kalu, C. B. and Eneje, R. C.

Department of soil science and Land Resource management, College of Crop and soil sciences, Michael Okpara University of Agriculture, Umudike.P.M.B. 7267, Umuhia, Abia State, Nigeria.

Corresponding Author's Email Address: amakabasilial@gmail.com

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ABSTRACT

A study was conducted to assess the structural and chemical properties of soils on sites where palm oil mill effluent (POME) and cassava mill effluent (CME) were deposited. Soil samples were collected from these effluent sites (POME and CME) at a depth of 0-30cm and the control sample collected 100m away from the sampling points. Soil samples collected were tested for structural properties such as (mean weight diameter(MWD), dispersion ratio (DR), clay dispersion index (CDI), clay flocculation ratio (CFR), aggregated silt+clay (ASC), bulk density (BD), porosity (P_t), saturated hydraulic conductivity (Ksat)) and chemical properties (pH, total hydrocarbon content (THC), organic carbon(OC)). The results showed that the agro industrial site of POME had a better chemical properties and structural stability than CME site. Soil samples from POME site had lowered BD(1.29g/cm^3), which invariably influenced P_t (51.08%) and Ksat($50.52\text{cm}^3/\text{hr}$) and also increased aggregate stability (MWD 5.12mm, ASC= 8.69%, CFI= 42.38%) in the site. While CME increased BD(1.7g/cm^3) which lowered structural stability of the site (MWD= 4.95mm, CFI= 35.82%, ASC= 7.69%, P_t =35.84% and Ksat= $19.54\text{cm}^3/\text{hr}$). The agro industrial effluent of POME and CME generally increased chemical properties (pH, THC, OC).The correlation analysis showed that chemical properties influence structural stability of the studied soils. POME can serve as amendment for improving soil properties.

Keywords; Agro Industrial, Chemical, Degradation, Effluent, structural

INTRODUCTION

Due to over exploitation by man, natural processes of soil have accelerated leading to major changes in soil physical and chemical properties. Such changes have altered and reduced the soils ability to sustain a particular quality and quantity of plant growth, lower the productivity of soil and environmental quality (Abad *et al.*, 2014). According to Stocking and Muchnaghan, (2001) the extent to which a soil deteriorate relies on its relative sensitivity to degradation and the sensitivity of a soils resilience are linked to its management history and inherent soil properties, (Ahukaemere *et al.*, 2012) such as structural and chemical properties. Chan *et al.* (2002) noted that losing of soil structure is increasingly seen as a form of soil degradation. This structure plays significant role in transportation of solute, water and gases in soil and also converting soil into a good medium for plant growth and other microbial activities (Snyder and Vazquez, 2005). Therefore, maintaining an optimum physical and chemical soil condition is essential for sustainable soil quality and health. Ekpe, (2002) reported that stable soil

structure has a strong correlation with fertility, but this fertility can be degraded chemically through agro-industrial waste, domestic and agricultural wastes that find their way into the soil.

Disposing waste indiscriminately into the environment contaminates the soil ecosystem with increased overload of metal concentration (Adewomi and Ajibade, 2015). Addition of some agro-industrial waste like palm oil mill effluents (POME) and cassava mill effluent (CME) can improve soil properties such as soil organic matter content, pH, microbial population, exchangeable cation, essential constituents of biomass, with increase in soil macro and micro nutrients (Rangara *et al.*, 2007; Nwaugo *et al.*, 2008). POME causes clogging on pores leading to water logging and its raw form can kill any vegetation on contact (Nta *et al.*, 2020), also raw CME has high cyanide and acidity which can lower the activities of microorganisms necessary for nutrient cycling, (Ibe *et al.*, 2014). Therefore, assessing structural and chemical properties of soils exposed to agro-industrial waste site in Ikwuano have not been studied extensively. This study intended to

provide base line information that will help ensure sustainable structural stability and effective management planning. The objective of this study was to assess the structural and chemical properties of agro-industrial sites in Ikwuano L.G.A, Abia State.

MATERIALS AND METHODS

Study Site

The study was conducted in Ikwuano L. G. A, Abia State which lies between Latitude 5° 24' to 5° 30'N and longitude 7° 31'to 7° 37' E. the study area is located within a tropical humid climate with a bimodal annual precipitation total of 2000mm, high relative humidity of 77% during rainy season and air temperature ranging from 22-31°C (Chukwu *et al.*, 2013). Rainy season starts April and ends October with peak in June and July while dry season last from November to March. The dry season is usually accompanied by a dry cold harmatan which prevails during the month of December and January (FDARR). The soils are derived from coastal plain sand of sedimentary origin and are highly weathered (Akamigbo, 2000, Ufot *et al.*, 2001). It is a food producing area with growing of arable crops like yam, maize, cassava etc. being dominant.

Field Study

Soil samples were collected from two agro industrial site, palm oil mill effluent (POME) and cassava mill effluent (CME) were deposited at 0-30cm depth. Core samples were collected for BD and Ksat while auger samples were collected for organic matter, aggregate stability, total hydro carbon and pH. A total land area of 300m² with spacing of 5m was adopted between sampling points for both POME and CME, control samples were collected 100m away from the point of sampling. A total of 36 samples each were collected for auger and core. All the collected soil samples were properly labelled, air dried for laboratory analysis.

Laboratory Analysis

Structural properties: 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/m³ for mineral soil, saturated hydraulic conductivity (K_{sat}) was determined using the constant head proposed by stolte (1997) and calculated using Darcy's equation for vertical flow of liquids, as explained by Young (2001). Aggregate stability: Mean weight diameter

(Macro) was determined by the wet-sieving method of Kemper and Roseuau (1986). Mean Weight Diameter was calculated thus;

$$MWD(mm) = \sum X_i W_i \dots\dots\dots 1$$

Micro Aggregate stability indices were determined by the method explained by Igwe *et al.* (1995) and calculated as follows:

Dispersion ratio (DR)

$$DR = \frac{\% \text{ silt} + \% \text{ clay in H2O}}{\% \text{ silt} + \% \text{ clay in calgon}} \times 100 \dots\dots\dots 2$$

Clay Dispersion index (CDI)

$$CDI = \frac{\% \text{ clay in H2O}}{\% \text{ clay in calgon}} \times 100 \dots\dots\dots 3$$

Clay flocculation index (CFI)

$$CFI = \frac{\% \text{ clay in calgon} - \% \text{ clay in H2O}}{\% \text{ clay in calgon}} \times 100 \dots\dots\dots 4$$

Aggregated silt + clay (ASC)

$$ASC = (\% \text{ clay} + \% \text{ silt in calgon}) - (\% \text{ clay} + \% \text{ silt in water}) \dots\dots\dots 5$$

Chemical properties: Organic carbon was determined using wet oxidation method described by Walkley and Black (1934) modified by Nelson and Somner (1982). The soil pH was determined electrometrically using pH meter. The 1:2.5 soil water suspension ratio was used. Total Hydrocarbon (THC) was determined by analytical method.

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.

RESULTS AND DISCUSSIONS

Soil Structural Properties of Agro-Industrial Effect throughout Site

Some structural properties of the soil such as mean weigh diameter (MWD), dispersion ratio (DR), clay flocculation index (CFI), aggregated silt + clay (ASC), clay dispersion index (CDI), bulk density (BD), Total Porosity (P_t) and Saturated hydraulic conductivity (K_{sat}) of the studied soils are

shown in table 1. The agro industrial site of (POME and CME) showed significant ($P < 0.05$) lower difference than their controls indicating that the POME-Control and CME-Control had better macro aggregation than

Table 1: Structural Properties of the Studied Soil

TREATMENT	MWD(mm)	DR%	CFI%	ASC%	CDI%	BDg/cm ³	P _t %	K _{SAT} (cm ³ /hr)
POME	5.12	52.73	42.38	8.69	57.62	1.29	51.08	50.52
POME-CON	5.27	47.45	56.67	14.40	43.33	1.50	43.39	38.40
CME	4.95	52.38	35.82	7.96	64.18	1.70	35.84	19.54
CME-CON	5.27	48.00	38.33	10.40	61.67	1.42	46.41	44.51
FLSD _(0.05)	0.06	1.54	2.23	0.58	2.22	0.09	3.37	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, MWD=mean weigh diameter, DR=dispersion ratio, CFI=clay flocculation index, ASC=aggregated silt+clay, CDI=clay dispersion ratio, BD=bulk density, P_t=total porosity, K_{sat}=saturated hydraulic conductivity.

This result support the findings of Lado *et al.* (2004), which stated that higher clay content increases stability of aggregates because clayey soil have cementing effect. Stable aggregate is an indicator of soils resistance to erosion and structural damage, Abdullahi, (2018), and according to Igwe and Agbata, 2017, the higher the MWD value, the higher the proportion of macro aggregate, the better the stability. For micro aggregation, DR and CDI for POME and CME were higher with an increase of 5.28%, 14.29% and 4.38%, 2.51% respectively than their control sites. Since high DR and CDI indicates soils susceptibility to erosion, easily dispersible, prone to degradation and high ASC and CFI indicates good micro aggregation (Igwe and Obalum, 2013), the soils of CME site indicated higher CDI which can led to easy breakdown of aggregates, dispersing and prone to degradation than POME. According to Legout *et al.* (2005), when soil disperses, there is a breakdown of micro aggregates that constitutes the structural frame work of the macro aggregates thus gradually detached at the weakest point of aggregate structure. The effluent site controls (POME-Control and CME-Control) showed a higher CFI and ASC at 5% significance indicating a better aggregates than the agro industrial sites (POME and CME), but despite the high organic matter content found on the effluent sites, it still showed a lower aggregation than the control sites. This could be linked to the fact that organic matter contents in soils has the capacity to aggregate or disperse soil depending on the quality and quantity of organic matter and the rate at which it occurred with other aggregating agents in the soil (Igwe and Agbatah, 2007), contrarily, Oguike *et al.* (2019), noted that organic matter helps to increase structural stability of soil.

POME and CME. Since stability of aggregates depends on many factors particularly organic matter, soil texture, oxide content (Zhang and Horn, 2001).

The POME site showed lower BD (1.29g/cm³) most likely to support root growth, improve physiochemical properties and significantly ($P < 0.05$) different from the POME control site (1.50g/cm³). The low BD (1.29) recorded in POME site could be attributed to the high organic matter content of the site. Leifield *et al.* (2005), noted that high organic matter content of soil lowers soil bulk density. Also, Athira *et al.* (2019), stated that BD varies inversely with respect to organic matter, BD is dependent on organic matter (kumark *et al.*, 2020). Since BD controls porosity (Athira *et al.*, 2019) that gives idea of pore spaces capacity for air and water exchange (Kara and Baykara, 2014), influencing water retention, water transmission and fluid flow (Rawls *et al.*, 1998), the low BD in POME site led to a better porosity (51.08%) and good K_{sat} (50.52cm³/hr) which enhances good conductor of air, water and nutrient 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 site showed a very high BD (1.70g/cm³), significantly ($P < 0.05$) different from CME control (1.42g/cm³) site, which indicates high soil strength which is unfavorable for root penetration and growth. The total porosity and K_{sat} were also significantly ($P < 0.05$) lower than the CME-control site. The high BD recorded in CME site could be due to higher clay dispersion index (CDI) found on this site. According to Rengasamy *et al.* (1984), reduction in macro-porosity, increase in soil strength, lower infiltration rate and hydraulic conductivity is caused by dispersion of clay. Also, the effluents of CME contains particles of cassava, which when deposited on soil, some will

infiltrate and evaporate remaining particles can

seal up soil pores and increase bulk density.

Table 2: Chemical Properties of the Agro-Industrial Sites

TREATMENT	pH	OC%	OM%	THC(mg/kg)
POME	8.13	2.34	4.03	177.22
POME-CON	5.90	1.67	2.88	45.00
CME	6.05	1.79	3.09	182.78
CME-CON	5.70	1.50	2.59	270.00
FLSD _(0.05)	1.11	0.11	0.19	19.78

Key: OC=organic carbon, OM= organic matter, THC=total hydrocarbon content, POME=palm oil mill effluent, POME-CON= palm oil mill effluent control, CME= cassava mill effluent, CME-CON=cassava mill effluent control.

The pH of the effluent sites (POME and CME) were significantly ($P<0.05$) different from their control sites. POME was moderately alkaline (8.13) and CME was moderately acidic (6.05). The increase pH in POME site is agreement with the report of Okwute and Isu, (2007), who stated that when raw POME is discharged into the soil, the acidic pH seems to gradually increase to alkaline as biodegradation takes place, and this was the case in this study as the pH of the polluted soil increase from 5.90 in the POME control to 8.13. The increase in pH of POME polluted soil has been reported by many researchers (Nwaugo *et al.*, 2008; Nwoko and Ogunyemi, 2010; Lim, 1987; Iyakndue *et al.*, 2017). The high level of basal respiration arising from higher decomposition of organic materials of cassava mill effluent must have produce enough carbonic acid most likely to lower the pH of CME site slightly below neutral. Orji and Ayogu, (2018). The control sites showed moderate acidity.

The effluent sites (POME and CME) showed a significant ($P<0.05$) difference with higher OM content than their control site. The higher OM observed in POME soil in this study is in concordance with the findings of (Okwute and Isu, 2007; Iyakudu *et al.*, 2017; Nwachukwu *et al.*, 2018). While the higher OM content of CME site corroborate with the findings of (Igbinsosa, 2015, Oviasogie and Ofomaja, 2007; Igbinsosa and Igiehon, 2015; Osakwe and Okpoveta, 2012). The presence of particles with organic materials contained in the effluent must have increased the OM content of the effluent sites. The higher THC content found in CME control could be due to increased plant residue (mostly angiosperm) found on this site which upon decomposition added more hydrocarbon to the soil. According to Bush and McInerney, (2013), terrestrial plants produce hydrocarbons as components of their epicuticular waxes to protect plant tissues from the external environment.

Table 3: Correlation Matrix Between Some Structural and Chemical Properties

	MWD mm	DR %	CDI %	ASC %	CFI %	BD g/cm ³	Ksat Cm ³ /hr	OM %	THC Mg/kg	pH
MWD	-									
DR	-0.277	-								
CDI	-0.688**	0.404*	-							
ASC	0.641**	-0.772**	-0.828**	-						
CFI	0.688**	-0.404*	-1.000**	0.829	-					
BD	-0.059	0.008	-0.022	0.013	0.022	-				
Ksat	-0.042	-0.167	0.012	0.068	-0.011	-0.817**	-			
OM	-0.665**	0.264	0.524**	-0.515**	-0.524**	-0.432**	0.524**	-		
THC	-0.605**	0.135	0.779**	-0.603**	-0.780**	-0.156	0.268	0.698**	-	
pH	-0.543**	0.286	0.432	-0.488**	-0.432**	-0.582**	0.695**	0.917**	0.560**	-

Key: MWD=mean weight diameter, DR= dispersion ratio, CDI= clay dispersion index, ASC= aggregated silt + clay, CFI= clay flocculation index, BD= bulk density, Ksat= saturated hydraulic conductivity, OM= organic matter, THC= total hydrocarbon content

The chemical properties influenced the structural stability of soils studied. Maintaining an optimum physical and chemical soil condition is important in sustaining soil health and its quality (Almendo-Candel *et al.*, 2018). At macro aggregation level, MWD showed a negative significant ($P<0.01$) correlation with organic matter (OM). This indicates that as

OM increases MWD decrease or vice versa, Igwe and Ejiofor, (2005) recorded same result. For micro aggregation, clay flocculation index (CFI) and aggregated silt + clay (ASC) were negatively and significantly ($P<0.01$) correlated with OM while clay dispersion index (CDI) positively and significantly ($P<0.01$) correlated with OM. This result indicates that OM is acting as a disaggregating

agent on stability of aggregates. Some researchers like Mbagwu and Schwertman, (2006); Oades, (1984); Arias *et al.* (1996) noted that soil organic matter can act as an aggregating or disaggregating agent or have no effect depending on its composition in soil. CFI and ASC showed an indirect relationship with OM. This indicates that as OM increases the higher the tendency of soil to disperse leading to structural breakdown. According to Obalum *et al.*, (2017), structural breakdown is caused mainly by clay dispersion, as dispersing effect of negatively charged organic materials seems to contradict the well-known aggregate stability effect of soil OM. Oades, (1984), noted that an increase in the ratio of fulvic and humic acid can render OM soluble which results in clay dispersion while Chandra and De, (1982), postulated that the formation of large quantities of organic acid from carbon dioxide evolved during manure decomposition reduce soil pH and bacteria population which can decrease soil aggregates. Formation and stabilization of soils are influenced by the type and amount of organic matter (Six *et al.*, 2000; Bossuyet *et al.*, 2001).

BD showed a negative correlation with chemical properties (OM, THC pH) while Ksat showed a positive correlation with chemical properties. This indicated that any waste product that improves porosity, which is an index of BD helps in the movement of water (Almendro-Candel *et al.*, 2018).

SUMMARY AND CONCLUSION

The results of this study revealed that POME had a better structural stability than the control site while CME showed a lower structural stability than the control site. There is a high significant difference in BD between the agro industrial sites. The POME site has a lowered BD which invariably increased porosity, Ksat and improve stability of aggregates (MWD, ASC, CFI). But CME increased the BD, which reduced porosity, Ksat and stability of aggregates in the site. Effluents from agro industrial sites (POME and CME) increased values of chemical properties (pH and OC). The correlation analysis showed that chemical properties influenced structural stability of the studied soils.

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