Assessment of Wood Waste Dumpsite on Dynamics of Soil Physico-Chemical Characteristics in Njoku Timber Market, Imo State, Nigeria

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***Abstract*– The study focus on the effects of wood wastes generated on the changing pattern of the soil quality in order to combat some of the environmental problems like air , land and water pollutions, because wood waste represents a significant proportion of the waste stream in Njoku Timber Industry in Owerri. The study of soil dynamics from the wood waste and without wood waste disposal sites was conducted through soil sampling at different depths for physico-chemical components. The results indicated that soil quality varied between soil profiles A and B, with (A) having better soil quality than B due to availability of wood wastes deposit. Overall results show that the wood waste exerted appreciable influence on physico-chemical parameters such as sand, silt, clay, pH, organic matter, total nitrogen, available phosphorus, aluminum, calcium, magnesium, potassium, sodium, cation exchangeable capacity and base saturation, hence improvement in the fertility status of the soil in soil profile A. It is then recommended that wood waste should be encouraged in organic agriculture to combat emission of green house gases which is detrimental to environment through ozone layer depletion and acid rain formations.**

***Keywords*–** Soil Dynamics, Soil Quality, Wood Waste and Biodegradation

I. INTRODUCTION

Biodegradable natural materials are permanently exposed to degradation processes of an environmental, chemical or microbial nature. The extent of the deterioration depends on the environment in which these materials are usually found. Among biodegradable materials, wood is considered to be a durable material that withstands weathering well without losing much of its structural properties (except for microbial attack) [15]. However, a number of environmental (non-biological) parameters contribute significantly to the degradation of wood, including humidity, temperature, solar light irradiation time, atmospheric ozone content, and pollution [15]. Another important aspect that may significantly affect the degradation rate of wood is the kind of wood, i.e. softwood or hardwood. Hardwood and softwood differ in several aspects, like fiber dimensions, chemical component composition and lignin and cellulose content. The hardwood presents a vessel element and lignin with both *guaiacyl* and *syringyl* units. Softwood does not contain vessel element, the lignin being composed mostly of essentially only *guaiacyl* units [14]. Wood waste represents a significant proportion of the waste stream. Wood wastes in the saw mills are derived from different tree species whose properties are bark, sawdust, slab, strips and substandard timbers and logs left to decay [12]. Effect of wood waste on the physico-chemical properties of soil has been studied by authors like [11], [15] who explained that wood waste on the soil surface releases nitrogen to crops and plants that were found within the vicinity due to increased soil fertility contents, as well as the humus, the extractives salts total content and pH values, was also approached [15]. In Nigeria, there are many districts that have significant sawmilling and timber harvesting industries that lead to wastes, which is of environmental concern because of its impact on soil, air, water and man.

The study then focus on the effect of wood waste disposal on dynamics of soil physico-chemistry for environmental sustainability in the area.

II. MATERIALS AND METHODS

A. Geographical Setting

Owerri Municipal of Imo State is within rainforest zone of Nigeria that lies between longitude 7^0.00’ and 7^0.05’ E and latitude 5^0.27’ and 5^0.31’. The area covers the total landmass of 24.88 km. It has mean annual rainfall of 213.2 mm, and mean annual temperature ranging between 26 – 28 ^{0}C, with humidity that varied between 50.5 -70.5 %. In Njoku Timber market, wood wastes are generated incessantly due to the high demand for wood products for human constructions. And wastes that are generated do not pass through effective bio-degradation because of the waste they are dumped and evacuated. Imo State is one of the areas due to its location advantage within forest zone of Nigeria where hard and soft woods are found. The wood wastes landfill as dumps in this region are generated through forestry and sawmilling activities.

III. METHODS OF DATA COLLECTION

A. Collections of Soil Samples

Soil samples were also collected from the virgin soil void of wood waste of any kind and from wood waste disposal sites at Nekede dumpsites for comparative studies. Soil samples were collected from the two types of soils categorized according to depth. For soil depth category of 0 to 15cm (Point (A) soils designated wood waste dumpsite and (B) designated without wood waste) , and soil samples were taken from surface layer to 15 cm with the help of auger**.** The soil samples were bagged in 350 cc sampling bag, labeled and transported to the laboratory for analysis.

B. Laboratory Analysis of Soil Samples

Soil samples were air-dried and sieved through 2 mm sieve and analyzed following the laboratory procedures of Canadian Society of Soil Science [5]. The p determined by the hydrometer method in which 50 g of sieved air dried soil was weighed into 250 ml beaker and 100 ml of calgon added and allowed to soak for 30 min. It was transferred to a dispersing cup and the suspension stirred for 3 min with mechanical stirrer. The suspension was transferred to a sedimentation cylinder and filled to the mark with distilled water. A plunger was inserted and used to mix the content thoroughly. The stirring was stopped and the time recorded. The soil pH was determined in water using a glass electrode pH meter. Organic carbon was determined by oxidizing soil sample with dichromate solution and later titrated with ferrous sulphate solution [16]. The total nitrogen was determined using micro-kjeldahl method and the available phosphorus colorimetrically by the molybdenum blue method [3]. The exchangeable cations were extracted by leaching 5 g of soil with 50 ml of ammonium acetate at pH 7. The potassium and sodium in the leachate were determined with a column model 21 flame spectrophotometer while the calcium and magnesium were determined with atomic absorption spectrophotometer. The exchangeable acidity was determined by adding barium chloride buffer solution to soil sample and titrated against 0.1 N HCl.

Table 1: Physico-Chemical Characteristics of soil samples from Wood wastes Dumpsite and Non-Wood Waste Soil

Soil Parameters	Soil Samples			
	Soil with Wood Waste (A)		Soil without Wood Waste (B)	
	0-30	30-45	0-30	30-45
Sand (%)	88.4	80.5	82.4	76.7
Silt (%)	9	11.6	4	6
Clay (%)	1.4	0.7	0.6	0.5
pH	6.7	6.8	5.9	6.1
Organic Matter (g.kg^{-1})	6.04	5.3	0.89	0.85
Total N (g.kg^{-1})	0.3	0.2	0.04	0.02
Avail. P (mg.kg-^{1})	6.35	7.02	3.75	3.98
Al cmol.kg-1	0.88	0.91	0.55	0.65
Ca^{++} Mg	3.2	4.32	1.6	1.04
Mg++	1.6	2.6	1.2	1.3
K^{+} (cmol.kg-1)	0.14	0.16	0.15	0.13
Na^{+} (cmol.kg-1)	0.27	0.31	0.23	0.31
CEC (cmol.kg-1)	6.51	6.67	4.08	4.21
BS (%)	80	97	77.9	79.2

Source: Fieldwork, 2010

IV. PARTICLE SIZE DISTRIBUTION

Fig. 1 and Table 1 indicate that sand, silt and Clay contents of the soil samples are generally high ranging between 80.5 – 88.45 % , 9- 11.6%, 0.7 – 1.4% in (A) and 76.7 – 82-4 %. , 4 – 6 % and 0.5 – 0.6 % respectively. The high percentage compositions of sand and silt fractions of the soil sample containing wood waste could be due to low transportation of humus [3]. Low clay content of the soil wood waste is suspected to be a result of bulky nature of wood waste on the top soil.

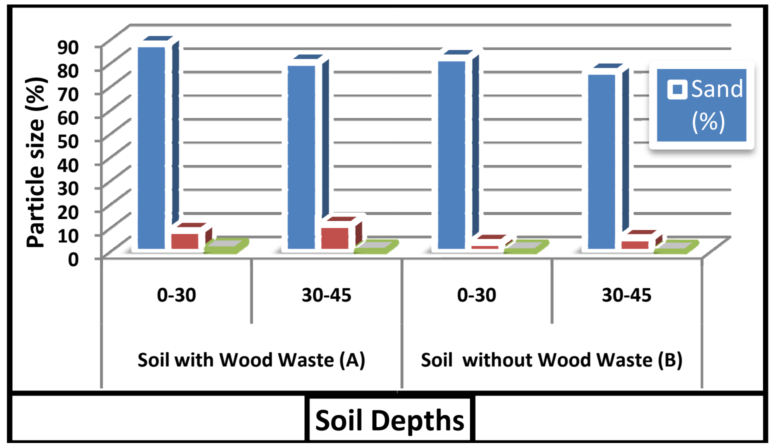

Fig. 1: Variations of Particle Size Distribution at Various Depths of the soil A and B

V. CHEMICAL PROPERTIES OF THE SOIL

Soil pH

From the result there was a slight variability in pH of soils in point A and B that ranged between pH 6.7- 6.8 and 5.9 -6.1 respectively (Fig. 2). This indicates that soil without wood ash is more acidic than soil with wood ash. This is consistent with the findings of [8], [17] who observed that soils of West African forest zones are naturally acidic due to heavy rain leading to leaching. But adding wood ash to the soil has helped in increasing the pH values in point A.

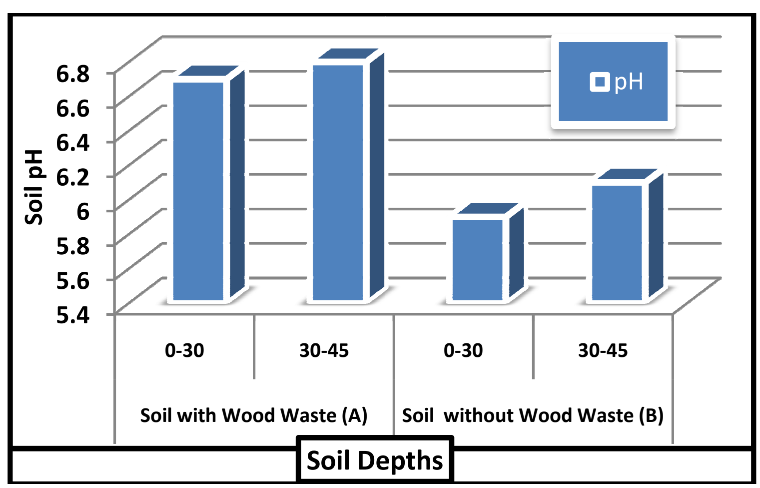

Fig. 2: Variations of Soil pH in A and B

The experimental data obtained on the soil with and without wood wastes chemical components are presented in Table 1 and Fig. 3.

Organic Matter

It is well recognized that soil organic matter increases structure stability, resistance to rainfall impact, rate of infiltration and faunal activities [13]. Soil fertility is closely linked to soil organic matter, whose status depends on biomass input and management, mineralization, leaching and erosion [10].

Organic matter of soils (A) and (B) decreased with depths (Table 1). Soil (A) values ranged between 5.3 – 6.04 $g.kg^{-1}$, (B) ranged between 0.85 – 0.89 $g.kg^{-1}$. Though point (A) has high value of OM in the soil than point (B), results of organic matter is very low, leading to high susceptibility of soil to erosion in the area. This is confirmed by [6] who explained that organic matter in the soil <50 is low.

Total Nitrogen

The nitrogen status of soil is closely associated with the soil organic matter [8]. As indicated in Table 1, the total Nitrogen in soils (A) and (B) was very low compared to the minimum rating of <1.5 [6]. But N was found to be higher in soil where wood waste was dumped than soil without wood waste. The low N in the soil is attributed to leaching of nitrates down the profile [7].

Available Phosphorous

The available phosphorus from the two soil sample sites in all depths were found to be very low, especially soil without wood waste (Table 4). The values ranged between 6.35 – 7.02 $mg.kg^{-1}$ in soil with wood waste, and soil without wood waste 3.75 -3.98 $mg.kg^{-1}$).

Exchangeable Cations

Al ranged from 0.88 – 0.91 cmol.kg-1 in point (A), 0.55 – 0.65 $cmol.kg^{-1}$ in point (B), and the result is attributed to leaching [7]. Ca ranged from 3.2 – 4.32 , 1.6 -1.04 $cmol.^{kg-1}$ in points A and B respectively, with point A having the highest value due to availability of wood ash in the soil. Mg and K ranged from 1.6- 2.6, 0.14 -0.16 in point A, 1.2-1.3, and point B 0.13 -0.15 $cmol.kg^{-1}$ respectively. Na ranged from 0.27 – 0.31 in A and 0.23 – 0.31 $cmol.kg^{-1}$ in B. From the result, it is observed that exchangeable cation in higher in soils with wood waste than soils without wood waste. The high levels of Ca, K and Mg can latter lead to deterioration in soil properties [9].

Cation Exchangeable Capacities and Base Saturation

The CEC and BS had respective ranges of 6.51 – 6.67 cmol.kg-1, 97 – 80% in point A, and 4.08 – 4.21 cmol.kg-1, 77.9 – 79.2% in point B respectively. The low CEC can be attributed to the low clay content and kaolinitic mineralogy of the soils [9]. However, [1] report that the low CEC is related to organic matter content than the clay content in Nigerian soils. Low CEC in soils with wood waste is suspected to be the result of a slowly biodegradation process for the wood waste. The result is consistent with the finding of [15] who reported that wood is considered to be a durable material that withstands weathering well without losing much of its structural properties (except for microbial attack) that helps in an increased CEC in the soil.

Considering the regression analysis of the soil samples containing wood waste and that without wood waste, the analysis indicated that the wood waste exerted great influence on the study. The regression calculated describe the strength of the relationship of the two variables: wood waste and that without wood waste was r^2 = 0.99. This indicated that the wood waste influenced positively the soil qualities such as sand, silt and clay compositions, pH, organic matter, exchangeable acidity(aluminum and hydrogen), total exchangeable cations (Ca^+, mg^+, k^+, Na^+), cation exchangeable capacity, base saturation and available phosphorus, thereby improving the soil fertility of the soil understudy. The wood waste had a perfect positive relationship, therefore contributed to the fertility status of the soil. This could be attributed to decomposition and mineralization of the organic matter resulting from addition of the wood waste.

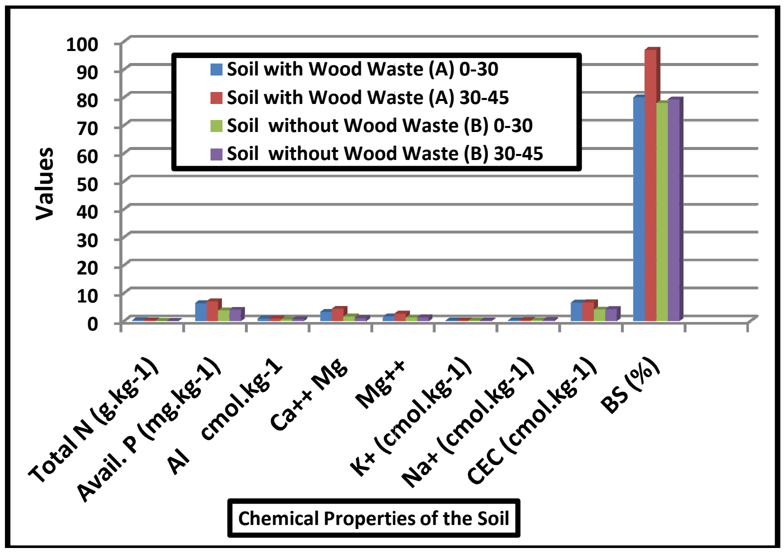

Fig. 3: Variations of Chemical Properties of the soil at Various Depths in A and B

VI. SUMMARY AND CONCLUSION

The soils under studied reflected some response to the addition of wood waste when compared to the soils without wood waste based on physical and chemical characteristics of the soils. The high percentage composition of sand, silt fractions of the soil sample containing wood waste could be attributed to low transportability as a result of organic matter binding effects. The low clay content of the topsoil of the soil sample containing wood waste is a result of bulky nature of the wood waste compositions on the surface of the soil. The soil with wood waste with buffer effect resisted the possible decreased of soil pH, while decreased soil pH was experienced in soil without wood waste indicating acidity.

Organic matter content of soil with wood waste increased tremendously due to organic carbon from wood waste, with availability of cations ($Ca^{2+,}$ K^{+}, mg^{2+} and Na^{2+}). The humus portions of soil organic matter is by virtue of its very high cation exchange is acting as a reserviour of cationic capacity could be attributed to low decomposition of wood waste due to lack of time. A slowly increase for the soil pH values is noticed for soil without wood waste calling for soil management for agricultural practices.

It is the concluded that wood waste dumped in agricultural soils has positive influence on the fertility of the soil, which is confirmed by the regression analysis that showed strong relationship as the result of wood waste addition to organic matter contents which in turn affected the nutritional value of the soil.

VII. RECOMMENDATION

Based on this results, it is then recommended that: Wood waste should be converted to compost. Wood chips from waste wood can be used as a bulking agent when composting materials such as sewage sludge. Wood chips mixed with sewage sludge aids the aeration of the compost pile and promotes the activity of the aerobic bacteria that results in the compost. Similarly, composting operations are not necessarily cost effective, but rather present an opportunity to divert some of the waste entering the landfill and present a social benefit rather than an economic opportunity. One potential use for wood waste as soil amendment is the soil application of wood fines resulting from wood processing [4]. Therefore increase usage of wood waste should encouraged in organic agriculture in order to stop the emission of obnoxious green house gases to the atmosphere that would have depleted ozone layer.

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