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The assessment of enzymatic activities of urban soils under different land use types in Owerri, Southeastern Nigeria

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Abstract

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The aim of this study was to assess the effects of different land use types, dumpsite and waterleaf farm on soil properties and enzymes production. The investigation was carried out using composite top soil sample (0–20 cm) by mixing sub-samples from six random points within 4 metres square (4 m^2), in three dumpsite soils and three waterleaf farms of Nekede, Ihiagwa and Akachi. A total of eighteen samples were used for the analyses of soil properties and enzymes production using standard procedures. The results revealed that soil pH (H_2O) varied from 5.30 to 5.57. Akachi dumpsite recorded the highest pH (H_2O) (5.57), while the least was observed in Ihiagwa waterleaf farm (5.30). Catalase production recorded highest value of 7.27 mg g^{-1} in Ihiagwa dumpsite soil while the least was 2.60 mg g^{-1} in Ihiagwa waterleaf farm. Urease was highest in Nekede dumpsite with value of 9.03 mg g^{-1} whereas the least was 3.00 mg g^{-1} recorded in Akachi waterleaf farm. The relationship between catalase and ECEC was positive and significant (r = 0.64*), while the relationship between urease and total nitrogen was also positive and significant (r = 65*). Soil organic matter, soil pH and ECEC were the major factors influencing activities of soil enzymes.

Keywords: land use types; enzymes; urban soils; soil properties

Introduction

In a bid to assess soil quality, soil enzymes play an essential role in soil processes, such as nutrient cycling and transformation by catalyzing numerous chemical, physical and biological reactions, which are important in the conversion of organic substances into plant nutrients and are helpful in the maintenance of a steady environment for crop plant to thrive. Natural and anthropogenic activities are very potent in the inducement of soil enzymatic activities (Pandey et al., 2014). Soil enzymes have a strong a relationship with soil properties and this relationship is influence by environmental factors mostly soil temperature, soil moisture and pH (Lipinska et al., 2014).

The incorporation of farmyard manure, agricultural waste, municipal solid waste into farm garden and dumpsite soils enhance microbial activities, and these microbial activities are key to releasing enzymes since enzymes in soils are biologically controlled (Tiwari et al., 2019). Deforestation, land use types such as farm garden, dumpsite and urbanization greatly influenced soil enzymes (Yan et al., 2016). Dumpsites and as well as garden soil are rich in organic manure, which improves soil chemical and biological properties, such properties such as organic carbon, nitrogen, phosphorus and as well as high microbial loads particularly bacteria, fungi and actinomycetes that stimulates the release of enzymes (Atalia et al*.,* 2015). Waste from dumpsite also improves the soil physical properties such as water retention, soil aggregation, and soil porosity (Celik et al*.,* 2004).

Land use types affect soil enzymes activities (Ewa et al., 2016). The activities of urease and catalase in dumpsite soil vary with the activities in farm garden and can be effectively used to evaluate soil quality in urban soils (Pandey et al., 2014). In the soil, urease is closely related to organic matter and silts (Alef & Nannipieri, 1995). According to some researchers, urease activity should be used as an indicator of soil quality and changes under the effect of land use (Sotres – Gil et al., 2005). Also, Qui et al. (2004) reported that soil catalse activity and urease activity are useful index for the measurement of soil fertility. Soil enzymes activities that involved in nutrient cycling mostly carbon, nitrogen , phosphorus and the breakdown of hydrogen peroxide into oxygen and water has been used to measure soil quality (Pandey et al., 2014). Soil catalase activity is sensitive to soil biological factors (Asmar et al., 1992). The research is geared toward hypothesizing that enzymes characteristics vary based on land use types and could be a useful tool to measure soil quality. Consequently many studies on the enzymatic activities in different land use types have been carried out. However, there is dearth of information on enzymatic activities in a dump site and farm garden soil. The main objective of this study was to assess catalase and urease activities in urban soils as influence by land use types of farm garden and dumpsite soil. The specific objectives were to determine the physico-chemical properties of these soils and to establish the relationship between soil enzymes and soil properties.

Materials and Methods

Study Area

The study was carried out in Owerri, Southeastern Nigeria, using three different locations namely; Ihiagwa (5.4006°N, 7.0122°E), Akachi (5.4685°N, 7.0414°E) and Nekede (5.4117°N, 6.9585°E) in a tropical rain forest zone of Nigeria. Rainfall in the area mostly begins from March to October, with the average monthly rainfall range of about 2400 mm. Relative humidity is about 25.6%. The temperature is uniform averaging between 28°C to 30°C. February to early April usually have the highest maximum temperature, while December to January often have the least temperature. The relative humidity is averaging about between 75 to 90%. The vegetation is rainforest characterized by secondary forest and usually interspersed with wild oil palm. Shifting cultivation is the traditional land use in the area associated with slash-and-burn. Common crops grown in this area include: *Manihot* spp. *Zea mays, Dioscorea* spp. etc.

Field study

The experimental design was randomized quadrant sampling method. Three garden farms and three dump site soils were used for the study. Nine samples were taken from dump site and another nine samples were obtained from garden soils. Composite top soil sample (0-20 cm) was obtained by mixing sub-samples from 6 random points within 10 m² in each sampling site by using hand auger. A total of eighteen samples were taken for enzymes analysis. For soil laboratory analysis, the soil samples were weighed, air-dried and allowed to pass through a 2-mm mesh sieve to obtain the fine earth fraction.

Laboratory Analyses

Particle size distribution hygrometer method (Gee & Or, 2002), organic carbon (Nelson & Sommers, 1982). Total nitrogen using modified Micro-kjeldhal digestion method (Bremner & Mulvaney, 2003). Soil pH was determined electrometrically using soil pH meter (Hendershot et al., 1993). Available Phosphorus (Olson and Sommers (1982). Effective cation exchange capacity (Bremner, 1996) and exchangeable acidity (Olson & Sommers, 1982). Urease activity was determined by the method described by (Yao et al., 2006)). Catalase activity was determined by method described by Stepniewska et al. (2009).

Statistical Analyses

The data obtained was subjected to analysis of variance. Significant means were separated using Least Significant Difference at 5% level of probability. Pearson correlation analysis was used to establish relationship between enzymes count and some soil properties.

Results and Discussion

The results of the physical properties of the soils are shown in (Table 1). The mean values of sand varied from (87.52–90.85%), clay ranged from (2.48–7.15%) and silt ranged from (4.67–6.67%). The results showed that sand fraction dominated other particle size fractions. This may be due to sandy nature of the parent material, in which the soils are formed since parent materials has significant influence on soil texture (Nnaji et al., 2002). Consequently, the soils of the study area might have developed from sandstone and quartzites parent material, and such parent materials are capable of impacting coarse texture of the soil. The texture of the soils fall within sand and loamy sand.

Table 2 shows chemical of the soil of the studied areas. The soils were acidic with pH ranging from 5.30–5.57. Ihiagwa waterleaf farm recorded the least pH value while the highest pH value was obtained in Ihiagwa dumpsite soil. There was significant difference in pH ($p < 0.05$). The acidic nature of the soils may be due to high intensity of rainfall in the area, which leaches basic cations away from the soil solution. Uzoho et al. (2007) reported that leaching of Ca and Mg is largely responsible for development of soil acidity. Total nitrogen varied from (0.11–0.15) %, available phosphorus ranged from (3.08–5.23) $mgkg^{-1}$, organic carbon increased from (0.68–1.44%). Organic carbon was significantly different ($p < 0.05$). Akachi dumpsite recorded the highest level of organic carbon, available phosphorus and total nitrogen (Table 2). The values of total nitrogen and available phosphorus were low and it characterized the true state of Southeastern Nigeria soils due to rapid loss of N by leaching of nitrate and inorganic PO_4^{-1} fixation by Fe and Al compounds as reported by Eshett et al. (1990). Also, Uzoho et al. (2014) reported that the low phosphorus content of the soils of Southeastern Nigeria may be due to soil acidity. Calcium ranged from (2.53–4.87) $Cmolkg^{-1}$, Magnesium ranged from (0.87–2.47) $Cmolkg^{-1}$, Potassium varied from (0.30–0.67) $Cmolkg^{-1}$ while Sodium ranged from (0.08–0.56) $Cmolkg^{-1}$ (Table 2).

Potassium and magnesium were high based on the critical limit of 0.16–0.25 $Cmolkg^{-1}$ and 0.20–0.40 $Cmolkg^{-1}$, respectively, as reported by Onyekwere et al. (2003). Calcium dominated other cations in both dumpsite and farm garden. Thus, the soils are expected to have better soil aggregate stability. The higher the calcium contents of the soils, the more supportive aggregate stability of the soil becomes since calcium acts as a binding agent aggregating soil particles (Baver et al., 1978). ECEC ranged from 4.86–8.03 $Cmolkg^{-1}$. ECEC was higher in dumpsite than waterleaf farm with the highest amount recorded in Akachi dumpsite, while the least was recorded in Akachi water leaf farm. ECEC was significantly different ($p < 0.05$). The elevated amount of ECEC in Akachi dumpsite relative to other dumpsites and waterleaf farms may be attributed to higher level of organic carbon in Akachi dumpsite. This finding agrees with the finding of Donahue et al. (1990) who reported that ECEC increased with an increase in organic carbon content of the soil. Generally, ECEC was low and could be attributed to high rate of weathering and leaching of the basic cations in these soils as a result of high temperature and rainfall associated with humid tropical climate. Akamigbo & Asadu (1983) noted that low ECEC could be as a result of high rainfall.

Table 1. The physical properties of the soil in the area

Location	Sand, %	Clay, %	Silt, %	TC
AKD	90.85	2.48	6.67	Sand
AKW	88.85	6.48	4.67	Loamy sand
IHW	90.85	3.81	6.00	Sand
IHD	88.85	5.81	5.33	Loamy sand
NKD	87.52	7.15	6.67	Loamy sand
NKW	90.85	4.48	4.67	Sand
LSD (0.05)	3.49^{NS}	2.27*	2.39^{NS}	

NS = not significant at 0.05 probability level, * = Significant at 0.05 probability level, AKD = Akachi dumpsites, AKW = Akachi waterleaf farms, IHD = Ihiagwa dumpsites, IHW = Ihiagwa waterleaf farm, NKD = Nekede dumpsites, NKW = Nekede waterleaf farms

Table 2. Chemical properties of studied soil

Sample	PH (H_2O)	O.C %	TN %	AV.P $mgkg^{-1}$	Ca^{2+}	Mg^{2+}	K^+	Na^+ (→ $Cmolkg^{-1}$ ←)	E.A	Al^{3+}	ECEC
AKD	5.47	1.44	0.15	5.23	4.87	1.63	0.39	0.31	0.84	Trace	8.03
AKW	5.43	0.73	0.13	4.18	2.53	0.87	0.30	0.08	1.05	Trace	4.86
IHW	5.30	0.81	0.13	4.04	3.27	2.47	0.58	0.24	1.21	Trace	7.76
IHD	5.57	0.68	0.12	3.45	2.63	1.17	0.41	0.15	0.85	Trace	5.22
NKD	5.50	0.68	0.11	3.08	2.73	1.03	0.67	0.56	0.63	Trace	5.38
NKW	5.42	0.82	0.13	3.24	2.63	1.27	0.35	0.12	1.23	Trace	5.61
LSD ($p < 0.05$)	0.45^{ns}	0.02*	0.18^{NS}	2.21^{NS}	0.19*	0.05*	0.96^{NS}	0.51^{NS}	1.17^{NS}		0.17*

NS = not significant at 0.05 probability level, * = Significant at 0.05 probability level, AKD = Akachi dumpsites, AKW = Akachi waterleaf farms, IHD = Ihiagwa dumpsites, IHW = Ihiagwa waterleaf farms, NKD = Nekede dumpsites, NKW = Nekede waterleaf farm, OC = Organic Carbon, OM = Organic Matter, AP = Available Phosphorus, TN = Total Nitrogen, EA = Exchangeable Acidity, ECEC = Effective Action Exchange Capacity

Production of selected enzymes in the studied soils

The result of enzymes production in the soil of the study area are presented in (Table 3). Catalase production ranged from (2.60 – 7.27 mg g^{-1}), Ihiagwa dumpsite had the highest catalase production, while the least was observed in Ihiagwa waterleaf farm. Catalase was significantly different at ($p < 0.05$). Waterleaf farm recorded less organic matter and less catalase production. Higher level of catalase in dumpsite soil may be associated with domestic wastes, high contents of organic matter. Similar observation was reported by Avellandea - Torress et al. (2014). The higher level of enzymes production in dumpsite soils maybe due to the fact that these soils contain more microbial counts than waterleaf farm .The research is at par with the finding of Rasmussen et al.(2006) that reported that the release of microbial enzymes is in response the density, quality and quantity of microorganisms and soil organic matter. Urease varied from (3.00–9.03 mg g^{-1}). Nekede dumpsite recorded highest amount of Urease whereas the least was observed in Akachi waterleaf. Urease was significantly different ($p < 0.05$). The elevated amounts of Urease may be attributable to increase in amount of total nitrogen in dumpsite soils relative to water leaf farm (Table 3). Similar findings were reported by Liang et al. (2003) that increase in nitrogen level of the soil often lead to increase in urease activity. Also, soil reaction may constitute variations in enzymes production in dumpsite and water leaf farm. Blonska et al. (2016) reported that enzymes are highly susceptible to soil reaction.

Table 3. Enzymatic production of the studied land use types in Owerri

Sample	Catalase, mgg^{-1}	Urease, mg g^{-1}
AKD	5.67	8.07
AKW	2.93	3.00
NKD	6.07	9.03
NKW	4.70	5.47
IHD	7.27	9.03
IHW	2.60	3.27
LSD (P<0.05)	0.02*	0.14*

AKD = Akachi dumpsites, AKW = Akachi waterleaf farms, IHD = Ihiagwa dumpsites, IHW= Ihiagwa waterleaf farms, NKD = Nekede dumpsites, NKW = Nekede waterleaf farm

Table 4. Correlation matrix between soil enzymes and selected physical and chemical properties of the studied soil

Statistical Pairs	R
Catalase and Clay	0.35*
Catalase and ECEC	0.65*
Catalase and Available P	0.63*
Catalase and Total N	0.05*
Catalase and pH	0.16^{ns}
Catalase and OC	0.23^{ns}
Catalase and Urease	0.87**
Urease and Clay	0.23^{ns}
Urease and ECEC	0.04^{ns}
Urease and Available P	0.39*
Urease and Total N	0.65*
Urease and pH	-0.33^{ns}
Urease and OC	0.54*

* = Significant at 5% probability confidence level, ** = Significant at 1% probability confidence level, R = Correlation Coefficient, ECEC = Effective action exchange capacity, OC = Organic carbon

Relationship between enzymes production and physiochemical properties of the soil of the study areas

The relationship between enzymes and soil properties are shown in (Table 4). Catalase activity was positively and significantly correlated with clay (r = 0.35*), ECEC (r = 0.64*) and available phosphorus (r = 0.63*). These relationship implies that increase in catalase production will lead to increase in Clay, ECEC and Available P content of the soil. But the relationship between catalase and total nitrogen was positive, but non-significant ($r = 0.05^{ns}$). Similarly, urease activity had a positive and significant relationship with available p (r = 0.39*), total nitrogen (r = 0.65*) and organic carbon (r = 0.54*). These relationship also implies that increase in urease will lead to an increase in available phosphorus, total nitrogen and organic carbon content of the soil.

Conclusion

This research findings revealed that dumpsite improved soil chemical properties of the soil than water leaf farm. Soil pH (H_2O), organic carbon and total nitrogen were higher in dumpsite than water leaf farm. Catalase and Urease were higher in dumpsite than water leaf farm. The relationship between catalase and ECEC was significant while the relationship between total nitrogen and urease was also significant and positive. Catalase and urease production were higher in dumpsite than water leaf farm. For maximum benefits, further investigation is necessary to assess the potential of dumpsite and water leaf farm in the improvement of soil properties and enzymes production.

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