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REGULAR ARTICLE

Studies on soil quality indices and agricultural functionality potentials of Ariara Market Solid Waste Dumpsite Aba, Abia State, Nigeria

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Abstract

Soil physicochemical properties and selected enzyme activities were assessed at thirteen different points at a depth of 0-45cm (sample A) and 46-90cm (sample B) from Ariara Market solid waste dump site Aba, Abia State. Control samples were collected 100m away from discharge point devoid of solid waste impaction. The studied points were discharge point (DC), 4 meters away East (E1), West (W1), North (N1), and South (S1) from the center of the dumpsite and 8 meters away East (E2), West (W2), North (N2) and South (S2) from the center of the dumpsite. Results indicated an alkaline pH for all the studied points. Significantly high ($p<0.05$) temperatures and percentage moisture contents were also obtained at the discharge points (DC) of the dumpsite compared to control points. Similarly, dumpsite alkaline phosphatase, hydrogen peroxidase, dehydrogenase and urease activities were significantly ($p<0.05$) higher than those of control points at 0-45cm depth (sample A). These finding suggest that wastes from this dumpsite could be harnessed as biofertilizers for agricultural purposes.

Key words: Soil quality; agricultural potentials; Ariara market

Introduction

In most developing countries like Nigeria, waste dumping and accumulation is an ever-increasing problem throughout the country. The constituents of wastes depend on the location and nearby people [1]. This could mean that the composition of waste dumps in urban settings is greater than those in the rural areas. This dumping habit not only decrease the aesthetic view of the country but also increasing disease carrying vectors. These dumpsites also attract scavengers who often remove non-degradable materials while the rest are often set on open burning in order to reduce the volume. An earlier report, [2] showed the implication of cultivation and harvesting of vegetables grown in the dumpsites in Abia State, Nigeria. In that report, edible vegetables were noted to contain at high levels toxic metals observed from these dumpsites. Similarly, the burning of waste on dumpsites leads to production of toxic chemicals which may inhibit microbial activities. Microorganisms are essentials for degradation of waste and increase in soil fertility. These they achieve through the release of various enzymes into the soil. The release of nutrients at the time of decomposition of wastes is almost similar in effect to that of other organic manures [3]. These nutrients may enrich the soil and soil microorganism thereby improving the soil characteristics. The organic matter decomposition depends upon the soil enzymes in the soil system [3]. They catalyse the

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organic waste decomposition and releasing of important nutrients back to the soil [4]. These enzymes regularly being synthesized in soil and got accumulated and play a significant role in recycling of major nutrients [4]. All soils contain a group of enzymes that determines soil metabolic processes which in turn depend on its inherent physical, chemical, microbiological and biochemical properties [4]. Better understanding about the activities and production rate of these important nutrient releasing activities are necessary in soil management and preservation and there by supporting the sustainable agricultural practices [5]. Soil enzymes measurement is a sensitive indicator of alteration of soil quality through management. Factors that affect the soil fauna and flora critically affects the soil enzyme activities. This study therefore focuses on the impact of Ariara market solid waste dumping on soil quality through soil enzyme analyses.

Method of analysis

Soil sample collection

Twenty six (26) soil samples were used for the analysis. Two soil samples each were collected from 13 different points considered from the studied waste dumpsite`s vicinity. The soil samples were collected using plastic auger at the depths of 0-45cm and 46-90 cm. Collection points were the center of the dumpsite (DC), 4 meters away East (E_1), West (W_1), North (N_1), and South (S_1) from the center of the dumpsite and 8 meters away East (E_2), West (W_2), North (N_2) and South (S_2) from the center of the dumpsite. The controls soil samples were taken at 100 meters away from the dumpsite center East (E_3), West (W_3), North (N_3), and South (S_3). The collected soil samples were placed in covered plastic plates and were properly labelled.

Preparation of soil sample

The soil samples were air-dried, mechanically grounded using a stainless steel roller, mortar and pestle. The grounded soil was sieved to obtain <2mm fraction and stored at 4^{o}C

Physicochemical parameters determination

Temperature of the soil samples and pH were determined *in situ* using the JENWAY multipurpose tester HANNA 1910 as described by APHA [6]. Soil moisture was determined using the method described by APHA [6]. Cation exchange capacity was determined by the method of Dewis and Freitas [7], while exchangeable acidity determinations was done using the method as described in AOAC [8].

Soil enzymes

The activities of soil dehydrogenase, acid phosphatase and alkaline phosphatase were determined using the methods of Tabatabai [9]. Soil hydrogen peroxidase and protease were estimated by the methods of Alef and Nannipieri [10,11] while soil urease was determined by the method of Tabatabai and Bremner [12].

Statistical analysis

Data collected were subjected to statistical analysis using one-way analysis of variance (ANOVA) procedure. The student package for social sciences (SPSS) version 20 computer software was used for the analysis.

Results and discussion

Soil temperature is known to play crucial roles in soil biochemical processes [13,14]. In this study (Table 1) soil temperature of the dumpsites ranged from 25.8^{o}C to 36.4°C. At 0-45cm, the soil temperature was significantly higher ($p<0.05$) compared to the other depth (46-90cm). This difference in soil temperature with soil depth may have resulted from decaying debris by microbes. The highest values of temperature were observed at the centre of the dumpsite (DC). The significant increase ($p<0.05$) in temperature of dumpsite centre (DC) compared to other sampling points in the present study could be attributed to biogeochemical reactions due to degradation of large volume of wastes at the centre of the dump. Temperature rise in soil has been reported to increase metal activity in soil solutions as well as absorption rate in plants through higher evaporation and transpiration from plants [15]. Akubugwo *et al.* [17] noted that soil pH is the master variable that affects virtually all soil properties. Soil pH influences a number of factors affecting soil fertility such as solubility and ionization of inorganic and organic soil solution constituents and these will in turn affect soil enzyme activity. The pH of 0-45cm soil depth was significantly ($p<0.05$) higher than the pH obtained for 46-90cm soil depth in all the sampling points. The reduction in the pH with increased soil depth might be due to possible concentration of the contaminant down the soil depth. Result indicates an alkaline pH generally in all the

sampling points relative to control. It has been noted that nature and biodegradation of wastes generate compound which dissolves in soil moisture to affect the soil pH [17]. Acidic pH in solid waste dumps sites soils are usually as a result of metal scraps [15]. It has been shown that acidic soils increase the availability of some metals which may build to toxic levels in soil and increase heavy metal phytoavailability [18]. Most crops thrive at pH 6.2 -6.8 as obtained here and attest to the potential usage of this soil for agricultural purposes as the pH obtained from this study are within the FEPA acceptable limit for agricultural soils. Soil moisture (Table 1) also followed the same pattern observed for soil temperature and pH in this study. Seasonal changes are known to affect dumpsite soil moisture contents [2]. Similarly binding of the soil by wastes at dumpsite (DC), which reduced pore spaces, may aid the insufficient aeration of the soil and affect the overall predisposition of the area under study. Findings generally indicate increase in soil moisture with increasing soil depth.

Tables 1. Physicochemical characteristics of Ariara Market solid waste dump soil.

Site	Temp ^{o}C Sample A	Temp^{o}C Sample B	pH sample A	pH sample B	% moisture Sample A	% moisture sample B
DC	36.4±1.00^{c}	36.0±1.01^{c}	6.8±0.08^{b}	6.0±0.11^{a}	65.50±0.11^{a}	44.90±0.90^{c}
E_1	31.4±0.02^{b}	30.1±0.47^{b}	6.5±0.01^{a}	5.8±0.02^{a}	24.22±0.29^{c}	29.11±0.21^{b}
E_2	30.2±1.02^{c}	29.3±0.02^{b}	6.2±0.00^{a}	5.5±0.07^{b}	20.00±0.07^{b}	21.21±0.01^{a}
E_3	28.4±0.11^{a}	26.7±0.92^{c}	6.1±0.79^{c}	5.4±0.81^{c}	14.21±0.00^{a}	16.28±0.01^{a}
W_1	30.4±0.02^{b}	29.1±0.21^{b}	6.4±0.08^{b}	5.0±0.79^{c}	22.41±0.48	25.72±1.00^{a}
W_2	29.8±0.91^{c}	28.9±1.00^{c}	6.1±0.09^{b}	5.0±0.01^{a}	18.31±0.01^{a}	20.61±0.08^{b}
W_3	28.3±0.01^{a}	26.6±0.22^{a}	6.1±0.01^{a}	5.4±0.00^{a}	15.20±0.08^{b}	17.11±0.01^{a}
N_1	32.4±0.02^{b}	30.6±0.11^{a}	6.0±0.01^{b}	5.4±0.21^{c}	16.31±0.48^{c}	23.73±0.21^{b}
N_2	30.1±0.91^{c}	29.4±0.02^{b}	6.0±0.22^{a}	5.2±0.11^{a}	15.42±0.44^{c}	22.61±0.22^{b}
N_3	27.6±0.79^{c}	25.8±0.01^{a}	6.3±0.01^{a}	5.8±0.47^{c}	9.30±0.00^{a}	12.52±0.11^{b}
S_1	31.3±0.78^{c}	29.9±0.89^{c}	6.1±0.37^{c}	5.0±0.21^{b}	15.70±0.27^{c}	20.80±0.00^{a}
S_2	28.6±0.91^{c}	27.5±0.01^{a}	5.9±0.22^{b}	5.1±0.00^{a}	14.18±0.11^{b}	20.00±0.11^{a}
S_3	28.4±0.01^{a}	28.0±0.00^{a}	6.0±0.11^{a}	5.6±0.01^{a}	15.74±0.08^{b}	18.20±0.00^{a}

Values are mean of triplicate determination ±standard deviation. Values in the column having the same superscript are not significant P<0.05.
A= Soil sample collected 0-45cm; B =Soil sample collected 46-90cm; DC=Discharge point
E_1, W_1, N_1, S_1= 4m away from discharge point, Eastwards, Westwards, Northwards and Southwards.
E_2, W_2, N_2, S_2=8m away from discharge point, Eastwards, Westwards, Northwards and Southwards
E_3, W_3, N_3, S_3=Result obtained for control samples, Eastwards, Westwards, Northwards and Southwards

Table 2. Cation exchange capacities and exchangeable acidities of Ariara solid waste soils.

Sites	CEC (mol/kg) Sample A	CEC (mol/kg) Sample B	EA (meq) Sample A	EA (meq) Sample B
DC	0.03±2.3x10^{-3}b	0.02±2.1x10^{-3a}	4.0±0.03^{c}	8.0±0.01^{a}
E_1	0.04±1.2x10^{-3c}	0.01±1.0x10^{-3a}	3.2±0.02^{d}	4.8±0.01^{a}
E_2	0.02±2.2x10^{-3a}	0.01±3.3x10^{-3a}	3.6±0.03^{b}	4.0±0.01^{a}
E_3	0.05±1.0x10^{-3b}	0.03±3.1x10^{-3b}	3.6±0.03^{c}	3.8±0.01^{a}
W_1	0.06±1.2x10^{-3b}	0.03±2.7x10^{-3b}	2.8±0.01^{a}	4.1±0.00^{a}
W_2	0.04±2.7x10^{-3c}	0.03±3.2x10^{-3a}	3.8±0.01^{a}	3.4±0.01^{a}
W_3	0.04±1.1x10^{-3c}	0.02±1.2x10^{-3a}	3.4±0.02^{b}	4.0±0.00^{a}
N_1	0.04±3.2x0^{-3c}	0.03±7.1x10^{-3d}	2.8±0.01^{a}	4.1±0.02^{b}
N_2	0.02±1.1x10^{-3e}	0.02±1.1x10^{-3a}	3.8±0.00^{a}	3.40.00^{a}
N_3	0.04±2.0x10^{-3a}	0.03±2.9x10^{-3b}	3.4±0.02^{b}	4.0±0.01^{a}
S_1	0.03±7.0x10^{-3a}	0.01±3.3x10^{-3a}	3.5±0.02^{c}	4.1±0.02^{b}
S_2	0.02±2.6x10^{-3a}	0.01±7.2x10^{-3c}	2.9±0.01^{a}	3.2±0.00^{a}
S_3	0.04±1.2x10^{-3c}	0.02±3.6x10^{-3a}	3.9±0.00^{a}	4.3±0.02^{b}

Values are mean of triplicate determination ±standard deviation. Values in the column having the same superscript are not significant P<0.05.
A= Soil sample collected 0-45cm; B =Soil sample collected 46-90cm; DC=Discharge point
E1, W1, N1, S1= 4m away from discharge point, Eastwards, Westwards, Northwards and Southwards.
E2, W2, N2, S2=8Mm away from discharge point, Eastwards, Westwards, Northwards and Southwards
E3, W3, N3, S3= Result obtained for control samples, Eastwards, Westwards, Northwards and Southward

Table 3. Soil enzyme activities of Ariara Market dumpsite soils.

Sites	Acid phospatase (µmol-pnitrophenol) Sample A	Acid phospatase (µmol-pnitrophenol) Sample B	Alkaline Phosphatise (µmol-pnitrophenol) Sample A	Alkaline Phosphatise (µmol-pnitrophenol) Sample B	Hydrogen peroxidase ($Mlg^{-1}1h^{-1}$) Sample A	Hydrogen peroxidase ($Mlg^{-1}1h^{-1}$) Sample B	Dehydrogenase $mgTPFg^{-1}6h^{1}$ Sample A	Dehydrogenase $mgTPFg^{-1}6h^{-1}$ Sample B	Protease µtyrosine g^{-1} dwt $2h^{-1}$ Sample A	Protease µtyrosine g^{-1} dwt $2h^{-1}$ Sample B	Urease $mgNH_3$-$NG^{-1}2H^{-1}$ Sample A	Urease $mgNH_3$-$NG^{-1}2H^{-1}$ Sample B
DC	3.1 ± 1.00^{a}	3.8 ± 0.01^{b}	5.4 ± 0.01^{c}	3.8 ± 0.01^{a}	8.1 ± 1.10^{c}	7.4 ± 0.01^{c}	13.8 ± 1.00^{c}	12.7 ± 0.91^{c}	$3.4x10^{4}$	6.0x104	$3.4\pm0.01c$	2.7±1.10b
E_1	3.7 ± 0.02^{b}	4.1 ± 0.47^{b}	5.2 ± 0.00^{c}	3.6 ± 0.02^{a}	6.1 ± 0.50^{c}	4.3 ± 0.01^{b}	9.4 ± 0.04^{c}	7.1 ± 0.01^{b}	$2.4x10^{4}$	$3.8x10^{4}$	2.4 ± 0.01^{b}	2.1 ± 0.50^{c}
E_2	3.9 ± 1.02^{b}	4.5 ± 0.02^{b}	4.1 ± 0.01^{b}	3.4 ± 0.00^{a}	4.3 ± 0.02^{b}	3.1 ± 0.00^{a}	4.4 ± 0.01^{a}	3.9 ± 0.04^{a}	$1.7x10^{4}$	$1.9x10^{4}$	2.0 ± 0.00^{b}	1.7 ± 0.02^{a}
E_3	4.1 ± 0.11^{b}	4.9 ± 0.92^{c}	3.4 ± 0.01^{a}	3.0 ± 0.01^{b}	3.4 ± 0.02^{a}	3.8 ± 0.01^{a}	3.9 ± 0.01^{a}	2.2 ± 0.31^{a}	$1.1x10^{4}$	$1.4x10^{4}$	1.3 ± 0.01^{a}	1.0 ± 0.02^{e}
W_1	4.1 ± 0.91^{b}	4.4 ± 1.00^{b}	4.1 ± 0.00^{b}	3.8 ± 0.02^{b}	6.3 ± 0.03^{c}	4.4 ± 0.21^{b}	10.3 ± 0.91^{c}	7.4 ± 0.21^{b}	$1.1x10^{4}$	$1.2x10^{4}$	4.2 ± 0.21	3.8 ± 0.03^{c}
W_2	4.4 ± 0.01^{c}	4.9 ± 0.22^{c}	4.9 ± 0.02^{c}	4.8 ± 0.03^{c}	3.7 ± 0.01^{a}	2.6 ± 0.01^{a}	4.8 ± 0.02^{b}	2.6 ± 0.02^{a}	$1.9x10^{4}$	$2.2x10^{4}$	3.8 ± 0.01^{c}	3.6 ± 0.01^{c}
W_3	3.4 ± 0.02^{a}	3.8 ± 0.11^{b}	4.2 ± 0.01^{b}	4.0 ± 0.01^{b}	3.8 ± 0.00^{a}	4.1 ± 0.31^{b}	3.4 ± 0.03^{a}	2.6 ± 0.01^{a}	$8.5x10^{4}$	$1.4x10^{4}$	1.6 ± 0.31^{a}	1.5 ± 0.00^{e}
N_1	3.5 ± 0.91^{a}	4.1 ± 0.02^{b}	4.1 ± 0.02^{b}	3.8 ± 0.02^{b}	4.7 ± 0.01^{b}	3.4 ± 0.22^{a}	9.4 ± 0.01^{c}	6.1 ± 0.00^{b}	$2.6x10^{4}$	$3.7x10^{4}$	3.8 ± 0.22^{c}	3.2 ± 0.01^{c}
N_2	4.2 ± 0.79^{b}	4.9 ± 0.01^{c}	4.9 ± 0.00^{c}	4.1 ± 0.00^{a}	3.2 ± 0.02^{a}	2.6 ± 0.04^{a}	6.3 ± 0.02^{b}	4.1 ± 0.02^{b}	$1.8x10^{4}$	$2.2x10^{4}$	3.4 ± 0.04^{c}	2.8 ± 0.02^{b}
N_3	3.1±0.02a	3.8 ± 0.12^{b}	4.4 ± 0.03^{b}	3.9 ± 0.01^{a}	3.9 ± 0.03^{a}	4.3 ± 0.01^{b}	5.7 ± 0.03^{b}	3.7 ± 0.03^{a}	$1.4x10^{4}$	$1.7x10^{4}$	1.8 ± 0.01^{a}	1.4 ± 0.03^{a}
S_1	4.1 ± 0.91^{b}	4.6 ± 0.01^{b}	4.9 ± 0.00^{c}	3.7 ± 0.02^{a}	4.2 ± 0.01^{b}	3.8 ± 0.12^{a}	10.4 ± 0.91^{c}	6.1 ± 0.01^{b}	$1.2x10^{4}$	$1.7x10^{4}$	3.6 ± 0.12^{c}	3.1 ± 0.01^{c}
S_2	4.4 ± 0.01^{b}	4.9 ± 0.00^{c}	5.3 ± 0.01^{c}	3.1 ± 0.01^{a}	3.1 ± 0.01^{a}	2.8 ± 0.21^{a}	7.1 ± 0.21^{c}	3.7 ± 0.02^{a}	$1.3x10^{4}$	$1.3x10^{4}$	3.0 ± 0.21^{b}	2.4 ± 0.02^{b}
S_3	3.0 ± 0.78^{a}	3.9 ± 0.89^{b}	4.8 ± 0.02^{c}	3.0 ± 0.00^{a}	4.0 ± 0.02^{b}	4.3 ± 0.02^{b}	3.2 ± 0.01^{a}	2.1 ± 0.00^{a}	$1.2x10^{4}$	$1.6x10^{4}$	2.0 ± 0.02^{a}	1.4 ± 0.02^{a}

Values are mean of triplicate determination ±standard deviation. Values in the column having the same superscript are not significant $p<0.05$.
A= Soil sample collected 0-45cm, B =Soil sample collected 46-90cm
DC=Discharge point, E_1, W_1, N_1, S_1= 4m away from discharge point, Eastwards, Westwards, Northwards and Southwards.
E_2, W_2, N_2, S_2=8m away from discharge point, Eastwards, Westwards, Northwards and Southwards
E_3, W_3, N_3

Cations helps soil aggregation which reduces the chance of soil erosion and crusting. Exchangeable acidity of soils samples (Table 2) ranged from 0.01- 0.06 meq while cation exchange capacity (Table 2) ranged from 2.9-8.00 mg/kg. The observed exchangeable acidity values of dumpsite (DC) in the present study were lower than those of the controls and the values increased with depth of samples collection. Increased level of exchangeable cations is synonymous with increase in pollution rate [13]. The cation exchange capacity obtained from the present study was highest at the dumpsite compared to control ($p<0.05$). Similar increases have been reported earlier [3,4]. It has been noted that cation exchange capacity gives the soil a buffering capacity. These will in effect slow the leaching of nutrient. This may be related to the observed higher values of cation exchange capacities for 46-90cm depth against those of 0-45cm (Table 2). Soil enzymes activities influences functional processes occurring in soil and plays important role in catalysing chemical and biological processes necessary for soil microbes. Acid phosphatase activity (Table 3) was lowest at the dumpsite (DC) compared to other points in the present study. However, the activities of these enzymes increased ($p<0.05$) with increase in depth of sample collection. This is in accordance with increase in soil acidity with depth of sample collection obtained here. Dehydrogenases are produced by all organisms and are intracellular [9,19] and serve as good measure of microbial oxidative activities in the soil [12] Dehydrogenase had high activities in the soil samples analysed in this study (Table 3). These increases in its activities at the dumpsites soils relative to control may be ascribed to increased nutrient availability indicating better conditions for microbial biodegradation of waste and release of plant nutrients. Dehydrogenase activities increased in 0-45cm depth relative to 46-90cm depth. Similar observations for dehydrogenase activities in refuse dumpsite soils was obtained by other workers [1,20]. The dumpsite (DC) had the highest hydrogen peroxidase activities than other points considered presently. Organic matter activates the activities of hydrogen peroxidase [19]. This probably explains its higher activities at 0-45cm depth than 46-90cm depth in the present study. Urease activities in soils have been reported to play important roles in the regulation of nitrogen supply to plants [21,22]. Factors such as cropping history, organic matter content, soil depth, soil amendments, heavy metals, temperatures, etc, are among the factors that influence the urease activity in soil [23]. It has been suggested that the activity coefficient of urease increases with increase in temperature [23]. However, the low urease activity at dumpsite (DC) correlate positively with observed temperature of the dumpsite studied. The soil protease activity obtained was highest in dumpsite (DC). This probably due to organic

debris from domestic refuse dumped there. The numerous leather materials at the dumpsite (DC) may have enhanced the protease activity. The enzyme activities can be influenced by changes in pH value, increasing water content and nutrient addition on soil [24].

The observation made from this work suggest that dumping of solid waste at Ariara market dumpsite generally affected the soil enzyme profile which may lead to increased plant nutrient availability. It is therefore recommended that adequate use of the soil for agriculture be made after proper treatment of the soil as to reduce possible contamination of plant products from it.

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