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Physicochemical and enzymatic activities of mining effluent contaminated soil from Ishiagu Ebonyi State South- East Nigeria

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Abstract

Soil physicochemical parameters and enzymatic activities of mining effluent contaminated soil of Ishiagu, Ebonyi State Nigeria were evaluated. Effluents of Crush Rock, Crush Stone and Ezza quarry sites in Ishiagu were used for the study. Homogenized soil samples were collected at a distance of 100m (sample B), 200m (sample C) away from discharge points (sample A) from each of the sites at a depth of 0-30cm. The physicochemical properties investigated showed significant difference in the test samples when compared to control ($P<0.05$). Enzymatic activities correlated negatively with heavy metal concentration. This shows that the enzymatic activities increased with distance away from the discharged points

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Introduction

Mining activities are synonymous with environmental degradation as wastes generated in the process are often discharged into the surrounding environment, especially in developing countries. (Li et al., 2005; Nwaugo et al., 2007a). These waste ends up interacting with the soil system thereby changing the physical and chemical properties (Piccolo and Mbagwu, 1997).

The soil is known to serve several human needs in addition to agricultural purposes. It has also been described as the habitat with the greatest amount of biogeochemical transformation (Pelczar et al., 2003; Prescott et al., 2004). Onwuchekwa et al., (2009) reported that transformations are mediated by soil dwelling organisms and their metabolites. The contamination of agricultural soil by mining wastes has been known to cause pollution of the impacted soil which in turn destabilizes the ecological balance and also alters the soil quality in terms of nutrients and the agents which mediates the biogeochemical cycles (Parham et al., 2003; Montallin and Tourine 2004; Olivera and Pampulla, 2006). Nwaugo et al., (2007b) and Obiekezie et al.,(2006), reported that ishiagu has remained a metal mining community for over 30years with its attendant problems un-addressed

This study is therefore aimed at evaluating the physichochemical properties and enzymatic activities of mining effluent contaminated soil in Ishiagu with a view to determining its functionality for agricultural purposes.

Material and methods

Study area

The study was carried out with mining effluent contaminated soil samples from Ishiagu in Ivo Local Government area of Ebonyi State, south-East Nigeria. Effluents of Crush rock, Ezza West Africa and Crush stone industries were used for the study. These ever increasing quarry, lead and zinc industries dispose their waste into nearby farms and these farms are cultivated by the rural settlers.

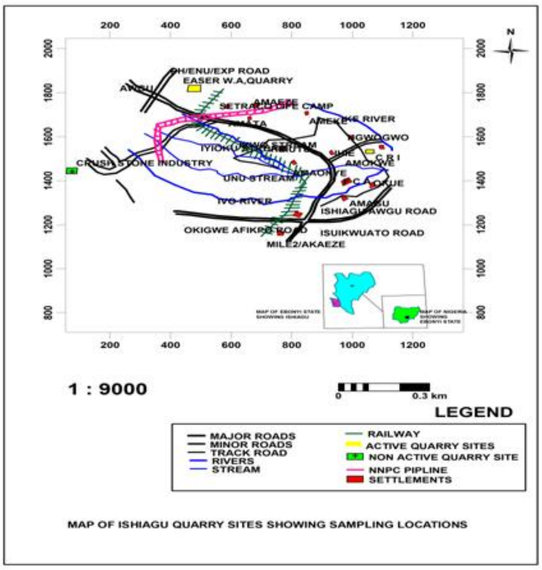

Fig. 1. Map of Ishiagu showing sample locations(Source: Aroh et al.,2007)

Research method

Soil sample collection

Soil samples were collected 100m (Sample B), 200m (Sample C) away from the discharge points (Sample A) at a depth of 0-30cm from each of the mining sites. The sample were collected using auger

Determination of physicochemical parameters of soil samples

The physicochemical parameters analyzed were temperature, pH, moisture, electrical conductivity, cation exchange capacity, soil sulphate, soil phosphate, soil chloride, soil nitrate and soil organic carbon

Soil Temperature was determined at the site of soil sample collection using mercury in glass thermometer as described by APHA (1998).

Soil pH was determined using fresh soil samples according to the methods described by Bates (1954).

Soil moisture content was determined according to the procedure described by APHA (1998).

Soil Conductivity was determined using using conductivity meter in 1:2 soil/water ratio as described by whitney (1998)

Soil Organic Carbon was determined according to the procedure prescribed by Walkely and Black (1934).
Other soil physicochemical parameters: Cation exchange capacity, Sulphur (So42-), Phosphate (Po42-), Nitrate (No3) were determined by the method described by Dewis and Fraitas (1970).
The soil enzymes were also determined. Urease was determined according to the method prescribed by Tabatabai and Bremner (1972). Soil alkaline Phosphatase, Dehydrogenase and acid Phosphatase were determined by the method prescribed by Tabatabai (1982) while Hydrogen Peroxidase was determined by the method described by Alef and Nannipieri (1995).

Data analysis

Data collected were subjected to statistical analysis using the one way analysis of variance (ANOVA) procedure and differences in mean were separated using Least Significant Difference (LSD) as described by Onuh and Igwemma (2000).

Results and discussion

The range of values for the physichochemical analysis (Table 1) is as follows. Soil pH observed in the soil samples (5.00-6.07) were significantly ($P<0.05$) lower that the value recorded in the control soil (6.70). soil pH is considered a master variable that affects virtually all soil properties and low pH in heavy metal polluted soils has also been reported by Lee et al., (2002); Akubugwo et al., (2010) and Osuji and Adesiyan (2005). Result obtained from the study showed that the soil electrical conductivity increased with distance closer to the discharge points except in Ezza quarry sites. Akubugwo et al.,(2010) reported that this could be due to excessive amount of heavy metals in the soil closer to discharge points. Arias et al., (2005) reported that high electrical conductivity may occur from various chemical and industrial wastes or may develop naturally as a result of poor irrigation, water quality and excessive use of fertilizer which affects seed germination, plant growth and soil water balance. Electrical conductivity values between 0 and 0.8 dsm-1 are generally accepted for plant growth (Arias et al., 2005).
Cation exchange capacity: Result of Cation exchange capacity showed that the discharge points have lower Cation exchange capacity. Higher Cation exchange capacities were recorded from the control and sites away from the discharge points. This could be attributed to lesser effect of the heavy metals since Cation exchange capacity is directly related to the capacity of the absorbing heavy metals (Brandy and Well, 1999).

Soil moisture: The study showed that soils contaminated with mining effluents have higher moisture content than uncontaminated soils. Li et al., (2005) reported that high soil moisture content may have a drastic effect on the organic matter decomposition through indirect reduction of soil ventilation.

Soil organic carbon of the analyzed soil samples showed that the test samples have lesser organic carbon content when compared to control. Anikwe and Nwaobodo, (2002) reported that high organic carbon is directly related to high productivity. The low organic carbon content of the test samples may be attributed to high level of heavy metal contamination of the sites. This agreed with Lee et al., (2002) who observed low organic carbon/organic matter content in soil contaminated with heavy metals. The low nitrate recorded may also be as a result of high moisture content which may affect the organic matter decomposition through indirect reduction of soil ventilation.

Enzymes are the direct mediators for biological catabolism of soil organic and mineral components. The oxidoreductases used in the work (dehydrogenase, urease, hydrogen peroxidase, acid and alkaline phosphatases) showed a decreased activity when compared to control and were more sensitive to the effect of mining effluent. The enzyme activities such as (urease and dehydrogenase) increased with distance away from discharge points.

This shows lesser effect of the mining effluent away from discharge points. This is also in line with Omprakash et al., (2011) who reported that as a result of soil pollution with heavy metals, soil enzymes such as dehydorgenase are significantly reduced. Soil enzymes can be a good assessment of soil quality. This agreed with Nwaugo et al., (2008); Leiros et al., (2000) and a host of others that soil enzymatic activities could be easily applied in assessment of soil quality.

Table 1. Soil physicochemical parameters

LOCATION	SITE	SOIL TEMPERATURE (^{o}C)	SOIL PH	CEC (cmol/kg)	ELEC. CONDUCTIVITY (µS/cm)	SOIL MOISTURE (%)	ORGANIC CARBON (%)	SOIL PHOSPHATE (%)	SOIL SULPHATE (%)	SOIL CHLORIDE (%)	SOIL NITRATE (%)
CONTROL		27.50^{a}	6.70^{a}	25.80^{e}	34.64^{j}	8.99^{h}	20.58^{a}	61.20^{c}	6.36^{a}	1.06^{d}	0.91^{c}
EZA QUARRY	A	27.04^{b}	5.03^{e}	15.23^{k}	89.60^{g}	30.67^{d}	17.53^{d}	54.48^{k}	4.20^{b}	1.07^{c}	0.83^{d}
	B	27.01^{b}	5.00^{e}	28.00^{c}	114.50^{e}	25.37^{g}	18.42^{c}	58.56^{g}	1.30^{b}	1.08^{b}	0.76^{e}
	C	26.43^{c}	5.43^{d}	24.00^{f}	104.50^{f}	59.44^{a}	17.03^{e}	59.04^{e}	2.00b	1.08^{b}	0.71^{f}
CRUSH ROCK QUARRY	A	26.00^{d}	5.50^{d}	20.27^{h}	149.87^{c}	31.85^{c}	18.44^{b}	56.88^{i}	0.10^{b}	1.07^{c}	0.16^{j}
	B	26.08^{d}	5.50^{d}	28.80^{b}	74.40^{h}	29.65^{e}	15.32^{i}	66.33^{a}	0.20^{b}	1.07^{c}	0.15^{k}
	C	26.00^{d}	6.00^{c}	11.65^{l}	66.40^{i}	54.73^{b}	14.62^{j}	57.84^{h}	1.00^{b}	1.42^{a}	0.14^{l}
CRUSH STONE QUARRY	A	27.10^{a}	6.00^{c}	18.00^{j}	157.82^{a}	27.48^{f}	15.43^{h}	58.73^{f}	0.10^{b}	1.07^{c}	0.19^{h}
	B	27.50^{a}	6.07^{c}	19.20^{i}	150.74^{b}	6.68^{j}	11.83^{k}	57.84^{h}	0.10^{b}	1.08^{b}	0.18^{i}
	C	27.00^{b}	6.00^{c}	30.43^{a}	140.00^{d}	5.08^{l}	11.78^{l}	56.67^{j}	1.20^{b}	1.08^{b}	0.20^{g}
LSD		0.12	0.18	0.30	0.52	0.33	0.01	0.05	0.75	0.002	0.004

Values are mean of triplicate determination. Means in the same column, having the same letter(s) are not significantly different ($p< 0.05$) using Least Significant Difference (LSD).

A = Soil sample from discharge point

B = Soil sample 100m away from discharge point

C = Soil sample 200m away from discharge point

Table 2. Soil enzyme activities.

LOCATION	SITE	SOIL DEHYDROGENASE mgTPFg-1 drysoil6h-1 (x 10-5)	ACID PHOSPHATASE mg/g/h	ALKALINE PHOSPHATASE mg/g/h	HYDROGEN PEROXIDASE Ml 0.1ML-1 Kmno4g-1 drysoil	UREASE mgNH3-Ng-1 drysoil 2h-1
CONTROL		1.09 x 10-4b	6.82b	2.90a	0.009c	37.98b
EZA QUARRY	A	3.4 x 10-5e	3.41e	2.41e	0.086b	9.16k
	B	5.1 x10-5k	3.93d	2.50d	0.004d	15.21g
	C	5.7 x 10-5d	4.13d	2.85b	0.091a	17.32f
CRUSH ROCK QUARRY	A	4.4 x 10-5f	11.09a	2.67c	0.008c	1.48i
	B	3.6 x 10-5j	2.56f	2.85b	0.008c	11.45j
	C	3.7 x 10-5i	3.41e	2.32f	0.007c	14.68h
CRUSH STONE QUARRY	A	3.8 x 10-5h	5.12c	2.67c	0.001e	14.28i
	B	3.9 x 10-5g	3.41e	2.50d	0.001e	32.16c
	C	3.8 x 10-5h	1.71g	2.24g	0.001e	43.38a
LSD		(9.1 x 10-5) 0.000091	0.282	0.011	0.003	0.09

Values are mean of triplicate determination. Means in the same column having the same letter(s) are not significantly different ($p<0.05$) using Least Significant Difference (L SD).

A = Soil sample from discharge point
B = Soil sample 100m away from discharge point
C = Soil sample 200m away from discharge point

Conclusion

The findings of this study showed that the mining effluent contamination of soils in Ishiagu, Ebonyi state Nigeria, adversely affected the soil physicochemical properties and soil enzymatic activities. Its effects however, decreases with distance away from the discharge points

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