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IMPACT OF OPEN CAST MINE LAND USE ON SOIL PHYSICAL PROPERTIES IN ENYIGBA, SOUTHEASTERN NIGERA AND THE IMPLICATION FOR SUSTAINABLE LAND USE MANAGEMENT

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ABSTRACT

The study examined the extent of soil physical properties deterioration due to mining activities in Enyiba Ebonyi State, Southeastern Nigeria. In the study, two factors were considered: factor A - Soil depths (surface soil: 0-15 cm and subsurface soil: 15-30 cm) and factor B - Distances from mine pits (100 m, 200 m, 300 m, 400 m and 500 m away from mine pit). Four mining sites (Mbaraeke Enyigba, Mkpoda Ugwvu, Nwamgbam Uchakuru and Azu Enyigba) within Enyigba mining vicinity were selected for the study. For standardization, a control was located 1.5 km away from Enyigba mining vicinity. A total of 82 core soil samples and 184 auger soil samples were used for the study. The results showed textural classes at different distances and depths to be predominantly sandy clay loam including those of the control. However, higher values of clay were obtained at lower depths (15 – 30 cm) at both mine area and control. The bulk density value at the subsurface soil of mine site (1.67 g/cm3) was significantly ($p < 0.05$) higher than the surface soil (1.53 g/cm3) and control (1.59 g/cm3). The values of total porosity in all distances and depths were significant ($p < 0.05$), recording a reverse trend compared to bulk density values. Massive deterioration as a result of heavy machineries at the mine area lead to high bulk density mostly at lower depths, low porosity and surface capping compared to the control. Highest bulk density value of 1.79 g/cm3 was recorded at 300 m subsurface soil of the mine area. Limited use of heavy machinery was recommended to reduce soil compaction. Farmers within the study area are encouraged to practice conservation tillage since soil physical properties deterioration affect soil use and productivity.

Keywords: Land degradation, soil depths, mine area, soil physical properties

INTRODUCTION

It is well established that one of the primary anthropogenic sources of heavy metal is mine (Goyer, 1996). Mining causes large amount of destruction of the environment in the form of alteration of landscape, deterioration of vast land areas, extinction of wild life, destruction of natural habitat, changes in river regime, dust inhalation and air emissions (Ezeaku, 2012). Increased operations of artisanal and small scale miners as well as large scale mechanized mining are very destructive both to the landform, vegetation and to adjacent aquatic ecosystems (Okolo, 2014). Soil physical properties are dominant factors affecting the use of soils (Chude et al., 2011). The success or failure of agricultural projects often hinges on the physical properties of soil, because they are more difficult to change than chemical properties. In areas of wilderness, mining may cause destruction and disturbance of ecosystems and habitats, and in areas of farming it may disturb or destroy productive grazing and croplands. Increase in soil bulk density as a result of heavy equipments used in mining usually indicates a poor and unsuitable environment for root growth, soil compaction and undesirable infiltration and drainage. Moreso, dredging using heavy equipment and implements causes damage to the soil surface with evident changes in landscape and soil compaction.

With respect to the foregoing and equally owing to the fact that there has been no study of this kind in the area, it is very pertinent that this study is conducted, especially now that large scale mechanized mining is about resuming in the area.

The major objective of this study was to investigate the present status of soil physical properties deterioration in the vicinity of Enyigba mine as impacts of solid minerals mining. The expected output of this research aims to address the paucity of information in the study area with regards to changes in soil physical properties and especially to aid relevant stakeholders in agricultural land use planning and sustainable land use management to ensure soil productivity optimization.

MATERIALS AND METHODS

The study area

The study was conducted at Enyigba in Abakaliki Local Government Area of Ebonyi State. Enyigba is 14 km southeast of Abakaliki in Southeast Nigeria (Fig. 1). The area of study lies between latitudes 6° 07’ N and 6° 12’ N and longitudes 8° 05’ E and 8° 10’ E as obtained with a handheld GPS in the derived savanna vegetation zone.

Four active open mine pits studied were located at Azu Enyigba, Mbaraeke, Nwamgbam Uchakuru and Mkpoda Ugwvu with their coordinates shown below:

Mine site location	Latitude	Longitude
Mbareke	06°11.590'	008° 08.408
Azu Enyigba	06°11.426'	008° 08.411
Nwagbam Uchakuru	06°11.325'	008° 08.426
Mkpoda Ugwvu	06°11.745'	008° 08.345

The area experiences bimodal pattern of rainfall (April-July) and (September-November) with short dry spell in August normally called “August break”. The total mean annual rainfall is between 1700 to 2000 mm. At the onset of rainfall it is torrential and violent, sometimes lasting for 1-2 hours. The minimum and maximum temperatures are 270C and 310C, respectively while relative humidity is in the range of 60-80% (ODNRI, 1989). The soil belongs to the order Ultisol (FDALR, 1985).

Land use

The main form of land use is arable cropping of yams, sweet potatoes, maize, cassava and vegetable crops. The major combinations of crops are cassava (Manihot esculanta)/maize (Zea mays)/yam(Dioscorea spp), cassava (Manihot esculanta)/maize (Zea mays), sweet potato (Ipomea batata)/maize(Zea mays) and maize (Zea mays)/vegetables (Telferia occidentalis, Pterocarpus spp, Gnetum africana).

Stone mining/quarring, hunting, palm wine tapping and farming constitute the major socio-economic activities of the people of the study area.

Field sampling

Four mine sites were selected for the study. Each sampling site was given geographical co-ordinates using a hand-held global positioning system (GPS). Auger soil samples (0-15 and 15-

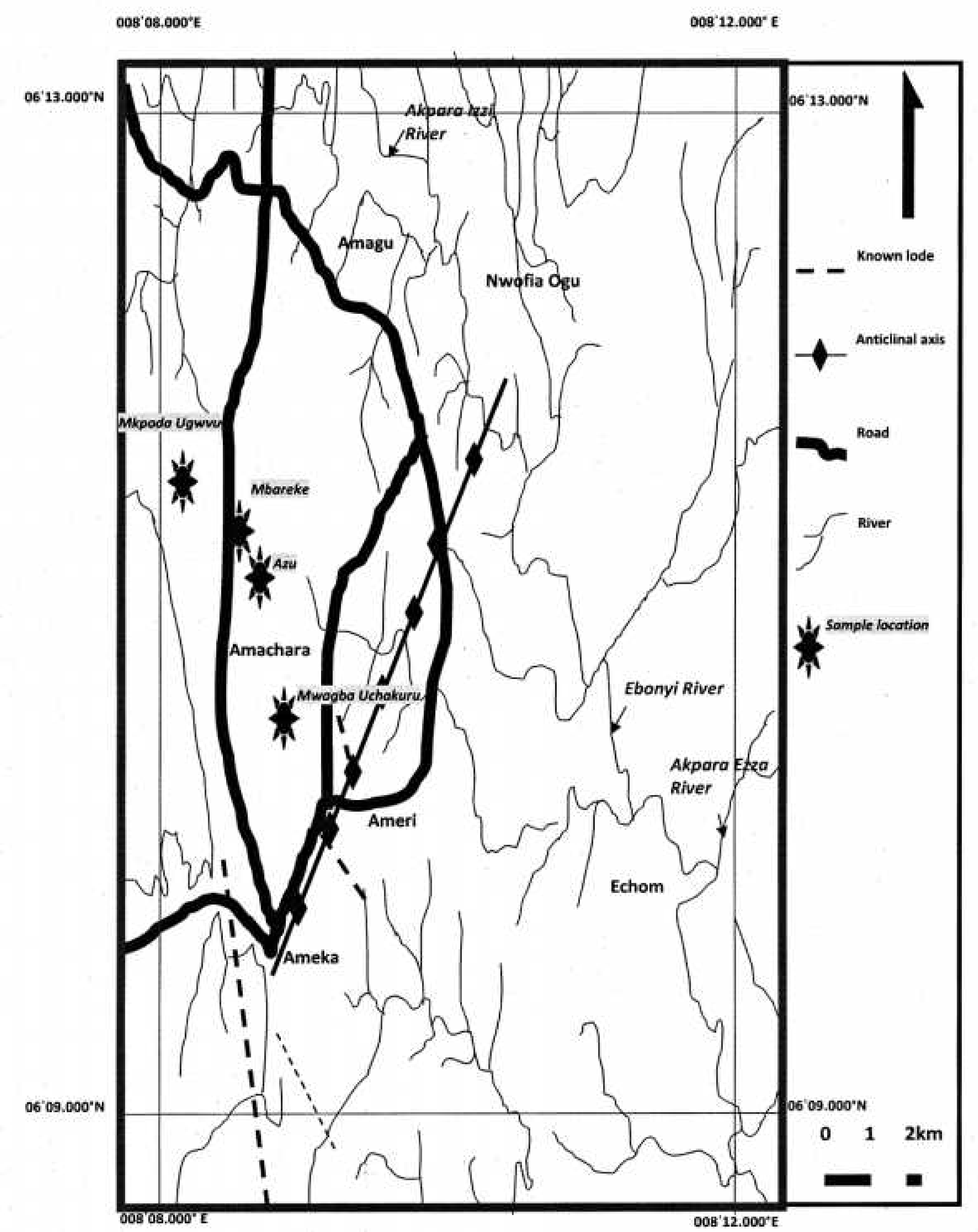

Fig. 1: The physiographic map of Enyigba Pb – Zn Province with the location of sample points (modified from Orajaka, 1965).

30 cm) were collected starting from 100 m away from the mine site and at 100 m intervals up till 500 m (i.e, 100 m, 200 m, 300 m, 400 m, 500 m distance). Core soil samples were also collected at similar distances. At each mine site, sampling was done eastwards and westwards. Similarly, a control site was selected at a distance of 1.5 km away from the Enyibga mining vicinity and soil samples collected at depths 0-15 cm and 15-30 cm. The soils of the control site and those of the mine site were assumed to be pedologically similar.

Two core samples were collected from the surface and subsurface soil (one from each depth) giving 10 samples per sampling line. There were therefore 20 core samples per mine site, giving 80 core samples for the four mining sites. Additional two core samples were collected from the surface (0 – 15 cm) and subsurface (15 – 30 cm) soil of the control site (one from each depth). Altogether there were 82 core samples. Auger sampling was done in a similar manner, but in duplicates. There were therefore 164 auger samples. The core samples were used for soil bulk density and total porosity determination while the auger soil samples were air-dried and passed through 2 mm sieve and used for routine analyses.

Sample treatment and laboratory determinations

The auger soil samples were air-dried at ambient temperature of 210C to 270C, then crushed and sieved through a 10 mesh (2 mm) screen sieve. Particle size analysis of the soil was determined using the Bouyoucos hydrometer method as described by Gee and Bauder (1986). Bulk density was determined on the core samples by core method as described by Anderson and Ingram (1993). Total porosity was calculated as follows:

$$Tp = 1 - \left(\frac{bd}{Pd}\right) \frac{X\ 100}{1}$$

Tp = total porosity, bd = bulk density pd= particle density (assumed to be 2.70 gcm-3).

Experimental design and data analysis

This study was considered as a factorial experiment in which distance from the mine pit and soil depth were two factors under consideration. The experiment was laid out in 2 X 5 factorial in RCBD replicated four times compared alongside a control. Analysis of variance (ANOVA) was done according to Obi (2002) and significantly different means were separated using F-LSD at 5% level of probability. The statistical analysis was done using Genstat Discovery Edition 3 (Genstat, 2003).

RESULTS AND DISCUSSIONS

Results of soil physical properties are shown in Table 1. The soils percentage of coarse and fine sand generally decreased with increasing depth, while the clay contents increased down the profile. There was no definite trend in the particle size distribution across the distances but coarse sand dominated the total sand fraction in all distances. The control surface soil and subsurface soil recorded the highest values of 31% and 45 % for silt and clay respectively compared to the soils of mine area (Table 1). The dominance of coarse sand over other particles was essentially a reflection of the parent material and climatic (rainfall) effects on particle size movement (Igwe et al., 1999). Most soil formation and/or degradation processes such as elluviation/illuviation, erosion and leaching affect finer particles; climate is an active factor influencing such processes (Jenny, 1980; Akamigbo, 2010). The texture of the soil is related to its parent material (Akamigbo and Asadu, 1983), and this accounts for the similarity in textural classes obtained irrespective of locations, distances and soil depths. This is expected as soil texture is mainly inherited from the soil forming parent materials. The highest bulk density value of 1.79 Mgm-3 was recorded at 300 m subsurface soil of mine area and was higher than the control both at the surface soil (1.51 Mgm-3) and subsurface soil (1.66 Mgm-3). The high bulk density value observed in mine area may be due to removal of vegetative cover arising from series of mining activities. Crops grown within 300 m of the mine area may face problems of poor root growth, poor rate of water infiltration and drainage thus leading to low crop yield. Increase in bulk density usually indicates a poor environment for root growth and undesirable infiltration and drainage (Chude et al., 2011) thus limiting agricultural productivity. Similar reports have been made relating high bulk density to poor vegetal cover (Ezeaku and Anikwe, 2005), soil surface crusting and compaction by raindrop and machine impacts (Neil et al. 1997; Chude

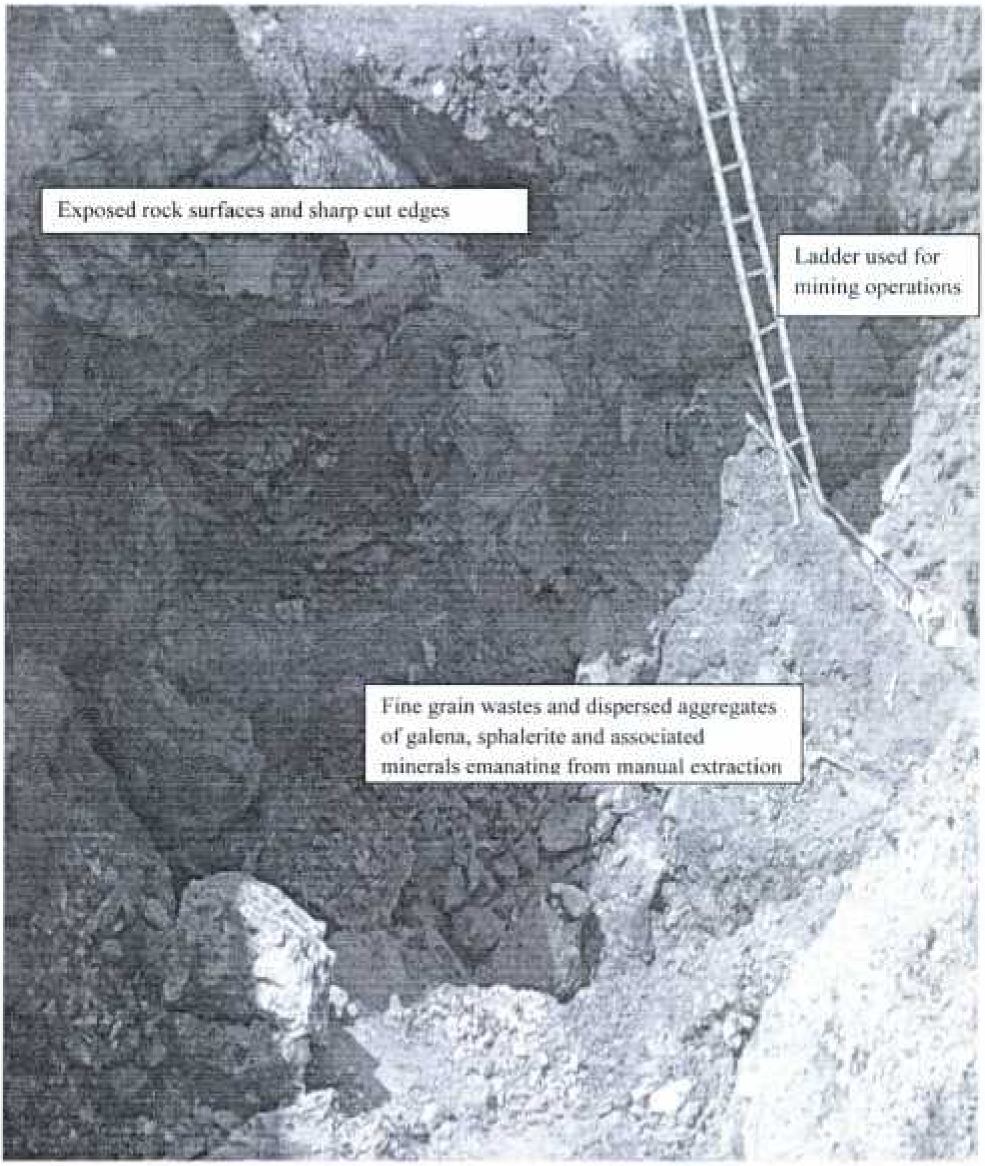

Plate 1: Dry mine pit with exposed rock surface and sharp cut edges, evidence of manual extraction processes giving rise to dispersed aggregates of galena, sphalerite and other associated minerals.

99

et al., 2011), and surficial erosion (Lal, 1994). Vegetation destruction is a major consequence of surface mining and this applies to the mine area where the impact is seriously felt. Massive structure or structural deterioration leads to high bulk density, low porosity, and surface cappings (Chude et al., 2011). This is however expected since the bulk density of the mine area was higher than that of the control. The values of total porosity in all distances and depths were significant ($P<0.05$), recording a reverse trend compared to bulk density values (Table 1).

Table 1: Interaction of distance and depth on soil physical properties

Distance (m)	Soil depth zone (cm)	CS (%)	FS (%)	Silt (%)	Clay (%)	BD (Mgm-^{3})	%TP	T Class
100	Surface soil	41.5	12.5	17.88	28.12	1.59	40.00	SCL
	Subsurface soil	32.75	10.25	23.75	33.25	1.70	35.85	CL
200	Surface soil	41.75	11.12	20.50	27.25	1.44	45.66	SCL
	Subsurface soil	37.50	11.62	19.88	30.69	1.72	35.09	SCL
300	Surface soil	34.75	9.50	22.38	33.31	1.68	36.60	CL
	Subsurface soil	33.88	8.88	27.50	29.75	1.79	32.45	CL
400	Surface soil	42.88	16.00	15.13	26.00	1.30	50.94	SCL
	Subsurface soil	38.75	13.38	17.25	30.62	1.66	37.35	SCL
500	Surface soil	43.37	13.37	17.25	25.56	1.58	40.37	SCL
	Subsurface soil	41.75	13.62	18.12	26.50	1.67	36.98	SCL
Control	Surface soil	17.00	7.00	31.00	35.00	1.51	43.02	SCL
	Subsurface soil	15.00	9.00	27.00	38.75	1.66	37.35	CL

LSD (0.05)	%CS	%FS	%Silt	%Clay	BD	TP
Distance	4.38	1.86	2.49	3.47	0.13	4.58
Depth	2.53	1.07	1.44	2.00	0.07	2.64
Interaction	6.19	2.63	3.53	4.91	0.18	6.48

CS= Coarse sand, FS= Fine sand, CL=Clay Loam, SCL=Sandy Clay Loam, BD= Bulk density ,%TP= Percent total porosity, T Class= Textural class

CONCLUSION

Results of the study showed high bulk density in mine area compared to the control. The high bulk density value at the mine area was as a result of massive structural deterioration arising from mining activities. Limited use of heavy machinery is highly recommended to reduce soil compaction. Farmers within the area are encouraged to practice conservation tillage since soil physical properties deterioration affect soil use and productivity.

100

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