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EFFECTS OF MINING ACTIVITIES ON CHEMICAL PROPERTIES OF SOIL FROM IKWO L.G.A AND ITS BORDERS IN EBONYI STATE, NIGERIA

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ABSTRACT

Mining is essential in the economic development of any country endowed with mineral resources. This refers to both internal and external economic benefits made available to the communities and countries involved in the extraction of mineral resources. Though the mining industry continues to support a nation's growth and development, the practices of mineral extraction, production, refining, and distribution have negatively impacted the environment. This study evaluates the effects of mining activities on soil in Ikwo L.G.A. and its border in Ebonyi State, Nigeria, to determine their potential impact on chemical properties. The study involves collecting three soil samples from different mining sites and a control site 3km away from the mining sites. The soil samples were collected from a depth of 0-20 cm using a soil auger, taken to the laboratory, and analyzed using Standard methods. The mean result of all the parameters are as follows; pH (5.51 – 5.62), Electrical conductivity (0.59 – 1.05 dSm^{-1}), Organic Carbon (0.05 – 0.07 %), Nitrogen (0.03 -0.09 %), Phosphorus (17.9 -2.02 $Mgkg^{-1}$), Potassium (13.24 -17.67 Mg/kg^{-1}), Magnesium (16.85 – 20.56 Mg/kg^{-1}) and Calcium (14.42 – 18.87 Mg/kg^{-1}) of mined samples, respectively. This shows that the mined samples were acidic, non-saline, and had low nutrient values. This could be due to mining activities, which have led to a loss of soil biomass, erosion of the topsoil layer, and cation infiltration or leaching. This study recommends appointing community stakeholders from the mining areas to engage with the Ministry of Environment at all levels to support effective management and ensure the regulation of mining activities.

Keywords: Agricultural Soil; Exchangeable Cation; Mining Activities; Nutrient Status; Soil Quality.

1.0.Introduction

The mining industry remains a major source of government revenue and sustains the livelihoods of many residents, especially in mining communities in Ebonyi State (Obasi et al., 2017; Olanrewaju et al., 2022). Over the years, the contribution of mining industries to the communities are enormous and include provision of Christmas gifts, tarring of some of the farm roads, provision of pipe borne water, creation of jobs, generation of electricity, clinic and banks in the host community (Rawashdeh et al., 2016) Though mining continues to support growth and development of the economy, the adverse

impacts of mining activities on soil have been severally documented. The initial process of mining involves disruption of the ecosystem through environmentally damaging practices such as deforestation, bush burning, habitat displacement, and loss of biodiversity (Naibbi and Chindo, 2020). In addition, during the mining process, the sites are prone to disturbing living organisms in the host communities. The environmental pollutant acid mine drainage is caused by the naturally occurring process of acid rock drainage (ARD), in which sulfide in rocks reacts with air and water to produce acid mine drainage on a larger scale (Nwosu, 2011; Saha et al., 2022). The permeation or flow of acid mine drainage into agricultural land can alter the physical, chemical, and biological properties of the soil, including pH and the availability of essential nutrients (Nwosu, 2011; Saha et al., 2022).

They also inadvertently release greenhouse gases and emissions, which result in increased temperature and deteriorating living conditions (Obasi et al., 2020). The mixing and burying of different geological substance result to inability of soil to support life and poses a serious environmental and public health risk, especially through the contamination of soil by heavy metals (Obasi et al., 2020) and loss of essential physicochemical elements that are required for plant growth and establishment (Essandoh et al., 2021). Therefore, the samples were analyzed to assess the effects of mining activities on chemical properties, including soil pH, electrical conductivity, organic carbon, nitrogen, phosphorus, and exchangeable cations. This study will provide useful information on the chemical properties of mining sites in Ikwo L.G.A. and its borders, and will uncover the inherent dangers posed to the communities, as metal uptake depends on the physicochemical properties of the soil-plant rooting environment.

2.0.Methodology

2.1.Sampling

2.1.1. Study Area

The study area lies at the borderlines of Ikwo, Abakaliki, and Ezza South Local Government Areas. They are Enyim Agalegu (latitude 6^0 10’ 29□ and longitude 8º 8’ 8□) in Ikwo Local Government Area, Enyigba (latitude 6^0 11’ 30□ N and longitude 8º 8’ 45□) in Abakaliki Local Government Area and Ameka (latitude 6^0 10’ 19□ N and longitude 8º 7’ 59□) in Ezza South Local Government Area in the derived savannah vegetation. The mining sites are involved in mining granite, lead, zinc, and other quarrying products. It is located in Nigeria's Benue Trough, a major mining province with large deposits in the lower and middle Benue regions.

2.1.2. Sample Collection and Preparations

Soil sample collection and analysis were done in line with the method outlined by Obasi et al. (2020). The soil samples were collected at four (4) different communities (Enyim Agalegu in ikwo LGA, Enyigba izii and Obichie Amaeka Ezza) near each facility. Random sampling was conducted at each location, and soil samples were collected at a depth of 0-20 cm using a soil auger. A control site was also selected 3 km from the communities, and a composite sample was collected. All the samples collected was taken to the laboratory and air dried for 2 - 3 days at ambient temperature of 21ºC to 27ºC, then crushed with mortar and sieved through a 10 mesh (2mm) screen sieve before laboratory analyses for soil pH, electrical conductivity (EC), organic carbon (OC),

nitrogen (N), phosphorus (P), potassium (K), magnesium (Mg) and calcium (Ca).

2.1.3. Determination of Chemical Parameters

The physicochemical properties of the soil sample were determined according to standard methods. Soil pH was determined using a digital pH meter according to the method described by Bates (2004). The electrical conductivity, total nitrogen, and the exchangeable cations (calcium, magnesium, and potassium) were determined using the Association of Official Analytical Chemists (AOAC) method (1995). Then the phosphorous values were determined using methods described by Dickman and Bray`s method (1940), and total organic carbon was determined using methods described by Osuji and Adesiyan (2005).

3. Results and Discussion

3.1. Physico-chemical Properties Analysis

Table 1.0: Results of Chemical properties of mining sites and non-mining site

Physicochemical properties	pH	Electrical Conductivity (dS/m)	OC (%)	N (%)	P (Mg/kg)	K (Mg/kg)	Mg (Mg/kg)	Ca (Mg/kg)
Enyim Agalegu	5.51	0.59	0.05	0.03	20.2	17.67	20.56	18.87
Enyigba	5.54	0.79	0.06	0.04	18.2	15.17	18.80	15.34
Obichie Ameka	5.62	1.05	0.07	0.09	17.9	13.24	16.85	14.42
Control	6.65	1.98	0.87	0.17	27.9	20.57	30.32	28.02

Table 1.0 above shows the effect of mining activities within three sites and a control. The results show acidity in the mined soil, which could be due to mining activities involving mineral deposits, parent material, and acid mine drainage (Matsumoto et al., 2018; Dong et al., 2018). The pH values determined in this study range from 5.51- 5.62, showing moderately acidic soil, but in the case of the control, it was within the recommended pH value of 6.5 to 7.5 for optimum plant growth (Queensland Department of Environment and Heritage Protection (QDEHP), 2019). These results are consistent with the findings of Fagbenro et al. (2021), who reported increased soil acidity near the mining site due to the oxidation of sulfide minerals, resulting in acid mine drainage. The reports by Oluyemi et al. (2023) also showed low pH values in mine soils, in contrast to Kou et al. (2022), who observed high (alkaline) pH values in mines. The findings of this study, in relation to others, showed that the nature of mine soils depends on the inherent mineral/elemental content, as soil pH has been attributed to the degree of mineralization of the geologic rocks (Kuo et al., 2022).

Electrical conductivity (EC) values have been classified as $0 < 2$ (non-saline), $2 < 4$ (very slightly saline), $4 < 8$ (slightly saline), $8 < 16$ (moderately saline and ≥ 16 (strongly saline) (USDA, 2011). The results of this study were below the EC value of 2, indicating that the mine soils were all non-saline. These results are similar to values reported by Essandoh et al. (2021). The

results of this study may be attributed to high precipitation in the study area, which has been reported to promote the flushing of soluble salts from the soil, thereby reducing soil EC values (USDA, 2011).

In this work, the nitrogen (N) concentration across the study area ranged from 0.03% to 0.09%, compared with 0.17% in the control. According to Hazelton and Murphy (2007), nitrogen concentration in agricultural soils is considered low when between 0.05 and 0.15%, medium between 0.15 and 0.25%, high between 0.25 and 0.50%, and very high when>0.5%. However, the concentration of N in the mined area falls within the low range of 0.03% to 0.09%, while the un-mined area has 0.17% (medium). This could be due to mining activities, as this observation is consistent with the findings of Eludoyin et al. (2017), who reported significant loss of soil nitrogen.

Soil organic carbon is a key indicator of soil health and is generally positively correlated with crop yield (Bennett et al., 2010). Soil organic carbon affects important functional processes in soil, such as nutrient storage (mainly N), water-holding capacity, and aggregate stability (Silva & Sá-Mendonça, 2007). In addition, the soil organic carbon also affects microbial activity (Olanrewaju et al., 2021). From the study, there is a reduction in the percentage of organic carbon between the mined and unmined soil, which could be due to loss of biomass, its production, and decay of organic matter, or leaf litter accumulation over time (Essandoh et al., 2021; Costa & La Mantia, 2005). These sites had bare soil surfaces with no tree cover and thus had little or no accumulation of organic matter.

Phosphorus is also a key nutrient for agricultural yields and is essential in assessments of soil health (Muindi, 2019). The results of this study revealed that the concentration of phosphorus in the mine soils was lower than that of the control soils. However, the phosphorus concentration in the mine and control soils observed in this study was generally low, and these values were similar to those reported by Oladipo et al. (2014) and Ukpe et al. (2021) in mining areas. Their reports (Oladipo et al., 2014; Ukpe et al., 2021), which corroborate my findings, indicate that mining activities may be responsible for reduced levels of available phosphorus in soils. The reduction in soil phosphorus levels in mine soils may be attributed to erosion of the topsoil layer or to infiltration caused by mining activities (Chen et al., 2016). According to Salem *et al*. (2014), mining activities often reduce the fungi needed to produce soil phosphorus and lower pH and organic matter in mine soils, thereby reducing soil phosphorus content.

The concentration of exchangeable cations (potassium, magnesium, and calcium) was generally higher in the mine soils compared to the control soils, and this observation is in line with the findings of Ukpe et al. (2021) and Essandoh et al. (2021), as they attributed it to the mining activities, which often accelerate through leaching of cations (Ca, K, and mg). The exchangeable cation concentration at the mining site also agrees with the findings of Warhate et al. (2006), who attributed the relatively higher concentrations to the release of metals and metalloids from mining activities. The variation in mineral composition reflects differences in soil mineralogy and mining-induced disruption (Warhate et al., 2006).

4. Conclusions

The study revealed that mining activities significantly affect soil chemical properties in Ikwo and its borders in Ebonyi State. Soil samples from mining sites exhibit low chemical properties, which will influence the soil quality required for plant growth and establishment. Therefore, proper soil management strategies include preventing future loss of biodiversity by using native species for progressive rehabilitation, cleaning up existing acid-generated mine sites using organic manures, protecting wildlife corridors, re-vegetation, organic manure application, and continuous long-term monitoring of ecosystems to restore soil health and productivity.

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