 

# Assessment of Coal Mining Effects on Soil Quality in Owukpa District, Ogbadibo Local Government Area, Benue State Nigeria

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**Abstract**
This study assessed effects of coal mining on soil quality in Owukpa district, Ogbadibo local government area of Benue State Nigeria. Its objectives were to compare the quality of soil in Owukpa (the affected area) with quality of soil in Otukpa (control site) and then compare the quality of soil in the affected area with Food and Agricultural Organisation (FAO) standard for crop production. The result of this research work was gathered through laboratory analysis of soil collected around abandoned Owukpa coal mining site and control site Otukpa both in Ogbadibo local government area. Data collected were analsysed using mean, range and student t test and presented in tables and figures. This study found that soil samples around the mining site have lower pH and soil nutrients (calcium, magnesium, sodium potassium, nitrate, sulphate and chloride) than the control samples, however, there were higher concentrations of EC and heavy metals compare to the control site. There is a significant difference in soil quality parameters between the mining affected area and the FAO standard for crop production at 95% confidence level (calculated't' > critical't' @ 0.05). It was concluded that the abandoned Owukpa coal mining affected the environment of Owukpa District to a large extent as soil quality parameters differ significantly with FAO regulatory limit for crop production. It was recommended among other things that erosion control practices such as afforestation, channelization and others should be done to reduce input and spread of mine waste on the environment through erosion.
**Keywords:** Coal mining, Soil quality, Heavy metals, Pollution, Soil nutrients.

## 1. Introduction

The mining sector worldwide is greatly important for income generation, employment, economic growth, development and competitive advantage ( Oelofse, 2008). Mining, however, poses major threats and hazards that can degrade the natural environment. Mining operations alter a site's soil and water quality thereby disrupting the ecological balance, natural landscapes, agricultural lands, forests, plantations and vegetation as well as the economic food and tree crops.

Though, past efforts in coal mining in Nigeria have been hampered by environmental concerns about the effects of open cast coal mining. The current economic diversification plans of Nigeria government is predominantly on improving agriculture and mining of solid minerals. However, mining activities in the study areas may, consequently, result in the pollution and destruction of the natural environment. The effects may also have serious consequences for livelihood, particularly in agrarian communities such as Owukpa whose residents are predominantly arable crop farmers. Based on these facts and economic diversification plans of the Federal Government of Nigeria that have led to debate among environmentalists on the potential environmental effects of mining, which stress on the need for countering the potential environmental effects of mining solid minerals. This study intends to contribute on the ongoing debate by assessing the effects of coal mining on the soil quality of Owukpa District in Ogbadibo Local Government.

### 1.1 Research Methodology

Mixed data were applied to this study; data were both quantitative and qualitative. Quantitative data include the values of concentrations of soil quality parameters recorded during soil quality test and their FAO regulatory limits for crop product while qualitative that are facts drawn from existing literature concerning environmental effects of coal mining.

Data were sourced from both primary and secondary sources; primary sources of data were obtained through the collection of soil samples. Photographing and observation of striking features were made at the mining site, while secondary data sources include the review of textbooks, journals, thesis, published seminar papers, reports of commission, the internet and other published materials.

Simple random sampling technique was used to collect soil samples. The sampling points were adequate points to take samples in other to capture variability and were Geo-referenced using Global Positioning System. Soil samples (using auger) were collected at 0-15 cm for the top-soil and 15-30 cm for the sub-surface soil.

One kilogram (1Kg) of soil samples were collected at four (4) sampling points in the mining site and control site. In each sampling point, two samples were collected (top and subsurface soil). Samples were collected in polyethylene bags and were taken to laboratory within immediately to eliminate micro/macro variabilities by ensuring that samples collected on the field were not exposed before laboratory analysis to determine the soil quality.

**1.1.1 Results and Discussion**

**A. The Soil Quality of Owukpa Coal Mining Area Compared to the Soil Quality of Otukpa (Control Site).**

Table1 Present the range and mean values of the soil quality parameters of Owukpa Coal Mining Area and the control samples.

The soil hydrogen ion (pH) around the mining site ranged from 3.84 to 5.26 with mean value of 4.74. This suggests acidity of all soil samples of the mining sites as compare to the control soil samples with pH range of 6.2- 7.9 with mean value of 6.8 which are slightly acidic to slight alkalinity. Similar results were reported for coal mining area by other researchers (Ezeaku, 2011; Biswas *et al,* 2013; Oladipo et al., 2014; Sufian *et al 2015*). Soil temperature ranged from $27^0$c to$37^0$c around the mining site against $25^o$c to $30^o$c recorded at the control sites. Thus, soil sampled around the mining site has higher temperature than the control samples. This can be attributed to the exposure of soil due to deforestation for mining activities (Plate1).

Plate1: Soil Exposed to Erosion during Site Clearing around the Mining site.
Source: Field Study (2017)

**Concentration of Soil Nutrients**

The concentration load of soil nutrients such as calcium, magnesium, sodium, potassium, nitrate, sulphate, phosphate and chloride were observed to be low in samples around the mining area than the control samples. Average concentrations of these essential elements around the mining site were 8.94 mg/kg, 2.99 mg/kg, 0.91 mg/kg, 1.10 mg/kg, 3.42 mg/kg, 24.67 mg/kg 0.98 mg/kg and 23.40 mg/kg kg for these parameters respectively compare to 15.55 mg/kg, 5.95 mg/kg. 1.16 mg/kg, 1.50 mg/kg,5.35 mg/kg 33.53 mg/kg mg/kg, 1.18 mg/kg and 27.00 mg/Kg recorded at the control site (Figure 2)

**Concentrations of Heavy Metals**

Table1 shows that the concentrations of the heavy metals analyzed from the soil samples around mining site were in the range of 0.74-2.78mgkg-1 for Pb, 1.05-16.7 mgkg-1 for Ni, 1.5-6.8mgkg-1 for Cd, 19.7-12.98 mgkg-1for Cu, and 10.87-28.7 mgkg-1 for Fe whereas the control samples recorded lower concentrations of these harmful metals as follows: 0.01-0.3mgkg-1 for Pb, 0.05-1.2.mgkg-1for Ni,0.06-0.354mgkg-1 for Cd, 1.1.-2.03.8 mgkg-1for Cu, and 1.4-2.5mgkg-1 for Fe respectively. Heavy metal concentrations of the soil around the mining sites were in the order of Fe > Cu > Cd> C >Pb> Ni (Figure 3).

Figure 3 shows that concentrations of heavy metals are higher around the mining area than the control site and that iron is highest element in the soil samples. The implication is that heavy metals at higher concentrations are toxic and present different problems to soil microorganisms, because they cause oxidative stress by formation of free radicals. They can also replace essential metals in pigments or enzymes, thus disrupting their function (Henry, 2000) and may render the land unsuitable for plant growth and destroy the biodiversity.

**B. The Quality of Soil in the Affected Area Compare with FAO Standard for Crop Production**

The mean values for results of the soil quality in affected area as shown in table 1 and FAO regulatory standard are shown in table 2, while table 3 shows the student‘s test at 95% confidence level for the two data sets (soil quality around mining site and FAO regulatory standard).

Table 2 present the mean values for results of the soil quality in mining affected area and FAO regulatory

**Nutrients -** Since the calculated t values of 2.17, 1.93,1.91, 3.21, 4.67, 1.98, 2.56 and 5.12 for calcium, magnesium, sodium, potassium, nitrate, sulphate, phosphate and chloride respectivelyare all greater than their critical ‘t’ value of 1.82, Ho is rejected for all the nutrients. Thus, there is a significant difference in the concentration of these soil nutrients and the FAO recommended level. Then, as soil nutrients show lower means than the FAO recommended level (Table 4.2), it means that the concentration of these soil nutrients is significantly lower in the mining affected area than FAO standard for crop production. Therefore, it can be deduced that mining activities have significant effects on soil nutrients. This may be due to deforestation for mining activities and its consequences such as erosion ( Plate 2).

Plate 2: Soil Erosion Resulting from Deforestation for Mining Activities
Source: Field Study (2017)

**Heavy Metal -** Since the calculated t values of3.43,3.87,1.95, 2.89 and 5.23 for lead, nickel, cadmium, copper and iron respectively are all greater than their critical 't' value of 1.82, Ho is rejected for all the heavy metals. Thus, there is a significant difference in the concentration of these heavy metals and the FAO recommended level. Then, as heavy metals show higher means than the FAO recommended level (Table 2), it means that the concentration of these heavy metal are significantly higher in the mining affected area than FAO standard for crop production. Therefore, it can be deduced that mining activities enhances the concentration of heavy metals in the soil. This may be due to acid mine drainage which reduces soil pH thereby reduces soil solubility and consequently nutrient deficient and increased the availability of heavy metals (Plate 3).

Plate 3: Evidence of Acid Mine Drainage
Source: Field Study (2017)

**1.1.2Conclusion**

Data from the survey show a large extent of soil contamination as Soil samples around the mining site have lower pH, nutrients than control site but higher concentration of heavy metals; There is a significant difference in soil quality parameters between the mining affected area and the FAO standard for crop production at 95% confidence level.

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**Table1**: The Soil quality of Owukpa Coal Mining Area and the Control Samples

**The Soil Quality of Coal Mining Area** | **The Soil Quality of Otukpa (Control Site)**

| Parameters | Range | Mean | Range | Mean |
|---|---|---|---|---|
| **Physical** | | | | |
| pH | 3.84 -5.26 | 4.74 | 6.2- 7.9 | 6.8 |
| Temperature($^o$c) | 27 ¯ 37 | 30.5 | 25- 30 | |
| EC (µS/cm) | 21.0 – 46 | 29.04 | 18.2 – 29.3 | 22.34 |
| **Nutrients** | | | | |
| Calcium(mg/kg) | 6.2-9.4 | 8.94 | 12.45-17.89 | 15.55 |
| Magnesium(mg/kg) | 1.97-4.20 | 2.99 | 3.78-7.37 | 5.94 |
| Sodium(mg/kg) | 0.34-1.76 | 0.91 | 0.86-2.00 | 1.16 |
| Potassium(mg/kg) | 0.98-2.0 | 1.1 | 0.98-2.45 | 1.5 |
| Nitrate(mg/kg) | 2.78-5.67 | 3.42 | 4.35-6.12 | 5.35 |
| Sulphate(mg/kg) | 20.07-27.34 | 24.67 | 27.48-37.56 | 33.53 |
| Phosphate(mg/kg) | 0.54-1.64 | 0.98 | 1.07-1.90 | 1.18 |
| Chloride(mg/kg) | 19.23-26.25 | 23.4 | 24.13-29.34 | 27 |
| **Heavy Metal** | | | | |
| Pb(mg/kg) | 0.94-2.12 | 1.6 | 0.02-0.10 | 0.09 |
| Ni(mg/kg) | 5.45-10.23 | 8.56 | 0.00- 0.12 | 0.08 |
| CD(mg/kg) | 2.46-6.17 | 4.1 | 000-2.34 | 1.3 |
| Cu(mg/kg) | 5.34-11.78 | 8.07 | 1.85-3.06 | 2.7 |
| Fe(mg/kg) | 11.27-17.88 | 15.72 | 1.3-1.96 | 1.6 |

**Table 2:** The mean values for results of the soil quality in affected area and FAO regulatory standard for crop production**.**

| Parameters | Mining Area(X) | FAO standard(Y) |
|---|---|---|
| Physical | | |
| pH | 4.74 | 6.8 |
| Temperature($^o$c) | 30.5 | <40 |
| EC (µS/cm) | 29.04 | 10 |
| Nutrients | | |
| Calcium(mg/kg) | 8.94 | 150 |
| Magnesium(mg/kg) | 2.99 | 50 |
| Sodium(mg/kg) | 0.91 | 200 |
| Potassium(mg/kg) | 1.1 | 100 |
| Nitrate(mg/kg) | 3.42 | 20 |
| Sulphate(mg/kg) | 24.67 | 500 |
| Phosphate(mg/kg) | 0.98 | 5 |
| Chloride(mg/kg) | 23.4 | 250 |
| Heavy Metal | | |
| Pb(mg/kg) | 1.6 | 0.05 |
| Ni(mg/kg) | 8.56 | 0.05 |
| CD(mg/kg) | 4.1 | 0.01 |
| Cu(mg/kg) | 8.07 | 0.01 |
| Fe(mg/kg) | 15.72 | 1.5 |

Source: Field Study (2017)

**Table 3:** Student't' test Result Comparing Soil Quality Parameters Between Affected Area and FAO Regulatory Standard for Crop Production

| Parameters | Calculated 't" Value | Critical 't' |
|---|---|---|
| Physical | | |
| pH | 2.66 | 1.82 |
| Temperature($^o$c) | 2.17 | 1.82 |
| ECµS/cm | 2.82 | 1.82 |
| Nutrients | | |
| Calcium(mg/kg) | 2.17 | 1.82 |
| Magnesium(mg/kg) | 1.93 | 1.82 |
| Sodium(mg/kg) | 1.91 | 1.82 |
| Potassium(mg/kg) | 3.21 | 1.82 |
| Nitrate(mg/kg) | 4.67 | 1.82 |
| Sulphate(mg/kg) | 1.98 | 1.82 |
| Phosphate(mg/kg) | 2.56 | 1.82 |
| Chloride(mg/kg) | 5.12 | 1.82 |
| Heavy Metal | 2.90 | 1.82 |
| Pb(mg/kg) | 3.43 | 1.82 |
| Ni(mg/kg) | 3.87 | 1.82 |
| CD(mg/kg) | 1.95 | 1.82 |
| Cu(mg/kg) | 2.89 | 1.82 |
| Fe(mg/kg) | 5.23 | 1.82 |

Source: Field Study (2017)

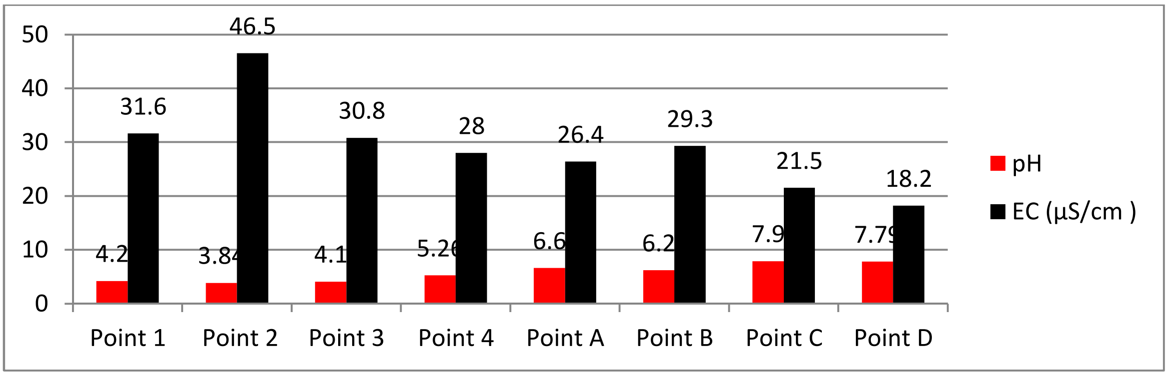


**Figure 1:** The Soil pH and Electrical Conductivity (EC) Concentration of Soil Samples

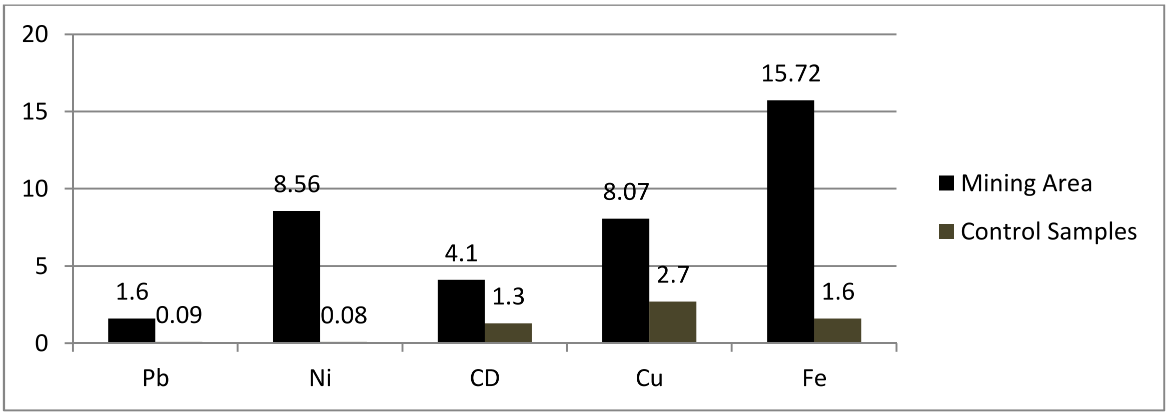


**Figure 2: Concentration of Soil Nutrient in Samples of Mining Area and Control Sites**

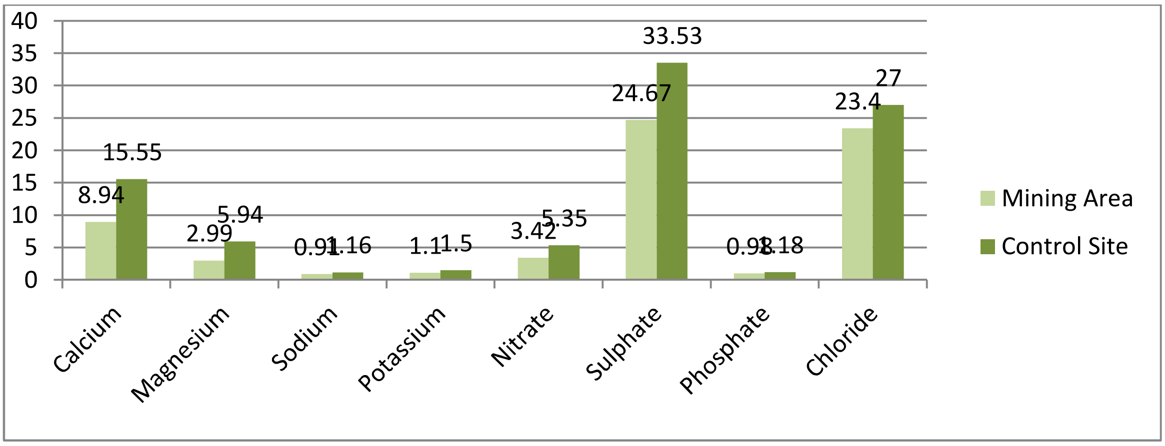


**Figure 3: Concentration of Heavy Metals Around Mining Area and Control Site**