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Analytical Evaluation of Heavy Metals Obtained from Clay Samples in Ute, Nigeria

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Abstract

Clay are abundant, common, inexpensive as well as, they have numerous industrial applications.The presence of these metals in an ecosystem above certain concentration limits constitutes contamination. In this study, the concentration of heavy metals in clay samples was investigated so as to know the level of environmental contribution in order to ascertain the level of contamination. The clay samples were collected from five different locations in Ute Township, a town in Ose local government area of Ondo North Senatorial district of Ondo State, Nigeria. Parts of the sample's location include places where there are human activities.The result of the study shows that there were no significant differences between the heavy metals' concentrations and their respective MPL. The research on the five sites investigated (Abekun, Ogwa, Okiti-ota, and Ogudu) have low to normal heavy metal concentrations, which are within the MPL allowable in soil. The abundance of these metals were in the order Pb> As > Zn>Cd>Mn>Se> Cr. Therefore As, Pb, Cd, Hg, Se and Cr are not pollutants in the clay samples. Hence, the clays samples obtained from Ute Town in Ose local government area of Ondo state may be said to be uncontaminated due to negligible concentration of heavy metals ascertained by this research. The clay samples are safe for utilization in both domestication and industrialization.

Keywords: Contamination, Concentration limits, Clay, Heavy metals, Ute.

1. Introduction

Clays are naturally occurring soil materials, which are formed from weathering of igneous and sedimentary rocks (Ali and Khan, 2018). The weathering of these rocks is achieved by the combination of the mechanical action of water, wind, glaciers, and earth movement working together with the chemical action of water and carbon dioxide, all of which is assisted by variation in temperature over time (Howard and Lekse, 2017). Clay minerals principally are layered hydrous aluminum-silicate with varying amount of iron, potassium, sodium and other ions. Clay soils have varying physical structure, mineralogical composition, they can be reformed, transformed or they can be inherited clays (Ochieng, 2016).

Heavy metals pollution is a menace to our environment as they are foremost contaminating agents of our food. Heavy metals contamination in the soil has a lot of adverse effects and thus is of great concern to the public health. Heavy metals and metalloids are classified into three classes of hazards: the first (high – hazard) class include As, Cd, Hg, Se, Pb, and Zn; the second (medium-hazard) class contain B, Co, Ni, Mo, Cu, Sb and Cr and third (low- hazard) class encompass Ba, V, W, Mn, and Sr (Vodyanitskii, 2016). The presence oftrace metals in an ecosystem above certain concentration limits constitutes contamination (Olaniran*et al.,* 2013). This can result in the possibility of accumulation, magnification, and transformation into more toxic compounds. They also have semi or non-degradable properties and can accumulate in the food chain through the soil thereby, causing danger to human health (Adeyanju, 2018). Hence, when heavy metals are present in clay soil beyond Maximum Permissible Limit (MPL), it might not be safe for farming, pottery, domesticated uses and even industrial applications known for (Srinvasaro*et al.*, 2014; Hussein *et al.*, 2014).

Ute, is a town in Ose local government area of Ondo state. The town is moderately populated with sparse traffic. This town is known for her abundance of kaolin clay, which is about 80% of the soil in the town. About 70% of the people in this town are farmers, 20% are traders and 10% are commercial drivers.

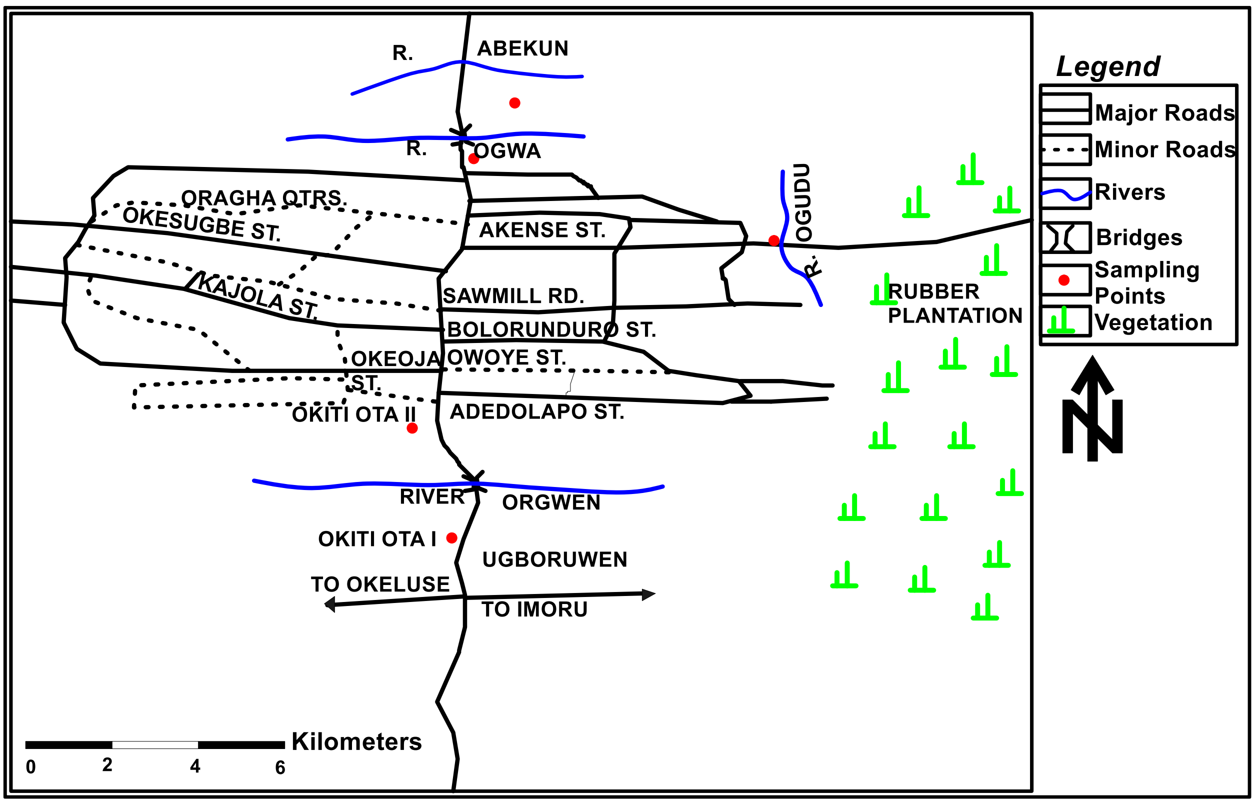

Figure 1: Map showing sample sites in Ute

Therefore, there could be little automobile exhaust emission pollution in Ute town. The study areas were so chosen to know the level of contamination of clay in this area in relation to the intensity of human activities, so also to give a good coverage to the town as regards the kaolin clay that the town is known for.

Due to the absorptive property of clay soils to heavy metals, it is therefore worthwhile to give consideration to the origin and occurrence of heavy metals in clays from different locations (Ugwu and Igbokwe, 2019).

This study aimed at evaluating the clay materials obtained from Ute deposits for the presence of some metals including heavy metals. The concentration of these metals was investigated in order to know the level of environmental contribution in order to ascertain the level of contamination.

1.1 Sample Sites and Description

Abekun: sample I is cream coloured clay along the hilly road side, not far from AbekunRiver.

Ogudu:sample II wascollected very close to the bank of the OguduRiver within Ute town. It is creamy white-coloured fine clay particles.

Okiti-Ota I:sample III is astrong heavy red rock of clay which was collected in Okiti-Ota along a major road which is connected to Okeluse – Imoru road.

Okiti-Ota II:sample IV is reddish brown particle size of clay obtained along a major road in Okiti - Ota.

Ogwa: Sample V is a very fine particle size of light brown clay samples. It was obtained around a dumpsite that is very close to OgwaRiver.

2. Materials and Method

2.1 Sample Treatment

The samples were taken from five different locations, namely; Abekun, Ogudu, Okiti-ota, and Ogwa. Surface soil (0-2 cm) samples of (100) g each, were obtained with 3m distance from the road shoulder within a radius of 3m from other sampling sites, by means of a stainless-steel trowel within a location. Four (4) replicate samples were collected for each location and was pulled together. The soil samples collected from these sites were kept in plastics bags before subsequent treatment and analyses.

Five (5) g of the representative sample of the clay soils were oven dried at 105 °C, ground in a mortal and sieved with 2 mm mesh size sieve. Two (2) g of thepowder were weighed into kjehldah digestion flasks. Thereafter, ratio 1:1 digestion of the samples with concentrated $H_2SO_4$was prepared, and then put in the digester of model 1007 (Tectator) at 60 °C for 3 hours until a homogenous solution was obtained. It was allowed to cool to room temperature, the digest was filtered using Whatz man No. 1 filter paper. Ten percent 10% (v/v) of the filtrate was prepared to analyze for concentration of each metal in the sample using Atomic absorption spectrophotometer.

2.2pH and Conductivity Measurement

Two (2) g of the representative clay samples were weighed into 50 ml test tube and 10 ml of distilled water was added to make 20% (w/v) of the representative clay samples. They were left to stay for some minutes before measuring the pH by dipping the electrode into the soil solution and also the conductivity was also measured.

3.0 Results and Discussion

Table 1 show the pH values of the clay samples fromdifferent collection sites in Ute, Ose Local government area of Ondo State, Nigeria.ThepH reading for the clay samples range from 5.57 - 7.25 which show that these samples are neither too acidic nor too basic in nature, it tends towards neutral pH. Low soil pH level below 4.5 causes increased solubility of micro-elements like; Aluminum, Iron and Manganese thereby releasing these elements into the environment which may constitute toxicity. The Soil pH is a useful tool in making decision on the level of purity and safety of the clay soil. (Dora, 2019).

Table 2 shows the conductivity values of the clay samples fromdifferent collection sites in Ute, Ose Local government area of Ondo State, Nigeria. The acceptable soil conductivity value range from 110000-570000 Sm^{-1} (Krassimir*et al.*,2020) which is farabove the conductivity values obtained in the five locations. This may be an indication of low mineral content of the clay soil, thereby ascertaining the possibility of high level of purity of the clay soils. Pure clay soils are regarded as Kaolin clay which is required for use in production of sophisticated and finer grades of ceramic materials other than bricks, tile and unrefined pottery that impure clays are used for.

The charts (Figures a to h) represent the results of heavy metal concentration levels of clay samples gotten from different locations in Ute Township. This analysis is in respect to different human and commercial activities taking place in the locations. The concentration of heavy metals in the clay samples from different locations across the Ute township have lower concentrations compared to their respective MPL except Selenium which is higher than its MPL.

Abekun shows a variable difference in its concentration of the metals which are below the Maximum Permissible Limit (MPL). The

Table 1: pH of Clay Samples from Different Locations in Ute

Sample code	pH reading
ABEKUN	7.25
OGU	7.10
OKI_I	5.70
OKI_{II}	5.57
OGW	6.12

Table 2: Conductivity of Clay Samples from Different Locations in Ute

Sample code	Conductivity (S m^{-1})
ABEKUN	1.2×10^{-5}
OGU	0.90×10^{-5}
OKI_I	2.64×10^{-5}
OKI_{II}	3.70×10^{-5}
OGW	1.95×10^{-5}

concentration of As, Cd, Hg, Pb, Mn, and Cr were lower than the MPL except for Se (0.16mg/ kg) which is within the normal range of the MPL (0.1- 0.8 mg/ kg). Furthermore, Zn (0.53 mg/ kg) in the same sample is extremely lower than its MPL (80 mg/ kg). The low MPL for the metals testify to the non-hazardous nature of samples from this location (Musa *et al.*, 2017).

Ogudu location shows that the concentrations of metals are within the maximum permissible limits MPL for the various metals. The concentration of As (1.80 mg/ kg) Cd(0.68 mg/kg), Hg (0.22 mg/kg),Pb(29.33 mg/ kg),Zn (2.63mg/kg), Mn(0.52 mg/kg), and Cr (0.23 mg/kg) are all lower compared to the MPL for each of the metals whereas, the concentration of Se (1.50mg/kg) is higher than the MPL value (0.1- 0.80 mg/kg). Selenium element is toxic in high doses even though it is necessary for normal health functioning. However, tropical soils have a concentration of selenium between 2 and 4.50 mg/kg, while clay soils are between 0.8 and 2mg/kg (Adebayo*et al.*, 2020). Hence concentration level of selenium in OGUDU can be said to be 'enriched' according to the classification of Tan (1996). Okiti-Ota_Ihas low concentrations values for the metals As (2.90 mg/ kg), Cd (0.64 mg/ kg), Hg (0.15 mg/ kg), Pb (44.30mg/ kg), Zn (1.90 mg/ kg), Mn (0.43 mg/ kg), and Cr (0.11mg/ kg) and are much lower than the MPL while the concentration of Se (0.00mg/ l) is negligible.

Okiti-Ota_{II} clay soil sample also has low concentrations of As (2.90 mg/kg), Cd (0.66 mg/kg), Hg (0.18 mg/kg), Pb (44.89 mg/ kg), Zn (1.85 mg/ kg), Mn (0.72 mg/kg), and Cr (0.13 mg/ kg). The concentration of Se (0.000 mg/ kg) is also negligible. The relationship between metalconcentration in the samples of Okiti-Ota_I and Okiti-Ota_{II} are close as the two sites are adjacent to each other. Generally, it was observed that there is elevation in lead (Pb) content in the sites by the road side and this is higher in Okiti-Ota_I(44.30mg/kg) and Okiti-Ota_{II} (44.89mg/kg), which show a good relationship between metal concentration and their traffic volume (Ayidinalp*et al.*, 2004; Fakayode *et al*., 2003). Okiti-Ota_Ihas lower concentrations in all

The following charts representing the concentration of heavy metals from clay samples obtained from five different locations in Ute are as follows:

The metals compared to Okiti-Ota$_{II}$except for Se which is insignificant for both Okiti-Ota$_{I}$ and Okiti-Ota$_{II}$. However, the differences in the concentration of Okiti-Ota and Okiti-Ota$_{II}$ may be as a result of a little more human activities in Okiti-Ota$_{II}$compared to Okiti-Ota$_{I.}$ Also, the low concentration of selenium in the two adjacent locations by the road side could be as a result of little or no source of selenium addition to the soil from fertilizer or selenium containing chemicals. Okiti-Ota$_{I}$ and Okiti-Ota$_{II}$ have the lowest pH concentration in all the locations which comply with the fact that the soil acidity is an important factor resulting in decreased selenium availability in soil due to increased absorption (Umesh and Subhas, 2010).

Ogwa also has high concentration of Selenium (0.75mg/kg), which is still within the MPL for Selenium in clay soil, while the others like Arsenic (3.40mg/kg), Cadmium (0.79 mg/kg), Mercury (0.19 mg/ kg), Lead (30.09 mg/ kg), Zinc (0.97 mg/ kg), Manganese (0.70 mg/ kg),) and Chromium (0.28 mg/ kg) are all lower in concentration than their corresponding MPL values which may be as a result of little or no human activities in Ogwalocation. This slight increase in concentrations of As, Cd and Se compared to other sites may be attributed to the presence of dumpsite close to the location.

Hence, the general low concentration of metal such as Zn, Mn and Se in clay samples could be due to the low industrial activities such as metallurgical, glass ware, dye, pesticide, electroplating, textile, printing, ore mining, fertilizer and others in the area(Wuana and Okieimen, 2011) (Slaveykova and Lanoutte, 2018).

4. Conclusion and Recommendation

The tables show a good relationship between the soil pH of samples and their conductivity from the various locations. pH is a measure of the concentration of hydrogen ions and hydroxyl ions whereas, conductivity is a measure of specific ions or salt compound in the soil. Hence, according to Bruckner (2012), the conductivity increases with higher concentration of both hydrogen ions and hydroxyl ions and vice visa in the soil samples. Soil electrical conductivity affects soil yields, crop suitability, plant nutrient and availability of microorganism activity which directly translates into causing imbalance in clay water content.

The result of the study shows that there are no significant differences between the heavy metals' concentrations and their respective MPL. The research on the five sites investigated (Abekun, Ogwa, Okiti-ota, and Ogudu) have low to normal heavy metal concentrations, which are within the MPL allowable in soil. The abundance of these metals were in the order Pb> As > Zn>Cd>Mn>Se> Cr. Therefore As, Pb, Cd, Hg, Se and Cr are not pollutants in the clay samples. Hence, the clays samples obtained from Ute Town in Ose local government area of Ondo state may be said to be uncontaminated due to negligible concentration of heavy metals ascertained by this research. The clay samples are safe for utilization in both domestication and industrialization.

The clay samples from Ute are free from contamination and therefore can be recommended for massive industrial utilization.

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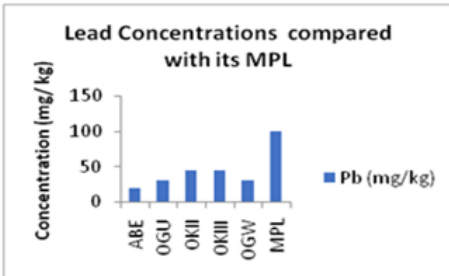
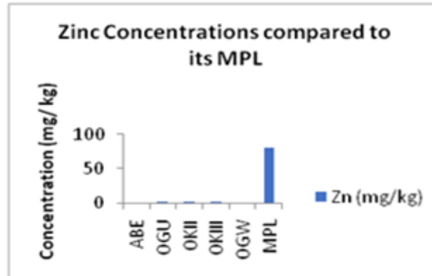


Figure (a)



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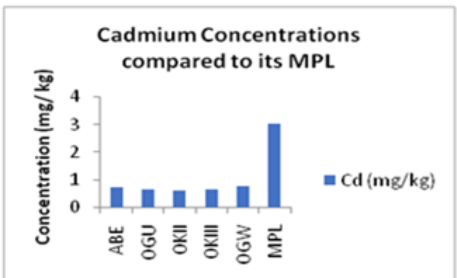

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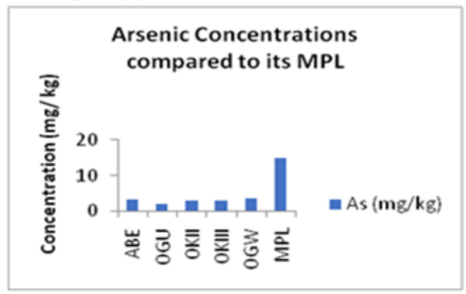

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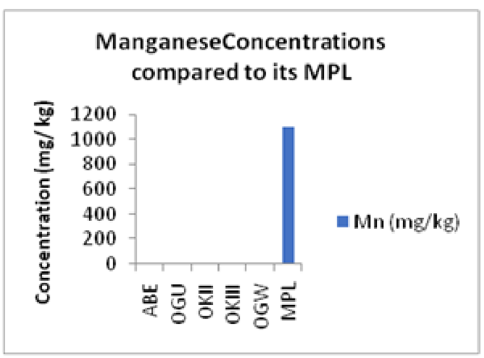

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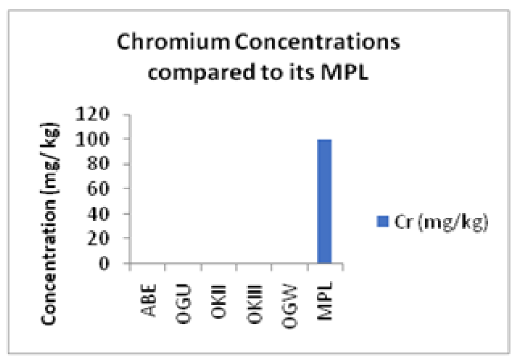

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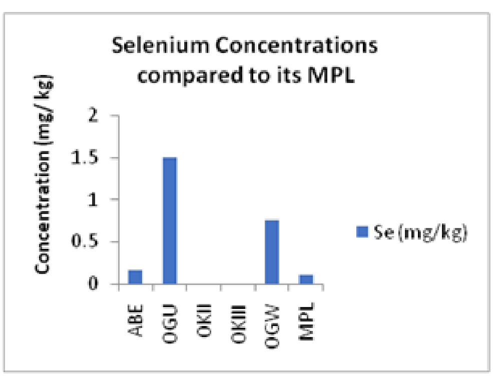

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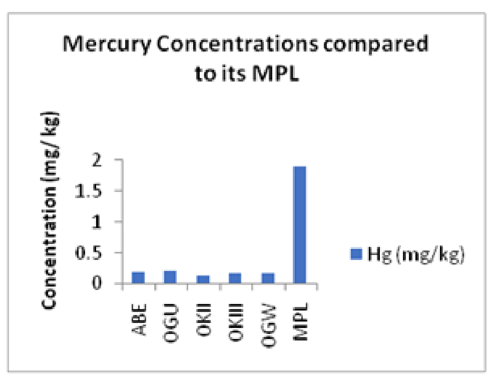

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