Physicochemical Characteristics and Heavy Metals Contents in Soils and Cassava Plants from Farmlands within Nnamdi Azikiwe University, Awka, Anambra State

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Original Research Article

ABSTRACT

Soil samples and cassava tubers collected from farmlands within Nnamdi Azikiwe University, Awka vicinity were analyzed for their heavy metal levels using Atomic Absorption Spectrophotometer (AAS) in order to assess their levels of contamination on the environment as a result of excessive fertilizers and automobile emission. Physiochemical properties of the soil samples were determined using standard methods. The soil pH had a mean value of 6.27 ± 0.07, 6.10 ± 0.06 and 6.57 ± 0.03 respectively indicating that the soils were slightly acidic to neutrality. Total organic carbon and nitrate mean values were 105.20 ± 6.20, 95.75 ± 9.57 and 94.6 ± 2.27 and 138.07 ± 12.09, 149.35 ± 14.25 and 149.20 ± 1.17 respectively showing presence of some organic matters. The mean levels of heavy metals in the soil samples were 0.01 ± 0.01, 0.05 ± 0.03 and 0.05 ± 0.03 for lead (Pb), 0.24 ± 0.16, 0.001 ± 0.001 and 0.001 ± 0.000 for cadmium (Cd) and 0.00 ± 0.00, 0.010 ± 0.006 and 0.001 ± 0.001 for chromium (Cr). These metals levels were in the abundance trend of Pb>Cd> Cr. The mean metal concentrations obtained in the cassava tubers respectively were 0.001 ± 0.001, 0.001 ± 0.001 and 0.005 ± 0.005 for lead (Pb), 0.000 ± 0.000, 0.0003 ± 0.0003

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and 0.000 ± 0.000 for cadmium (Cd) and 0.002 ± 0.002, 0.000 ± 0.000 and 0.002 ± 0.002 for chromium (Cr). These metals levels were in the abundance trend of Pb> Cr > Cd. For both the soil and cassava samples, there were no significant variations in the heavy metal concentrations and also in physicochemical parameter except for pH; this showed that there is low heavy metal enrichment in the soils studied. Based on the study, the following heavy metals (Pb, Cd, and Cr) falls within the Codex maximum permissible limits 0.1mg/l or ppm expect soil cadmium in science village which is above the Codex limit. The overall results showed that the farmlands (on soils and cassava tuber) appear to be free from poisoning or some metal enrichment and safe for agricultural purposes and also safe for human health and consumption.

1. INTRODUCTION

Pollution is one of the most important problems around the world in which thousands of millions of world inhabitants suffers health problems related to industrial (effluents, sewage, oil spillage etc.), agricultural and atmospheric pollutants [1] Industrial wastes and effluents are being discharged randomly on the soil, into canals, rivers, along road sides or in the vicinity of industry without any treatment in Nigeria and other parts of the world. Traffic associated environment pollution is one of the most critical or challenging sources, because it is a non point source and ventricular emissions spread beyond the expected distances polluting the air, land and water bodies.

Heavy metals are extremely persistent in the environment [1][2]. They are non-biodegradable and thermo-degradable and therefore readily accumulate to toxic level [2]. Heavy metals are natural components of the earth crust and as a result, they are found naturally in soils and rocks with a subsequent range of natural concentrations in soils, sediments, water and organisms [3].Heavy metals are defined as elements in the periodic table having atomic number more than 20 or having densities more than 5g/cm^3.

Soil is the unconsolidated mineral or organic material on the immediate surface of the earth that serves as a natural medium for the growth of land plants [4]. Soil constitutes a crucial component of rural and urban environments. Soil can become contaminated due to natural and anthropogenic activities and also by the accumulation of heavy metals and metalloids through the emission from the rapidly expanding industrial areas, disposal of high metal wastes, leaded gasoline and paints [5].

Heavy metal contamination levels in agricultural soil are of major significance because of the potential to accumulate in soil for a long period of time [6]. High concentration of metal ions in soil environment may pose a significant risk to the quality of soils, plants, natural waters and human health [7]. Excessive accumulation of heavy metals in agricultural soils may result not only in soil contamination but also consequences for food quality and public health safety issues. Heavy metals in the soil can bio accumulate in plant and bio magnify along the food chain causing serious health risk to humans and animals when consumed [8] [9].It is In the interest of the public to know whether vegetables, fruits and crops cultivated in polluted soils are safe for human consumption, especially now that environmental quality of food products are of major concern [10]. Absorption of heavy metals in low doses by humans over a long period of time through food resulted in serious health consequences. Some common health implications of heavy metals in humans includes: kidney disease, damage to the nervous system, diminished intellectual capacity, heart disease, gastro intestinal disease, bone fracture, cancer and death.

Cassava plants constitute important functional food components by contributing carbohydrate, vitamins, iron, calcium and other nutrients which have marked health effects [11].Research on the mechanism of heavy metal uptake by crops or plants from contaminated soils has become of ever-increasing importance as heavy metal accumulation in crops may lead to the lowering, damage and alteration of animal or human physiology functions through the food chain [11]. Apart from cassava, other vegetables can take up and accumulate heavy metals in quantities high enough to cause clinical problems in humans [12]. Cassava *(Manihot Esculenta)* was selected for this study because it is one of the major crops in the study area.

The main objective of this study was to access the level of contamination of soils and cassava

tubers from farm land in Nnamdi Azikiwe University, Awka also to enlighten the general public on environmental hazards and risks of contaminated soil and how they impact on food crops.

2. MATERIALS AND METHODS

2.1 Study Area

The study area is conducted in Nnamdi Azikiwe University, Awka farmlands. It lies within the geographical coordinates of latitude $06^0 15^1 40^{11}$N and longitudes $7^0 7^1 30^{11}$E.

2.2 Sample Collection

From the farmlands, we determine the contamination level by taking soil and cassava samples in various study location. Soil samples were collected from three different location/ sites in Unizik farmland (Site A-within science village, Site B- behind bank area and Site C-opposite zoology farm). About two sample each at the three different sites were taken using soil auger at the depth of 15-30cm. Cassava sample were collected from three different location/site in Unizik farmland

(Site A, Site B, Site C). About two samples each at the three different sites were taken using machete.

2.3 Sample Analysis

Analysis of physiochemical properties of soil samples: The soil was determined using the approved standard methods for each of them. Soil pH was measured in water suspension (1:2.5). Nitrate was determined using the methods described by [13]. Total organic carbon and organic matter was determined by using a gravimetric method.

2.4 Sample Preparation

The Soil samples were dried at 45°C in an oven for 1hr. They were crushed into fine powder using mortar and pestle and sieve through 2mm stainless sieve to remove coarse particles before chemical analysis. The cassava tubers were thoroughly washed with clean portable water to remove dirt, insect fragments, surface acids etc. They were peeled and sliced before they were dries in electric ovens at 45°C for 2hours to a constant weight.
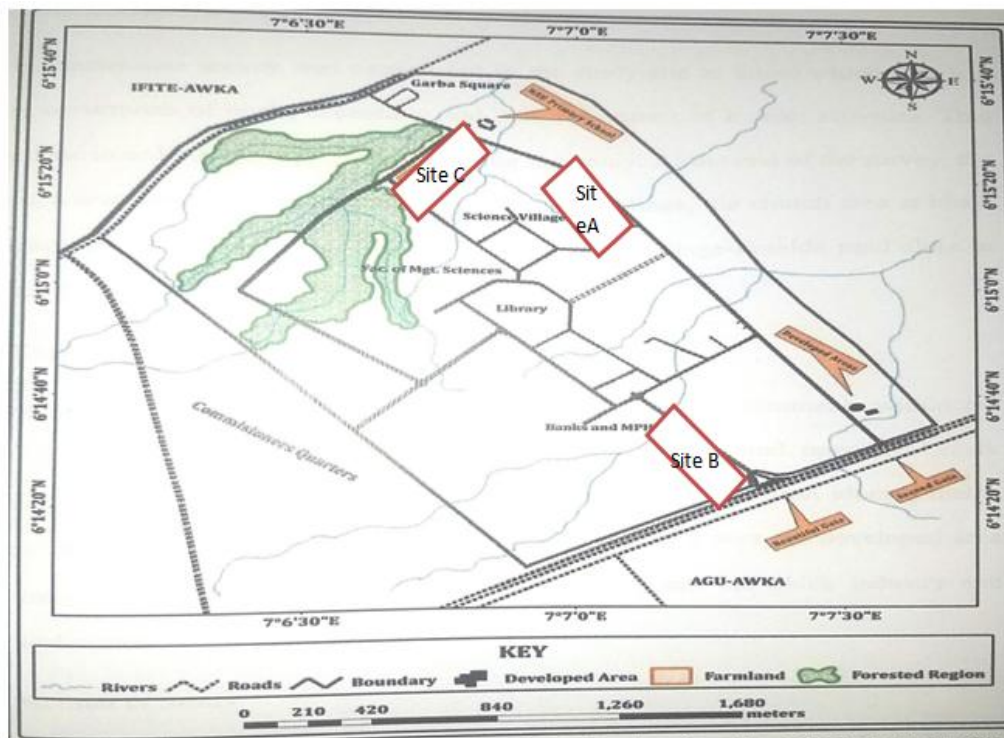

Fig. 1. A Map of Nnamdi Azikiwe University Showing the Selected study sites

The samples for metal analysis were digested using methods of American Public Health Association, 1995 (APHA, 1995). 2g of cassava samples was weighed into porcelain crucible. The samples were then heated at $400°C$ for 2hour in a muffle furnace (digital temperature controller, max thermo (MC-1601).After 2hrs they were then removed from the furnace and allowed to cool in a desiccators. 5ml of 1M Trioxonitrate(v) acid (HNO_3) solution was added to the left-over ash and evaporate to dryness on a hot plate and returned to the furnace for heating again at $400°C$ for 10-15mins until perfect grayish- white ash was obtained. The samples were then allowed to cool in a desiccators. 15ml (cm^3) hydrochloric acid (HCL) was added to dissolve it and the volume of distilled water of $100cm^3$ was added; the solutions were filtered using Whiteman filter paper into a standard volumetric flask.

2.5 Analysis of Heavy Metals

The digested samples were analyzed for the metals (Pb, Cd, Cr) using Varian AA240 Atomic Absorption Spectrophotometer (AAS).

3. RESULTS AND DISCUSSION

Soil physiochemical properties: Table 1 presents the results of the physiochemical properties of the soil samples.

3.1 Soil pH

The pH values of the soil samples in all of the sites ranged from 6.0 to 6.6 with mean values shown above. This shows that the soils were slightly acidic to neutrality and that the differences are statistically significant at ($P \leq 0.05$). The values of this study were attributed to the high concentration of heavy metals of soil samples from the farmlands, low pH led to the high heavy metals availability in the farmlands. The pH values obtained in this study which are in same range with the values reported by [14]; [15] but lower than those reported by [16]; [17]; [18].The availability of some plant nutrients are greatly affected by soil pH which showed that the ideal soil pH is close to neutral and the neural soils are considered to fall within a range from a slightly acidic pH 6.5 to slightly alkaline pH of 7.5.

3.2 Nitrate

The Nitrate values of the soil samples in all of the sites ranged from 0.597 to 0.884 with mean values shown above in Table 1. This shows that there were high nitrate content in the soils and that the differences with no statistically significant at ($P \geq 0.05$).it can be attributed to differences in anthropogenic activities of the soils as a result of excessive usage of fertilizers, herbicides and other agro-chemicals, and as well as the use of waste water in irrigating the soils, and the environmental conditions pertinent in the areas. The values obtained in this study were lower than those reported by [19].

3.3 Total Organic Carbon and Organic Matter

The values of the soil samples in all of the sites ranged from 48% to 68% in TOC and 90% to 116% in TOM with mean values shown above the Table 1. This shows that differences with no statistically significant at ($P \geq 0.05$).These two parameters (TOC and TOM) are used to express the organic richness of the soil environment. This values obtained in this study were higher than those reported by [20].

Heavy metals on both soil and cassava tubers: the concentrations are shown in the Fig. 2 below.

All the metals (Pb, Cd, Cr) were detected in all sites. The metals levels in all sites showed the differences with no statistically significant at ($P \geq 0.05$).

Lead has the highest mean concentration among all the metals studied as shown in Fig 2. In the above figure, Bank Avenue and Opposite Zoology farm in soil sample has same level of contamination while in cassava tubers, science village and Bank Avenue are of same level. The concentration of lead in both the soil and cassava samples falls within 0.1mg/l, the permissible limit of [21] and WHO standard limits. The lead concentration was in similar range with the study in [22] and [23]. The study appeared to be free and safe of lead poisoning which will result in memory loss and restlessness because higher lead concentration is injurious to human health.

Cadmium concentration from the Fig 2 shows that science village in soil samples has the highest values among the other sites but in cassava tubers, there was no uptake of cadmium in both science village and opposite zoology farm. In soil samples, the Cadmium concentration in bank venue and opposite zoo farm falls below the codex permissible limit

Table 1. Physiochemical properties of the soil samples

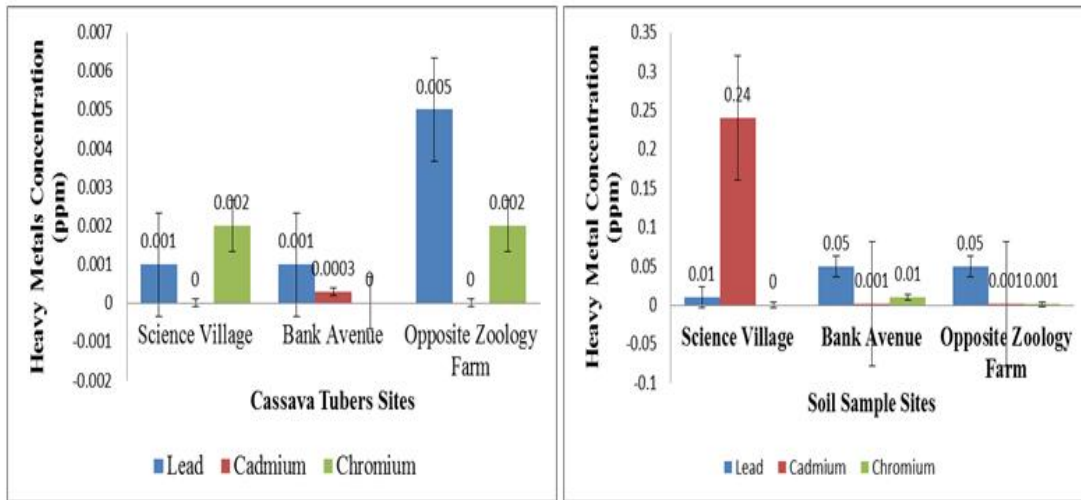| Parameter	Science village	Bank Avenue	Opposite Zoology Farm
pH	6.27 ± 0.07	6.10 ± 0.06	6.57 ± 0.03
Nitrate	138.07 ± 12.09	149.35 ± 14.25	149.20 ± 1.17
Organic Carbon Content	61.17 ± 3.61	55.67 ± 5.57	55.00 ± 1.32
Organic Matter Content	105.20 ± 6.20	95.75 ± 9.57	94.6 ± 2.27

Fig. 2. Showing levels of heavy metals on soil and cassava tubers in the three sites

0.1mg/l which appeared to be safe for agricultural purposes while in science village they are above permissible limit, hence higher Cadmium concentration leads to Cadmium poisoning in man which could lead to anemia, renal damage, bone disorder and cancer of the lungs. This result is in agreement with the study of [21]; [24]. The permissible limit of Cadmium in the cassava tubers was lower than $0.02mg/kg^{-1}$ recommended by WHO.

Chromium concentration from the table shows that science village in soil samples has no uptake of metal and in cassava tubers, no uptake of metals in bank avenue. In this metal, Bank Avenue has the highest level of contamination in soil. The value obtained in this study is within the permissible limit of 0.1mg/l for WHO standard. The Chromium value of this study has a similar range with the study reported by [21]; [25] but the study is lower than those reported by [3].

Taking all heavy metals into consideration for soil and cassava samples from the three different farmlands, the decreasing order of the mean concentration of heavy metals in the soil samples were followed as Cr < Cd <Pb and that of cassava samples were followed as Cd < Cr <Pb.

4. CONCLUSION AND RECOMMENDATION

The results obtained from the physiochemical analysis of the soil samples revealed that the different farmlands soils were slightly acidic to neutrality and contained significant amounts of organic matters and some ion sable inorganic substances. The data gathered during this study shows that for heavy metals, lead had the highest concentration amongst all the parameters measured. Heavy metals from the farmlands, soil was higher than the cassava tubers showing a high concentration of heavy metal contamination in the study area. This study was recommended to bring the potential health risk from cultivated crops consumption in the area to a full disclosure. Proper bio monitoring of the environment should be done as often as possible so as to enlighten the general public on the dangers of heavy metal pollution.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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