HUMAN HEALTH IMPACTS OF TOXIC TRACE METALS IN SOILS AND VEGETABLES IN ISHIAGU AREA OF THE LOWER BENUE TROUGH, NIGERIA.

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ABSTRACT

A study was conducted to evaluate the levels of cadmium, arsenic, lead, copper, and antimony concentrations in igneous rocks (parent materials), soils and edible vegetables from Ishiagu in the Lower Benue Trough of Nigeria. The study area Ishiagu is a town in Ivo Local Government Area of Ebonyi State, Nigeria, which lies within the Asu River Group and is underlain by Ezeaku Sandstone Formation of Turonian age which uncomformably overlies the Abakaliki Shale Formation dated Albian. Ishiagu lies on latitude 5o 56’ 33” N, and longitude 7o 34’0”E and topographically, it has an undulating terrain. The igneous rock intrusions in the study area mostly occur as dykes of dolerite within the Abakaliki Formation. Field samples obtained comprise igneous rocks (10), soils (10), and vegetables (5). These were analyzed with X-Ray Fluorescence (XRF) spectroscopy, to determine the elemental compositions of the materials. The mean concentrations for the igneous rocks are Cd (90ppm), Pb (10ppm), As (20ppm), Sb (0ppm), Cu (130ppm); in soils, Cd (100ppm), Cu (90ppm), As (10ppm), Pb (210ppm), Sb (40ppm); and in vegetables, Cd (240ppm), Cu (380ppm), As (0ppm), Pb (120ppm), Sb (40ppm). The concentration averages for rocks, soils and vegetables are higher than the World Health Organization (WHO) (2020) for igneous rocks, International Permissible Limit (IPL), (2012) control standards used for soils, and the Department of Petroleum Resources (DPR), (1991) control standard used in this study for edible vegetables. The results from pollution index suggest that the study area have pollution of Cd, Cu, As, Pb, and Sb in soils, and Cd, Cu, Pb, and Sb in vegetables. High levels of these toxic trace metals in vegetables, if consumed regularly are capable of causing human health problems such as cancer, lungs and kidney damage, birth defects and developmental issues in children, and skeletal and respiratory systems damage. It is therefore strongly recommended that the toxic trace metal with high concentration levels in the soils used for growing vegetables be regularly monitored, to control plants’ roots intake of the metals from the soils, and also to follow safe farming practices to reduce the risk of pollution.

**Keywords: toxic trace metals; concentrations; health problems; pollution; control standards.**

**Introduction**

Trace metals are present in small amounts and constitute a vital part of the plant and animal kingdom. Trace metal deficiencies have been linked to a reduction in the antioxidant potential of organisms, a high rate of aging, developmental retardation in children, and an increase in pregnancy abnormalities (Can *et al.,* 2021). While these metals are essential for many biological processes, they can also be toxic in high concentrations. Consequently, monitoring and managing trace metal levels in the environment are crucial for maintaining healthy ecosystems and ensuring human and animal health. Trace metals in soil can significantly impact plant growth and soil quality. For instance, when trace metals such as lead, cadmium, and arsenic are present in high concentrations, they can be toxic to plants and animals alike. Therefore, monitoring and managing trace metal levels in soil is crucial for maintaining healthy ecosystems and ensuring food safety. Trace metal levels in vegetables can be a concern for human health, particularly if the vegetables are grown in soils with high levels of these metals. These metals, such as lead, cadmium, and arsenic, can accumulate in vegetables from the soil, water, or weathering of rocks. High levels of these metals in vegetables can pose a risk to human health if consumed regularly over time, as they can cause a range of health problems, including cancer, kidney damage, and developmental issues in children. It is therefore important to monitor and manage trace metal levels in soil and water used for growing vegetables and to follow safe farming practices to reduce the risk of contamination and pollution. The toxicity of trace metals in the environment depends not only on their level but also on where they are found, such as in water, plants, air, or soil; their source, whether from natural rock weathering or mining activity; the acidity of the environment in the area of interest or study, with acidic areas being more problematic for trace metals; and whether the metal exists independently or constitutes part of larger chemical compounds (Gamberg *et al*., 2005). For instance, in North Canada, trace metals in mining areas, especially old, abandoned mines with tailings that have leaked into lakes or streams, are of great concern. The lakes and streams become acidic due to mine pollution, and these metals become toxic to the local fishes and bugs in the streams and lakes (Morel, 2003). This clinical aspect of knowledge relating to trace metals is becoming essential to front-line clinicians (Osamu, 2004). WHO has recommended the quantity of some trace metals in igneous rock, soil, and edible vegetable samples required by the human body for proper functioning, as shown in Table 1.1 Exceeding this threshold is risky to human health (WHO, 2020).

**Table 1.1: Recommended amount / quantity of trace metals in different medium, WHO, (2020).**

**Trace Rock Soil Vegetables**

**Metals (mg/kg) (mg/kg) (mg/kg)**

Cadmium - 0.8 0.02

Copper 35.7 36 73.3

Antimony - - -

Lead - 85 0.3

Arsenic 2 0.15 0.5

 (-) control standard not known

**The study area**

The research was focused on studying the presence and concentrations of toxic trace metals recorded in igneous rock intrusions from different communities in Ishiagu, Ebonyi State, by obtaining field sample data from different geospatial locations and laboratory analyses afterwards. Ishiagu is characterized by igneous rock intrusions that hosts trace metals naturally, and are introduced into the environment during weathering process or anthropogenic activities. Sample points for materials were obtained from various locations such as in Amaeze, Amaeke, Amokwe, Ihie, and Amagu communities in Ishiagu, Ebonyi State.

**Geological setting**

The chemical properties of soil reflects the composition of the source rock or intrusion that underwent weathering. The study area Ishiagu is a town in Ivo Local Government Area of Ebonyi State, Nigeria, which lies within the Asu River Group is underlain by the Abakaliki Formation and the Ezeaku Formation dated Albian (Ezepue, 1984). The Ezeaku Sandstone Formation dated Turonian (Edeani, 2015) unconformably overlies the Abakaliki Formation (McConnel, 1949). Ishiagu lies on latitude 5o 56’ 33” N, and longitude 7o 34’0”E and topographically, it has an undulating terrain. The igneous rock intrusions in the study area mostly occur as dykes of dolerite within the Abakaliki Formation. Field expressions show that the pyroclastics erupted parallel to the axial plane of the Abakaliki anticlinorium in NE-SW direction and are spatially associated with shales of the Asu River Group and Nkporo Shale (Ukaegbu, 2008). The igneous rocks in the study area mostly occur as dykes and sills of dolerite within the Abakaliki Formation (Chukwu, 1981). Abakaliki Formation underwent double deformational dips between 15o to 22o NW and 20o to 30o SW while Ezeaku formation dips between 18o to 220 SE.



Fig. 1: Location and geologic map of the study region with sampling points.

**Method of study**

Igneous rock samples (10), soil samples (10), and vegetable samples (5) were obtained from various quarries/mining sites, farmlands, and other different locations or communities within Ishiagu town. This was done after careful study and understanding of how the processes are carried out through reviews of previous works, from collection of the right quantities, preparation, laboratory analysis, interpretation of findings, and conclusions. All rock samples were prepared using a Concrete Compression Testing (CCT) machine 2000KN, and rock dust passed through a 75-micron mesh. Soil samples were collected at a shallow depth of 0.15m and bagged. After pulverization of the rock and soil samples, they were passed through sieve shakers of different diameters. The dust retained from the least diameter of 0.09 mm mesh size was packaged at 20g for the geochemical analysis. The vegetable samples (cucumber) were properly washed with distilled water and oven-dried at 60oC (Peng et al., 2017) to make them flaky for easy pounding with the porcelain mortar and pestle. Each vegetable sample powder was packaged at 2g weight. The samples (rocks, soils, and vegetables) preparation was carried out in the Civil Engineering Laboratory of the University of Port Harcourt, Nigeria. Samples evaluations were carried out at the Bayero University Kano Laboratory, Nigeria, using an XRF spectrometer.

**Results**

This study on toxic trace metals, twenty-five samples comprising igneous rock samples (10), soil samples (10), and edible vegetable samples (5) from Amaeze, Amaeke, Amokwe, Ihie, and Amagu communities in Ishiagu were analysed to determine the concentration levels of Cd, As, Pb, Cu, and Sb. Results of sample analysis in Table 1.2 reveals the mean concentrations of toxic trace metals across the five communities within study area, and provide details of the relationship between igneous intrusions and pollution of other media. Toxic trace metals with concentrations below or exceeding the permissible threshold in comparison with the control standards used for this research was also evaluated.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Trace Metals**  | **Soil 1 Amaeze** **quarry 1** | **Soil 2 Amaeze quarry 2** | **Soil 3 Amaeze quarry 3** | **Soil 4 Amaeze farm 1** | **Soil 5 Amaeze farm 2** | **Soil 6 Ama****okwe 1** | **Soil 7 Amaokwe 2** | **Soil 8 Ama****okwe** **3** | **Soil 9 Amagu** | **Soil 10 Ihie** | **Min** | **Max** | **Mean** | **DPR 1991****(mg/kg)** |
| Copper | 100 | 100 | 100 | 100 | 100 | 100 | 200 | 0 | 100 | NIL | 100 | 200 | 90 | 36 |
| Lead | 0 | 0 | 100 | 0 | 100 | 0 | 0 | 1700 | 100 | 100 | 100 | 1700 | 210 | 85 |
| Cadmium | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 0.8 |
| Arsenic | 0 | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 10 | 0.15 |
| Antimony | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 100 | 100 | 0 | 100 | 40 | - |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

**Table 1.2: Results of physiochemical analysis on soil samples from the study area.**

**Table 1.3: Results of physiochemical analysis on vegetable samples from the study area.**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Trace** **Metals** | **VEG1** **Ihie** | **VEG2 Amaeke 1** | **VEG3 Amaeke 2** | **VEG4 Amaeke 3** | **VEG5 Amaeke 4** | **Min** | **Max** | **Mean** | **IPL 2012****(mg/kg)** |
|  |  |  |  |  |  |  |  |  |  |
| **Antimony** | 100 | 0 | 0 | 0 |  100 |  **0** |  **100** |  **40** |  **-** |
| **Copper** | 300 | 300 | 400 | 500 |  400 |  **300** |  **500** |  **380** | **73.3** |
| **Lead**  | 100 | 100 | 100 | 200 |  100 | **100** |  **200** |  **120** |  **0.3** |
| **Cadmium** | 300 | 200 | 200 | 300 |  200 | **200** |  **300** |  **240** | **0.02** |
| **Arsenic** | 0 | 0 | 0 | 0 |  0 |  **0** |  **0** |  **0** | **0.5** |
|  |  |  |  |  |  |  |  |  |  |

Table 1.4: Toxic trace metals mean concentrations across the communities, control standards, and pollution index.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| TRACE METALS | Rock Mean values | WHO (2020) for igneous rocks | Pollution Index | Soil Mean values | DPR(1991)forsoils | Pollution Index | Veges. Mean values | IPL(2012) for veges. | Pollution Index |
| Copper (Cu) | 130 | 35.7 | E.P | 90 | 36 | E.P | 380 | 73.3 | E.P |
| Lead (Pb) | 10 | - | - | 210 | 85 | E.P | 120 | 0.3 | E.P |
| Cadmium (Cd) | 90 | - | - | 100 | 0.8 | E.P | 240 | 0.02 | E.P |
| Arsenic (As) | 20 | 2 | E.P | 10 | 0.15 | V.Se.P | 0 | 0.5 | V.S.C |
| Antimony (Sb) | - | - | - | 40 | - | - | 40 | - | - |

Figure 1: a pie chart showing mean distribution pattern and percentages of toxic trace metals in soil samples.

Figure 2: a pie chart showing the mean distribution pattern and percentages of toxic trace metals in vegetable samples.

Figure 3: an XY chart showing the mean value concentrations of trace metals in rocks, soils, and vegetables on the Y axis; where 1=Cu, 2=Pb, 3=Cd, 4=As, 5= Sb on the X-axis.

Cadmium

Cadmium is a trace metal found in zinc ores (USAS, 2018). Its natural occurrence is in tiny amount in air, water, and food. Practically it is insoluble in water (ATSDR). Cadmium is poisonous and causes birth defects and cancer (Waalkes, 2000). It is toxic on the lungs, kidneys, skeletal and respiratory systems (WHO, 2015; Yoshida et al., 1999). Cadmiun finds its way into the environment through mining operations, wind actions and rain. Cd in the body is by consumption of certain foods grown on contaminated soils. Cadmium is toxic even in moderate amount and counters several essential trace metals (US. DHHS, 2020). Sources of cadmium from diets include vegetables, cereal products, potatoes, shellfish, and contaminated water from exposure in the environment. Children are at a higher risk of Cd exposure effects. 20 - 30mg consumption of Cd from diet is deadly. Vegetarians are at a higher dietary exposure due to their high consumption of vegetables. Due to low permissible exposure in humans, over-exposure may occur even in situation where trace quantities of Cd are found. Long-term exposure to Cd weakens the bones and can lead to permanent deformation. (Yoshida et al., 1999). Cadmium in small quantity in the air is highly toxic to humans as the lungs absorb more of it and also the kidneys which have higher concentrations in them (Gustin *et al*., 2018). Cadmium increases with age in the body and women with higher absorption through oral intake are at greater risk of cadmium accumulation in the blood compared to men (Olsson *et al.,* 2002). Acute symptoms of excess cadmium exposure are abdominal pain, vomiting, diarrhea, chronic symptoms are kidney disease leading to glucosuria (glucose in urine) and proteinuria (protein in urine), lung damage and bone weakness (Nordberg, 1999).

Antimony

Antimony is a non-essential metal for the human body and can be found as a native-naturally abundant metal. Antimony oxide is introduced into the environment as a by-product of lead and other metal emission into the air, water, and land during smelting, and coal-fined power plants; also by volcanic eruptions, sea spray, forest fires and biogenic sources (Dietl *et al.,* 1997). Humans are exposed to antimony from the source rock by either skin contact, inhalation/breathing of air saturated with antimony dust, drinking water and eating foods that contain antimony such as vegetables, fruits, cereal products all grown on soils with antimony concentration (Belzile *et al.,* 2011). Eyes, skin and lungs irritation may occur in individuals that are exposed to high concentration of antimony (9mg/m3) in the air over a long period of time (Cooper and Harrison, 2019).

Antimony concentration from igneous rock pollutes the air, and ranges from 1ng/m3 to 170ng/m3; in rivers, dissolved antimony is usually <5ppb that is attached to dirts, in soil concentration ranges from <1ppm to 8.8ppm (ATSDR, 2010). Exposure to low levels of antimony in soils, air, water or food from polyethene water bottles and fire retardants may not be detrimental to human health but higher levels of exposure is risky and can cause delayed growth in children, dermatitis and inflammatory lesions, pulmonary damage, myocardial damage and gastrointestinal irritation. Occupational exposure / inhalation of antimony has been reported to cause respiratory issues like chronic bronchitis, inactive tuberculosis, wheezing, and upper airway inflammation to the workers (Potkonjak and Pavlovich,1983). Acute exposure to antimony leads to headache, nausea, dizziness, metallic taste and diarrhea; Chronic occupational exposure leads to respiratory irritation, eye irritation, miscarriage or premature birth, damage to liver or spleen, stomach ulcers and heart problem (US. DHHS, 2017).

Copper

Copper is an essential metal from igneous rock source which is present in the environment and used for various purposes. Copper is a metal that occurs from hot sulphur solutions, created in volcanic regions by volcanic pressure and high temperature alterations. Copper is an ever-present trace element in basaltic magma; during magmatic crystallization, it appears either in silicates and oxides, sulphides or in native state (Pramod and Hanel, 2011).The sources of copper in the body of human are shellfish, liver, nuts, legumes, bran, meat offal, beans, and dark leafy green vegetables. The presence of copper in its sources is due to its abundance in rock materials that weather to form soils on which the vegetables are grown.

Copper is useful in the body for production of energy, connective tissues, and blood vessels, brain development, maintenance of both the immune and nervous systems, and gene activation, Cromwell, (1997). Copper is required in small amount for healthy bones, nerves and collagen, but excessive ingestion can result in vomiting, and diarrhea, nose and throat irritation, damage to the liver and kidney of humans, hemolytic anaemia, and neurodegeneration. Short term exposure of humans to copper dust from geogenic source can cause eye and respiratory tract irritation, drowsiness and metal fume fever (a short term illness that can last between 24 to 48 hours with symptoms of chills, fever, muscle aches, mouth and throat dryness) (U.S. AF, 1990).

The deficiency symptoms of copper are anaemia, osteoporosis, and growth retardation in young children, change in hair pigment, cerebral and cerebellar degeneration, and degenerative change in aortic elastin. (Ortiz, *et al.,* 2020). The recommended dietary allowance of copper by World Health Organization (1996) is as follow: adult men and women 900mg/day, 340 – 890mg/day for children depending on their age, pregnant women 1000mg/day, and lactating mothers 1300mg/day. The toxicity of copper occurs at an intake of 10,000mg/day.

Arsenic

This trace metal exists both as toxic and non-toxic form; the inorganic arsenic compound (when combined with other elements but not carbon) are likely more toxic and can be linked to cancer unlike the organic arsenic compound (combination of carbon with other elements), are less toxic and are not linked to cancer (Panagiotaras and Nikolopoulos, 2015). Mitra *et al., (*2020)*,* Arsenic existence in the environment is through volcanic eruptions which is natural and contributes about 80,000 tonnes by fossil fuel burning, and lead-zinc production process; this cause its mobility to several places. Arsenic might be considered as partially an essential trace metal for humans with RDA as low as 0.01mg/day, due to its toxicity (U.S DHHA, 2017). Arsenic levels may be very high in seafoods since fishes live in water and absorb it from the water containing high level of arsenic and making the fishes dangerous to human health when consumed (Francesconi, 2010).

Children have high metabolic rate, developing nervous system, and increased hand to mouth behaviour, so they are more susceptible to toxins from arsenic and other metals of such. Sources of arsenic in the body is through contaminated water and food, industrial processes, that introduce arsenic into the air we breathe (Binder *et al.,* 1987). Acute symptoms of excess arsenic in the body are abdominal pain, vomiting, diarrhea, muscle cramp, high blood pressure, rapid heart rate, in extreme cases numbness, tingling, muscle cramps and death (Saha *et al.,* 1999). Chronic symptoms (>5years of exposure) include: hyperpigmentation of skin, muscle weakness, amaemia, leukopenia, skin lesions, skin cancer, sensory-predominant peripheral neuropathy, hard patches on hands and bottoms of feet, infertility and miscarriages in women of reproductive age (Rahman *et al.,* 2001). Acute and low-level exposure of arsenic in the body can be diagnosed by use of urine specimen, while for recent exposure and large dose poisoning, blood specimen is preferable. (US. DHHS, 2010).

Lead

Lead is a toxic metal from source igneous rocks present in the environment (air, water, soil, vegetables). Human activities like smelting, mining, manufacturing and recyclying activities, leaded aviation fuel and leaded paints in homes are means of environmental contamination and the most form of lead exposure to humans. According to Robbins *et al., (*2010), Lead is harmful even in small amount especially to young children; they are more vulnerable to the toxic effect of this metal that can cause permanent health impacts on the development of brain and nervous system, while in adults there’s increased risk of high blood pressure (HBP) and kidney damage, in pregnant women it is stored in the bones and released into the blood and becomes a source of exposure to the developing foetus. This can cause miscarriage, stillbirths, low birth weight, and premature birth.

The main source of lead poisoning or exposure routes are inhalation (occupational) of lead particles generated during smelting about 15% or burning of leaded aviation fuel, and by ingestion of lead contaminated dust, water from leaded pipes (20%), and food (65%) from lead-glazed containers. Also, certain types of traditional medicines from herbs grown on lead polluted soils are sources of lead exposure to humans. Children absorb about 4-5 times as much as adults ingest from lead contaminated soils due to their usual hand to mouth behavior; Lead in the body is distributed to various organs of the body like kidney, liver and bones and accumulate there; excess lead can affect children’s intelligence quotient, cause anaemia, HBP, and infertility in men (Mason *et al.,* 2014).

It is important to note that no amount of lead is healthy for the body not even as low as 5mcg/L concentration in the blood, hence total avoidance is advised. Certain fruits, vegetables, and grains may contain significant amount of lead. (WHO, 2021).

**DISCUSSION**

Ten rock samples, ten soil samples, and five edible vegetable samples were collected from study area and evaluated to determine the chemical composition of trace metals in them. The focus was on the trace metals that occurred in the samples and exceeded the permissible limits, thereby making them toxic. This makes such trace metals become major interest in this study.

Rock samples

Table 1.4 shows the mean values of toxic trace metals reported in rock, soils and vegetable samples, and the control values according to WHO (2020) permissible standard. From the table, it is observed that As, and Cu are the trace metals with control values and their mean values exceeded the permissible limits of the WHO (2020) standard values. Note that not all trace metals (Pb, Cd, Sb) reported with mean values have control standards to compare with its mean concentration in this study. It is therefore not certain how toxic or friendly the environment of study area is, but it is important to note that Cd, Pb, and Sb are toxic metals by nature and not tolerable by the human body. The implication of having mean values higher than permissible standard is toxicity effects of the trace metals (As, and Cu) on humans health for the residents of study area as pollution index quality for rock samples recorded excessive pollution for Cu and As.

The effects of As toxicity in humans include muscle weakness, skin cancer, sensory-predominant peripheral neuropathy (Rahman *et al.,* 2001); Copper toxicity results in diarrhea, nose and throat irritation, liver and kidney damage in humans (WHO, 1996).

Soil samples

The results of the study indicate that the mean concentrations of As, Cu, Pb, and Cd in the soil samples collected from the study area are above the permissible standard set by DPR (1991), with the exception of Sb which has no control standard. The copper concentration in the soil samples exceeds the permissible limit set by DPR (1991), with an average concentration of 90ppm compared to the permissible limit of 36ppm. This finding suggests excessive pollution and toxicity of copper in the study area, which may have implications for the overall health of the population residing in the area. Excessive copper intake can lead to various toxic effects such as diarrhea, hemolytic anemia, cramps, kidney disease, liver damage, and vomiting (Brito *et al*., 2005). In summary, the study highlights the presence of high concentrations of toxic metals in the soil samples collected from the study area, with copper being the most concerning. Therefore, the study recommends the use of electrokinetic remediation (EKR) technology to remove copper from the soil (Talib *et al.,* 2019). The findings emphasize the need for further and prompt action to mitigate the risks posed by excessive copper pollution in the study area.

The concentration of lead in soils in the area has been found to have exceeded the standard recommended by the DPR (1991) for Pb in soils (85 ppm). This indicates that the health of the residents in the area is at risk due to exposure to excessive quantities of Pb, which may cause lead toxicity. Goyer (1993) has stated that exposure to radiogenic lead in children can impede the development of their brains and nervous systems. Adults may also suffer from kidney damage, high blood pressure, miscarriages, premature births, and stillbirths in pregnant women. Robbins (2010) has pointed out that even the ingestion of a small amount of lead, as low as 5 micrograms in the blood, can pose a threat to health. However, Zhang and Lo (2006) have suggested that soil washing using ethylenediamine-tetraacetate (EDTA) is an effective method for the remediation of Pb in soils.

Cadmium was detected in all ten soil samples collected from the area, with an average concentration of 100 ppm. This exceeds the permissible limit recommended by DPR (1991) standard of Cd in soils (0.8 ppm) in all ten locations, indicating a threat of cadmium toxicity to those living in the area. Cadmium is a highly mobile and bioavailable metal that can accumulate in crops and human vital organs such as the spleen, liver, and kidney, as stated by Alloway (1995). Exposure to excessive levels of Cd can lead to damage to vital organs like kidneys, lungs, and bones, as well as an increased risk of lung cancer, as noted by EFSA (2009). It is worth noting that the toxic effects of Cd are more pronounced in women than in men due to the higher rate of oral intake absorption, which leads to more Cd accumulation in the blood, as mentioned by Olosson *et al*., (2002). To address soil contamination with Cd, Martins and Ruby (2004) recommend the use of nanopolymers in agricultural and environmental applications.

The mean concentration of As was found to be 10ppm, which is significantly higher than the recommended standard of 0.15ppm. This indicates a severe level of pollution, which poses a substantial risk to human health. The symptoms of excess As in the body may include vomiting, diarrhea, muscle cramps, high blood pressure, rapid heart rate, numbness, tingling, muscle cramps, and even death (Saha *et al.,* 1999). The study recommends soil washing with chemicals such as sulfuric acid, or nitric acid to remove As from the soil, which can be an effective solution to reduce the risk of toxicity to human health in the study area (Jang *et al.,* 2005).

The study found that the mean concentrations of As, Cu, Pb, and Cd in soil samples collected from the study area exceeded the permissible threshold set by DPR (1991), with the exception of antimony (Sb), which had no control standard in this research for comparison. According to the pollution index after Lacatusu (2000), the evaluation of trace metals in the ten soil samples shows that Pb, Cu, and Cd have pollution index quality of excessive pollution, and As is of very severe pollution in the study area, making them the primary pollutants of soil in the study area, with Pb recording the highest mean value/level.

In conclusion, the study highlights the presence of high concentrations of toxic trace metals (As, Cu, Pb, Cd, and Sb) in soil samples collected from the study area, and from the results interpretation for soil samples, the findings of Ezeh and Chukwu (2011) soil assessment for Pb, Cd, and Zn from Ishiagu is in line with the findings from this research that the soil from study area is polluted with the above trace metals. Also, Obiora *et al*., (2019) reported pollution of soil samples in study area with Pb, Zn and Cd. These are related findings from previous studies with this present study.

Vegetable samples

The vegetable samples collected from the study area likewise demonstrate alarming levels of Cadmium concentration. All locations of vegetable samples showed concentrations above the control standard set by the IPL in 2012. Mean value analysis revealed a concentration of 240mg/kg, exceeding the control value of 0.02mg/kg, rendering the vegetables unfit for consumption due to the risk of Cadmium poisoning. Symptoms of Cd toxicity include abdominal pain, chronic kidney disease symptoms like glucosuria (glucose in urine) and proteinuria (protein in urine), and lung damage (Nordberg, 1999).

The study revealed a mean concentration of 120mg/kg for Lead (Pb) in vegetable samples collected from the study area, which significantly surpasses the control standard of 0.3mg/kg set by the IPL in 2012. This finding suggests Pb poisoning in the area, posing a severe risk to the health of residents. The effects of Pb, including radiogenic lead, in humans have been extensively studied, and the findings reveal several symptoms. Children exposed to Pb are at risk for impaired cognitive development, as evidenced by a decrease in their intelligence quotient (Onwurah *et al*., 2020). Adults exposed to Pb may experience high blood pressure, while men may suffer from infertility (Mason *et al*., 2014). In light of these findings, the study recommends prompt measures to mitigate the risk of Pb poisoning and ensure the safety of food consumed in the study area. Further research is also necessary to gain a comprehensive understanding of the issue and develop effective strategies for addressing it. In summary, the study underscores the presence of high concentrations of Pb in vegetable samples collected from the study area, indicating Pb poisoning in the area and posing a significant health risk to the population. The findings emphasize the urgency of taking immediate action to address the problem and ensure the safety of food consumed in the area.

The study has revealed that the average concentration of copper in all five vegetable samples collected from the study area was 380mg/kg, greatly exceeding the IPL (2012) standard of 73.3mg/kg for copper in vegetables, indicating the presence of copper pollution in the vegetables grown within the study area. The result interpretation from this study has also demonstrated the contamination of vegetable samples in the study area with Pb, Cu, and Cd, which is consistent with previous studies conducted by Oje *et al*., (2011) and Obiora *et al*., (2019). Control values for IPL (2012) serve as a guide to determine the tolerable and toxic levels of trace metal concentrations reported in the vegetable samples. The study recommends soaking vegetables in a vinegar and water solution or a water and baking soda solution for a few minutes as a method to remove toxic metals from them (Bora *et al*, 2022). Cooking vegetables with plenty of water can also help to leach out the metals, although it may not remove the entire concentration, especially for vegetables that require longer cooking times. In light of the presence of copper pollution and toxic metals in the vegetable samples, the study recommends the implementation of measures to reduce the toxic metal concentrations in vegetables grown in the study area to safeguard public health. These measures could include the use of appropriate soil remediation techniques and monitoring of vegetable growth and safety.

**CONCLUSION**

This study identified the primary source of pollution within study area is from trace metals contained in the igneous rock intrusions. Toxic trace metals present in the samples from physiochemical analysis with mean values above permissible limit are Cu and As in rock samples, Cu, Pb, Cd, As in soil samples and Cu, Pb and Cd in vegetable samples. Sb has no control value for comparison with mean values in both soils and vegetables.

The results of toxic trace metals evaluation on soils, and edible vegetables samples in the study area when compared to the standard and guidelines given by DPR (1991), and IPL (2012), and the pollution indices for the toxic trace metals of interest (Pb, Cd, Cu, As, Sb), it clearly reveals that the metals exceeds the expected threshold which is unsafe for the human body when ingested or inhaled.

The study area under investigation has shown that toxic trace metals (Pb, As, Cd, Sb, Cu) in plants, particularly vegetables, may be consumed in their raw or cooked form, and subsequently be transmitted into the human body either in their normal or toxic state. Analysis of the laboratory results has revealed that the chemical compositions of toxic trace metals in the study area exhibit a range of pollution from very severe pollution to excessive pollution, as observed from the calculation of the pollution index. Cu, Cd, As and Pb are major pollutants of soils and vegetables in the area, with excessive pollution indexes in both samples. As is of very severe pollution in soils, and very slight contamination in vegetables. Sb had mean values for both soils and vegetables, but there were no control standards for either of the two at the time of the study. It is paramount to monitor the concentration levels of toxic trace metals in our environment to ensure the safety of human health and the ecosystem. The laboratory analysis results of the present study have identified potential health risks associated with the presence of toxic trace metals in soils and vegetable samples within Ishiagu. In conclusion, it is imperative to take timely and proactive measures to address the potential health risks associated with the presence of toxic trace metals in our environment. The findings of this study emphasize the need for further interventions to mitigate the risks posed by excessive pollution of toxic metals in the study area.

**RECOMMENDATIONS**

The high concentration of toxic trace metals (As, Pb, Sb, Cd, Cu) present in the source rocks or other materials portend imminent danger to the study area environs and the distal parts on the long run. For this,

1. It is therefore necessary to implement proactive measures to mitigate the health risks that may arise from exposure to these toxic metals.
2. Possible measures include the use of appropriate soil remediation techniques and monitoring of vegetable growth and safety.
3. The study recommends various methods to remove toxic trace metals from the soil, such as electrokinetic remediation (EKR technology: in-situ) for Cu pollution (Talib *et al.,* 2019); soil washing using ethylenediamine-tetraacetate (EDTA) for Pb pollution (Zhang and Lo, 2006).
4. For Cd pollution in soils, Martins and Ruby (2004) recommend the use of nanopolymers in agricultural and environmental applications for detoxification.
5. Soil washing with chemicals such as sulfuric acid, or nitric acid to remove As from the soil, which can be an effective solution to reduce the risk of toxicity to human health in the study area (Jang *et al.,* 2005).
6. To reduce the concentration of toxic metals in vegetables, it is recommended that the vegetables be soaked in vinegar and water solution or cooked with plenty of water.
7. The study emphasizes the need for immediate measures to mitigate the risk of poisoning and ensure the safety of food consumed in the study area.
8. The study's findings reinforce the need for prompt action to mitigate the risks posed by excessive contamination of toxic trace metals in the study area.
9. It is worth noting that previous studies have also reported soil contamination with trace metals in the study area, but without the source of pollution made known, and this further underscores the importance of addressing this issue.
10. It is critical to take action to reduce the levels of toxic metals in vegetables grown in the study area to protect public health.
11. There is need for further research to gain a comprehensive understanding of the issue and develop effective strategies for addressing it.

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