

Assessment of some Heavy Metals and Health Risk Analysis of Arable Farmlands from selected LGAs of Taraba State, Nigeria

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ABSTRACT

Background: Soil plays a major role in food safety and security. Lack of food security and safety has become a major problem in most developing nations. The soil environment is a reservoir of nutrients as well as pollutants. This study evaluated the health risk and some heavy metals content of certain arable farmlands in Ussa, Gassol and Yorro, Local Government Areas of Taraba State, Nigeria. **Methodology:** Three different soil samples from three Local Government Areas in three geopolitical zones of Taraba State (Ussa, Gassol and Yorro) were collected using sterile glass sample collection bottles measured at 5 cm depth. Unwanted materials were removed by hand picking. The soil was there after air-dried for 5 days to remove excess moisture. The dried soil samples were crushed with mortar and a pestle, the crushed soil sample was sieved through a 2 mm sieve made of stainless steel the sieved soil sample was further pulverized to a fine powder and passed through a 0.5-mm sieve. Heavy metals (Pb, Cd, Cr, Hg and As) concentrations were determined using Atomic Absorption Spectrophotometry (AAS). The health risk was assessed a certain model called Hazard quiescent model (HQ) **Results:** The results showed that Chromium had a high concentration with values ranging from 1.83 mg/kg to 2.62 mg/kg. While Lead and Mercury had the lowest concentration of less than 0.03 mg/kg across the studied areas. For ecological risk assessment parameters; target cancer risk, hazard index (HI) estimated daily intake (EDI) were all determined to assess the non-carcinogenic health risk. Gassol recorded the highest levels of Heavy metals HM, followed by Yorro, whereas Ussa had the lowest concentration. Consumption of crops harvested from the sampled location may pose a serious health challenge; bio-accumulation of toxicants in the soil across the studied areas may pose a health risk due to high concentration of heavy metals which are known to generate free radicals that may lead to oxidative stress and other cellular damages in humans. **Conclusion:** Although most of the studied heavy metals were significantly present in all the analyzed soil except lead and mercury, their concentration in various soil samples across the studied areas exceeded the permissible levels as recommended by WHO.

Keywords: Risk assessment, Heavy metals, Toxicity, Bioaccumulation and Carcinogenesis.

INTRODUCTION

Food insecurity is a major problem in most of the developing nations. Most of the food items are laden with lots of pollutants ranging from fertilizer and pesticides. Consuming foods contaminated with these pollutants has detrimental effects on the population's health and economic situation (Otitoju *et al.*, 2014). Heavy metals are naturally occurring metallic elements that have a relatively high density compared to water (Habibu *et al.*, 2024). Heavy metals also include metalloids like arsenic, which can cause toxicity at low exposure levels. Even though heavy metals are naturally present in the ecosystem, their levels are rarely harmful (Otitoju *et al.*, 2014). However, due to their extensive usage, dispersion particularly their toxicity to humans and animals, heavy metals have become a common problem for environmental contamination (Okoli *et al.*, 2021). They constitute continuous environmental contaminants being that they cannot be easily degraded (Tatah *et al.*, 2017). This has resulted in the release of pollutants (hydrocarbons and heavy metals) capable of contaminating soil and water bodies (Okoli *et al.*, 2022).

Soil is the main factor of agricultural output and the most significant aspect of a farmer's produce. In poor communities where control over and access to land are key indicators of wealth and survival, land is a crucial socioeconomic resource (Olawale *et al.*, 2023). Land is a valuable economic resource, especially in developing nations where the majority of the population lives in rural areas and depends on agriculture for living. Since the dawn of humankind, it has continued to be a significant force in production and an essential component of the global agricultural industry. Furthermore, it lays forth a plan for agricultural output in Nigeria and the rest of sub-Saharan Africa (Habibu *et al.*, 2022). Gaining access to arable land is vital for the millions of impoverished rural residents who rely on farming, raising livestock, or cutting down trees for their survival (Oko *et al.*, 20204). It lessens their vulnerability to hunger and poverty and affects their capacity to engage in productive activities and manage resources sustainable

The studied areas are highly endowed with purposeful diversity and arable farmlands which is an important element in development from natural to human resources (Habibu *et al.*, 2024). Taraba State is largely blessed, it is the host of the largest base of solid minerals, (including gold, diamond, limestone, zinc lots more) in Nigeria (Habibu *et al.*, 2022). The major occupation of the residents in the studied areas is farming due to its fertile nature and abundant arable farmlands, whereas report has it that in some places around Gassol, there may be no much need of fertilizer application due to its natural fertile lands in production of Crops such as maize, rice, sorghum, millet root crops such as cassava and yam. Other important economic activities taking place in the region including fishing and rearing of variety of animals such as cattle, sheep, goats donkeys are taking place in the studied areas (Rashed *et al.*, 2010). There are several threats to human health and ecology from the buildup of heavy metals and metalloids in soil, water plants, including Cadmium, Chromium, Copper, Lead, Nickel and Zinc (Ezeonu *et al.*, 2022). Heavy metals are introduced into the environment and most especially into the soil from different sources such as industrial, agricultural municipal waste (Olawale, *et al.*, 2022). automobile emissions¹⁶, mining activities and agricultural practices (Gatti *et al.*, 2008). According to other findings, it can be seen that farmers apply variety of pesticides at various concentrations to curtail the losses due to illnesses

and pests (Habibu *et al.*, 2024). Pesticides, however, are a significant environmental concern even though they help in agricultural production. In addition to not biodegrading, many pesticides also bioaccumulate in food chain, harming both the living and the environment (Zouboulis *et al.*, 2004). Heavy metals can enter the body through skin, inhalation, or dermal contact and swallowed directly from the soil. These heavy metals enter the body system and may impede a variety of clinically aberrant forms of typical physiological and metabolic activities in cells (Ahmad *et al.*, 2012). The diverse chemical forms/species of the metals in the soil, as opposed to the total amount of heavy metals, have a significant impact on the uptake of heavy metals by plants (Habibu *et al.*, 2024). The mobility and bioavailability of the metals to the plants are thus determined by the chemical species these factors vary with the species of plants (Habibu *et al.*, 2024).

A health risk assessment model has been developed to evaluate the non-carcinogenic and carcinogenic risks associated with these metal contaminants' concentrations; a good assessment will consider the various exposure routes (Huang *et al.*, 2004). The present study evaluated heavy metals assessment and health risk analysis of arable farmlands in Gassol, Ussa and Yorro, Local Government Areas in Central, Southern and Northern region of Taraba State, Nigeria.

MATERIALS AND METHODS

Study area: This research was carried out in some Local Government Areas of Northern, central and southern Taraba State, North-Eastern Nigeria, popularly known for its numerous agricultural and mining activities. The research covered the following Local Government Areas (Ussa, Gassol and Yorro LGAs).

Sample collection: Three different soil samples from three Local Government Areas of Taraba State (Ussa: Ussa town, Bika-babba, Jatau. Gassol: Mutumbiyu, Gassol town, Tella, Yorro: Lnakaviri, Pupule, Pantisawa) were collected using sterile glass sample collection bottles measured at 5 cm depth. The samples were then kept in polythene sealed bags, labeled and transported to Laboratory quality control unit, in an air-dried place for the analysis of some heavy metals (As, Cd, Pb, Hg and Cr).

Sample preparation: Unwanted materials were removed from the soil sample by handpicking. There after the soil was air-dried for one week. the dried soil samples were crushed using a pestle and porcelain mortar. The crushed soil samples were then passed through a 2 mm stainless steel sieve.

Sample digestion: A measured volume of well-prepared sample appropriate for the expected metal concentration was transferred into a conical flask in a fume cupboard, 3 mL of conc. HNO₃ was added and covered with a ribbed watch glass and then placed on a heating mantle and cautiously evaporated to less than 5 mL, making sure that the sample did not boil. The mixture was then allowed to cool and the flask wall was rinsed and washed with distilled water. There after 5 mL of conc. HNO₃ was added and the flask was covered with a ribbed watch glass and returned to the heating mantle. Heating continued until digestion was completed. It was cooled flask was washed down with water. The solution was filtered and the filtrate was then transferred to a 100 mL

volumetric flask built up to the required concentration with distilled water before being used for analysis (Liu *et al.*, 2015).

Determination of heavy metal concentration: A conical flask in a fume cupboard was filled with a measured amount of well-mixed acid-preserved sample that was appropriate for expected metals concentration. The 3 mL of concentrated HNO₃ was added the flask was covered with a ribbed watch glass. It was then placed on a heating mantle and slowly evaporated to less than five milliliters, being careful that the sample did not boil. The mixture was allowed to cool and the flask wall was rinsed and washed with distilled water. 5 mL of conc. HNO₃ was added and the flask was covered with a watch glass and returned to the heating mantle. Heating continued until digestion was completed. It was cooled the flask was washed down with water. The solution was filtered and the filtrate was then transferred to a 100 mL volumetric flask built up to the required concentration with distilled water before being used for analysis. Heavy metal concentration was determined by the use of an Atomic Absorption Spectrophotometer model 6650F using a modified standard method of Liang *et al.*, (2017) The concentration of each element in the sample solutions in the sample bottles was measured. Each element has a unique cathode discharge lamp it was this lamp that was utilized to identify a certain element. Each element being tested by the discharge lamp emits light at a certain wavelength. The only way to achieve this specificity is from a pure sample of the element that has undergone electrical excitation to create an arc spectrum on that element. The following heavy metals were examined: Cadmium (Cd), Lead (Pb), Chromium (Cr), Mercury (Hg) and Arsenic (As)

Risk assessment

Hazard quotient: Hazard quotient is the ratio of the potential exposure concentration to a substance and the level at which no adverse effects are expected. If HQ<1, adverse health effects would be unlikely experienced, whereas potential non-carcinogenic effects would occur when HQ ≥1 (Liang *et al.*, 2017).

$$\text{Hazard Quotient (HQ)} = \frac{(\quad)}{(\quad) \text{ average daily intake}}$$

Hazard index (HI):

$$HI = \sum HQ_i$$

Where:

HI = Summation of an individual HQs

HI = THQ = THQ (Pb) + THQ (Cr) + THQ (Cd) + THQ (As) + THQ (Hg).

Where;

HI = Hazard index.

THQ= total hazard quotient.

if HI > 1, it means an unacceptable risk of non-carcinogenic effects on health, while HI < 1 means an acceptable level of risk (Habibu *et al.*, 2024)

Estimated Daily Intake (EDI)

Estimated Daily Intake (EDI) was calculated by the following equation (Juan *et al.*, 2010).

$$EDI = \frac{(CHM \text{ as mg/ kg}) \times (DIF \text{ in kg/person})}{ABW (60 \text{ kg})}$$

Where:

CHM = Concentration of Heavy Metals as (mg/kg)

DIF = Daily intake of food in kg/person

ABW = Adult body weight (60 kg)

Target Cancer Risk:

$$\text{Target cancer risk (TR)} = \frac{Efr \times ED_{tot} \times SI \times MCS \times CPSo}{BWA \times ATc} \times 10^{-3}$$

Where:

Efr = Exposure frequency (350 days/years)

ED_{tot} = Exposure duration, total (30 years)

SI = Soil ingestion, gram per day (1 gram) x 1000mg/kg

MCS = Metal concentration

CPSo = Carcinogenic potency slope, oral (1 mg/kg/day)

BWA = Body weight adult (60 kg)

ATc = Average time carcinogenic (25,550 days)

Statistical analysis

Statistical analysis was carried out using ANOVA and further with Duncan's multiple comparison test and results were expressed as Mean±Standard Error. The statistical analysis was performed using Statistical Package for Social Sciences (SPSS) version 23 and significance was at p < 0.05

RESULTS

Heavy metal concentration (mg/kg) of soil samples from Ussa, Gassol and Yorro Local Government Areas of Taraba State: The results of heavy metal concentrations are presented in the Table below. Heavy metals were detected in all the soil samples from the 9 sampling points of 3 LGAs of Taraba State. The results showed that Chromium had a very high concentration across all the studied areas with values ranging from 2.01 mg/kg to 2.62 mg/kg. Cadmium had values ranging from 0.07 mg/kg to 0.09 mg/kg and Arsenic followed moderately with values ranging from 0.06 mg/kg to

0.07 mg/kg while Lead and Mercury had lowest concentrations of less than 0.03 mg/kg across the 3 LGAs. As shown in table below (Table 2).

Table 2: Heavy metal concentration of Soil samples from selected LGAs in Taraba State

Study areas	Pb (mg/kg)	Cd (mg/kg)	Cr (mg/kg)	As (mg/kg)	Hg (mg/kg)
Ussa	0.02 ± 0.01 ^{ab}	0.06 ± 0.02 ^{ab}	1.71 ± 0.54 ^{ab}	0.05 ± 0.02 ^{ab}	0.02 ± 0.01 ^{ab}
Yorro	0.02 ± 0.01 ^{ab}	0.06 ± 0.02 ^{ab}	1.83 ± 0.67 ^{ab}	0.05 ± 0.02 ^{ab}	0.02 ± 0.01 ^{ab}
Gassol	0.03 ± 0.01 ^b	0.09 ± 0.02 ^b	2.62 ± 0.61 ^b	0.07 ± 0.02 ^b	0.03 ± 0.01 ^b

Results are expressed in mean ± standard deviation of triplicate determination. Values with the same superscript have no significant difference between groups, while Values with different superscripts significantly differs between groups within the same column at P < 0.05.

Lead Concentration, Calculated risk and Hazard index in Soil samples from selected LGAs in Taraba State

The result of lead concentration in soil from some LGAs sampled in Taraba State is presented below. The result indicate that both Ussa and Yorro has the lowest concentration of Pb (0.02 ± 0.01 mg/kg) while Gassol had the highest level of Pb (0.03 ± 0.01 mg/kg). However, the Pb level showed statistical significant difference across all the sampling point (P < 0.05). Similarly, the calculated risk shows that both Ussa and Yorro has the lowest value (0.13), while Gassol had the highest calculated risk of (0.19). (Table 3)

Table 3: Calculated risk and Hazard index of Lead in Soil samples from selected LGAs in Taraba State

Study areas	Pb Concentration(mg/kg)	EDI	Calculated risk	HI
Ussa	0.02 ± 0.01 ^{ab}	0.000030	0.13	12.17
Yorro	0.02 ± 0.01 ^{ab}	0.000030	0.13	13.03
Gassol	0.03 ± 0.01 ^b	0.000046	0.19	18.70

Results are expressed as mean ± standard deviation of triplicate determination. WHO permissible value of Pb is 2.00 mg/kg, HI>1 is an unacceptable risk level of non-carcinogenic, while HI<1 is an acceptable risk level, HI. Hazard index and source (Ramírez *et al.*, 2013).

Cadmium Concentration, Calculated risk and Hazard index in Soil samples from Selected LGAs in Taraba State

The results of Cadmium concentration in soil from some LGAs in Taraba State is presented below. The result showed that Ussa and Yorro have the lowest concentration (0.06 ± 0.02 mg/kg) while Gassol have higher concentration of (0.09 ± 0.02 mg/kg). However, Cd level in Gassol is higher across the studied areas at ($P < 0.05$). Similarly, the calculated risk shows that both Ussa and Yorro has the lowest risk value 0.39 while Gassol has the highest calculated risk value of 0.59.

Table 4: Calculated risk and Hazard index of Cadmium in Soil samples from Selected LGAs in Taraba State

Study areas	Cd Concentration (mg/kg)	EDI	Calculated risk	HI
Ussa	0.06 ± 0.02^{ab}	0.000092	0.39	12.17
Yorro	0.06 ± 0.02^{ab}	0.000092	0.39	13.03
Gassol	0.09 ± 0.02^b	0.000138	0.59	18.70

Results are expressed as mean \pm standard deviation of triplicate determination. WHO permissible value of Cd is 0.003 mg/kg, $HI > 1$ is unacceptable risk of non-carcinogenic while $HI < 1$ is an acceptable risk level and source (Ramírez *et al.*, 2013).

Chromium Concentration, calculated risk and hazard index of Cr in Soil samples from selected LGAs in Taraba State

Result of Chromium concentration in soil samples from some LGAs in Taraba state is presented below. The result showed that Ussa had low concentration (1.71 ± 0.54 mg/kg), Yorro had (1.83 ± 0.67 mg/kg) while Gassol had higher concentrations of (2.62 ± 0.61 mg/kg) respectively. Therefore, the level of Cr in all the studied areas implies that there is a significant difference in all the studied areas at ($P < 0.05$). However, the calculated risk showed that Ussa has lower risk value of 11.20 and Yorro had 12.02 compared to Gassol which has the highest value of 17.27.

Table 4: Calculated risk and Hazard index of Chromium in Soil samples from Selected LGAs in Taraba State

Study areas	Cr Concentration (mg/kg)	EDI	Calculated risk	HI
Ussa	1.71 ± 0.54^{ab}	0.00263	11.20	12.17
Yorro	1.83 ± 0.67^{ab}	0.00281	12.06	13.03
Gassol	2.62 ± 0.61^b	0.00403	17.27	18.70

Results are expressed as mean \pm standard deviation of triplicate determination. WHO permissible value of Cr is 0.001 mg/kg, $HI > 1$ is unacceptable risk of non-carcinogenic while $HI < 1$ is an acceptable risk level and source (Ramírez *et al.*, 2013).

Arsenic Concentration, Calculated risk and hazard index in Soil samples from selected LGAs in Taraba State

The results of Arsenic content in soil sample from some LGAs sampled in Taraba state is presented below in table 5. The result showed Ussa and Yorro had 0.05 ± 0.02 mg/kg, while Gassol had the highest concentration of 0.07 ± 0.02 mg/kg. the As level in all the studied areas showed no significant difference at $P < 0.05$. The calculated risk shows that both Ussa and Yorro had the lowest risk value of 0.32, while Gassol had the highest calculated risk value of 0.46.

Table 5: Calculated risk and Hazard index of Arsenic in Soil samples from Selected LGAs in Taraba State

Study areas	As Concentration (mg/kg)	EDI	Calculated risk	HI
Ussa	0.05 ± 0.02^{ab}	0.0000769	0.32	12.17
Yorro	0.05 ± 0.02^{ab}	0.0000769	0.32	13.03
Gassol	0.07 ± 0.02^b	0.0001076	0.46	18.70

Results are expressed as mean \pm standard deviation of triplicate determination. WHO permissible value of As is 0.200 mg/kg, $HI > 1$ is unacceptable risk of non-carcinogenic while $HI < 1$ is an acceptable risk level and source (Ramírez *et al.*, 2013).

Mercury Concentration, Calculated risk and hazard index in Soil samples from selected LGAs in Taraba State

The result of Mercury content in soil sample from some LGAs sampled in Taraba state is presented below. The result showed that Ussa, Yorro had low concentration (0.02 ± 0.01 mg/kg), while Gassol has the highest concentration (0.03 ± 0.01 mg/kg). Similarly, the Hg level across all the LGAs showed statistical significant difference across all the sampling points at ($P < 0.05$). However, the calculated risk showed that both Ussa and Yorro had the lowest risk value of 0.13, while Gassol had the highest calculated risk value of 0.19.

Table .6: Calculated risk and Hazard index of mercury in Soil samples from Selected LGAs in Taraba State

Study areas	Hg Concentration (mg/kg)	EDI	Calculated risk	HI
Ussa	0.02 ± 0.01^{ab}	0.000030	0.13	12.17
Yorro	0.02 ± 0.01^{ab}	0.000030	0.13	13.03
Gassol	0.03 ± 0.01^b	0.000046	0.19	18.70

Results are expressed as mean \pm standard deviation of triplicate determination. WHO permissible value of Hg is 0.05 mg/kg, HI>1 is unacceptable risk of non-carcinogenic while HI<1 is an acceptable risk level and source (Ramírez *et al.*, 2013). EDI: Estimated daily intake and HI: Hazardindex.

Heavy metals quantification was carried out in the study to ascertain the levels of metal concentrations as a result of artisanal activities in arable farmlands (Tatah *et al.*, 2017). Heavy metals are among the most harmful environmental pollutants that can bioaccumulate in biological tissues (Ramírez *et al.*, 2013). The consumption of food which is the source of energy and other nutrient for human and animal existence that is mostly cultivated by the people in the studied areas is of great concern. However, safety of populace living in the studied areas which is the environment from which food is gotten gives a reason to worry.

The study showed the presence of heavy metals (Pb, As, Hg, Cd and Cr) in the soil samples collected from Ussa, Yorro, Gassol LGAs of Taraba State, Nigeria. All the metals are present in concentrations that are higher than the WHO-approved safe levels with exception of Lead and Mercury. The Cd concentrations range from 0.06-0.09, As from 0.05-0.07 mg/kg, Hg from 0.02-0.03 mg/kg, Pb from 0.02-0.03 mg/kg and Cr from 1.71 mg/kg and above in this study. The distribution of trace heavy metals in soil samples allows us to predict their mobility and bioavailability toxicity. Base on this study, Cr, Cd and As seemed to be easily mobilized since a high percentage of these metals were found in all the studied areas and most higher in Gassol LGA. The significant difference may be due to vast agricultural, commercial activities in the sampling areas.

Chromium seems to be the most mobile element, followed by Cd and As, while Pb and Hg were the less mobile elements in the studied arable farmlands (Table 2). Therefore, since Cr concentration was highest among the other metals analyzed in all the soil in the studied areas. It indicates that Cr is the most mobilized element as it is mostly distributed among arable farmlands in its higher amount with high-risk value compared to Cd, As and Hg as shown in the study. This high amount of Cr in the arable lands shows that it may be easily transferred into the food chain through uptake by plants growing in the soil. For this reason, there is a need for a high level of concern regarding the level of Cr present in the soil, since it can be poisonous to mammals. The Cr mostly finds its way to the soil (in arable farmlands) through the application of organic manure and fertilizers, since fertilizer and organic manure remain the primary source of nutrients to the soil in arable farmlands (Li *et al.*, 2008).

According to the values set by WHO for Cr is 0.001 mg/kg, while Cr concentrations in this study varied from 1.71 mg/kg to 2.62 mg/kg in all study areas, the maximum risk value was computed for the Cr concentration, which was over the WHO-recommended minimum of 0.001 mg/kg. This implies that the populaces in all the studied areas are predisposed to Cr-induced health conditions such as asbestosis, lung cancer, chromosomal aberration DNA damage which leads to the formation of DNA adducts alteration in replication and transcription of DNA and sometimes lead to cell death due to DNA strand breaks (Kabata-Pendias *et al.*, 2017).

Cadmium followed with high concentration after Cr across the sampled areas, showed that its availability is susceptible to ionic composition change in the environment. The Cd being one of the cumulative poison for mammals find its way into the soil primarily through the application of fertilizer, pesticides herbicides to the arable farmlands as the source of nutrients to the soil, which then can bio-accumulate in plants and get into humans via food, soil with high concentrations of Cd causes chlorosis, stunted growth, browning of the root tips eventually plant death (WHO, 2021). Excessive cadmium in wheat (*Triticum sp.*) inhibits seed germination, lowers nutritional content in the plant, and shortens the length of both the shoots and the roots. The accumulation of Cd in garlic (*Allium sativum*) stunts the growth of new shoots (Tatah *et al.*, 2017). Finally, it inhibits root growth and decreases shoot growth in maize (*Zea mays*). Cd concentrations in this study range from (0.07-0.09 mg/kg) which is higher than the WHO-stipulated permissible limit value of (0.003 mg/kg). Therefore, people living in these study areas could be in danger of Cd-related health problems. High exposure to Cd can lead to health conditions such as obstructive lung disease, cadmium pneumonitis, anemia, renal damage and bone disorder cancer of the lungs (Boonyapookana *et al.*, 2002).

Arsenic (As) as one of the metals of concern was confirmed to be present in the sampled areas in high value above the permissible limit at (0.06-0.07 mg/kg), while the WHO stipulated value is (0.02 mg/kg). The tomato (*Lycopersicon esculentum*) has low fruit production and a fresh leaf yield due to its high arsenic content (Shanker *et al.*, 2005). As opposed to this, arsenic in canola (*Brassica napus*) produces stunted growth, chlorosis wilting (Aman *et al.*, 2008). Reduces the production of dry matter, seed germination, seedling height leaf area in rice (*Oryza sativa*) (Ansari *et al.*, 2007). So, Base on the result of this study, the populace in these studied areas could be predisposed to As-induced health problems such as arsenicosis (Jaishankar *et al.*, 2014). Most of the reports of chronic arsenic toxicity in men focus on skin manifestations because of its specificity in diagnosis. Pigmentation and keratosis are the specific skin lesions that indicate chronic arsenic toxicity.

Lead (Pb) is among the most plentiful and widely dispersed hazardous elements. Hormones have a negative impact on plant development, growth photosynthetic activities. Reduced plant, decreased plant protein content, delayed growth decreased germination percentage have all been seen in the maize (*Zea mays*) plant (Das *et al.*, 2016). Lead courses in Portia trees (*Thespesia populnea*) result in fewer leaves, smaller foliage shorter plants (Jiang *et al.*, 2001). Reduced plant biomass and inhibition of CO₂ fixation-related enzyme activity in oat (*Avena sativa*) (Wang *et al.*, 2007). The concentration of Pb and Hg was low across all the soil samples studied. They are detected in low amounts in this study which may be a minor pollution indicator since their presence in the soil to some extent may cause a serious concern to the populace living in the area. Since the majority of the soil samples were taken from areas near highways, Pb might have come from traffic. The Pb mainly enters into the soil by means of atmospheric dry and wet depositions and disposal of sewage sludge. Lead is known to induce reduced cognitive development and intellectual performance in children and increased blood pressure and cardiovascular disease in adults (Emmanuel *et al.*, 2009). The WHO has set a maximum threshold of Pb in soil at 2.00 mg/kg, but according to

the findings of this study, Pb concentrations in all of the soil samples are extremely low, ranging from 0.02-0.03 mg/kg. The Pb exposure may not have a severe negative impact on the population's health in certain locations in the short term, but it may in the long term (Hughes *et al.*, 2002).

Mercury is a harmful heavy metal whose poisoning (or excessive consumption) can cause a variety of health issues. When compared to other metals like lead, cadmium, chromium, arsenic and mercury is recognized to be a latent neurotoxic. Contamination of Hg to the soil is often due to the addition of this heavy metal as part of fertilizers, lime, sludge manures. The large input of mercury (Hg) into the arable lands has resulted in the widespread occurrence of mercury contamination in the entire food chain. In rice (*Oryza sativa*) excess mercury decreases plant height, reduces tiller and panicle formation yields reduction (Manaham *et al.*, 2004). In tomatoes (*Lycopersicon esculentum*) Hg causes a reduction in germination and plant height, reduce in flowering and fruit weight finally, resultant chlorosis appears on the whole plant (Kim *et al.*, 2019). It has been suggested that a high dietary intake of organic mercury above the recommended limit of consumption raises the risk of coronary heart disease (Demirevska-Kepova *et al.*, 2004). The Hg levels in all of the soil samples used in this investigation range from (0.02-0.03 mg/kg). These amounts exceed the permissible limit set by the WHO. This suggests that if the uptake by plants is directly proportionate to the available concentration in the soil, then prolonged intake of food grown in the research areas could result in health issues associated with Hg.

CONCLUSION

Although the studied HM were significantly present in all the analyzed soil with the exception of Lead and Mercury which were very minute, their concentration in various soil samples across the studied areas exceeded the permissible levels as recommended by WHO, therefore, there is need of more efforts to be put in place to address the bioaccumulation of these metals from anthropogenic sources. The anthropogenic input of Cr was found mainly from this study in Gssol in high concentrations which may be due to high Agricultural and mechanical activities in the area as an agrarian environment, including Cd and As which are moderate in concentrations were significantly high in these study areas above the WHO/FAO permissible limit. The Hg and Pb appeared to be in low concentration, but all other heavy metals (Cr, Cd, As) analyzed were present in the study areas. These heavy metals may be transferred to human on the consumption of crops cultivated in the studied areas which may be hazardous to human health due to their cumulative effect on the human body, hence, It appears that anthropogenic heavy metals, as opposed to lithogenic and pathogenic heavy metals, are more easily transported and, possibly, more phytoavailable on arable farmlands. Anthropogenic pollution sources may be useful in determining which metals have recently reached the soil since a high mobile level of any metal could be an indication of which metals have entered the soil. Lastly, in order to decrease or improve the current levels of these harmful heavy metals in the area, it is necessary to properly regulate the use of agricultural pesticides and monitor the mechanical activities in the area.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest

REFERENCES

- Abah, M., O. Olawale, E.C. Okoli, O.P. Emmanuel, D.C. Bando and Z.H. Shenia, 2021. Determination of selected pesticide residues in leafy vegetables (*Amaranthus Spinosus*) consumed in Donga, Taraba State. *International Journal of Biochemistry and Bioinformatics. Biotechnology Studies.*, 6: 9-16.
- AdeKola, O., S. Whanda and F. Ogwu, 2012. Assessment of policies and legislation that affect management of wetlands in Nigeria. *Wetlands*, 32: 665-677.
- Afolabi, A., F.A. Francis and F. Adejomo, 2012. Assessment of health and environmental challenges of cement factory on ewekoro community residents, Ogun State, Nigeria. *Am. Journal of Human Ecology.*, 1: 51-57.
- Ahmad, I., M.J. Akhtar, Z.A. Zahir and A. Jamil, 2012. Effect of cadmium on seed germination and seedling growth of four wheat (*Triticum aestivum*L.) cultivars. *Pak. Journal of Botany.*, 44: 1569-1574.
- Al-Khashman, O.A. and R.A. Shawabkeh, 2006. Metals distribution in soils around the cement factory in Southern Jordan. *Environmental Pollution.*, 140: 387-394.
- Amachundi, Z.P., M.A. Abah, E.R. Yohanna, E.C. Okoli, A.S. Saaku and B. Habibu, 2022. Investigation of trace metal contamination in bread baked and sold in Wukari. *Global Science Journal.*, 10: 2076-2082.
- Aman, T., A.A. Kazi, M.U. Sabri and Q. Bano, 2008. Potato peels as solid waste for the removal of heavy metal copper(II) from waste water/industrial effluent. *Colloids. Surf. B. Biointerfaces*, 63: 116-121.
- Ansari, M.I. and Abdul Malik, 2007. Biosorption of nickel and cadmium by metal resistant bacterial isolates from agricultural soil irrigated with industrial wastewater. *Bioresour. Technol.*, 98: 3149-3153.
- Balali-Mood, M., K. Naseri, Z. Tahergorabi, M.R. Khazdair and M. Sadeghi, 2021. Toxic mechanisms of five heavy metals: Mercury, lead, chromium, cadmium, and arsenic. *Front. Pharmacol.*, Vol. 12. 10.3389/fphar.2021.643972.
- Boonyapookana, B., E.S. Upatham, M. Kruatrachue, P. Pokethitiyook and S. Singhakaew, 2002. Phytoaccumulation and phytotoxicity of cadmium and chromium in duckweed *Wolffia globosa*. *International Journal of Phytoremediation.*, 4: 87-100.
- Cao, S., X. Duan, X. Zhao, B. Wang and J. Maetal., 2015. Health risk assessment of various metal(loid)s via multiple exposure pathways on children living near a typical lead-acid battery plant, China. *Environmental Pollution.*, 200: 16-23.
- Das, S., H.R. Dash and J. Chakraborty, 2016. Genetic basis and importance of metal resistant genes in bacteria for bioremediation of contaminated environments

- with toxic metal pollutants. *Applied Microbiology Biotechnology.*, 100: 2967-2984.
- Demirevska-Kepova, K., L. Simova-Stoilova, Z. Stoyanova, R. Hölzer and U. Feller, 2004. Biochemical changes in barley plants after excessive supply of copper and manganese. *Environ. Exp. Bot.*, 52: 253- 266.
- Emmanuel, E., M.G. Pierre and Y. Perrodin, 2009. Groundwater contamination by microbiological and chemical substances released from hospital wastewater and health risk assessment for drinking water consumers. *Environmental International.*, 35: 718-726.
- Ezeonu, C.S., S.V. Tatah, C. Imo, O.E. Yakubu and Q.H. Garba et al., 2022. Antioxidant potential of ginger extract on metals (lead, cadmium, and boron) induced oxidative stress in maize plant. *Asian Journal of Tropical Biotechnology.*, 19: 45-51.
- Gatti, A.M., D. Tossini, A. Gambarelli, S. Montanari and F. Capitani, 2008. Investigation of the presence of inorganic micro-and nanosized contaminants in bread and biscuits by environmental scanning electron microscopy. *Crit. Rev. Food Sci. Nutr.*, 49: 275-282.
- Habibu, B., O. Olawale., Y.O. Ejeh., M.A. Abah and O.T. Idris, 2024. Heavy metals speciation and health risk analysis of arable farmlands in Ardo-kola, Bali and Wukari local government areas of Taraba State, Nigeria. *Asian Journal of Bioscience.* 17 (4): 587-598.<https://doi.org/10.3923/ajbs.2024.587.598>
- Habibu, B., O.O. Francis, Y.O. Ejeh and M.A. Abah, 2022. Heavy metals and health risk analysis of arable farmlands in selected local government areas of Taraba State, Nigeria. *Toxicol. Adv.*, Vol. 5. 10.53388/202305015.<https://doi.org/10.3923/ajbs.2024.587.598>
- Huang, S.S., Q.L. Liao, M. Hua, X.M. Wu and K.S. Bi *et al.*, 2007. Survey of heavy metal pollution and assessment of agricultural soil in Yangzhong District, Jiangsu Province, China. *Chemosphere*, 67: 2148-2155.
- Hughes, M.F., 2002. Arsenic toxicity and potential mechanisms of action. *Toxicology Lett.*, 133: 1-16.
- Irwandi, J. and O. Farida, 2009. Mineral and heavy metal contents of marine fin fish in Langkawi Island, Malaysia. *International Food and Research Journal.*, 16: 105-112.
- Jaishankar, M., T. Tseten, N. Anbalagan, B.B. Mathew and K.N. Beeregowda, 2014. Toxicity, mechanism and health effects of some heavy metals. *Interdisciplinary Toxicology.*, 7: 60-72.
- Jan, A.T., M. Azam, K. Siddiqui, A. Ali, I. Choi and Q.M. Rizwanul Haq, 2015. Heavy metals and human health: Mechanistic insight into toxicity and counter defense

- system of antioxidants. *International Journal of Molecular Science.*, 16: 29592-29630.
- Jiang, W., D. Liu and W. Hou, 2001. Hyperaccumulation of cadmium by roots, bulbs and shoots of garlic (*Allium sativum*L.). *Bioresour. Technol.*, 76: 9-13.
- Kabata-Pendias, A. and A.B. Mukherjee, 2007. *Trace Elements from Soil to Human*. 1st Edn., Springer, Berlin, Germany, ISBN: 978-3-540-32713-4, Pages: 550.
- Kim, J.J., Y.S. Kim and V. Kumar, 2019. Heavy metal toxicity: An update of chelating therapeutic strategies. *Journal of Trace Element and Medical Biology.*, 54: 226-231.
- Li, X., Y. Gan, X. Yang, J. Zhou, J. Dai and M. Xu, 2008. Human health risk of organochlorine pesticides (OCPs) and polychlorinated biphenyls (PCBs) in edible fish from Huairou Reservoir and Gaobeidian Lake in Beijing, China. *Food Chemistry.*, 109: 348-354.
- Liang, Y., X. Yi, Z. Dang, Q. Wang, H. Luo and J. Tang, 2017. Heavy Metal contamination and health risk assessment in the vicinity of a tailing pond in guangdong, China. *International Journal of Environmental Research and Public Health*, Vol. 14. 10.3390/ijerph14121557.
- Liu, Y., H. Wang, X. Li and J. Li, 2015. Heavy metal contamination of agricultural soils in Taiyuan, China. *Pedosphere*, 25: 901-909.
- Manaham, S.E., 2004. *Environmental Chemistry*. 8th Edn., CRC Press, Boca Raton, Florida, ISBN: 9781566706339, Pages: 816.
- Obasi, N.A., S.E. Obasi, S.O. Elom, K.M. Kalu and C. Alopeet al., 2017. Health risk assessment of heavy metals in ameri lead-zinc mining community via consumption of cassava (*Manihot esculenta*Cruz) In Ikwo L.G.A., Ebonyi State, Nigeria. *American European. Journal of Sustainable Agriculture.*, 11: 22-30.
- Ogunbanjo, O., O. Onawumi, M. Gbadamosi, A. Ogunlana and O. Anselm, 2016. Chemical speciation of some heavy metals and human health risk assessment in soil around two municipal dumpsites in Sagamu, Ogun State, Nigeria. *Chem. Speciation Bioavailability*, 28: 142-151.
- Oko, J.O., E.A. Yerima., S. Atiku., B. Habibu and S. Yakubu, 2024. Polycyclic aromatic hydrocarbon (PAHs) levels in treated spent engine oil contaminated soil from automechanic workshop site in Wukari, Nigeria. *Lafia Journal of Scientific and Industrial Research*, 2(1), 70 – 77. <https://doi.org/10.62050/ljsir2024.v2n1.308>
- Okoli, E.C., M.A. Abah, O. Olawale, E.R. Yohanna and Z.S. Hananiah, 2022. Ecological risk assessment of heavy metals in fish samples from Donga River, Taraba State, Nigeria. *Asian Journal of Applied Science.*, 15: 2428. <https://doi.org/10.62050/ljsir2024.v2n1.308>

- Okoli, E.C., O. Olawale, M. Abah, O.P. Emmanuel, D.C. Bando and Z.H. Shenia, 2021. Ecological risk assessment of pesticide residues in fish samples from River Donga in Donga, Taraba State, Nigeria. *International Journal of Biochemistry, Bioinformatics and Biotechnology Studies.*, 6: 1-8.
- Olajire, A.A., E.T. Ayodele, G.O. Oyediran and E.A. Oluyemi, 2003. Levels and speciation of heavy metals in soils of industrial Southern Nigeria. *Environmental Monitoring Assess.*, 85: 135-155.
- Olawale, O., M.A. Abah, O.T. Grace, B. Habibu, E.C. Okoli and P.U. Omajali, 2022. Risk assessment of pesticide residues in water samples from River Gongola, Adamawa State, Nigeria. *World Journal of Advance Research. Rev.*, 13: 424-432.
- Olawale, O.F., M.A. Abah, O.P. Emmanuel, G.T. Otitoju and A.L. Abershiet al., 2023. Risk assessment of heavy metal content in yam tubers locally produced in selected local government areas of Taraba State, Nigeria. *Asian Journal of Natural Product Biochemistry.*, 21: 6-12.
- Oluyemi, E.A and I.O. Olabanji, 2011. Heavy metals determination in some species of frozen fish sold at Ile-Ife main market, South West Nigeria. *Ife Journal of Science.*, 13: 355-362.
- Otitoju, G.T.O., O. Otitoju and C.J. Igwe, 2014. Quantification of heavy metal levels in imported rice (*Oryza sativa*) consumed in the Northern parts of Nigeria. *Journal of Biodiversity and Environmental Sciences.*, 4: 202-207.
- Otitoju, O. and G.T.O. Otitoju, 2013. Heavy metal concentrations in water, sediment and periwinkle (*Tympanotonus fuscatus*) samples harvested from the Niger Delta Region of Nigeria. *African Journal of Environmental Science Technology.*, 7: 245-248.
- Pieczenik, S.R. and J. Neustadt, 2007. Mitochondrial dysfunction and molecular pathways of disease. *Experimental Molecular Pathology.*, 83: 84-92
- Ramírez, R., 2013. The gastropod *Osilinus atrata* as a bioindicator of Cd, Cu, Pb and Zn contamination in the coastal waters of the Canary Islands. *Chemical Ecology.*, 29: 208-220.
- Rashed, M.N., 2010. Monitoring of contaminated toxic and heavy metals, from mine tailings through age accumulation, in soil and some wild plants at Southeast Egyptian Journal of Hazardous Mater. 178: 739-746.
- Shanker, A.K., V. Ravichandran and G. Pathmanabhan, 2005. Phytoaccumulation of chromium by some multipurpose-tree seedlings. *Agro forestation Syst.*, 64: 83-87.
- Tatah, V.S., K.L.C. Ibrahim, C.S. Ezeonu and O. Otitoju, 2017. Biosorption kinetics of heavy metals from fertilizer industrial waste water using groundnut husk powder as an adsorbent. *Journal of Applied Biotechnology Bioengineering.*, 2: 221-228.

- Tatah, V.S., O. Otitoju, C.S. Ezeonu, I.N.E. Onwurah and K.L.C. Ibrahim, 2017. Characterization and adsorption isotherm studies of Cd (II) and Pb (II) ions bioremediation from aqueous solution using unmodified sorghum husk. *Journal of Applied Biotechnology, Bioengineering.*, 2: 113-120.
- Wang, M., J. Zou, X. Duan, W. Jiang and D. Liu, 2007. Cadmium accumulation and its effects on metal uptake in maize (*Zea mays*L.). *Bioresource Technology.*, 98: 82-88.
- WHO, 2021. Trace Elements in Human Nutrition and Health. World Health Organization, Geneva, Switzerland, ISBN: 9789241561730, Pages: 343.
- Wongsasuluk, P., S. Chotpantararat, W. Siriwong and M. Robson, 2014. Heavy metal contamination and human health risk assessment in drinking water from shallow groundwater wells in an agricultural area in Ubon Ratchathani Province, Thailand. *Environmental. Geochemistry. Health*, 36: 169-182

