Annals of Ecology and Environmental Science
Volume 4, Issue 1, 2020, PP 12-22
ISSN 2637-5338

Human Risk on Heavy Metal Pollution and Bioaccumulation Factor in Soil and Some Edible Vegetables around Active Auto-Mechanic Workshop in Chanchaga Minna Niger State, Nigeria

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ABSTRACT

Heavy metal contamination arises from the disposal of used engine oil which is one of the environmental problems in Nigeria and is more widespread than crude oil pollution. The aim of this research is to evaluate the human risk of heavy metal and its bioaccumulation factor in soil and some edible vegetables around active auto-mechanic workshop in Chanchaga Minna Niger State, Nigeria. Soil samples were collected at 15-20 cm depth with the aid of soil auger and a control sample was also collected (generally about 100 m away from each cluster) where neither car repairs, industrial nor commercial activities are carried out. All vegetable Fluted pumpkin (Telfairia occidentalis), Jute mallow (Corchorus olitorius), water leaf (Talinum triangulare), Roselle (Hibiscus sabdariffa) and African spinach (Amaranthus cruentus) samples were collected from farms close to the workshop. The soil samples were collected at random and physicochemical parameters such as pH, total nitrogen, total phosphorus, organic matter and exchangeable cations (i.e., K+, Mg2+ and Na+) using a standard method and concentrations of the heavy metals in soils and vegetables, As, Cd, Hg and Pb were analyze using Flame Atomic Absorption Spectrometer (FAAS). The bioaccumulation factor and the risk health risk assessment from the consumption of these vegetables was calculated using standard methods and formulas. The physicochemical properties shows a significant (P<0.05) different in the auto mechanic soil and the control soil. The soil samples from auto-mechanic workshops in Chanchaga revealed elevated levels of heavy metals than the control. The concentration of all heavy metal in vegetables exceeded the permissible limits of 0.5, 0.2, 0.1 and 0.3 mg/kg for As, Cd, Hg and Pb respectively as prescribed by FAO/WHO. The Bioaccumulation factor shows that metals are transferred from the contaminated soil to the vegetable with Hg in Talinum triangulare greater than one. The estimated health risk shows that children are more prone to toxic elements from the consumption of these vegetables grown around auto mechanic site. The research conclude that these auto mechanic workshops accumulate potentially toxic elements in the soil and do have a negative impact on the plants, human and surrounding environment, which calls for stricter regulation on their location within cities.

Keywords: *Auto-mechanic, Bioaccumulation, Health risk, Heavy metal, Soil, Vegetable*

INTRODUCTION

Heavy metals pollution is considered as one of the most serious pollutants in the ecosystem due to their toxicity effect, persistence and bioaccumulation. These potentially toxic elements can bio-accumulate in plants such as vegetables and animals eventually making their way to humans through food chain (Oguh et al., 2019a).

Soil samples are an excellent media to monitor the concentration of heavy metal pollution because anthropogenic heavy metals are usually deposited in the soils. Plants planted on a land polluted with engine oil can absorb heavy metals through their roots. These absorbed metals get accumulated in the roots, stems, fruits, buds, grains and leaves of these plants. Heavy metals gradually accumulate in the soil, and its stability will cause accumulation and pollution since they could not be decomposed or are not biodegradable, like other organic pollutants through biological or chemical processes. Leafy vegetables are the major sources of micronutrients (vitamins, mineral elements), antioxidants and other photochemical required for the maintenance of good health and prevention of degenerative diseases. They also contain dietary fibers for bowel movement which helps in the reduction of blood cholesterol levels and may lower the risk of heart diseases. Although leafy vegetables contain some amount of carbohydrates, proteins and fats, they are not considered as the primary sources of these macronutrients, thus the nutritional values of the leafy vegetables investigated in this study is basically on some vitamins, mineral elements and antioxidants content.

The nutrients help to repair worn out tissues, reduce cancer risks, lower cholesterol levels, normalize digestion time, improve eye vision, fight free radicals, and boost immune system. The vegetables also act as antioxidants that help to protect human body from oxidant stress, cardiovascular diseases and cancers (Santhakumar et al., 2018). In addition to their nutritional role, leafy vegetables increase attractiveness and palatability of diets by providing sensory appeal through their variety of colours and flavors (Musa, 2016).

A group of metals and metalloids with an atomic density greater than 5.0 g/cm3 is describe as Heavy metals (Oguh et al., 2019b).Toxicity of heavy metal can result in damaged or reduced mental and central nervous function, lower energy levels and damage to blood composition, lungs, kidneys, liver and other vital organs.

Metals elements such as Cd, Hg, as and Pb are non-essential and therefore have toxic effects on living organisms such as damage to the renal and nervous systems. Lead (Pb) is not an essential element but is toxic even at low concentration. It can accumulate in the brain, which may lead to poisoning or even death (Ayansina and Olubukola, 2017). Mercury (Hg) poisoning symptoms are blindness, deafness, brain damage, digestive problems, kidney damage, lack of coordination and mental retardation. The most prominent chronic manifestations of Arsenic (As) involve the skin, lungs, liver and blood systems.

Concentrations of Cadmium (Cd) have gastrointestinal effect and reproductive effect on livestock (Maobe et al., 2012). Cd causes adverse effect on kidney, liver, vascular and the immune system and also both acute and chronic poisoning (Ndukwu et al., 2008).In Nigeria, heavy metals pollution is widespread especially from auto-mechanic workshop. These auto mechanic workshops are found in open plots of land in the vicinity of urban towns and cities. Within the clusters are people who specialize in electrical aspects of auto repairs, while others engage in repairs of brakes and steering, automatic or standard transmission engine, and spray painting, recharging of auto batteries, welding and soldering etc (Nwachukwu et al., 2011).

Each of these activities generates various types of waste (gasoline, diesel, spent engine oil and paint) which are disposed of by simply dumping in nearby bushes or surrounding areas. Pollution effects of mechanic site activities in Nigeria have received limited attention even though these activities have been shown to produce harmful wastes. Urgent attention is call by the prevalent mode of indiscriminate disposal of these spent engine oils in the environment. Environmental pollution results from mishandling, deliberate disposal, spilling and leakage of petroleum products, such as gasoline, lubricating oils, diesel fuel, heating oil's, used or spent engine oils.

The local utilization of engine oil in Minna City has increased in recent time this is due to the upsurge in the number of vehicles due to ever-increasing demand for personal vehicles, most of which are used "Tokunbo" vehicles i.e. fairly used vehicles and other machines that makes use of these lubricants such as generator and household engines.

These unguided practices have worsened the rate at which used engine oils spread and contaminate the soils, plants and water with heavy metals around the town. Risk assessment is an effective tool which enables decision makers to manage and control contaminated sites in a cost-effective manner while preserving public and ecosystem health. Ecological risk is the likelihood that a given activity or series of activity may have damaged or will damage the habitat, ecosystem or environment immediately or over a given period of time.

Metal pollution index is a value that shows the level of contamination and pollution on a given substance under scientific investigation. On the other hand, human health risk assessment are usually done through a series of calculations to estimate the nature and probability of adverse health effects in humans who may be exposed to chemicals in contaminated environmental media. One of the major sources of increase in heavy metal level of the ecosystems is auto mechanic activities. Many studies on the impact of auto repair workshop sites have been carried out by many researchers in different Cities in Nigeria (Odjegba and Sadiq, 2002; Ipeaiyeda and Dawodu, 2008; Luter et al., 2011; Nwachukwu et al., 2011; Idugboe and Tawari-Fufeyin, 2014, Anegbe et al., 2019). However, many of these researchers focused on the study of the heavy metals contamination in soil within the epicenter of the environment without checking the impact on plants around the vicinity and it bioaccumulation rate. Thus the aim of this research is to evaluate the Human risk of heavy metal and its bioaccumulation factor in soil and some edible vegetables around active auto-mechanic workshop in Chanchaga Minna Niger State, Nigeria.

Materials And Methods

Material

Five commonly consumed leafy vegetables were selected for the study; Fluted pumpkin (Telfairia occidentalis), Jute mallow (Corchorus olitorius), water leaf (Talinum triangulare), Roselle (Hibiscus sabdariffa) and African spinach (Amaranthus cruentus). The vegetable leaves used for the study were harvested fresh from the sites located around the mechanic workshop in Chanchaga Minna Niger State.

Study Area

The study was conducted in farms around the Auto-mobile workshop at Chanchaga, Bosso Local Government Area in North-central, Niger State of Nigeria.

Chanchaga is situated at 9º34'North latitude, º33'East longitude, with an area of 72km2(Fig. 1) and a population of 201,429 at the 2006 census.

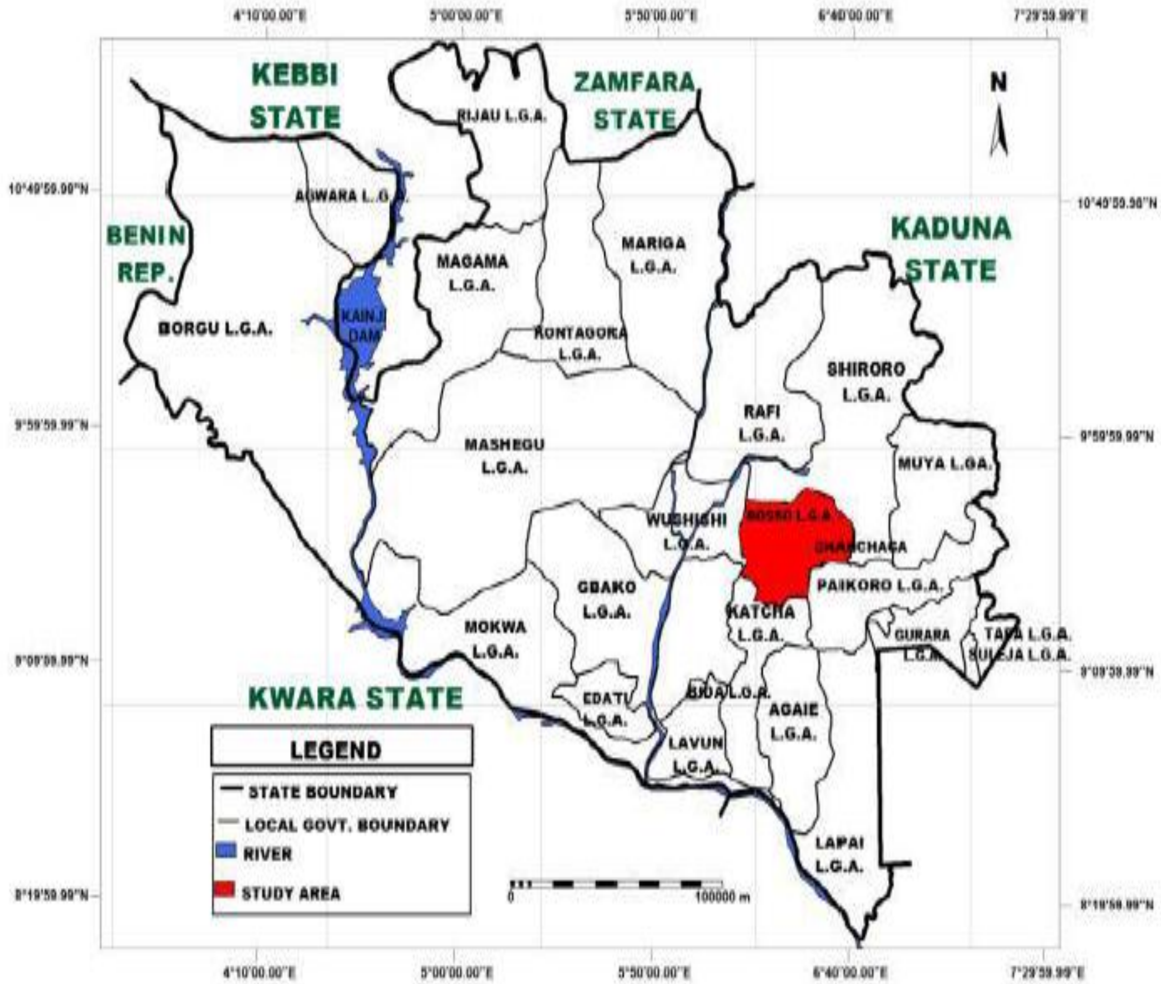

Figure1. *Showing map of Niger State and the study area indicated with red.*

Samples Collection

Soil samples were collected using a hand soil auger in random replicates of three, at 20 cm depth around the mechanic workshop. One control sample was also collected (generally about 100 m away from each cluster) where neither car repairs, industrial nor commercial activities are carried out. The samples were placed in labeled polythene bags and transported to the laboratory. The soil sample was air-dried under room temperature 27ºC to ensure constant weight for 3 days and to avoid microbial degradation. They were homogenized, made lump free by gently crushing repeatedly using an acid pre-washed mortar and pestle, and passed through a 2 mm plastic sieve prior to analysis. Vegetable Leaves were also randomly sampled within the farms close to the workshop to get a representative sample. All samples were collected aseptically in a sterilized universal container and plastic bags.

METHODS

Physico-Chemical Parameters

Soil samples (10 gm) were stirred with 100ml of distilled water and KCl2with a glass rod and the pH of the suspension were measured by potentio metric meter using a digital pH meter and recorded. Physicochemical parameters of the soil were determined according to Nimyel et al., (2015).

The physicochemical parameters measured are pH, Organic Matter, Total Nitrogen, Total Phosphorus, and Exchangeable Cation (Na+, Mg2+ and K+). The Physico-chemical properties of the soil were analysed in order to check the biodegradable process.

Heavy Metal Analysis

Soil

One gram of the dried fine soil sample was weighed and transferred into an acid washed, round bottom flask containing 10 cm3 concentrated nitric acid. The mixture was slowly evaporated over a period of 1 h on a hot plate. The solid residue obtained was digested with a 3:1 concentrated HNO3 and HClO4 mixture for 10 m at room temperature before heating on a hot plate.

The digested mixture was placed on a hot plate and heated intermittently to ensure a steady temperature of 150°C over 5 h until the fumes of HClO4 were completely evaporated. The mixture was allowed to cool to room temperature and then filtered using What man No.1 filter paper into a 50 cm3 volumetric flask and made up to the standard mark with deionized water after rinsing the reacting vessels, to recover any residual metal.

The filtrate was then stored in pre-cleaned polyethylene storage bottles ready for analysis. Heavy metal concentrations were determined using an Atomic Absorption Spectrophotometer (AAS). The instrument settings and operational conditions were in accordance with the manufacturer's specifications. The instrument was calibrated with analytical grade standard metal solutions (1 mg/dm3) in replicates.

Vegetables

The edible portion of the vegetable samples were properly separated and thoroughly washed under a running tap water to remove dust, dirt and possible parasite or their eggs. Exactly 1% nitric acid solution was use to remove surface contaminants, and rinsed with distilled water. Vegetables sample was chopped into small pieces using a clean stainless table knife and dried to a constant mass in an oven at 80^{o}C for 48h. Replicate samples of each dried vegetable from the site were combined and pounded to fine powder using a porcelain mortar and pestle. Particle sizes of 0.05 to 0.2mm were obtained using laboratory sieves.

The powder vegetable sample (2 g) was transferred into a clean dry round-bottomed flask and digested in a mixture of 4, 25, 2 and 1 ml of concentrated HClO4, HNO3, H2SO4 and 60 % H2O2, respectively, at 100^{o}C on a hot plate for two hours in a fume cupboard. Each digest was filtered through a separate What man No.42 filter paper and the resulting solution was left over night and made up to 100 ml with deionized water and concentrations of As, Cd, Hg and Pb were determined using flame AAS.

Bioaccumulation Factor (BAF)

The BAF was calculated by using the following equation described by (USEPA, 2010).

BAF = Cveg/ Csoil ------------------------- (i)

Where; Cveg = Heavy metal in vegetable tissue, mg/kg fresh weight
Csoil = Heavy metals in soil, mg/kg dry weight.

BAF > 1 indicates that vegetable are enriched with heavy metal from the soil (Bio-accumulation)
BAF < 1 means that the vegetables do not take up much heavy metal from soil (excluder)

ESTIMATION OF HUMAN RISK ASSESSMENT

Daily Intake of Metal (DIM)

The Daily intake of a given heavy metal was calculated using the following equation used by (USEPA, 2011).

ADDM = DI x Mveg/BW------------ (ii)

Where; ADDM = Average daily dose (mg,kg/d) of the metal

DI = Daily intake of leafy vegetable (0.182 kg/d for adults and 0.118kg/d for children according to (Oguh et al., 2019c)

Mveg = Metals in the vegetables tissues (mg/kg)

BW = Body weight of average individuals (55.7 kg for adults and 14.2kg for children) as used by (Oguh et al., 2019 c).

Hazard Quotient (Hq)

The following equation was used for calculating human health risk (HQ) from consumption of leafy vegetables in such areas describe by (USEPA, 2017).

HQ = ADDM/MPL----------------- (iii)

Where; ADDM = Average daily dose (mg,kg/d) of the metal

MPL = maximum permissible limits of metal with no adverse effect (mg,kg/d)

If the ratio is lower than one (1), means there will be no obvious risk.

Hazard Index (Hi)

The overall risk of exposure to all the heavy metals via the consumption of contaminated vegetable was determined using the formula describe by (USEPA, 2002). However the HI greater than 1 indicates that the predicted exposure is likely to pose risks.

HI = ∑HQAs + HQCd + HQHg + HQ------(iv)

Statistical Analysis

Data were analysed using Statistical Product and Service Solution (SPSS) version 21. The results were expressed as mean ± standard deviation (SD). One way analysis of variance (ANOVA) was carried out as $p<0.05$ considered statistically significant.

Results

Physicochemical Properties of Soil

The pH of the soil in H2O and KCL2 were 6.04 and 5.43 in mechanic soil and control site were 6.50 and 6.45 respectively. The mechanic soil and control soil for nitrogen (2.32 and 2.92 %), phosphorus (10.25 and 10.06 %), organic matter (3.21 and 2.37 %), and exchangeable cation (K+, Mg2+, and Na+) (3.47, 4.32, 6.58 and 3.09, 4.24, 5.93 meq/100g).The results of the physicochemical characteristics of the soils investigated are summarized in Table 1.

Table1. *Physicochemical Properties of Soil Samples*

Parameters	Mechanic soil	Control soil
pH in H_2O	6.04 ± 0.13	6.50 ± 0.05
pH in KCl	5.43 ± 0.04	6.45 ± 0.09
Total Nitrogen %	2.32 ± 0.34	2.92 ± 0.10
Total Phosphorus %	10.25 ± 0.09	10.06 ± 0.12
Organic Matter %	3.21 ± 0.12	2.37 ± 0.19
K^+ meq/100g	3.47 ± 0.15	3.09 ± 0.21
Mg^{2+} meq/100g	4.32 ± 0.20	4.24 ± 0.18
Na^+ meq/100g	6.58 ± 0.09	5.93 ± 0.20

Results was expressed as Mean ± SD. n=3

Heavy Metals in Soil Samples from Automobile Workshops

The soil samples from auto-mechanic workshops in Chanchaga revealed elevated levels of these heavy metals (Table 2). The mean concentration of metals (As, Cd, Pb, and Hg) in auto-mechanic soil (8.05, 6.32, 6.03 and 7.73 mg/kg) and control soil (2.09, 1.09, 1.67 and 3.46mg/kg) respectively. The results showed that heavy metals concentrations in the soil samples were higher in the auto-mechanic workshops than the control.

Table2. *Heavy Metal in Soil Samples from Automobile Workshops and Control Soils*

Heavy Metals (mg/kg)	Soil samples		PL(mg/kg) in soil (WHO/FAO, 2001)
	Automobile	Control site	
As	8.05 ± 0.22	2.09 ± 0.10	20
Cd	6.32 ± 0.26	1.09 ± 0.21	3.0
Hg	6.03 ± 0.17	1.67 ± 0.29	2.0
Pb	7.73 ± 0.21	3.46 ± 0.11	50

Results was expressed as Mean ± SD.PL= Permissible limit. n=3

Heavy Metal Concentration in Vegetables around Auto-Mechanic Workshop

The mean concentration of As, Cd, Hg and Pb ranged between 2.01 – 6.19, 2.41- 5.17, 3.34 – 6.73 and 2.39 – 4.34 mg/kg respectively in the vegetables.

The concentration of all heavy metal in vegetable exceeded the permissible limits of 0.5, 0.2, 0.1 and 0.3 mg/kg for As, Cd, Hg and Pb respectively as prescribed by FAO/WHO, 2016.Talinum triangulare is shown to bioaccumulate more metals (As, Cd and Pb) from the contaminated soil. Concentration of heavy metals analysed in vegetables were significant (P<0.05).

Table3. *Heavy Metal Concentration in Vegetables around auto-mechanic workshop*

Metals (mg/kg)	Vegetable Samples					
	Telfairia occidentalis	Amaranthus cruentus	Corchorus olitorius	Talinum triangulare	Hibiscus sabdariffa	PL(FAO /WHO)
As	5.50 ± 0.13^b	5.53 ± 0.16^b	3.35 ± 0.01^c	6.19 ± 0.12^a	2.01 ± 0.03^d	0.5
Cd	2.45 ± 0.09^d	4.80 ± 0.05^b	4.19 ± 0.01^c	5.17 ± 0.14^a	2.41 ± 0.18^d	0.2
Hg	5.59 ± 0.22^b	4.28 ± 0.25^c	3.34 ± 0.09^d	6.73 ± 0.23^a	4.18 ± 0.18^c	0.1
Pb	4.02 ± 0.13^b	2.39 ± 0.15^d	4.34 ± 0.45^a	4.08 ± 0.19^b	3.63 ± 0.90^c	0.3

Results was expressed as Mean ± SD. Mean values with same superscript letters on the rows are considered not significant (P>0.05). PL= Permissible limit. n=3

Bioaccumulation Factor (BAF)

The amount of elements transferred from soil to vegetables was Telfairia occidentalis (0.68, 0.38, 0.92 and 0.52), Amaranthus cruentus (0.68, 0.75, 0.70 and 0.30), Corchorus olitorius (0.41, 0.66, 0.55 and 0.56), Talinum triangulare (0.76, 0.81, 1.11 and 0.52) and Hibiscus sabdariffa (0.24, 0.34, 0.69 and 0.46) respectively for As, Cd, Hg, and Pb.

Table4. *Bioaccumulation Factor (BAF)*

Metals (mg/kg)	Vegetable Samples				
	Telfairia occidentalis	Amaranthus cruentus	Corchorus olitorius	Talinum triangulare	Hibiscus sabdariffa
As	0.68	0.68	0.41	0.76	0.24
Cd	0.38	0.75	0.66	0.81	0.38
Hg	0.92	0.70	0.55	1.11	0.69
Pb	0.52	0.30	0.56	0.52	0.46
Total	2.50	2.43	2.18	3.20	1.77

The BAF of Hg in Talinum triangulare is greater than one. Where the accumulation factor is greater than one (>1) indicates that the vegetable are enriched with the elements from the soil (Bioaccumulators). Also where BAF is less than one (<1) means that the vegetables are not much enriched with the trace metals from the soil shown in table 4.The class of bioaccumulation factors ranges from unpolluted to highly polluted.

Table5. *Seven classes of Bioaccumulation factor*

Class	Value of soil quality
<0	Unpolluted
0-1	Unpolluted to moderately polluted
1-2	Moderately polluted
2-3	Moderately polluted to highly polluted
3-4	Highly polluted
4-5	Highly polluted to very highly polluted
>5	Very highly polluted

Daily Intake, Hazard Quotient and Hazard Index For Individual (Children and Adult)

The Daily intake and hazard quotient was calculated for both adults and children from trace metals in leaves of fluted pumpkin (Telfairia occidentalis), Jute mallow (Corchorus olitorius), water leaf (Talinum triangulare), Roselle (Hibiscus sabdariffa) and African spinach (Amaranthus cruentus).

The vegetable T. triangulare shows the highest daily intakes of metal (Hg) for children and adult with 0.055 and 0.021 respectively which indicate that continuous consumption can eventually cause health risk. The estimated DIM through the food chain is given in (figure 2) for children, and (figure 3) for adult. The HQ of As, Cd, Hg and Pb in vegetables ranged from 0.03 to 0.55for children, while ranged from 0.01 to 0.21for adult. The HQ of metals through the consumption of vegetables for both adults and children is given in (figure 4).

The calculated HI for both children and adult in vegetable from contaminated site is shown in figure 4. The value obtained for children were 1.03, 0.76, 0.69, 0.65, 0.57 and Adult were 0.37, 0.29, 0.25, 0.22 and 0.20 in Telfairia occidentalis, Corchorus olitorius, Talinum triangulare, Hibiscus sabdariffa and Amaranthus cruentus respectively shown in figure 5.

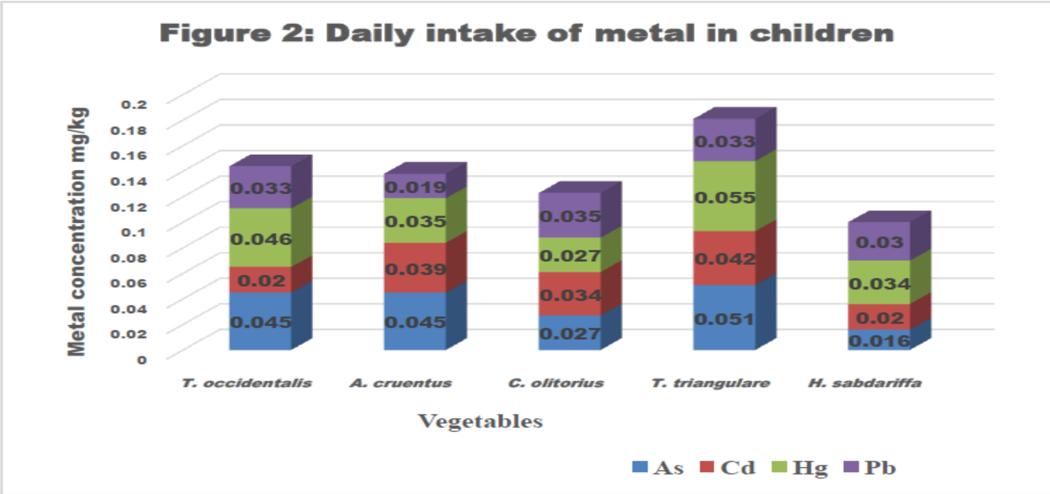

Figure2. *Daily intake of metal in children*

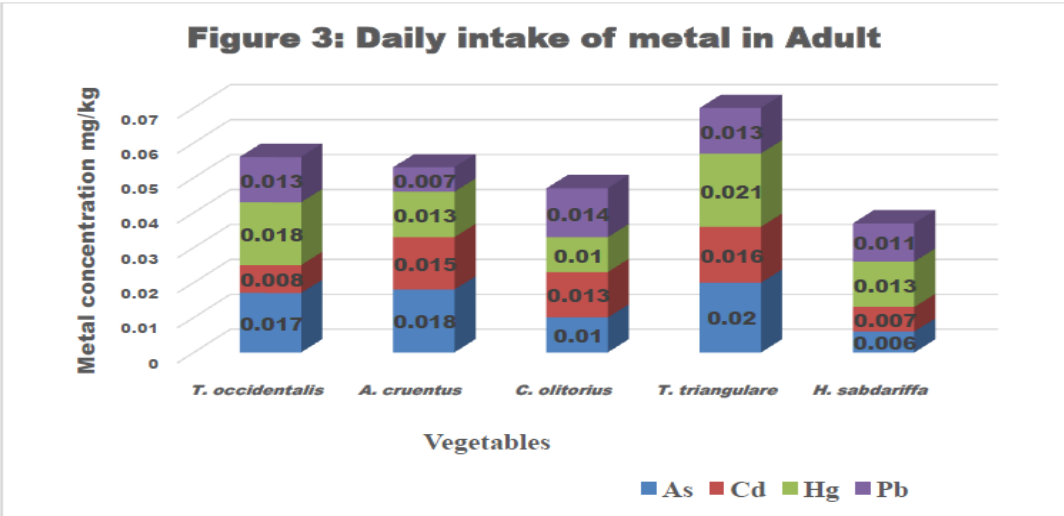

Figure3. *Daily intake of metal in Adult*

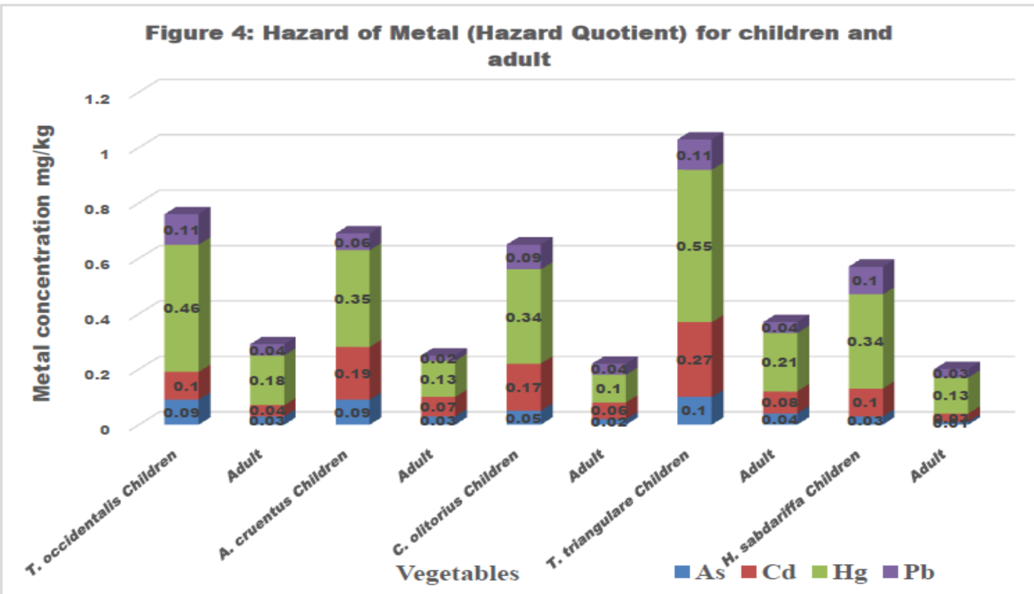

Figure4. *Hazard of Metal (Hazard Quotient)for children and adult*

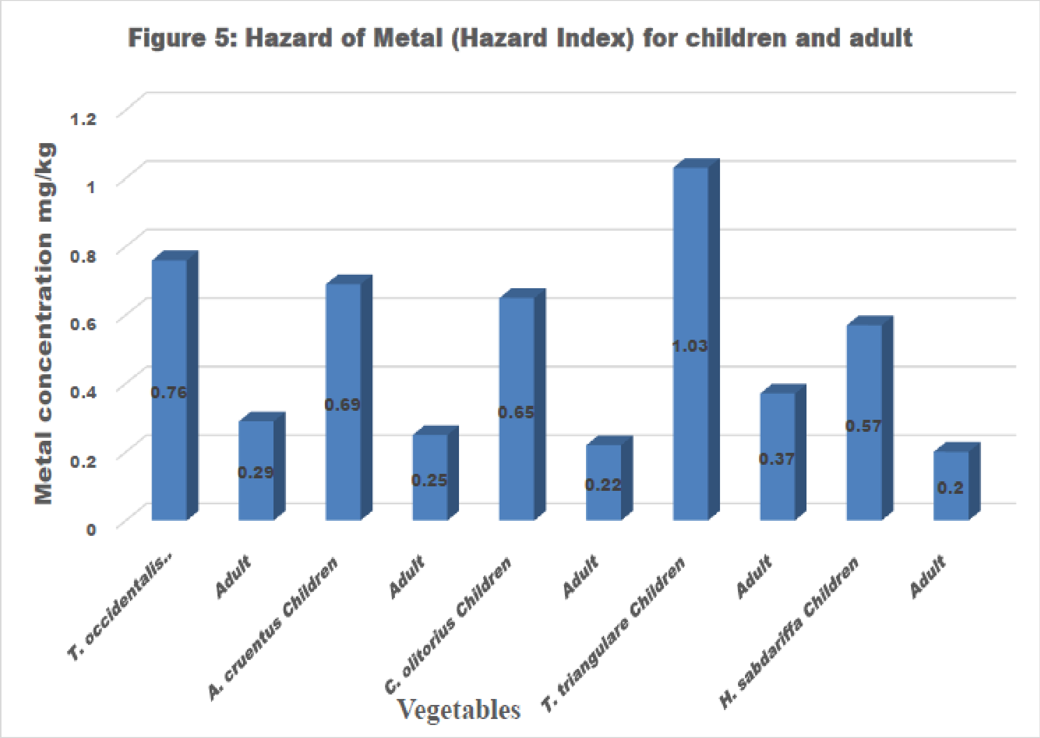

Figure5. *Hazard of Metal (Hazard Index) for children and adult*

Discussion

Soil pH is a major factor influencing metal in the soil. Most metals tend to be less mobile in soils with high pH i.e. basicity as they form insoluble complexes (Anegbe et al., 2014). Metals are more mobile when the pH is towards acidity. These findings are in line with Aloysius et al., 2013 with a mean value of the pH of soils in the vicinity of auto mechanic workshop clusters ranged from 5.02 to 5.70 in aqueous CaCl2 and 6.36 to 6.4 in deionized water. The control soil was within the pH range of 5.70 – 6.50 which favours plant growth and viability of microorganisms.

Presence of residual hydrocarbon spills and oil may have had some direct impact in lowering the pH of the soil samples. It is also more likely that production of organic acid by microbial metabolism is responsible for the difference in pH (Okoro et al., 2011). However there is significant ($P<0.05$) different in physicochemical properties between the auto mechanic soil and the control soil.

The amount of organic matter has been reported by Akoto et al. (2008) to have the potential to bind toxic ions. High organic matter of soils immobilizes heavy metals at strongly acidic conditions and mobilizes metals at weakly acidic to alkaline reactions by forming insoluble or soluble organic metal complexes, respectively (Brümmer and Herms, 1982).Arsenic recorded the highest metal detected with 8.05 which is below the permissible limit of 20 mg/kg by WHO/FAO, 2001. Mercury concentration in the auto mechanic soil was greater than the permissible limit of 2.0 mg/kg given by WHO/FAO, 2001 in soil. This finding of elevated Cd concentration is consistent with that of Luter et al. (2011) who investigated heavy metals in soils of auto-mechanic shops and refuse dump sites in other parts of Makurdi, Central Nigeria, as well and reported a range of 0.6 - 3.5 mg/kg.

The high Cd, As and Hg levels obtained from the soil samples of auto-mechanical workshop sites may be due to the motor vehicle repair such as body work, painting, soldering, brake fluid, engine oils, shear off from metal plating, leachates from used oils and old tyres frequently burnt on these sites, corrosion of metal, batteries and metal parts such as radiators and indiscriminate dumping of waste products are likely source of cadmium. The mean Pb values in the study area were however lower than the value (22.4 mg/kg mg.kg-1) reported by (Anegbe et al., 2019), 1162 mg/kg reported by Nwachukwu et al. (2011) for auto mechanic workshop area in Owerri, South-East Nigeria and also lower than the value recommended in the soil (50 mg//kg) by WHO/FAO. It is reported that Pb has the highest composition of heavy metals in waste oils (Oguntimehin et al., 2008). It is possible that these levels of Pb is increase by the amount of waste oil, presence of automobile emissions, and expired motor batteries indiscriminately dumped by battery chargers and auto mechanics in the surrounding areas.

Urban soils receive loads of contaminants that are usually greater than the sub-urban or rural areas, due to the higher tempo of anthropogenic activities of urban settlements. When engine oil and other transmission fluids is discharged, it increases the concentration of heavy metals in soils and was responsible for the higher concentration in the auto-mechanic soils than the control which is not exposed to any waste engine oil.

A similar result has been reported by (Nwachukwu et al., 2010), from Okigwe, Orji and Nekede mechanic villages in Imo State, Nigeria, and by (Adelekan and Abegunde, 2011) from auto-mechanic villages in Ibadan, Nigeria. These elevated levels observed may be connected with the large amounts of waste engine oil and other chemical fluids discharged in the workshops, metal scrap deposits, welding and other wastes that are potential sources of heavy metals.

The ability of plants to accumulate essential metals also enables them to acquire other nonessential metals. The variation in heavy metal concentrations in vegetables collected from the same farm may be ascribed to their morphological and physiological differences in uptake, exclusion, and accumulation of heavy metals. The high mean concentrations of As and Cd in vegetables around auto mechanic workshop may be due the amount of waste oil, presence of automobile emissions, and expired motor batteries indiscriminately dumped by battery chargers and auto mechanics in the surrounding areas, which can be absorbed into foliage and translocated through the plants. Arsenic affects almost all organs during its acute or chronic exposure especially the liver.

Arsenic effect many cell enzymes, which affect metabolism, DNA repair and brain problem. The prominent chronic manifestations of As involve the skin, lungs, liver and blood systems (Oguh et al., 2019a). Researchers reported that Cd causes both acute and chronic poisoning, adverse effect on kidney, liver, vascular and the immune system (Ndukwu et al., 2008). Mercury poisoning symptoms include blindness, deafness, brain damage, digestive problems, kidney damage, lack of coordination and mental retardation especially in children. Oguh et al., 2019a reported that lead causes both acute and chronic poisoning and cause effects on kidney, liver, vascular and immune system. Lead can causes serious injury to the brain and low IQ. Lead can affect the nervous system, and red blood cells.

High accumulation can lead to impaired development, shortened attention span, hyperactivity, mental deterioration, decreased reaction time, loss of memory, reduced fertility, renal system damage, nausea, insomnia, anorexia, and weakness of the joints when exposed to high lead.

The high concentration of As, Cd, Pb and Hg levels obtained from the vegetable samples around auto-mechanical workshop sites may be due to the motor vehicle repair such as body work, painting, soldering, brake fluid, engine oils, shear off from metal plating, leachates from used oils and old tyres frequently burnt on these sites, corrosion of metal, batteries and metal parts such as radiators and indiscriminate dumping of waste products.

Bioaccumulation factor (BAF) of trace metals gives the ratio of the concentration of metals in vegetable to the total concentration in the soil. The soil-vegetables BAF is one of the key components of human exposure to toxic metals through the food chain. The BAF values decreased with the increasing respective total metal concentrations in the soils and low concentration in the vegetables.

Talinum triangulare accumulated more metals from the contaminated soil with a total of 3.20 which indicate risk. The sequence of bioaccumulation rate from all the vegetables were Talinum triangulare > Telfairia occidentalis >Amaranthus cruentus >Corchorus olitorius >Hibiscus sabdariffa.

The bio-accumulated trace metals on the vegetable interact directly with biomolecules such as nucleic acid, protein, lipids, and carbohydrate, disrupting critical biological processes, resulting in toxicity and the concomitant transfer of these metals through the food chain could ultimately pose risk to human life. The daily intake of heavy metals was estimated according to the average vegetable consumption. The DIM values for heavy metals were significantly high in the vegetables grown on the contaminated soil around auto mechanic workshop especially for children. The result of hazard quotient (HQ) shows that children can be more affected by the consumption of vegetables grown around such areas.

Most of the values obtain in HQ especially in children were high which indicate that the more the vegetables are consume the liable the effect which may lead to accumulation of these metals in the body. There were high toxicity in T.triangul are from children since the value is greater than one (>1). When the ratio is lower than one (1), means there will be no obvious risk and ratio greater than one shows health risk. The result shows that children are more prone to toxic elements from the consumption of these vegetables grown around auto mechanic site.

Conclusion

The elevated levels of As, Cd, Pb, and Hg in the vicinity of automobile workshops in Minna City are of environmental and public health concern. The research conclude that these auto mechanic workshops accumulate potentially toxic elements in the soil and do have a negative impact on the plants, human and surrounding environment, which calls for stricter regulation on their location within cities. The result of the risk assessment shows that children can be more affected by the consumption of vegetables grown around such areas.

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Citation: *Oguh C.E, Obiwulu E.N.O."Human Risk on Heavy Metal Pollution and Bioaccumulation Factor in Soil and Some Edible Vegetables around Active Auto-Mechanic Workshop in Chanchaga Minna Niger State, Nigeria".Annals of Ecology and Environmental Science 4(1), pp.12-22,2020*