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Research Article

Bioaccumulation of heavy metals concentration in some selected cereals grown near illegal mine Sites at Poyentanga in Wa of the Upper West Region, Ghana

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Abstract: The contamination of cereals by heavy metals due to illegal mining activities in most farming communities has been a major challengeto food production in Ghana. The research is thus to examine bio-accumulation of heavy metals (Cadmium (Cd), Arsenic (As), Iron (Fe), Lead (Pd) and Zinc (Zn)) concentration in Maize and Millet grown near illegal mining sites at Poyentanga. The study area was divided into five farming zones (farm 1, 2, 3, 4 and 5)and soil and crop samples were taken from each of the zones to the laboratory for analysis using the Atomic Absorption Spectrometer and the results compared to World Health Organization (WHO) permissible limits. The results indicate presence of the selected heavy metals in the cereals and soils sampled from the community. Cd, Pb and Fe concentrations in the cereals were found to be above the WHO permissible limits whereas As and Zn concentrations were below. The soil concentrations of all the five heavy metals were extremely below the WHO permissible limits. It was also observed that farms near the mining sites have higher concentrations with the concentration in the maize being lower than that of Millet. The contamination levels in both cereals are as follows: Zn<As<Fe<Pb<Cd.The bioaccumulation ratio indicated that Cd, As and Pb levels were higher in Millet whereas Fe and Zn were highest in the Maize. Theseresults therefore show that the consumption of these cereals for a very long time could have adverse health effect on the community and an indication that activities of illegal mining could thus affect the quality and safety of food produced in many farming communities. The research was concluded with recommendations to improve agricultural activities in such communities.

Keywords: heavy metals; cereals, soils; bioaccumulation; illegal mining sites; concentration

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1. Introduction

Gold mining in Ghana is one of the lucrative jobs which providequick returns for the teeming youth. According to Ghana Chamber of Mines (GCM) report (2008) illegal mining activities have been increasing with an estimated number between 300,000 and 500,000 artisan miners which are mainly the youth are engaged in the sector. The illegal mining (galamsey) activities also contribute to the economy in various ways such as production of gold for export, boost businesses in the mining communities, facilitate social cohesion, and community development(Wood, 1999).

However, the activities of the small and medium scale mining especially those without proper licenses have affected the environment in many different ways. Among the challenges of the illegal mining are soil and water pollution, biodiversity loss, collapse of sinkholes, destruction of vegetation cover which exacerbates the phenomenon of climate change, erosion and deposition of unwanted materials in river bodies among others. According to Asante and Ntow (2009) the exploitation of gold results in the destruction of the soil, pollution of water bodies, vegetation and poses human health hazards among the miners. Besides, inappropriate handling and the method of amalgamating the gold particles with mercury (Hg) and other heavy metals has also caused pollution to both soil and water bodies (Swain et al., 2007) with its attendant effect on humans. Hg alone is known to affect the immune and nervous systems, heart, kidney, lungs and the brain. It is estimated that about 5 tonnes of Hg and other heavy metals are released into the environment annually during mining operations (Hilson, 2001). These heavy metals get into the environment through both natural and anthropogenic pathways and are being associated with toxicity and contamination. Apart from the effect on human health, the heavy metals associated with illegal mining also affect the food production chain in high concentrations. Essumang*et al*. (2007) has observed that agricultural production such as fresh vegetables and food stuffs are affected by the activities of illegal mining through the release of heavy metals in soils. The accumulation of heavy metals in the soil not only pollutes the environment but causes an increase in the uptake of the metals by crops, which has a higher tendency of significantly affecting food quality and safety (Muchuweti et al. 2006, Sharma and Chettri 2005, Sharma et al. 2007) which enters into humans throughingestion and inhalation. They are usually taken up by crops in their solubilized forms by root exudate within the soil (Blaylock and Huang, 2000). Heavy metals at relatively smaller amounts do not necessarily affect plants growth but become toxic to the plant at higher concentrations. Most heavy metals are not essential for plant growth and metabolism though they are readily absorbed and accumulated by crops which thereby reduce the quantitative and qualitative productivity of the crops.

Despite the challenges associated with heavy metals, some of these heavy metals are very essential for the proper functioning of the biological systems of living things. Heavy metals like Iron (Fe), Zinc (Zn) and Copper (Cu) exert some nutritional and physiological benefits to humans and plants at very low amounts but other heavy metals like Arsenic, Mercury, Lead and Cadmium do not. Among the beneficial functions of the useful metals are Copper (amine oxidases, dopamine hydrolase and collagen synthesis); Zinc (protein synthesis, stabilization of DNA and 20-RNA); and Iron (haemmoeties of heamoglobin and cytochromes) (Suruchi and Khana, 2011).Inadequate supply of these nutrients may result in serious health implications.However, all forms of heavy metals have the tendency of becoming toxic to a biological system upon high accumulation from frequent exposure.

Heavy metals such as Cadmium and Lead are known to be toxic and abundant in nature and also noted to be capable of causing nervous, cardiovascular, bone and kidney diseases (Jarup 2003).It is for this reason that this research is being carried out to determine the concentration of Arsenic, Cadmium, Iron, Lead, and Zinc in commonly cultivated food crops (Zea mays (Maize) and Pennisetumglaucum (Millet)) and the soil in Poyentanga in Wa west inthe Upper West region of Ghana.

1.1 Characteristics of selected the heavy metals

Lead (Pd): It is very common in nature and can be very harmful to both plants and humans in high concentrations. Lead contamination is one of the major environmental challenges identified globally and mainly comes from industrial, agricultural and urban activities. When lead comes into contact with soil of high organic contents, it gets absorbed by the root and sometimes passes on to the shoots of some plant and enters the cell walls. Lead may thus hinder the chemical breakdown of inorganic soil fragments which can cause lead in the soil to become more soluble, thus being more readily available to be taken up by plants. The plant absorbs lead from the soil that has been accumulated or retained in the roots. The uptake of lead can be minimized by the addition of phosphorus and calcium into the soil. As human constantly takes in crops that have been highly accumulated with lead, it will affect the central nervous system and prevent their ability to synthesize red blood cells. It has been suggested that lead on a cellular and molecular level may permit or enhance carcinogenic events (Silbergeld, 2003).

Zinc: It is an essential trace metal and micronutrient for human health that can also affects several metabolic processes of plants (Cakmak and Marshner 1993). The high level of Zn in the soil may retard plant growth and inhibit the metabolic activities of many plants. According to (Ebbs and Kochian 1997), the toxicity of Zn in plants limits growth of the root and shoots systems. Furthermore, prolonged exposure of plants to Zn causes chlorosis in the fresh leaves which can extend to the older leaves (Ebbs and Kochian 1997). The most common sources of Zn toxicity to the environment is through anthropogenic activities such as mining, coal and fuel combustion and facilities that produce zinc. Zinc deficiency has been associated with dermatitis, anorexia, growth retardation, poor wound healing,impaired immune function, and depressed mental function; increased incidence of congenital malformations in infants has also been associated with zinc deficiency in mothers (Sandstead, 1981; Elinder, 1986; Contran et al., 1998). A considerable amount of zinc is needed in our diet for normal growth, protein synthesis, development of reproductive organs, stabilization of DNA and RNA. Zinc deficiency in the diet may be highly detrimental to human health than too much zinc in diet (Kudirat and Funmilayo, 2011).

Arsenic: Soil pollution by arsenic is widely generated from As pesticides as reported by (Woolson, 1975; Merry et al., 1983; and Nriagu, 1994). Arsenic is known to disturb and alter the uptake and transport of plant nutrients (Päivöke and Simola, 2001), the phytotoxicity of As can be physically seen during leaf wilting and retarded growth of the root and shoots system. This effect is usually accompanied by necrosis and discolouration of the tip and margin of leaves indicating an inhibition of water uptake by the roots which finally could result in the plant death from wilting (Woolson et al., 1971).

Arsenic is a naturally occurring abundance element with metalloid properties, which is widely present in rocks, soils, sediments and metal ores in the form of sulphide or oxyhydroxides.The medical conditions that may arise include: gastrointestinal symptoms, peripheral neuropathy, diabetes, renal damage, conjunctivitis, cardiovascular diseases like arrhythmia, hypertension, destruction of red blood cells, liver cancer and bone marrow depression. Arsenic has the ability to cross the placenta which poses greater risk in pregnant women exposed to the metal especially through water. This could cause pre-term birth, still birth, and miscarriages.Arsenic poisoning in humans may depends on the age, sex, duration of exposure, dose and chemical speciation in particular oxidation states.

Iron: Among the lots of heavy metals available, iron is one of the essential elements in plants and humans. It plays some vital roles in these living organisms. Iron is essential in plants as it helps to execute several diverse biological roles in plants including chlorophyll biosynthesis, photosynthesis and chloroplast development. Irrespective of these known benefits of iron in plants, it can become toxic at higher concentrations upon frequent exposure resulting in the accumulation of the metal. Iron toxicity causes free radical production that damages membranes, proteins, DNA and impairs the cellular structure irreversibly (Arora et al. 2008; de Dorlodot et al. 2005). Iron is an essential element naturally present at lower concentrations in some vegetables, fruits and eggs. The high concentration of iron in humans depends on the route of exposure (oral, dermal or inhalation), frequency of exposure to metal, chemical form of the metal and rate of absorption, metabolism and excretion of the metal.

Iron happens to be one of the heavy metals noted to increase the risk of several oestrogen-induced cancers in humans (Liehr and Jones, 2001). In as much as the excess of iron can be toxic to humans and plants, its deficiency can equally be detrimental to living organisms especially human beings. Deficiency in iron can result in symptoms such as: sore tongue, headache, dizziness, weakness, chronic fatigue, restless leg syndrome, sensitivity to cold, reduced resistance to infections, and shortness of breath from doing easy tasks like climbing stairs. There have not been any reported cases of acute iron toxicity from the normal dietary intake in humans.

Cadmium: It is one of the non-essential elements which is not needed in the human body. This heavy metal is among the most toxic heavy metals found in the soil, air and water and has detrimental effects in humans, animals and plants..The only known significant uses of cadmium is in Ni/Cd batteries, rechargeable or secondary power sources exhibiting high output, high tolerance to physical and electrical stress, low maintenance, and longevity.

Cadmium is known to be readily taken up by plants which facilitate its accumulative effect. The accumulation of cadmium in plants can result in growth inhibition, browning of root tips, chlorosis and finally plant death. The acceptable regulatory limit of cadmium in agricultural soil is 100 mg/kg soil. Cadmium in plants is known to interfere with the transport and use of water and essential elements such as (K, Ca, and Mg) by plants. It equally affects the absorption and transportation of nitrates from the roots to the shoot system of plants. The exposure of plants to cadmium leads to series of detoxification processes within the cells which may include immobilization at the cell wall level, exclusion through the action of plasma membrane, complexing of the metal by phytochelatins, compartmentalization in vacuoles, and production of stress proteins.

2. Materials and Methods

2.1 The study area

The Upper West Region is the 10th and youngest region in Ghana which was established in 1983. The region is situated in the north-western part of Ghana. It lies between latitude 9 30°N and 11N and at longitude 1 25°W and 2 45°W. It covers a geographical area of 18.476 sq. km constituting 12.7% of the total geographical area of Ghana. The region is bordered by Upper East region (Bolgatanga) to the east, to the south Northern region (Tamale) and to the north Burkina Faso. The region is divided into nine different administrative districts with the latest being Lambussie district. The districts include: Jirapa, Lawra, Sissala East, Sissala West, Wa East, Wa West, Nadowli, Wa Municipal and Lambussie District.

This study was carried out in *Poyentanga*, a farming community in the Wa-West District. The indigenes of *Poyentanga* are widely *Dagartis* and *Waalas*and are mostly farmers who cultivate Maize, Millet and Groundnut. The land area is 1,492 km² and the population is 81, 348 with a population density of 65.83/km² (GSS, 2012). The rainfall is unimodal with annual mean rainfall between 840mm and 1400mm. Temperatures are high in most part of the year, ranging between 22.5 ^{o}C to 45 ^{o}C between December and January, and high between February and March, The vegetation of the Wa West District is of the Guinea Savanna grassland. Some of the predominant trees in the district are Shea (Vitellariaparadoxa), dawadawa (Parkiabiglobosa), mahogany (Khayasnegalensis). Cashew (Anacardiumoccidentale) and mango (Mangiferaindica) are exotic species which also thrive well in the district (MoFA, 2012).

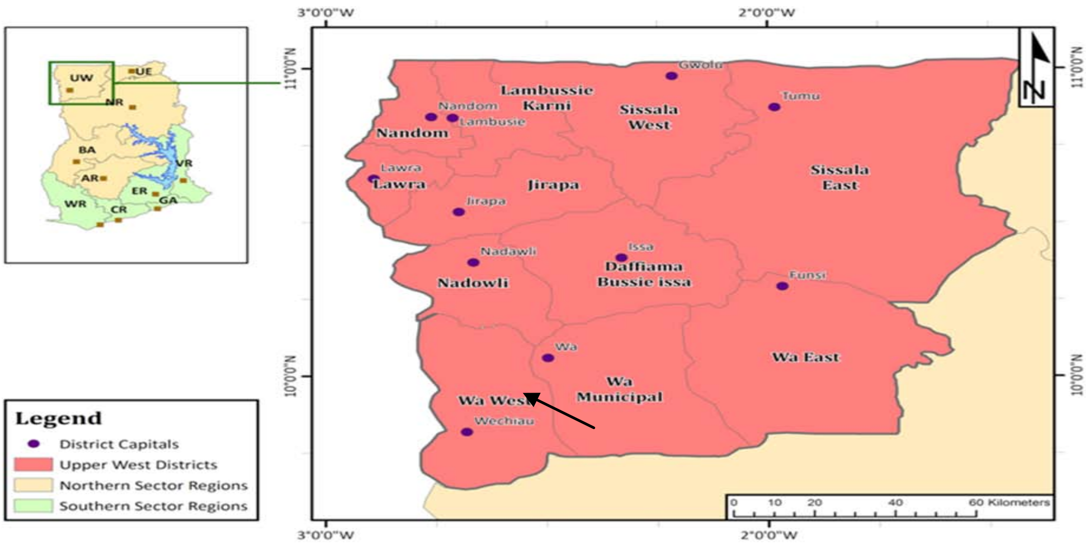

Fig.1 Map of Upper West region indicating Wa West District.

2.2. Sampling

Soil and crop sampling: the use of large amount of chemicals in agriculture, mining and other anthropogenic activities affect the properties of the soil and changes the soil chemistry (Tölgyessy, 1993). Such activities including natural occurrence may also introduce certain heavy metals in higher concentration. Soil analysis is therefore carried out to determine the chemical composition and evaluate its agricultural characteristics. High doses of certain heavy metals in the soil may restrict the growth of plants and also affect the potential productivity of the soil. The presence of heavy metals may also directly or indirectly threaten human and animals, and disturb the natural cycle. According to (Tölgyessy, 1993) soil pollution through large concentrations of heavy metals **(**Hg**,** Cu, Cd, Pb) and also other toxic metals, such as Zn, Se and As in soils are continually increasing by the action of intense human activities including the use of pesticides and industrial fertilizers.

Mercury and cadmium enter the soil either as a part of chemical preparations used or as micro-components of fertilizers as well as the occurrence from industrial and municipal waste disposal areas.

2.3 Sampling procedure

Before the sampling, the study area was divided into farm zones (Farm 1, 2, 3, 4, 5) at different locations around the illegal mining areas with both maize and millet planted separately on each of the selected farms. The farms sizes were about 2 ha each and selected portions of the farms were sampled. First, the surface of the soil was cleared with shovel to prevent roots and leaves of plants to mix with the soil sample. A soil sample of about 0.5kg of soil was taken at a depth of 5-7cm during the rainy season. The sample is then put into separate polythene bags and each labelled. The same is done at the four other sample sites and in all, a total of 5 samples were collected and stored for analysis.

The crops were also sampled by ramdomly selecting each of the two crops (Panacumglaucum and Zea mays) from the five different farms. The samples were then put into separate polythene bags and labelled. A total of 10 crop samples were collected and taken to the laboratory for preparation and analysis.

2.4 Preparation of sample and digestion

The soil samples were air dried in a clean room and residual plant and other materials removed. The samples were then ground to break all the agglomerate lumps for uniform soil particles. The ground samples were passed through a sieve and the fine soil collected and stored for analysis. A gram of each sample was put into a beaker and weighed separately on an electronic scale. The sample is then transferred into a conical flask. An amount of 10 ml of concentrated solution of (HCL and HNO_3) were added and heated on a hot plate at 100°C for 10 minutes. The heated samples were then allowed to cool with sufficient amount of deionised water. The mixture wasthen filtered separately into a 50ml volumetric flask using Whatman filter paper and topped up to the mark. The filtrate was collected and stored for analysis.

Samples of the crops were first dried and foreign materials removed. The dried samples were separately pounded to smaller pieces and were put into a dry blender and ground to fine powder for about 30 minutes. An amount of 1gram from each sample was weighed separately using an electronic beam balance in a beaker and transferred into a conical flask each and labelled. To each, 10 ml of concentrated solution of (HCL and concentrated HNO_3) was added and heated on a hot plate at 100°C. The heated samples were allowed to cool with sufficient amount of deionised water. The mixture was then filtered with Whatman filter paper into a 50ml volumetric flask and topped up to the mark. The filtered sample was then collected and stored for analysis.

2.5 Instruments and materials used

The instruments used are beaker, conical and volumetric flask for sample analysis and measurement, plastic containers for taking samples, weighing scale for taking measurements, Atomic Absorption Spectrometer (AAS) for sample analysis. Others are HCL and concentrated HNO_3, Whatman filter paper including cutlass and shovel for clearing.The atomic absorption spectrometer is the scientific equipment used for analytical determination of metals in solutions. Samples to be analysed are fragmented into very small drops which is fed into a flame. The isolated metal atoms interact with radiation that has been pre-set to specific wavelengths where the interactions are measured and interpreted. Since the instrument uses light in the form of radiation to measure concentration of gas-phase atoms, the amount of light absorbed by the metallic atom indicates the concentration of that metal.

The concentration of the heavy metals of interest was determined by aspirating the metal filtrates into excitation regions of the AAS where they get desolvated, vaporized and atomized by a flame discharge. The specific wavelength of emitted light by the hallow cathode lamp was isolated from the non-analytical ones by means of a monochromator. A light sensitive detector measures the absorbed light whilst a computer measures the detector response and translates it into concentration. The hallow cathode lamp used depended on the metal being analyzed. The concentrations obtained were then recorded.The results were then used to calculate the Means and Standard Deviations of the respective metallic samples from the five farms using basic excel spreadsheet.

3. Results

Table 1 Heavy metal concentration in the Cereals (Maize and Millet) and the soil from the five selected Farms

Farm	Sample	Cd (mg/kg)	Fe (mg/kg)	As (mg/kg)	Pb (mg/kg)	Zn (mg/kg)
Farm 1	Maize (A1)	0.37±0.08	22.23±0.18	0.12±0.03	0.78±0.08	0.95±0.10
	Millet (A2)	0.50±0.09	22.33±0.13	0.25±0.05	0.95±0.10	0.75±0.10
	Soil (S1)	0.50±0.13	94.75±0.13	0.35±0.05	3.07±0.13	4.30±0.10
Farm 2	Maize (B1)	0.68±0.10	6.88±0.10	0.18±0.03	2.60±0.15	1.38±0.08
	Millet (B2)	0.63±0.08	6.63±0.13	0.17±0.03	2.77±0.13	1.20±0.10
	Soil (S2)	0.40±0.13	95.25±0.10	0.30±0.05	3.25±0.10	4.08±0.13
Farm 3	Maize (C1)	0.32±0.08	12.90±0.10	0.12±0.03	3.65±0.10	1.83±0.08
	Millet (C2)	0.20±0.05	12.80±0.10	0.20±0.05	3.78±0.15	1.63±0.10
	Soil (S3)	0.95±0.10	142.65±0.15	6.15±0.10	6.23±0.18	5.17±0.10
Farm 4	Maize (D1)	0.37±0.08	60.85±0.10	0.25±0.05	3.47±0.08	1.20±0.09
	Millet (D2)	0.43±0.10	60.68±0.13	0.33±0.06	3.30±0.10	1.30±0.05
	Soil (S4)	0.55±0.13	118.75±0.20	0.25±0.05	4.18±0.13	4.95±0.15
Farm 5	Maize (E1)	0.58±0.06	73.00±0.10	0.30±0.05	1.68±0.15	2.57±0.13
	Millet (E2)	0.68±0.15	73.28±0.09	0.27±0.06	1.85±0.10	2.73±0.10
	Soil (S5)	0.80±0.10	104.10±0.10	0.25±0.05	3.30±0.05	4.72±0.15
Standards	Grain Limits	0.1	40.7	0.5	0.2	11
(*FAO/WHO Permissible Limits*)	Soil limits	1.4	750	12	70	200

Graphical representation of heavy metal concentration inMaize (A1), Millet (A2) & Soils (S1) from 5 farms

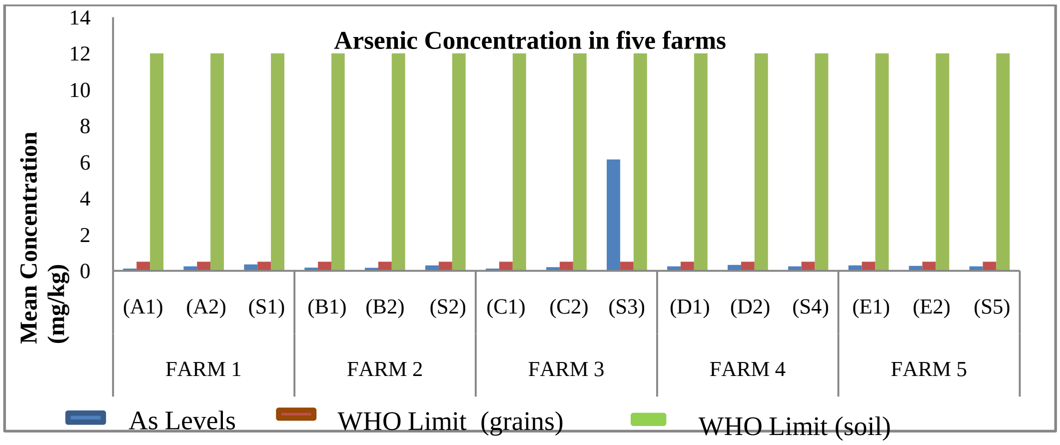

Figure 2 Mean Concentration of Arsenic (As) Compared in Maize, Millet and Soils

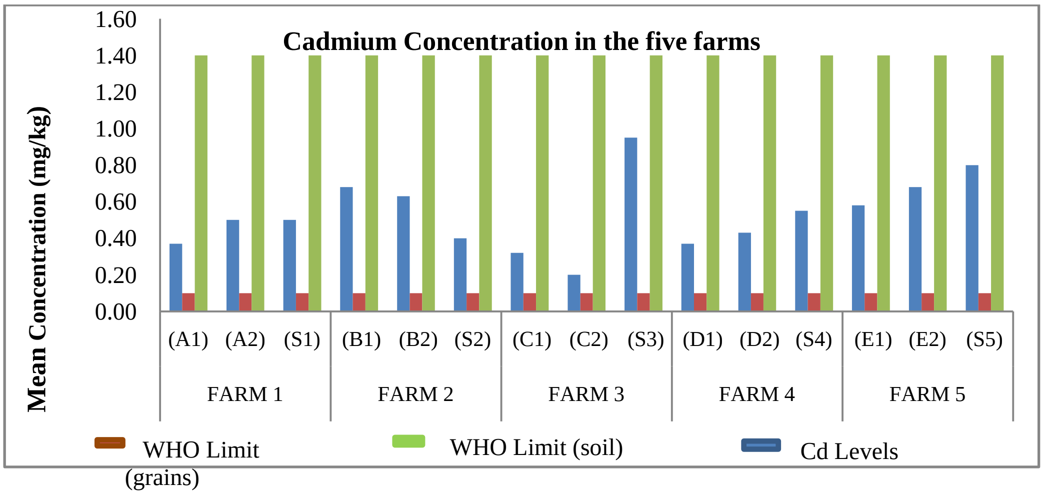

Figure 3 Mean Concentration of Cadmium (Cd) Compared in Maize, Millet and Soils

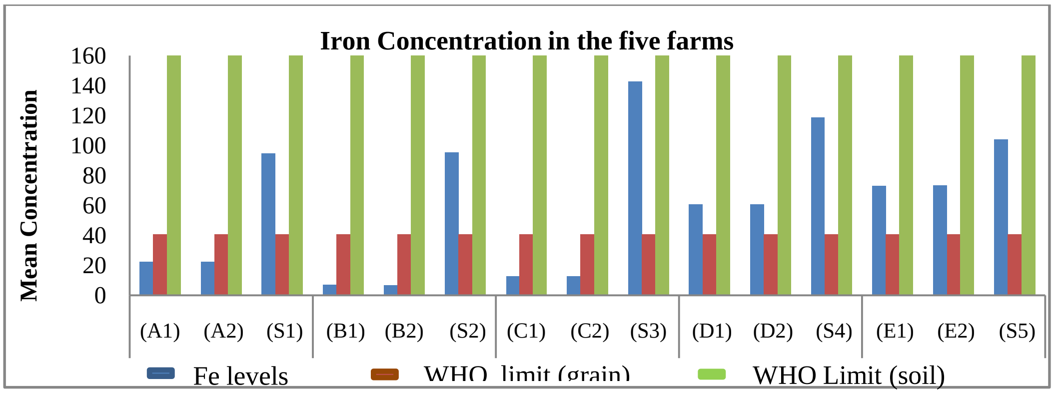

Figure 4 Mean Concentration of Iron (Fe) Compared in Maize, Millet and Soils

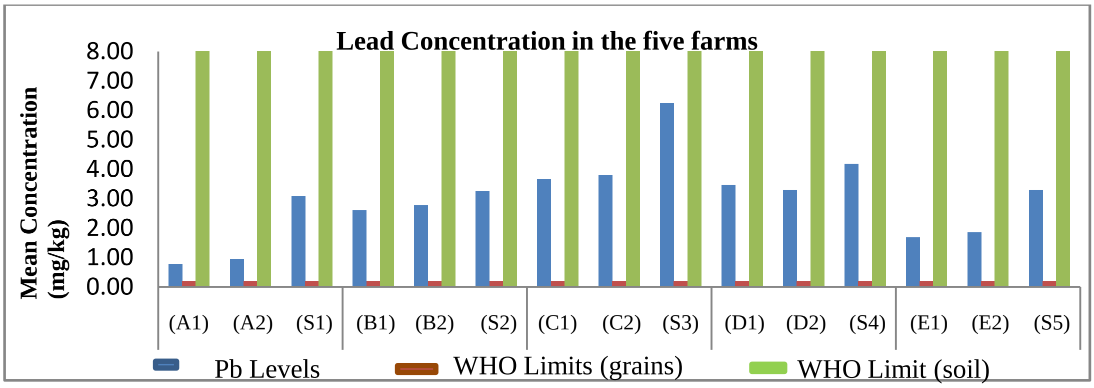

Figure 5 Mean Concentration of Lead (Pb) Compared Maize, Millet and Soils

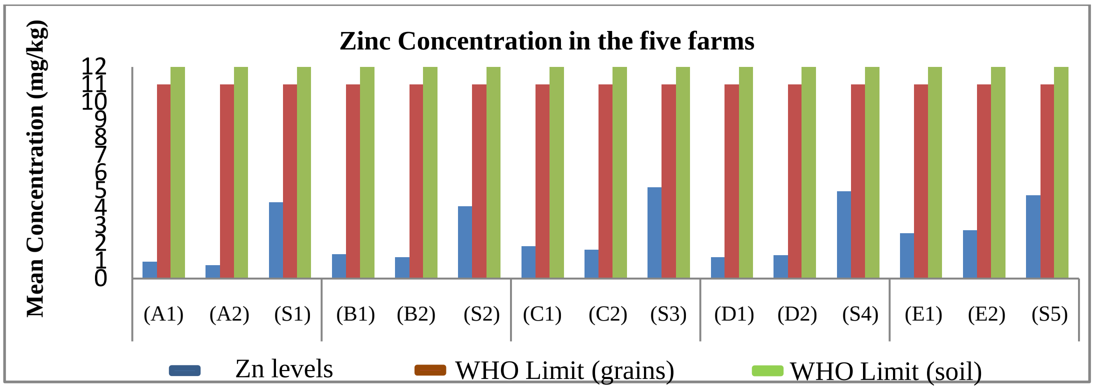

Figure 6 Mean Concentration of Zinc (Zn) Compared Maize, Millet and Soils

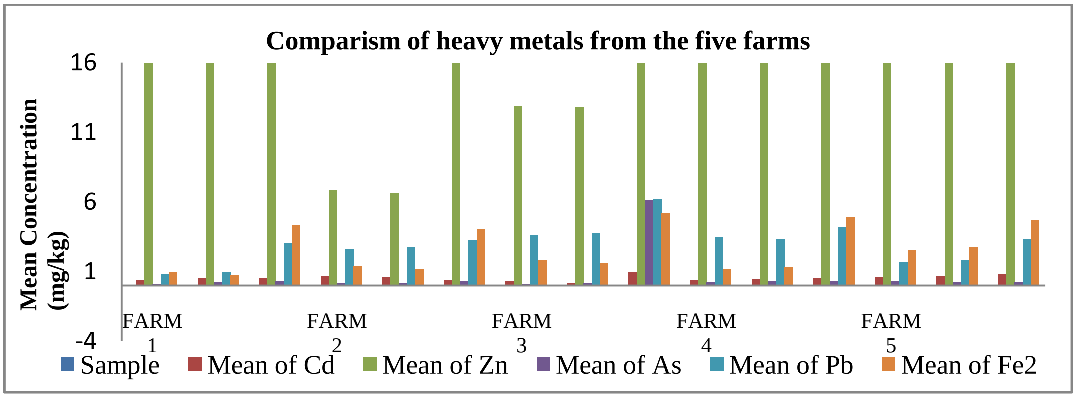

Figure 7 Comparism of the levels of all the heavy metals on the five different farms

4. Discussion of results

Contamination of the soiland water bodies is a serious and growing environmental problem, which is usually brought about by increasing anthropogenic activities such as illegal mining, bush burning, sand winning,agricultural, commercial and industrial activities and dumping of sewage into unapproved areas (Pestle, 1997) which results in the outbreak of several diseases and other undesirable effects. However, heavy metals are considered the most hazardous of all environmental pollutants due to its bioaccumulation and toxicity tendency. The role of soil in plant, human and animal life can never be over emphasis since it is very essential to the survival of all living organisms. Soil serves as a habitat for most plants and animal species as well as a source of foodfor both animals and human.

Results of analysis of five heavy metals (Cd, Fe, As, Pb, Zn) for soil, maize and millet samples near illegal mining sites at Poyentanga are summarized in Tables 1. In all, Farm 3 recorded the highest level of all heavy metals contamination in the soil. Iron (Fe) was recorded as the highest value in all the samples in Farm 3 as 142.65±0.15mg/kg whereas Arsenic recorded the least value both in Farm 4 and Farm 5. But the highest value of Cd was recorded as 0.95±0.10mg/kg in Farm 3 which is less than the value of As in Farm 3 as 6.15±0.10mg/kg thus Cd recorded the least value in all. In as much as the excess of iron can be toxic to humans and plants, its deficiency can equally be detrimental to living organism especially human beings. The mean concentrations of the Fe ranged from 94.75±0.13mg/kg to 142.65±0.15mg/kg in this study and is below the detectable limit recommended by WHO and less compare to results of findings from similar study by Akubugwo et al. (2012) with recorded value of Fe ranging from 73.62mg/kg to 226.39mg/kg and Tsafe et al. (2012) with recorded value of 195.25mg/kg.

The rate of heavy metal contaminations in the soil varied for the various findings. The differences may be due to the nature of the soil, the climate of the study area and the soil pH. Heavy metal concentration in soils is usually high near the sources of contamination, and reduces with both distance and depth due to physical dilution and increasing limits of movement (Liu, 2007).Some activities including the use of fertilizers and pesticides in the cultivation of crops may have caused the rise and fall of the amount of the heavy metals naturally present and needed in soils (Patel and Shah, 2008). Other heavy metals such as Lead, Cadmium and Arsenic are not beneficial to the soil thus pose a threat to plants and animals when highly accumulated as indicated by (Hilson, 2001). Lead recorded the second largest value ranging from 3.07±0.13mg/kg to 6.23±0.18mg/kg more especially in Farm 3. Soil is a major source of Pb toxicity but their concentrations were much lesser in this study as compared to WHO limits. The presence of Pb in the soil may be due to waste water disposal to the soil and other anthropogenic activities. Zinc which also serves as essential heavy metal that is needed in significant amount in soil, and cereals recorded values ranging from 4.08±0.13mg/kg to 5.17±0.10mg/kg. Though Zn is needed in a small amount, the concentrations in the soil were far below the recommended WHO limit which is 200mg/kg. The heavy metals concentrations in the soils in all the farms arein increasing order of Fe>Pb>Zn>As> Cd. Food crops serves as a source of energy, vitamins, protein which are very essential minerals to a living system. Despite these facts, these cereals contain a minimum amount of heavy metals such as iron, zinc and copper. However, an increase amount of these elements contaminate the cereals and make them toxic to humans. The mean concentrations of all the heavy metals (As, Cd, Fe, Zn, and Pb) in the selected food cereals (Maize and Millet) were less than the values in their corresponding soils in all the farms. This indicates that the rate of metal uptake by the cereals could have been affected by other factors such as the nature of the soil in which the cereals were cultivated, the plant species, climate and plant age thus their wide differences (Alloway and Ayres, 1997; Uwah et al., 2009).

Nonetheless, this study recorded concentrations of the heavy metals range for the maize as follows: As (0.12±0.03mg/kg to0.30±0.05mg/kg), Cd(0.32±0.08mg/kg to 0.68±0.10mg/kg), Fe (6.88±0.10mg/kg to 73.00±0.10mg/kg), Pb (0.78±0.08mg/kg to 3.65±0.10mg/kg) and Zn (0.95±0.10mg/kg to 2.57±0.13mg/kg). The heavy metals concentrations in the millet were also recorded as follows: As(0.17±0.03mg/kg to 0.33±0.06mg/kg), Cd(0.20±0.05mg/kg to 0.68±0.15mg/kg), Fe(6.63±0.13mg/kg to 73.28±0.09mg/kg), Pb(0.95±0.10mg/kg to 3.78±0.15mg/kg), and Zn(0.75±0.10mg/kg to 2.73±0.10mg/kg).

The comparative analysis of concentrations of heavy metals in maize and millet were significantly different and the order of ranking in the cereals (maize and millet) in decreasing orderis represented as follows: Cd>Pb>Fe>As>Zn. The highest concentrations of Fe in the maize and millet were recorded in farm 5 as 73.00mg/kg and 73.28mg/kg which were far more than the required daily intake for Fe by WHO permissible limit of 40.7mg/kg thus the soil in the area should not be cultivated with maize and millet but other suitable cereals. The increase concentrations of Fe in the cereals recorded in farm 5 was because cereals naturally have a permissible amount of heavy metals such as Fe, Zn and Cu in them thus higher in accumulation when contaminated.

Apparently, it was expected that the metal concentrations of the soil could be transported to the cereals sample. Though the concentrations of heavy metals in the soil were far below WHO permissible limits but the metals concentrations in the selected crops exceeded the daily permissible intake by WHO limits. Therefore, the higher levels of heavy metal contamination of the cereals may be due to other factors. Studies have shown that cereals cultivated on soils contaminated with heavy metals from mining sites could have a detrimental effect on the health of the people (Pruvot et al., 2006; Zhuang et al., 2009). The decreasing order of concentrations of the heavy metals in the soil was Fe>Pb>Zn>As>Cd whereas their concentrations in the cereals (maize and millet) were both as follows: Cd>Pb>Fe>As>Zn. The concentrations of Fe and Pb were found to be higher in the crops as well as the soil. However, there were significant changes in the concentration of Zn, Cd and As in the cereals and soil. That is, As which recorded the third higher level of concentration in soil in farm 3 was the least recorded level of concentration in the cereals. The higher concentrations of heavy metals in the soil and cereals were recorded in farm 3 which indicates that they are hyperaccumulators of heavy metals. These denote that the indigents of Poyentanga in Wa were at higher risk of being exposed to health diseases by constant consumption of the cereals contaminated with heavy metals in farm 3 as supported by the data from the work.

5. Conclusion and recommendations

The results of this study have shown that the selected food crops were highly accumulated with heavy metals thus continuous consumption could pose a serious threat to the people in Poyentanga.However, heavy metal concentrations in the maize were higher than millet with a significant difference. These staple crops were found to contain high levels of heavy metals which exceeded WHO recommended limit and thus should not be cultivated on the affected farms.

The mean concentrations of the heavy metals Cd, Fe and Pb exceeded WHO acceptable limit in the cereals except As and Zn. As and Zn concentrations in the soil and crops were within the limit of WHO which indicates their safety for consumption though Zn is an essential mineral and arsenic is a non-essential micronutrient which is not needed in living system. The increase in the levels of the heavy metals in the crops (maize and millet) may be due to the contamination of the soil. Even though, the levels of heavy metals in the soil was within the acceptable limit by WHO but resulted in the increase of the heavy metals in the crops. Just like Zn, Iron is also an essential micronutrient which naturally is contained in crops in minimal amounts of heavy metals thus the increase in their concentrations. Lead and cadmium are non-essential elements which are mostly released during mining activities thus their presence in the soil and crops cultivated at the mining site. However, higher levels of iron were recorded both in farm 4 and farm 5 which exceeded the WHO limit and this may cause health challenges as shown by (Arora et al. 2008).

The farmers in Poyentanga are therefore to be educated on the effect of heavy metal contaminated soils on crops which should not be limited to the study areas. TheRural communities depend on farming and thus the activities of the small and medium scale mining should be properly monitored to avoid the consistent contamination of soils and farmers should be discouraged from farming in such areas. The regulatory agencies such as the District Assembly of the community, Food and Drug Authority, Environmental Protection Agency and the Mineral Commissions should ensure the implementation and enforcement of laws governing mining and the use of chemicals for mining operations. Finally, there should be similar research in the communities around the mining concessions to identify areas of high risk of heavy metal contamination.

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Conflicts of Interest

The authors declare no conflict of interest.

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