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Settlements Adjoining Tin Mines in Plateau State Are Exposed to Higher Concentrations of Heavy Metals

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ABSTRACT: *Heavy metals are present in the environment naturally at low levels which may not be harmful to humans. Human activities such as dumping of waste, smelting, waste incineration, vehicle exhausts, agricultural waste, fertilizers, mining activities and so on has increased the levels of heavy metals in the environment. Among all the factors that increases the concentration of heavy metals, mining activity is considered as one of the most influential anthropogenic activities which results in changes in landscapes, destruction of habitats, and contamination of soil, ambient air and water, and degradation of land resources. The presence of heavy metals in the environment. Artisanal tin mining activity has continued to increase in communities in Jos plateau state. This activity may be exposing heavy metals that may be harmful to humans and animals. The study aims to check the concentration of Lead (Pb), Cadmium (Cd), Chromium (Cr), Nickel (Ni), Manganese (Mn) and Zinc (Zn) in soil, ambient air, vegetables, fish, and water samples from the mining site. The metals were also analysed in soil and air in a community close to the mining site.*

KEY WORDS: tin mining, heavy metals, exposure, barkin-ladi

INTRODUCTION

Heavy metals are ubiquitous in the environment. Their presence occurs in both natural and anthropogenic forms. While usually natural forms are present at relative low concentrations, in recent years a number of anthropogenic sources such as dumping of waste, smelter stacks, waste incineration, vehicle exhausts, fertilizers, agricultural waste, and sewage sludge have implied notable contributions to the increase of environmental heavy metal concentration (Markus and McBratney 1996, Koch and Rotard 2001). Heavy metals form a major source of environmental contamination leading to adverse effects on the ecosystem and also the human health. Human activities are a major source of heavy metals in the environment(He, Yang and Stoffella 2005). Among all the factors that increases the concentration of heavy metals, mining activity is considered as one of the most influential anthropogenic activities which results in changes in landscapes, destruction of habitats, contamination of soil, ambient air and water, and degradation of land resources(Acosta et al. 2011, Jian-Min et al. 2007). Mining activity by humans in quest to harness the mineral deposit leaves the soil contaminated by heavy metals and a part of the expose heavy metals may eventually get into air, water bodies, and also get absorbed by crop hence posing health threat to animals and humans mainly through the food chain(Roberts, James and Williams 2014, Sexton, L. Needham and L. Pirkle 2004). In recent times there has been increase in the rate of the influx of people to artisanal Mining activities leaving a large level of environmental contamination. One peculiar case was recorded in northern Nigeria were artisanal gold mining was prevalent, there was an epidemic of Lead poisoning lead to the death of so many people especially children (Lo et al. 2012). The epidemic was as a result of the artisanal mining activity that resulted in exposing Lead (Pb) to the environment. In Jos Plateau state, there has been a history of tin and columbite mining which is evident by the vast patches of old mining ponds scattered in many locations in the state. In recent time there is a rise in the influx of people to artisanal tin mining from all over the state and neighbouring states. This activity may be a threat as it may be exposing heavy metals to the environment. High concentrations of heavy metals have been detected in several mining site in soil water, vegetables grown with water from mining ponds and fishes harvested from those mining ponds (Anazoba, Eneji and Sha’Ato 2019, Orisakwe et al. 2017, Latif et al. 2018). This is a pilot study that aims to check the concentration of some selected heavy Metals (Lead (Pb), Cadmium (Cd) Chromium (Cr) Nickel (Ni) Manganese (Mn) and Zinc (Zn)) in ambient air, soil, vegetable grown around the mining ponds by irrigation using water from the Mining pond, Fish harvested from the mining pond and water collected from the mining pond. The study went further check the concentrations of same metals in soil and air at an adjourning settlement close to the mining site to establish any similarity or difference in the concentration of those metals between the mining site and the adjourning settlement as the incident in Zamfara state in northern Nigeria claimed the lives of mostly children who are not involved in mining activity (Lo et al. 2012).

2.0 Methodology

Sample collection was carried out in November 2017 usually a period when the tin mining activity begin to grow to its peak due to drop in rain fall as most farm activities have subsided and its safer to go into the tunnels dug as it will not easily collapse compared to periods when the rains are much. Because the rains are no more at this period, vegetable irrigation farming also take place around the mining sites using water from the mining ponds.

Samples were taken from three locations: Site 1 - at the mining site, Site 2 - hundred meters away from the mining site and Site 3 - an adjourning settlement about 250 meters away from the mining site. Soil samples, air samples, vegetable samples and fish samples were collected from the mining site while only air and soil samples were collected from the location hundred meters away from the mining site and at the adjourning settlement. Air samples were collected on a filter paper using an AIRCHECK sampler model 224-PCXR8 SKC INC for 120 Minutes. Water samples were collected from the abandoned mining ponds used for irrigation by local farmers and also fishing activities takes place at the ponds fish samples were taken from the mining ponds and vegetable samples were collected from farms around the mining pond irrigated by water from the mining ponds. All sample collected and preserved fresh and taken to the laboratory where they were analysed for concentrations of selected heavy metals. Sampled were collected in triplicates from each of the sampling points Analysis of heavy metal concentration were done using the atomic absorption spectrophotometry using the ThermoFisher Scientific iCE 3300 Atomic Spectrophotometer at the Advanced Chemistry Laboratory of Sheda Science and Technology complex, Abuja. Standard digestion technique was used to treat all samples as described previously(Peña-Icart et al. 2011).

Database management and statistical analysis was performed using the IBM SPSS version 24. Mean concentrations of metals was computed by site of sample collection.

RESULTS

Mean Concentration of Cadmium (Cd) in Tin Mining Vicinity at Barkin Ladi LGA Plateau State

Figure 1 shows that Cadmium was detected only in site 1(at the mining site) and site 2(a location between the mining site and the residential area) with highest concentrations in site 2. The concentration of cadmium in soil and in air at site 2 was similar but higher in air at site 2 than it is at site 1. Cadmium had higher concentrations at site 2 than site 1 in both soil and air samples where it was detected.

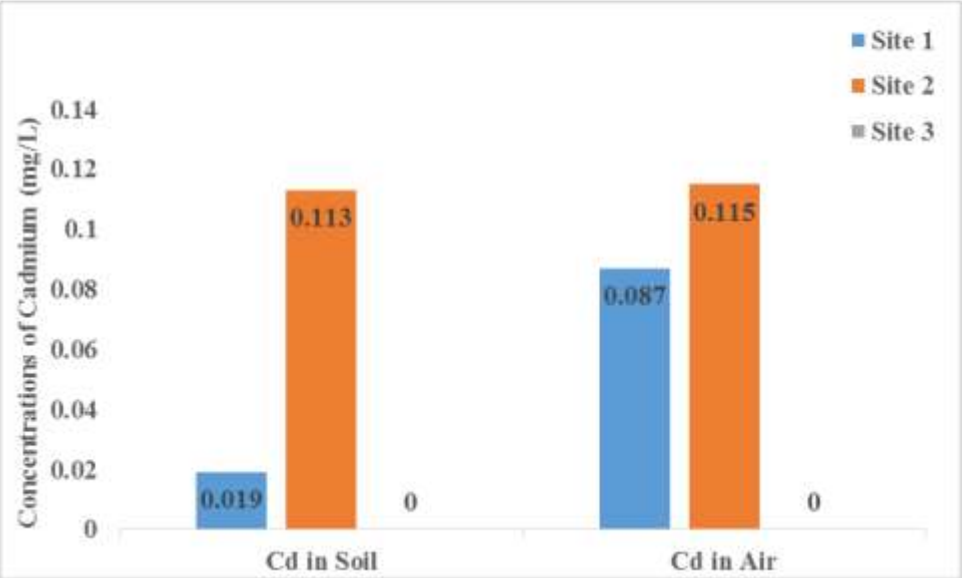

Figure 1: Mean Concentrations of Cadmium (Cd) in soil and air at the mining site (site 1), a location between the mining site and a nearby community (site 2) and at a community close to the Mining site (site 3).

Mean Concentration of Chromium (Cr) in Tin Mining Vicinity at Barkin Ladi LGA Plateau State

Chromium was detected at all the sites samples were taken from (figure 2). The mean concentration of Chromium had highest value at site 3 and showed a decreasing progression down to site1. Figure 2 also shows that the concentration of chromium at site 1 was slightly higher in air than it is in soil but higher in soil at site 2 and site 3 than it is in air.

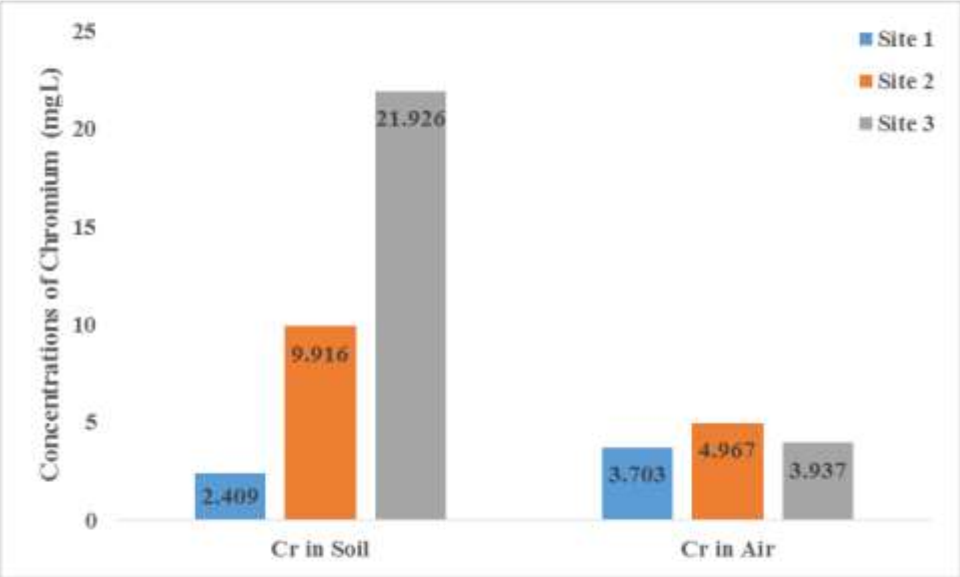

Figure 2: Mean Concentrations of Chromium (Cr) in soil and air at the mining site (site 1), a location between the mining site and a nearby community (site 2) and at a community close to the Mining site (site 3).

Mean Concentration of Nickel (Ni) in Tin Mining Vicinity at Barkin Ladi LGA Plateau State

Nickel was detected at all the sites in the soil samples but was detected only at site 1 and site 2 and was not detected in the residential area. The concentrations of Nickel in the soil sample were detected at higher levels in the soil sample than detected in the air samples except for site 1 where the concentration of Nickel in the soil sample it was lower than in air sample (figure 3).

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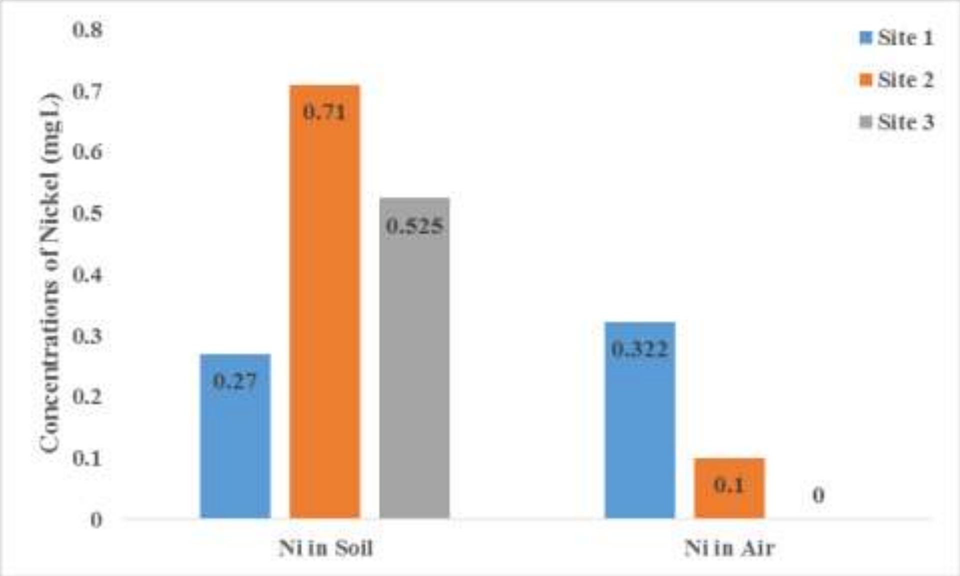

Figure 3: Mean Concentrations of Nickel (Ni) in soil and air at the mining site (site 1), a location between the mining site and a nearby community (site 2) and at a community close to the Mining site (site 3).

Mean Concentration of Manganese (Mn) in Tin Mining Vicinity at Barkin Ladi LGA Plateau State

Manganese was detected only at site 1 in the air sample but was detected at all the sites in the soil sample with an increasing trend from site 1 to site 3 (Figure 4). The concentration of Manganese detected in the air sample is smaller than the concentration detected at all the sites of sample collection in the soil samples (Figure 4)

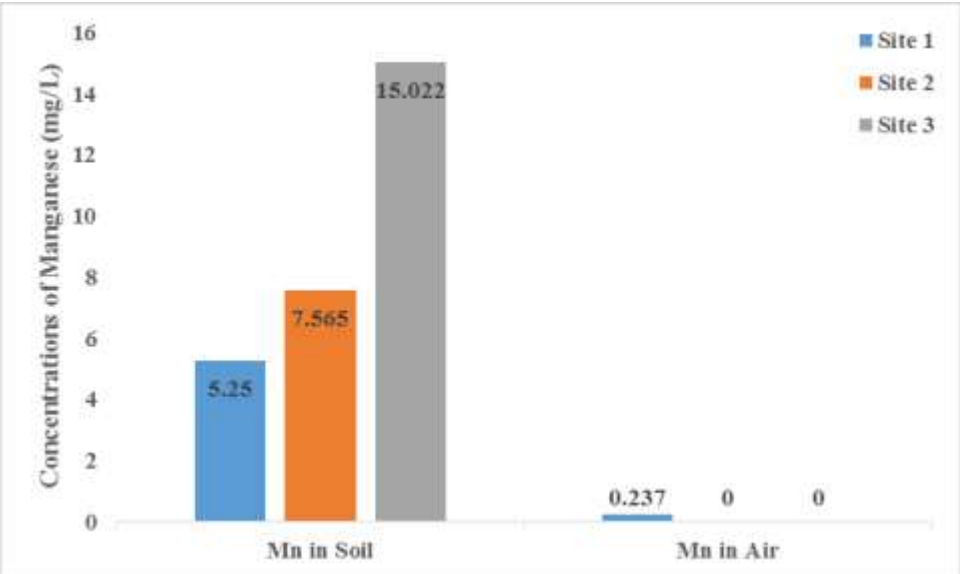

Figure 4: Mean Concentrations of Manganese (Mn) in soil and air at the mining site (site 1), a location between the mining site and a nearby community (site 2) and at a community close to the Mining site (site 3).

Mean Concentration of Zinc (Zn) in Tin Mining Vicinity at Barkin Ladi LGA Plateau State

In figure 5, Zinc was detected at all the sites where samples were collected both in air and in soil samples. The concentration of Zinc detected in the soil samples showed an increasing trend from site 1 to site 3 but increased from site 1 to site 2 and the decreased at site 3 where the lowest concentration was recorded in air.

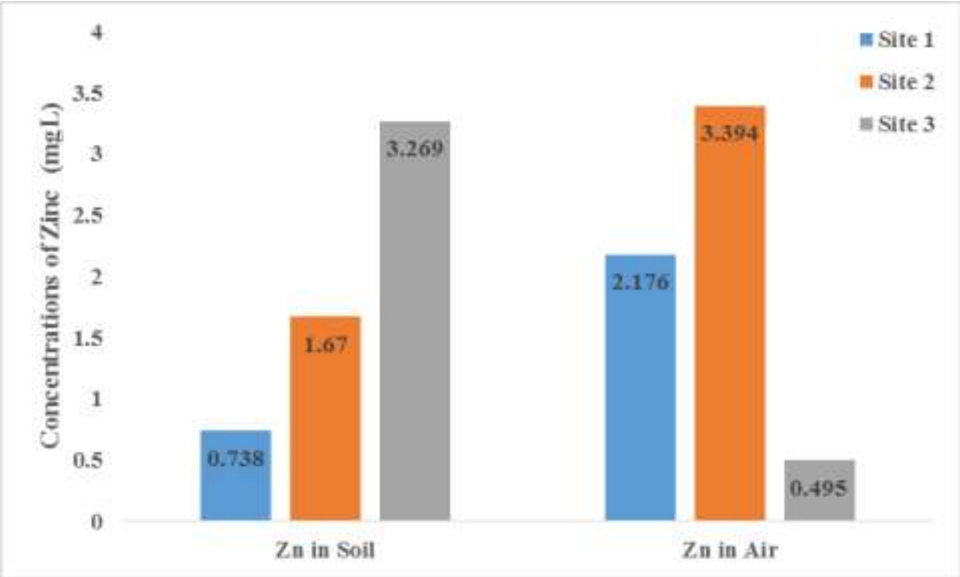

Figure 5: Mean Concentrations of Zinc (Zn) in soil and air at the mining site (site 1), a location between the mining site and a nearby community (site 2) and at a community close to the Mining site (site 3).

Mean Concentration of Selected Heavy metals in Vegetables, Fish and water samples in Tin Mining Vicinity at Barkin Ladi LGA Plateau State

Lead (Pb) was detected only in fish samples collected from the mining pond and the concentration detected is higher than the WHO guideline limit (WHO 2017) but was not detected in vegetables and water samples (Table 1). Cadmium was not detected in all the consumable samples collected from the mining vicinity (Table 1). Chromium was detected in all the consumable samples collected at the mining vicinity and the levels detected was higher than the WHO guideline limit (Table 1). Nickel was also detected in all the consumable samples collected but it is only higher than the WHO guideline limit in vegetable samples.

Table 1: Mean Concentration of Selected Heavy metals in Vegetables, Fish and water samples in Tin Mining Vicinity at Barkin Ladi LGA Plateau State

Sample	**Pb (mg/L)**	**Cd (mg/L)**	**Cr (mg/L)**	**Ni (mg/L)**
Fish	0.236 ± 0.153	ND	3.840 ± 0.05	0.052 ± 0.260
Vegetables	ND	ND	5.985 ± 1.224	0.243 ± 0.387
Water	ND	ND	4.051 ± 0.128	0.038 ± 0.138
WHO guideline value	0.010	0.003	0.050	0.070

ND = Not Detected (below detectable limit)

DISCUSSION

Heavy metals have both natural and anthropogenic sources. The latter are however the most significant, emitting greater amounts of these pollutants in more toxic and mobile forms into the environment. Heavy metals such as chromium (Cr), manganese (Mn), nickel (Ni), Zinc (Zn), and Cadmium (Cd) are found in rocks and soil. Increased anthropogenic activities and other disturbances with the natural environment has resulted in the increased concentration of these elements in the environment, there by posing an adverse effect on the ecosystem and human health (Jakhu and Mehra 2018, Vareda, Valente and Durães 2019). Metals are essential for healthy functioning of the body. They help in maintaining structures of proteins and enzymes. Deficiency and/or excess of certain metals might causes malfunctioning and toxicity. The most common heavy metals listed by Environment Protection Agency (EPA) as pollutant are: As, Cd, Cr, Cu, Hg, Ni, Pb and Zn (Swaleh and Usmani 2016). They occur in soil in various concentration and forms. Soils contaminated by heavy metals have raised serious concerns in recent decades and these include potential risk to human health through the direct intake, bioaccumulation through food chain (Musilova et al. 2016). Heavy metals are known to have toxic, carcinogenic and mutagenic effects on organisms that get exposed to them. It has been speculated that heavy metals disturb the metabolism, ionic balance and cell division. High concentrations in the human system are toxic to the liver, kidneys and lungs (Swaleh and Usmani 2016). For instance, inhalation of cadmium fumes or particles are life threatening and exposure to this toxic metal (cadmium) may cause kidney damage. Cadmium may enter into the atmosphere from zinc, lead and copper smelters or it may be carried as dust particles from one place to another. The results of high cadmium concentration in air is true because heavy metal contaminant can be carried to places many miles away from their original sources by wind, depending upon whether they are in gaseous form or as particulates. Hence air is also a route for the pollution of environment (Mahurpawar 2015, Quispe-Zuniga et al. 2019). Cadmium enters the environment from a variety of anthropogenic sources. Wastewater is a major source of environmental cadmium contamination, while diffuse pollution of these metals occurs through industrial air emissions and widespread use of fertilizers on agricultural soils (Ashraf, Maah and Yusoff 2010, Mahurpawar 2015). Lead poisoning causes disturbance in haemoglobin synthesis, and long-term lead exposure might lead to Anaemia. The result shows that Nickel occurs in the environment only at very low levels. Humans may be exposed to nickel by Skin contact with nickel-contaminated soil, breathing air or drinking water that is contaminated with nickel (Mahurpawar 2015). Chromium compounds are known to produce chronic effects on liver, lungs, kidneys and gastrointestinal cramps in humans. The presence of high concentration of chromium in the soil may be due to the fact that metallic pollutants are ultimately washed out of the air into land or the surface of water ways as a result of disturbance in the natural environment (Mahurpawar 2015, Vareda et al. 2019). In contrast to Copper and Iron Zinc does not form free- radicals and it has anti-oxidant properties, also, a report has it that zinc supplementation enhances host immune response by up-modulating the host's immune response, thus contributing to a reduction of blood parasites and the harmful pathogenic effects caused by the parasites. The sources for Zn in residential areas is vehicle tires (Isaac et al. 2011, Tepanosyan et al. 2018a). This explain why we record high concentration of Zn in air at site 2 which is a residential site. Another source of the contents of these elements may be through the winds which cross the mining sites and the close residential sites or through vehicular emissions.

Heavy metal contamination have devastating effects on ecological balance of the recipient environment as its wide occurrence in almost every industry whether it is fertilizer, pharmaceutical, steel, chemicals and so on. Besides these; daily life products like detergents, shampoos, cosmetics and batteries also contain heavy metals which when turned waste are poured into the environments contaminating them (Swaleh and Usmani 2016). These may have contributed to the higher concentration of heavy metals in the soil that we obtained at site 2 and site 3, which are residential area. It is clear that the anthropogenic input of heavy metals is much higher than natural input. For example, anthropogenic input is almost double the natural input of lead and zinc (Swaleh and Usmani 2016). Anthropogenic sources of cadmium include cigarette smoking, while food is the most important source of cadmium exposure in a non- smoking population. Cigarette smoking may be the reason why we obtain high concentration of cadmium is air at site close to mining area, which is also a residential area full of heavy smokers (Swaleh and Usmani 2016, Quispe-Zuniga et al. 2019).

The processes of extraction and transportation result in the penetration of these heavy metals to the surface environment and further accumulation into soils which may have explained the reason for high concentrations of these heavy metals as shown in our results (Tepanosyan et al. 2018b).

Our experiment on vegetable is in agreement with the works of (Latif et al. 2018) where the found that vegetables such as spinach and melon showed greater potential to absorbed Chromium and Nickel respectively. Their findings were well above the allowed threshold set by WHO/FAO. We found that the fish was contaminated with Lead, with values higher than the WHO guidelines, this finding also support the works of (Chinenye J. Anazoba, Ishaq S. Eneji and Sha'Ato 2019), where the found that fish from artificial in Heipang and Rayfield where heavily contaminated with Lead. The present of Chromium and Nickel in Water, Vegetable and Fish give us and inside as to how heavy metals can affect humans through food chain.

CONCLUSION

The results from the figures confirm that the soils from the sites close to the mines are polluted with heavy metals. The heavy metals around those sites are unevenly distributed. The elements being explored at the site are present in high concentrations in the soil, as expected. Careful observation of the results shows that the heavy metal contaminants are well spreads to the surrounding cultivated soils.

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