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Potential Heavy Metals Pollution in Soil of Some Selected Goldsmith Workshops in Gusau, Zamfara State

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ABSTRACT

The research investigated the concentration of some heavy metals in soil samples from selected goldsmith workshops in Gusau, Zamfara State using Atomic Absorption Spectroscopy (AAS) and Micro Plasma Atomic Emission Spectrophotometer (MP AES). The results obtained for these metals (Fe, Hg, Cd, Pb and Au) from the sample location indicated that Fe was higher than all other metals. The results obtained in dry weight; Fe (117.3±7.70-157.78±9.55mg/kg), Pb (0.08±0.01-0.283±0.234mg/kg), Cd (0.013±0.003-0.002±0.01mg/kg), Hg (0.033±0.012-0.843±0.05mg/kg) and Au (0.023±0.07- 0.043±0.19mg/kg) were below the standard set up by EU and SEPA in soil with exception of Hg and possibly Au which may be attributed to anthropogenic impute from the sampled area. The result also reveals that there is no significant difference ($p > 0.05$) between the samples in terms of heavy metal concentration except for Pb and Hg. However, possible adverse effect may occur among the inhabitants of this study area especially in the cases of Hg, and Au if they bio-accumulates beyond the tolerable concentrations in the body.

Keywords: Heavy Metals, Soil, Goldsmith, Atomic Absorption Spectrophotometer, Micro Plasma Atomic Emission Spectrophotometer.

Environmental degradation is not a new phenomenon. Recently, rapid increase in population, urbanization, advances in science and technology as well as economic growth has all immensely contributed to aggravate the situation in most countries (Filazi *et al.* 2003). These aforementioned activities generate high concentration of toxic heavy metals and other elements in the soil which can pose serious effect on the immediate environs (Filazi *et al.* 2003). Many soils contain a wide range of heavy metals with varying concentrations, ranges from surrounding geological environment, anthropogenic and natural activities occurring (Dube *et al.*, 2000).

Pollution associated with heavy metals pose serious problem to the environment, health, diet/food, soils among others (Abimbola *et al.*, 2007). However, mining and other gold related

1.0 INTRODUCTION

business are common in Zamfara state and this has resulted to the increasing number of goldsmith workshops in Gusau, the state capital. Unlike established manufacturers of gold jewelry, small goldsmith workshops lack technical know-how as well as the adequate resources to provide effective control methods to reduce exposure of both their surroundings and the staff to toxic heavy metals.

The environmental impact of goldsmith activities would be severe because of the chemical processes involved right from the mining, particularly the use of mercury and other toxic solvent. The Nigeria Ministry of Mines and Steel Development in 2010, reported that gold bearing deposits contain high concentration of Pb and other heavy metals, and no reports has shown that these mined gold undergo pretreatment process to remove the solvent and other toxic element before it is transported to goldsmith workshops. Therefore, the levels of these metals (Cd, Fe, Pb,

Au and Hg) in the soils require constant monitoring because of the location of these workshops, and also the toxicity of these metals that can damage the health of the ecosystem in general (Voet. *et al.*,2016).

However, there have been a limited number of studies on heavy metals exposure in goldsmith workshops in Nigeria, perhaps there have been no studies as of yet which have measured heavy metals in the soil of goldsmith workshops. There is a need to provide a baseline data of heavy metals exposures in goldsmith workshops in order to compare to the existing studies.

2.0 MATERIALS AND METHODS

2.1 Sampling

The samples were collected from four selected goldsmith workshops and a control site all in Gusau metropolis of Zamfara state. The samples were collected at a depth of 15 cm from the surface using clean stainless steel materials. Grid sampling method was employed and the sample was thoroughly mixed to have composite samples and transferred into clean and well labeled polythene bag for onward analysis in the laboratory.

Table 1: Sample Location Coordinate and Their Respective Designation

S/N	POINT COORDINATE	SAMPLE LOCATION	DESIGNATION
1	12°10' 7.3'' N 6°39' 52.8'' E	Alh. Abdulraheem Goldsmith Workshop (at Sabongari Unguwar Toka Area, Gusau Zamfara State)	RHM
2	12°10' 12.10'' N 6°39' 46.70'' E	Alh. Abdulrauf Goldsmith Workshop (along Unguwar Toka Road, Gusau Zamfara State)	RUF
3	12°10' 15.23'' N 6°39' 57.02'' E	Baban Abdulsalam Goldsmith Workshop (at polo Market Opposite Old Park Gusau Zamfara State)	BAS
4	12°10' 13.39'' N 6°39' 54.34'' E	Sarkinruwa Goldsmith Workshop (along Railway Track Gusau Zamfara State)	SKR
5	12°10' 1.70'' N 6°40' 2.63'' E	Nizzamiyah primary school (football pitch) gusau Zamfara State	NPS

2.2 Sample Treatment

1g of the oven dried ground and sieved sample was weighed using a top loading balance and placed in a 250 ml beaker which was previously washed with nitric acid and distilled water. The sample was reacted with 5 cm³ of HNO₃, 15 cm³ of concentrated H₂SO₄ and 0.3 cm³ of HClO₄ using dropping pipette. The mixture was digested in a fume cupboard, heating continued until a dense white fume appeared which was ingested for 15 minutes, set aside to cool and diluted with distilled water. The mixture was filtered through acid washed Whatman filter paper into a 50cm³ volumetric flask and diluted to mark volume (Walinga *et al.*, 1989, Sahrawal *et al.*, 2002 and Inuwa, 2004). The sample solution was then

aspirated into the Atomic Absorption Spectroscopic machine and Microplasma Atomic Emission Spectrophotometer (MP-AES).

2.3 Sample Analysis

The metal concentration were determined using Atomic Absorption Spectroscopic machine (210 VGP model) and Microplasma Atomic Emission Spectrophotometer MP-AES (MY17380004 model) at intervals by adopting specific cathode – ray tube for each metals (Garry, 1989).

All samples were determined in triplicate. Mean and standard deviation of all the values were calculated using SPSS21Version.

3.0 RESULTS AND DISCUSSION

3.1 Results

Table 2: Heavy Metals Of Soil Sample From Goldsmith Workshops In Gusau Zamfara State

METALS	RHM	RUF	BAS	SKR	CRL
Au (Mg/Kg)	0.043±0.19 ^a	0.023±0.07 ^a	0.040±0.000 ^a	0.027±0.01 ^a	ND
Cd (Mg/Kg)	0.020±0.01 ^a	0.013±0.003 ^a	0.013±0.003 ^a	0.020±0.00 ^a	ND
Fe (Mg/Kg)	150.4±18.7 ^a	134.7±17.9 ^a	117.3±7.70 ^a	157.78±9.55 ^a	120.6±13.7 ^a
Hg (Mg/Kg)	0.370±0.27 ^a	0.25±0.05 ^a	0.843±0.05 ^a	0.033±0.012 ^b	ND
Pb (Mg/Kg)	0.08±0.01 ^a	0.15±0.1 ^{ab}	0.15±0.05 ^{ab}	0.283±0.234 ^{ab}	ND

- Data Are Mean ± The Standard Deviation Of Three Replicate Results
- Values Within The Same Row With Different Subscript Are Significantly Different At P<0.05

Table 3: Standard Values Of Heavy Metals In Soils

STANDARD (Mg/Kg)	Au	Cd	Fe	Hg	Pb
EU	---	3	---	---	300
FEPA	80	0.3	400	0.03	1.6

Key ND = Not Detected

EU = European Union

FEPA = Federal Environmental Protection Agency

4.0 DISCUSSION

The summary of the results of heavy metals analyzed in all the samples were reported in table 2.

4.1 Gold (Au)

Table 2, showed clearly that Au was either absent or below the detection limit of the machine in the control site designated as NPS and maximum value of 0.043±0.19 mg/kg was recorded at a workshop designated as RHM. Similarly, the results indicated no significant ($p>0.05$) different between all the goldsmith workshops. The concentration is clearly as a result of anthropogenic impute (mined gold). Inhalation of impure gold may cause irritation, if exposure is prolonged or excessive. Ingestion has no adverse effects, but may also cause irritation and allergic reaction on skin and also causes eye irritation (lenntech, 2013). Gold however, is used

to cure rheumatoid arthritis, under a treatment called Chrysotherapy. It is prescribed when treatment with non-steroid anti-inflammatory drugs is failing to give relief. Gold has not been evaluated for its ecotoxicity. The biodegradation of gold under aerobic conditions is expected to be very poor and there is no evidence to suggest it creates ecological problems when released into the environment. Since gold is insoluble, it is believed to have minimal bioaccumulation and bioavailability characteristics (lenntech, 2013).

4.2 Cadmium (Cd)

The results for Cd revealed that it was absent or below the detection limit of the machine in the control site designated as NPS and maximum value of 0.02±0.01 mg/kg was also recorded at a workshop designated as RHM. Similarly, the results indicated no significant ($p>0.05$) different between all the goldsmith workshops. The

concentration can also be traced to an anthropogenic impute from the gold. However, the concentration were although below the permissible limit of (3 and 0.3 mg/kg) set by the EU and FEPA respectively for soils. The values reported slightly agreed with the mean concentration of (0.01 ± 0.03 mg/kg) reported by (Eze *et al.*, 2018) in an irrigated site along the bank of Mpape river in FCT, Abuja but above (0.005 ± 0.0013 mg/kg) reported by (Muhammad *et al.*, 2013) in sediment of Abare gold mining site in Zamfara state.

4.3 Iron (Fe)

It can be observed, from the table that, Fe is the highest metal in the samples. The values of Fe obtained in all the sampled soils ranged from 117.3 ± 7.70 mg/kg to 157.78 ± 9.55 mg/kg. The maximum value of 157.767 ± 9.548 mg/kg was recorded at a workshop designated as SKR while the minimum value of 117.3 ± 7.70 mg/kg was recorded at a workshop designated as BAS. Similarly, the results indicated no significant ($p > 0.05$) different between all the samples analysed. It is therefore obvious that the concentrations were due to the geology of the sampled area (Gusau). The concentrations were below the permissible limit of (400mg/kg) set by FEPA for soils. The values reported were below (195.25 mg/kg) reported by (Tsafe *et al.*, 2012) in a soil around Yangalma area Zamfara state, and far below mean concentration of (1024 ± 0.0013 ppm) reported by (Muhammad *et al.*, 2013) in a sediment in Abare gold mining site in Zamfara state.

4.4 Mercury (Hg)

The results for Hg revealed that either it was absent or below the detection limit of the machine at the control site designated as NPS. On the other hand the maximum value of 0.84 ± 0.05 mg/kg was recorded at a workshop designated as BAS. Similarly, the results indicated no significant ($p > 0.05$) different between the samples except for SKR which were significantly ($p < 0.05$) different from the remaining samples. The concentration can also be traced to anthropogenic impute, through both point and non point sources. Hg is one of the chemicals often used at the workshop for trapping gold from soil, or as a result of

excessive Hg from mined gold. However, the concentrations were above the permissible limit of (0.03 mg/kg) set by both the EU and FEPA for soils. The values reported were far below the mean concentration of (2.540 ± 0.0007 ppm) reported by (muhammad *et al.*, 2013) in a sediment in Abare gold mining site in Zamfara state but above the mean concentration of (0.212 ± 0.149 ppm) reported by (Boamponsem, 2010) in a sediment of Tarkwa gold mining area of Ghana. Exposure to high levels of metallic, inorganic, or organic mercury can permanently damage the brain, kidneys, and developing fetus. Effects on brain functioning may result in irritability, shyness, tremors, changes in vision or hearing, and memory problems. Short-term exposure to high levels of metallic mercury vapors may cause effects including lung damage, nausea, vomiting, diarrhea, increases in blood pressure or heart rate, skin rashes, and eye irritation. Very young children are more sensitive to mercury than adults (UNEP / UNOCHA, 2010).

4.5 Lead (Pb)

Lead is known to exert its most significant effect on the nervous system, including motor disturbances, sensory disturbances, the hematotoxic system and the kidney and ultimately, major brain damage (Macrea *et al.*, 2010). The results for Pb also revealed that either it was absent or below the detection limit of the machine in the control site (NPS). However, maximum value of 0.283 ± 0.234 mg/kg was recorded at a workshop designated as SKR. Similarly, the results indicated no significant ($p > 0.05$) different between all the samples except for RHM which were significantly ($p < 0.05$) different with the remaining samples. The concentration here again varies from different workshop to another but can also be as a result of anthropogenic activities at the sampled area (mined gold). Nigeria Ministry of Mines and Steel Development in 2010, reported that gold bearing deposits contain usually problematic concentration of Pb and other heavy metals. However the concentrations were below the permissible limit of (1.6 mg/kg) FEPA but very far below (300 mg/kg) of EU for soils. The values reported were very far below the mean concentration of

(59.13 ± 48.9 ppm) reported by (Oyeleke *et al.*, 2015) in a surrounding soil of an Automobile battery factory in Ibadan but agree with (0.216 ppm) reported by (Abiya, *et al.*, 2018) in a gold mining site of Ilesha Osun State.

5.0 CONCLUSION

The present study revealed that all the metals contents investigated were within the limit recommended by EU and FEPA in soils with the exception of Hg, and Au which were higher. The high level of these metals could be attributed to the Anthropogenic impute (inorganic chemicals at the workshops and as well as the mined gold).

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- Other metals like; Pb and Cd, were generally below the recommended levels by EU and FEPA but their presence cannot be far fetch from the anthropogenic impute either, considering the absence of these metals in the control site. Fe on the other hand is from the geology of the sampled area. Similarly, the results indicated that the metals were distributed differently in the soils with high significant ($p < 0.05$) different between the samples. However, possible adverse effect may occur among the inhabitants of this study area especially in the cases of Hg, and Au if they bio-accumulates beyond the tolerable concentrations in the body.
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