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Heavy Metals Contamination of Soils around Dan–Kande Gold Mine Environment at Maru, Nigeria

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ABSTRACT

Soil and Tailing samples in Dan-Kande gold mining environment were analysed with the aid of X-Ray Fluorescence technique. The long period of artisanal mining exercises in the environment calls for investigation for health benefits of critical group. Of the detected elements, It was observed that Mn, Fe, Ni, Cu, and as occurs in raised concentrations at many folds above USEPA regulatory benchmarks at the café and residential areas. There is a close correlation between the raised values obtained from the House and café samples indicating that minerals are being taking into various houses for processing. This is a potential health bomb due to explode.

Introduction

Background to Research

In March 2010, an unusually high number of deaths, primarily among children under age 5 in Bukkuyum and Anka Local Government Areas (LGAs) of Zamfara State, northern Nigeria, was reported by Médecins sans Frontières (MSF-Holland) to state health authorities.(UNEP, 2013). Analysis of cause of the crisis was traced to poisoning due to pollution by Lead generated as a result of artisanal gold mining activities. The world's attention beamed focus on Nigeria. Ever since then a lot of remediation activities had been underway in the affected zones.

The Lead poisoning outbreak is just an index of the health problem sources that lurks behind the mining exercises based on the method applied. The high concentration of Lead discovered is one of the many possibilities of raised heavy metal concentrations that can accompany human anthropogenic activities such as mining. As a result of their physical and chemical properties, a different form of heavy metals exhibits different variations of characteristics. These characteristics determine the possible health effects that can results if allowed to bio-accumulate in human body. The resulting health effect may range from immediate to latent effects. Of latent effects, cancer formation is one of the most noticeable ones.

Heavy metals normally occurring in nature are not harmful to the environment. This is because they are only present in small amounts. The heavy metals become pollution when they show up in huge amounts primarily due to industrialization. (Baranowski R., et. al.,2011, Ewa, I.O.B., et.al., 2000, Ewa. I. O. B., et.al, 1989). Mining exercises is a major industrial activity that can generate heavy metals at elevated levels. Once generated they bio-accumulates and become potential source of health hazards to exposed populace. As human activity impacts upon the environment, metal contamination issues are becoming increasingly common (Fernandes and Henriques, 1991).

The concerns for heavy metals arise from their persistence and harmful effects on the environment and human health (Purves, D., 1985, Biney, C. A., 1991). Trace amounts of heavy metals can accumulate in the food chain (Gupta, A., 1995, Gulson, B. L., et.al. 1996, Folt Carol L., Cheu Celia Y., 2001), eventually causing diseases such as autism, cancer, dementia, dyslexia, leukaemia, lymphoma etc and health condition such as neuro-degeneration and senility (ASTDR,1999, Windham, B., 2000). Metals such as selenium, zinc, manganese, copper, nickel etc are essential for proper metabolism and development in living organisms (Rainbow, P. S., 1985. Hunter, M., et.al.1986), however, they are detrimental to health at elevated levels.

Justification for the research

Médecins Sans Frontières (MSF-Holland) focuses its attention mainly on the resulting immediate effect of the Lead poisoning; the possibility exists of a host of other heavy metals present in the polluted zone to occur at raised concentrations with various resultant latent effects. Thus the need arises for surveys and researches on;

I. Dan-Kande as one of the yet-to-be-covered areas by documented survey to determine possible immediate and latent hazards that may exist due to the artisanal exercises,

II. Dan-Kande in a bid to establish preliminary data on the environment and raise possible alert were potential threat to human life is found to exist.

Methodology

The soil and tailing samples were collected from different mining stages and the compounds of the villagers with the aid of sterilized plastic container, the samples were pulverized with the aid of agate mortar and pestle into a fine powder. The powders were prepared into a thick pellet of 13mm diameter. The analysis was carried out at the Center for Energy Research and Development (CERD), Obafemi Awolowo University, Ife, Nigeria.

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Table 1. Location characteristics of study area

	Location Characteristics			
Sample code	Description	Coordinates		Elevation
		Lat (N)	Long (E)	(M)
DKM1	Mill samples	12.17579	6.3835	484
DKM2	Mill samples	12.17591	6.3836	481
DKM3	Mill samples	12.17624	6.38352	480
DKM4	Mill samples	12.17653	6.38313	483
DKH1	House samples	12.17577	6.38354	486
DKH2	House samples	12.17514	6.3829	479
DKH3	House samples	12.17486	6.37652	482
DKH4	House samples	12.17432	6.37054	477
DKH5	House samples	12.17379	6.37021	480
DKC1	Mine cave samples	12.19195	6.36968	498
DKC2	Mine cave samples	12.19242	6.37	500
DKC3	Mine cave samples	12.19289	6.37038	502
DKC4	Mine cave samples	12.19335	6.37073	514

Table 2. Dan-Kande Mining café sample results

Dan-Kande Café Samples (PPM)									
Element	DKC1	DKC2	DKC3	DKC4	Mean	Max.	Min.	Toxicology Benchmark	References
K	N.D	N.D	44759	28402	36580.5	44759	28402	N.S.L*	(OFNL, 2008)
Ti	N.D	N.D	7411	4815	6113	7411	4815	47000	(OFNL, 2008)
Mn	N.D	298	2087	3607	1997.333	3607	298	3200	(OFNL, 2008)
Fe	225759	42018	259222	25646.4	138161.4	259222	25646.4	55000	(OFNL, 2008)
Ni	15286	26	2740	1190	4810.5	15286	26	1600	(OFNL, 2008)
Cu	21029	11	1582	670	5823	21029	11	2900	(OFNL, 2008)
Zn	16145	351	4888	3300	6171	16145	351	23000	(OFNL, 2008)
Sr	N.D	884	N.D	N.D	884	884	884	47000	(OFNL, 2008)
As	72119		42200	61997	58772	72119	42200	100	NEPC (2003), ANZECC (2000)

N.S.L.*: No Screening Level, N.D: Not Detected

Table 3. Dan-Kande residential Compound sample results

House samples										
Element	DKH1	DKH2	DKH3	DKH4	DKH5	Mean	max	Min.	Toxicological Benchmarks in PPM	References
Ca	163000	N.D	N.D	28900	N.D	95950	163000	28900	N.S. L.	OFNL, 2008
Ti	3000	3000	3000	24706	29400	12621.2	29400	3000	47000	OFNL, 2008
Mn	604	465	693	2519	21600	5176.2	21600	465	3200	OFNL, 2008
Fe	42371	42534	42479	287734	221484	127320.4	287734	42371	55000	OFNL, 2008
Ni	26	26	26	N.D	16310	4097	16310	26	1600	OFNL, 2008
Cu	11	11	11	N.D	23531	5891	23531	11	2900	OFNL, 2008
Zn	249	233	170	23140	15632	7884.8	23140	170	23000	OFNL, 2008
Sr	329	319	1111	N.D	N.D	586.3333	1111	319	47000	OFNL, 2008
As	N.D	N.D	N.D	N.D	56045	56045	56045	56045	100	NEPC (2003), ANZECC (2000)

Table 4. Dan-Kande Mill sample results

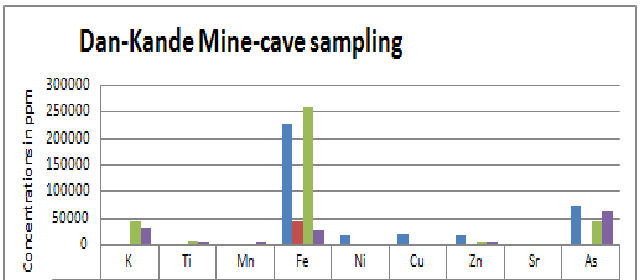
HOU										
Element	DKH1	DKH2	DKH3	DKH4	DKH5	Mean	max	Min.	Toxicological Benchmarks in ppm	References
Ca	163000	N.D	N.D	28900	N.D	95950	163000	28900	N.S. L.	EPA Human health
Ti	3000	3000	3000	24706	29400	12621.2	29400	3000	47000	EPA Human health
Mn	604	465	693	2519	21600	5176.2	21600	465	3200	EPA Human health
Fe	42371	42534	42479	287734	221484	127320.4	287734	42371	55000	EPA Human health
Ni	26	26	26	N.D	16310	4097	16310	26	1600	EPA Human health
Cu	11	11	11	N.D	23531	5891	23531	11	2900	EPA Human health
Zn	249	233	170	23140	15632	7884.8	23140	170	23000	EPA Human health
Sr	329	319	1111	N.D	N.D	586.3333	1111	319	47000	EPA Human health
As	N.D	N.D	N.D	N.D	56045	56045	56045	56045	100	NEPC (2003), ANZECC (2000)

The elemental analyses of the soil and tailing samples were carried out using the Energy Dispersive X-ray Fluorescent (EDXRF) spectrometer. The spectrometer an ECLIPSE III, supplied by AMTEK INC. MA; USA, is a self-contained miniature X-ray tube system. It features a 30 kV/100 μA power supply, silver (Ag) transmission target, and a beryllium end window. In order to facilitate the use of this spectrometer, a portable controller is attached to it which generates all the voltages needed to operate the X-ray tube and provides both the voltage (kV) and current (μA) display and control. All our measurements were taken using the voltage 25 kV and current 50 μA. Each sample was irradiated for 1,000 seconds. The dead time was less than 5% using Teflon filters before the detector. The detection system for all the measurements is a Model XR-100CR which is a high performance X-Ray Detector with preamplifier and a Cooler System which uses a thermoelectrically cooled Si-PIN Photodiode as an X-Ray detector. The power to the XR-100CR is provided by the PX2CR power supply. The detector is coupled to the Pocket MCA 8000A Multichannel Analyzer. The resolution of the detector for the 5.9 keV peak of 55Fe is 220 eV FWHM with 12 μs shaping time constant for the standard setting and 186 eV FWHM with 20 μs time constant for the optional setting. The optional setting was used for our measurements with the resolution of 186 eV for the 5.9 Peak of 55Fe. The quantitative analyses of samples were carried out using the Quantitative Analysis Software package. It converts elemental peak intensities to elemental concentrations and/or film thicknesses.

Figure1. One of the mining cafes in the study area where soil samples were collected

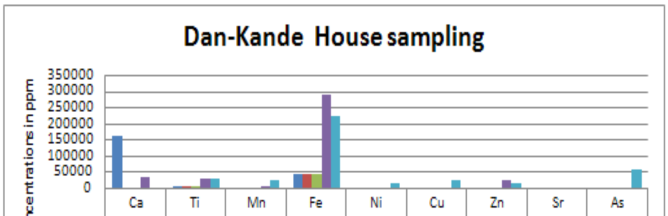
Figure 2. A research member discussing events with a tour guide. To the right are heaps of Tailings from mineral processing

Results



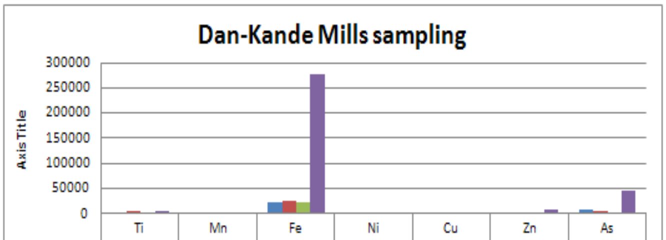
	K	Ti	Mn	Fe	Ni	Cu	Zn	Sr	As
DKC1	N.D	N.D	N.D	225759	15286	21029	16145	N.D	72119
DKC2	N.D	N.D	298	42018	26	11	351	884	N.D
DKC3	44759	7411	2087	259222	2740	1582	4888	N.D	42200
DKC4	28402	4815	3607	25646.4	1190	670	3300	N.D	61997

Figure 3.Mine café sampled results



	Ca	Ti	Mn	Fe	Ni	Cu	Zn	Sr	As
DKH1	163000	3000	604	42371	26	11	249	329	N.D
DKH2	N.D	3000	465	42534	26	11	233	319	N.D
DKH3	N.D	3000	693	42479	26	11	170	1111	N.D
DKH4	28900	24706	2519	287734	N.D	N.D	23140	N.D	N.D
DKH5	N.D	29400	21600	221484	16310	23531	15632	N.D	56045

Figure 4. Dan-Kande house sampled results



	Ti	Mn	Fe	Ni	Cu	Zn	As
DKM1	620	120	23859	N.D	N.D	1279	7932
DKM2	2940	2160	24336	1102	1439	1024	2753
DKM3	2940	2160	23164	910	1483	930	4055
DKM4	5130	1365	277720	N.D	N.D	8054	45696

Figure 5. Mill sample results

Discussion

The distribution of the heavy metals and metalloid in this exercise falls into three identifiable categories; Potassium, K, with maximum concentration at the mine café, as 44759 ppm and Calcium, Ca, with maximum level at the residence area at 163000 ppm, fall to the No Screening Level (N.S.L.) according to United States Environmental Protection Agency. Mn, Ti, Sr, Ni, Cu and Zn falling within regulatory benchmarks, thus are of no importance in the discussion in this context. The last category of heavy metal considerations in the present study fall on the ones that exceeds the benchmarks as stipulated by the regulatory bodies concerned. These are Arsenic, As, and Iron, Fe. The maximum concentrations of Arsenic at the three stages examined are 72119 ppm, 56045ppm and 45696 ppm at the mine café, house and the mill respectively. The regulatory benchmark considers 100 ppm as the upper limit of safety considerations for the metal in question. This implies that Arsenic is found to have been raised at many folds beyond benchmark at the three stages examined. These are indications of health risk factor for habitants and mine workers in the zone.

According to Khawar Sultan, 2006, citing USEPA (1996) and ATSDR (1989), arsenic is one of the top three elements identified as having adverse public health effects based on itstoxicity. It has been recognized as being poisonous to humans since ancient times. Elevated arsenic levels in soil/rock are one of the major sources of arsenic contamination of surface, ground and drinking water throughout the world and recently have become the focus of investigation of the possible source, mobility and fate of arsenic in local environments (Smedley and Kinniburgh, 2002; Grosz et al., 2004; Mahoney et al., 2005). The toxic effects of arsenic on plant, animal and human health have become a global issue due to the potential risk posed by arsenic entering the food chain (Khawar S., 2006). In this work, the recorded level of Arsenic reaching as far as 45696 ppm indicates the necessity to study the geochemistry of Arsenic in the zone. Arsenic is naturally associated with elements such as Pb, Zn, Cu, Fe and Au in ores. The high soil arsenic content is due to the elevated background soil levels and fixation of arsenic onto the secondary oxides of Fe, Al and Mn. This corresponding high level of Fe observed in the study is in accordance with noted association between As and Fe.

Conclusion

Based on the consistently high concentration levels at all the examined stages of Fe and As, there is a strong indication that the villagers at the mining locality under study interacts well with the processing activities. This in event is a potential risk factor to the development of health problems from the exercises by the local populace that are grossly unaware of what they are exposing themselves to.

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