



Assessment into the Effectiveness of Remediation Exercise of Heavy Metals Contaminated Villages of Abare and Dareta in Zamfara State, Nigeria

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Abstract

This work evaluated the heavy metals concentration in Abare and Dareta Villages of Anka Local Government of Zamfara State after remediation exercise. The mean concentration of these metals in rainy season is Cu > Pb > Mn > Cd > Cr in both Abare and Dareta. While for dry season is Pb > Cd > Cu > Mn > Cr in Abare and Pb > Cu > Cd > Mn > Cr in Dareta. Seven samples out of ten samples collected from Abare during the dry season have lead concentration exceeding some European countries permissible value of 100mg/kg while only two samples shows Lead concentration exceeding that permissible value in rainy season. All the samples collected in both rainy and dry seasons have lead concentration below the United Kingdom (UK) and United State Environmental Protection Agency (USEPA) guide limits. Six samples out of ten samples collected during the dry season from Dareta have Lead concentration exceeding the permissible value of 100mg/kg for some European countries while four samples shows lead concentration exceeding that permissible value in dry season. All the samples collected in both rainy and dry seasons have lead concentration below the United Kingdom (UK) and United State Environmental Protection Agency (USEPA) guide limits. The concentration of chromium in both dry and rainy season is below the permissible values given by United Kingdom and some European countries. The overall result indicate that there is decrease in the concentration of most of the heavy metals analyzed from dry to rainy seasons in each of the remediated villages, which is largely attributed leaching processes and as well as reduction in the amount dust carried by the wind during rainy season, as such the concentration is expected to rise when the rain stop, due to the continuation of unsafe mining practice in the area.

Keywords: Remediation; heavy metals; environmental protection; concentration; leaching.

1.0 INTRODUCTION

Heavy metal contamination in the soils is a major concern because of their toxicity and threat to human life (Yahaya, *et al.*, 2010). Uncontrolled and illegal mining activities in developing countries have left a lot of environmental hazards, enormous amount of wastes and different types of pollutants on the mining communities.

The mining region of Northern Nigeria is known since the colonial era. The popular among them is the Jos in late 70's and the Zamfara mining belt. The Zamfara mining region has deposits of precious metals like tantalite and gold among other (Alhassan *et al.*, 2010). Mining of solid minerals has been identified as a major source of heavy metals in the environment because ore bodies generally include a range of minerals containing both heavy and essential metals. Opencast mines and underground mines are the most important and common methods of extraction of minerals from the earth (Sneha *et al.*, 2012). In most mining areas of Nigeria where illegal mining is commonly practiced, the interaction of solid minerals and the water sources is inevitable. In essence, water bodies such as rivers and lakes are used in floatation process to separate the ore after crushing. In most developing countries like Nigeria, underground water has remained a major source of water to the teeming population of the people in the rural areas. Water quality assurance is therefore a collective responsibility. Water quality is to some extent an index of water pollution, the indices presently used in Nigeria are inadequate to indicate the damage that is done by heavy metals (Wakawa *et al.*, 2008). The health implications of heavy metals like Ni, Pb, Co, Cr, Al, Mn, Zn and Cd had been fully documented. Significant contamination of seeds, plants and plant products with toxic chemical elements due to contaminated soil and water has been observed as result of release of these toxicants into the sea, rivers and even into irrigation channels. Afterwards, the consumption of contaminated vegetables constitutes an important route of animal and human exposure (Sajjad *et al.*, 2009).

Medecins Sans Frontieres (MSF) in March 2010 discovered an epidemic of Lead poisoning in

Zamfara state, Northern Nigeria. US Centers for Disease Control (CDC), the World Health Organization (WHO) and the Zamfara State Ministry of Health (ZMoH) investigations confirmed the report with over 10,000 people estimated to have been affected (Gale, 2011). The source was traced to environmental exposure to Lead from the processing of Lead-rich ore mined by artisans in the state for Gold extraction. Grinding of the rocks into fine particles in the mills scattered round the villages resulted in the dispersal of lead dust (Kelvin, 2011). These contaminants enter into the human body through inhalation, accidental ingestion of contaminated soil, drinking of contaminated water and absorption through the skin. There have been more deaths from Lead poisoning in Zamfara, than the whole world combined in the last 40 years, particularly amongst children who are uniquely susceptible to Lead poisoning (Shiloh, 2010 and Sola, 2010).

Dareta and Abare villages were remediated between June and mid July 2010 when work was suspended due to the onset of rains. The cleanup was a simple process of taking off five centimeters of the contaminated top soil and replacing it with clean soil having confirmed from previous investigations that the contamination was superficial. Studies have confirmed high Lead, Cadmium, and Copper levels in blood and water after the remediation exercise (Ogabiela, 2011a and Ogabiela, 2011b). This study was carried out after the remediation exercise in Dareta and Abare village, to assess Lead, Cadmium, Manganese, Chromium and Copper levels in surface soils and by implication the effectiveness of the cleanup exercise. The fact remains that unless the homes are fully decontaminated and the Lead removed from the environment, the risk of continued poisoning and death remains (Gale, 2011). Complete resolution of the situation also demands sustained changes to mining practices to prevent further contamination (Sertox, 2011). The current study reports an Assessment into the effectiveness of remediation exercise of heavy Metals contaminated villages of Abare and Dareta in Zamfara state, Nigeri

2.0 MATERIALS AND METHOD

2.1 Sample collection and preparation

Samples were collected from Abare and Dareta villages in Anka local government area, during the period of March and August to represent dry and rainy seasons respectively. All the containers and tools used for sample collection were washed with liquid detergent, rinsed with 20% (v/v) nitric acid and finally rinsed with distilled water.

2.2 Soil samples

The soil samples were collected at the surface level of 0-5cm depth from various locations in Dareta and Abare villages, in each of the two visits. The areas covered includes residential compounds, market square, playground, and around water wells. The collected soil samples were air dried and crushed using laboratory mortar and pestle. The fine soil particles were sieved using 200mm mesh sieve before wet digestion. Well-mixed samples of One gram each of the ground soil samples was weighed into a 250 ml beaker and digested with a mixture of 4 ml, 25 ml and 2 ml each of concentrated HClO₄, HNO₃ and H₂SO₄, respectively, on a hot plate in a fume cupboard. At completion of digestion, the samples were cooled and diluted

with 50 ml of distilled water, then the samples were filtered. And then make to 50 ml with distilled water (Chiroma *et al.*, 2012).

2.3 Water samples

50 ml each of the water samples was transferred to an evaporating dish and evaporated on a steam bath to about 20 ml. 10 ml of 8 M HNO₃ of 98 % purity was added and evaporated on a hot plate to near dryness. The residue was quantitatively transferred using two aliquot of 10 and 15 ml of concentrated HNO₃ into a 250 ml flask. 20 ml of HClO₄ was added and boiled until the solution became clear and white fumes of HClO₄ appear. It was then cooled and distilled water (about 50 ml) was added and the solution filtered. The filtrate was quantitatively transferred to a 100 ml volumetric flask with two portions of 5 ml of distilled water. The solution was diluted to mark and mixed thoroughly by shaking (Chiroma *et al.*, 2012).

2.4 Heavy metal analysis

The concentrations of Cd, Cr, Cu, Mn, and Pb in the final solutions were determined using Buck Scientific Model 210VGP Atomic Absorption Spectrometer (AAS).

3.0 RESULTS AND DISCUSSION

Tables 1 and 2 reported the mean concentrations of heavy metals in the soil samples. The mean concentration of these metals in rainy season is Cu > Pb > Mn > Cd > Cr in both Abare and Dareta. While for dry seasons is Pb > Cd > Cu > Mn > Cr in Abare and Pb > Cu > Cd > Mn > Cr in Dareta.

Abare: Seven samples out of ten samples collected during the dry season have lead concentration exceeding some European countries permissible value of 100mg/kg while only two samples shows Lead concentration exceeding that permissible value in rainy season. All the samples collected in both wet and dry seasons have lead concentration below the United Kingdom (UK) and United State Environmental Protection Agency (USEPA) guide limits. This finding shows that the lead

concentrations of the soil are relatively safe as at the time of the sample collection. All the samples collected (wet and dry seasons) have concentration of cadmium greater than the permissible value of some European countries (5mg/kg) and USEPA (3mg/kg). This shows that the soil around the Abare village is not safe as residential or commercial purpose. While two samples have copper concentration greater than the permissible value of some European countries (100mg/kg) in dry season, all the samples have copper concentration greater than the permissible value of some European countries in the dry season. Only one sample has concentration of copper exceeding the United Kingdom permissible value of 400mg/kg in the rainy season. However, two samples have copper concentration greater than the guideline

values given by USPEA (50mg/kg) in the dry season while the entire samples collected during the rainy season have copper concentration greater than the guide value given by USEPA. The concentrations of chromium in both dry and rainy seasons are below the permissible value of 400mg/kg (USEPA) and 100mg/kg (European Countries). No sample has concentration of manganese up to USEPA 80mg/kg guide level in the wet season. But, two sample collected in the dry season have concentration of manganese greater than the USEPA limit.

Dareta: Six samples out of ten samples collected during the wet season have Lead concentration exceeding the permissible value of 100mg/kg for some European countries while four samples shows lead concentration exceeding that permissible value in dry season. All the samples collected in both wet and dry seasons have lead concentration below the United Kingdom (UK) and United State Environmental Protection Agency (USEPA) guide limits. The concentration of chromium in both dry and wet season is below the permissible values given by United Kingdom and some European countries. Two samples have copper

concentration greater than permissible value in wet season and all the samples collected in dry season have copper concentration greater than the permissible value set by some European countries. Five samples collected during the wet season have concentration of copper greater than the guide value of 50mg/kg set by USEPA. All the samples obtained in the dry season have concentration of copper greater than the value set by USEPA. All the samples collected (wet and dry seasons) showed concentrations of cadmium greater than the permissible value of some European countries (5mg/kg) and USEPA (3mg/kg).

The high concentrations in some samples collected in both Abare and Dareta are due to the fact that processing activity is taking place in the study areas during the sample collection use period. It is therefore necessary to hold the processing activity after the remediation process since these metals have ability to accumulate with time. It is consequently misleading to conclude that the soil in Abare and Dareta is safe.

Table 1: Average Heavy metals concentration soil (mg/kg) from Abare.

DRY SEASON					
Sample	Cd	Pb	Mn	Cu	Cr
1	50	225	50	50	3.846
2	250	125	50	50	ND
3	150	100	50	100	ND
4	50	75	25	50	3.846
5	50	250	50	50	3.846
6	50	175	75	50	3.846
7	100	225	75	ND	3.846
8	150	175	50	50	ND
9	50	225	25	50	ND
10	150	75	50	100	ND
United kingdom	3	300	---	135	50
USEPA	3	400	80	50	400
European countries	5	100		100	100
RAINY SEASON					
1	50	50	75	250	7.692
2	25	50	150	200	11.538
3	25	100	50	350	3.846
4	25	100	75	450	15.385
5	50	100	25	250	19.231
6	100	75	75	300	11.538

7	25	150	50	200	15.385
8	50	100	100	250	7.692
9	25	75	50	200	11.538
10	100	150	25	350	19.231

ND= not detected.

Table 2: Average Heavy metals concentration soil (mg/kg) from Daretta.

DRY SEASON					
Sample	Cd	Pb	Mn	Cu	Cr
1	100	125	50	200	3.846
2	50	125	25	100	3.846
3	50	100	50	150	ND
4	50	125	50	50	ND
5	100	125	75	50	ND
6	150	100	50	50	ND
7	50	75	50	100	ND
8	100	125	50	ND	ND
9	50	100	50	200	ND
10	100	125	50	50	ND
United kingdom	3	300	---	135	50
USEPA	3	400	80	50	400
European countries	5	100		100	100
RAINY SEASON					
1	25	100	50	200	7.692
2	75	150	50	150	11.538
3	50	75	100	150	15.385
4	100	125	75	350	11.538
5	50	100	100	250	19.231
6	50	75	75	300	7.692
7	75	175	25	400	11.538
8	50	100	100	250	7.692
9	50	75	75	300	11.538
10	100	125	25	150	15.385
11	50	50	25	200	11.538

ND= not detected

Although the contamination situation was less severe compared to the levels before the remediation exercise, findings from this study shows that Cadmium and Copper levels in soil are worrying. The need for further attention is obvious as the levels of these metals are sufficiently high to cause significant health challenges. The implications of chronic exposure to these contaminants are also critical.

The concentrations of heavy metals in underground water in Abare and Daretta (dry and wet seasons) are presented in the Tables 3 and 4.

The concentration of Cadmium, Lead, and Manganese are greater than the WHO guideline values for drinking water in both Abare and Daretta during the first visit (wet season). Two wells out of the five wells in Abare and three wells out of the four wells in Daretta showed concentrations of chromium greater than the WHO guide line values for drinking water. While no well in Abare and Daretta have copper concentration greater than WHO guide line values for drinking water during the wet seasons. All the five wells in Abare and four wells in Daretta have concentration of Cd, Pb,

Cr, Cu, and Mn greater than WHO guide line values for drinking water during the dry seasons.

Table 3: Average heavy metal concentrations in water (mg/L) from Abare.

DRY SEASON					
Sample	Cd	Pb	Mn	Cu	Cr
Well 1	3	2.5	3.5	2	0.077
Well 2	5	2.5	0.5	2	0.077
Well 3	3	2	1.5	1	ND
Well 4	1	3	1.5	2	ND
Well 5	1	1.5	0.5	2	ND
RAINY SEASON					
Well 1	1.5	1.5	1	8	0.231
Well 2	0.5	2.5	2	6	0.231
Well 3	1	2	1.5	5	0.308
Well 4	2	1	1	4	0.154
Well 5	1	2	1.5	7	0.308
WHO Values	0.003	0.01	0.10	2.00	0.05
USEPA Vaues (MCL)	0.005	0.015	0.05	1.00	0.10

ND= not detected

Table 4: Average heavy metal concentrations in water (mg/L) from Dareta

DRY SEASON					
Sample	Cd	Pb	Mn	Cu	Cr
Well 1	3	2	1.5	2	ND
Well 2	3	3	1	1	0.077
Well 3	2	1	1	2	0.077
Well 4	3	1	0.5	2	0.077
RAINY SEASON					
Well 1	1	2	0.5	7	0.231
Well 2	1	2.5	0.5	5	0.231
Well 3	1.5	1.5	1	8	0.308
Well 4	1	2.5	2	6	0.154
WHO Values	0.003	0.01	0.10	2.00	0.05
USEPA Vaues (MCL)	0.005	0.015	0.05	1.00	0.10

ND= not detected, Maximum Contaminant Level (MCL)- Highest level of contaminant that is allowed in drinking water.

There is a decreased in the concentration of Cadmium and Lead in dry seasons compared with the concentration of these elements in wet season in both Abare and Dareta. This is consistent with findings from rural ground water mostly of mining district of Ghana. However, these findings are at variance with that of Dhemaji district, Assam, India (Buragohain et al., 2010) and Virudhunager district, Tamilnadu,

South India (Muthulakshni *et. al.*, 2012) where Lead concentrations were noted to be higher in the dry and wet seasons. While the concentration of Manganese, Copper, and Chromium increases in dry season compare with the concentration obtain in the wet season. The cause of high Heavy metals concentrations in the wells in this study is rather complex being a rural environment.

4.0 CONCLUSION

In this study, assessment of Lead, Cadmium, Manganese, Chromium, and Copper levels in surface soil (0-5cm) and underground water was carried out after the remediation exercise in Abare and Daretta village. There was reduction in soil levels of these metals compare with the pre remediation studies. However, Cadmium and Copper levels in many areas, including residential compounds, around drinking water sources and grinding mills exceeded the acceptable limit for residential areas. Soil chromium and manganese levels were found to be within the permissible limit, thus not implicated in the study but for their ability to bio accumulate over time, it is important to

investigate the concentrations of these metals from time to time. While commending all parties involved for the success of the remediation exercise, it is pertinent to add that serious environmental emergency of this nature cannot be resolved quickly, sustained periodic assessment and cleanup is recommended. Having acquired a remediation model and significant remediation capacity, Zamfara state authorities should rise up to the challenge.

However, the concentrations of Pb, Cd, Mn, Cr, and Cu in underground water in both Abare and Daretta far above the WHO guide level for drinking water. It is therefore necessary to find solution to this.

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