



Artisanal Gold Mining and Heavy Metals Pollution: Assessment of Drinking Water Sources in Nassarawa, Niger State, Nigeria

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ABSTRACT

Widespread artisanal mining operations are currently increasing in Nigeria. The activities are causing serious damage to the environment and populations that live in the vicinity of these mine areas. The discharges of Potentially Harmful Elements (PHEs) from these mining operations/mineral processing sites and their subsequent remobilization into the natural water bodies constitute serious human health problems. This study was carried out in Nasarawa in Magama Local Government area of Niger State, Nigeria to assess the effect of artisanal gold mining on the quality of drinking water in the community. Water quality was based on physico-chemical analysis of samples collected from water sources in the community. Water samples were collected from borehole and surface river water sources in the study area. Generally, some of the parameters analysed were well within the World Health Organization (WHO) recommend limits for drinking water quality. pH ranged from 5.3 to 6.4 conductivity ranged from 78 to 84 $\mu\text{S}/\text{Cm}$. Zinc was the only trace metal that was below maximum admissible limit for drinking water quality. Other metals (Cu, Pb, Cu, Fe and Mn) levels were however higher than WHO recommended limits for drinking water quality. However, Cadmium was not detected Cd (0.00 mg/L) Fe (241.500 mg/L), Ni (0.300 mg/L), Mn (0.800 mg/L), Zn (0.900 mg/L), Cu (0.850 mg/L) and Pb (1.00 mg/L) for surface river water, whereas, Pb (0.00 mg/L), Cd (0.850 mg/L), Zn (0.900 mg/L), Cu (0.850 mg/L), Mn (0.800 mg/L), Cd (0.00 mg/L), Fe (19.00 mg/L) and Ni (0.100 mg/L) for borehole water.

Keywords: Heavy metals, water, artisanal mining, Potentially Harmful Element (PHEs)

INTRODUCTION

In most developing nations, in fact, even in relatively advanced nations, safe drinking water is not easily available (Gabriel and Williams, 2004). In 2002, it was reported that, out of the 6 billion people on earth, over one billion people lack access to safe drinking water and about 2.5 billion do not have access to adequate sanitation services (Cobbina *et al.*, 2013). Nigeria is one of the countries in the world that is endowed with rich natural resources including gold (Lar *et al.*, 2013). Gold exploitation is in two types. That is large scale mining and small scale mining. Whereas the large scale mining involves the use of scientific methods and sophisticated machines in mining, the small scale mining makes use of simple tools or rudimentary tools in the recovery of gold from the land (Pawan and Malla, 2013). Although gold mining plays a significant role in the socio-economic life of a nation, in recent times it has become

unpopular as it is regarded as a significant source of heavy metal contamination of the environment owing to activities such as mineral exploitation, ore transportation, smelting, refining, disposal of the tailing and waste waters around mines (Cobbina *et al.*, 2013).

Both anthropogenic and lithogenic (natural) processes account for degradation in surface water and ground water quality (Dukiya, 2013). In Nigeria, contaminations of surface and ground water bodies have been experienced particularly in gold mining communities (Dukiya, 2013). Some of the impacts associated with gold mining include land degradation, destruction of vegetation and pollution of aquatic environments. With regards to gold mining in Nasarawa, gold

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bearing ore is ground thoroughly and mixed with mercury to form an amalgam. The gold amalgam is roasted to release mercury and to concentrate the gold (Idowu *et al.*, 2013). Excess mercury in the mine tailings is discarded into the environment which ends up in water bodies through runoff. Methylmercury in water and mercury oxides in air that result from gold amalgam finds itself in humans through inhalation or ingestion of water mercury contaminated fish or food (Huu *et al.*, 2010). Weathering of rocks and heaped waste materials in mining sites also result in the release of toxic chemicals into the environment especially, into aquatic bodies (Hentschel *et al.*, 2003). Other ills observed in the gold mining communities due to the small scale mining activities are rapid loss of farm lands, water in the study area, mining results in heaping of rocks and mine waste around trees. Silting of rivers and streams is also evident (AlJassir *et al.*, 2005). Heavy metals that can be leached from waste rocks into water bodies

include arsenic (As), cadmium (Cd), chromium (Cr), mercury (Hg), lead (Pb) and zinc (Zn) (Lar *et al.*, 2013). Literature sources point to the fact that most cognitive impairments especially in children is due to the presence of elevated levels of trace metals such as mercury (Hg), lead (Pb), zinc (Zn), arsenic (As) and cadmium (Cd) in the environment. The main goal of this paper is to determine the levels/concentration of some of the physicochemical parameters and trace metals (Fe, Cd, Mn, Pb, Cu, Zn and Ni) in drinking water in Nasarawa gold mining community and to compare the values with international organization such as the World Health Organization (WHO's) recommended drinking water standards. This will help to determine the state of the quality of drinking water in the community and suggest measures to reduce or prevent water pollution in the area.

Table 1: Forms of surface mining and their main environmental impacts (Dukiya, 2013).

Earth's sphere	Dry extraction	Wet extraction	Nearshore extraction	Deep-sea mining
Surface water	altered nutrient levels (potential eutrophication); pollution by contaminated wastewater, pollution by aggravated erosion.	denitrification; burdening of recipient with large quantities of muddy Wastewater, pollution by contaminated wastewater	turbidity; oxygen consumption; wastewater pollution	turbidity; oxygen consumption; wastewater pollution
Ground water	recession of groundwater; deterioration of groundwater quality	altered groundwater level; altered groundwater quality		
Miscellaneous	potential modification of microclimate	modification of microclimate; growth of pathogens in still-water areas		

METHODOLOGY

Equipment and the Method used at the mining sites

As earlier mentioned, the artisanal miners (illegal miners) totally depend on local tools like digger, hoes, axes, cutlasses, buckets and other local materials for digging into the earth crust. The few modern materials used include rock blaster and petrol pumping machine to

draw water out of the mining pits (Dukiya, 2013).

The drilling of rocks and evacuation of debris after blasting is purely manual by relay method. Different types of intoxicants are taken orally or injected into the bodies of the

young miners who work like machines tirelessly and many at times using drugs. Figures 1 to 7 show some mining sites and equipments used for mining activities.



Fig.1: Popo mining area in Kainji (Borgu LGA) Niger State



Fig.2: Unguwan Kawo mining site (Rafi LGA), Niger State



Fig. 3: Some artisanal miners extracting gold particles in the Popo mining area.



Fig. 4: Gold sample been ground using grinding machine at the processing site (Nassarawa Village)



Fig. 5: Fine gold particles after grinding at the Nassarawa processing site



Fig. 6: Shows some artisanal miners carrying out sluicing process at the Manyara river



Fig. 7: Sluicing process at the Manyara river

Study area

The study was conducted in Nassarawa Community in Magama Local Government Area of Niger State, Nigeria. The community lies between latitude 9° 55'N and Longitude 4° 31'E.

Water Sampling and analyses

Random sampling techniques were employed in the selection of sampling sites in the study area. Sampling was done between November 2016 and March 2017. Water samples were collected from two drinking water sources (River and Borehole) which are the main sources of drinking water in the study area. Sample bottles were rinsed with deionized water before samples were collected. Collected samples were preserved in an ice bath at temperature of 4°C (Gabriel and Williams, 2004). Samples were taken in separate containers for physicochemical and trace metal analysis. Samples for trace metal analysis were each preserved with 0.5 ml of concentrated nitric acid before transporting to the laboratory at ROTAS SOIL LAB LIMITED, located at Plot 10, Kobomoje Street, near D'Rowan Hotel, Ring Road, Ibadan, Nigeria for analysis. The samples were analysed for various parameters including electrical conductivity, pH, total metal concentration and trace metals such as cadmium (Cd), manganese (Mn), iron (Fe) etc. Physical parameters like conductivity meter and pH meter respectively. Total metals (Zn, Cu, Ni, Cd, Fe, Pb and Mn) analysis was done using Atomic Absorption Spectrophotometer (AAS).

RESULTS AND DISCUSSION

Physicochemical Parameters

The range, mean and standard deviation of two physicochemical parameters (electrical conductivity and pH) as well as WHO's maximum admissible limits for both parameters are presented on Table 1. The values for pH in the surface river water (5.3) were above WHO, 2008 guidelines for drinking water quality. However, the pH values for borehole water samples (6.4) were within the WHO guidelines (6.5 – 8.5) for drinking water quality.

Table 3: *Samples Physicochemical parameters*

Sample Description	pH	Temperature (°C)	EC (µS)
MYR-W	5.3	26	84
NSR-B	6.4	27.4	78
WHO Guideline	6.5 – 8.2	25±2	NG

Key:

MYR-W - Water sample from Manyara River.

NSR-B - Borehole water sample from Nassarawa mineral processing site.

NG- No guideline stated by WHO, 2008.

Electrical conductivity of the water samples was 78 µS/cm (for borehole water) and 84µS/cm (for river water). Electrical conductivity (EC) is a measure of water's ability to conduct an electric current. This is due to the presence of some dissolved minerals in the water. Electrical conductivity therefore indicates presence of minerals but it does not give an indication of which element is present, but higher value of EC is a good indicator of the presence of contaminants such as sodium, potassium, chloride or sulfate (AlJassir *et al.*, 2005). The concentrations of trace metals [Zn, Pb, Cd, Cu, Fe, Ni and Mn] in the drinking water samples analysed are presented in Table 2. Zinc was the only trace metal that was below maximum admissible limit for drinking water quality. Cadmium in both water sources was below detection limit (Table 2).

Table 3: Level of some trace metals for drinking water samples from the study area.

Sampling location	Metal (mg/L)						
	Fe	Cd	Mn	Zn	Pb	Ni	Cu
MYR-W	241.50	0.00	0.80	0.90	1.00	0.35	0.85
SR-B	19.00	0.00	3.35	1.30	0.00	0.10	1.60
WHO Guideline	0.30	0.003	0.50	5.0	0.01	0.07	0.005

Key:

MYR-W- Water sample from Manyara River.

NSR-B - Borehole water sample from Nassarawa mineral processing site.

Conclusion and Recommendations

This research was conducted to determine the levels/concentrations of some of the physicochemical parameters (pH and electrical conductivity) and trace metals (Cu, Cd, Mn, Fe, Pb and Zn) in drinking water in Nassarawa and to compare the values with international organization such as the World Health Organization's recommended drinking water standards. The results of the study have shown that cadmium was not detected in both borehole and river water sources. Only Zn was detected at concentration lower than prescribed by the WHO. Other metals were found in concentration higher than permissible limits especially Pb (WHO, 2008).

Based on the findings of the study, it is recommended that:

- i. Mining activities in the new site could be continued but with caution, because the building up of these heavy metals especially Pb over time is likely to cause immediate and long term damage to the aquatic ecosystem as well as to the people living in these areas especially children. Hence this calls for continual monitoring of heavy metals concentration at the mineral processing sites.
- ii. The artisanal miners should also avoid conducting mining activities close to residential areas, farmlands and water bodies. Mining should be restricted to specified locations with attendant facilities to improve the efficiency and economy of the operations.
- iii. Establishment and enforcement of adequate environmental quality standards coupled with awareness creation among miners on the health and environmental implications of the mining activities, protective measures and government policies on mining is advocated.

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