

## **SOCIO – ECONOMIC AND ENVIRONMENTAL IMPACT OF ARTISANAL MINING IN PARTS OF NARAGUTA SHEET 168, NORTH CENTRAL NIGERIA**

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### **Abstract**

*The aim of this study was to assess the socio – economic and environmental impact of artisanal mining in parts of Naraguta Sheet 168. Geochemical data, environmental analysis from previous studies and on the spot interviews and interactions were employed to obtain the data for this study. Results revealed over 5000 abandoned pits with varying depths ranging from 12 to 15 meters. Analysis of soils and water samples collected from the mining pits, some hand dug wells and boreholes in the area, indicate low levels of most trace and rare earth elements in the waters. However, individual elements concentration showed that farm soils generally have high levels of Pb and Th and in some places Cd. The calculated Index of geo-accumulation classified the soils as uncontaminated to moderately contaminated. With over 5000 pits already dug in the area, the arable lands have been devastated, with diversion in flow directions of most streams. Trees and shrubs have been uprooted rendering the land susceptible to erosion. Opened mined pits serve as death traps to animals and breeding grounds for mosquitoes, making the area prone to malaria disease. About N450, 000 (3000 Dollars) at the end of every week is obtained from sales of the ore, shared amongst 8 – 10 team members. However, the social vices associated with it, such as child labour, school drop-out, the use of drugs, deaths due to flooding and collapse of lotto pits, theft, inflation, and prostitution, sexually transmitted diseases is prevalent. The study suggest interventions such as; reclaiming open pits, dredging of streams, rivers and remediation of contaminated soils and health awareness campaign to ameliorate the negative impacts of artisanal mining on the communities.*

**Key Words:** Artisanal Mining, Trace Elements, Land Degradation, Tin Mining

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### **Introduction**

The mining industry in Nigeria has great potential (Mallo, 2012). It has the capacity to contribute to local and foreign exchange earnings as well as attracting direct foreign investment into the country's economy. However, this has been hampered by inconsistencies in monetary and fiscal policies of the government. This problem consequently

encouraged the insurgence of Artisanal, (Small scale) miners whose activities are largely informal. It is a highly unregulated sector and subject to harsh working and living conditions. This activity is practiced on a small scale by people who are often poor and often do not realize that the methods they use are potentially risky to life, the environment, the economy and their health. Artisanal

mining activities have stripped thousands of square kilometers of top soil and arable land across the Jos Plateau (Mallo, 2012). Consequently, forest, animals, fish habitats and natural water resources have been damaged or destroyed. The aim of this work is to determine the socio-economic impact of artisanal in parts of Naraguta Sheet 168 NE (Bismarck and Darkoh, 2001; Samuel *et al.*, 2016; Kitula, 2005; Stephen, 2008).

**Description of Study Area**

The study area falls within the following coordinates latitude 9°40'N – N9°44'N and longitude E8°51' – E8°53' (Fig 1). General Geology of the study area Kuru is generally characterized by

the abundant occurrence of the Younger Granite rocks which were emplaced during the Jurassic era. The formation of the Younger Granite is associated with the hot spot magmatism. The rock bodies are massif occurring ring complexes. The Younger Granites are known for hosting tin and columbite within Jos Bukuru and environs. It covers a total area of about 20 km<sup>2</sup>. With a total of six artisanal mining clusters (Fig.1), the area is highly devastated (Mallo, 2012).The geology of the Jos – Bukuru Complex has been excellently treated by (Buchanan *et al.*, 1971; Macleod *et al.*, 1971; Turner, 1976).

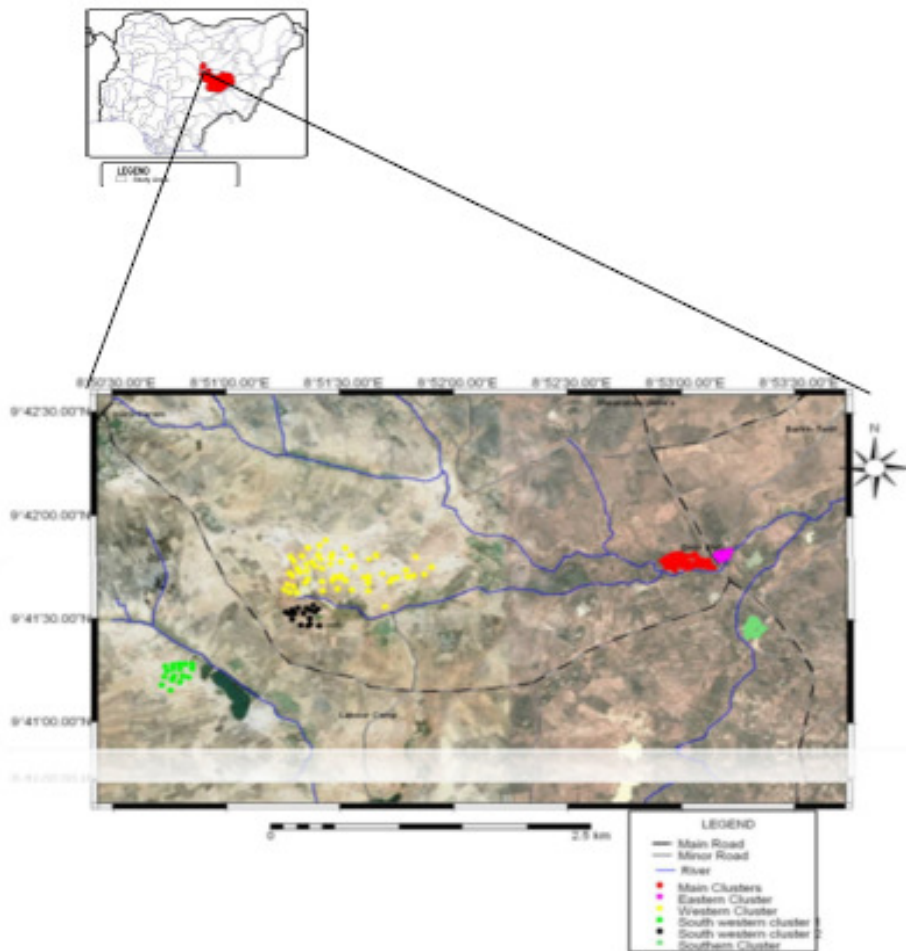


Figure 1: Satellite image showing mining clusters within Kuru and environs

## **Methodology**

### **Water and Soil Sampling:**

Systematic sampling of mine ponds, water wells, boreholes (hand pumped) and streams within the study area was carried out. Water samples were collected in a 1 liter plastic (one) screw cap bottles. The plastic bottles used in collection of samples were first rinsed with the water to be sampled 3 times after which concentrated nitric acid ( $\text{HNO}_3$ ) was added to the sample water (about 2 drops) for preservation. In-situ tests were carried out for conductivity, temperature and pH, using a simple Oakton pH 5/6 conductivity meter with an accuracy level of 1. Ground water from boreholes was pumped before samples were collected to eliminate stagnant water within the pipes. Soil samples were collected in polythene rubber bags from farms within the locations. The soil samples were pulverized into fine powder, using the agate mortar and put in sealed polythene bags. A total of sixteen water samples (2 - mine water, 5 - dam water, 2 - stream water and 2 - well water). Both soil and water samples were analysed at the ACME laboratory in Canada. The ICPMS method was used for both soils and water. Locations of sample collection points were taken using an Etrex Garmin Global Positioning System (G.P.S). Geochemical data from previous work were also collated and synthesized.

**Interviews:** Additional information during the course of the work was obtained from individuals, miners, (team/groups) through interviews. Information obtained includes:

- Amount of ore obtained per hole and income generated per hole per day

- Common forms of illnesses within the mining environment and their individual home.
- Cost of living within the mining sites and their homes, prices of vegetables and meat.
- Commonly noticeable problem within the environment, erosion, flooding.
- Availability of water.
- Dangers encountered during the mining activity inside the lotto pits.
- Drug problems

This information was provided through interviewing individuals encountered within and around the mining community during the course of the study.

## **Results and Discussion**

**Compositions of the Waters:** Table 1 and 2 show the compositions of rare earth, trace and major ions in the waters of the study area. Among the rare earth elements only Sc showed values below detection limit for all water points in the study area. Few of the sampling points showed values below detection for Ce, Eu, Pr, Ho, Lu and Tm. However, Ce in the water ranges from  $< 0.01 - 10.01$  ppb, Dy ranges from  $0.01 - 0.92$ , Er has values ranging from  $0.01 - 0.64$  ppb, Gd,  $0.02 - 1.11$  ppb, La,  $0.02 - 5.29$  ppb, Nd ranges from  $0.04 - 5.28$  ppb, Pr  $< 0.01 - 1.27$ , Ho  $< 0.01 - 0.20$  ppb, Lu  $< 0.01 - 0.14$  ppb, Sm  $0.02 - 1.02$  ppb, Tb  $< 0.01 - 0.16$  ppb, Tm  $< 0.01 - 0.14$  ppb, Y  $0.15 - 6.31$  ppb, Yb  $0.01 - 0.98$  ppb. With respect to water sources, the dam, mine and stream waters seem to have higher values for some of the rare earth elements than the hand dug wells and the boreholes. Perhaps this may be due to the discharge of the mined waters flowing into the streams, and the surface waters draining into the ponds.

Table 1: Compositions of rare earth elements in the waters of the study area

ELEMENTS	Lu	Sc	Sm	Tb	Th	Tm	Y	Yb	Ce	Dy	Er	Eu	Gd	La	Nd	Pr	Ho
MDL	0.01	1	0.01	0.02	0.05	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
COORD																	
WATER																	
SOURCE																	
Mine water	0.07	< 1	0.7	0.15	0.05	0.07	5.54	0.42	4.71	0.81	0.43	0.16	0.92	4.08	3.73	1	0.19
Dam	0.03	< 1	0.28	0.07	0.05	0.03	1.74	0.13	2.35	0.31	0.18	0.05	0.38	1.27	1.54	0.42	0.07
Stream	<0.01	< 1	0.11	0.02	0.05	0.01	0.79	0.09	0.73	0.12	0.07	<0.01	0.09	0.49	0.41	0.11	0.03
Mine water	0.14	< 1	0.53	0.09	0.05	0.14	5.07	0.98	2.51	0.75	0.64	0.07	0.55	2.94	2.72	0.69	0.17
Dam	0.06	< 1	0.36	0.06	0.05	0.05	3.29	0.36	2.64	0.4	0.3	0.04	0.39	1.61	1.73	0.46	0.09
Dam	0.02	< 1	0.13	0.02	0.05	0.02	1.25	0.13	1.26	0.16	0.11	0.02	0.15	0.7	0.83	0.21	0.04
Hand Dug Well	<0.01	< 1	<0.02	<0.01	0.05	0.01	0.66	0.03	<0.01	0.03	0.04	<0.01	0.02	0.02	0.04	<0.01	0.01
Hand Dug Well	<0.01	< 1	<0.02	<0.01	0.05	<0.01	0.15	0.01	0.03	0.01	0.01	<0.01	0.02	0.08	0.06	<0.01	<0.01
Borehole	<0.01	< 1	0.03	0.01	0.05	<0.01	0.84	0.03	0.22	0.05	0.05	<0.01	0.04	0.19	0.17	0.05	0.01
Dam	0.01	< 1	0.1	0.02	0.05	0.01	1.16	0.09	0.7	0.16	0.11	0.02	0.13	0.42	0.43	0.12	0.03
Dam	0.02	< 1	0.15	0.03	0.05	0.02	1.28	0.08	1.08	0.15	0.11	0.03	0.17	0.65	0.79	0.19	0.03
Stream	0.01	< 1	0.2	0.03	0.05	0.02	1.42	0.13	1.25	0.17	0.12	0.01	0.17	0.74	0.77	0.2	0.04
Stream	<0.01	< 1	0.09	0.02	0.05	<0.01	0.53	0.05	1.06	0.09	0.03	<0.01	0.1	0.55	0.52	0.11	0.01
Dam	0.06	< 1	1.02	0.16	0.05	0.06	6.31	0.38	10.01	0.92	0.03	0.19	1.11	5.29	5.28	1.27	0.2
Borehole	<0.01	<1	0.09	0.01	0.05	<0.01	0.46	0.04	0.78	0.08	0.04	0.02	0.08	0.4	0.51	0.12	0.02

\* all values are in ppb, MDL, Maximum Detection Limit

The trace elements in the waters (Table 2) As, B, Bi, Cd, Cr, Ge, Hf, Hg, In, Mo, Ta, Te, Th, Ti, Pd, Pt, Re, Rh, Rn, S, Sn have values below the detection limits. Values of 0.05 and 0.13 of Zr have been detected in the surrounding waters. Ag in the waters has values ranging from < 0.05 – 0.31 ppb, Al 3.3 – 560 ppb. Higher values are recorded in the surface waters and lower in the ground waters. Ba ranges from 7.62 – 144.9 ppb with no clear variations in the different sources. Be ranges from ranging from < 5 ppb – 82 ppb. All the ground water sources have values below detection limits. Co ranges from 0.02 – 3.44 ppb, Cs 0.02 – 1.01 ppb, Cu 0.1 – 125.2 ppb, Fe (Iron) < 10 – 4.59 ppb, Li 0.2 – 4.4 ppb, Mn 0.01 – 0.35 ppb, U , 0.013 – 3.13 ppb, Zn ranges from 0.8 – 314.2 ppb. Major elements, Ca, Na, Mg and K in the water ranges from 0.88 – 40.40, 1.24 – 12.44, 0.09 – 1.57 and 0.56

– 3.76 ppm respectively. One would expect the trace and rare earth elements (R.E.E's) to be very high in waters of the area, owing to the mineralized nature of the Younger Granites Rocks (tin and columbite) with associated Zircon and thorite minerals. However, Zirconium, thorium and Niobium are virtually absent in the waters. This may be because of the insolubility of their minerals. Since the host rock for these minerals have been found to be enriched in these radioactive elements (Solomon, 2007) probably, the waters although depleted in these elements may be found to be radioactive.

**Compositions of the Farm Soil samples:** The composition of the major, trace and rare earth elements for the farm soils samples are presented in Table 3. Index of geo-accumulation calculated for some of the trace elements are presented in figures (1-4). As, U, Au, Sb, Bi, S are all below detection limit (Table 3).

Table 2: Geochemical compositions of farm soils in the study area

Coordinates	Source	Elements	La	Cr	Mg	Ba	Ti	Al	Na	K	W	Zr	Sn	Y
		Units	Ppm	Ppm	%	Ppm	%	%	%	%	ppm	ppm	ppm	Ppm
9° 41.466N 8° 52.560E	Farm soil		48.00	44.00	0.08	330.00	0.51	5.59	0.07	1.81	<4.00	183.00	7.00	36.00
9° 41.571N 8° 52.000E	Farm soil		13.00	24.00	0.01	18.00	0.09	1.95	0.03	0.23	<4.00	152.00	4.00	20.00
9° 41.265N 8° 52 540E	Farm soil		25.00	52.00	0.07	79.00	0.35	5.94	0.02	0.38	<4.00	79.00	6.00	15.00
9° 40.345N 8° 51.522E	Farm soil		47.00	47.00	0.08	155.00	0.56	7.24	0.03	0.54	<4.00	142.00	6.00	30.00
		Elements	Pb	Zn	Ag	Ni	Co	Mn	Fe	As	U	Au	Th	Sr
		Units	Ppm	Ppm	Ppm	Ppm	Ppm	ppm	ppm	ppm	ppm	ppm	ppm	Ppm
9° 41.466N 8° 52.560E	Farm soil		34.00	64.00	<0.50	17.00	6.00	275.00	2.59	<5.00	<2.00	<4.00	34.00	45.00
9° 41.571N 8° 52.000E	Farm soil		59.00	49.00	<0.50	5.00	<2.00	125.00	1.78	<5.00	<2.00	<4.00	58.00	4.00
9° 41.265N 8° 52 540E	Farm soil		21.00	45.00	1.00	20.00	7.00	97.00	2.74	<5.00	<2.00	<4.00	12.00	20.00
9° 40.345N 8° 51.522E	Farm soil		30.00	57.00	0.70	25.00	7.00	99.00	3.61	<500	<2.00	<4.00	25.00	31.00
		Elements	Nb	Be	Sc	S	Mo	Cu	Cd	Sb	Bi	V	Ca	P
		Units	Ppm	Ppm	Ppm	Ppm	Ppm	ppm	ppm	ppm	ppm	ppm	%	%
9° 41.466N 8° 52.560E	Farm soil		107.00	3.00	6.00	<0.10	2.00	13.00	0.50	<5.00	<5.00	60.00	0.11	0.04
9° 41.571N 8° 52.000E	Farm soil		194.00	1.00	2.00	<0.10	<2	7.00	<0.40	<5.00	<5.00	33.00	0.01	0.01
9° 41.265N 8° 52 540E	Farm soil		77.00	4.00	7.00	<0.10	2.00	15.00	<0.40	<5.00	<5.00	61.00	0.02	0.03
9° 40.345N 8° 51.522E	Farm soil		100.00	3.00	9.00	<0.10	7.00	22.00	0.50	<5.00	<5.00	107.00	0.02	0.09

Pb ranges in the soils from 7 -22 ppm, three (3) of the sampling sites have values above the crustal average of 13 ppm. Zn ranges from 45 – 64 ppm. These values are below the crustal average of 70 ppm. Soil samples from both farms in Kuru Jantar have Cd above the crustal average of 0.2 pm. La values in farm soils in Kuru Jantar also have both values of 47 and 49 ppm which are above the crustal average of 30 ppm. Only the farm soils of kuru Jantar mining site have Zr 183 ppm above the crustal average of 165 ppm. Sn (values ranges from 4 – 7 ppm above the crustal average of 2 ppm. Y ranges from 15 – 36 ppm in farm soils in Kuru Jantar recording 36 ppm above crustal average of 33 ppm, Nb ranges from 77 – 194 ppm with all values far above the crustal average of 20 ppm, Sc values all fall below the crustal average of 22 ppm. Be ranges from 1 – 4 ppm with only soil from farm at Kokop mine site with value below the crustal average of 2.8. Index of geoaccumulation

calculated (Fig. 1 – 4) for some of the trace elements (Pb, Zn, Th, Cd, La, Zr, Sn, Y, Nb, and Be) have values ranging from 0.32 – 0.91, 0.13 – 0.18, 0.16 – 1.65, 0 – 0.50, 0.09 – 0.31, 0.10 – 0.02, 0.40 – 0.70, 0.07 – 0.22, 0.77 – 1.95 and 0.07 – 0.22. Most values indicate uncontaminated to moderately contaminated soils with exception of the three sites. Both soils at Kuru Jantar farms and at the Kokop mining site are moderately contaminated with Nb as well as with Thorium (Th). The soil samples in the area are enriched with Pb , Zr , Nb, Cd and La above the crustal average given by (Mason, 1966). Although calculated, index of geoaccumulation values for most elements in farm soils show uncontaminated to moderately contaminated with respect to Niobium and Thorium. These values of geoaccumulation are a source of concern as these values will steadily increase in the environment and will be a source of environmental hazard in years to come.

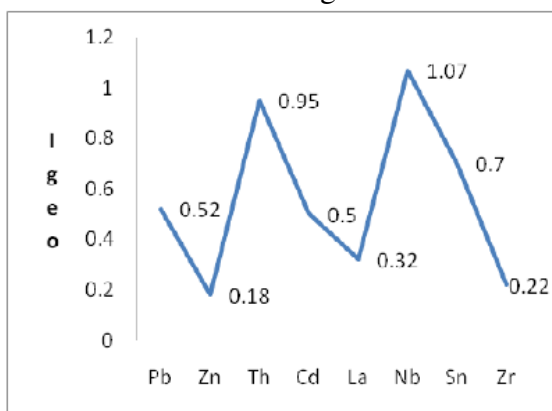


Fig 2: Igeo for some trace elements in farm soils at Kuru Jantar

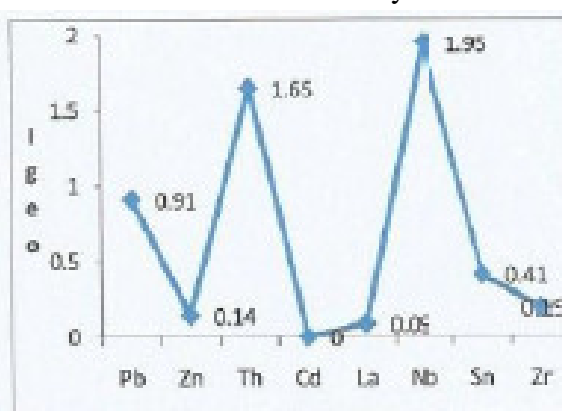


Fig 3: Igeo for some trace elements in farm soils at Kokop

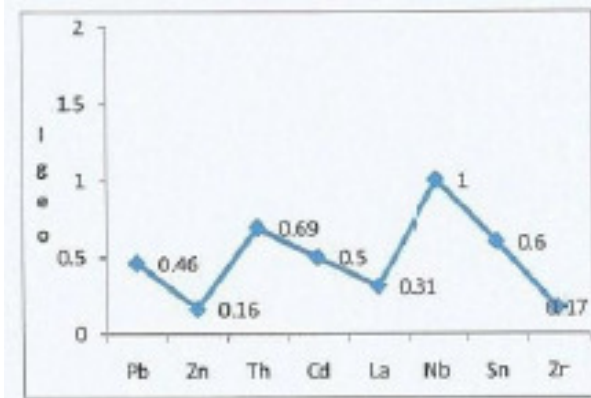


Fig 4: Igeo for some trace Elements in farm soils away from Kuru Jantar

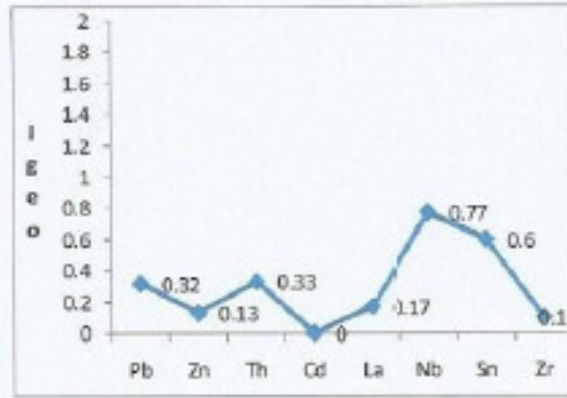


Fig 5: Igeo for some trace elements away from Kokop Mining site

Ranking of activities in the study area are presented in Table 3 – 7. Abandoned lotto pits ranked first among the environmental problems, followed by erosion, mine dumps, siltations of streams and collapse of lotto pits (Table 3). The economic activities (Table 4) show mining as ranking first, followed by farming, petty businesses and transportations of goods and people ranking least. Surveyed responses on

disease (Table 5) commonly found among populations and prevalent drug problem showed that, HIV/AIDS, drugs, alcoholism and prostitution rank first. Population wise, men constitute the largest population in the area, followed by women and children constitute the least population. However, age wise, among the men people between ages 22 – 40 are the largest.

Table 3: Environmental Problems Prevalent in the Study Area

Environmental Problem	Ranking
Abandoned lotto pits	1
Erosion	2
Mine dumps and large ponds	3
Siltation of streams and Rivers	4
Collapsing Lotto Holes	5

Table 4: Per wise ranking of economic activities at Kuru Jantar

Economic Activity	Ranking
Mining	1
Farming and livestock keeping (Goats, Chicken)	2
Petty businesses	3
Transport service	4



Table 5: Population at the Mine site

Population	Men	Women	Youth/Children
1,250	750	313	187
	60%	26%	14%
Age	22-43	22-43	<22
	500	200	Males & females
Age	44-56	44-56	
	175	90	
Main occupation			
Mining and farming	100*	100*	
Mining	550*	135	
Petty traders	20*	60	
Masons	80*	30	

(\*) combination of multiple jobs e.g. mining, farming, masonry, petty trading.

Table 6: Surveyed Responses on Disease common Amongst Miners

Disease	Ranking
STD/ H.I.V	2
Water borne (diarrhea dysentery)	1
Malaria	3
Worms (Tape worm)	4

Table 7: Surveyed responses on prevalent problems

Mining community	Ranking
Alcohol, Drugs, Prostitution	1
Injuries	4
Reduced Household Labour	5
Erosion and Theft	3
Unemployment	2

## Discussion

**Environmental Impact:** The active mining sites at Kuru Jantar and Kokop area show low to moderate levels of both rare earth and trace element concentrations in the waters and soils. All the surface water sources (Stream, dams, ponds) and those that are directly pumped out from the mine pits are enriched with respect to some of the trace and rare earth elements. The ground water sources have very low level concentrations of trace elements for example As, Co, Cu, Fe and Pb compared to values given by WHO in

2004, but some elements are high e.g., Zinc and strontium. Probably the reasons for enrichment may be the active artisanal mining currently taking place in the area which have been mobilized and dispersed during the separation of the ores from the gangue through washing. Since the ores are restricted to certain areas within the overburden of the study area, it may probably be the reason for the trace and the rare earth elements in the ground waters (boreholes and hand dug walls). The over 900 abandoned lotto pits varying in depth from 10-15 meters

are unmarked with no signs indicating their presence. Hence, their presences pose great threat to both humans and

animals. The use of locally made sluice boxes has resulted in severe siltation of streams in the area.



Plate 1: Tin separation using ground Sluice Boxes

Diversion of streams from washing of the ores has resulted in the death of most aquatic lives in the area (Plates 1 and 2). Removal of small trees and shrubs whose roots helps to bind soils has left the land bare making it susceptible to erosion (Stephen, 2008). Most of the lotto holes in the area are filled with stagnant water from rains and hence serve as breeding ground for disease vectors (both mosquitoes and houseflies) with high incidence of malaria and water borne disease such as dysentery. Indiscriminate

dumping of mine tailings both in streams and on land makes the environment look dirty. The use of processing water from the mines for irrigation could accumulate potential toxic elements in soils, where plants could absorb and subsequently passed into the food chain. Similar areas around the Ray – Field tin mining sites showed Pb and Cd content in Cabbages, Green Pepper and Green Beans above the FAO recommended limit (Dibal and Yakubu, 2012).



Plate 2: Utilisation of Mining Pond Water for Irrigation

***Economic Effects of Artisanal Mining:***

The economic impacts of artisanal mining on the livelihood of the people are numerous. The activity has created a lot of employment opportunity for the people in the community. People who are not directly involved in mining are engaged in trading and transportation. The community has a business where they lease or rent lands for mineral extraction (tin and columbite) and this helps to reduce social vices by promoting employment through entrepreneurship by employing unskilled labour force. A lotto pit produces between 10-12 tonnes of tin which yields 10-15 fifty kilogram bag weekly, shared amongst 8-10 people working as a group per hole. A 50 kg can

be sold for as much as (₦20, 000- ₦30, 000) twenty to thirty thousand naira (\$121-\$181) (Lekmang and Dibal, 2012). On the national level the export of these minerals may increase foreign exchange if properly managed. Worthy of note is that, the middle men who come to buy from these artisanal miners earned more than them at the end of the day.

Another problem, is inflation, the influx of mining money has brought about increase in food prices and goods. Food prices such as cooked rice at the mine sites are quite high ranging from ₦200 - ₦300 (\$1 - \$2) and a bottle of coke (coca-cola) sells at about ₦70 as against ₦50 market price.

**Social Effects of Artisanal Mining:** The mining in this area has resulted in people moving to the area from other places. Similar migration by people to mining areas has been reported (Bismarck and Darkoh, 2001; Stephen, 2008). This in turn has resulted in increased incidence of theft, prostitution, child labour, changes in indigenous life style and competition amongst locals. The displacement of people from arable farmlands due to perceived existence of minerals beneath the soil is a big problem, as inhabitants have to move to far places to obtain lands for farming (Kitula, 2005). On average, 6-8 deaths per year resulting from injuries due to tunnel/pit flooding and collapses have been recorded. Diseases commonly reported among the mining communities are sexually transmitted diseases such as gonorrhoea, HIV/AIDS and dysentery. Drug problems such as the use of Indian hemp and alcoholism are common. Perhaps these are used as enhancers to reduce tiredness. Although the activity has provided means of livelihood for the locals, the cumulative economic gains are quite minimal, when compared to the risks of being trapped in a pit, exposure to toxic trace elements and the devastation to surrounding farmlands and other social vices.

### **Conclusion**

The study investigated the environmental, economic and social impacts of artisanal mining in Kuru-Jantar and environs area of Plateau State, Nigeria. Artisanal mining in the study area, contributes economically to the well being of the inhabitants but with corresponding environmental effects which is associated with land

degradation, erosion, siltation of streams, trace element pollution and destruction of arable farmlands. Socially, inflation, theft, increase rate in schools drop outs, prostitution has increased in the communities. However, the government of Plateau State and Nigeria and other International bodies such as UNICEF can help improve the livelihood of these artisanal miners, by providing avenues where the locals can have access to professional advice and loans. This may improve the method of the mining, reduce the impact of the mining on the environment and reduce greatly the incidence of the social vices such as drug use and sexually transmitted diseases.

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