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SOCIO ENVIRONMENTAL IMPACTS OF ARTISANAL MINING ON IGUN GOLD MINING COMMUNITY, SOUTHWESTERN NIGERIA

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ABSTARCT

Artisanal small scale mining is characterized by the use of locally fabricated tools and exposes the miners and mining communities to several hazards and extreme environmental degradation. The study area, Igun, is located within Ilesa schist belt of South Western Nigeria. In this study, the socio-environmental impact of artisanal mining in the area was evaluated from field observations and geochemical analysis of seven surface water samples collected from current mining pits. Parameters analyzed include color, pH,conductivity, total dissolved solids, turbidity, total hardness, total alkalinity, calcium, magnesium, sodium, potassium, carbonate, bicarbonate, sulfate, nitrate and chloride. The results showed average concentration of the parameters in the water as Ca (26.48mg/l), Mg (23.04mg/l), Na (7.77mg/l), K (4.00mg/l), CO_3 (28.00mg/l), HCO_3(140.00mg/l), SO_4 (22.14mg/l), NO_3 (0.57mg/l) and Cl (27.32mg/l) while pH (7.26), TDS (841.42) and electrical conductivity (248.57s/m).The concentrations of Ca, Mg, Na,K,CO_3,HCO_3, SO_4,NO_3 andCl in the water fall within the permissible limit of World Health Organization Standard for Drinking water. However, the TDS exceeds WHO permissible limit which makes the water unsuitable for drinking. The environmental and social damages observed in the area include deforestation, land degradation, urban migration of the indigenous farming settlers, health and social vices.The study revealed that the farming communities are virtually deserted by the indigenous residents and farming activities abandoned. Artisanal mining in the communities induced different levels of human abuse, environmental degradation and artificial population growth arising from the presence of artisanal miners in the villages.

KEYWORDS: Artisanal mining,Water contamination,Land degradation,Urban migration, Gold mining.Igun, Potable water.

INTRODUCTION

Mining is the extraction of mineral material from the ground in either underground and or open pitminingArtisanal miners adopts crude mining methods that have potential to cause different form of hazards to the environment, the community and the miners who have no formal training in mining and mineral processing techniques. Fundamentally, artisanal small scale mining (ASSM) results in urban migration of indigenous farmers, child and women abuse, damage of farm lands, water pollution and the none accountability to government on minerals extracted .

The importance of the mining sector as sources of foreign exchange earning to government, employment generation and economic development, cannot be overemphasized (Aderogbin,*et.al*, 2018; Obaje and Abba, 1996;Obajen*et al.*, 2005 and Nwajiuba, 2000). Controlled artisanal small scale mining constitute a major source of livelihood to the rural dwellers in many mining communities (Veiga, 2003).

According to International Labour Organization, (1999) and UNDESA, (2003), artisanal and small scale mining (ASSM) is one sector that provides employment to as much as 2.5million people and a subsistence for more than 20 billion people in at least 25 countries in the African Continent.

In Nigeria, informal surface mining of metals, gemstones and industrial minerals is not new to residents in the basement complex terrain of the Southwestern Nigeria. Rare earth elements occur as non-intergrowth in igneous, metamorphic andpegmatite rocks (Okunlola, 1998). By weathering, these metals are dislodged from host rocks and subsequently transported and deposited as alluvial deposits along stream beds and river channels. This is in addition to the occurrence of these metals as primary ore deposits in veins of host rocks. Alluvial deposits are easily accessed by artisanal miners using local implements like hoes, cutlasses and diggers and unskilled cheap labor sourced from the mining community.

The local methods employed by artisanal miners' limits their mining operations to stream beds sporadically pitting areas suspected to host the metal. This informal method of mining is a potential source of extreme environmental damage, loss of farmland, inaccurate record keeping, poor accountability and subsequent economic loss to the government and the community where

they operate (Opafunso, 2010). Hazards peculiar to artisanal mining communities include degradation of the environment, deforestation, water and air pollution, loss of aquatic lives, loss of farmland and urban migration of the indigenous residents (Veiga, 2003).
Health hazards associated with mining has been reported by several authors, an example is the case of lead poisoning in Zamfara state of Northwestern Nigeria which affected an estimate of 10,000 people (Azubike, 2011).

Economic recovery of ores by the artisanal miners is very poor because they lack the prerequisite knowledge in geology and mineral processing technology that would have been an advantage to their operations. This makes loss of ore during mining inevitable. Documented report indicated that Nigeria is endowed with abundant solid minerals of diverse kinds (Garba, 2002; Okunlola, 1998, 2001, 2003, 2009 and Okunlola*et.al.* 2006).These minerals could be economically recovered for industrial revolution of the country if properly annexed.

Artisanal miners are not licensed by government and therefore it is difficult to apprehend offenders whenever damages are done to farmland, ground water or social fabrics of the once-upon- a- time peaceful communities. Because they are not licensed, accountability to either the government or community where they operate, is not obtainable. Substantial amount of money is therefore lost in revenue to the miners who induced community leaders to gain their consent. There is no record of Cadastral involvement in the operations of artisanal miners. Hazards like lead poison, land subsidence, air and water pollution and land degradation are common occurrences in artisanal mining districts.

The Igun artisanal gold mining field had become a thriving business center for miners of both elluvial and alluvial gold for decades. This study was carried out to evaluate some peculiar hazardsthat are associated with artisanal mining in these communities and proffer possible remediation for adoption.

The study area lies within the Southeastern Basement Complex on Ibadan sheet 261SE. The area is located between Latitude 4^0 $39^{'}$E and 4^0 $44^{'}$E and Longitude 7^0 $31^{'}$N and 7^0 $34^{'}$E within the Ilesa schist belt of the South Western Nigeria (Figure 1).The lithological setting of the southwestern basement complex has been described by various authors. The Proterozoic schist belts of Nigeria is predominantly developed in the western half of the countrywhere the Ilesha schist beltforms a part. Folami, (1992) and Elueze, (1986)reported that the rocks in the Ilesa schist - belt area are structurally divided by two major fracture zones referred to as the Iwarara faults at the eastern part and the Ifewara faults on the west of the fault. To the western part of the fault are mostly amphibolites, amphibole schist, meta-ultramafites, and meta-pelitesand extensivepsammitic units with minor meta-pelite constitute the eastern segment. These are found as quartzites and quartz schists. All therock assemblages are associated with migmatiticgneisses cut by a variety of granitic rock bodies, (Olusegun, et al, 1995, Rahaman, 1976).

The rocks in Ilsea area are grouped intomigmatite-gneiss complex, mafic-ultramafic suite (or amphibolite complex), meta-sedimentary assemblages and intrusive suite of granitic rocks with a variety of minor rock types related to these major units, may be encountered in the field. The migmatite-gneiss complex comprises migmatitic and granitic, calcereous and granulitic rocks. The mafic-ultramafic suite is composed mainly of amphibolites, amphibole schist and minor meta-ultramafites, made up of anthophyllite-tremolite-chlorite and talcschist.The major rock in the study area areMigmatite, Schist, Quartzite, Quartz Schist, and Epidiorite (Figure 1).

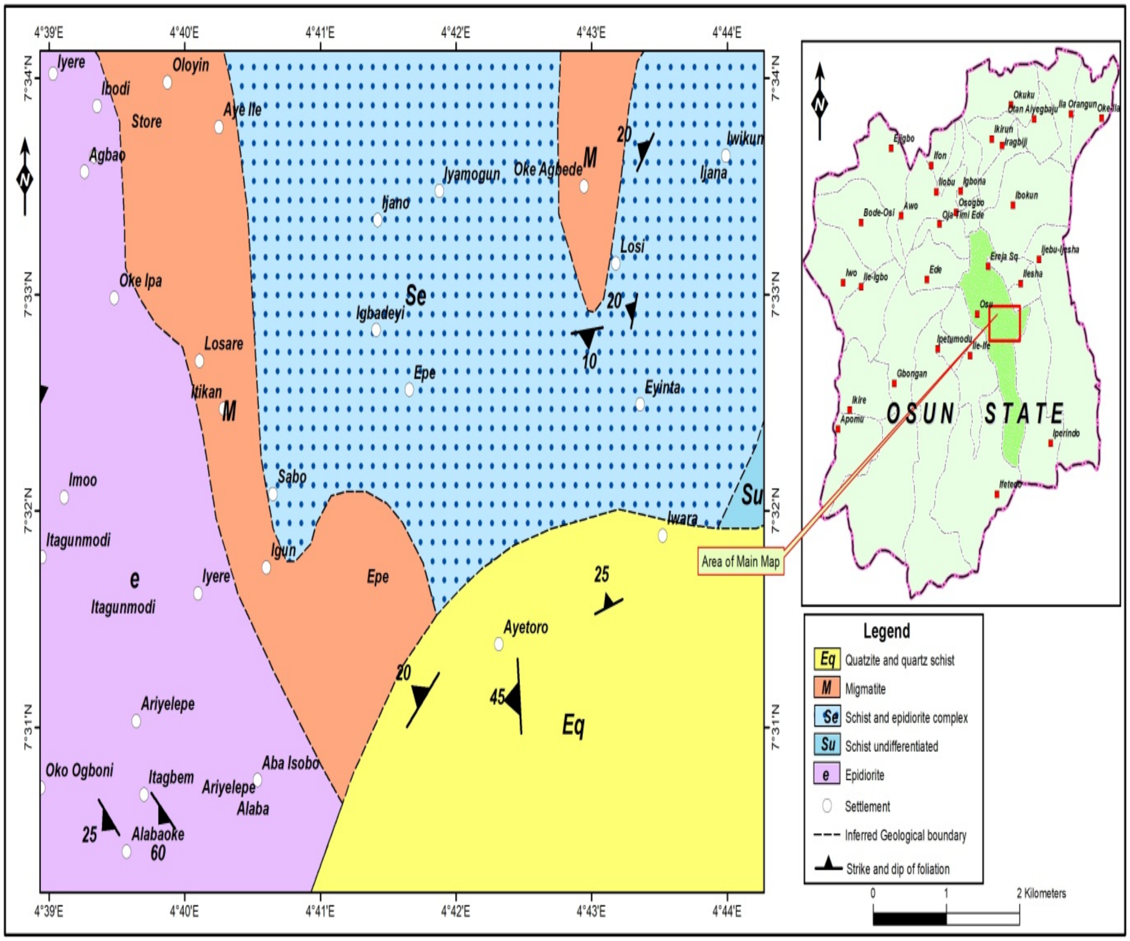

Figure 1: Geologic map of the study area (Adapted from NGSA Ibadan. Sheet 59).

MATERIALS AND METHODS

A total of eighteen old and new mining pits were encountered in the study areawhere water samples were collected. The general landscape of the mining area, the agricultural farm lands, streams and settlement pattern were carefully studied. Observations made were recorded in the field notebook to have a balanced evaluation of the physical impact of the mining on the people and the community.

Seven water samples were collected andstored in 5.0litre plastic containers each. These plasticcontainers were rinsed with 1:1 HNO_3 and distilled water before the water sample were poured into them.The samples were acidified with 2 mL nitric acid and stored at a temperature below 4 °C. chloride (mg/l), nitrate (mg/l), Bicarbonate (mg/l), carbonate (mg/l), calcium (mg/l), magnesium (mg/l), sodium (mg/l), calcium (mg/l) and the pH values were determined.

RESULTS AND DISCUSSION

The result of the physic-chemical parameters in the water samples is presented in Tables 1, while the World Health Organization Drinking Water Guideline (WHO, 2003) is presented in Table 2.

Table 1: Pysico-Chemical Properties of Water from Study Area

PARAMETERS	1	2	3	4	5	6	7	Mean
Ph	6.38	7.41	7.1	6.79	8.2	7.34	7.59	7.26
Conductivity(µs/cm)	180	390	80	560	290	110	130	248.57
Total Dissolved Solid g/l)	760	870	390	1510	1220	540	600	841.42
Chloride (mg/l)	15.9	51.8	11.95	67.78	27.89	5.98	9.96	27.32
Bicarbonate(mg/l)	160	180	60	120	260	100	100	140
Nitrate (mg/l)	0.25	0.38	0.16	1.15	1.32	0.63	0.42	0.53
Sulphate (mg/l)	8	12	20	39	38	22	16	22.14
Carbonate(mg/l)	0	60	0	20	20	20	20	28
Calcium (mg/l)	8.01	20.82	11.21	59	48	19.2	19.19	26.49
Magnesium (mg/l)	17.6	19.45	5.72	37.75	52.2	14.87	13.73	23.05
Sodium (mg/l)	5.15	6.33	3.75	11.89	13.11	7.19	6.99	7.77
Potassium (mg/l)	3.21	3.25	1.89	6.33	6.42	3.36	3.58	4.0

Table 2: World Health Organization Drinking Water Guideline (WHO, 2003)

PARAMETER	UNIT	LIMIT (mg/l)
Aluminium	mg Al/l	0.2
Arsenic	mg As/l	0.05
Barium	mg Ba/l	0.05
Berylium	ug Be/l	0.2
Cadmium	ug Cd/l	5.0
Calcium	mg Ca/l	200.0
Chromium	mg Cr/l	0.05
Copper	mg Cu/l	1.0
Iron Total	mg Fe/l	0.3
Lead	mg Pb/l	0.01
Magnesium	mg Mg/l	150.0
Manganese	mg Mn/l	0.1
Mercury	ug Hg/l	1.0
Selenium	mg Se/l	0.01
Sodium	mg Na/l	200.0
Zinc	mg Zn/l	5.0
Chlorides	mg Cl/l	250.0
Cyanide	mg Cn/l	0.1
Fluorides	mg F/l	1.5
Nitrates	mg NO_3/l	10.0

Water Quality Assessment

A human health risk assessment of the surface water exposed to the artisanal miners in the mining communities ofIgun, Southwestern Nigeria, was studied and the physio-chemical parameters measured are pH, TDS and conductivity as well as Chloride, Nitrate, Sulphate, Bicarbonate, Carbonate, Calcium, Magnesium, Sodium, Potassium and presented in Table 1.

Chloride (mg/l)

It has an average concentration of 27.32 mg/l in the surface water from the study area when compared to the World Health Organization guidelines for portable drinking water which is 250mg/l. **C**hlorides can be leached from basement rocks in the area into the soil and water by weathering because of highly mobile of chloride ions. Chlorides finds their way into surface and underground water from natural and artificial sources such as run-off containing road debris, the use of inorganic fertilizers, landfill leachates, septic tanks, animal feeds and irrigation drainages.

Table 1 showed that the highest chloride concentration is in Location 4 which may be assumed to have been sourced from human waste in the nearby dumpsite. Location 4 particularly has 36% out of the seven locations. Location 2 contains 27% chloride and Location 6 having the lowest concentration of 3%. Figure 2 is a pie-chart depicting a graphical expression of how the results vary in each locations

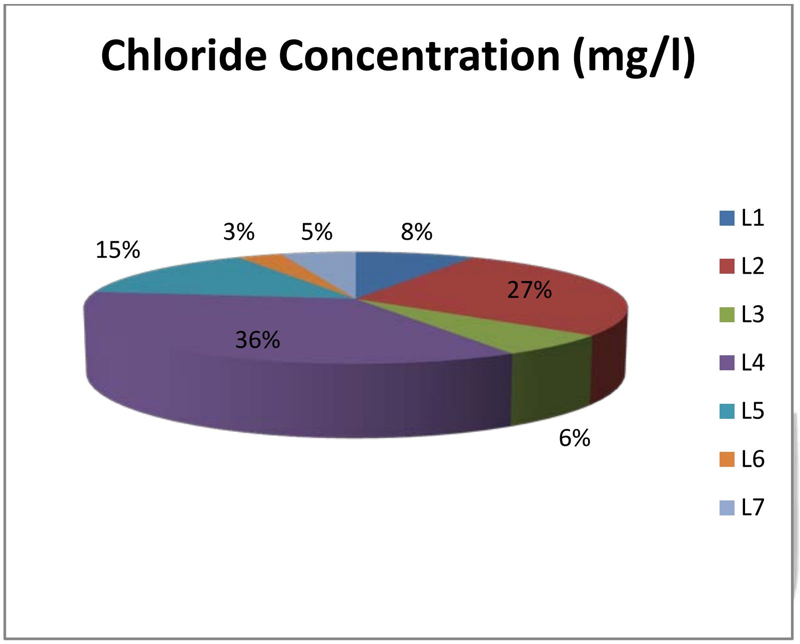

Figure 2: Pie-chart showing Chloride Concentration

Nitrate (mg/l)

Nitrates are essential nutrients for plant growth. Nitrates can be added to the soil through the use of fertilizer in agricultural work on human and animal wastes, nitrates from these various sources into the soil can be transported into the ground water through percolation. In the study area, the average concentration of 4.3mg/l. in the surface water when compared to the World Health Organization guidelines (Table 2) for portable drinking water which is 10mg/l. This is below the WHO recommended value of 10mg/l.The results of nitrate in water from all location in the study area is an indication that the area has not been cultivated previously by farmers at least not in the recent years. Nitrate levels above the recommended 10mg/l in humans are potential source of blood disorder particularly infants under six months of age. This phenomenon is referred to as Methemoglobinemia or "Blue-baby" syndrome this causes a reduction in the oxygen carrying capacity of the blood. An infant with a more serious blue-baby case may start to show obvious symptoms of cyanosis; the skin, lips and nail bed may develop a slate-grey or bluish colour and difficulty breathing. The pie-chart infigure3 shows the Nitrate Concentration in water sample for each location of study area

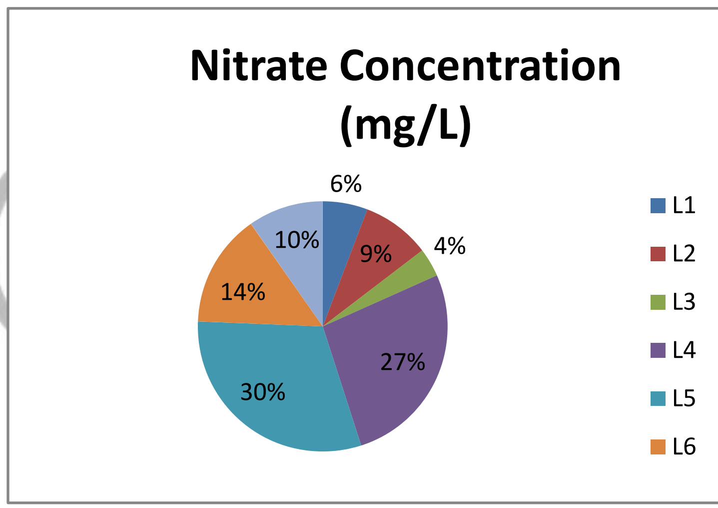

Figure 3: Pie-Chart showing the Nitrate Concentration in Water sample from study area

Sulfate (mg/l)

Sulfate is a salt of sulfuric acid. The sulphate ion is a polyatomic anion with the empirical formula SO_4^{2-}. In the study area, Sulfate has an average concentration of 22.14 mg/l , in the surface water of the area when compared to the World Health Organization guidelines (Table 2) for portable drinking water which is 400 mg/l. Sulfates occur naturally in numerous minerals, including barite (BaSO4), epsomite ($MgSO_4 \cdot 2H_20$) and gypsum (CaSO4·2H2O) (Greenwood and Earnshaw, 1984). These dissolved minerals contribute to the mineral content of many drinking-waters. Sulfates and sulfuric acid products are used in the production of fertilizers, chemicals, dyes, glass, paper, soaps, textiles, fungicides, insecticides, astringents and emetics. They are also used in the mining, wood pulp, metal and plating industries, in sewage treatment and in leather processing (Greenwood and Earnshaw, 1984). Aluminum sulfate (alum) is used as a sedimentation agent in the treatment of drinking-water. Copper sulfate has been used for the control of algae in raw and public water supplies (McGuire *et al.*, 1984). The sulfate concentration in all seven locations are within the WHO guideline for portable drinking water (Figure4).

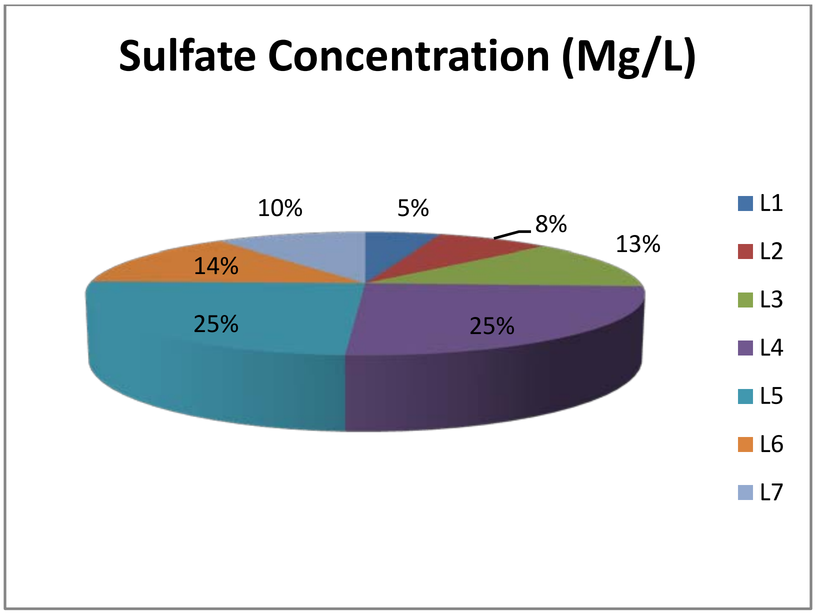

Figure 4: Pie-chart showingpercent Concentration of Sulfate in water sample

Bicarbonate (mg/l)

Bicarbonate is believed to enter the groundwater system as through the uptake of Carbon dioxide (CO_2) from gaseous soil zone or direct atmosphere (Langmuir, 1971).Because of this, shallow groundwater is expectedly high in bicarbonates. However, bicarbonate concentrations in crystalline ground waters decrease with depth (Langmuir, 1971).

Once in a closed system, it is proposed that a variety of reactions with silicates act to remove HCO^{-}_{3} ions usually as precipitated calcite, which is a common fracture-filling mineral in these environments (Gascoyne *et al.*, 1987; Nordstrom *et al.*, 1989a). In the study area, bicarbonate concentration averages 140 mg/l and the spread in the study area is presented in figure 5. Bicarbonates are helpful in the digestion of food in human beings. It is found in the mucus membrane of the human stomach. Bicarbonate is known to prevent dental plaque.

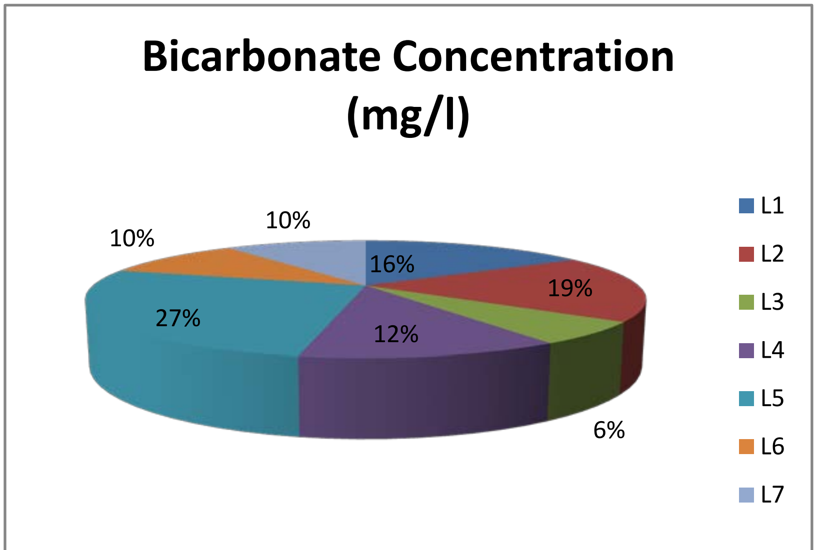

Figure 5: Pie-chart showing percent concentration of bicarbonates in water sample

Calcium (mg/l)

Calcium has an average concentration of 26.49 mg/l in the surface water when compared to the World Health Organization guideline for portable drinking water is 200 mg/l (Table 2). Figure 6 presents these results graphical in pie-chart. Calcium in water is of great importance as it contributes to the human dietary needs. Calcium and magnesium in water do not constitute any health hazard of health hazard. Calcium is naturally present in water.

Calcium may dissolve the source of calcium in water may be from rocks such as: limestone, marble, calcite, dolomite, gypsum, fluorite and apatite. The presence of calcium in water results in hardness of water. Hard water could assists in strengthening bones and teeth because of its high calcium concentration. However, excess intake of calcium by human beings may negatively influence human health. The lethal dose of oral uptake is about 5-50 mg/kg body weight (WHO, 2004).

However, in the study area Location 4 and Location 5 have the highest number of calcium concentrations having 59 mg/l and 48mg/l respectively. This must be as a result of the presence of calcium rich rocks such as: Limestone, Marble Calcite, Dolomite Gypsum, Fluorite and Apatite which may be present in these locations.

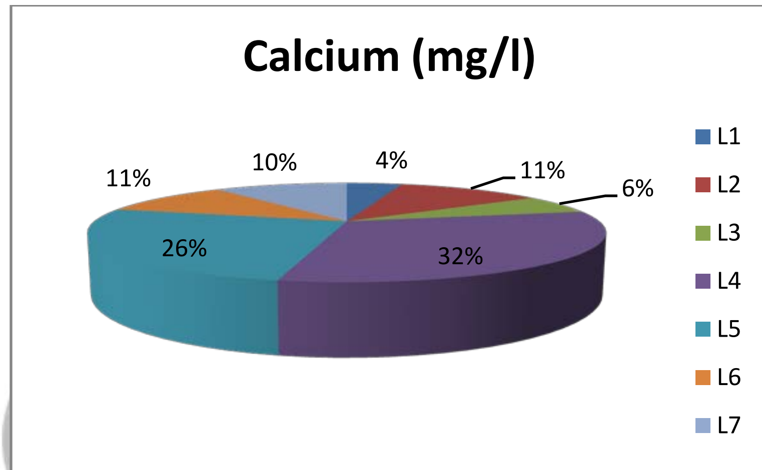

Figure 6: Pie-Chart showingpercent Concentration of Calcium in the Water Sample

Magnesium (mg/l)

Magnesium is the ninth most abundant element in the universe and forth most common element in the earth, making 13% of the planet's mass and a large fraction of the mantle (Housecroft and Sharpe, 2008).

Magnesium in the study area has an average concentration of 23.69mg/l in the surface water when compared to the World Health Organization guideline for portable drinking water (Table 2) which is 150mg/l. Magnesium is leached out from minerals like dolomite and magnesite. And subsequently ends up in the surface water.The Pie-chart (Figure 7) shows the percent concentrationof Magnesium in the water sample.

The pH gives the general indication that the water samples range from neutral to alkaline. The average and range of pH values of sampled water (Table 1) from study area (7.77; 8.2 -6.38) characterizes the water samples within fairly acidic, neutral to alkaline in composition. Based on this pH values, the water from study area is suitability for domestic purposes including drinking, and it is also suitable for the aquatic ecosystem. Low pH in water may be due to natural geochemical and biochemical processes within the aquifers (Schafer *et al*., 2016). The Pie-chart (Figure 8) shows the percent concentration of pH in the water sample.

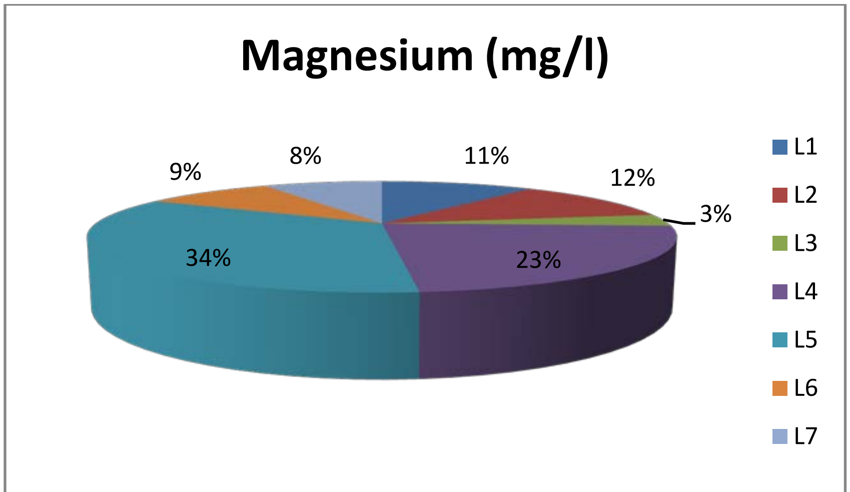

Figure 7: Pie-chart showing percent concentration of Magnesium in the water sample

Hydrogen Ion Concentration (pH)

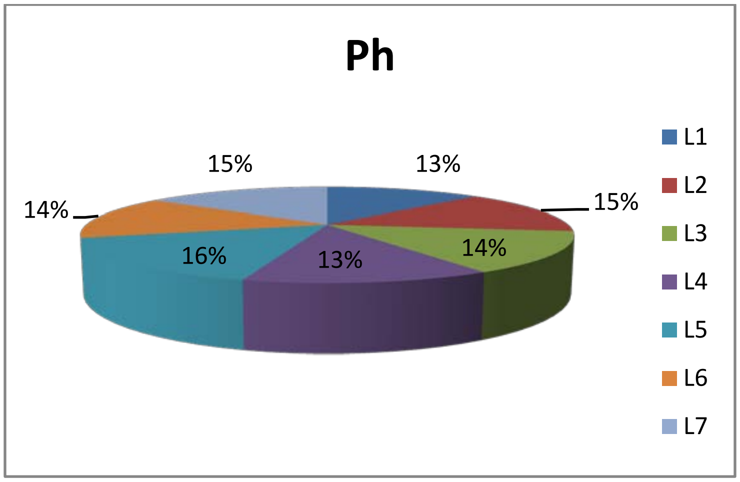

Figure 8: Pie-chart showing the pH of the water sample

Sodium (mg/l)

Sodium also has an average concentration of 7.48 mg/l in the surface water when compared to the World Health Organization guideline for portable drinking water which is 200 mg/l. Sodium is not considered to be toxic. The human body needs sodium in order to maintain blood pressure, control fluid levels and for normal nerve and muscle function. Sodium concentration s above 200 mg/l in water makes the water taste salty. The percentage sodium concentration in the study area qualifies the water for drinking water (Figure 9).

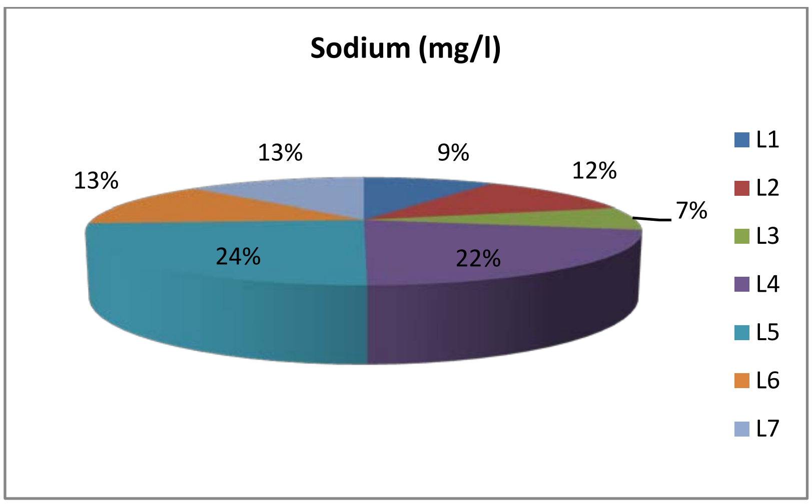

Figure 9: Pie-chart showing percentage Sodium

TDS (mg/l)

Total dissolved solids is a measure of the combined content of all inorganic and Organic substances contained in the water sample in a molecular, ionized or micro-granular suspended form. The Total Dissolved Solid (TDS) of water samples in the study varies between 540 mg/l-1510 mg/l with a limit of 500 mg/l. This implies that the surface waters in the area exceed the WHO permissible limit of portable drinking water. The suitability of water with TDS of less than 600 mg/l is generally considered good whereas with a TDS of above 1,200 mg/l is unsuitable (Karikari and Ansa-Asare 2006). The highest TDS concentration recorded at L5 may be due to seepage of effluent discharges, agriculture and domestic waste substances (Ayantobo*et al.*, 2012).The Pie-chart (Figure 10) shows the percent concentration of TDS in the water sample.

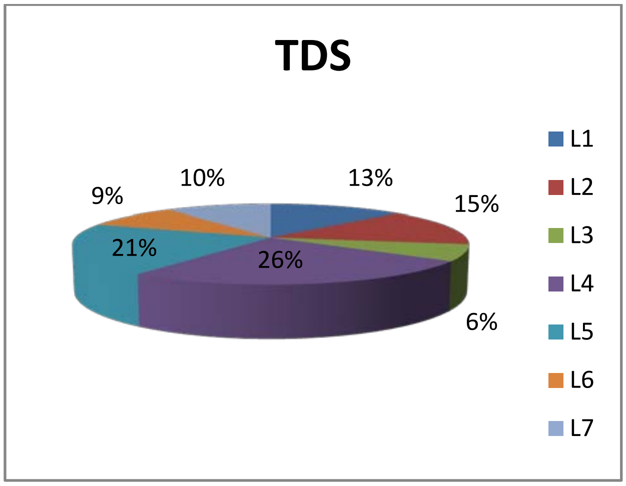

Figure 10: Pie-chart showing the TDS of the water sample

Electrical Conductivity

The conductivity of water is measured to know the ability of the water to conduct electricity. Common ions in water that conduct electricity includes sodium, chloride, calcium and magnesium. Because dissolved salts and other inorganic chemicals conduct electrical current. The more ions present, the higher the conductivity of the water. Just as in Table 1, the sample from L4 has the highest number of dissolved ions in which the conductivity is 560 s/m and the lowest being L3 at 80 s/m giving the average and range of EC values of water in the area as 560 - 80. The Pie-chart (Figure 11) shows the percent concentration of EC in the water sample.

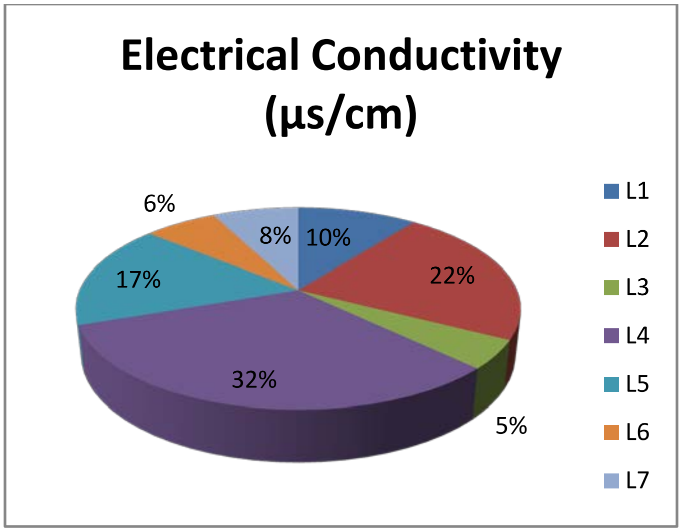

Figure 11: Pie-chart showing the electrical conductivity (µs/cm) of the water sample

Artisanal Small-Scale Mining and Impact Assessment

The Work of Artisanal Miners

Artisanal mining activities is carried out using low technology or with minimal machinery. It is normally low-capital and uses high labour-intensive technology. ASM can include men and women working in family groups, in partnership or as members of legal associations and enterprises involving hundreds or thousands of mine.

Social Impact

Drug and Alcoholic Abuse

Several studies have cited drug and alcohol abuse as a psychosocial hazard that affects both adult (mostly male) and child miners (Donoghue, 2004; International Labour Organization, 2006). The migratory nature of many people who engage in ASGM is believed to contribute to drug and alcohol abuse which are seen as a ways to cope with difficult circumstances (Hinton *et al.*, 2006; Thorsen, 2012).

Violence

Alcohol and drug abuse can lead to violence against partners, co-workers and community members. This has been well described in analogous scenarios, where subsistence work in settings far from home is associated with drug and alcohol abuse and consequent violence

(Hinton *et.al*, 2006). Prostitution is also a factor in some places. However, in many cases violence is not alcohol related and can be associated with stressful working conditions, forced child labour and criminal activities such as extortion, theft, sexual violence or intimidation. Where ASM operations are viewed as illegal, conflicts can lead to an escalation of violence between miners, authorities and local land users.

Nutritional Deficits

Food security is an important motivator of Artisanal Small-scale Mining operations which are frequently poverty-driven. Many miners already find it difficult to secure adequate food for their families. Nutritional deficits can be exacerbated in Artisanal Mining camps where foodstuffs may be hard to access, for example because of rising costs of local goods and/or deterioration in quality of agricultural lands (Hinton, 2006; Buxton 2013). Changes in availability of disposable income among ASM communities may also have an impact on quality of diets and therefore on nutritional status. For example, Long *et.al* (2015) found that residents of ASGM communities in Ghana reported lower fruit and vegetable consumption and higher sugar and fat consumption than residents of surrounding areas. The latter were reportedly more reliant upon locally grown food items, while the former were thought to consume more packaged foods and foods prepared by local vendors (Long *et al.*, 2015).

Water Pollution

Because the overburden from excavated material contains acerbic chemical, it pollutes the nearby water bodies causing severe harm to inhabitants relying on the water. This is even more risky if the miners make use of amalgam in the extraction of gold. Amalgam is the equal compound of gold and mercury. This is done to extract the gold from the earth. The mercury is later removed by heating leaving only the gold. The mercury sometimes is washed of by the miners in the nearby water body causing pollution and it also poses a threat on the health of both miners and inhabitants of the area since they consume the water for domestic purpose.

Health and Safety

Biological Hazards

Although artisal small scale mining communities (ASSM) are susceptible to a variety of infections, very common biological hazards affecting them are waterborne and vector-borne diseases, sexually transmitted infections, HIV/AIDs, and tuberculosis. Water and sanitation infrastructure is frequently lacking or inadequate in artisanal and small-scale mining camps because many sites are in remote locations that are hard to reach and the mining is often a transient activity. In some mining areas toilets are rare and pit latrines, if available, are usually shallow and can easily contaminate other water sources thus increasing the risk of waterborne diseases such as cholera. Stagnant water provides a favourable environment for reproduction of the mosquitoes that carry diseases such as malaria and dengue. Water contamination associated with ASGM can occur in mines and households in the form of mine waste and chemical discharge.

The seasonal and migratory nature of ASGM can lead to high-risk behaviour that can facilitate the spread of sexually transmitted infections (STIs), HIV and AIDS. HIV infection coupled with occupational exposure to silica dust are important risk factors for tuberculosis, particularly among ASGM miners.

Biomechanical and Physical Hazards

Biomechanical hazards such as heavy workloads, repetitive tasks, long working hours and unsafe equipment can lead to the development of musculoskeletal disorders, the most common of which are shoulder disorders, fatigue and lower back pain (McPhee, 2004). Physical hazards form a broad category that includes vibration, loud noise, heat and humidity, and radiation, all of which are present in ASGM.

Musculoskeletal Disorders

Miners experience shoulder disorders as a result of heavy lifting such as overhead work while suspending pipes and cables (Donoghue, 2003). They also experience chronic injury and fatigue from carrying heavy materials over long distances, and bending over in awkward positions, for example during panning or while digging in cramped spaces (Hinton *et al.*, 2006).

Overexertion

In artisanal and small-scale gold mining, overexertion results from uncomfortable postures and carrying out repetitive tasks using non-mechanized tools. Accidents caused by the repetitive use of sledgehammers, drills, pickaxes and rock crushers, while minor compared to those caused by power tools and electrical equipment, can result in serious injuries. Often, miners do not realize the extent of injuries resulting from overexertion and thus do not seek medical attention when needed (Hinton, 2006).

Physical Trauma

Trauma is a significant concern for miners. Traumatic injuries associated with ASGM include burns, eye injuries, fractures, impalement, and in some instances physical dismemberment (Calys, *et al.*, 2015; Long *et.al*, 2015). These injuries are often caused by rock falls, explosions and the inappropriate and unsafe use of equipment. The latter can not only cause biomechanical injuries but also result in electrical shocks and thermal and electrical burns. According to Hinton *et.al*(2006), rock falls are a result of unstable pillars, substandard supports and waste rock being stored next to pits. Reportedly, many artisanal and small-scale miners die in tunnel accidents, under collapsed walls, or in open-pit mines (Hentschel and Hruschka, 2002). In Ghana, (Kyeremateng-Amoah and Clarke 2015) found that injuries sustained by ASGM miners arise primarily because of unsafe working conditions and range from minor types such as contusions to severe types such as fractures and spinal cord injuries. The use of explosives can result in exposure to dangerous levels of dust, noise and vibration and lead to asphyxiation and, in some cases, death due to acute traumatic injury (Harari&Harari 2013). Explosions can also occur when rudimentary tools are used to break up material containing unexploded or misfired explosives (Walle and Jennings, 2001).

Noise

Many tasks carried out within the ASGM work process, for example extraction, crushing and milling, are associated with elevated occupational and community noise levels, often to levels that exceed WHO guideline limits for the prevention of hearing loss (Hinton, Veiga&Beinhoff, 2003; Eisler, 2003; Green *et al.*, 2015). Noise exposure is associated with the following health outcomes: hearing impairment, hypertension, ischemic heart disease, and stress (Basner*et al.*, 2014; Green *et al.*, 2015). Noise is also associated with sleep disturbance and cognitive impairment as well as social and behavioural effects including annoyance (WHO, 2011).

Heat and Humidity

The labour-intensive nature of ASGM can be compounded by extremely hot and humid working conditions. The health effects associated with heat stress are dizziness, faintness, shortness of breath or breathing difficulties, palpitations and excessive thirst (Walle and Jennings, 2001).

Environmental Degradation

Land Degradation

Land degradation is a process in which the value of the biophysical environment is affected by a combination of human-induced processes. Figures 12to 17represents the environmental degradation caused by artisanal mining activities in the study area. This is the result of indiscriminate pitting and digging in search of gold –carrying veins which in most cases, are futile efforts leading to abandoned pits all over the study area. These pits, in some places, have depths ranging between 4-100 meters and some are filled with water

These artisanal miners lack the knowledge of the geology of the area and so, they cannot precisely determine the actual location of and gold-carrying. By their operation, artisanal miners specializes in alluvial mining along river beds and beaches. Gold, as a heavy mineral, can be deposited along river channels which do not represent the environment of the host rocks.

Figure 12: showing land degradation in Igun.

Figure 13: Current mining pit in Igunshowing flood control mechanism inside pits.

Figure 14: Miners indiscriminately digging the ground in search of elluvial gold.

Figure 15: Artisanal mining destroying farmlands inIgun

Figure 16: Un-reclaimed land with exposed mining pits in Igun**.**

Figure 17: Alluvial miners along river channel in Igun

Deforestation

Deforestation occurs due to mining of precious metals such as gold, silver and gemstones. Mining is a destructive activity that damages rainforest ecosystem and causes problems for people living nearby (Figures 18, 19). It involves encroaching into the forest ecosystem causing a lot of trees being cut down by miners so as to have more spaces to dig pits, the trees are also fell to serve as support pillars to hold the walls of the pit being dug and sometimes for fire wood by the miners in the forest. Agricultural activities in the area of study has drastically reduced because of the land degradation and the high migration of the miners that come from the northern part of the country including Mali, Serra Leone, Cameroon and Togo because the area is now becoming a mining district than a residential area.

Figure 18: Deforestation and felling of trees in Igun

Figure 19: Old mining site showing the effect of artisanal mining on the environment

CONCLUSION

The result of the analysis shows the presence of these metals is at minimal level in all seven locations when compared with the World Health Organization limits. The artisanal small-scale mining in the area pollutes the surface water as reflected in the high TDS value recorded in the water samples. However, the socio-economic and environmental effects of the mining could be observed in land degradation, loss of farmlands, desertification and urban migration of indigenous farmers. In this communities, it appears the artisanal miners are not responsible to any government in particular which makes loss of revenue from mining in the area inevitable.

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