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Smart Artisanal Gold Mining from a Sudanese Perspective



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Abstract

Artisanal gold mining activities has increased tremendously over the Sudanese arid and semi-arid environment of the country and has resulted in significant environmental and socioeconomic impacts. This paper aims at identifying the impact of artisanal gold mining on the deserts environment of the Sudan and it is trying to draw a road map for attaining a smart traditional or artisanal gold mining. This paper is a review article and therefore it is dependent to a great extent on a critical review of the available and reliable literature, as well as, the personal experience of the author. These impacts can be summarized as follows: defacing of landscape and consequent change in the natural hydrology of the mining areas, pollution of desert's environment that occurs as result of gold extraction through using toxic and hazardous substances such as mercury, arsenic and cyanide, acid drainage which threatens the neighbouring rivers and ground waters. Therefore, pollution of ground and surface waters in nearby water body e.g. River Nile during the rainy season where rainwater will wash these pollutants polluting the previously mentioned sources. Moreover, Artisanal gold mining has resulted in polluting the soils of the neighbouring agricultural lands and range lands as well. Risks of accidents (land subsidence) and occupational hazards are significant and therefore cannot be ignored. With regard to socioeconomic impacts, they can be summarized as follows: improvement in the standard of living of the miners, agricultural and livestock production were negatively affected due to the abandonment of agricultural fields and range lands due to the fact that the majority of young people have joined the miners, spread of crime and drugs and alcohols and labour which in fact are children (below permissible working age). Artisanal gold mining should be organized by the Ministry of mining, raising the environmental awareness of the miners periodical training programmes for them on how to deal with use of chemical substance and how

Keywords: Artisanal; Acid Drainage; Cyanide; Mercury

Introduction

The adverse environmental impact of mining activities on the environment is well documented. Particular attention has been directed towards the impacts of large scale and small scale gold mining activities on environmental contamination. While the land degradation caused by the gold mining is pronounced, chemical contamination from the gold extraction process imposes a double burden on the environment, with harmful health implications for mining communities and people residing in close proximity to such activities. For instance, due to the informal nature of gold-mining in the South (Africa and Latin America), most studies concentrate on mercury exposure and intoxication incurred in the extraction and processing stage of mining. Results of studies indicate patterns of mercury intoxication during the gold amalgamation process. Most studies involve small numbers and are thus susceptible to predisposition, but some attempt more rigorous design. For example, in one site in the Philippines a study of 102 workers (occupationally Hg burdened ball-millers and amalgam-smelters), 63 other inhabitants (exposed from the environment), 100 persons living downstream of the mine, and 42 inhabitants of another site (serving as controls) was undertaken. Bio-monitors and medical scores for both workers and the surrounding communities were taken. The authors report that "By this method, 0% of the controls,

38% downstream, 27% from non-occupational exposed and 71.6% of the workers were classified as Hg intoxicated". Another study in Tanzania with a similar design found lower levels of intoxication and a more complex mix of mining-related and environmental exposures to mercury through household items such as soap. One study in Ecuador reports higher levels of intoxication in children involved in "gold washing".

One study in Venezuela found no mercury intoxication, despite occupational and community exposures In Ghana several studies in mining towns have revealed that environmental problems such as land degradation, pollution and others are associated with mining activities [1].

Objectives

- a) To identify adverse impact of traditional gold mining on desert environment.
- b) To draw a road map for smart gold mining.

Background About Artisanal Gold Mining

Many African countries are going through a phase of difficult economic conditions and a high rate of unemployment and poverty in their communities. Over the years artisanal gold mining has been a source of income generation of many communities.

A recent boom in mining is stirring in different parts of the continent where the prospect of mineral resources has already been announced. This is encouraged by governmental authorities and large mining companies, so as to fill the gap in the economy deficit and involve the unemployed. In some areas people holding essential jobs are leaving, attracted by the gold glitter and wealth [2].

Although mining, especially gold mining can be a good source of economic income, the malpractice in the process conducted can be damaging to the environment, surface and ground water resources and health of the untrained miners and communities. Careless use of chemicals, especially mercury, and

disposal of polluted water, can threaten the available water resources and the food chain. During the rainy seasons, this polluted water contaminates fresh water sources, mainly rivers and underground sources, and consequently, the socio-economic and health effects can be disastrous. Moreover, destruction of fertile graze lands, where disorganized digging is operated, can be devastating for the fragile agricultural environment.

Mining is an activity that employs many people in rural areas because the barriers to entry are minimal, with low technology, capital and limited specialized skills needed. Miners can earn higher incomes in mining than through other traditional activities. Artisanal mining can contribute to poverty alleviation and provides many opportunities. It is an activity associated with many negative social impacts. Miners are exposed to chemical contaminants, unsanitary conditions, prostitution, alcoholism and drug-taking. Women and children are generally the most affected by these hazards.

Artisanal mining is associated with a number of environmental impacts, which are deforestation and land degradation, open pits which pose animal traps and health hazards, and mercury pollution, dust and noise pollution. A large proportion of artisanal miners are unaware of the laws governing mining activities and the environment Impact of Water Pollution [2].

Method

This paper is a review article and therefore it is dependent to a great extent on a critical review of the available and reliable literature as well as the personal experience of the author.

Traditional Gold Mining in Sudan

Description of the Natural Environment of Traditional Gold Mining Areas: Mining areas are mostly confined to arid and semiarid areas of the country:

a) The Desert: The desert covers the Northern Sudan from a point north of Latitude 16, following a curve to Mohamed Qul on the Red Sea and westwards across Northern Kordufan and Darfur. The annual rainfall is below 75mm. The vegetation is virtually absent except along water courses represented by *Fagonia cretica*, *Indigofera oblongifolia* and *Aerva javonica*. Ephemerals and herbs appear after the rare rain showers.

b) The Semi Desert: This belt spreads in the northern parts of the country, the southern limits of which fall approximately at Wad Medani, ed Duiem after which it crosses lat 140 N to Um Dam in Kordufan and Um Kaddada in Darfur. The rainfall varies from about 75-300mm, very variable and unreliable. The vegetation is a variable mixture of grasses and herbs with a variable scatter of low shrubs and bushes interspersed with bare areas. The belt is represented by various vegetation formations according to changes in rainfall and soils. *Acacia toritllis* and *Maerua crassifolia* in the eastern clay plains, *Acacia mellifera* and *Commiphora africana* in the sandy soil of the west. The bushes are the main source of feed for livestock in the dry season. Accordingly, the type of vegetation is a grazing climax where the palatable browse species are reduced or eliminated. With a rainfall below 300 mm. the land is marginal for rain fed crop production [3].

Artisanal and Small Scale Gold Mining (ASGM)

It is an informal economic activity. ASGM is the process of extracting gold ore from the ground in the absence of land rights, mining license, exploration or mining mineral exploration permit or any legitimate document that allows the operation. Its haphazard nature, location close to and dependence on water have negative effects on the physical, chemical and biological composition of water. The socio-economic benefits of small scale mining, which include employment and income generation, are seriously outweighed by devastating environmental costs and impacts.

ASGM covers a broad spectrum of activities which depend on size of work force, timing, methods used to carry out the operations and whether operations are legal, illegal, formal or informal. The mining is done mainly by poverty driven rural individuals, groups, families or cooperatives with minimal or no mechanization, knowledge or technology in mining and mining safety. It is commonly associated with informal, unregulated, unregistered, unlicensed, undercapitalized and under-equipped mining operations [4]. Traditional mining artisanal scale mining is defined as an activity practiced by utilizing local traditional means within the specified area.

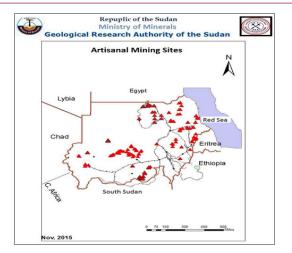


Figure 1: Map below shows the geographical distribution of traditional gold mining.

Over 1 million miners participate in gold mining and extraction. About 4 million dependents directly benefit from the activities. Gold

mining activities cover 14 of the 18 Sudanese states. It is found that Artisanal gold mining accounts for \sim 85% of the total gold extracted (2010-present). Total gold produced for the period 2010- 2015 reaches \sim 280 metric tons (Figure 1).

Results and Discussion

The Environmental Impacts of Traditional Gold Mining

The environmental impacts of Traditional gold mining can be summarized as follows:

Degradation of Land and the Biodiversity: The deforestation and generally the environmental degradation have indeed important implications for the economies concerned, particularly on agriculture, which is often the main economic activity. Pollution becomes an additional cause of poverty [4].

The sensitivity of specific ecosystems to mining is examined. The most obvious impact to biodiversity from mining is the removal of vegetation, which in turn alters the availability of food and shelter for wildlife. At a broader scale, mining may impact biodiversity by changing species composition and structure. For example, acid drainage and high metal concentrations in rivers generally result in an impoverished aquatic environment. Some species of algae and invertebrates are more tolerant of high metals and acid exposure and may, in fact, thrive in less competitive environments. Exotic species (e.g., weedy plants and insect pests) may thrive while native species decline. Some wildlife species benefit from the modified habitat provided by mines, such as bighorn sheep that use coal mine walls as shelter.

The Impact of Mining on Landscape: The impact of mining activities on the environment is very remarkable. First of all, mining activities require acquisition of large tracts of land. Both deep and surface mining degrade the land surface since there is destruction of the entire forest. Consequently, land for farming and other agricultural purposes is lost. Furthermore, spillages of chemicals such as cyanide, mercury and other toxic materials into the nearby streams cause water pollution, destroying water bodies and aquatic life.

Exposures of such chemicals are also harmful to human health. Linked to this, gas and other forms of vapour produced from heavy machines and equipments used, as well as other chemicals are sources of air pollution to the environment. On health, several health implications are associated with mining activities. Mining activities such as blasting of rocks lead to air and noise pollution that affect the people within the surrounding areas. These sometimes lead to incidence of upper respiratory tract infections such as cancer, cough or cold and asthma. There are also the incidence of malaria, diarrhoea, acute conjunctivitis and accidents all of which result in morbidity and mortality conditions in the mining areas. In response to these, mining companies usually seek to lay down health measures by providing health facilities such as clinics, hospitals, and health education of various forms. Notwithstanding this, the negative environmental and health impacts of mining activities are so immense that they call for urgent interventions.

According to the literature that was reviewed, the compounding environmental and health cost and damages of mining activities far outweigh their economic and social benefits, the magnitude of which cannot be quantified. There is therefore high health cost incurred as a result of mining activities]. Land subsidence has resulted annually in the death of hundreds of miners [2].

Production of Immense Quantities of Solid Wastes: By nature, mining involves the production of large quantities of waste, in some cases contributing significantly to a nation's total waste output. For example, a large proportion of the materials flows inputs and outputs in the United States can be attributed to fossil fuels, coal, and metal mining. The amount of waste produced depends on the type of mineral extracted, as well as the size of the mine. Gold and silver are among the most wasteful metals, with more than 99 percent of ore extracted ending up as waste. By contrast, iron mining is less wasteful, with approximately 60 percent of the ore extracted processed as waste Disposing of such large quantities of waste poses tremendous challenges for the mining industry and may significantly impact the environment. The impacts are often more pronounced for open-pit mines than for underground mines, which tend to produce less waste. Degradation of aquatic ecosystems and receiving water bodies, often involving substantial reductions in water quality, can be among the most severe potential impacts of metals extraction. Pollution of water bodies results from three primary factors: sedimentation, acid drainage, and metals deposition [5].

Sedimentation: Minimizing the disturbed organic material that ends up in nearby streams or other aquatic ecosystems represents a key challenge at many mines. Erosion from waste rock piles or runoff after heavy rainfall often increases the sediment load of nearby water bodies. In addition, mining may modify stream morphology by disrupting a channel, diverting stream flows, and changing the slope or bank stability of a stream channel. These disturbances can significantly change the characteristics of stream sediments, reducing water quality.

Higher sediment concentrations increase the turbidity of natural waters, reducing the light available to aquatic plants for photosynthesis In addition, increased sediment loads can smother benthic organisms in streams and oceans, eliminating important food sources for predators and decreasing available habitat for fish to migrate and spawn. Higher sediment loads can also decrease the depth of streams, resulting in greater risk of flooding during times of high stream flow [5].

Acid Drainage: Acid drainage is one of the most serious environmental impacts associated with mining. It occurs when sulfide-bearing minerals, such as pyrite or pyrrhotite, are exposed to oxygen or water, producing sulfuric acid. The presence of acidingesting bacteria often speeds the process. Acidic water may subsequently leach other metals in the rock, resulting in the contamination of surface and groundwater. Waste rock piles, other exposed waste, mine openings, and pit walls are often the source of acidic effluents from a mine site. The process may occur rapidly and will continue until there are no remaining sulfides. This can

take centuries, given the large quantities of exposed rock at some mine sites. Although the process is chemically complex and poorly understood, certain conditions can reduce likelihood of its occurrence. For example, if neutralizing minerals are present (e.g., carbonates), the prevailing pH environment is basic, or if preventative measures are taken, then acid drainage is less likely to occur Acid drainage impacts aquatic life when acidic waters are discharged into nearby streams and surface waters. Many fish are highly sensitive to even mildly acidic waters and cannot breed at pH levels below 5. Some may die if the pH level is less than Predicting the potential for acid drainage can help determine where problems may occur. Methods vary from simple calculations involving the balance of acid generating minerals (e.g., pyrite) against the existence of neutralizing minerals (e.g., calcium carbonate) to complex laboratory tests (i.e., kinetic testing). However, even laboratory-based tests cannot be relied upon to accurately predict the amount of metals that will be leached if acid drainage occurs, because of the differences in scale and composition that occur when samples are analyzed exsitu.

Metals Deposition: Most mining operations use metals, reagents, or other compounds to process valuable minerals. Certain reagents or heavy metals, such as cyanide and mercury, are particularly 2 On a pH scale of 0-14, neutral pH is 7, while pH levels of 2 or lower are not uncommon in acid drainage. The release of metals into the environment can also be triggered by acid drainage or through accidental releases from mine tailings impoundments.

While small amounts of heavy metals are considered essential for the survival of many organisms, large quantities are toxic. Few terrestrial and aquatic species are known to be naturally tolerant of heavy metals, although some have adapted over time. In general, the number of plant and animal species decreases as the aqueous concentration of heavy metals increases. Some taxa are known to be more sensitive to the presence of heavy metals. For example, salmon species are particularly sensitive to increased concentrations of copper. Furthermore, juvenile fish are more sensitive than adult fish, and the presence of heavy metals may affect critical reproductive and growth stages of fish.

Air and Noise Pollution: Mining activities and mining support companies discharge particulate matter into the ambient air. The grievances of the affected communities on air quality have been the airborne particulate matter, emissions of black smoke, noise and vibration. Airborne particulates of major concern the mining areas include respirable dust, sulphur dioxide (SO₂), nitrogen dioxide (NO₂), carbon monoxide (CO) and black smoke. The activities that produce this particulate matter include site clearance and road building, open-pit drilling and blasting, loading and haulage, vehicular movement, ore and waste rock handling as well as heap leach crushing by companies during heap leach processing. Others include fumes from the roasting of sulphide ores by assay laboratories and in refining processes. The discharge of airborne particulate matter into the environment principally minute dust particles of less than 10 microns -- poses health threats to the people living in areas neighbouring the mining areas. All fine dust at a high level of exposure has the potential to cause respiratory diseases and disorders and can exacerbate the condition of people

with asthma and arthritis. Dust from gold mining operations has a high silica content which has been responsible for silicosis and silico-tuberculosis in the area.

Unfortunately, the mining companies have not laid down adequate measures to prevent harmful emissions of dust into the ambient air. Measures to reduce dust emission are restricted to occasional spraying of roads within the premises of the mining concessions. This seems to be a misplaced effort because road dust does not appear to be the main source of dust pollution. Black smoke from fuel burning, fumes make up additional sources of airborne pollutants. There were cases where the values recorded for smoke exceeded the acceptable and tolerable levels of the EC, WHO and EPA. The uppermost value recorded was 207 gm-3 as against the tolerable levels of 100 gm-3 for the EC, 85 gm-3 for the WHO [2].

Noise and Vibration: The sources of noise and vibration in the area comprise mobile equipment, air blasts and vibration from blasting and other machinery. The impact of high-pitched and other noises is known to include damage to the auditory system, cracks in buildings, stress and discomfort. These noises can also terrify animals, hinder their mating processes and also cause abortions, therefore adversely affecting the animal population. However, the measures being put in place by the mining companies have not sufficiently addressed the problem of noise pollution in the area.

A critical assessment of the literature under review showed that much of the negative environmental and health effects of mining activities have been documented. However, little do we know as to suggestions and policy directives needed to be implemented to redress hazardous health effects of mining. In addition, most of the literatures reviewed were focused mainly on mining and economic development. Hence, these presented less findings on environmental and health impacts of mining on surrounding communities [2].

Impact of the Artisanal Gold Mining on Socio-Economic Life in Sudan

Recent Studies point to a number of indicators attributed to the impact of gold produced on the national macro-economy: boosted GDP and economic growth, enhanced balance of trade through exports and increased employment opportunities.

a) The Economic Indicators:

- i. Total gold production escalates with the advent of artisanal gold activities.
- ii. Artisanal gold mining operations currently contributing \sim 85% of the total national production.
- iii. 12 to 15% of production comes from large and small-scale mining and tailings processing operations.
- iv. Prior to 2008, production solely come from the Sudanese-French JV Ariab Mining Co. (6 MT in 2005).
- **b)** In 2014 Sudan Ranked 3rd in Gold Production Among African Countries: Gold exports make an average of 33% of total national exports for the period 2012-2014.

c) Contribution of Artisanal Gold Mining Activities to Employment:

- i. A one million individuals involved in artisanal small-scale gold mining and extraction.
- ii. Another 4 million of family dependents benefit from mined gold revenues.
- iii. The total ASM activity-dependents (5 millions) translate to ${\sim}14\%$ of the total population.
- iv. Over 30 types of occupations are practiced within the ASM gold mining and processing centres.

d) Social Impact Indicators of Artisanal Gold Mining Activities

- i. Recent surveys indicate that majority of the miner's sample are young (below 45)- constitutes $\sim 93\%$ of the community.
- ii. Child labour is diminishing (<1%)- in some sites children under 15 and women are visible minorities.

Participating artisanal gold miners' dwell in 2 types of settlements:

- i. Ø Mining camps located around pits- transient.
- ii. \emptyset In or around processing centres established at out skirts of towns- semi-permanent.
- iii. Processing centres (suq) provide over 30 type services ranging from gold extraction techniques to food, health care, entertainment.
- iv. Low level hygiene, occupational health problems and different ailments reported.
- v. Security and crime cases among the miner's communities generally low- vary from vice encounters to serious offenses.
 - vi. Theft, cheating, and drug abuse make >90% of cases.

e) Micro-Economic Impacts of Artisanal Gold Mining and Extraction

- i. Surveys of artisanal gold mining community depict the majority have previous occupations and a source of income.
- ii. The study shows that only 7.5% of sampled were previously unemployed.
- iii. Average daily wages of farming labour increased from SDG32 (2011) to SDG80 (2013). Hike could be attributed to migration of workforce from traditional agriculture sector to artisanal mining sub-sector.
- iv. Consequences of sectorial migration: less land cultivated, lower crop yield, shortages, less exports
- v. Gold sales proceed-sharing is dominant labor relation set up among facility owners and hand labor.

f) Mercury:

i. Field observation indicate that ASM gold is extracted from ore through amalgamation (Hg^{0} – Au^{0} /amalgam).

- ii. Gold extracted through burning off mercury. Hg vapour released in the atmosphere and ultimately into the environment.
- iii. Released Hg poses serious health issues-vapour inhalation or consumption of contaminated water, animal and crop products contamination.
- g) Research and Development Work Carried Out on Hg Use Provide Two Options: Reduced and safer use of mercury, or elimination of mercury from ASM gold extraction process [3] (Figures 2-4).



Figure 2: Artisinal gold mining in Sudan.



Figure 3: Gold mining in Darfur Sudan.



Figure 4: Contaminated water due to Mining processes in Barbara ream River Nile State of the Sudan.

Moreover, food unreliability, unaffordability, and unavailability, with reflections of susceptibility to food deficiency diseases, infectious diseases, and morbidity are wide spread in the mining areas. Deficiency to micro nutrients might subject miners in the study area to hidden hunger, which represents the most prevailing form of nutrition deficiency diseases in the world. On the other

hand, nutrition insecurity of miners might expose them to protein - energy malnutrition. In addition, good nutrition requires healthy environment which is not available, because mining areas lacking to adequate water services, food supplies, and basic medical services, and suffer from poor living conditions. These conditions put gold miners under hazards of infectious and communicable diseases, such as respiratory and gastrointestinal diseases, fever, and malaria [6].

In fact, health problems among miners are worldwide phenomena spread in Australia, North America, South America, and Africa. Including frequency of cancer of the trachea, bronchus, lung, stomach, and liver, increased frequency of pulmonary tuberculosis (PTB), silicosis, and pleural diseases, increased frequency of insectborne diseases, such as malaria and dengue fever, noise-induced hearing loss, diseases of the blood, skin, and musculoskeletal system. All these health complications decrease life expectancy of the gold miners. The outbreak of yellow fever in Sudan October 2012 in general, and in Darfur in particular, was found that 18% of the recorded cases working in traditional gold mining areas.

Health records of Abu Hamad's Central Hospital, which is one of the main hospitals close to the study area, received 107 cases of undiagnosed fever from gold mining areas, in addition to some cases of cancer and respiratory diseases (Abu Hamad Central Hospital, March 2011). Cancer that was diagnosed in the hospital is due to the use of mercury and cyanide for gold extraction by these gold miners. Mercury goes into the human body through inhalation or by eating polluted food or water, and it was found that 48% of miners blood affected by mercury compounds. Mercury cause health problems, which may appear for years later which include brain damage, kidney failure, skin and eye problems; and dysfunctional neurological development in infants and children.

In fact, the quick and dirty production process of gold amalgamation emits mercury into the atmosphere in the study area. It was found that, the small-scale gold mining is responsible for 37 percent of global mercury emissions and is the largest source of air and water mercury pollution (United Nations Environment Program, 2011). Such emissions might also seeped into soil, water bodies and agricultural fields, similar to the Amazon Basin where the release of large concentrations of mercury through mining inhibited plant growth and animal immunity, resulting in the death of flora and fauna [6].

Miners Environmental Health Conditions: Workers consume unsafe water which is insufficient in amount and expensive, giving rise to multiple health problems. This is particularly true in Sudan, where only 67% of the population have access to safe drinking water (Nation Master, 2010). However, even those served by clean water do not get 40-50 liters per day per person as stipulated by WHO (WHO, 1983). These deficiencies in quantity and quality of water in the mining areas make the workers exposed to water washed and water borne diseases such as diarrhea, dysentery, typhoid, and cholera. Since gold miners do not have access to piped water and

are therefore served by water vendors, the risk of contamination become extremely high [6].

Smart Artisanal Gold Mining from a Sudanese Point of View

Smart artisanal gold mining can be achieved through:

- a) Gradual withdrawal from using toxic compounds such as cyanide and mercury by more friendly technique for extraction of the gold.
- b) Government should supply the mining areas with clean and healthy water
- c) Provision of essential sanitary services to avoid spread of infectious diseases
- d) Rearrangement of gold markets and give incentives for the minors to avoid or reduce gold smuggling.
- e) Prevention of working of children
- f) Improvement the healthy conditions of the food consumed by the minors $\label{eq:minors} % \begin{aligned} & \text{ on the food consumed } \\ & \text{ on the food consumed } \\$
- g) Avoid mining in areas close to settlements or neighbouring agricultural fields.
- h) Improving methods for the reuse of gold wastes or tailing
- i) Raising the environmental awareness of the minors by conducting periodical training in the mining areas.
- j) Take the necessary precaution against spills and acid drainage to avoid polluting the River Nile water and ground water.
- k) Preparation of land use map to protect settlements and agricultural as well as range lands [7].

References

- Yeboah, Joseph Yaw (2011) Environmental and health of mining of surrounding communities: A case study of Anglogold Ashanitin in Obuuas.
- McKeon EA, Bugyi G (2015) Impact of Water Pollution on Human Health and Environmental Sustainability Pennsylvania State University, USA, A volume in the Practice, Progress, and Proficiency in Sustainability (PPPS) Book Series Published in the United States of America by Information Science Reference (an imprint of IGI Global) 701 E. Chocola. American Based Research Journal 4(7).
- Abdel Magid T, Badi KH (2005) Ecological Zones of the Sudan, paper prepared for the Nile basin Initiative in Sudan (Biodiversity in Sudan).
- (2014) Sudanese National Academy of Sciences (SNAS) Academy of Sciences of South Africa (ASSAF). Workshop on The Impacts of Artisanal Gold Mining in Sudan Khartoum, Future University, Future University (FU) and Sudan Medical Heritage Foundation (SMHF).
- 5. Appendices.
- Wadi EI Ali, Alredais SMAH (2015) Socioeconomic and Environmental Implications of Traditional Gold Mining in Sudan: The case of Barber Locality, River Nile State. American Based Research Journal 4(7).
- 7. Personal experience of the author.

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