Impact of Mercury Use in Artisanal Gold Mining on Community Health: Kahama Case Study, Tanzania

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Abstract: *This study is part of the main research carried out in 2010 which investigated social economic impact of uncontrolled artisanal mining on local communities and the environment using a case study of sampled gold mining sites in selected villages in Lunguya and Segese wards in Kahama District, Tanzania. The methodology involved a study sample size of 210 households, forming 70% of the targeted mining villages. They were interviewed on various social economic variables related to artisanal mining and environmental issues in the study area. Interviews to respondents were counterchecked by medical laboratory examination records to validate the results on the impact of mercury use by uncontrolled artisanal mining activities on human health and the local environment at large. In short, uncontrolled artisanal miners' practices of site clearing of trees to give way to open cast mining in extraction of ore; and washing processes involving use of mercury in shallow ponds which frequently acted as sources of domestic water compounded the polluting effects to human population in the study area. Laboratory investigation results indicated that there were mercury concentrations in soil and water ranged between 0.012 mg/kg in water to 0.85mg/kg in soil with pH ranged from 2.8 (acidic) in the water that miners re-used in the processing of gold ore, to 4.1 in the water pool, for example, at Kakola in Lunguya ward where residents used the same water for domestic purposes; while soil acidification recorded (2.7) pH. In the overall, 89% of interviewed respondents in the study area stated they partially benefited economically through self-employment gained from artisanal gold mining at the expense human health and environmental pollution and degradation in general. This study concluded that although the community in the study area apparently gained economic benefits from artisanal gold mining; the consequent public ill-health and environmental hazards outweighed the benefit gained. The study recommended to the government, law enforcers and other stakeholders at different levels to take immediate safety measures to ensure safe artisanal gold mining for sustainable development. This to be paralleled by community awareness building on the negative effects of poor mining methods in order to take collective remedial action for the welfare of the local community and the nation at large.*

Key words: Uncontrolled artisanal mining, medical laboratory examination, mercury concentrations, environmental pollution, community health.

1 INTRODUCTION

Mining is a human activity that involves digging into the earth to extract naturally occurring minerals either through open cast or shaft mining. Mining can be done at

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large scale where large companies are involved; or at small scale as the case of artisanal mining where minimal capital is invested in the extraction of mineral deposits by using fairly rudimentary implements in the production process (Chiri and Gawu, 2013). Gold artisanal mining is key to this study.

Artisanal mining is frequently practiced in rural areas by semi-skilled artisans with various social, economic and technical constraints which impede optimal extraction of mineral deposits. This disadvantaged standpoint position, deprive artisanal miners accessing various social economic opportunities to maximize profits from the mining activity unlike large scale mining companies. In short, their disadvantaged position makes them lack the necessary technical – economic information for long term planning (Veiga, 2006). As a result, frequently artisanal miners experience limited financial resources to invest in essential capital goods and services for efficient mining fuelled by often no access to bank loan facilities largely due to lack of loan securities. As a result, often they carry out mining operations at own risks and in a haphazard manner causing various negative effects to the environment and surrounding communities. It is due to the fact that during the process of mining, artisanal miners are compelled to clear the site by cutting down trees excessively in order to get land for settlement. Tree felling is followed by actual digging pits into the belly of the earth for ore extraction, concluded by the use of water and mercury to wash away impurities from gold ore. The aggregate of all these processes immensely contribute to environmental destruction and many human health hazards (Ogola *et al.*, 2002).

Tanzania is endowed with abundant mineral resources including gold reserves. She is the largest gold producer in Africa, after South Africa and Ghana. However, no comprehensive studies have measured the contribution of artisanal mining to the national income. Nevertheless, it significantly contributes to national income accrued from small scale mining from various parts of the Lake Zone which is endowed with gold deposits. They include, three recently opened major open-pit gold mines, namely, Golden Pride at Geita, North Mara and an underground mine at Bulyanhulu in Kahama district. These mines are all within the Nyanzian greenstone belts in the Lake Victoria Goldfields (Lissner, 2009). Gold production in Tanzania contributes 50% of all non-traditional exports (URT, 1999).

Kahama, which is highly endowed with gold is the largest gold producer in Tanzania surrounded by a number of gold artisanal mining activities. They occur around Bulyanhulu gold mine which is allegedly said to have substantially reduced local fauna due to increasing tree felling basically for mining activities. Impliedly, this has diverse social economic threat to wildlife and human settlements. Much of the mining process in Kahama district is dominated by crude methods of extracting gold ore from the ground while processes involved in separation of gold from the ore use river water and mercury for cleansing purposes. As a result, great mercury concentrations in humans and in the environment linked to gold mining activities in Kahama district has been reported (Glahder, 2009). The human health risks motivated us to conduct this study in order to investigate such effects caused by gold artisanal mining in selected local communities with a view to ascertain its magnitude and impacts to the environment and social economic condition of the

surrounding communities in the villages of Segese and Lunguya wards in Kahama district, and consequently come up with alternative suggestions for sustainable development in the study area. Specifically, the study examined the gold mining method, safety and technology used by artisanal miners in from the extraction of gold ore to the ore purification process using mercury and water from streams and the human health risks involved. It is hoped that, the added knowledge and experience from the study exposed the magnitude of the polluting problem caused by uncontrolled artisanal mining worth-intervention by different stakeholders at different levels to improve the health situation in the study area and the country at large.

2 LITERATURE REVIEW

Small scale mining for gold is a worldwide phenomenon which directly and indirectly supports an excess of 100 million people (World Bank, 2005). Small scale gold mining provides jobs in remote villages, reduces migration of able bodied people to urban areas, and helps fight poverty. On the other hand, artisanal mining has considerable risks to the environment and people's health. Generally, artisanal miners belong to the informal sector (World Bank, 2005). Very little reliable data exists to document employment levels in the small scale sector. A large proportion of small-scale miners, notably artisanal miners, are employed in the informal sector and therefore not necessarily accounted for in official statistics. Artisanal mining activities degrade the environment when there is uncontrolled use of mercury in the mining processes, the processing of gold using mercury, is known as gold amalgamation. Amalgam formation is thought by some authors to be a formation of alloys between mercury and metals. Others believe that amalgamation may be an adhesion process or an interpenetration of the two elements. Mercury forms amalgams with all metals except iron and platinum (Veiga *et al.*, 2006).

Studies made by the World Bank (2006) show that the cutting of trees in Mongolia which also involved massive burning of wood in the process of clearing the forest for mining activities degraded the environment, leaving behind no chance for other economic activities like agriculture. In Indonesia artisanal mining activities led to excessive cutting of trees which affected the forest cover and increased the rate of environmental degradation and poverty (World Bank,2000).

A Papua New Guinea study revealed plenty of gold mostly found in Lihir village. Apart from mining activities, rural communities of Papua New Guinea depend on nature to sustain their livelihood. The introduction of mining activities in remote areas of the country had a greater effect as the mining activities degraded severely the environment and made it unsuitable for agriculture and other economic activities. These rural communities were also affected by water born diseases caused by insects that dwell in water sink holes made by pit digging during the mining processes (Shearman *et al.,* 2010).

Venezuela artisanal mining practices degraded the environment through heavy deforestation caused by tree cutting for mining activities. Aryee *et al.* (2003) observe in Ghana that, where artisanal mining activities for gold are taking place

large tracts of agricultural land are destroyed due to excessive vegetation removal and the consequent destruction of soil structure.

Mwaipopo *et al.* (2004: 113) estimate the number of artisanal miners in Tanzania to be around 600,000 in 2004. Conversely, artisanal mining has been reported to cause environmental degradation through deforestation, pit digging, and uncontrolled use of mercury (Curis and Lissu, 2008). Artisanal mining has gained pace recently in the post neo-liberalization time; so far very limited studies have been conducted on the adverse impact of artisanal mining to human health and the environment. This motivated the researchers to conduct a study in Kahama district basically to add knowledge to the data bank on human health hazards caused to local communities with a view of finding a permanent solution.

Though the National Environmental Policy (NEP) of Tanzania was launched in 1997 addressing, among other things, the urgent need to care for the environment against any human activities including mining which degrade the environment and human health; it lacked legal protocol to oversee its implementation. This situation necessitated a review of NEP which gave birth to Environmental Management Act (EMA) of 2004. EMA institutionalized a legal framework to monitor, supervise and enforce the law against defaulters of NEP. However, one of its objectives highlighted these shortcomings "... the deteriorating state of the national environment [caused by] ... inadequate institutional coordination; inadequate monitoring and information systems; inadequate involvement of major stakeholders (e.g. local communities, NGOs, private sector) in addressing environmental problems" (NEP, 1997). To a great extent these inadequacies still exist, for example, quite often artisanal miners violate regulations required for safe method of mining mainly due to lack of law enforcers' close supervision and ignorance (View more http://www.redorbit.com/news/science/1484000/a_review_of_current_tanzanian_national_environmental_policy/#KTjMj8ojQ1DC4KRW.99)

2.1 Theoretical framework

This section presents the study's theoretical framework in attempt to link theory and this study. This study employs the Progressive Utilization Theory (PROUT). PROUT is a social and economic theory developed in 1959 by the late Indian scholar-author and activist Sarkar (1959). Mr. Sarkar sought a practical alternative to the theories of Marxism (communism) and capitalism. The following updated explanations about PROUT have been extracted by this study from Trond (2011). The theory is based on universal values recognizing and protecting the rights of all to the fulfillment of their basic needs; the protection of the environment, plants and animals; and a dynamic, incentive-based multi-tiered economy with local and cooperatively-employee-owned enterprises at its core. It encourages a balance in the effort of satisfying individual and collective needs. No one should be left behind as society marches forward. In principle, PROUT refers to the utilization of human resources, and states that a healthy society must develop the potentialities of all people. By denying large segments of humanity chances for educational and economic development, the present day society is not correctly utilizing precious human resources. This principle also calls for the need to balance collective good with individual good. Mainstream argument is built on super being spiritual belief

that any progress is challenged by a counter action force. For instance, "development" such as the invention of automobiles face counter-forces involving automobiles pollution, risk of injury and death in accidents.

Sakar (*Ibid)* advanced five main PROUT propositions as follows: Firstly, no individual should be allowed to accumulate any physical wealth without the clear permission or approval of the collective body. Secondly, as basis of a collective approach to economic questions, there should be limitations on the individual possession of physical wealth which is something finite as compared to moral or mental and spiritual sphere, because that is an infinite treasure of humanity which should not be restricted. Thirdly, there should be maximum utilization and rational distribution of all mundane, supra mundane and spiritual potentialities of the universe. This principle encourages society to utilize all resources of the universe to satisfy human needs. "Rational distribution", means that the minimum necessities of all should be guaranteed but that individuals who have contributed special services to society should be given special rewards to encourage their work and to encourage others also to contribute more to society. Fourthly, there should be a proper adjustment amongst these physical, metaphysical, mundane, supra mundane, and spiritual utilizations. He underlined society to inspire people to work for the individual and collective good, and thus he urges that provisions will be made so that all can earn their minimum necessities through appropriate work. Fifthly, that the method of utilization should vary in accordance with changes in time, space and person, and the utilization should be of a progressive nature.

This study intended to use PROUT to make analysis on whether the financial of wealth gained from gold by artisanal miners equally benefits the local community in terms of health in rationality to resource utilization. On the one side of the coin, while exerting environmental degradation, diseases, poverty and deforestation on the other side it is not sustainable in society. The mainstream argument of PROUT lies on the assumption that, when animate "utilize" inanimate at sustainable levels animate and inanimate objects in the environment co-exist harmoniously forming the unit of opposites under supreme consciousness. The problem arises when animate or human population overexploit inanimate for "development"; it is when counteractions surface out. Situating it to this study; the artisan miners as part of the human society want gold for social development, however mismanagement of extraction of inanimate symbolized by gold mining shortly brings in disharmony as interaction trends emerge in the form of environmental degradation in various ways including depletion of forests, soil and water pollution giving way to social and public health hazards which in turn afflict both the human society in terms of disease and the environment due to uncontrolled artisanal mining.

Critics of PROUT argue that, the theory advocates an ideal society with dogmatic perfection hanging between Socialism and Social Democrat bound by a spiritual belief fibre. This question has its practicability in a secular society with diverse institutional belief; and so far no country has introduced and practiced PROUT. Despite the foregoing criticism, this study partly took its logical recognition that for every action there is a counter-action. In social development perspective, every "development" has its "costs". Likewise, artisanal miners commercially benefits

from the fruits of gold minining, however, there could be disastrous health effects on the surrounding communities and environment at large. Thus, this study used PROUT as a framework to guide the research in unveiling the artisanal mining issues and suggest the way forward to sustainable community and environmental health.

3 MATERIALS AND METHODS

3.1 Study area

Kahama District is located in Shinyanga region, northwest of Tanzania. It lies between latitudes $3^0$15 and 4 ^{0}30 south of Equator and longitudes 31^0 and 33^0 east of Greenwich and covers an area of 8,477 square km (Figure 1). According to the 2002 Tanzania Population and Housing Census, Kahama District has a total population of 596,456 persons with an annual population increase of 3.3% (NBS, 2012).

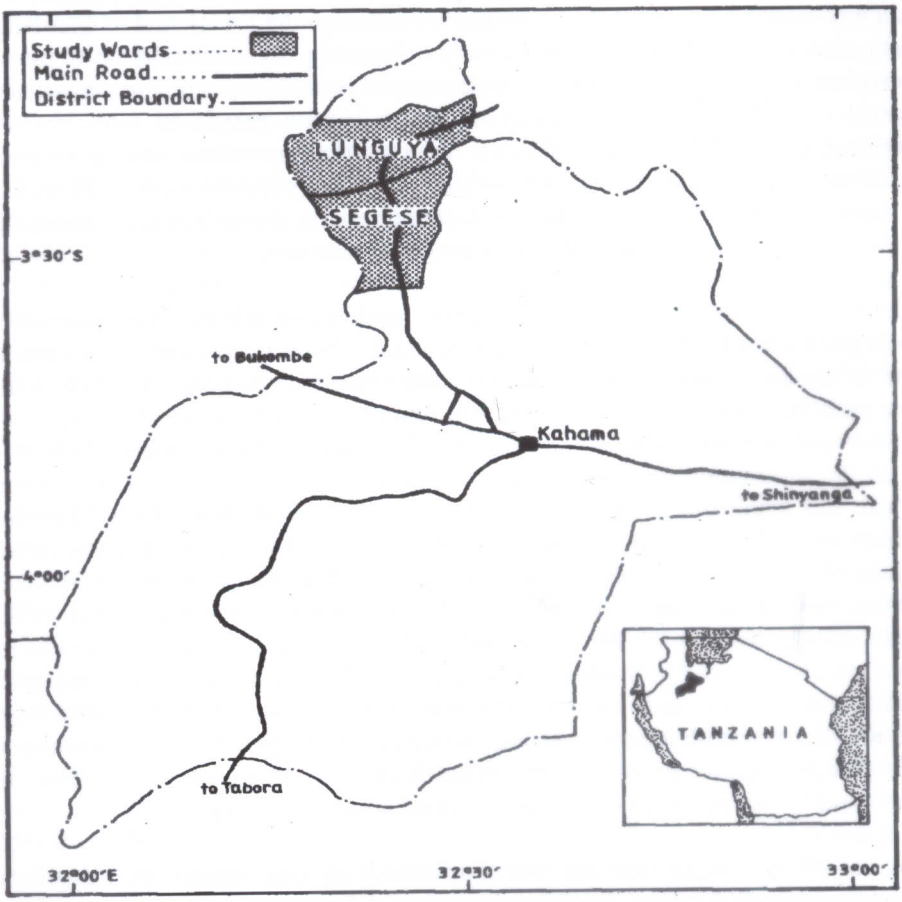

Figure 1: Sampled Artisanal Mining Villages in Kahama District, Tanzania
***Source**: Kahama District Survey, 2011*

Kahama District experiences Equatorial climate with mean daily temperatures ranging from 20° to 26° C, August and September are the warmest months. On

average, rainfall ranges from 750 to 1,030 mm per year between October and May. However, the recent years have experienced rainfall variability rendering unreliable rainfall distribution pattern (Kahama Meteorological Department, 2009). The District is drained by several seasonal streams collecting water from five catchments areas known as Mtoni, Kigozi, Isanga, Manonga and Kadongkeni. Mtoni and Kigozi catchments drain the southern and western part of the District into Lake Tanganyika, whereas, Isanga and Kadongkeni catchments drain the eastern and northern parts respectively into Lake Victoria. According to the Kahama Agricultural Department (2009), the topography of the District include the inter-rift plateau at altitudes ranging from 1,050 to 1,500 m. above sea level. The land surface is made up of undulating upland plains duplicated by isolated residual low relief hills. These undulating to flat plains are characterized by frequent occurrences of bottomlands covered with a mixture of silt, volcanic and black clayey soils termed by indignant people as *mbugas* are wide spread over the upland valleys which experience floods during the rainy season.

The geology of the Kahama is formed by the Nyanzian greenstone belts within the Lake Victoria Goldfields basin divided into two parts: the Eastern "outer arc" of the Sukumaland Greenstone Belt; and the Western part of the Rwamagaza Greenstone near the largest gold producer in Tanzania, the Bulyanhulu Gold Mine located at the north-west point of Kahama West. The gold mineral ore at Bulyanhulu is associated with major quartz vein systems at the contact between mafic-intermediate flows and felsic pyroclastics, locally with lenses of Argillite. Economic gold mineralisation in the Tanzanian Craton is principally associated with the greenstone belts of the Nyanzian System. The study area covers the two wards of Lunguya and Segese which fall under the Greenstone Belt and are located near the main Bulyanhulu Gold Mine.

According to the Kahama District Agricultural Department (2009), the economic activities are mainly agriculture and livestock. Estimated 483,320 ha form arable land which is either put under crop cultivation or livestock grazing. There are five major crops named as main income earning crops, namely cotton, paddy, tobacco, maize and chickpea. These crops contribute more than 40% of the district economy. Basically agriculture and livestock employ more than 80% of the district population. Forestland occupies 211,000 ha. Mining is another important economic activity carried out in two official mines in operation, Kahama Gold Mines (underground mining), and Buzwagi mines (open ground mining) while artisanal gold mining is commonly found in Segese, Lunguya, Bugarama, Isaka, Kahama Mjini and Chela wards.

3.2 Methods

A variety of data collection methods were used in order to triangulate information as follows:

(*i*) *Documentary Review*: includes, policy documents, technical papers, journals, government and district reports, medical records related to social economic effects of artisanal gold mining in the study area. Secondary data on diseases associated with environmental pollution were collected from clinical officers in nearby health facilities.

(ii)Quantitative methods: structured and unstructured questionnaire interviews for households were administered. Using a questionnaire, each head of the randomly selected household was interviewed on his/her household's daily practices and attitudes related to mining environment. With this method, data on sources of environmental pollution, morbidity and the general health of the public linked to artisanal mining were tested and established.

(iii) Qualitative methods: interviews, the use of objective questions but capitalized more on open -ended questions in order to obtain in depth information on effects of artisanal mining activities to the environment. Questions related to environmental degradation; designed to capture factors that affect communities living within the artisanal mining environment.

(iv)Observation: different types of observation were employed to assess social economic effects of artisanal mining activities. It involved direct observation during fieldwork on the social economic conditions, tools used in artisanal mining, mining practices and processes which in one way or the other affected the health of miners and members of the community in the study area. Also the study observed the existence and adherence to environmental management laws to protect people and the environment. Participant observation was employed by the researchers directly observing artisanal miners practices of processing gold ore from crushing the rock, washing the ore in ponds or nearby streams to amalgamation of gold by mercury under uncontrolled mining methods. Also, the researchers observed women fetching water for domestic uses from such contaminated water sources; and visited fields of crops which were partly drained by water sources interchangeably used by artisanal miners for gold ore processing.

(v) Laboratory tests: had to be conducted in order to assess whether the environment, particularly water and soil were polluted by the use of water and mercury in washing the crushed gold ore in the refining process to get gold. Samples of water and soil in different sites found within the ponds and river water used for gold ore purification processes were taken to an identified soil laboratory for test in order to establish the degree of pollution by mercury or other polluting materials sand. This test was necessary because pollution of water and soil usually affect people, animals and crops. Once these were polluted the users of such resources in form of water for drinking, washing or consumption by plants, human beings and plants would definitely be polluted hence experience health problems. The laboratory test also assisted to confirm the existence of polluting effects thus gave a clue on the prevailing environmental diseases affecting humanity and the environment related to uncontrolled artisanal mining practices.

(a) Sampling frame

The sampling frame for this study consists of the total number of 3,509 households of two wards with a population of 35,086 people almost 6.25% of the whole Kahama district population of 596,456 people (NBS, 2002). Due to resource and time budget limitations, this study could not manage to interview the entire population. It covered only 6% of the sampling frame, a total of 210 households. Interviewed households were 70 including Mwazimba village in Segese ward; and

140 households from Nyangalata and Kalole mining village in Lunguya ward. Table1 shows the representative sample from each study ward.

Table 1: Sampled households

WARD	Total Number of Households	6% proportional of representative sample (PRS) of households	Number of Households to be sampled
Segese	1170	1170 x 3509 x 210	70
Lunguya	2339	2339 x 3509 x 210	140
Total	**3509**	**x**	**210**

Source: Kahama District Survey, 2011

(b) Selection of study wards

Kahama District is endowed with gold reserves found within the Nyanzian Greenstone Belts in the Lake Victoria Goldfields. The selection of the study area was based on the availability of artisanal gold mining activities deposits as compared to other areas of the District. The choice was equally influenced by Taylor's (2010) observation that within the 34 wards in Kahama District, some wards had artisanal mining activities. This study purposely selected two artisanal mining wards. The rationale for the selection was based on their longer time involvement in artisanal mining activities than others. They were deemed to possess relatively established information and experience on the impact of small scale mining on the environment and human health. For this reason, Segese and Lunguya wards were selected.

(c) Selection of households for questionnaire interview

Simple systematic random sampling (SRS) was be used in administering a person to person interview of the 210 households. This gave equal chance for every sample to be selected for interview (Kothari, 1992). The use of data from the Tanzania National Population Census and from Kahama District household records were used to draw a reliable households sampling frame. From each ward the researcher obtained a list of names of households per sub ward (streetwise). Then random sampling was employed to pick households to match the number of households selected for interview. Sub ward leaders assisted in locating the respective households.

The units of analysis for this study were twofold. Firstly, heads of households who were interviewed by researchers on the impact of artisanal miners on the environment and human health on day to day activities. Secondly, public institutions which provided water and soil laboratory tests formed a partnership unit of analysis with households and established the degree of pollution caused by artisanal mining activities. Thirdly, medical records which contained diseases reported by members of households who visited health facilities for treatment assisted in analysing types of diseases commonly found in the area; and to judge whether they originated from direct or indirect use of mercury contaminated materials.

3.3 Data Analysis

The collected raw data were edited to detect errors and omissions, coded for efficient analysis as suggested by Kothari (1992). The raw data were entered into a computer and analysed using SPSS program. Different data were tabulated in order to establish their relations. Laboratory analysis was done to test pH of water and soil samples with a view to assess the presence and degree of heavy metals. Descriptive analysis using percentage, figures and maps was employed to interpret data. These formed a basis for drawing policy and legal implications related to health impact of artisan mining in the study area; and recommendations at micro and macro levels for improvement.

4 RESULTS

4.1 Socio-economic Effects Related to Artisanal Miners' Working Conditions

Ninety nine percent of miners in the study wards responded that, their lives were at risk when working in the mining pits. The risks were more serious in rain seasons when rain water fills the pits while water pumps are scarce. They also suffered from lack of safety mining system and advanced working tools. In all the mines, it was only at Nyangalata where there were at least enough tools for hire such as drilling machines, water pumps, and enough crusher machines called *karasha* (a Swahili name for a crusher machine). The hiring of such tools was risky due to the uncertainties whether or not one can extract gold; failure to which could lead to financial crisis. When this happened, artisanal miners and their families became victims of various social economic problems. Such problems could trigger off ill behaviours like prostitution and child labour in order to subsist.

4.2 Laboratory Test and Results

This study collected two samples from Kakola artisanal miners processing plant. The purpose was to investigate them in the SGS laboratory (The Société Générale de Surveillance laboratory) to check whether or not the soil and water were contaminated by heavy metals.

Sample 1: Constituted two types of materials that is, soil and water obtained from Kakola processing plant as follows:

(i) Soil was extracted from a waste rock pilenwhich was reported by artisanal miners to have spoiled metal tools such as shovel and hoes.

(ii) Water was obtained from a pond which miners frequently used it for amalgamation with mercury in the process of extracting gold.

Sample 2: Consisted of water obtained from a pond which supplied water for domestic use such as drinking, bathing, washing utensils and so on. The two samples were taken to the SGS laboratory for investigation and analysis. The results are shown in Table 2.

The results generally show heavy metals particulary mercury concentrations in water and soil and the levels of water and soil pH; their impact to the environment and human are discussed in the next section.

Table 2: Laborary Analytical Report

Samples	Soil and water pH tests	Different tests for mercury (Hg tests)			
	pH units	EC[1]	Hg	Hg(BA)[2]	Hg(Total)
	Number of pH unit	**mg/l**	**mg/l**	**mg/kg**	**mg/kg**
Sample 1 water	2.8	369	0.012	-	-
Sample 2 water	4.1	17.5	< 0.001	-	
Sample 1 sediment	2.7	270		0.15	0.85

1 EC-Escherichia Coli medium (Oxidation and Methylation of elementary mercury by bacteria, Escherichia coli is one of the bacteria

2 BA = Implies Bio Available

Source: SGS (African Assay Laboratories (T) Ltd Mwanza Tanzania)

4.3 Common Disease which Affect the Community Health

The study interviewed a total of 210 households of the study sample on the common environmental associated diseases which frequently affected household members. Thus, 70 households were interviewed in Segese ward and 140 in Lunguya. The results are presenred in Table 3. In both cased malaria was leading by an average slightly over 80% followed by diarrhoea averaged 10.5% while skin and eye infections reported in Segese and Lungya wards ranged from 1% to 6% respectively. When the latter results were related to the laboratory test which showed the presence of heavy metals in water, suggested the prevalence of such environmental diseases.

This study went further to seek medical evidence by interviewing medical personnel at Lunguya Health Centre and Bugarama Dispensary.. They provided explanations and written medical data which were compiled by this study. The data based on medical records of patients who reported and got examined in hospital laboratories and recorded from 2007 to 2009 (Table 4). According to the medical personnel four types of diseases were caused by mercury polluting water sources as presented in Table 4. They included diarrhoea, pneumonia, eye and skin infections in different proportions. On the average, these diseases have been increasing over the years. Diarrhoea increased from 5.3% in 2007 to 12.6% making an average of 8.2%. Pneumonia slightly decreased from 5.4% in 2007 to 3.9 possibly due to some patients' failure to report to medical facility. Eye and skin infections more or less remained constant with an average fluctuating between 1.2% and 1.3% in from 2007 to 2009. The low percentage can be explained that, the diseases more affected the artisanal miners who often come into contact with mercury directly as compared to the rest of the total population of 18746 patients who reported to the health centre from 2007 to 2009. What is important here is, regardless of the magnitude, the diseases due to mercury pollution which affected the community at large. Further observation also showed that, the prevalence of malaria was indirectly a manifestation of artisanal mining evidenced by the existence of several manmade ponds.

Table 3: Common Environmental Diseases in Segese and Lunguya by Households

Ward	House holds	Malaria	Diarrhoea	Pneumonia	Eye Infection	Skin Infection	Total					
Diseases		**Number**	**%**	**Number**	**%**	**Number**	**%**	**Number**	**%**	**Number**	**%**	
Segese	70	58	83	8	11.4	2	2.8	1	1.4	1	1.4	70
Lunguya	140	110	79	14	10	4	3	6	4	6	4	140
Total	**210**	**168**	**X**	**22**	**X**	**6**	**X**	**7**	**X**	**7**	**X**	**210**

Source: Kahama District Survey, 2011

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Table 4: Most common diseases in Lunguya and Segese wards

DISEASES	YEARS OF DISEASES OCCURRENCES							
Years	**2007**		**2008**		**2009**		**TOTAL**	
	Number	%	Number	%	Number	%	Number	Av. %
Malaria	3834	87.5	5882	86.0	6228	82.7	15944	85.4
Diarrhoea	233	5.3	463	6.8	949	12.6	1645	8.2
Pneumonia	238	5.4	225	3.3	226	3.0	689	3.9
Eye infection	34	0.8	141	2.1	54	0.7	229	1.2
Skin infection	42	1.0	122	1.8	75	1.0	239	1.3
Total of Patients	4381	100	6833	100	7532	100	18746	100

***Source*:** Lunguya Health Centre, Kahama District

Other diseases also found in varying proportions included coughing, vomiting, peptic ulcers and ulceration of fingers, legs and some allergy problems. The medical personnel stated that the diseases were mainly caused by poisonous materials such as metals, chemicals and dust resulting from mining activities. The medical doctors further explained two main ways for the spreading of the diseases. Firstly, by direct

mercury contacts or other poisonous materials, when artisanal miners directly washed by hands the gold ore using mercury and water obtained either from a nearby river or ponds during the refining process. Also, residents contracted the diseases by drinking contaminated water from rivers and wells. Secondly, by indirect ways such as people washing their bodies from the same water sources contaminated with mercury and other poisonous materials. From the medical records of diseases reported for three different years (2007-2009), see Table 4.

The laboratory technicians at Lunguya, went further by explaining that, such poisonous materials affected plants too. This was confirmed by the study as plants were observed to have stunted growth, wilting, discoloration, poor germination and death of plants especially around ore processing plants. The situation was worse off where the ore processing plant was placed closer to people's residents such as in Kakola town centre where miners from Lunguya ward process their gold (Figure 2). Such premises also acted as breeding areas for parasitic insects mainly mosquitoes from the water ponds, these spread malaria in surrounding residential areas. Though they were primarily constructed for gold washing, increased the surface water for mosquito breeding area hence increased malaria cases in the study area, fluctuating at high levels between 87.5% in 2007 and 82.7% with an annual average of 85.4%. It was further observed by this study and confirmed by Lunguya health centre and Bugarama dispensary records that, the community at large frequently suffered from epidemic diseases including malaria due to poor shelter, degraded environment fuelled by few toilets available in use.

Figure 2: A processing plant closer to people's residence at Kakola
***Source**: Kahama District Survey, 2011*

5 DISCUSSIONS

The findings of this study on the impact of mercury to humans and the environment resemble the previous studies carried out by scientists from a National

Environmental Research Institute (DMU) and the Geological Survey of Denmark and Greenland (GEUS) both from Denmark in collaboration with the University of Dar es Salaam who conducted a joint survey in South Western Tanzania. The aim was to establish the impact of the use of mercury in purification of gold ore by artisanal miners. The evaluation study was conducted in two important small scale mining areas. It included studies on the metal pollution of the nearby river and the Katavi National Park some 50 km away from an abandoned lead-copper mine in South Western Tanzania; and near Lake Victoria in Northwest Tanzania where also gold mining is performed with nearly no machinery.

The findings from the two studies almost showed similar results. They observed the gold ore treatment right from the initial stage of crushing the ore and ground by hand, then adding mercury to the crushed material until an amalgam is formed. Finally the amalgam is heated over open fire, mercury evaporates and the gold is left. About 20 tons of mercury is annually released to the environment. The study further tested the concentration of mercury in human hair from 22 men; both miners and controls (non-miners). The amalgamists and burners contained about 30 times more mercury in their hair than did men on a restaurant in town. Fish and sediments were analyzed for mercury as well and in fish the concentrations were equal to or above the Danish threshold value for fish used for consumption (Glahder, 2009). The uncontrolled use of mercury by artisanal miners as established by the foregoing two studies and this study (Kahama district case study), testify careless mining without serious intervention by legal instruments. It implies that, having the National Environmental Policy (NEP) and the Environmental Management Act of 2004 as a law instrument is one thing, but implementing them is another thing altogether. There is great a need to appeal to political will and accountability for these tools to work effectively for the welfare of community heath and improved environment.

6 CONCLUSION

Artisanal mining practices in some parts of Tanzania have brought diverse adverse negative effects to the local communities and the environment. This study has shown villages in Segese and Lunguya wards in Kahama District which are affected by contamination of water sources caused by discharge of mainly mercury by artisanal miners when they wash gold ore in the purification process. Through contacts with or domestic use of such polluted water, caused increasing contraction of diseases affecting communities surrounding artisanal mining sites. The same contaminants polluted the environment denoted by discoloration, poor germination and death of plants an indication of uncontrolled mining hostile to the environment and the human population. The hostility by far exceeded the social economic benefits accrued by artisanal miners. They included water and soil pollution, damage of biodiversity, land degradation, diseases due to water and soil pollution. To conclude, PROUT has effectively guided the study's analysis by revealing uncontrolled artisanal gold miners economic gains at the expense of the local communities' health and theirs at the expense of rationality in resource utilization for the benefit of all. As a result, the few benefited while causing diseases to humanity and exerting environmental degradation on the other side. It calls for policy makers, environmental and mining law enforcers, and different stakeholders

to take urgent intervention measures to arrest the situation for the community welfare and a healthy environment.

7.1 RECOMMENDATIONS

In order to check bad artisanal mining activities from afflicting negative effects to both society and the environment in the study area,

(i) The Government and other stakeholders in dealing with environmental protection should intervene effectively by providing and supervising implementation of environmental education to artisanal mining communities.

(ii) The society through Community Based Organizations (CBOs) can act as a watchdog or regulators to ensure only pro-sustainable mining activities are undertaken.

(iii) The Government should set a budget, for training artisanal miners on how to handle mercury. This is crucial in order to save the society from this deadly chemical. Training can be done through mass media- radio and television. This should go hand in hand with dissemination of the environmental policy.

(iv) The Government should invest on stabilizing artisanal mining activities and improving the performance of these miners through offering them incentives like loans and working instruments, for improvement of production. This will help formalize the activities and the government will gain through tax collection.

(v) The Government should demonstrate what have been decided by the Global Mercury Project (GMP), to adopt the best practices in Artisanal and Small Scale Gold Mining (ASGM). These include the waste minimization strategies and pollution prevention measures that limit contamination of international water.

(vi) The Government should engineer the environmental impact assessment to ASGM, as artisanal miners cannot afford it. The Government should also set a monitoring and evaluation team, which will inspect all ASGM sites in Tanzania for monitoring and evaluation.

(vii) The society and the Government should conduct a continuous rehabilitation of artisanal mining sites; so as to revitalize any degraded environment. This should involve covering of left out pits for farming projects, use of manure and reforestation; this will go a long way in transforming abandoned land full of mining pits into fertile arable land.

7.2 Future Research Agenda

Research should be directed to investigate safe methods of conducting artisanal mining paralleled by empowerment of artisanal miners who operate under poor working environment with futile working tools.

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