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Effect of small scale mining on the environment in Ghana

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Illegal mining in Ghana has had a devastating effect on the environment, especially on water bodies. Even though small-scale and illegal mining have contributed to the growth of the Ghanaian economy; its damaging effects has caused more harm than good.

This thesis aims at bringing to the fore the effects of small scale and illegal mining on the environment. The popular mining method (surface mining) and the reason why many youth are interested in mining is discussed. The negative impacts of some reagents used in mining on the environment and waterbodies in and around mining sites are considered in this thesis.

The thesis project was carried out by reviewing literature and media information as well as by observing some illegal mining sites in the western region and the Ashanti region where the illegal mining activities are prominent. Some miners and some community members were also interviewed.

The results of the thesis showed that both small scale and illegal mining produce huge volume of waste which are expensive to treat. Most of the mine waste are discharged into water bodies without any treatment. This has impacted the water quality of the various mining communities and the environment. It has also destroyed forest reserves which used to harbour endangered species. Farmlands and the livelihood of the inhabitants of these communities have also been destroyed.

Some suggestions have been made to curb the activities of small scale and illegal mining and its impacts on water bodies and the environment.

### Keywords
- galamsey, galamseyers, small-scale mining
DEDICATION

This work is dedicated to my late mum Akosua Kyerewaa, my dear wife Rebecca Agyapong and my lovely daughter Yaa Kyerewaa Boateng for their motivation and inspirations.
ACKNOWLEDGEMENTS

I am forever grateful to the Almighty God for his blessings upon my life and family.

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To my family and dear ones, I register my appreciation and heartfelt thanks, for without their prayers and support, I would not have gone through these difficult but fulfilling years.
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<td>PNDCL</td>
<td>Provisional National Defence Council Law</td>
</tr>
<tr>
<td>EPA (Ghana)</td>
<td>Ghana Environmental Protection Agency</td>
</tr>
<tr>
<td>TMF</td>
<td>Tailings Management Facility</td>
</tr>
<tr>
<td>SSM</td>
<td>Small scale mining</td>
</tr>
<tr>
<td>USEPA</td>
<td>United States Environmental Protection Agency</td>
</tr>
<tr>
<td>DMR</td>
<td>Department of Mineral Resources</td>
</tr>
<tr>
<td>CN</td>
<td>Cyanide</td>
</tr>
<tr>
<td>Hg</td>
<td>Mercury</td>
</tr>
<tr>
<td>As</td>
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1 Introduction

Small-scale mining and illegal mining also referred to as galamsey in Ghana has become the most discussed topic in recent history in Ghana because of the damages it is causing to water bodies, agriculture, education and our everyday lives. The galamsey menace has caught the attention of all stake holders in Ghana, but there seems to be no solution in the forecast as it is believed politicians and traditional leaders are deeply involved in the illegal mining business. This has made it extremely difficult to win the "battle" on illegal mining and the result is dire.

Even though Ghana has abundant fresh water on its land, its availability depends on the season of the year and currently there is no known method to store water during the rainy season. During the lean season (dry season), fresh water or water in general can be difficult to obtain. Mining is particularly profitable during the dry season because the miners can dig deep into the ground and will not have to contend with water gushing out. During this period, they divert water to the mining sites to get easy access to water for their operations. Mining in general uses a huge volume of water in its operations; hence illegal miners and small-scale miners establish their mining site close to sources of water. Their operations affect the chemical nature of these water bodies and make it unusable for human consumption. The activities of miners closer to water sources cause great damage to the normal functioning of the aquatic organism as well as humans who depend on these water sources for living.

Government institutions established to supervise and regulate the activities of small-scale mining have been incapacitated as they are either not equipped with logistics or are understaffed. This has given the illegal miners some field day to continue to destroy farm lands, water sources and vegetations. Since small-scale mining is not strictly monitored by authorities in Ghana, they are able to move to national protected forests and destroy them as well.

Ironically, the areas or regions which are well endowed with gold (mineral) deposits are the poorest in Ghana because illegal mining or small-scale mining have destroyed their source of livelihood (agricultural land) since most Ghanaians in the rural areas are into subsistence farming and depend directly on land and the water bodies in their catchment areas. Again, very few of the indigenous people engage in the small-scale mining since
they cannot afford the initial investment required such as the tools needed in the operation. They are employed by those who are rich and are paid about €3 for 12 hours' work.

1.1 Background

1.2 Overview of Ghana

Ghana is found in the Sub Saharan Africa and is bounded in the east by the Republic of Togo, Burkina Faso and Côte d'Ivoire at the north and the west respectively and the Gulf of Guinea at the south. Because Ghana is endowed with a substantial number of gold deposits, the first European who arrived in the 14th century name it the Gold coast. Ghana adopted its current name from the former Ghana empire which lasted between the 6th and the 13th century.

Ghana now has 10 administrative regions and about 275 districts (2018). The major occupation in Ghana is farming or its related fields. About 65% of the Ghanaian population are into farming. The major food crop exported in Ghana is cocoa (the raw material for chocolate). Ghana is the first runner-up to Côte d'Ivoire in terms of cocoa production.

1.3 Mineral deposits in Ghana

Ghana has many natural resources such as timber, bauxite, diamond, manganese, fresh water, rubber, petroleum, silver and limestone. Minerals export contribute significantly to the gross domestic product (GDP) of Ghana. Even though most of these minerals are mined in commercial quantities, gold is the most mined mineral because it is relatively easy to mine and more abundant. The mining industry of Ghana accounts for 5% of the country's GDP and minerals make up 37% of total exports, of which gold accounts for over 95 per cent of Ghana's total mineral revenues. (ICMM,2015). Ghana is the second largest producer of gold in Africa with South Africa been the largest producer.

Even though gold deposits can be found throughout the country, it is mostly found in the southern sectors of the country, namely Ashanti, Western, Central, Greater Accra and some parts of the Volta region. Some part of the northern region has recently been
shown to have some gold deposits as well. Figure 1 shows the parts of Ghana with gold deposits.

![Map of Ghana showing the location of major gold mines. (Suglo, 2009)](image)

From the map it can be observed that the southern part of Ghana has many gold deposits and coincidentally: these are also the bread basket of Ghana. Again, these are the areas where illegal mining has had negative impact on the environment.
2 Theory

2.1 Contribution of SSM on the Ghanaian economy

Small scale mining in Ghana contributes significantly to the growth of the Ghanaian economy. Gold is the number one major export which brings in foreign exchange to the country apart and most of the developmental projects in Ghana was done with proceeds from gold export. Ghana trades in gold with countries like Australia, India, Malaysia, China, the United Arab Emirates and other countries.

Since the liberalization of gold trade and gold mining activities in Ghana in the 1980s, it has served as a source of employment. During my research, it was observed that many of the youth are engaged in direct and indirect gold mining or a related activity such as selling food and water at the mining sites.

The youth also engage in the trading of the gold mined to prospective buyers who later sell them to the mineral marketing companies. The chain of employment is huge in the mining sector of Ghana since it employs most of the youths especially those in the rural parts of the country. This has help curb the rate at which the youths migrate into the urban areas to seek for jobs.

The small-scale miners also pay royalties to the localities where their mining concessions are located and this is used in the developmental projects in the countries. They are also obliged to employ the indigenes of the community in which they do the mining thereby reducing the rate of unemployment among the youth.

2.2 Regulatory bodies of mineral mining in Ghana and their roles.

As part of measures to protect flora, fauna and the environment as a whole in Ghana, the government through the ministry of Lands and Natural Resources has established agencies that are to regulate and streamline the activities and issue the required licenses for small scale miners. The regulatory agencies include the Mineral Commission of Ghana, Ghana Environmental Agency, the Forestry Commission and Water Resources Commission. These agencies were created by the minerals and mining law of 1986 by the Provisional National Defence Council law 153 (PNDCL 153) and amended in 1994 by Act 475 and
the mineral and mining bill in 2005 (Law number 703). The functions of the agencies are to regulate mining in Ghana. For example, the EPA is to monitor, control and prevent the pollution of the environment, the mineral commission is to issue license to prospective miners while the water resources commission role is to ensure the safety of water bodies and to prevent water courses from being diverted for mining purposes.

Ghana chamber of mines is an independent association of miners which champions the interest of miners. They help government to formulate policies to ensure sustainable mining and provide some forms of education to its members from time to time.

Per the laws of Ghana, every miner in Ghana should register with the agencies name above. If one refuses to register with these agencies and undertake any form of mining is regarded as an illegal mining.

2.3 Small scale mining and illegal gold mining in Ghana

There are two main types of mining in Ghana which includes large-scale mining (LSM) and small-scale mining. The LSM in Ghana is mostly performed by the multinational companies that mine gold on very large concessions of land and use heavy machinery for this process. They usually employ large numbers of skilled workers and pay huge tax and revenue to the government.

The minerals and mining Act, 2006 (Act 703) defines small scale mining as mining by any method not involving substantial expenditure by an individual or group of persons not exceeding nine in number or by a co-operative society made up of ten or more persons. Usually small-scale miners are not skilled workers and do not used heavy machinery as the large-scale miners does.

Small scale mining started from the 12th centuries when Ghanaian indigenes used to dig for gold using pick axe, shovels and even their bare hands and small quantities of gold was mined per day or week. Figure 2 shows a small-scale mining in Ghana where simple tools are used in mining.
In the early days gold was only mined for its beauty and not for its economic value as the miners did not have the skills to turn the gold into valuable items. Small scale miners did not cause much destruction to flora, fauna and the environment until the invasion of foreigners into the business who started introducing heavy machinery into the mining. Per the mining and minerals laws, foreigners are prohibited from engaging in small-scale mining since that is only allowed for Ghanaians.

Small scale miners are those who are registered and are issued with license that permits them to mine after they have gone through some form of orientations and trainings.

In Ghana however, many people are not into small-scale mining but are engaged in illegal gold mining popularly referred to as galamsey. Galamsey is a corrupted version of "gather and sell" which was common among the indigenes after laws were passed to allow locals to buy and sell gold in 1986.

Illegal gold miners are those who are not regulated by any governmental agencies as discussed earlier. Because they are not regulated, they cause more harm to the environment than those in both small scale and large-scale mining. The illegal miners are mostly
unskilled workers who have no idea about best and sustainable mining practices and for that matter use any chemical that they come across for gold mining.

Even though those performing small-scale mining are regulated, they are not monitored to ensure they use proper mining methods, so they may also engage in illegal mining. This has made it very difficult to distinguish between small scale mining and illegal mining, therefore small-scale mining and illegal mining will be used interchangeably in this thesis project since both have moved from using simple tools to using complicated tools in their mining activities.

The only dichotomy of small scale mining and illegal mining is the recognition given to the former by relevant state institutions and are given license to operate otherwise their operations are very similar.

Small-scale miners usually practice surface mining which is relatively friendly to the environment as compared to underground mining. Ore-bodies in most part of the country are close to the surface which makes it easier to be mined by surface mining. (Agyapong et al., 1992). However, lack of law enforcement and regulations have made it unsafe as well. This is because they allow the waste water (tailings) and other pollutants they use in the operations back into environment and water bodies to cause pollution.

2.3.1 Contributory factors of illegal mining in Ghana

Small-scale mining and illegal mining is on the ascendency in the past decade. This is largely due to reasons mentioned below:

a. Law of law enforcement

As discussed earlier, Ghana has very good laws and regulatory bodies that should be able to deal with the menace of both small scale and illegal mining, but lack of political will and corruption on the part of government and their agents has given the illegal miners a free range to destroy the environment. Successive governments lack the political will to prosecute those who flout the laws of small-scale mining and those who engage in illegal mining.

b. Chiefs and opinion leaders
In Ghana, chiefs (traditional rulers) are custodians of any land found in their jurisdictions. They allocate lands to the illegal miners at a fee, and this makes it difficult for the agencies in charge of supervision to know those involve in mining. Because they are not properly registered with authorities, no proper plan for reclamation is given to them and they abandon the site after mining making the land not good for any purpose.

c. Lack of education

During my interactions with some of the miners, I realized most of them lack knowledge about the harm they were causing to the environment. Most of them had left school especially those doing illegal mining, thus they had no idea the harm they were causing to the environment especially water bodies. They did not know how to reclaim the land after mining and had no idea the consequences of the chemicals they were using to recover the gold.

d. High rate of unemployment and poverty

The minimum wage in Ghana for the year 2018 is GH₵8,8 per day which is less than €2. This wage coupled with high cost of living, and high unemployment rate among the youth has rendered most Ghanaians, especially those in the rural areas poor. Sheldon et al. (2002) argue that small scale is largely poverty-driven activity, typically in the poorest and most remote rural areas of a country by a largely itinerant, poorly educated populace with few employment alternatives. This is not different from what happens in Ghana where unemployment rate is very high especially among the youth who are strong to engage in illegal mining.

2.4 Water in mining operation

Water is affected the most in mining since mining uses a huge volume of water in its operations and most mining sites are located very close to water bodies or water is diverted to the mining sites. Water is used for many purposes such as sluicing, dust control, drilling of rocks and amalgamation. It is almost impossible to mine without water. If the water at the mine site is more than required, the excess finds its way into water bodies and this causes serious environmental problems.
2.4.1 Sources of water pollution at mining sites

There are two main ways by which surface water gets polluted. Since surface water seeps through the soil to form part of the groundwater, every pollutant in the surface water ends up in the groundwater and vice versa. The two main sources are, point source and non-point source.

Point source pollution means pollutants that enter waterbodies from an identifiable source. Since the source of pollution is easily identifiable, the types of pollutants are easily identified, for example, discharge of mine tailings or discharge from factory.

Non-point source pollution refers to water pollutants that do not come from a unit discharge source but usually from many different sources. These pollutants cannot be predicted unless experiment is performed to ascertain them. Example, runoff water from urban centre or a leachate from landfill site.
3 Effects of small-scale mining on the environment

3.1 Mining tailings and its effects

Gold mine tailings are the residue (finely ground rocks) after gold and other minerals have been extracted from rocks. It is usually a mixture of chemicals and reagents that was used to extract the desired minerals.

The most common problem of all mining sites is how to treat mine tailings. It is very expensive to successfully treat mine tailings to an environmentally friendly level as this usually increases cost of exploration. It is the major pollution of both surface and underground water as it does not become safer with time without proper remediations or treatments.

The most important source of water pollution in mining communities are from mine tailings flowing into water bodies either by failures (accidents) or lack of standards practice in operations. Natural disasters such as floods, seismic impacts, landslides may cause tailing management facility (TMF) to break thereby allowing mine tailings to get into water bodies and the environment.

As discussed above mine tailings contain the reagents that were used to extract the gold from rocks. The most common reagents used by small scale miners and illegal miners in Ghana include, mercury, arsenic, and cyanide. thus, most mine tailings contain the above-mentioned heavy metals. These reagents remain in the tailings at the end of the process and later leach into any close by water body or in ground water making it harmful for aquatic life. Apart from these reagents, other substances may also be found in mine tailings due to chemical reaction between the ore and the chemicals used. This usually leads to what is referred to as acid mine drainage. Acid mine drainage is formed when iron sulphur is oxidized.

Acid mine drainage has corroding effects on infrastructure such as bridges which may lead to its collapse. Acid mine drainage degrades water quality and can result in the death of aquatic organisms and make water unusable and leads to high heavy metals level in underground water. The high sulphides content result in high acidity and high metal concentrations in groundwater in the vicinity of the tailings. (Vega et al. 2004)

When tailings flow into receiving water, it causes turbidity which affect the normal functioning of the ecosystem within the water body. Turbidity affect the rate at which sunlight
penetrates through water and this inhibits photosynthesis. Other organisms in the water that depend on plants for food and oxygen are affected since the plants are not able to be photosynthesized.

Again, in Ghana many of the miners mine closer to farmlands and near communities; therefore, there is always a high incident of fertilizers seeping into water bodies and the environment. These fertilizers may be acidic or basic depending on its composition and this renders the water either acidic or basic as demonstrated by Asante et al, (2007): when they said, *where large and small-scale gold mining occur along with subsistence farming, found median groundwater and surface water pH (5.71, 5.05 and 6.40 for bore-hole, well and stream water respectively) below the WHO guideline range (6.5-8.5).* Their observations made it clear how mine tailings affect the pH of water bodies they pollute. The instability in pH in water affect aquatic life. It can kill many fishes and water plants necessary to maintain biota.

3.2 Erosion and its effect on food security

Erosion is the vehicle through which mine tailings get into surface water. This is usually due to the digging through the sand and breaking of rocks to get the gold ore. The digging and the breaking of these materials make the sand and rocks loose to be easily carried away by water or wind when there is rainfall. Since erosion moves through farmlands and the forest, it increases the sediment loads of most water bodies thereby affecting the balance of life.

Illegal miners often divert water course so that they can either have access to the river beds for their mining activities or divert the water to their mining sites for use since mining depends on huge volume of water in its operations. This changes the composition of the water they have diverted. The water is coloured and not fit for any purpose especially in the rural areas where people depend on river for their daily chores. Ghanaian farmers usually depend on rainfall for their farming activities and sometimes depend on water bodies closer to the farms for irrigation. Mining deprive the farmers of this vital resource because the quality and quantity of the water is reduced. Figure 3 shows a diverted water at a mining site in the eastern region of Ghana.
Figure 3. diverted water at a mining site in the eastern region of Ghana.

It will be difficult and expensive to turn the water and the soil for any economic purposes as it has no life in it at this stage. From this development, it will be difficult for Ghana to achieve the Sustainable Development Goal 6 of the United Nations, which is “by 2030, achieve universal and equitable access to safe and affordable water for all”. (UN SDG goal 6). Ghana is likely to miss this target because it is becoming increasingly expensive to treat water for consumption because of excess pollution. Ghana water company, the agency responsible for water management and treatment, has shut down many water treatment plants due to the activities of small-scale and illegal miners. (Adogla-Bessa, 2017)

Apart from this, erosion washes away the fertile topsoil of farmlands making them barren. This reduces crop yields and affect the total crop exportation of the country. The local currency (which the Ghanaian cedis) is always depreciating against the US dollar because of the excess importation of food crops from other countries.

Mining and agriculture may co-exist and interact to generate economic and social benefits, but at the same time compete for resources including water, land and labour (Djurfeldt et al. 2005). Even though their observations may be correct in some countries, it is totally the opposite in Ghana where the small-scale mining and illegal mining are
completely taking away most of the labour force especially among the youth. In the mining communities, the farmers are mostly old men from the ages ranging from 45 to 70. These old people are not able to produce more crops as in Ghana farming is on subsistence level. This often leads to low crop production and low exports. This situation has forced Ghana to import staple food from its neighbouring countries.

The organisms in the soil are affected when small scale and illegal mining are not well regulated. There is excavation and blasting of rocks during gold mining and these activities affect the normal growth and functioning of these soil organisms. There is also stockpile of sand into mounds which limits the rate at which oxygen infiltrates to the soil organisms for respiration and reproduction. Figure 4 shows stockpile of sand at a mined site in Tarkwa in the Western region.

![Figure 4. Stockpile of sand at a mining site in Tarkwa in the western region of Ghana.](image)

The organisms may be inactive or die as when the stockpile is high. These organisms are important for crop production and when they are destroyed it reduces crop yield in the farming communities thereby affecting the food security of the country.

As erosion competes with farmers for their farmland, many farmers sell their farmlands to small scale miners and sometimes to galamsey workers because they do not have
alternative since the farms do not produce enough yields. At times, the small-scale miners forcefully take over farmlands they suspect contain gold from the farmers. This has affected the numbers of farmers at various mining communities in Ghana. The forceful takeover of farmlands sometimes leads to homicide of the farmers by the miners.

Small scale and illegal mining are rapidly causing deforestation in Ghana forest reserves. As discussed earlier, mining removes sand and causes the fertile topsoil to wash away during rainfall into water body. This prevents the plants from getting nutrients for growth and eventually causes deforestation and destruction of biodiversity. The fertile soil washed into water bodies causes eutrophication.

The dredges created during mining collect water during rainfall and this breeds mosquitoes. Female anopheles’ mosquitoes which has the plasmodium parasite is the number one killer in Sub-Saharan Africa. Abandoned illegal mining pits with stagnant water in the Amansie West district of Ashanti region have become breeding grounds for mosquitoes. (Gyima, 2017). The mortality rate in galamsey areas is higher than in the rest of the country, and most of these deaths are caused by mosquito bites.

3.3 Mercury

Another significant constituent of most mine tailing in Ghana is mercury because that is the reagent mostly used by miners. It is the readily available in the open market in Ghana and one does not require license to purchase it. It is comparatively cheaper than the other reagents used by miner in mining gold and effective to obtain gold from its ore.

Mercury is a metal which at room temperature is liquid. Table 1 gives a summary of the chemical and physical properties of mercury.
Table 1. physical and chemical properties of mercury. USEPA. (1997)

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
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<tbody>
<tr>
<td>Atomic weight</td>
<td>200.59</td>
</tr>
<tr>
<td>Crystal system</td>
<td>Rhombohedral</td>
</tr>
<tr>
<td>CAS registry number</td>
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</tr>
<tr>
<td>Atomic number</td>
<td>80</td>
</tr>
<tr>
<td>Valences</td>
<td>1, 2</td>
</tr>
<tr>
<td>Outer electron configuration</td>
<td>5d^16s^2</td>
</tr>
<tr>
<td>Ionization potentials, normal, eV</td>
<td></td>
</tr>
<tr>
<td>1st electron</td>
<td>10.43</td>
</tr>
<tr>
<td>2nd electron</td>
<td>18.75</td>
</tr>
<tr>
<td>3rd electron</td>
<td>34.20</td>
</tr>
<tr>
<td>Melting point, °C</td>
<td>-38.87</td>
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<tr>
<td>Boiling point, °C</td>
<td>356.9</td>
</tr>
<tr>
<td>Latent heat of fusion, J/g (cal/g)</td>
<td>11.80 (2.8)</td>
</tr>
<tr>
<td>Latent heat of vaporization, J/g (cal/g)</td>
<td>271.96 (65.0)</td>
</tr>
<tr>
<td>Specific heat, J/g (cal/g) solid.</td>
<td></td>
</tr>
<tr>
<td>-75.8°C</td>
<td>0.1333 (0.0319)</td>
</tr>
<tr>
<td>-40°C</td>
<td>0.141 (0.1337)</td>
</tr>
<tr>
<td>-263.3°C</td>
<td>0.0231 (0.00552)</td>
</tr>
<tr>
<td>Liquid</td>
<td></td>
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<tr>
<td>-36.7°C</td>
<td>0.1418 (0.0339)</td>
</tr>
<tr>
<td>210°C</td>
<td>0.1335 (0.0319)</td>
</tr>
<tr>
<td>Electrical resistivity, Ω-cm, at 20°C</td>
<td>95x10^-8</td>
</tr>
<tr>
<td>Density, g/cm³</td>
<td></td>
</tr>
<tr>
<td>At 20°C</td>
<td>13.546</td>
</tr>
<tr>
<td>At melting point</td>
<td>14.43</td>
</tr>
<tr>
<td>At -38.8°C (solid)</td>
<td>14.193</td>
</tr>
<tr>
<td>At 0°C</td>
<td>13.595</td>
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<tr>
<td>Thermal conductivity, W/(cm·K)</td>
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<tr>
<td>Vapor pressure, 25°C</td>
<td>2x10^-2 mm Hg</td>
</tr>
<tr>
<td>Solubility in water, 25°C</td>
<td>20–30μg/L</td>
</tr>
</tbody>
</table>

Mercury is part of the heavy metals that have a devastating effect on the environment especially water bodies due to its physical and chemical properties. For example, their low melting point make it easy to be absorbed in water and the environment.

Mercury is used to extract gold from its ore. The figure 5 is a flow diagram showing a summary of how mercury is used in the extraction of gold.
Mercury is not biodegradable but can change to other forms. The three basic forms of mercury include elemental mercury, inorganic mercury and methylmercury, which is not environmentally friendly because it is able to accumulate in organisms, especially fishes.
3.3.1 Effect of mercury on water and the environment

Mercury pollution is very common among miners as they burn the amalgam, which releases smoke and the miners are the first casualties as they have direct contact with the smoke. The mine tailings also find its way into nearby water bodies, and if it finds its way into rivers, lakes or streams then it can pollute the water several kilometers from its source. In Ghana, most villages are established along river banks; thus, they use the polluted water daily for their household chores and even drink them directly without treating it.

Mercury usually enters the human system either by breathing in the smoke from burnt amalgams or by eating organisms (especially fishes) which has accumulated methylmercury ($\text{CH}_3\text{Hg}^+$). When $\text{CH}_3\text{Hg}^+$ bioaccumulate in organism, its toxic level increases and becomes dangerous for any organisms in the food chain that consumes it. Mercury can affect the central nervous system, the brain and the spinal cord when inhaled or consumed. It may also affect the reproduction of important aquatic organisms such as loons and walleye.

3.4 Cyanide

Cyanide (CN) was formally not used in gold extraction by small scale miners until recently. It is believed that workers that were made redundant from the large mining firms such as AngloGold Ashanti Mining Company and Newmont Ghana Gold Limited introduced the small-scale miners to mining using cyanide.

Cyanide is a chemical that is lethal to organisms even though it can be found in both plants and animal in smaller quantity. It is a pale blue liquid at room temperature. It has a short life span compared to mercury in the environment, but it may accumulate in water and other organisms if used in excess. Very little cyanide is required to extract the same quantity of gold as with mercury. This is because cyanide forms compounds with many other elements, but this makes it dangerous to aquatic organisms and the environment.

Gold cyanidation is the process in which gold is extracted from its ore using cyanide. Comparatively, the use of cyanide in gold exploration is much safer than the use of mercury provided the right quantity is used. In Ghana most of the miners are not educated; thus, they find it difficult to use the right volume for each heap of the crushed ore. The excess volume normally finds its way into water bodies and the environment.
Cyanide spillage into water bodies is very common in Ghana even among the large-scale mining firms. It is easily discharged by galamseyers (those who engage in illegal mining) who are not under any supervision and usually practice their trade deep in forest reserves.

3.4.1 Effects of cyanide on the environment

Animal (including human) systems can convert small dose of cyanide into less harmful thiocyanate in their bodies; large doses are a threat as they can lead to death. Large doses of cyanide prevent cells from receiving oxygen; as a result, the organism is not able to respire and eventually dies.

As discussed earlier, cyanide easily form compounds with other elements and easily breaks down to form other compounds. Hilson and Monhemius, (2006) state that cyanide in open air breaks down into other compounds relatively quickly; however, the exact composition and toxicity of these products is not well understood. This explains why cyanide is very toxic to the environment and human health.
Even though small scale mining and galamsey have some sorts of benefits for the individual who engages in it as well as some economic value to the state, its effect is dire. SSM disturbs the ecosystem and reduces the quality of life for those who partake in SSM as well as those who lives along the path of mining sites. These mining activities cannot be stopped entirely because they employ so many youth who will otherwise be engaging in other illegal activities. In addition, the SSM contributes to the GDP of the country.

What should be done is to properly streamline the activities of these miners to conform to international best practices as it is been done in south Africa. South Africa is the largest producer of gold in Africa and has been able to manage the negative impact its mining industries have had on its water bodies and the environment relatively better. South Africa has a well-established institution which regulates its mining activities. This institution has a history which dates back to 1897. These institutions through reforms and guidelines have tailored the mining industries to practice robust and sustainable mining thereby protecting the environment and water bodies closer to mining sites. The Department of Mineral Resources (DMR) regulates the mining activities in South Africa through what is known as the Mineral Regulation Management.

The core function of the DMR is to issue prospecting right, mining right, mining permit and environmental development to prospective miners. Since only one organization is responsible for the issuing of mining license, bureaucracies which delay the issuance of the mining license is avoided. In Ghana however, there are several bureaucracies that one must follow to get the mining license. The idea was to avoid corruption on the part of state officials, but unfortunately, this has rather worsened due to lack of enforcement of laws on corruption. There is virtually no coordination among the agencies in charge of minerals exploitation and people take advantage of this weakness to exploit the system. The process of acquiring small-scale mining license can take a whole year or more. This frustrates many prospective miners who either bribe their way through the process or engage in illegal mining. Ghana can learn from South Africa practice to avoid unnecessary delay in issuing license since illegal miners destroy the environment more than SSM.

Apart from the above, the South African government has established institutions such as MINTEK which is an autonomous institution devoid of politics which supports the SSM through research. They provide technical support to small-scale miners and modern
method of mining gold. In the case of Ghana, there are rather institutions to ensure compliant of the rules and regulations but not a well-established institution to train miners. However, universities such as university of mines and technology and Kwame Nkrumah university of science and technology do organize some training for the miners from time to time. A model like the MINTEK can be established in Ghana to provide support for SSM.

Field officers and other authorities should be well trained to provide technical support for small-scale miners. For effective supervision, government agencies should share data and synchronize their activities to ensure effective monitoring on the activities of SSM. There should also be quick way to issue license to prospective miners to prevent them from going into illegal mining. The current bureaucracy in acquiring license to operate a small-scale mining is encouraging people into the illegal mining.

To reduce the effect of mine tailing and other heavy metals from polluting water bodies, government of Ghana through parliament must enact legislations that will ensure that both large and small-scale miners proposed how they will reclaim mined concessions they are given. If feasible, some funds from prospective miners should be deposited in an escrow account to serve as a guarantee. Miners who refuse to reclaim their concessions after mining can be tried and jailed as it is been done in some countries. Also, the sale of mercury and other heavy metals reagents used in mining should be regulated and should not be sold in the open market as it is the case now.

Also, inspectors from government institutions pay regular visits to mining site to ensure the right processes as spelt out in the mining guidelines are been followed. Also, drones can be deployed in the remotest part of the forest where illegal miners normally practice their trade to arrest and prosecute the perpetrators.

Mine tailings can be pumped in a form of slurry to a common area called tailings management facility (TMF) and other tailing management such as the use of dams, embankments and other types of surface impoundments. It is at this place where further treatments are done before discharge. Conventional and effective treatments such as alkaline dosing, aeration, flocculation and sedimentation should be used in the treatment of waste from mine (tailings). Control and emergency plan should be in place in case there is spillage of tailings. Early detection mechanisms such as sensors can be in co-operated into the building of the TMF to alert spillage.
Harmless methods of mining which does not make use of mercury and other heavy metals such as panning, the use of concentration method, shaking table methods and sluicing method. Even though the gold recovered from these methods may not be substantial as compared to the use of mercury and cyanide, it is sustainable and safer to the miners themselves and the environment.
5 Conclusions

Galamsey (illegal mining) and small-scale mining has contributed in diverse way to help the Ghanaian economy as far as employment of the youths are concerned, but its negative impact on the environment cannot be over-emphasized. Others are of the view that, since it provides economic relief to the nation, it should be left as it is because the multinational companies take advantage of the economic woes of the country and exploit the youths in terms of the labor output and the remuneration they receive. The economic gains in illegal mining is far below the damages it causes the environment such as pollution, diversion of river courses, destruction of river banks which leads to flooding and the introduction of heavy metals in water bodies. Government of Ghana spends more money in reclaiming the destroyed land. Waterborne diseases are mostly common in mining communities, which implies that the country spends a large amount of resources to import medicine and other health materials.

Small-scale mining and illegal mining can be streamlined and made better by enforcing the laws and regulations. There should be cooperation among all the state institutions to help control the activities of small-scale mining and regularize those in the illegal mining as well since their contribution to the economy of Ghana cannot be over emphasized. There should be education on the best practice of gold mining to the miners.

Effective involvement of people in mining communities in decision making about the environment helps to address the level at which the environment is polluted. When the community are consulted on environmental issue pertaining to their localities, they feel part of it and strictly adhere to any by-laws that will be made. Chiefs and opinion leaders must be asked to help address the environmental degradation caused by small-scale and illegal mining because they are the custodian of the land under their jurisdiction.
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