The International Journal Of Engineering And Science (IJES)
|| Volume || 4 || Issue || 12 || Pages || PP -12-20|| 2015 ||
ISSN (e): 2319 – 1813 ISSN (p): 2319 – 1805

Environmental Problems of Surface and Underground Mining: a review.

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ABSTRACT

Economic mineral resources lying in the earth are necessary ingredients of all our modern conveniences. Its mining yields huge profits for the companies that own them, a source of revenue for the government, and provides employment to a large number of people. Nevertheless, getting at them comes at a price on the environment with externalities such as pollution, erosion, destruction of natural ecosystem etc. Mining affects all the components of environment and the impacts are permanent/temporary, beneficial/harmful, repairable/irreparable, but irreversible.

Keywords: *environment, externalities, irreversible, mining, mitigation, pollution and review.*

Date of Submission: 02 November 2015 — Date of Accepted: 16 December 2015

I. Introduction/Background.

Mining the earth is a process by which the earth is drilled by machinery to extract economic materials such as gold, coal, diamonds, galena, sphalerite, sand, limestone etc. Mining operations is across the globe and have contributed heavily to environmental issues. Mining has been done since pre-historic times some 300,000 years BC [25]. A known mine on archaeological record is the "Lion Cave" in Swaziland, which radiocarbon dating shows to be about 43,000 years old [18]. At this site, Paleolithic humans mined hematite to make the red pigment ochre.Mines of a similar age in Hungary were where Neanderthals may have mined flint for weapons and tools[33]. While mining yields economic materials for use, sale or industrial production; it affects, harms and contributes to a disruption nature and appearance of the natural environment around it [24]. It induces some major geohazards, atmospheric hazards as well as civil engineering structural hazards. Mining decimates entire mountain, turns once a scenic area into huge reminiscent craters and gaping pits [15]. Deterioration of the quality of surface and ground water is imminent [10],[14]. Also, unexpected water runoff from mines can be hazardous to life in nearby rivers and streams [32], [14]. Mining geohazards throughout the world inflict heavy losses on life, damage to property and environment. For instance, between October 2011 and July 2013, a total of 118 people were reported dead from mine related hazards in China [30], [4]; [*The New York Times, July 16, 2013*]. In 1896 at Burnner Mine disaster, New Zealand, 65 miners died. In 2007 at Ulyanovskaya mine mishap in Russia, 107 people died. Over the periods 1850 to 1930 at Southwales Coalfield in UK, a total of 3,119 deaths were recorded (*The Coal Mining History Resource, 2009*). On December 1866 in Yorkshire, mining accident claimed 388 lives. Coal sludge spill that occurred in 1966 at Aberfan killed 310 people [28]. In Nigeria, on November 18, 1949 at Iva Valley Mine Udi, Enugu Nigeria, 21 miners died in a mine related issue [29]. Twenty-eight children excluding livestock reportedly died of Lead Mine poisoning in Rafi LGA [22]. Between 2010 and March 2013, 734 children were confirmed dead of Lead poisoning in Zamfara state [21]. Large-scale deforestation is carried out in the areas where mining has to be done. Rainforests which are the biggest source of oxygen, wood and medicines are devastated. Besides clearing the mining area, vegetation in the adjoining areas also needs to be cut in order to construct roads and residential facilities for the mine workers. The human population brings along with it other activities that harm the environment. Further, various activities at mines/quarries release noise, dust and gas into the air. Chemicals like cyanide, sulfuric acid, and arsenic and methyl mercury used in various stages of mining process often escape into the environment causing large-scale pollution. Also, while separating the mineral, workers who are less equipped than industrial workers, may ignorantly release into nearby water bodies harmful pollutants. This enters the food chain through these organisms and their predators and sometimes escapes into the surrounding environment. Thus, mining is one of the major causes of deforestation and pollution.

The forests that are cleared for mining purposes are home to a large number of organisms. Indiscriminate clearing of the forests puts the survival of a large number of animal species at stake, leads to loss of habitat of a large number of animals. Besides, some mining processes e.g. dredging require suctioning water from nearby water sources thereby reducing availability. Hence, dependents on these water bodies do not have enough water for their survival. Also remaining mud and gravel after panning is released back into the river, sometimes at a location different from where they were taken. More so, leakage of channels used to dispose wastes and chemicals slowly percolate through the layers of the earth, reach the groundwater and pollute it. This disrupts the natural flow of the river and may cause aquatic organisms to die. Further, during mining previously buried metal sulfides are exposed. When they come in contact with the atmospheric oxygen, they get converted into strong sulfuric acid and metal oxides. Such compounds get mixed up in the local waterways and contaminate local rivers with heavy metals. For example, in 1995, in Guyana, more than four billion liters of mine waste water that contained cyanide, slipped into a tributary of the Essequibo; when the tailings dam, which was filled with cyanide waste, collapsed. All the fish in the river died, plant and animal life was completely destroyed, and floodplain soils were heavily poisoned, making the land useless for agriculture. The main source of drinking water for the local people was also polluted. This was a major set-back for the eco-tourism industry on the river [32]. Sometimes a stagnant pool of water in a derelict pit becomes the breeding ground for water-borne diseases causing insects and organisms like mosquitoes to flourish, spreading diseases. When trees are cut and water sources are contaminated, animal populations migrate or die. The Kahuzi-Biega National Park, Congo, was declared as 'World Heritage Site' in 1980 because of its rich bio-diversity. As thousands of people started extracting tantalum and cassiterite at hundreds of sites throughout the park, most of the large animals were killed within 15-20 years. The number of Grauer's gorilla, the species which is found in this area only, decreased significantly. Statistics show that now, there are only 2-3 thousand Grauer's gorillas left [30], [26];[37].In Indonesia, the Indonesian government has sued a gold mining company for throwing away poisonous waste, such as arsenic and mercury, into the Buyat Bay. Fish in the bay was killed [38]. People in the surrounding area can no more eat fish. They suffer from various illnesses like constant headache, skin rashes, tumors and breathing difficulty. In Alabama, mining is considered to be the backbone of the state’s economy. Its mining industry ranked sixteenth nationally in total nonfuel mineral production value and thirteenth in the production of coal put at \$993 million, produced 19,504 thousand tons of coal in 1999. The industry employs 9,700 workers, with an average annual income of \$48,968. Alabama's combined direct and indirect economic gain from the mining industry is \$8,061,602,000’. In 2006, Alabama coal mines produced 18.8 million tons of coal (1.6% of the U.S. total), making Alabama the 15th-biggest coal-producing state in the country employed 4,195 coal miners. It had 45 coal-fired generating stations in 2005, with 12,684 MW of capacity - representing 38.2% of the state's total electric generating capacity, and making Alabama the 11th biggest coal energy producing state in the U.S. In 2006, its coal-fired power plants produced 80 million tons of CO_2, 450,000 tons of sulfur dioxide, and 110,000 tons of nitrogen oxide; coal-fired power plants were responsible for 59% of the state's total CO_2 emissions. In 2005, Alabama emitted 29.8 tons of CO_2 per person, 50% more than the U.S. average. In Alabama, over 70% of all electricity generated is produced at coal-fueled steam plants. Annually the total value of coal produced in Alabama exceeds \$1 billion [9], [36]. Consequently, the pollution problem has become a nightmare for the entire population. The problem has transformed into a real crisis and the survival of living species is at stake at certain places. Internally it poses a threat to the life and health safety of the workers and outside the mine the safety of the surrounding ecosystem is at stake. The toxic gases released are responsible for acid rain and greenhouse effects in the environment. It is an undeniable fact that the unregulated or irresponsible surface mining of coal may cause soil erosion, damage from rolling stones, landslides, and stream pollution, increases the likelihood of floods, reduces the value of land for agricultural purposes, can be detrimental to the conservation of soil, and may create hazards to life and property. Dust produced during mining operations is generally injurious to health and causes lung disease known as black lung, or pneumoconiosis. Some fumes generated by incomplete dynamite explosions are exceptionally toxic. Methane gas, emitting from coal strata, is always dangerous. Although mining is an immediate site specific activity done at the sites where the minerals exist and the land is of no use to the miner in the pre and post mining times, it affects beyond its immediate environment. Consequently, mining companies are increasingly making efforts to reduce the environmental impacts, minimize footprint of their activities throughout the mining cycle, including working to restore ecosystem post mining.

II. Overview of Mining methods

Mining is the extraction of valuable minerals (orebody, lode, vein, seam or reef) or other geological materials which forms the mineralized package of economic interest to the miner from the earth [7],[35]. It includes extraction of any non-renewable natural resource such as petroleum, natural gas, or even water. Approach for selection of mining method is most at times based on orebody characteristics. Selection involves summation and ranking of numerical values associated with orebody characteristics that reflect the suitability of a particular method. Modern mining processes involve prospecting for ore bodies, analysis of the profit potential of a proposed mine, extraction of the desired materials, and final reclamation of the land after the mine is closed. Mining creates a potential impact on the environment both during and years after the mine is closed. This impact has led most of the world's nations to adopt regulations designed to moderate the negative effects of mining operations. Safety has long been a concern as well, and modern practices have improved safety in mines significantly. Mining operations can be grouped into five major categories in terms of their respective resources. These are oil and gas extraction, coal mining, metal ore mining, nonmetallic mineral mining and quarrying, and mining support activities. Tatiya (2005) divided mining techniques into two common excavation methods: surface mining and sub-surface (underground) mining, fig 1.

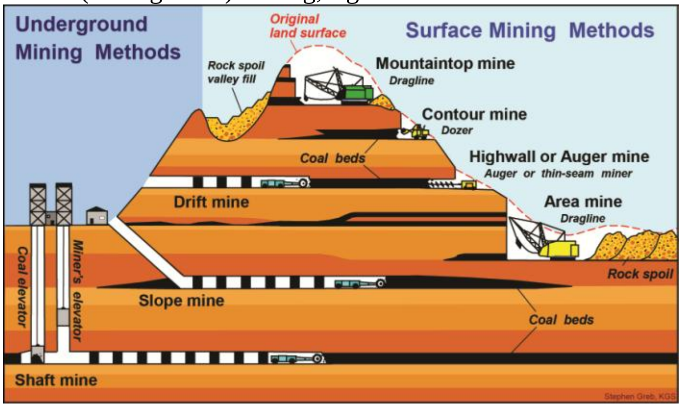

Fig1.Diagrammatic representation of mining methods, Kentucky Geological Survey, 2000.

Surface mining is removing minerals that are near the earth's surface. Some minerals are found very deep below Earth's surface - sometimes hundreds or thousands of feet deep! To remove these minerals from the ground, subsurface mining is used. Surface mining is done by removing (stripping) surface vegetation, dirt, and if necessary, layers of bedrock in order to reach buried ore deposits. Techniques of surface mining include: open-pit mining, quarrying or gathering building materials from an open-pit mine, strip mining and mountain removal, commonly associated with coal mining. Most (but not all) placer deposits, because of their shallowly buried nature, are mined by surface methods. Finally, landfill mining involves sites where landfill are excavated and processed. Sub-surface mining consists of digging tunnels or shafts into the earth to reach buried ore deposits. Ore and waste rock are brought to the surface through the tunnels and shafts. Sub-surface mining can be classified by the type of access shafts or the extraction technique used to reach the mineral deposit. Drift mining (horizontal access tunnels), slope-mining (diagonally sloping access shafts), and shaft mining (vertical access shafts). Other methods include shrinkage stopped mining, which is mining upward, creating a sloping underground room; long wall mining, which is grinding a long ore surface underground; and room and pillar mining, which is removing ore from rooms while leaving pillars in place to support the roof of the room. Room and pillar mining often leads to retreat, in which supporting pillars are removed as miners retreat, allowing the room to cave in, thereby loosening more ore. Additional sub-surface mining methods include hard rock mining, which is mining of hard rock (igneous, metamorphic or sedimentary) materials, bore hole mining, drift and fill mining, long hole slope mining, sub level caving, and block caving [3].Another method is solution mining, which is when hot water is injected into the ore to dissolve it. Once the ore is dissolved, air is pumped into it, and it's bubbled up to the surface. Either of the mining method has its own merits and demerits, and causes some environmental and health impacts.

III. Environmental Problems/Impacts Due to Mining.

Mining has important economic, environmental, labour and social effects— both in the countries or regions where it is carried out and beyond. Its resources also serve as inputs for consumer goods and the processes and services provided by nearly all other industries, particularly in agriculture, manufacturing, transportation, utilities, communication, and construction. For many developing countries, mining accounts for a significant proportion of GDP and, often for the bulk of foreign exchange earnings and foreign investment. Mining industry faces a number of challenges in the near future. Working conditions in mines, quarries, and well sites can be unusual and sometimes dangerous. Some of the mining challenges including quarrying closer to cities and civil structures and greater quarry depths with highwalls subjected to more rock stress and water pressure. The environmental impact of mining can be significant and long-lasting due to bad practice in the management and rehabilitation of mined areas. The environmental effect is becoming an important issue for the industry and its workforce. Mining industry generate the majority of Global warming effect products- electricity energy source to fuel in vehicles. This is also responsible for thinning the protective ozone layer that protects us from harmful

ultraviolet radiation from the sun, and is also contributing to the phenomenon known as global warming- the steady increase in average temperature of the global climate (Environmental assessment and policy).
However, more underground operations that are inherently more dangerous. They are damp and dark, and some can be very hot and noisy. In underground mining operations, unique dangers include the possibility of cave-in, mine fire, explosion, or exposure to harmful gases, in addition, dust generated by drilling in mines places miners at risk of developing serious lung diseases. In any system of mining there is potential environmental risks introduced. Surface mining requires large areas of land to be temporarily disturbed. This raises a number of environmental challenges, including soil erosion, dust, noise and water pollution, and impacts on local biodiversity. About 23 billion tonnes of minerals, including coal, are produced each year. For high-value minerals, the quantity of waste produced is many times that of the final product. For example, each ounce of gold is the result of dealing with about 12 tonnes of ore; each tonne of copper comes from about 30 tonnes of ore. Environmental clearance of Mining, Oil and Gas Fields Projects etc., is becoming more stringent every day. That is understandable and acceptable, but what is more alarming is the lack of skill sets required to handle such challenges that can come from different agencies such as the department of environment, department of forest etc. By carefully pre-planning projects, implementing pollution control measures, monitoring the effects of mining and rehabilitating mined areas, the mining industry minimises the impact of its activities on the neighbouring community, the immediate environment and on long-term land capability. Recently, the mining agenda has changed, as the world has taken the carbon-cutting culture to its heart. New challenge is to implement measures to ensure mining operations sustainable, around the world.3.1 Causes of Environmental Impacts

- Engineering activities
- Blasting
- Noise
- Dust
- Mine Accidents
- Acid rock drainage (ARD) or Acid mine drainage (AMD)
- Release of obnoxious gas e.g. Methane
- Subsidence, Caving ins and Rock fall
- Socio-cultural impact/Addictions
- Economic disparity and frustration
- Socio-economic conflict/Cost of living
- Displacement of the people
- Loss of livelihood
- Employment of Women and Children etc.

3.1.0 The problems or impacts on environment
3.1.1 Engineering Impacts. Some environmental disturbances are created by engineering activities during aggregate extraction and processing. The most obvious engineering impact of quarrying is a change in geomorphology and conversion of land use, with the associated change in visual scene. This impact may be accompanied by loss of habitat, noise, dust, vibrations, chemical spills, erosion, sedimentation, and dereliction of the mined site.

3.1.2 Cascading Impacts. Mining may alter sensitive parts of the natural system at or near the site thus creating cascading environmental impacts [32]. Cascading impacts are initiated by such activity as the removal of rock massif. The natural system responds, causes another impact which causes yet another response by the system, and on and on. For example, mining in karst might lower the water table, which will reduce the buoyant support of rock that overlies water-filled caverns or other solution features, which might result in land collapse and creates a sinkhole. Cascading impacts may be severe and affect areas well beyond the limits of the aggregate operation. Cascading impacts may manifest during and continue well after mining has ceased.

3.1.3 Blasting. One of the most frequent complaints the public makes to the mining industry is about blasting noise, vibration effects, air concussion, pollution and stray rubbles (fly rocks). The blasting frequency and techniques are significantly different and dependent on some factors such as geology, topography and weather etc. Blasting noise generally increases with the amount of explosive, specific atmospheric conditions, and proximity to a blast. The area closer to a blast commonly receives greater impacts than areas further. People also differ greatly in their response to blasting (National Academy of Sciences, 1980).

3.1.4 Mine-Induced Seismicity. Mine-induced seismicity cause slope instability in underground and surface mining and is a major threat for all miners and environment. Mines located in seismically active regions, such as the Andean region (also known to be one of the wealthiest metallic mining zone in the world), are even more at risk. The use of explosives might cause earthquake-like events that collapse mine workings, and traps miners in, as happened to the 33 miners stuck underground from August to October 2010 in a Chilean mine near the city of Copiapo, or kill them, flood the mine and damage structures on the surface [8].

3.1.5 Noise. Earth-moving equipment, processing equipment and blasting are the primary source of noise from mining site. The impacts of noise are highly dependent on the sound source, topography, land use, ground cover and climatic conditions. The beat, rhythm, pitch of noise, and distance from the noise source affect the impact of the noise on the receiver [32].

3.1.6 Dust. Dust is one of the most visible, invasive, and potentially irritating impacts associated with quarrying. Its visibility often raises concerns that are not directly proportional to its impact on human health and the environment (Howard and Cameron, 1998). Dust may occur as fugitive from excavation, from haul roads, and from blasting or can be from point sources, such as drilling, crushing and screening [1], [32]. Site conditions that affect the impact of dust generation include rock properties, moisture, ambient air quality, air currents and prevailing winds, size of the operation, proximity and other nearby sources of dust. Dust concentrations, deposition rates and potential impacts tend to decrease rapidly away from the source. Diseases caused by inhalation of respirable mine dust includes:

• Fibrotic Lung diseases– damage/destroy lung tissue e.g. Coal workers' pneumoconiosis (CWP), Silicosis
• Airflow diseases– block movement of air in and out of lungs:– Bronchitis,

emphysema, mineral dust airway diseases, asbestosis, asthma etc. Figure 2 and 3 shows trend of mine workers disease prevalence and related deaths.

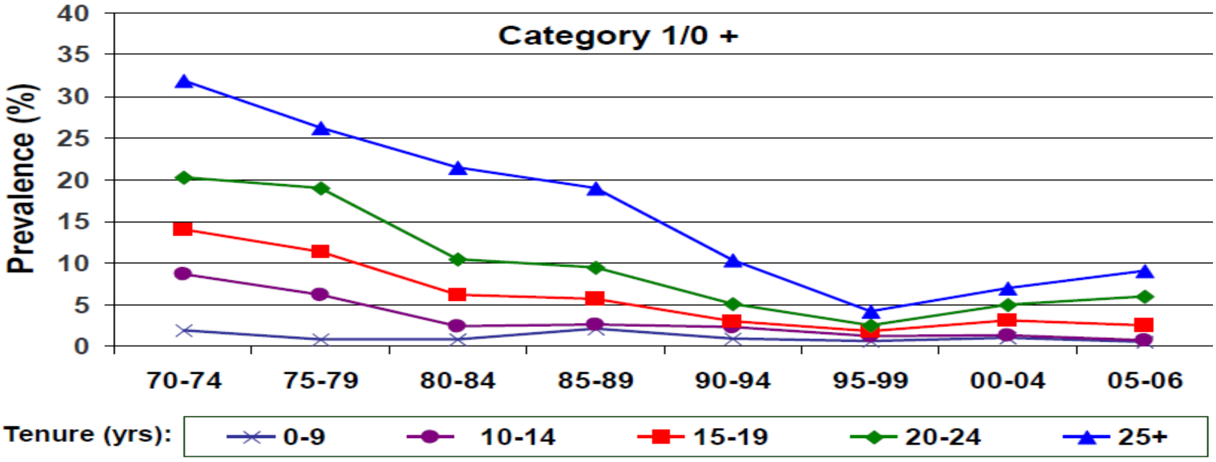

Fig.2. Trends in Coal Workers Pneumoconiosis (CWP) Prevalence by Tenure Among Examinees Employed at Underground Coal Mines. (U.S. National Coal Workers' X-Ray Surveillance Program, 1970–2006).

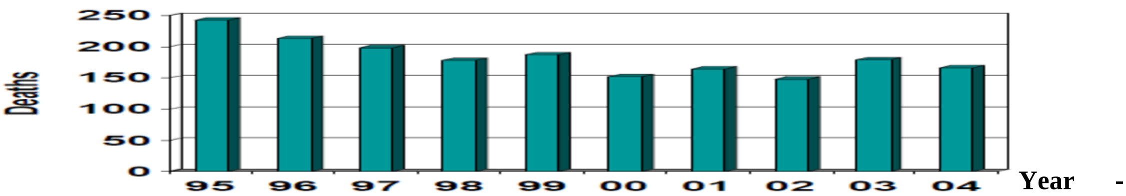

Fig.3. Silicosis-related Deaths (U.S. National Coal Workers' X-Ray Surveillance Program, 1970–2006)

3.1.7 Socio-cultural impact/Addictions. Miners are often migrants from other areas and bring along associated problems including prostitution, addictions, violence and a displaced way of life [11],[12].Increased economic activities and effluence brings in more addictions in the society.

3.1.8 Economic disparity and frustration. Industrial and economic activities in mining complexes bring about economic disparity among the population living in the complexes. The people employed in the organized activities usually earn more than those employed otherwise. This economic disparity leads to the development of frustrations in the poorer class of the people.

3.1.9 Displacement of the people. Mining requires to remove buildings, structures along with the vegetation not only in the area designated for mining purposes but also in a large area nearby which is required for making external dumps and placing associated activities. Therefore, all the people living in this area get displaced.

3.1.10 Loss of livelihood. The ethnic people living in the designated areas depend generally for their livelihood on the land. Since, in mining areas the land is taken for mining and associated activities these people lose their livelihood.

3.1.11 Changes in population dynamics. Most often the managerial, skilled, and semi-skilled manpower required for mining and associated activities comes from outside because such trained manpower is usually not available in ethnic population. In addition people come to the mining areas for trade, etc. Thus, the population dynamics of the area undergoes a major change over the years resulting in dilution of the ethnic population and their culture and religion, reduction in sex ratio, etc. When the mining activities come to an end the population decreases at a faster rate but their impacts remain.

3.1.12 Employment of Women and Children. Employment of women is very popular in mines because they are more regular, available, dependable and do not indulge in excessive drinking [13],[23]. Although employment of children and women in mines is on the decline, at times such employment is prevalent in small mines to augment the income of parents whom they often work with jointly. They are in demand for jobs which cannot be gainfully carried out mechanically. They very rarely work in mines proper and their working in underground mines is totally banned.

3.1.13 Socio-economic conflict/Cost of living. Most mining operations are done in remote areas. The employment of women, poor and young people increases their spending powers. This invariably affects their socio-cultural lives leading to invasion norms. Societies dependent on agriculture and forests usually have a lower level of economic scenario. The development of industrial and other associated activities in such areas increase the level of the economic activities manifolds. The increased industrial and economic activities generate more money and increase the buying power of the people. This leads to an increase in the cost of living, which adversely affects the other ethnic people who are not associated with these activities.

3.1.14 Health impacts. Health and well-being of the people living in and around the mining complexes get affected due to the pollution. In fact, the society in the mining complexes has to bear the various costs of abating the effects of environmental pollution in various ways. The people working in the mines and associated facilities also get affected by the work place environmental problems e.g. skin problems, lung diseases, deafening, etc.

3.2 Mitigation of Impacts.
It is evident that mining and associated activities have considerable impacts on the ecology of the mining and surrounding areas. The impact of mining and processing of mineral resources is part of the price we bear for the benefits of mineral consumption and it is unrealistic not to expect such. These externalities of mining on the environment depends upon such factors as:- mining procedures, local hydrologic conditions, climate, rock type/s encountered, size of operation, topography, human factors such as managerial expertise, technological factors, socio-political and many more interrelated factors. Although most of these hazards to the environment are not always reversible, they can be minimized. A number of variations exist but sustainable development is most commonly defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. The principles of sustainable development involve integrating economic activity with environmental integrity, social concerns, and effective government systems. These principles have had a growing influence on the development of environmental and social policy in recent decades, and have been adopted and promoted by a number of international organizations, including the United Nations and World Bank. Modern technology and scientific investigation methods have made it possible to reduce environmental impacts associated with extraction of minerals and manage impacts at acceptable levels that do not cause significant harm to the environment. Impacts can be controlled, mitigated, kept at tolerable levels, and restricted to the immediate vicinity of aggregate operation by employing responsible operational practices that use available recent engineering techniques and technology. In order to be more environmentally sustainable, mining operations are increasingly conducted in a manner that minimizes their impact on the surrounding environment, and leaves mine sites in an acceptable state for re-use by people or ecosystems. A number of management strategies and technologies are being developed and used by the mining industry to reduce the environmental impacts of mining, and they include:-

i). Mining can become more environmentally sustainable by developing and integrating practices that reduce the environmental impact of mining activities. This include measures such as reducing water and energy consumption, minimizing land disturbance and waste production, preventing soil, water, and air pollution at mine sites, and conducting successful mine closure and reclamation activities.
ii). The activities of mining adversely affects the inhabitants, their health standard being compromised, their abode endangered, and their means of livelihood (especially farming) jeopardized. The government at all levels should investigate the activity of the operator and others in this area, review/re-evaluate their EIA and appraise their activity regularly and at close intervals, and adequate compensation administered appropriately.
iii). It is recommended that a detailed Environmental Impact Assessment should be carried out before Quarrying License can be obtained from government. A task force should be set up by the government to investigate operators that are not complying with Code of Practice for Quarrying activities, offenders should be prosecuted.
iv). A modality should be agreed upon by both the inhabitants, government and operator company of a proposed quarry site. Settlers should be relocated and compensated appropriately. The interest of the locals should be considered objectively during issuance of license and monitoring activity by the government. The government task force team should include geologists, engineers, environmentalists, and surveyors.
v). Plan the mining layout so as to have the least requirement of the forest land and take necessary steps for reclamation to bring back the forest.
vi). Develop a compensatory forest (*flora bank*) and replant when needed.
vii). Surface layout of the mining complexes be designed to have the least negative impacts on the ecology of the area.
viii). The noise and vibration producing activities in the mines and the associated activities be planned to have the minimum possible intensity and impact on the surrounding area ecology.
ix). Mine wastes— potential for environmental contamination should be well managed. In addition to preventing soil, water, and air pollution, waste management plans are required in order to select and design appropriate buffer facilities. It is generally recognized that preventing pollution is a better economic and effective at reducing environmental impacts than cleaning it up later on. Methods for minimizing and eliminating wastes in the production of minerals and metal commodities include:
» Using cleaner production techniques,
» Environmental control technologies,
» Using waste as raw material, and
» Reducing the amount of waste produced through process re-engineering.
Water management strategies are used to reduce the volume of waste water produced and if necessary, to treat it to an acceptable quality before it is released. Over the past years, most countries have passed formal environmental legislation describing acceptable standards of human impacts to air, water, and land. As a result, mine waste management plans are increasingly required in order to obtain a mining permit in many parts of the world.
x). Acid rock drainage (ARD) forms when sulphide minerals at a mine site are exposed to air and water [2]. ARD can pollute surface and groundwater with acidity and dissolved metals, which can adversely affect aquatic organisms and water users downstream. A number of strategies are used to predict, prevent, and mitigate ARD at mine sites. Advances in ARD prediction include the development of computer programs, chemical evaluations and acid-base accounting which are used to anticipate whether ARD is likely to form at a mine site.
Note: Mining operations that expose sulphide-bearing rock do not always lead to ARD because the ore may contain a high proportion of acid-buffering minerals such as lime, calcite, carbonate or bicarbonate, which are able to neutralize acidic waters. For example, when baking soda (soda bicarbonate, a buffer) is added to vinegar (a weak acid), it reacts with the vinegar and neutralizes it. Mining companies are increasingly required to evaluate the ARD potential at future mine sites and provide detailed plans to prevent or suppress ARD at all phases of mine operation as part of the environmental impact assessment (EIA) process practiced in most countries. The most cost-effective and low-risk ARD management strategy is the prevention of ARD formation through prediction and mine planning [34]. Where sulphide mineral excavation is unavoidable, a number of ARD prevention strategies have been developed:
»*Storing waste rock underwater:* Storing wastes underwater reduces the rate of sulphide mineral oxidation by air to almost zero, effectively stopping ARD formation. Underwater storage is considered to be the most reliable and effective ARD prevention strategy.
»*Flooding and sealing underground mines:* The flooding of underground tunnels is used where it is possible to isolate the mine by sealing all the entrances. Sealing the mine prevents water moving in and out, which could result in water contamination.
»*Mixing acid-producing materials with acid-buffering materials:* Combining sulphide wastes with limestone or calcite can result in ARD neutralization.

»***Covering waste rock:*** Installing a cover of clay, plastic or soil over piles of waste rock prevents rain and other precipitation from contributing to ARD formation and transport, and reduces the amount of oxygen available to react with the sulphide minerals.
»***Chemical treatment of sulphide wastes*:** Organic chemicals designed to kill sulphide-oxidizing bacteria have been applied to sulphide wastes in order to slow the rate of ARD. However, there is concern that some of these chemicals may kill beneficial microorganisms in the environment, thus becoming pollutants themselves.
Preventative measures have been most effective when used in combination and adapted to the situation at the specific site. In addition, the groundwater and surface water surrounding mines are monitored in order to provide an early warning system for the detection of ARD formation. Where the complete prevention of ARD formation is unsuccessful, it can be captured and treated. Hedin (2003) added bicarbonate to ARD from an abandoned coal mine in Pennsylvania to produce an iron oxide sludge which was comparable to iron oxide mined for use in paint pigments. The development and use of passive treatment technologies to treat ARD has received a lot of interest because of low operation and maintenance costs. However, constructed wetlands and bioreactors have been used in full-scale treatment systems so far.
xi). Restoring environmental function at mine sites. Mining is a relatively temporal activity hence, have finite operating lives. Reclamation and closure activities should aim to restore land disturbed by mining activities to an acceptable state for re-use by people or ecosystems. Fill a depleted mine with water or by earth to replace the earth and ore removed. Such action can eliminate the dangers associated with falling into a depleted mine, as well as restore beauty to the landscape.
xii). Surface layout of the mining complexes be designed to have the least impacts on the ecology of the area.
Further ultramodern equipment with safety control facilities could be used. Also advances in technology and changes in management techniques mean that many negative impacts are now avoidable.

4.0 Conclusion
Effects of mining on the environment may not be evident immediately; many are usually noticed after some years. In view of this, of particular concern is to understand the system requirements and specifications and to address human interface issues to improve component and system reliabilities, and minimize the occurrence of unplanned environmental catastrophes. Mining can become more environmentally sustainable by developing and integrating practices that reduce the negative environmental impact of mining operations. These practices include the above mentioned measures as well as reducing water and energy consumption, minimizing land disturbance and waste production, preventing soil, water, and air pollution at mine sites, and conducting successful mine closure and reclamation activities.
Norms regarding mining must be strict and not even by ignorance be flouted. Any freak accident that may lead to incidents like the Guyana spill of 1995 should not occur again. This highlights the fact that issues like mining's effect on the environment are worth some serious deliberation.
The government at both the local and state level should investigate the activity of operators, review/re-evaluate their EIA and appraise their activity. The settlers should be relocated and compensated appropriately. It is recommended that a detailed Environmental Impact Assessment should be carried out before License can be obtained from government. A task force should be set up by the government to investigate operators that are not complying with Environmental regulations or code of Practice, offenders should be prosecuted. A modality should be agreed upon by both inhabitant and government of a proposed mine site. The interest of the locals should be considered objectively during issuance of license and monitoring activity by the government. The government task force team should be composed of a geologist, engineer, environmentalist, and surveyors. There should be policy forbidding locating mines near residential houses and vice-versa.

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