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AN INVESTIGATION INTO THE MANAGEMENT STRATEGIES USED IN MITIGATING MINING IMPACTS ON WATER RESOURCES OF URBAN ENVIRONMENTS IN DEVELOPING COUNTRIES

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Abstract: *This review examines the management strategies used in mitigating mining impacts on water resources and urban environments in developing countries. The specific objectives are designed to: highlight the difficulties associated with mining in these urban areas; and to examine the management strategies needed to mitigate these impacts on water resources and the environment. In principle, the areas or resources affected by mining should be returned to a safe and productive condition through rehabilitation, which may or may not involve a return to pre-mining conditions and reclamation, should be an ongoing activity throughout the life of the operation as well as after decommissioning. The mining industry, the government and the local people must work together to care for future generation. This review has shown that environmental management is not just the responsibility of the mining industry but also of government who plays critical role in providing legislative and regulatory frameworks that encourage or demand best practices in mining. Thus, to achieve ecologically sustainable development especially as it concerns the water resources and urban environment, there should be a clearly defined, rigorous and monitorable environmental principles and standards with which the mining sector in developing countries must comply with. Finally, constant research and development effort are required to find out newer and latest technologies and methodology to minimize the impact of mining in the environment, and technologies to reclaim the land for better use since mining for economic development must have respect for environmental integrity.*

Keywords: *Management Strategies; Mitigating Mining Impacts; Urban Environments; Developing Countries.*

Introduction

Mining is the process of digging into the earth to extract naturally occurring solid or liquid/fluid minerals. It is the world's second oldest and most important industry after

agriculture (Down and Stocks, 1977). It is currently the fifth largest industry in the world and it plays a crucial role in world economic development. The urban environment encompasses the interaction of population, health, economic growth, urban structures and the built environment with the natural environment or ecological system in which a city is located (UN habitat, 2005).The urban environment is well known to pose hazards on a global scale including global warming amongst others (Mc-Michael, 2004). Thus, according to (working group, 2004). 'urban environmental problems are threats to people's present or future well- being, resulting from human-induced damage to the physical environment, originating in or borne into urban areas'. In more than 100 countries around the world, mining companies and individual miners dig minerals and metals out of the ground, satisfying a slowly but continuously increasing demand from industrial production, agriculture, high tech sectors, and merchandise producers (World Bank 2002). Among these countries are more than 50 that can be considered as mining "countries" well known for the sectors contribution to export earning, including, Australia, South Africa Chile, Botswana. About 3.9 billion people live in today's 56 mining countries 90% of them in the 51 developing and transition countries (World Bank, 2002). Among the 3.5 billion people in these developing countries, about 1.5 billion live on less than $2 a day, making up nearly two thirds of the world's poorest population.

Africa produces more than 60 metal and mineral products and is a major producer of several of the world's most important minerals and metals including gold, pge's diamonds, uranium, manganese, chromium, nickel, bauxite and cobalt (Anderson, 1997). Although unexplored, Africa hosts about 30% of the planets' mineral reserves, including 40% of gold, 60% cobalt and 90% of the world's Pgm reserves – making it a truly strategic producer of these precious metals. Nigeria and Madagascar are but a few countries that has tremendous potential for base metal and industry mineral deposits. South Africa, Ghana, Zimbabwe, Tanzania and dominate the African mining industry whilst countries such as Angola, Sierra Leone, Namibia, Zambia and Botswana rely heavily on the mining industry as major foreign currency earner. Unfortunately, several African civil wars are funded by and are often caused by some of these minerals including diamonds. (Aigbedion, 2005), remarks that by its very nature the mining industry in these countries leaves behind a footprint – an environmental, social and economic impact which if badly managed impacts on the

environment and the social fabric of society. It is thus important to weigh the benefits against the risks and costs surrounding the mining industries operation in these countries, and to mitigate and minimize these impacts.

The trade of mineral commodities represents a substantial part of international trade (Madeley, 1999). The mining industry remains a priority area for foreign direct investment (fdi) in most developing countries with mineral resources (Weber-Fahr, 2002). The mineral sector is heavily relied on by many of these developing countries as a driving force for economic development (Zank, 1995). There is growing evidence that the sector forms a large source of government revenues in most mining countries and continues to be the highest contributor in terms of fdi of most developing countries. In response to economic and political reforms, the international mining industry is expanding in areas formerly closed to mineral exploration for legal, political and economic reasons and new mining projects progress into remote areas of the world (Madeley, 1999).

Over the past decade more than 100 countries have introduced new regulatory regimes resulting in the growth of the mining industry. Over 75 mineral producing countries in the developing world have liberalised their investment regimes since 1989 and investment flows overseas have increased (Warhurst and bridge, 1997). This movement has allowed trans-national mining companies to explore in areas which for years have been inaccessible. While these companies operating in developing countries have contributed towards improved social development through providing jobs, paying taxes, building an industrial base, enhancing efficiency, earning foreign exchange and transferring technology, they have also been linked publicly to deepening environmental degradation, disparities in wealth, poor labour conditions, pollution incidents, health and safety failings, forced displacement of people a and other human and civil rights abuses (Thomson and Joyce 1997). This has led to an increasing pressure from NGOs, community based organisations and civil society organisations over the world for multinational corporations to become more accountable and for the governments in this part of the world to enforce environmental regulations (Kwesi and Kwasi 2011).

Aims & objectives of the review

The specific objectives are designed to:

(i) Highlight the difficulties associated with mining in the urban areas.

(ii) Examine the management strategies needed to mitigate these impacts

Overview of Mining, Its Impacts and Mitigating Strategies towards Negative Effects.

Mining activities releases particles of various kinds into air, which has impact on air quality (Harrison 2010). Some of these substances are harmless, such as dust particles, while others can be potentially dangerous. Dangerous particles include arsenic, cadmium and lead (green peace, 2010). Overtime, in sufficient quantities, these dangerous particles can have an effect on human health, especially respiratory health. The exhaust air from underground mines contributes carbon iv oxide co2/ methane ch4, nitrogen oxide Nox, sulphur oxide and other pollutants.

Likewise, improper management of chemicals used in mining process leads to incidences of spontaneous combustion (Cedric, 2005) thus, contributing to pollution. The extraction and transportation of minerals also causes atmospheric pollution. Fires from poor mining practices releases fly ash, green house gases, and toxic chemicals into the atmosphere, the results of which may be long lasting considering that these fires may burn for decades (Saxena, 2011). Mining also releases coalmine methane, a green house gas twenty times more powerful than carbon dioxide (Gomes, Mendes and Costa, 2011).

The equipments used in the open cast mines for various purposes including the transport of the over burden and mineral, generate continuous noise, while blasting produces impulsive noise and cracking of houses and structures (Aigbedion, 2005).

In a research carried out in lignite mine in turkey, which was located close to the residential city of can, they discovered that the principle disturbances created by blasting in open pit mines are vibration, air blast and fly rock and all these problems may cause severe damage to structures and may be possible sources of permanent conflict with the inhabitants living close to the mine (Kahriman, 2002). In addition, result from research carried out on the incessant complain of cracks on houses in mine town of ObuasiGhana, the result revealed that much lower ground vibration levels than those currently adopted by the authority were required to protect the type of structures prevalent in the mining communities (Amegbeys, Yormekpe and Akayuli 2012)

Difficulties associated with mining in urban environment

Mining under urban areas are presented with challenges that must be considered when assessing and managing potential impacts (Waddington, 2006) these include:

a. High density of surface feature - there are high proportion of covered areas in urban environment, (particularly in high density developments). These increases the chances of adverse impacts occurring when compared to rural areas.
b. Great variety of services infrastructure - urban areas are serviced by power and communication systems, potable water net works, sewerage systems and some times, gas pipelines. Additionally, there are also many transport systems such as rail networks. There is a great inter-dependence between services for example if electrical network is compromised, sewage pumping stations can lose power, which could lead to other adverse impacts.
c. More people are potentially affected - this presents many challenges for the mining industry since, the populations of urban dwellers are higher thus, the impacts will affect more people.
d. There are many business and commercial establishment within urban centers- mining companies are exposed to consequential losses associated with subsidence impacts in these areas.
e. Urban areas are dynamic and continually changing.
f. Structures in urban areas are in various conditions - some contain dwelling of many ages, some dwelling are listed as item of heritage significance while others may be recently constructed.
g. Impacts are more easily observed in urban areas- given the high density of surface features and the number of people who live and work in urban areas, potentially affected by mine subsidence, there are more opportunities to observe any impact that might occur. In rural environment for example, there is a good chance that a crack in the ground will not noticed however in urban environment, the movement may result in adverse impacts which can be observed and reported by many people.

Management of Impact/ Future Trends of Mining in Developing Countries.

Mining, exploration and energy extraction are carried out in many different geographic regions in developing countries. Differences in climate, topography, soils, flora and fauna, land use, mining techniques and commodities being extracted leads to differences in possible impacts. Environmental management and rehabilitation techniques are required to

minimize, mitigate and repair these impacts. Below are measures that developing countries should undertake to see that best mining practices are undertaken and are put in place.

Sound environmental legislation/ key regulatory issues

The degree to which mining contributes to economic development and wise use of natural resources depends in large part on the quality of national regulations. Countries lacking strong regulations and the ability to enforce the law lack an important safeguard for ensuring that mining, oil, and gas development do not result in the destruction of important natural resources critical to ensuring the livelihoods of their citizens. The key component of a regulatory framework includes.

Regulatory framework

A strong regulatory framework allows countries to set standards that companies mustfollow. Some experts contend that a more flexible regulatory framework is preferablethan the more traditional command-and-control approach. Others acknowledge that a minimum set of rules by which companies must operate isnecessary (Warhurst, 1999). Key components of a regulatory framework for mineraldevelopment include environmental impact assessments, environmental quality and social laws, environmental liability, and monitoring capacity.

Environmental Quality and Social Laws.

A framework of environmental laws and regulations provides guidance to mining and oil companies regarding a country's expectations for environmental and social performance. Some countries have strong laws and regulations on the books, including soil, water and air standards, indigenous/ local community rights; and requirements for decommissioningand site clean-up.However, there are gaps in legislation in many of these countries. According to black's law dictionary (black 1990), "legislation is the act of giving or enacting laws, the power to make laws, the act of legislating, preparation and enactment of laws." From the above definition, it is noteworthy to say that legislations are laws made or passed by the appropriate organs invested with the powers to make such laws for the regulation of human conducts and behavior. Legislations as said earlier are geared towards addressing the above problems. The aim of these legislations would not be achieved, if they are not properly implemented or enforced. The question now remains, how far has existing framework in matters of environmental protection been addressed, tackle, halt or otherwise abate the

problem of environmental pollution in its entire ramification? It is clear that uncontrolled industrial activities pose greater danger to the environment than any other activity. The problem facing most developing countries is the problem of enforcement and implementation of the environmental laws.

Some of the international instruments binding on most developing countries include the Stockholm conference of 1992, where United Nations assembly adopted a number of resolutions concerning the environment. The United Nations environmental programme was established after the conference. This has proved particularly an important agency in the evolution of conventions and instruments in the field of environmental protection (Nwifo and Chinwe 2010). The UNEP has been responsible for the development of a number of initiatives including the 1985 Vienna convention for the protection of the ozone layers. Then there was the earth summit which gave birth to the Rio declaration of 1992 with the broad objectives of the governments on the environmental issues. More recently was the international convention on the conservation of biological diversity aimed at management and exploitation of biological resources in a sustainable way. These international and regional conventions, agreement and protocols ratified by most developing countries are aimed at regulating pollution in the environment. However, the problem still is the level of commitment shown by the government of these countries in enforcing these laws and bringing to book the offenders especially where large scale mine companies are involved.

In a developed world like the United States, hard rock mining is exempt from many regulations applied to other polluting industries, and specific standards are left to the discretion of state governments. As a result, there are no federally mandated minimum reclamation standards and government agency investigations have revealed that reclamation is inadequate at many mines on federal land (Galloway and Perry, 1997).

Papua New Guinea and Zimbabwe routinely provide mining companies with exemptions from meeting water quality standards (Hughes and Sullivan, 1989, Sherman, 2001, Maponga and Mutemerewa, 1995).in some cases implementation of existing legislation may also be lacking. For example, Chile has 2,200 laws and presidential decrees relating to the environment, but most are not implemented, due to a lack of political will (Lagos and velasco, 1999).another difficulty implementing these laws may stem from conflicting mandates amongst government agencies.

For example, (Hughes and Sullivan, 1989) stated that a major dilemma facing policy makers in Papua new guinea is balancing its role as advocate (and beneficiary) of mining projects with its mandate to protect the country's natural resources for future generations. In the Philippines, more than 20 government agencies are involved in the regulation of water resources in urban areas, resulting in fragmented management and overlapping jurisdictions (Essc, 2003).

Environmental liability

Another important component of sound environmental legislation is the ability to hold polluters accountable. This may be accomplished through a requirement to post a reclamation bond, which is held until the company has satisfactorily complied with government standards for closure and remediation of a mine site. There are no set international standards for the amount that should be retained in reclamation bonds, and estimates of potential environmental damages are often provided by the companies, which have an incentive to underestimate true costs (global witness 1998).

Seventeen mines have recently closed in the Philippines, many of which did not have the resources to implement post-closure measures. In 1999, 5.7 million cubic meters of acidic waste were discharged from the abandoned atlas mine on the island of Cebu. The resulting impact on the marine environment, including an extensive fish kill, was considered one of the country's top 10 recent environmental disasters (Denr-pab, 2000). Countries may also pass legislation that establishes fines and punishment for those found guilty of polluting. However, most developing countries lack any kind of legislation making polluters liable for clean- up (Warhurst, 1999). Since 1977, the mines and geosciences bureau in the Philippines has collected a flat-rate "mine waste and tailings fee" of $0.001 per ton, which is set aside to compensate for negative impacts caused by mining. As this rate has remained flat since 1977, environmental liability is capped at a relatively low level, providing an incentive for companies to surreptitiously discharge tailings rather than pay for more costly environmental remediation measures.

Monitoring capacity

Although many countries have legislation requiring mitigation of environmental and social impacts of mining and oil development, the ability to enforce laws and monitor performance is largely lacking. Even in the united states, the lack of resources and staff

means that many mines are not frequently inspected. A survey by the mineral policy center revealed that eight western states have less than one inspector per 100 active mine sites (galloway and perry, 1997). In the Philippines, each regional office of the mines and geosciences bureau is staffed with roughly the same number of technical inspectors. As a result, monitoring capacity is uneven across provinces; region xii has more than 72,000 hectares of approved mining areas, which amounts to approximately 400 hectares per person. Nine of the other 15 regions have less than 5,000 hectares of approved mining areas, resulting in a more manageable monitoring target of approximately 30 hectares per person (Maponga And Mutemererwa,1995).in the Philippines, also inspectors rely on companies to provide access and additional resources, eliminating the element of spontaneity required for auditing (Essc, 2003).

Due to the lack of available resources for monitoring the performance of mines in Papua New Guinea, the government relies on company reports rather than conducting periodic site visits to determine compliance with standards set in the mine contract. The same is seen in most developing countries.

Mine planning

Planning is the key to identifying and minimizing the environmental impact of mining. Every mineral deposit is unique and so planning needs to take into account the detailed nature of the resources to be mined (Green peace 2010).

The nature and sensitivity of the surrounding area/environment must be understood through base in monitoring and data collection in order to provide environmental information for mine planning community. A sound information base will allow appropriate and sensitive options to be developed, which include the rate and direction of mining, alternative process designs, optional facility layout and the location of supporting services and infrastructure. Mines should be properly planned to minimize the amount of hazardous waste they produce (sawyer, McCarty 1967). It is also important that mines are built as planned and approved during the government assessment process, and that environmental monitoring and auditing are undertaken throughout the mine life to check on the adequacy of performance and to implement improvement where necessary (Anthea, roe 2002).

Environmental impact assessment (EIA)

Environmental impact assessment is a central part of project approval process for mining in developed countries and is gradually institutionalized in the developing world (Atheaa and

roe 2002). EIA is the best way of predicting potential impacts and identifying early on in the planning process effective and efficient ways of mitigating them. The EIA provides a sound basis upon which to devise special environmental regulatory requirement, design appropriate management systems, plan the environmental monitoring regime, and identify focal issues for environmental auditing and reporting in an urban environment (Terah, 2012). There should be a detailed environmental impact assessment carried out before mining license can be obtained from government. Also a taskforce should be set up by government agencies to investigate operators that are not complying with environmental regulations or code of practice for mining activities.

Environmental management strategy

The process of rapid urban environmental assessment (data collection, profile and consultations) is designed to provide an information and consensual basis for preparing an urban environmental management strategy (ems). The goal of the ems is to accelerate the improvement of environmental condition in cities, especially by integrating key aspects of urban policy and environmental management. The objectives according to (Josef, 1993) includes

(a) Establish long term environmental goals for the urban region

(b) Set interim environmental goals and objectives

(c) Rank pollution control and other measures to improve environmental quality

(d) Identify priority sectors for channeling investments

(e) Recommend policy reform instruments and institutional arrangements needed to implement the ems. The ems process builds on existing sector and project work but emphasizes continuity in decision making to implement agreed policies and approaches.

Environmental Risk Management

Environmental impact is unavoidable in mining thus; decisions are constantly being made, with action or inaction, which affect the likelihood of negative impacts from seen or unforeseen events on the mine site. Assessing these changes should include risk management (Anthea and Roa 2002). For example in the pre-mining stage, careful and considerate mine planning, concept development and thorough environmental impact assessment, are very influential and effective tools in reducing risk and the potential for major financial outlays for the remainder of the mines life. The true picture here is that

some level of risk is unavoidable, but it can be significantly reduced if an integrated approach ERM is taken. In an urban environment, ERM helps to ensure that environmental risk is contained to acceptable levels, thus, it should be applied to all aspects of the mining operation in a structured process to ensure that all relevant issues are addressed.

Identification and Characterization of All Surface Features That May Be Affected

As part of the environmental impact assessment tool, all surface features in the urban area should be studied (Wong and Nora 2000). This includes identification of all houses and other structures, public amenities, commercial and business establishment. Information on all services should be collected from infrastructure owners. This will help address any potential issue and arrangement made for additional monitoring during mining.

Community Consultation and Involvement

The expectations and needs of communities affected by mining should be considered. The consultation should be on many levels. A community centered, rather than a project centered approach to community consultation and involvement is preferred. According to (Colby 2011), there is no short cut to developing effective community programs. Gaining local support involves convincing all community's sub-group that their interest will not be ever looked or prejudiced. It helps for companies to start consultation very early, it clearly demonstrate the integration of social, economic and environmental aspects of the project, emphasizes tangible benefits to the community e.g. jobs, skills, trainings etc). Mining companies should be always visible and accessible to openly discuss issues, be aware of changing concerns and interest in the community over time and address these directly though direct consultation, and maintain a flexible approach to consultation and ongoing modification to project design over the life of the mine. Mining and energy extraction has substantial social impacts and leads to land use conflicts, difficulties in relationships with neighbors, communities and the mining industry .in his work,(Waddington (2006) maintains that many land-use conflicts can be managed by recognizing that mining and energy extraction are temporally, thus, initiating community consultation programs and taking account of community needs can improve relationships with neighbors and local communities.

Advances in Technology and Information

Technology can help provide solutions to pressing environmental issues. For example, better mining processes reduce potential negative impact on the environment. (Hartman and

Howard 1992). The capacity of technology to provide solution is illustrated by the way ozone depleting substances were phased out and replaced with new ozone- friendly alternatives. Biotechnology is being harnessed to remove toxic metals and organic wastes from industrial and mined effluents (Wong and Nora 2000). Other biotechnology application include environmentally friendly mine processing techniques, pollution prevention technologies etc.

Cleaner production approach

This is an integrated and preventative approach to minimizing environmental risk, rather than a curative approach (Steve Pearce 2012). It is aimed at maximizing resources usage and operational efficiency, not only during production of mineral commodity at the mine, but also in its fabrication, use and ultimate disposal e.g. (as copper wiring and tubing in a refrigerator). Cleaner production requires change in attitudes, acceptance of responsibility for environmental management, ongoing evaluation and, where appropriate, upgrading of technological options. It looks to identify, remediate, minimize or remove an environmental problem before it happens. This application has been linked to continuous improvement in environmental and economic performance.

Water Resources Management

Water is integral to virtually all mining activities and typically the prime medium, besides air, that can carry pollutants into the wider urban environment.

Consequently, sound water management is fundamental for most mining operations to achieve environmental best practice (Anthea and Roa 2002). As mine planning is commonly based on limited data, it is important to validate initial predictions as soon as possible in the operational phase and adjust the water management system to minimize the risk of environmental impact. A mine's water management system (wms) must account for site-specific physical, chemical and climatic characteristics as well as mine process factors. As water features in most operational aspects, total company commitment to integrated water management is critical. Periodic risk/consequence assessments will check wms effectiveness and allow change to reduce the risk of system failure and environmental impacts, and also help to "fine tune" rehabilitation planning to achieve desirable post-mining land use objectives. In order to do such a planning, comprehensive knowledge of the water regime is essential.

Management of Atmospheric (Non Dust) Emissions

Most of the techniques involved in ore processing are sources of non-dust emissions to the atmosphere. For example, radioactive gases and particles from uranium ore, odorous gases during ore concentration, acid gases from roasting of sulphide ores, and hydrogen sulphide and other acid gases. Key elements in managing atmospheric pollution are to use technology which reduces generation of gaseous emissions and which eliminates gaseous waste streams through recycling. Emission should be treated to reduce them as far as practicable. All pollutants must be identified and appropriate technologies selected to control them effectively. Care must be taken in designing stacks to suit local meteorological, topographic and built environment conditions, and to take account of gas cleaning technologies that reduce the temperature of emission inside the stack. Fugitive emission should be captured by hooding systems. Odour monitoring is important to provide fast warning of emission problems, as dispersion models may not provide information quickly enough to allow speedy response to emission levels which may give rise to health concerns or complaints from workers and the public (Anthea and Roa 2002).

Dust Control

Dust is unavoidable for almost all form of mining – it is one of the most visible, invasive and potentially irritating impact of mining in the environment. Many dusts do contain potentially hazardous metals which have associated health impacts. Dust affects flora and fauna and poses severe health risk to mine workers (Aloh 2007). Dust control must therefore be part of a mine environmental management plan, incorporated at the mining stage. Measures of dust management/control include:

a) Generation of dust in the removal of the vegetation and soils can be minimized by maintaining adequate moisture in the soil. This can also be expected to improve the efficiency of mining operations as in dusty atmosphere the efficiency decreases.
b) Use of dust extractors with the drill machines can be expected to minimize air pollutions due to drilling.
c) By optimizing the blast design, the generation of dust due to blasting can be reduced.
d) Proper maintenance of the haul roads can minimize the generation of air borne dust due to movement of dumpers on them.

e) Water spraying at the transfer points tends to reduce air pollution.

f) Enclosing the mineral handling and preparation units tend to reduce the contribution of SPM to the atmosphere.

g) Proper maintenance of the equipment and machines in the mines and other places in the complexes helps not only in m minimizing the contribution to the air pollution but also the noise generation.

h) The locations of the residential locations should be planned such that they are on the up wind side of the mines and plants so that for most of times the atmospheric pollutions are taken away rather them being brought towards this location.

i) Green belts of adequate widths, say 25-50 m, may be planned between the residential areas and the mines not only to attenuate noise but also to arrest dust.

Noise, Vibration and Air Blast Control

Noise, vibration and air blast are unavoidable in many mining activities. It constitutes significant threats to workers and the entire communities' health and safety if not well managed. Noise and vibration require particular management at projects close to communities, where they can give rise to concern for public health, safety, and damage to private and public buildings and other infrastructure. The mine planning stage should recognize the potential for adverse impacts. Hence, layout, infrastructure and systems should be designed to mitigate possible impacts. The extent of noise, vibrations and air blast should be quantified during the environmental impact assessment stage and predictions made of the levels likely at potentially sensitive locations, such as the nearest dwellings, school or public place. A management plan should be prepared in consultation with the local community, including specific measure to minimize emission levels. Ongoing monitoring during construction and operation will provide information for assessment of performance and data for effective auditing throughout the life of the mine.

Hazardous Materials Management, Storage and Disposals

Hazardous materials include any substance that may pose a hazard to human health or the environment when improperly treated, stored or disposed of. Most mining and mineral processing facilities use and generate hazardous materials. Approaches to minimizing risk from these substances include: identifying and properly preparing materials, compiling inventories of all hazardous materials including waste products, characterizing the potential

environmental hazards associated with them, documenting method for transport and storage, handling and use, identifying options for disposals and long term storage, preparing contingency plan, emergency response plans and training of all managers, workers and contractors who deal with or handle hazardous substances.

Land Management

Creative land management, landscaping and development of alternative land-use can reduce physical impacts during mining operations and improve post mining aesthetics. For example, the Sesa goa is the largest private sector mine of iron ore in India producing 9 million tons of iron annually for clients in Europe. The company has a fully fledged team to plan, monitor and implement environmental management (Sahu and dash 2011). In fact, the pit in Sanquelim mine in goa has been managed as a pisciculture pond and the fishery resources are being used by the local communities while the mine overburden dumps were planted with native species of economic value (Hickie and Wade 2007). The underground galleries of a gypsum quarry in France were converted into storehouse for wines and spirits and an underground mining museum set up to educate the tourists about the history of the gypsum mining (Bloodworth, Scott and McEvoy 2009).

Landform Design for Rehabilitation

Mining is a temporary use of land and the land should be returned to some beneficial use for the community after mine closure. Landform design is critical to achieving this objective. Land management is the design of land reclamation and development of the post mining land use, which is a requirement for the efficient management of the land as well as the overall environmental scenario (Saxena 2010).the value of land, its proximity to urban areas, and its natural attributes (such as slope, rainfall, fertility) and the type of mine, dictates sensible and achievable post-mining land use options and thus, the most appropriate objectives for land form design. The land developed after reclamation can be brought into various uses as per the requirement of the area in the post mining times.

Rehabilitation and Re-Vegetation

Rehabilitation is an essential part of achieving ecologically sustainable development in mining. It cannot be considered only towards the end of mine life; to be effective it must be part of an integrated management plan right from the mine planning stage, and must incorporate research and trials to improve the probability of success and acceptance by

regulators and the community. Rehabilitation can take different forms for example in mining areas close to towns a range of land-use options such as playing fields, industrial development, housing, water recreation and parkland is potentially appropriate. In more remote area, restoration into natural rangelands may an option. In developed countries, mining organizations and research institutions have developed expertise to re-established floral and faunal species that will develop into communities with similar biodiversity to undisturbed system; examples can be found in France and Australia (Anthea and Roa 2002).

Environmental Monitoring and Performance

The environmental monitoring and performance programme involves collection and interpretation of information necessary to determine whether the environmental management plan and related systems are being applied effectively, and whether the environmental objectives set by the company, regulators and community are being properly met.

According to (Anthea and Roa 2002) a clear quality monitoring programme is critical to inform the company, the regulatory authorities and the community on the level of environmental protection being achieved. Proper interpretation will provide the information necessary to enable early changes to the mining operation if unacceptable impacts are indicated or predicted, and this will form the basis of credible technical reporting occurring.

Environmental Auditing

Environmental auditing is an essential management tool to measure overall performance objectively and to develop action plans for ongoing improvement in the effectiveness and efficiency of environmental protection (Bloodworth, Scott and McEvoy 2009).

an audit program will help demonstrate due diligence in the event of confrontations with stakeholders, or prosecution. Environmental audits should be repeated at regular intervals to provide periodic assessments of the effectiveness of environmental management system. Whilst internal auditors can undertake them, independent audits are usually needed for the result to be credible to regulators and stakeholders. The benefits of environmental auditing include identification and management of risk, lower probability of non-compliance, preferred access to lending institutions, lower insurance premiums for environmental risk, and improved public image.

Mine Decommissioning

Mine decommissioning and closure is the process of shutting down an operation so that the area is left in a safe and stable condition, which is consistent with the surrounding environment, and does not need ongoing maintenance (Colby 1990).

Decommissioning determines what is left behind as a benefit or legacy for future generations. If decommissioning and closure are not undertaken in a planned and effective manner, the site may continue to be hazardous and a source of pollution for many years to come. The overall objective of mine closure is to prevent or minimize adverse long term environmental impacts, and to create the agreed beneficial land- use objective (Colby, 2011).

Appropriate mine decommissioning outcomes need to be determined on a site-specific basis taking into account climate, land capability, land form, water resources, ongoing land use and the risks associated with alternatives. Factors important in considering decommissioning options include; public safety, hazards and risks, ecological compatibility, potential for ongoing pollution, community expectations, future land use and resource demands, and aesthetics. The benefits from mine decommissioning include; reduction of liabilities, sufficient financial and material resources set aside for final closure requirements, rehabilitation design and/or processes tested for their suitability for the specific site, less double-handling of waste materials and topsoil, less land disturbed, identification of areas of high risk as priorities for ongoing research and/or remediation, realistic estimation of rehabilitation costs, potential to progressively recover performance bonds, and reduced impacts on local communities that may be economically reliant on mine operation.

Conclusion

In principle, the areas or resources affected by mining should be returned to a safe and productive condition through rehabilitation, which may or may not involve a return to pre-mining conditions and reclamation, should be an ongoing activity throughout the life of the operation as well as after decommissioning. The mining industry, the government and the local people must work together to care for future generation.

This review has shown that environmental management is not just the responsibility of the mining industry but also of government who plays critical role in providing legislative and regulatory frameworks that encourage or demand best practices in mining. Thus, to

achieve ecologically sustainable development especially as it concerns the urban environment, there should be a clearly defined, rigorous and monitorable environmental principles and standards with which the mining sector in developing countries must comply with. Finally, constant research and development effort are required to find out newer and latest technologies and methodology to minimize the impact of mining in the environment, and technologies to reclaim the land for better use since mining for economic development must have respect for environmental integrity.

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