International Journal of Advance Research in Science and Engineering
Vol. No.5, Issue No. 04, April 2016
www.ijarse.com
IJARSE
ISSN 2319 - 8354

# MINING INDUSTRY AND ITS IMPACT ON ENVIRONMENT AND HUMAN HEALTH

**M.S.R. Gowtham Raju[1], A. Naga Sai[2]**

[1]*Dept of Automobile Engineering*

[2]*Dept of Mining EngineeringGIET(A)Rajahmundry*

## ABSTRACT

In an era of increased attention to global warming, it is as hour to keep an eye on obvious reasons, the mining industry in terms of environmental concerns. The use of mineral resources, and thus also mining, is per definition unsustainable since it is based on the production of non-renewable resources from finite deposits. Furthermore, mining potentially causes severe environmental consequences and some of the worst industrial disasters are mining related. Mining is the compound of activity referred to explore, extract and process minerals from the earth. Minerals can be metals (like copper, gold, silver, iron, lead) or non metals (like coal, asbestos, gravel). Normally metals are mixed with many other elements, but sometimes is possible to find big quantity of a specific metal in a restricted area, the vein, where is possible to extract it with economic benefit. In that areas, normally, are located mines. Mines can have different size. There are mining operations that move less than 100 tons of rock each day, and there are big mining operations that move hundreds of thousandth of tons every day. The way of extract metals from the deposit depends form type, dimension and depth of the vein and also from economic, financial and sustainable aspect. Environmental and social impacts of mining have been well-documented and an ample literature exists on this topic. One of the most important issues in mining activity is the workers safety. Miners are one of the most endangered workers in the world. Even if modern practices have improved safety in mines significantly, mining accident is quite usual and mining workers are among the most exposed to risk all over the world. Only in Coal mines in China the Government indicate more than 5.000 died every year but other sources registers more than 20.000 accidents,18 and in USA over 104.000 miners have died in coal mines in the last century; in 2007, in USA, there were at least 65 dies in mining operations. A part to the problems linked with the mining workers the nature of mining processes creates a potential negative impact on the environment during the exploration, during the mining operations and for many years after the mine is closed. In this paper, the authors made an attempt to summarize the environmental and social issues that formed the basis for the Mining and Critical Ecosystems framework. The main aim of the review is to explore the health and environmental impacts mining of metals and minerals. The goal is to determine the relative environmental performance of the mining and processing of the different minerals.

***Keywords: Mining Industry, Environment, Human Health, Exploration, Minerals.***

## I. INTRODUCTION

Mining can generally be divided into four phases:

- Exploration
- Development
- Extraction
- Processing and decommissioning

Exploration is the defining of the extent and value of the ore. During the development stage, the deposit is opened for production (exploitation or extraction), i.e. access is gained to the deposit. This is done by either stripping the overburden to expose the ore near the surface or by excavating openings as preparation for underground mining for deeper deposits.

The following will provide an overview of different mining methods and processes involved inthe extraction of the mineral.

## 1.1 Mining

The choice of extraction method is based on the characteristics of the mineral, safety and environmental concerns, and technology and economics. The most traditional methods are surface mining and underground mining.

Surface mining can be further divided in to mechanical excavation methods such as open-pit and open-cast mining and aqueous methods, of which leaching is the most common. Underground mining methods are usually divided into three classes: unsupported, supported and caving.

### 1.1.1. Surface Mining

Surface mining is, as the name implies, mining methods of ore, coal, or stone that are carried out at the surface with basically no underground exposure of miners. This group of mining methods is the dominating category worldwide. Of the global mineral production, 80% is performed by surface mining methods. Surface mining can be divided into mechanical excavation and aqueous excavation. The mechanical excavation class consists of open pit mining, quarrying and open-cast mining. Aqueous extraction consists of all methods using water or a liquid solvent to recover minerals and can be further divided into the subclasses placer mining and solution mining methods. In placer mining methods, water is used to excavate, transport and/or concentrate heavy minerals from alluvial or placer deposits. In solution mining, minerals that are soluble, fusible or easily recovered in slurry form are extracted, normally by using water or liquid solvents.

Below, the most common methods for the extraction of copper, gold and uranium are treated more thoroughly.

### 1.1.2 Open-Pit Mining

Open-pit mining is used when the minerals occur near the surface. A surface pit is excavated, using one or several horizontal benches. For mining thick deposits, several Environmental Impacts and Health Aspects in the Mining Industry7 benches are excavated and form the pit walls like an inverted cone. The reason for using benches is that it enables control of the blast holes as well as the slope of the pit walls.

For small open-pit mines, capital investments and running costs are low compared to underground mines of equal size. However, large open-pit mines require much more preproduction investments than comparable underground mines. Nevertheless, the running costs are still low for large open-pit mines and the mining rate can be extremely high. Furthermore, ores can be mined at a grade that is not economically feasible using other mining methods.

#### 1.1.3 Placer Mining

Placer mining is used for the mining of gravel and sand containing gold, tin, titanium and rare-earth minerals. Placer mining can be done by dry-land methods or by dredging. Dry-land placer mining is very similar to shallow open-cut mining and strip-mining, except that gravel banks can be removed by pressurised water stream, undercutting and caving it.

#### 1.1.4 Leaching

Leaching is the chemical extraction of metals or minerals in the deposit or from material already mined. Bacteriological extraction also exists but is not as common. There are two variations of leaching, percolation leaching and flooded leaching. If the extraction is done within the confines of a deposit, it is called in situ leaching, which will be treated separately. Heap leaching is the method performed on already mined dumps, tailings or slag piles.

### 1.2 Underground Mining

When ore veins are steep or deposits bedded, the costs of removing waste rock makes it impossible to use surface mining methods. Instead underground mining can be used. Commonly, surface mining methods are used to a certain depth until it is only economically feasible to continue excavations with underground mining. Underground methods differ by the wall and roof support, the opening configuration and the direction of the extraction process. The alternative methods of underground mining are unsupported, supported and caving operations.

Underground mining operations generally follow a procedure of drilling, blasting, mucking (i.e.removal of broken rock) and the installations of ground support (timber or roof bolts). Waste rock and broken ore is collected and transferred to different haulage units by air- or electric operated mechanical loaders, cable guided scraper systems or by mobile conveyors. Electric-, diesel- or compressed-air-powered locomotives with trains of ore cars are normally used for haulage to transfer points and the mine portal.

## II. HEALTH AND ENVIRONMENT IN THE MINING INDUSTRY

The following will discuss environmental impacts and health aspects in the mining industry in general. Special attention will be given to the issues of tailings and radiation.

### 2.1 Environmental Impacts

Three main types of changes are distinguished as a result of mining: change in the natural topography which results in restrictions in the possibilities of using the land for other purposes,changes in the hydro-geological conditions with consequences for both groundwater and surface water and finally changes in the geotechnical conditions of the rock. The impact varies with local conditions of the specific site of mining. These changes caused by mining can give rise to various impacts on the geo-environment, described below.

**2.1.1 Impacts on the Lithosphere**

Depending on the type of mining conducted and the site of mining there are several types of impacts on the lithosphere. The results range from formation of ridges, depressions, pits and subsidence on the surface as well as underground cavities affecting the stability of the ground. Furthermore, both the area for mining and the area used for waste dumps, occupy and degrade land that could be used for e.g. farming and agriculture.

**2.1.2. Impacts on the Hydrosphere**

Impacts on the hydrosphere resulting from mining include lowering of the groundwater table, mine water discharge into rivers, seas and lakes, leakage from settling tanks and evaporators that have a negative effect on the groundwater quality and pumping of water into the ground for the extraction of a mineral. Significantly lowered groundwater levels can result in huge surface depressions and drained rivers and lakes with serious impacts on surrounding agriculture for example. Furthermore, depending on the chemical composition of the rock, the drained water usually becomes highly acidic with the resulting capability of taking into solution a variety of toxic and heavy metals.

**2.1.3 Impacts on the Atmosphere**

Atmospheric emissions during mining occur not only from internal combustion engines in mining machinery but dust and gases are also released from blasts and rocks and mineral masses. One tone of explosives produces about 40-50 m3 nitrogen oxides and huge amounts of dust. Smelters are commonly used for mineral purification and emissions from these processes include particulate matter and gases such as sulphur dioxide, carbon monoxide and carbon dioxide. Although some installations use different kinds of flue gas purifications, these are never completely effective.

**2.1.4 Impacts on the Biosphere**

The biosphere is adversely affected by mining mainly by pollution and by degradation of land and vegetation resulting in loss in biodiversity. Mining can also have impact on local microclimate.

## 2.2 Health Aspects

Mining is one of the most hazardous industrial occupations and during the period 1980-89, mining was the industry with the highest annual number of traumatic fatalities. Health impacts from mining can be divided into two categories: immediate impacts such as accidents; and accumulative and progressive impacts such as stress, radiation and pulmonary diseases. In terms of health hazards, four different types can be distinguished: physical, chemical, biological and mental hazards:

**2.2.1 Physical Hazards**

Physical hazards include noise, heat, vibrations, falls and explosions, flooding and various forms of dust, aerosols and fine particles with resulting fibro genetic and carcinogenic effects. Ionizing radiation is included in the category of physical hazards.

**2.2.2 Chemical Hazards**

Chemical hazards arise from chemical pollutants in water, solid wastes and air with the most common substances being carbon monoxide and dioxide, oxides of sulphur, nitrogen oxides and fluorine compounds.

#### 2.2.3 Biological Hazards

Biological hazards caused by living organisms such as fungus, bacteria and parasites are more common among mine workers in developing countries with poor standards of hygiene and sanitation.

#### 2.2.4 Mental Hazards

Mental hazards involved with mining include claustrophobia, anxiety, tension or irritability involved with the awareness of the dangerous working site. Fatigue and other disorders linked to shift work are other potential problems among mine workers.

## III. SOCIAL IMPACTS

Environmental and social impacts are divided into waste management issues, impacts to biodiversity and habitat, indirect impacts, and poverty alleviation and wealth distribution. Those seeking additional details may wish to consult the many resources available on this topic.

### 3.1 Waste Management

By nature, mining involves the production of large quantities of waste, in some cases contributing significantly to a nation's total waste output. For example, a large proportion of the materials flows inputs and outputs in the United States can be attributed to fossil fuels, coal, and metal mining. The amount of waste produced depends on the type of mineral extracted, as well as the size of the mine. Gold and silver are among the most wasteful metals, with more than 99 percent of ore extracted ending up as waste. By contrast, iron mining is less wasteful, with approximately 60 percent of the ore extracted processed as waste.

Disposing of such large quantities of waste poses tremendous challenges for the mining industry and may significantly impact the environment. The impacts are often more pronounced for open-pit mines than for underground mines, which tend to produce less waste. Degradation of aquatic ecosystems and receiving water bodies, often involving substantial reductions in water quality, can be among the most severe potential impacts of metals extraction. Pollution of water bodies results from three primary factors: sedimentation, acid drainage, and metals deposition

### 3.2 Sedimentation

Minimizing the disturbed organic material that ends up in nearby streams or other aquatic ecosystems represents a key challenge at many mines. Erosion from waste rock piles or runoff after heavy rainfall often increases the sediment load of nearby water bodies. In addition, mining may modify stream morphology by disrupting a channel, diverting stream flows, and changing the slope or bank stability of a stream channel. These disturbances can significantly change the characteristics of stream sediments, reducing water quality. Higher sediment concentrations increase the turbidity of natural waters, reducing the light available to aquatic plants for photosynthesis. In addition, increased sediment loads can smother benthic organisms in streams and oceans, eliminating important food sources for predators and decreasing available habitat for fish to migrate and spawn. Higher sediment loads can also decrease the depth of streams, resulting in greater risk of flooding during times of high stream flow.

### 3.3 Acid drainage

Acid drainage is one of the most serious environmental impacts associated with mining. It occurs when sulfide-bearing minerals, such as pyrite or pyrrhotite, are exposed to oxygen or water, producing sulfuric acid. The presence of acid-ingesting bacteria often speeds the process. Acidic water may subsequently leach other metals in the rock, resulting in the contamination of surface and groundwater. Waste rock piles, other exposed waste, mine openings, and pit walls are often the source of acidic effluents from a mine site. The process may occur rapidly and will continue until there are no remaining sulfides. This can take centuries, given the large quantities of exposed rock at some mine sites. Although the process is chemically complex and poorly understood, certain conditions can reduce likelihood of its occurrence. For example, if neutralizing minerals are present (e.g., carbonates), the prevailing pH environment is basic, or if preventative measures are taken, then acid drainage is less likely to occur.

Acid drainage impacts aquatic life when acidic waters are discharged into nearby streams and surface waters. Many fish are highly sensitive to even mildly acidic waters and cannot breed at pH levels below 5. Some may die if the pH level is less than 6. Predicting the potential for acid drainage can help determine where problems may occur. Methods vary from simple calculations involving the balance of acid generating minerals (e.g., pyrite) against the existence of neutralizing minerals (e.g., calcium carbonate) to complex laboratory tests (i.e., kinetic testing). However, even laboratory-based tests cannot be relied upon to accurately predict the amount of metals that will be leached if acid drainage occurs, because of the differences in scale and composition that occur when samples are analyzed ex situ.

### 3.4 Metals Deposition

Most mining operations use metals, reagents, or other compounds to process valuable minerals. Certain reagents or heavy metals, such as cyanide and mercury, are particularly valued for their conductive properties and thus are frequently used. The release of metals into the environment can also be triggered by acid drainage or through accidental releases from mine tailings impoundments. While small amounts of heavy metals are considered essential for the survival of many organisms, large quantities are toxic. Few terrestrial and aquatic species are known to be naturally tolerant of heavy metals, although some have adapted over time.

In general, the number of plant and animal species decreases as the aqueous concentration of heavy metals increases. Some taxa are known to be more sensitive to the presence of heavy metals. For example, salmon species are particularly sensitive to increased concentrations of copper. Furthermore, juvenile fish are more sensitive than adult fish, and the presence of heavy metals may affect critical reproductive and growth stages of fish.

### 3.5 Biodiversity and Habitat

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

Recognizing the importance of natural ecosystems, many governments have set aside areas for protection in national parks and other protected areas. The World Conservation Union (IUCN) maintains a list of all of the world's protected areas and categorizes them according to management objective. International conventions also establish guidance and mechanisms for listing areas with special global significance. The United Nations Educational, Cultural and Scientific Organization (UNESCO) maintains a list of World Heritage Sites and reported threats to these sites. Mining, oil, and gas development have been reported to threaten a significant number of these sites.

## IV. INDIRECT IMPACTS

In addition to waste management issues, mines also pose environmental and social challenges due to potential disruptions to ecosystems and local communities. Mining requires access to land and natural resources, such as water, which may compete with other land uses. Although the size of most mining operations is small compared to other land uses (e.g., industrial agriculture and forestry), mining companies are limited by the location of economically viable reserves, some of which may overlap with sensitive ecosystems or traditional indigenous community lands.

Often the larger-scale impacts from mining occur from indirect effects, such as road building and subsequent colonization. An area of approximately 400-2,400 hectares has been colonized in the Amazon Basin for every kilometer of oil pipeline built. In the Philippines, upland ecosystems are under pressure as a result of the migration of small-scale farmers. Mining could threaten these sensitive ecosystems by stimulating additional migration.

Recent concerns regarding the potential conflicts between mining and other land uses has prompted some communities to pass non-binding referendums banning mineral development. According to a study commissioned by the mining industry, displacement may result in serious social problems, including marginalization, food insecurity, and loss of access to common resources and public services, and social breakdown.

## V. POVERTY ALLEVIATION AND WEALTH DISTRIBUTION

Developing countries often seek to exploit mineral resources as a way of providing much needed revenue. According to some, mineral wealth is part of a nation's natural capital and the more capital a nation possesses the richer it becomes. Papua New Guinea receives almost two thirds of its export earnings from mineral deposits. Diamond mining accounts for approximately one third of Botswana's GDP and three quarters of its export earnings.

Although mineral exports may make up a significant share of a country's exports, mineral development does not always boost a country's economic growth and may, in some cases, contribute to increased poverty. The reasons for the lack of economic growth in oil- and mineral dependent states are not entirely conclusive. However, low levels of employment in the sector, use of mostly imported technology, high market volatility of minerals, competition with agricultural sectors, and institutional corruption and mismanagement may be contributing factors. In addition, lack of full cost accounting can result in overestimating the benefits if subsidies offered to the mining sector are not taken into account.

Even when mineral development results in national economic growth, the benefits are not always equitably shared, and local communities closest to the source of mineral development can suffer the most. In some cases, mining has provided jobs in an otherwise economically marginal area. However, typically these jobs are limited in number and duration. In addition, communities that come to depend on mining to sustain their economies are especially vulnerable to negative social impacts, especially when the mine closes. Mining tends to raise wage levels, leading to displacement of some community residents and existing businesses, and elevated expectations. Mining may also trigger indirect negative social impacts, such as alcoholism, prostitution, and sexually transmitted diseases. In a worst-case scenario, mines have even fueled conflict in some developing countries by providing revenue for warring factions to purchase weapons. The best-known and publicized of these cases have been in Africa, where control over diamond mines has become an objective for rebels seeking income to finance civil wars. In these cases, the presence of mining has exacerbated conflicts and human rights abuses have been widely reported. In some cases, the military has been known to engage in violence and human rights abuses in order to extort additional payments from companies operating in West Papua.

## VI. 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 components of a regulatory framework are discussed below.

## VII. REGULATORY FRAMEWORK

A strong regulatory framework allows countries to set standards that companies must follow. Some experts contend that a more flexible regulatory framework is preferable than the more traditional command-and-control approach. Others acknowledge that a minimum set of rules by which companies must operate is necessary. Key components of a regulatory framework for mineral development include environmental impact assessments, environmental quality and social laws, environmental liability, and monitoring capacity.

## VIII. 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 decommissioning and site clean-up.

However, there are gaps in legislation in many countries. For example, none of the Andean countries has legislation addressing employment benefits, training opportunities, or social benefits from oil development. The need for consultation, land titles, and compensation is also not adequately covered. In the United States, hardrock 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. Papua New Guinea and Zimbabwe routinely provide mining companies with exemptions from meeting water quality standards. Implementation of existing legislation may also be lacking. For example, Chile boasts 2,200 laws and presidential decrees relating to the environment, but most are not implemented, due to a lack of political will. Difficulty implementing laws may stem from conflicting mandates amongst government agencies.

## IX. 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. 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 to the marine environment, including an extensive fish kill, was considered one of the country’s top 10 recent environmental disasters.

Countries may also pass legislation that establishes fines and punishment for those found guilty of polluting. However, most countries lack any kind of legislation making polluters liable for clean-up. Where fines are collected, they are often low. 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.

## X. 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, a 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. Lack of funding, staffing, and training is common constraints in many countries.

## XI. CONCLUSION

Relationships between mining and environment are particularly complex and not yet fully understood especially in developing countries. This complexity is due partly to the level of research and lack of adequate analytical capabilities as well as foolproof diagnostic ability for environmentally related health conditions. Notwithstanding this, concerted effort is still required in order to improve the health standards of the mining community.

Measures to be taken include:

- Providing technical and professional assistance for artisan miners so as to improve their skills in mining and gold processing.
- Encouraging the use of protective gear at all times during gold mining and processing.
- Formation of strong mining committees with the task of planning and man-aging mine sites and working hand in hand with the Government authorities on health and pollution control, for example, on protection of water sources.
- Strict observation of sanitation within the mines, including provision of pit latrines, boiled water, and hot meals.
- Campaigns on sexually transmitted diseases (STDs) including HIV/AIDS, which spreads at an alarming rate among the mining communities in the district.

This study is one of the attempts towards comprehensive analyses of health impacts of mining on local population. The authors find consistent environmental health impacts on the people living in close proximity to mines have higher incidences various diseases.

This paper provides important insights on the full impacts of mines, encouraging policy makers to look beyond the obvious positive economic impacts of mining. Of course, these may not be inevitable impacts of mines, but rather, possible to mitigate with appropriate regulation and enforcement, imposing accountability for local environmental and health quality.

## REFERENCES

[1] Auty, R.M. (1990), *Resource-Based Industrialization: Sowing the Oil in Eight Developing Countries*. Oxford: Clarendon Press.

[2] Ballard, C. (2001), “Human Rights and the Mining Industry in Indonesia: A Baseline Study,” MMSD Working Paper No. 182. Available online at: http://www.iied.org/mmsd/mmsd_pdfs/indonesia_hr_baseline.pdf

[3] Bryant, D. et al. (1998), *Reefs at Risk: A Map-Based Indicator of Threats to the World’s Coral Reefs* WRI: Washington.

[4] Christmann, P. and N. Stolojan (2002), “Management and Distribution of Mineral Revenue in PNG: Facts and Findings from the Sysmin Preparatory Study A Consultant’s Perspective,” Report

Commissioned by the Mining, Minerals and Sustainable Development (MMSD) project of the IIED. London, England: MMSD.

[5] Collier, P. and A. Hoeffler (2001), "Greed and Grievance in Civil War," World Bank Paper.

[6] Collier, P. and A. Hoeffler (1998), "On Economic Causes of Civil War," *Oxford Economic Papers* 50: 563- 573.

[7] Da Rosa, C.D. and J.S. Lyon (1997), *Golden Dreams, Poisoned Streams: How Reckless Mining Pollutes America's Waters and How We Can Stop It*. Washington, DC: Mineral Policy Center.

[8] Davis, G.A. and J.E. Tilton (2003), "Should Developing Countries Renounce Mining?: A Perspective on the Debate," Paper contributed to Extractive Industries Review (EIR). Available online at www.eireview.org.

[9] Department of Environment and Natural Resources – Pollution Adjudication Board (DENR-PAB) (2000), "Mining Related Incidents." Unpublished public records (used with permission from PAB), Quezon City, Philippines.

[10] Environmental Science for Social Change (ESSC) (2003), "Mining and Critical Ecosystems: Philippines Case Study." Case Study commissioned by World Resources Institute. ESSC: Manila, Philippines.

[11] Environmental Science for Social Change (ESSC) (1999a), *Decline of the Philippine Forest*. Makati City, Philippines: Bookmark Inc.

[12] Environmental Science for Social Change (ESSC) (1999b), *Mining Revisited: Can an Understanding of Perspectives Help?* Quezon City, Philippines: ESSC.

[13] Energy Sector Management Assistance Programme (ESMAP) (1999), *Environmental and Social Regulation of Oil and Gas Operations in Sensitive Areas of the Sub-Andean Basin*, Report 217/99. Washington, DC: The World Bank, 1999.

[14] Fearnside, P. (1989), "The Charcoal of Carajás: A Threat to the Forests of Brazil's Eastern Amazon Region," *Ambio* Vol 18 (2): p. 142.

[15] Galloway, L.T. and K.L Perry (1997), "Mining Regulatory Problems and Fixes," In C.D. Da Rosa (ed.) *Golden Dreams, Poisoned Streams*

[16] Gardner, G. and P. Sampat (1998), *Mind Over Matter: Recasting the Role of Materials in our Lives*, Worldwatch Paper No. 144 Washington, DC: Worldwatch Institute.

[17] Gelb. A. et al. (1988), *Oil Windfalls: Blessing or Curse?* New York: Oxford University Press. Government of Papua New Guinea (GoPNG) (2002), "Fourth Quarter Bulletin: Annual Bulletin, 2001" PNG Department of Mining. Port Moresby, PNG: GoPNG.

[18] Global Witness (1998), *A Rough Trade: The Role of Companies and Governments in the Angolan Conflict*, London: Global Witness, available at http://www.globalwitness.org). Last accessed 11/5/01.

[19] Global Witness (1999), *A Crude Awakening: The Role of the Oil and Banking Industries in Angola's Civil War and the Plunder of State Assets*, London: Global Witness, available at http://www.oneworld.org/globalwitness/. Last accessed Nov. 5, 2001.

[20] Hughes, P. and M. Sullivan (1989), "Environmental Impact Assessment in Papua New Guinea: Lessons for the Wider Pacific Region," *Pacific Viewpoint* Vol 30 (1).

[21] Hyndman, D. (2001), "Digging the Mines in Melanesia," *Cultural Survival Quarterly* Vol 15(2): 32-39.

[22] Johnson, S.W. (1997a), "Hydrologic Effects," In J.J. Marcus (ed.) *Mining Environmental Handbook*. London: Imperial College Press

[23] Johnson, S.W. et al. (1997b), "Effects of Submarine Mine Tailings Disposal on Juvenile Yellowfin Sole (*Pleuronectes asper*): A Laboratory Study," *Marine Pollution Bulletin* Vol. 36 (4)

[24] Kelly, M. (1998), *Mining and the Freshwater Environment*. London: Elsevier Applied Science/ British Petroleum

[25] Kuyek, J. and C. Coumans (2003), *No Rock Unturned: Revitilizing the Economies of Mining Dependent Communities*. MiningWatch Canada: Ottawa, Canada. Available online at: http://www.miningwatch.ca. Last accessed September 6, 2003.

[26] Lagos, G. and P. Velasco (1999), "Environmental Policies and Practices in Chilean Mining," In A. Warhurst (ed.) *Mining and the Environment: Case Studies from the Americas*, Ottawa, Canada: International Development Research Center.

[27] Ledec, G. (1990), "Minimizing Environmental Problems from Petroleum Exploration and Development in Tropical Forest Areas," *Proceedings of the First International Symposium on Oil and Gas Exploration and Production Waste Management Practices*, New Orleans, Louisiana, September 10-13, 1990.

[28] Mapong, O. and A. Mutemererwa (1995), "Management of Natural Resources and the Environment in Zimbabwe: The Case of Gold," Paper prepared for UNCTAD, United Nations Conference on Trade and Development.

[29] Mason, R.P. (1997), "Mining Waste Impacts on Stream Ecology," In C.D. Da Rosa (ed), *Golden Dreams, Poisoned Streams, How Reckless Mining Pollutes America's Waters and How We Can Stop It* . Washington, DC: Mineral Policy Center.

[30] Matthews, E et al. (2000), *The Weight of Nations: Material Outflows from Industrial Economies* Washington, DC: World Resources Institute.

[31] MacCallum,B (1989), "Seasonal and spatial distribution of bighorn sheep at an open pit coal mine in the Alberta foothills," In D.G. Walker et al. *Proceedings of the Conference: Reclamation, A Global Perspective, Vol. 1* Report #RRTAC 89-2, Edmonton, Alberta: Alberta Conservation and Reclamation Council.

[32] Miller, K.R (1995), *Balancing the Scales: Guidelines for Increasing Biodiversity's Chances Through Bioregional Management*, World Resources Institute: Washington, DC.

[33] Mining, Minerals and Sustainable Development (2002), *Breaking New Ground*, Earthscan Publications: London.

[34] Miranda, M. A. Blanco-Uribe Q., L. Hernández, J. Ochoa G., E. Yerena (1998), *All That Glitters is Not Gold: Balancing Conservation and Development in Venezuela's Frontier Forests*, World Resources Institute: Washington, DC.

[35] Otto, J. and J. Cordes (2002), *The Regulation of Mineral Enterprises: A Global Perspective on Economics, Law and Policy*. Westminster, Colorado: Rocky Mountain Mineral Law Foundation. Oxfam America (2002), "Tambogrande Speaks Out," Oxfam America Issue Update. Available online at: http://www.oxfamamerica.org/advocacy/art2763.html?backresults=TRUE, last accessed April 30, 2003.

[36] Peres, C.A. and J.W. Terborgh (1995), "Amazonian Nature Reserves: An Analysis of the Defensibility Status of Existing Conservation Units and Design Criteria for the Future," *Conservation Biology*, Vol 9(1): 34-46 Power, T.M. (2002), "The Role of Metal Mining in the Alaskan Economy," A report prepared for the Southeast Alaska Conservation Council and Northern Alaska Environmental Center.

[37] Redwood, J. (1998), "Social Benefits and Costs of Mining: The Carajás Iron Ore Project, In G. McMahon (ed.) *Mining and the Community: Results of the Quito Conference*, Washington, DC: The World Bank, 1998.

[38] Ripley, E.A. et al. (1996), *Environmental Effects of Mining*. Delray Beach, Florida: St. Lucie Press.

[39] Ross, M.L. (2001a), *Extractive Sectors and the Poor,* Oxfam America: Washington, DC.

[40] Ross, M. (2001b), "Natural Resources and Civil Conflict: Evidence from Case Studies," Paper prepared for the World Bank/UC Irvine Workshop on "Civil Wars and Post-Conflict Transitions," May 18-20, 2001, Irvine, CA.

[41] Ross, M.L. (1999), "The Political Economy of the Resource Curse," *World Politics* Vol. 51(2): 297-322.

[42] Sampat, P. (2003), "Scrapping Mining Dependence," In C. Bright et al., *State of the World:2003*

[43] Washington, DC: Worldwatch Institute Schmiermund R.L. and M.A. Drozd (1997), "Acid drainage and Other Mining-Influenced Waters (MIW)" in J.J. Marcus (ed.), *Mining Environmental Handbook: Effects of Mining on the Environment and American Environmental Controls on Mining*. London: Imperial College Press.

[44] Shearman, P. (2001), "Giving Away Another River," In B.Y. Imbun and P.A. McGavin, *Mining in Papua New Guinea*, *Analysis and Policy Implications* Port Moresby: University of Papua New Guinea.

[45] Sherman, J.H. (2000), "Profit vs. Peace: The Clandestine Diamond Economy of Angola," *Journal of International Affairs*, 53 (2): 699-719.

[46] Sideri, S. and S. Johns (eds) (1990), *Mining for Development in the Third World: Multinational Corporations, State Enterprises and the International Economy*. New York: Pergamon Press.

[47] Stratigos, C. (1993), "Mining, Resistance, and Nationalism in the Republic of Bougainville," *Social Alternatives* Vol 12(1): 55-62.

[48] United Nations Environment Programme (UNEP) (1996), "Environmental and Safety Incidents concerning Tailings Dams at Mines," Results of a Survey for the years 1980-1996, London: Mining Journal Research Services.

[49] Warhurst, A. (1999), "Environmental Regulation, Innovation, and Sustainable Development," In A.

[50] Warhurst (ed.) *Mining and the Environment: Case Studies from the Americas* (Ottawa, Canada: International Development Research Center

[51] Winfield, M. et. al (2002), *Looking Beneath the Surface: An Assessment of the Value of Public Support for the Metal Mining Industry in Canada*. MiningWatch Canada and Pembina Institute: Ottawa, Canada. Available online at: www.miningwatch.ca. Last accessed September 6, 2003