CHAPTER 27

AN OVERVIEW OF INDUSTRIAL AND MINING WASTE

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An Overview of Industrial and Mining Waste

Introduction

Mining and industrial activities are by their very nature offensive and unfriendly to the physical environment. There is emphasis on 'physical environment' because the *social well-being* and other *positive impacts* must be recognised. Industrial and mining technological developments have without doubt improved the living standards of people especially in developing countries, to the extent of, for example, improved life expectancy.

The question about wastes and negative environmental impacts associated with mining and industrial development is not about their existence, but rather about their management. These impacts are usually, to an overwhelming extent, unnecessary because they can be anticipated and avoided or mitigated.

This anticipation puts into the hands of responsible officials a simple, straight forward working tool that will allow them at the earliest stages of technological intervention to plan for the environmental consequences. The focus here pertains to the earliest stages: planning and predevelopment in the form of Environmental Impact Assessments (EIA). These would help to determine the Best Practicable Environmental Options (BPEOs) in dealing with and managing wastes and other impacts arising from any technological development.

Wastes normally found or arising from a generic industrial and/or mining concern include the following:

- **Aesthetic Pollution:** Deformation of natural landscapes e.g. open pits, waste rock dumps and slag dumps.
- **Air Pollution:** Air pollution in the form of Noise, Dust, Odours, Fumes and Gases, Volatile Organic Compounds, Ozone etc.
- **Land Contamination:** Contamination by Oils, PolyChlorinated Biphynels (PCBs), Heavy metals, Salts etc.
- **Water Pollution:** Pollution of water by Acid Mine Drainage, Oils, Heavy Metals, Chemical and Toxic wastes and Thermal pollution.
- **Solid Waste:** This includes Waste tyres, Scrap metal, Waste paper, Electrical and Electronic waste.
- **Hazardous and Chemical Waste:** Includes Acid, PCBs, Pesticides,

Drugs, Chlorofluorocarbons (CFCs), Greenhouse Gases, Cement Dust, Radioactive Waste, Hydrocarbons, and Dioxins.

Preventive Approach to Pollution Control

A number of statements have been made in the literature, which supports a preventative approach to pollution control.

"Project planning and evaluation process will take environment processes fully into account at the same time as the economic factors are likely to produce better and more sustainable economic returns. Higher initial investment and research costs may well have to be accepted in order to achieve cleaner technologies and more efficient waste management, but when costs of expensive retrofits and restoration are taken into account such an approach will often be economically justifiable over the life of the project"

– Norman, 1985.

"There is a need for a dynamic, anticipatory approach to pollution problems, which seeks to avoid the closing of options for future generations."

– Royal Commission, 1984.

It is predicted that anticipatory and preventative approaches to pollution problems are most likely and must feature strongly in future developments. In many Developing countries EIA Legislation is either scheduled to be put in place or is newly in existence. EIAs have been voluntary or as a requirement by the funding organisation such as the World Bank.

Activities in Mining and Industrial Development are likely to include: site construction, installation of ancillary services e.g. power lines and railway lines, pipelaying, storage of process liquids, fuel and chemicals, drilling and testing, waste disposal, processing, transport, storage of products, and decommissioning. These in turn may need analysis in terms of the implied movement of people and vehicles, landscape, physical pressure and visual intrusion, noise, discharges, emissions, solid waste generation, spill risk, and hazard risk. Any of these may lead to environmental problems; including effects on:

- ❑ Flora and Fauna;
- ❑ Habitats;
- ❑ Air, Soil and Water Quality;
- ❑ Landscape and Amenity;
- ❑ Archeological Sites;
- ❑ Residents;
- ❑ Agriculture and Forestry; and
- ❑ Tourism and Recreation.

The Political Economy of Industrial/Mining Development and Environmental Management in the SADC Region

Mining and Industrial Development has traditionally played a major role in the economic development of member countries of the Southern African Development Community (SADC) and will continue to do so given that the mining sector alone contributes more than 60% of the region's foreign exchange and more than 11% of the region's GDP (Warhurst, 1992). With some estimated 200 000 employees, excluding the many small scale miners, the mining industry is a major employer in the SADC region.

Environmental and Waste Management

To minimise environmental impacts in the form of wastes, companies should adopt a systematic approach to Environmental Management. This can help in the establishment of:

- A corporate environmental policy with clear goals, responsibilities, activities and target;

- Establishment of a structure to implement the ideals of the policy, e.g. Waste Management Program, to allocate adequate resources, to monitor effluents and emissions and to interpret and report results.

Legislation

In many countries, specific mining and industrial laws incorporate environmental requirements such as waste disposal, control of water contamination, as well as rehabilitation and occupational safety. In Botswana the following sets of legislation are applicable:

- Mines and Minerals Acts;
- Mines, Quarries and Machinery Regulations;
- Factories Act;
- Public Health Act;
- Air Pollution (Prevention) Act; and
- Water Act.

The National Conservation Strategy (Co-ordinating) Agency in Botswana has carried out a number of studies which have resulted in findings and recommendations, which are widely used as guidelines, including:

- ❑ Study on the management of oil containing wastes;
- ❑ Recycling of metal wastes;
- ❑ Study on management of medical wastes; and
- ❑ Guidelines on the disposal of waste by landfill.

Under consideration are the enactment of the Waste Management Act and the EIA Act. A new Department of Sanitation and Waste Management is to be set at the Ministry of Local Government, Lands and Housing (MLGLH).
Environmental concerns normally cover a range of ecological, conservation, pollution and health issues, each of which is covered by separate laws and regulations administered by different governmental agencies.

Current situation in SADC

Until very recently there had been no co-ordinated efforts to assess the environmental impacts of mining and industry or guidelines prepared to enable governments and industry to undertake appropriate environmental practice. Few or no specific standards exist which are pertinent to air and water quality. Air and water quality standards for Botswana are shown on Tables 27.1 and 27.2.

Sample Period	**micro-grams per cubic metre**	**milli-grams per cubic metre**	**ppm**
24 Hour Average	90% of the time <300	90% of the time 0.3	90% of the time <0.12
Monthly Average	160	0.16	0.06
Annual Average	80	0.08	0.03

Table 27.1: Sulphur Dioxide Standards

Parameters (mg/l) (or as specified)	Perennial Streams	Ephemeral Streams
Temperature (degC)	35	35
pH	6.5 - 9.5	5.5 - 9.0
BOD	75	30
COD	20	30
Nitrate	2.0	-
Copper	1.0	1.0
Lead	1.0	0.05
Cynade	0.1	0.1
Cadmium	0.005	0.05
Mercury	0.001	0.02
Iron	1.0	1.0
Manganese	0.1	0.5
Sulphate	400	600
Fluoride	1.5	2.5
TDS	1000	2000

Table 27.2: Waste Water Discharge Guidelines for Perennial & Ephemeral Streams in Botswana.

Mining and Other Selected Production Technologies

The waste impacts of mining are, first, that on any reasonable industrial scale, it *creates large cavities in the earth.* The problem is what to do with these cavities or open pits. Mines are often distant from populated areas and consequently one often finds problems arising and continuing simply because "out of sight is out of mind."

Secondly, mining is carried out to *extract the mineral product which in one form or the other can be toxic*, such as nickel or copper. Thirdly, there is a problem of what to do with *mine waste in the form of waste rock, tailings and discard slag.* The more dramatic effect of mining is perhaps the *pollution of water bodies* connected to the mine sites, either directly or by rivers. The most common cause of water pollution is *Acid Mine Drainage* (AMD).

Biochemistry of Acid Mine Drainage

Acid Mine Drainage (AMD) may be defined as the *inorganic chemical water pollution* resulting from oxidation of sulphide-containing minerals mainly pyrite

and pyrotite. Consequently, acid effluents containing elevated levels of dissolved metals are produced.

AMD potentially affects the following:

- ❑ Sulphide ores underground and surface mine water;
- ❑ Drainage from sulphide bearing waste rock dumps; and
- ❑ Seepage and drainage from sulphide-bearing concentrator tailings.

AMD is a problem that not only takes place while the mine is in operation but also after closure. AMD formation involves chemical and biological phenomena which can simply be represented by the following equation:

$$2FeS_2 + 7O_2 + 2H_2O \qquad 2FeSO_4 + 2H_2SO_4$$

Cement Manufacture

The negative environmental effect of Cement Manufacture is the uncontrolled release of cement dust from the Factory which can be a blight on the environment and a terrible aesthetic insult. The raw material is usually some form of limestone, other materials are sand, clay, coal ash and slag. The material is prepared and ground finer. This is the primary source of polluting dust from cement mills.

Pulp and Paper Manufacture

Pulp and Paper Manufacture use large amounts of water and product waste water containing substantial amounts of chemicals and fiber. Such chemicals could include ethyl alcohol, acetic acid, vanillin, dimethyl sulphoxide and others. The potential major source of pollution from paper making is the discharge of pulp waste into water bodies. The supporting technologies which must be monitored closely involve wood harvesting, movement and storage of chemicals and power generation.

Pharmaceutical Manufacturing

Pharmaceutical Manufacturing, as with chemical manufacturing, must be looked at as a total system. The material coming into the factory are themselves sometimes dangerous to human health, as solvents might be, or have chemical characteristics which make them dangerous. Close attention must be given to ISO 9000 Quality Control and ISO 14000/1 Environmental Management Systems as well as GMP/GLP "Good Manufacturing Practice" and "Good Laboratory Practice".

Biotechnology

Biotechnology resembles a pharmaceutical manufacturing facility with very similar risks. Quality control must be very strong as in the pharmaceutical facility. The escape of bacteria or viruses if directed at human health and medicine are likely to have dramatic biological effects.

Oil and Gas Production

Oil and Gas production are similar. There are, however, special problems with each. However, gas production presents less an environmental risk than oil production since at worst the gas ultimately will evaporate or go off into the atmosphere. But Petroleum accidents tend to be around for a long time because of the viscosity and the volume of the liquid. There is often a risk of a well blowing, that may or may not be accompanied by fire. The Gulf War sparked a number of fires in Kuwait which resulted in a major air pollution occurrence. The waste arising are similar to mining waste such as noise, solid waste etc.

Environmental Mishaps

The following are a selected set of environmental problems directly related to mining and industrial technologies. Few mishaps are due to failure in technology in the narrow sense of the word. The failure is sometimes due to *management* (or mismanagement), *lack of training*, sometimes to *poor or no regulation.*

The Chicago Environmental Crime

"The owner of a Chicago metal plating plant orders a worker to pour 4000 gallons of cyanide and cadmium waste down a floor drum, delivering a toxic jolt that temporarily shut down a branch of the City Sewer System and killed 20000 fish in the Chicago river." (Coates, 1995)

Cyanide Contamination

Galactic Resources Limited had set up a research arrangement using a technique called 'Heapleach'. This process uses cyanide percolated through heaps of ore to extract gold. The company went bankrupt leaving behind pollution estimated at $100 million in clean up. Included in the mess to be cleaned up were millions of gallons of cyanide contaminated water.

Chernobyl Disaster

"On April 26 1986, reactor No 4 of the nuclear power station reduced its power to below 25%, triggering an explosion and meltdown of the reactor core. Many people were killed and a land area of 1000 square kilometers was contaminated, 6000 buildings required decontamination and an emergency supply of safe water." (Pope et al, 1991).

Minamata Bay Poisoning

The *poisoning of Minamata Bay* in Japan was one of the first major human disasters to highlight the *dangers of chemical pollution*. In 1953, inhabitants of Minamata fishing village were first diagnosed as suffering from *nervous diseases* caused by eating fish contaminated with methyl mercury, a disease to be later known as Minamata disease. Thirty years later, Minamata disease had more than 300 *people killed* and almost 1500 experienced symptoms including *blindness, convulsions* and *brain damage.*

The fish were contaminated by industrial discharge from Chisso Corporation Chemical Plant which had been dumping waste methyl mercury directly in the Bay (KATO).

Seveso Chemical Disaster

A Northern Italian village was the scene of one of Europe's worst *air pollution disasters* when a nearby chemicals factory released a cloud of toxic TCDD gas into the atmosphere on July 10th 1976. The most poisonous of the dioxins, TCDD, was being produced as a by product of the manufacture of trichlorophenol (TCP), an active ingredient of some herbicides like 2/4/5-T. Five hundred people were affected and 700 *evacuated*, some 7000 *animals died or were slaughtered* as a result of the leak.

Bhopal Chemical Disaster

"December 2 - 3, 1984, poisonous gas escaped from a tank containing forty five tons of toxic isocynate (MIC) at the BHOPAL pesticide factory in Madhaya Pradesh, India. The disaster was caused by entry of a foreign substance into the MIC storage tank. This caused a runaway chemical reaction adding to an increase in temperature which turned the liquid MIC into gas. A total of 2352 people were *killed* and a further 80 000 *treated."* Pope et al (1991).

Exxon Valdez Oil Leak

"The oil tanker that struck Bligh Reef, twenty five miles from Alaskan oil terminal of Valdez on March 24, 1989. The ship was grounded and spewed 11 million gallons of crude oil which contaminated at least 200 kilometers of shoreline and affecting four national parks. At least 1000 sea otters perished up to 36 000 sea birds were found dead in pools of oil." Pope et al (1991)

Environmental Management

In order to improve industrial and mining environmental performance, and to take care of waste from predevelopment to decommissioning cost-effectively, new environmental concepts and management systems are continually being developed by governments, industry and NGOs.

Environmental management tools are structured or systematic instruments for improving decision making or information management or for effecting changes in the behaviour of others, with the overall aim of improving the environmental performance of industry. Thus environmental management tools can be used by companies to monitor, better manage or improve this environmental performance, and by governments to influence the performance of industry. The following are selected environmental management tools for consideration.

- **Corporate Environmental Benchmarking:** comparing and measuring a company's business processes against the best in class to inspire movement.

- **Cost Benefit Analysis:** tradeoffs and complimentarities amongst environmental goals.

- **Environmental Auditing:** There are numerous specific audits; Waste Audits are of two types. The first identifies and quantifies waste streams and is a precursor to waste minimisation programmes and collating an environmental effects register. The second assesses waste management practices and procedures.

- **Environmental Impact Assessment:** This is an activity designed to identify and predict the impact on the biogeophysical environment and on mans health and well-being of developmental prospects and to interpret and communicate information about the impacts.

- **Life Cycle Assessment:** This includes the entire life cycle of a product, process or activity encompassing extraction and processing of raw materials, manufacturing, transportation and distribution, use/re-use, maintenance, recycling and final disposal.

- **Risk Assessment:** This is a quantitative and qualitative evaluation performed in an effort to define the risk posed to human health and the environment by the presence or potential presence, or use of specific pollutants.

- **Environmental Management System** includes the organisational structure, responsibilities, practices, procedures, processes and resources for determining and implementing the environmental policy. [ISO 14000/1]

- **Corporate Environmental Reporting** can be a simple document written for formal and informal, internal education or detailed document for specific target audiences.

- **BATNEEC, BPEO, PPP, BATNEP, EnTA, Waste Minimisation and Recycling Strategies.**

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