# PROBLEMS OF MINING WASTES MANAGEMENT IN INDIA AND ITS SUGGESTIVE MEASURES – CASE STUDIES

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## ABSTRACT

Mining generates significant quantity of wastes, especially solid wastes in terms of overburden and rejects. Chemical wastes are mainly generated in the mineral processing plant particularly in the metal mines. Surface mines are the prime source of solid waste may be in the tune of million cubic meter because of overburden. However, overburden is not chemically hazardous, but it destroys the ecosystem of the large area where it disposed. Present paper envisages the waste generations and its consequent effects at every stage of mining operations along with the available procedures for judicious management of the same.


**Keywords:** mining waste, solid waste disposal, solid waste management.

## 1.0 INTRODUCTION:

Mining is a major industrial activity that is conducted in locations throughout the world. It involves a full "life cycle" of industrial activities, all conducted in accordance with a range of engineering, legal, regulatory, economic, social, scientific and environmental protocols and practices. Mining activities dates back to 2600 B C with the Egyptian expedition in the Sinai Peninsula. Presently, mining activities are carried out almost in every part of the world, including underwater and seabed (Fig. 1). Today, the mining industry occupies a unique position in the world and contributes roughly 6% of the world production with value of US $ 30 trillion (Douglas and Lawson, 2000).

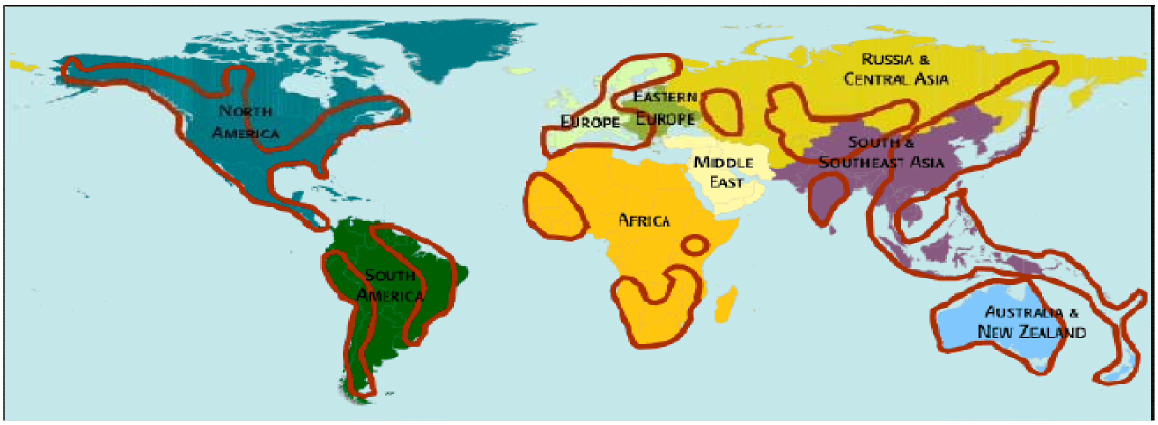


**Fig. 1: Major mining regions in the world (Anon, 2005) marked in Red**

The International Labor Organization estimates about 23 billion 1ones of minerals, including coal, are produced every year. For high value minerals, the quantity of waste produced is many times that of the final product. e.g., each ounce of gold is the result of mining and processing about 12 tonnes of ore; similarly each tone of copper comes from about 30 tonnes of ore. An estimation of metal and waste generated in processing those metallic ore and the volume of waste generation due to mining activity are given in Table 1.

The growth of mineral industry in India has been phenomenal; from just Rs.58 crores value of minerals produced at the time of independence to a staggering Rs. 55000 crores today (Deshpande

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and Shekdar, 2005). India registers an aggregate production of about 600 million tonnes per annum through 65 major minerals and 22 minor minerals. It accounts for 11 % of the total industrial production from mining sector which occupies less than 1% of the total land area in the country.

**Table 1: Generation of waste from processing of metal ores (Anon, 2005)**

| Metal | Typical percentage of metal in ore | Ore mined (Million Tonnes) | Percentage waste | Waste mineral Ratio |
|---|---|---|---|---|
| Iron | 33.00 | 25503 | 60 | 5.2:1 |
| Copper | 0.6 | 11026 | 99 | 450:1 |
| Gold | 0.0004 | 7235 | 99.99 | 950000:1 |
| Lead -zinc | 3.7 – 5.0 | 1077 | 97.5 | 32:1 |
| Aluminum | 8 - 20 | 856 | 70 | 3:1 |
| Silver | 0.03 | N.A. | 99.97 | N.A. |
| Tungsten | 0.5 | N.A. | 99.5 | N.A. |
| Molybdenum | 0.2 | N.A. | 99.8 | N.A. |

## 2.0 GENERATION OF MINING WASTE

Mining typically begins with the exploration for and discovery of minerals, followed by industrial and infrastructural activities, that are focused upon the operational extraction and processing of these commodities. Mining is site-specific and can only be carried out where the minerals occur. The most important impacts of mining operations, together with beneficiation, is generating mining waste which cannot be disregarded. The direct on-site effect of the accumulated mine waste is at the area of disposal. In most of the mines in India, the waste is disposed on the lands within the mining lease area. The fact remains that it cannot meet other technical or economic requirements. In case of underground mines, the waste disposal problem can be minimized to some extent, by resorting to 'backfilling' of mined-out areas by mine waste. The mine waste is a prime environmental issue, which faces significant disposal problems. Therefore, it is necessary, to plan out the disposal of waste in a systematic and scientific manner with due emphasis on environmental protection. Waste generation in mining life cycle can be shown as in Fig. 2.

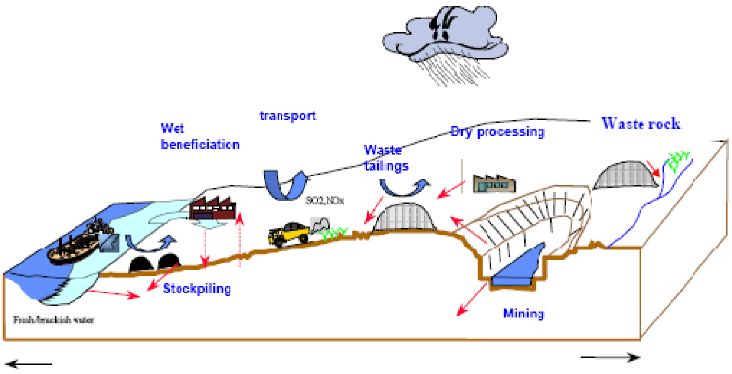


**Fig 2: Waste Generation in Mining Life Cycle**

Mining waste can be defined as a part of the materials that results from the exploration, mining and processing of ore. It may consist of ordinary mining waste, unusable mineralized materials or of natural materials, processed to varying degrees during the ore-processing and enrichment phases, and possibly containing chemical, inorganic and organic additives. Overburden and top soil are also classified as waste if found unusable. The generation of mine waste in different forms can be depicted as follows.

**Waste Rock**

Waste rock includes the overburden and mine development rock. "Overburden" refers to the soil and rock that covers an ore body and "mine development rock" refers to material removed from underground mines to access the ore body. These waste rocks are non-mineralized, or contain insufficient minerals to process economically. They are typically hauled from the mine site to waste dumps for disposal. Generally, open pit operations produce far more waste per tones of ore than

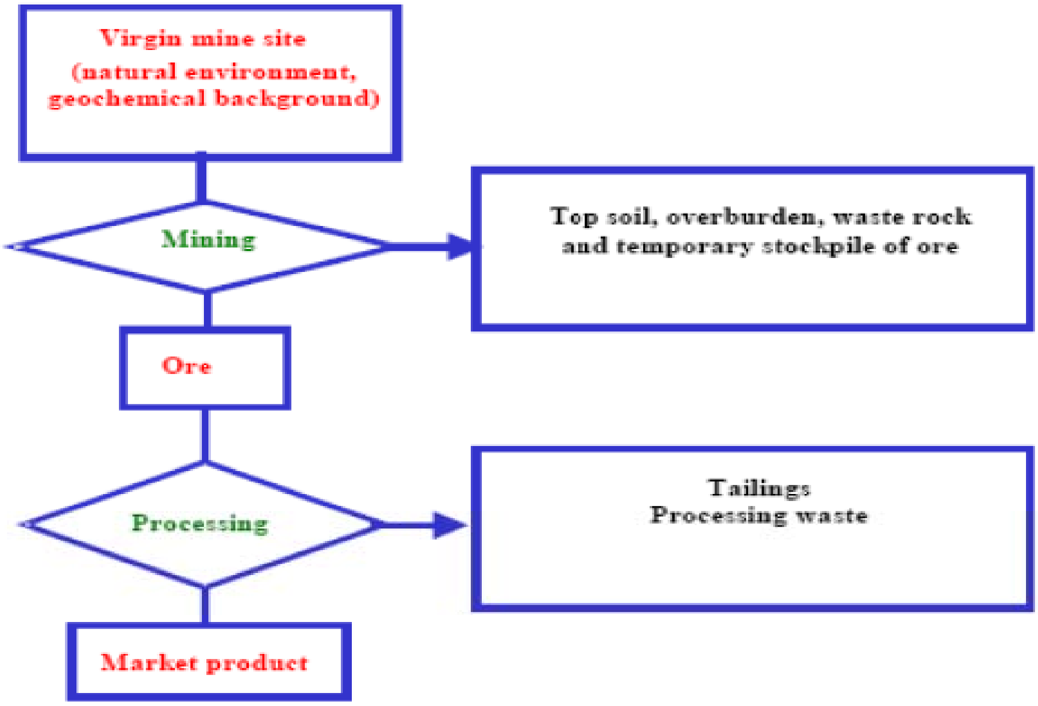


**Fig. 3: Generation of waste during mining operation**

underground operations. In opencast mining, huge quantities of overburden have to be removed in order to win the ore. Surface top soil is removed first and set aside before commencing the removal of the overburden. The top soil may be utilized for re-vegetation/ rehabilitation while overburden may be used for backfilling of the mined out areas. A study of geochemical characteristics of overburden may determine the contamination potential of the material and would help in deciding about the future course of action (Fig. 3).

**Tailings**

Ore extracted from the mine is beneficiated to separate out the valuable mineral from the gangue minerals by crushing, grinding and concentration. The waste portion of the ore/gangue left out after the recovery the mineral in slurry form is known as 'Tailings'. Particle size is an important characteristic of tailings, which differentiates between 'sand' and 'slime' and has attributed the method of disposal (Eriksson and Adamek, 2000). Tailings are the waste products generated during the recovery of the minerals. In such cases, the tailings can contain heavy metals and other toxic substances, including chemicals added during the mineral extraction process. Typically, the ore is crushed to a particle size of less than 0.1 mm in order to release the valuable constituents. Water and small amounts of chemical reagents are usually added during this process to enhance the separation of the minerals from the ore. The tailings are usually dumped into tailings dams or adorable dumps which is designed such that the tailings gradually wash into a nearby waterway).

**Sub-Grade Ore/Rejects**

It is the low – grade ore having no economic value or it may be a mix of ore and barren rock. The sub- grade ore is generally of low economic value and is stacked separately at the mine site.

**Leached Ore**

Various processes for extraction of metal from low-grade ores (heap leaching, pad leaching, etc.) are being practiced as modern technologies for beneficiation. After extraction of metal, the spent ore is either left on the leach pads or removed and dumped elsewhere. For the extraction purpose, highly acidic, corrosive and poisonous materials like sodium cyanide, arsenic, etc are commonly used and they remain in the residual solution after leaching. The pulp may also contain cyanides and sulphates apart from the spent ore (Khanna, 2000). The remaining pile can be of significant size and must be made environmentally safe at mine closure.

**Mine Water**

Mine water is the water that collects in both surface and underground mines. It comes from the inflow of rain or surface water and from groundwater seepage. During the active life of the mine, water is pumped out to keep the mine dry and to allow access to the ore body. Pumped water may be used in the extraction process, pumped to tailings impoundments, used for activities like dust control, or discharged as a waste. The water can be of the same quality as drinking water, or it can be very acidic and laden with high concentrations of toxic heavy metals.

**Radioactive Waste**

In general, radioactive waste classes are based on the waste's origin, not on the physical and chemical properties of the waste that could determine its safe management. Other categories of radioactive waste not listed here include mixed waste and NARM wastes (Naturally-Occurring and Accelerator-Produced Radioactive Materials). One common factor for all categories of nuclear waste is the presence of at least some amount of long-lived radionuclide (Raj et al., 2006).

## 2.1 ENVIRONMENTAL EFFECTS OF MINE WASTE

Mining operations, both open-pit and underground, typically produce large volumes of tailings deposits and waste rock piles. One of the most widespread management problems in the mining industry relates to the large volume and/or chemical composition of waste material. Mine tailings and wastes are generally disposed of on land or mined out areas, although limited ocean, lake and river line disposal do occur. These wastes can affect environment through the following intrinsic criteria:

- its chemical and mineralogical composition,
- its physical properties,
- its volume and the surface occupied,
- The waste disposal method.
- climatic conditions liable to modify the disposal conditions,
- geographic and geological location,
- Existing targets liable to be affected (man and his environment).

Thus, identification of the environmental risks associated with the exploitation of mines and quarries and with ore processing not only requires the characterization and quantification of the different types of waste, as well as a knowledge of the processes used, but also an assessment of the vulnerability of the specific environments contingent upon the geological and hydro-geological conditions and peripheral targets. Since this is a generic description, it is important to keep in mind that not all plants or deposits will release pollutants. Meteoric precipitation can transfer pollutant from a tailings dam or a processing plant to the river if the waste management is not efficient. If there is no impermeable layer, below the deposit, the infiltration of meteoric precipitation through deposit can transfer the pollutants to the river *via* groundwater flow (Fig. 4).

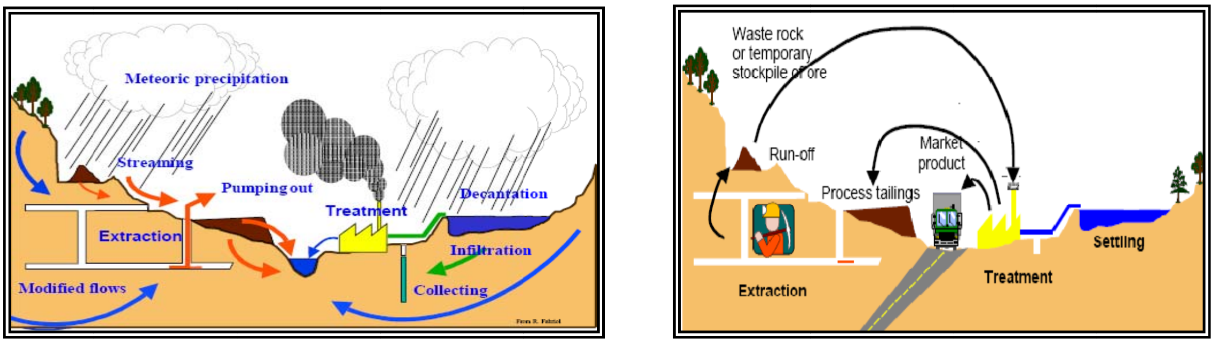


**Fig. 4: Pollutant transfer – A conceptual view (Ritcey, 1989)**

## 2.2 MINING WASTE DISPOSAL TECHNIQUES

Disposal of coarse mining waste consists in conversing large areas with dumps or in filling abandoned open-pits. There are two major problems encountered during waste dump construction. First is the availability of suitable land (which is technically, environmentally and economically viable) then the control over its construction. Technically suitable means the land have the capacity to accommodate the quantity of waste and can withstand the ground bearing pressure. Environmentally suitable means allowable contamination to ground/surface water; restoration of top soil both area of disposal and area of mining etc. Tailing and other finer waste can be disposed in various ways. By order of importance, the disposal of tailings is generally by:

- Terrestrial impoundment (tailings ponds),
- Underground backfilling,
- Deep water disposal (lakes and sea),
- Recycling.

***a. Terrestrial impoundment***

Terrestrial deposition is the predominant method for tailings disposal. It concerns fine waste and slurries such as mill tailings. The principle of tailings dams (or ponds) is to dispose of the tailings in an accessible condition that provides for their future reprocessing (once improved technology or a significant increase price makes it profitable). Actually, the vast majority of tailings facilities are design as permanent disposal facilities. Tailings are often transported to the impoundment *via* pipelines.

***b. Underground backfilling***

This method is possible only for ore deposit without communication with an aquifer. Such an operation is usually costly and will be carried out for stability and safety reasons.

***c. Deep water disposal***

The disposal of tailings and solid waste directly into bodies of water although sometimes used in past operations, is rapidly becoming non-authorized as a standard practice due to the significant pollution effects it can have on the receiving waters and the possible subsequent impacts on the livelihoods of the local communities. This method requires specific conditions and specific impact assessments. There seems to be a consensus among scientists that an appropriately designed underwater disposal of sulphidic tailings is the ideal solution from an environmental point of view in the short term with control of the level of water (Ritcey, 2006).

***d. Recycling***

Coarse mining waste and especially barren rock is sometimes considered as materials for roads, building foundations or cement factories, depending on its geotechnical and geochemical characteristics. Recycling is not classified as disposal. In the German Potash Industry, the solid waste is 22% recycled, 58% dumped and 7% backfilled; the liquid waste is 8% deep well disposal and 5% discharged into rivers (Klade, 2000). Waste rock may have no market at the moment occurs. If a market will emerge later, the rock stored temporarily can be sold as aggregate when environmental specifications are met. With new techniques, the tailings can be reprocessed.

## 3.0 SUGGESTIVE PLANNING FOR MANAGING MINING WASTES

Proper planning is essential to manage the mining wastes. Mining wastes generated in every stage of the operations are required to handle immediately. The objectives should be aimed towards – minimization of waste generation, prevention of wastes to become hazardous, alternative use of the generated wastes and systematic waste disposal (Tandia and Pal, 2008). However, the possible waste generation in different stages of mining and how to handle those has been given in Fig. 5.

## 4.0 CONCLUSION

Mining operations generates significant quantities of wastes, especially in metal mining sectors in which the usable quantity is in the tune of 1-20 percent or even less. If the mining is carried out using surface mining methods, further more wastes are generated from overburden rock. Mining wastes like overburden/development rocks are the unprocessed rock and may be chemically harmless. However, mining wastes from the tailing or slag are subjected to chemical reactions and commonly associated with environmentally non-acceptable chemicals. Due attention is required to minimize waste generation, to prevent wastes to become hazardous, to use generated wastes alternatively and to dispose waste systematically. Disposal of mining wastes demands due attention in planning and execution to achieve environmentally acceptable disposal practice.

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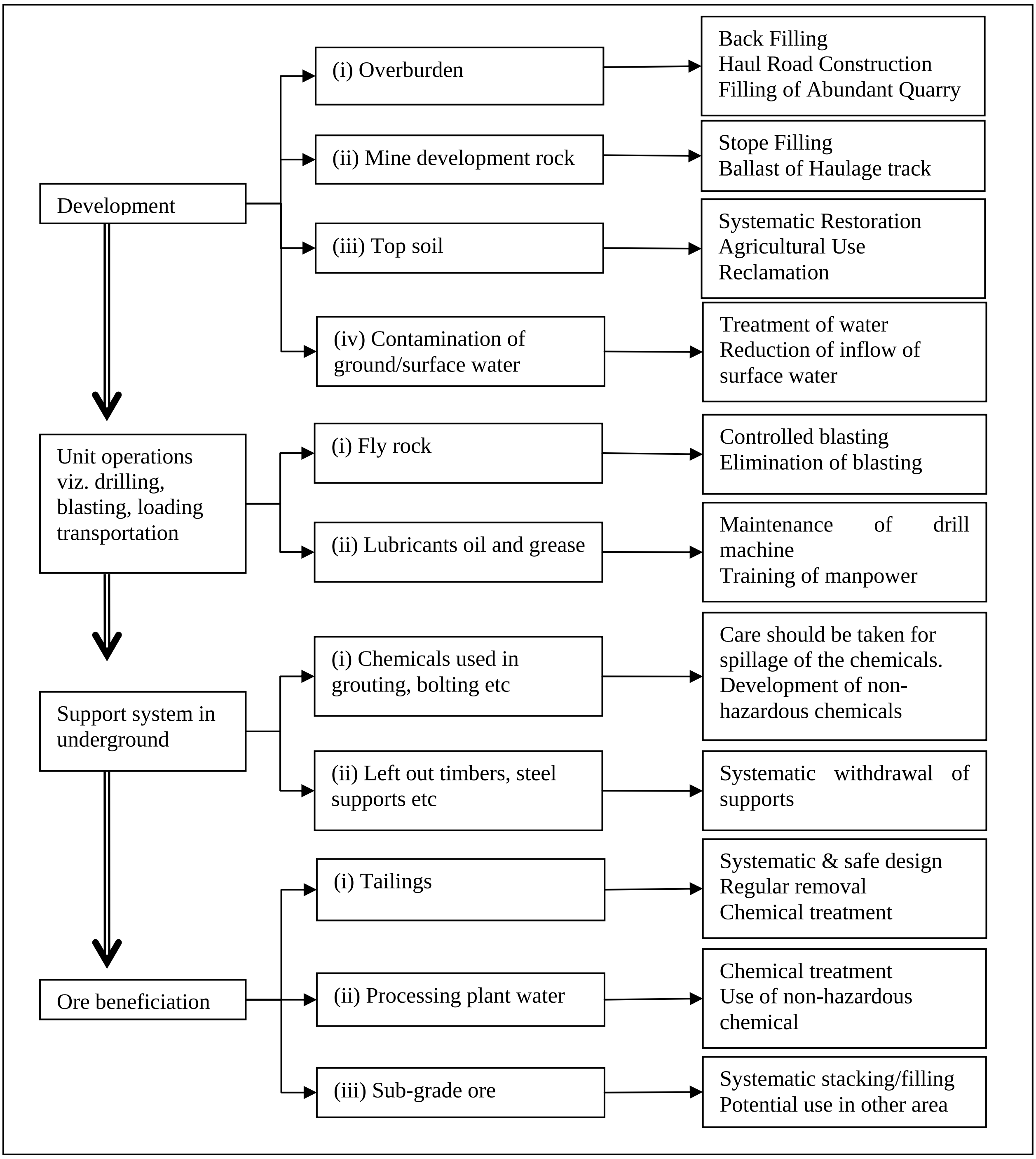


**Fig. 5: Generation of waste in stages of mining and handling possibilities.**