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REVIEW ARTICLE

MINING AND ITS IMPACTS ON ENVIRONMENT WITH SPECIAL REFERENCE TO INDIA

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ABSTRACT

Mining is the extraction of valuable minerals or geological materials from the earth, usually from an ore body, vein or coal seam. Materials recovered by mining include bauxite, coal, copper, gold, silver, diamonds, iron, precious metals, lead, limestone, magnesite, nickel, phosphate, oil, shale, rock salt, tin, uranium and molbedium. Any material that cannot be grown from agricultural processes, or created artificially in a laboratory or factory, is usually mined. Mining in a widersense comprises extraction of any non renewable resource eg, petroleum, natural gas. Mineral resources are vital for the economic growth and development of the country. Minerals worth Rs. 73945 crore were produced in India in 2004-05. Opencast mining operations to result the minerals like limestone, bauxite, iron-, chromite, copper- ores and coal are getting more emphasis because of obvious reasons but are associated with various environmental concerns. One of the major environmental challenges is to handle and manage the huge volumes of overburden generated in the opencast mines. This paper presents the assessment of environmental impacts of overburden such as visual (aesthetics, landscape), soil erosion, ecological disruption, air and water pollution, safety, risk and health etc. Economic valuation aspects of environmental impacts of overburden are also briefly described in his paper.

INTRODUCTION

Minerals are indispensable components of the national economy of any country. India is endowed with significant mineral resources. More than 0.8 million hectares of land is under mining - a substantial portion of which lies in forest areas. There are about 20000 known mineral deposits in India and as many as 89 minerals (4 fuel, 11 metallic, 52 non-metallic and 22 minor minerals) are produced worth Rs. 73944.59 Crore. (Annual Report 2004–05, Ministry of Mines). There are about 3000 working mines in the country (excluding crude petroleum, natural gas, atomic and minor minerals) including 350 opencast mechanized mines of which two thirds belong to limestone and iron ore. There is a progressive increase in average size of mine due to adoption of heavy earth moving machinery with increased production of overburden thus aggravating the existing environmental challenges. Opencast mining operations result in dumping of huge volume of overburden on unmined land in addition to pit-scarred landscape. This overburden originates from the consolidated and unconsolidated materials overlying the minerals and coal seams, and is required to be removed. One of the major environmental challenges is to manage the huge volume of overburden generated in these opencast mines which is associated with the problems of aesthetics, visual impacts and landslides, loss of topsoil, soil erosion, water and air pollution, ecological disruption, social problems, safety, risk and health etc. In addition, open cast mines makes a marked change in the land use and the challenge lies in developing suitable post-mining land use.

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Visual Impacts

Among the potential negative impacts of mining, the visual impact of opencast mining (over burden dumping, etc) deserves special attention. Visual impacts include aesthetic & scenic and landscape aspects. Visual and land use compatibility of rehabilitated mined land is the single most important consideration in designing a combination of landforms and revegetation processes. While there can be occasions where a change to a completely different land use is beneficial, for example from previous agriculture to industrial real estate. Generally speaking, the significance of the change is linked to the topography of the area and to the type of landscape and vegetation. The significance of the visual impact depends on the distance, the weather conditions and the height of the viewpoint. In any case visual impact is not easily discussed in absolute terms. Whether or not an over burden dump is unpleasant to the eye besides the subjective dimension of the question is very much a matter of integration into the surrounding environment (Jain, 2003). Physical screening, screen planting, landscaping and the use of existing features contribute to local surroundings. Clearly, it is difficult to measure visual impacts quantitatively through standards and regulations. It is generally agreed, that the value placed on a certain type of landscape is a subjective issue and in some cases, for example, authorities have refused permits for landscape reasons, when in fact, there is no opposition from local residents.

Erosion and sedimentation

Degradation due to erosion starts right from the source viz., rainsplash on overburden dumps induce erosion which goes on increasing in the form of sheet, reel and gully erosion. Gully erosion affects the aesthetic quality of the site as well as stability of the dumps. Nutrient value of the dumps goes down which might be helpful in revegetation of the dump top and dump slopes. Along with these the material is also lost from the dumps. Because of the large area of land disturbed by mining operations and the large quantities of earthen materials exposed at sites, erosion can be a major concern at hard-rock mining sites. Consequently, erosion control must be considered from the beginning of operations through completion of reclamation. Erosion may cause significant loading of sediments (and any entrained chemical pollutants) to nearby water-bodies, especially during severe storm events and high snowmelt periods. Sediment-laden surface runoff typically originates as sheet flow and collects in rills, natural channels or gullies, or artificial conveyances. The ultimate deposition of the sediment may occur in surface waters or it may be deposited within the flood plains of a stream valley. Historically, erosion and sedimentation processes have caused the build-up of thick layers of mineral fines and sediment within regional flood plains and the alteration of aquatic habitat and the loss of storage capacity within surface waters (Barve, 2011). The main factors influencing erosion includes the volume and velocity of runoff from precipitation events, the rate of precipitation infiltration downward through the soil, the amount of vegetative cover, the slope length or the distance from the point of origin of overland flow to the point where deposition begins, and operational erosion control structures. Major sources of erosion/sediment loading at mining sites can include open pit areas, heap and dump leaches, waste rock and overburden piles, tailings piles and dams, haul roads and access roads, ore stockpiles, vehicle and equipment maintenance areas, exploration areas, and reclamation areas.

Impacts on water quality

Surface Water

One of the problems that can be associated with mining operations is the release of pollutants to surface waters. Many activities and sources associated with a dumpsite can contribute toxic and non-toxic materials to surface waters. The mobility of the pollutants from these sources is magnified by exposure to rainfall and snowfall. The eventual discharge of surface runoff, produced from rainfall and snow melt, is one mechanism by which pollutants are released into surface waters. Impacts to surface waters include the build-up of sediments that may be contaminated with heavy metals or other toxic products, short- and long-term reductions 3 in pH levels (particularly for lakes and reservoirs), destruction or degradation of aquatic habitat, and contamination of drinking water supplies and other human health issues.

Acid drainage

It is generally acknowledged that one of the major environmental problems facing the mining industry is the formation of acid drainage and the associated mobilisation of contaminants. Commonly called acid mine drainage (AMD) or acid rock drainage (ARD) primarily depends on the mineralogy of the rocks and the availability of water and oxygen. AMD occurs at mine sites when metal sulphide minerals are oxidised. Before mining, oxidation of these minerals and the formation of sulphuric acid is a (slow) function of natural weathering processes. Natural discharge from such deposits poses little threat to aquatic ecosystems except in rare instances. Mining and beneficiation operations greatly increase the rate of these same chemical reactions by removing sulphide rock overburden material and exposing the material to air and water. The dominance of the oxidation reactions become obvious when discharged ground water comes into contact with oxygen, precipitating iron oxihydroxides and decreasing pH (Wisotzky and Obermann, 2001). Once acid drainage has occurred, controlling the releases is a difficult and costly problem. Hence prediction is becoming an important tool for regulators and operators. The addition of alkaline substances (crushed limestone to the overburden before dumping can reduce the acid drainage (Wisotzky and Obermann, 2001).

Siltation of Nallah and other Retaining Structure

Carrying Capacity: Pumped out water from the sump goes outside the leasehold boundary and siltation of nallah and other retaining structure is caused due to erosion of overburden dumps by rainfall. This also results in the loss of carrying capacity of the stream thus increasing the potential for flooding. Water Quality Effect on Human Health: Reduction in the quantity and deterioration in the quality of water is also an associated physical effect to nearby dwellers. Impact on health of human and other creatures using the polluted water is another identified physical impact. Nutrient levels, such as, N & P also increases resulting in eutrophication and other water pollution problem.

Ground Water

Mining operations can affect ground water quality in several ways. The most obvious occurs in mining below the water table, either in underground workings or open pits. This provides a direct conduit to aquifers. Ground water quality is also affected when waters (natural or process waters or wastewater) infiltrate through surface materials (including overlying overburden waste or other material) into ground water (Thakur, 2013). Contamination can also occur when there is a hydraulic connection between surface and ground water. Any of these can cause elevated pollutant levels in ground water. Further, disturbance in the ground water flow regime may affect the quantities of water available for other local uses. Finally, the ground water may recharge surface water down-gradient of the mine, through contributions to base flow in a stream channel or springs. Dumping of overburden should be avoided from mines in valleys or depressed tracts on the side of mined area that constitute the basic source of water supply either from surface or groundwater bodies (Nriagu, 1988). In Jamarkatra phosphorite mines, this impact is reflected as the major waste dumps made in the southern valley that contains the shallow groundwater and surface water for providing water supplies.

Impacts on air quality

Air erosion on the dump is very low compared to water erosion but it also degrades the air environment of the mine leasehold area as well as outside the boundary (Nriagu, 1988). During the course of 4 water erosion, material gets loosened and makes it susceptible to air erosion. The primary air pollutant of concern at mining sites is particulate matter. US/EPA has established National Ambient Air Quality Standards for particulate matter with a diameter of less than 10 microns. Operation of heavy earth moving machinery in the overburden dumps generate huge amount of dust and the high wind velocity moves the dust particle to the nearby residential areas which creates a lot of problems.

- The generation of dust particles can be controlled with the help of following methods: Water sprays can be used for control.
- The slope of the haul road in the dump should be optimized for the smooth movement of the dumper and that reduces the dust generation.
- Height of the waste rock dumping should be minimized to reduce the dust generation by wind erosion.
- The dumps should be, wherever feasible, made in such a manner that the impact of predominant wind direction is minimum.
- Wind also entrains dust from overburden dumps and spoil piles (either dry as disposed or the dry portions of impoundments), and other disturbed areas. Sprays from water trucks are often used when the mine is operating.
- During temporary closures, particularly after the active life, stabilization and reclamation should be aimed in part at reducing fugitive dust emissions. Rock and/or topsoil covers, possibly with vegetative covers, can be effective controls.

Noise pollution

The heavy earth moving machinery operations in the overburden handling leads to an increase in the noise levels in the nearby residential areas also. However, at the planning stage the proper selection of the dumpsite can eliminate noise impacts to the residents. During the operation stage the noise level in the overburden dump sites can be minimized by the following methods:

1. Minimize the haul road gradient in the dump as far as possible. Since the noise level of the dumper depends upon the power required by the engine. Lower the gradient of the haul road, lower the power needed and hence the noise level can be minimized to some extent.
2. Reduce the overburden material falling during the dumping operation.

Ecological disruption/ impacts

Opencast mining activities cause severe changes to the landscape. Overburden dumps are man-made habitat causing multifarious environmental problems ranging from erosion and enhancing sediment load in receiving water bodies, dust pollution, damage to visual & aesthetics, fragmentation of habitat and overall disturbance of ecosystem in the entire area. The magnitude of ecological impacts depends upon existing ecological setting of the area where mining activities are taking place. Sediments deposited in layers in flood plains or terrestrial ecosystems can produce many impacts associated with surface waters, ground water, and terrestrial ecosystems. Minerals associated with deposited sediments may depress the pH of surface runoff thereby mobilizing heavy metals that can infiltrate into the surrounding subsoil or can be carried away to nearby surface waters. The associated impacts could include substantial pH depression or metals loading to surface waters and/or persistent contamination of ground water sources. Contaminated sediments may also lower the pH of soils to the extent that vegetation and suitable habitat are lost (Barve, 2011).

Effect on aquatic life

The nallas ultimately terminate into river or reservoir. There the water pollution is caused due to increase in total solids, other minerals and leachates from the dumps. This results in reduction of dissolved oxygen of water. This in turn affects the aquatic life. Discoloration of water is another facet of pollution from aesthetic point of view. The types of impacts associated with erosion and sedimentation are numerous, typically producing both short-term and long-term impacts. In surface waters, elevated concentrations of particulate matter in the water column can produce both chronic and acute toxic effects in fish and other aquatic life.

Loss of soil fertility

The run-off water directly going to nearby fields or passing through them changes the salt content of soil and subsoil layers thereby reducing the fertility of the land. This manifests itself in the form of loss of yield of crop. Apart from this nearby settlements are always affected by the degraded environment in terms of water and air pollution, which also affect the health as well as their production from the fields (Nriagu, 1988). Beyond the potential for pollutant impacts on human and aquatic life, there are potential physical impacts associated with the increased runoff velocities and volumes from new land disturbance activities. Increased velocities and volumes can lead to downstream flooding, scouring of stream channels, and structural damage to bridge footings and culvert entries.

Safety, risk and health

Physical stability of mine is an important long-term environmental concern because of the amounts of materials involved and the consequences of slope failure (Mehta, 2002). Mining operations can result in the formation of slopes composed mainly of overburden (earth, rock, tailings, other mine wastes, or combinations of materials). Landslides in the hilly terrains due to steepening of slopes during opencast mining operations

are quite common. Other than sheer physical impacts, catastrophic slope failure can affect the environment or human health when toxic materials are released from the failure especially if it occurs in an area where such a release results in a direct pathway to receptors (Saxena, 2002). Ensuring physical stability requires adequate pre-mining design of overburden waste management units and may require long-term maintenance. Slope failure results from exceeding the internal mass strength of the overburden materials composing the slope. This occurs when the slope angle is increased to a point where the internal mass strength can no longer withstand the excess load resulting from over steepening or overloading of the slope. When the driving forces associated with over steepening exceed the internal resisting forces, the slope fails and the materials move to a more stable position. In 1996, Mr Dhani Ram, senior OM got buried in the OB dump of Kusmunda Project and then Sub area Manager Mr. O P Singh could only escape by a hair line difference of the sliding punch of the OB dump which was momentary. Sliding of some of the UK dumps which tolled up 100s of the school kids is an infamous episode. These are the lessons to be learnt for future for encountering such types of risks and safety from overburden dumps.

Effect on social life

Settlements near to the overburden dump sites are prone to the risk of mud sliding from the dumps in the case of slope failure. In that situation the entire muck etc. enters in the settlement and affect in many ways (Sengupta, 1993). This was the case happened in Chilkad and Basti, nearby Khadia overburden dumps. In the mean time a channel has been constructed through the Basti to drain run-off water successfully.

Economic valuation of environmental impacts of overburden

The costs of externalities like soil erosion, fertility loss, water and air pollution safety risk & health etc. should be envisaged and commensurate with the production cost so as to highlight the economic valuation of environmental costs associated with handling of overburden. These costs of externalities should be internalized in the cost of production. Overburden dumps should be both physically and biologically stabilized and the cost of such reclamation considered as cost of replacement should be included in the cost of production. Overall this will provide economic value to the rehabilated overburden dumps in the long run. It has been established that over 70% of total annual cost associated with erosion is assigned to the production loss in the mine as a result of overburden run-off blocking the haul road and faces and only about 10% of the total cost in assigned for various control measures to check siltation and in cleaning maintenance etc. (Adibee, *et al.,* 2013). Many of the impacts of overburden inside the pit are generally taken into account of the lost of production. However, most of the impacts of overburden outside the pit are still externality and signaling the failure of market for environmental goods and services and environment degradation takes place on continual basis. Economic valuation of environmental impacts of overburden facilitates to draw a picture of true lost associated with the impacts as well as the externalities, not being taken into account of the cost of production.

Overburden management

The following factors are of crucial importance in selecting a site for disposal of overburden including mines wastes:

i. Proper area for disposal should be identified at the planning stage.
ii. The sites should always be located on a secure and impervious base (solid rock if possible).
iii. Their location and building up should ensure minimum leaching effects due to natural precipitation
iv. The sites should be as far away as possible from natural water courses, shallow aquifers etc.
i. Where this is not feasible uncontaminated fresh water streams etc. should be diverted from such waste storage areas.
ii. Overburden wastes with abnormally high concentrations of iron sulphides or other undesirable reactive elements should be disposed off in sanitary landfills.
v. Such dumps and piles must not be permitted to become a major visual feature of the local landscape. The height of the dump should preferably to exceed the mature tree top level in the area. The type and characteristics of the overburden waste rock is also important in determining the height of the dump. Low height dumping of pyritical material minimizes oxidation and leaching, while low height coal dumps reduce the risk of spontaneous combustion.

Various techniques for overburden waste disposal

i. Utilization of the overburden and mine waste by back-filling to help in reclamation, restoration and rehabilitation of the terrain, without affecting the drainage and water regimes.
ii. Dumping the over-burden and wastes in available low lying areas accompanied by leveling and providing soil cover to utilize the land profitably.
iii. If considered suitable, the wastes may be used as road metal or construction aggregates, after crushing to proper size.
iv. The overburden dump must be properly graded and terraced with contour drainage as necessary.
v. Terracing of overburden dumps must be accompanied by stabilization of the slopes and terraces using proper vegetation.

Contamination of water

The effects of untreated effluent of mining industries pumping into public water ways, releasing harmful gas emission into the atmosphere, uncontrolled toxic dust, or dumping wastage which leeches dangerous chemicals into the groundwater table, has fatal implications to the people living in the surrounding areas. The infamous Bhopal gas tragedy threatens the health of an entire new generation of the city's inhabitants, out of non-disposed toxic waste contaminating groundwater. One article states Abdul Jabbar, a crusader for the rights of survivors of the tragedy, "We believe that around 40,000 people in localities close to the plant have been drinking the contaminated water for the last several years"9. Toxic water includes the contamination of heavy metals such as lead, mercury and uranium and other pollutants such as arsenic and cyanide (Warhate, 2006).

- **Lead:** A build up of lead through consumption develops in the skeleton which is highly dangerous for infants and children up to the age of six years. High levels of lead in the blood lead to central nervous system disorders, decreased vitamin D metabolism, anemia and cancer. For pregnant women the high prevalence of lead in the blood may cross over the placenta increasing the risks of birth defects and difficulties during labor.
- **Mercury:** High levels of mercury can cause brain damage, paralysis, delirium, and incoherent speech. Exposure to mercury through food, water and air can cause significant harm to human health. Methyl mercury, which is the most commonly found form of mercury in the environment, can cause permanent damage to the central nervous system, lungs and kidneys. Methyl mercury intake through fish can put unborn fetuses at great risk. The mercury can cross the placental barrier and cause fetal brain damage without any symptoms in the expectant mother. Newly born infants may experience mental and physical disabilities and delayed development of motor and verbal skills. The symptoms of methyl mercury poisoning are varied and difficult to detect as they can mimic other illnesses. In relatively mild cases, the condition is barely distinguishable from common ailments. Some common symptoms are headache, fatigue, numbness of extremities, depression, memory loss, and in extreme cases, madness, coma or death.
- **Uranium:** The exposure of radioactive wastes to water has fatal health implications such as increased risks of birth defects, brain damage and cancers. In Jharkhand women are delivering physically and mentally challenged children due to the impact of radiation from uranium mines.
- **Arsenic:** occurs naturally or is possibly aggravated by over powering aquifers and by phosphorus from fertilizers. High concentrations of arsenic in water can have an adverse effect on health. A few years back, high concentrations of this element was found in drinking water in six districts in West Bengal. A majority of people in the area was found suffering from arsenic skin lesions. It was felt that arsenic contamination in the groundwater was due to natural causes. The government is trying to provide an alternative drinking water source and a method through which the arsenic content from water can be removed (Thakur *et al.*, 2013).
- **Cyanide:** is used during gold and silver mining to assist in the dissolving of heavy metals during processing. It is highly toxic to humans, as it causes a decrease in Vitamin B12, thyroid damage, decrease in iodine uptake, essential for hormone production and stability an imbalance of hormones disrupts the reproductive system. Exposure during pregnancy increases the risk of birth defects and complications pre and post natal care.

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