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Emerging Issues Regarding Environmental Management in Mining Sector

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***Abstract:** Now days, the impact of mining activities on pollution of air, water, land, soil quality, vegetation including forest ecosystems, and on human health and habitation has become a matter of serious concern. Any deterioration in the physical, chemical, and biological quality of the environment affects human health, flora and fauna. Mining creates the negative impacts on the landscape and the human environment and are permanent. While some segments of the mining & minerals industries, governments and others are much more conscious of these issues, effective sector-wide management of these problems is neither universal nor adequate.*

The realization for protection of environment was generated much early and discussed in the Stockholm Conference on 5th June'1972. Since then the attempts are going on to protect different aspect of environment. While on 5th June 1999, the then honorable Prime Minister of India has stressed on the requirement of 33% of forest cover over the country. However, India is far behind the target. Though huge plantation activities are going on, even then it is observed that these areas are gradually getting forest cover depleted.

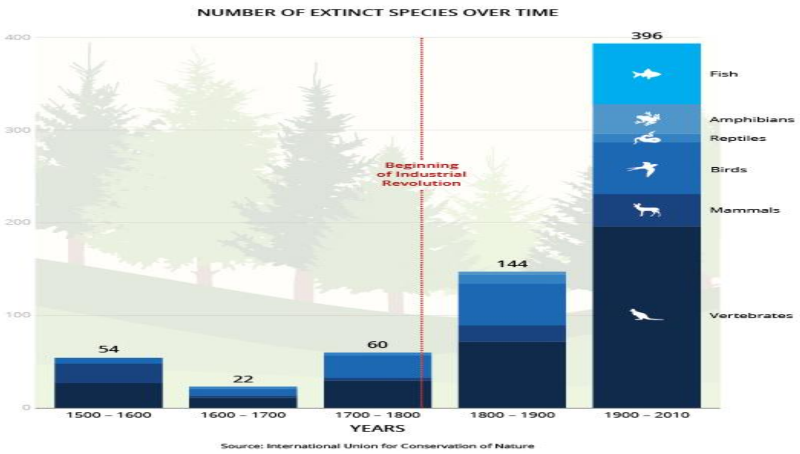
Mining process damages/depletes the forests, flora & fauna which are the important components of the environment. The damaged forests invite land degradation and hence alters land use pattern over the region. It is realized that some natural factors must have some control over the change in the land use pattern being caused by mining. Some of these may be geological and demographic characteristics of the area, climate etc. Further as mining changes land use patterns in an area while planning for developing any new (post-mining) land use through an appropriate land use plan, it is imperative that the need of the growing population should be supported by the newly developed land use plan and should be such that the land (with all its geological and other earth science characteristics) should be capable to support it.

The present paper discusses emerging issues regarding Environmental Management in Mining Sector and various practices that can be adopted to control the adverse effect of mining on environment / land in India and developing new (post-mining) land use through an appropriate land use plan.

***Keywords:** coal mining; stripping ratio; reclamation, underground mining, Surface/Opencast mining, Overburden*

I. Introduction

There is general agreement among scientists that extinction of species rates have reached levels unparalleled since the dinosaurs died out 66 million years ago. The new study, published in the journal Science Advances, shows that even with extremely conservative estimates, species are disappearing up to 114 times faster than the normal rate between mass extinctions, known as the background rate. "If it is allowed to continue, life would take many millions of years to recover, and our species itself would likely disappear early on," said lead author Gerardo Ceballos of the Universidad Autónoma de México.



Cause and Effect

To history's steady drumbeat, a human population growing in numbers, per capita consumption and economic inequity has altered or destroyed natural habitats. The long list of impacts includes:

» Land clearing for farming, logging and settlement
» Introduction of invasive species
» **Carbon emissions that drive climate change and ocean acidification**
» Toxins that alter and poison ecosystems.

Now, the specter of extinction hangs over about 41 percent of all amphibian species and 26 percent of all mammals, according to the International Union for Conservation of Nature, which maintains an authoritative list of threatened and extinct species. "There are examples of species all over the world that are essentially the walking dead," Ehrlich said. As species disappear, so do crucial ecosystem services such as honeybees' crop pollination and wetlands' water purification. At the current rate of species loss, people will lose "many" biodiversity benefits within three generations, the study's authors write. "We are sawing off the limb that we are sitting on," Ehrlich said.

Hope for the Future

Despite the gloomy outlook, there is a meaningful way forward, according to Ehrlich and his colleagues. "Avoiding a true sixth mass extinction will require rapid, greatly intensified efforts to conserve already threatened species, and to alleviate pressures on their populations—notably habitat loss, over-exploitation for economic gain, and climate change." the study's authors write.

In the meantime, the researchers hope their work will inform conservation efforts, the maintenance of ecosystem services, and public policy.

World as well as India has seen development in many aspects and it is expected that the 21st century will put the century more towards the climax. While the development includes industrial development so also the development of the mining industry, the fact is, any interaction with land, damages land; it is more so for the very important developmental activity for mining.

Land forms an important component of the environment and the need for environmental protection does not require any explanation in today's world situation. This land is a finite natural resource to be used by human beings for almost all purposes. To meet this in present days World situation, per capita land availability is even less than 0.3 hectare. This situation is more severe in India as this country holds 16% of global population in only about 2.3% of usable land area of the globe.

The need of environment protection was realized in second half of 20th century as was officially recorded in the Stockholm Conference on 5th June 1972, the First World Environment Day, but even at this moment the situation has not improved much. It is matter of concern because if the activities run uncontrollable manner as in 20th century, the post 21st century period may encounter with an inhabitable earth. In fact mining forms the stepping stone for development of those regions, which hold minable wealth and hence is an unavoidable and important activity. Hence there is a very serious requirement to have a compromise between damage to land environment. (I.e. land and land use patterns) by mining and protection of land. Here the study is limited to coal mining.

II. Coal Mining

The basics of the coal mining are discussed before going in details of the subject matter.

MINING METHODS

Coal is mined by two methods: surface or 'opencast' mining & underground or 'deep' mining.

The choice of mining method is largely determined by the geology of the coal deposit. Underground mining currently accounts for a bigger share of world coal production than opencast; although in several important coal producing countries surface mining is more common.

1. SURFACE MINING

Surface mining - also known as strip or opencast mining - is only economic when the coal seam is near the surface. This method recovers a higher proportion of the coal deposit than underground mining as all coal seams are exploited - 90% or more of the coal can be recovered.

The overburden of soil and rock is first broken up by explosives; it is then removed by draglines or by shovel and truck. Once the coal seam is exposed, it is drilled, fractured and systematically mined in strips. The coal is then loaded on to large trucks or conveyors for transport to either the coal preparation plant or direct to where it will be used. Large opencast mines can cover an area of many square kilometers and use very large pieces of equipment, including: draglines, shovel, large trucks/dumpers, conveyors for loading and transporting overburden and coal.

2. UNDERGROUND MINING

There are two main methods of underground mining: room-and-pillar and longwall mining.

a. ROOM & PILLAR MINING

In room-and-pillar mining, coal deposits are mined by cutting a network of 'rooms' into the coal seam and leaving behind 'pillars' of coal to support the roof of the mine. These pillars can be up to 40% of the total coal in the seam - although this coal can sometimes be recovered at a later stage i.e. closure of the mine.

b. LONGWALL MINING

Longwall mining involves the full extraction of coal from a section of the seam, or 'face' using mechanical shearers. A longwall face requires careful planning to ensure favorable geology exists throughout the section before development work begins. The coal 'face' can vary in length from 100-350m. Self-advancing, hydraulically-powered supports temporarily hold up the roof while coal is extracted. When coal has been extracted from the area, the roof is allowed to collapse. Over 75% of the coal in the deposit can be extracted from panels of coal that can extend 3km through the coal seam.

Technological advancements have made coal mining today more productive than it has ever been. To keep up with technology and to extract coal as efficiently as possible modern mining personnel must be highly skilled and well-trained in the use of complex, state-of-the-art instruments and equipment.

The most economical method of coal extraction from coal seams depends on the depth and quality of the seams, and the geology and environmental factors. Coal mining processes are differentiated by whether they operate on the surface or underground. Many coals extracted from both surface and underground mines require washing in a coal preparation plant. Technical and economic feasibility are evaluated based on the following: regional geological conditions; overburden characteristics; coal seam continuity, thickness, structure, quality, and depth; strength of materials above and below the seam for roof and floor conditions; topography (especially altitude and slope); climate; land ownership as it affects the availability of land for mining and access; surface drainage patterns; ground water conditions; availability of labor and materials; coal purchaser requirements in terms of tonnage, quality, and destination; and capital investment requirements.

III. Effects of Mining on Environment

Coal mining may results in a number of adverse effects on the environment. Surface mining of coal completely eliminates existing vegetation, destroys the genetic soil profile, displaces or destroys wildlife and habitat, degrades air quality, alters current land uses, and to some extent permanently changes the general topography of the area mined. This often results in a scarred landscape with no scenic value. Of greater concern, the movement, storage, and redistribution of soil during mining can disrupt the community of soil microorganisms and consequently nutrient cycling processes. Rehabilitation or reclamation mitigates some of these concerns and is required. Mine dumps (tailings) produce acid mine drainage which can seep into waterways and aquifers, with consequences on ecological and human health. If underground mine tunnels collapse, they cause subsidence of the ground above. Subsidence can damage buildings, and disrupt the flow of streams and rivers by interfering with the natural drainage. During actual mining operations, methane, a known greenhouse gas, may be released into the air which is dangerous to mankind.

As demand for coal increases to meet the India's energy requirement, the coal companies are digging deeper and deeper and even opting for lower grades of coal. The country is even planning for production from 300 m depths at stripping ratio of 1:15 for D and F grade quality of coal. If these mines were operational, it would mean that even if 1 million tonnes of coal were extracted, it would generate 15 million tonnes of waste material. This is huge quantity and in a country like India where land is at premium, it would be very difficult to find enough land to store this waste.

However, some toxic chemicals are also found in waste, as they are added intentionally during extraction and processing. Impact of mining on land environment gets reflected in land-use pattern of the respective area because the more the land gets exposed to erosion by losing its green cover or by getting disturbed otherwise due to mining (excavation, overburden dumping etc.) and related activities, its water resources gets damaged, soils get contaminated, part or total of flora and fauna gets lost, air and water gets polluted and the more damages go on proceeding in accelerated rates and the cumulative effects push the land towards degradation. The process works through a cycle known as land degradation cycle (discussed in next section).

Coal mining has been a very dangerous activity and the list of historical coal mining disasters is a long one. Underground mining hazards include suffocation, gas poisoning, roof collapse and gas explosions. Underground mining does not severely alter landscape as compared to opencast mining. However, the roof collapses (subsidence) have the potential to produce major effects above ground, which are especially devastating in developed areas. Open cut hazards includes mine wall failures, vehicle collisions etc.

Opencast/Strip/Surface mining severely alters the landscape, which reduces the value of the natural environment in the surrounding land. The land surface is dedicated to mining activities until it can be reshaped and reclaimed. If mining is allowed, resident human populations must be resettled off the mine site; economic activities, such as agriculture or hunting and gathering food and medicinal plants are interrupted. Usually reclamation of disturbed lands to a land use condition is not equal to the original use. Original land uses are eliminated from the mining area. Geomorphic and geophysical features and outstanding scenic resources may be sacrificed by indiscriminate mining. Paleontological, cultural, and other historic values may be endangered due to the disruptive activities of blasting, ripping, and excavating coal. Stripping of overburden eliminates and destroys archeological and historic features, unless they are removed beforehand. The removal of vegetative cover and activities associated with the construction of haul roads, stockpiling of topsoil, displacement of overburden and hauling of soil and coal increase the quantity of dust around mining operations. Dust degrades air quality in the immediate area, has an adverse impact on vegetative life, and constitutes health and safety hazards for mine workers and nearby residents.

Surface mining disrupts virtually all aesthetic elements of the landscape. Alteration of landforms often imposes unfamiliar and discontinuous configurations. New linear patterns appear as material is extracted and waste piles are developed. Different colors and textures are exposed as vegetative cover is removed and overburden dumped to the side. Dust, vibration, and diesel exhaust odors are created (affecting sight, sound, and smell). Residents of local communities often find such impacts disturbing or unpleasant. In case of mountaintop removal, tops are removed from mountains or hills to expose thick coal seams underneath. The soil and rock removed is deposited in nearby valleys, hollows and depressions, resulting in blocked (and contaminated) waterways.

In short, the environmental impact of the coal industry includes issues such as land use, waste management, water and air pollution, caused by the coal mining, processing and the use of its products. In addition to atmospheric pollution, coal burning produces hundreds of millions of tons of solid waste products annually, including fly ash, bottom ash, and flue-gas desulfurization sludge, that contain mercury, uranium, thorium, arsenic, and other heavy metals.

In spite of above, coal is important for today's life. Hence it is required that all those efforts to control the ill effects of coal mining are taken in time so that future generation will not suffer. Following table indicates the Mineral Production (including coal), waste generation and land affected in 2005-06.

Table-1. Mineral Production, waste generation and land affected in 2005-06

Sl No	Minerals	Production (MT)	Overburden / Waste (MT)	Estimated land affected (ha.)	Norms used (land in ha/MT of coal/ore
1	Coal	407	1493	10175	25
2	Limestone	170.38	178.30	1704	10
3	Bauxite	12.34	7.50	123	10
4	Iron Ore	154.40	143.90	1544	10
5	Others	9.44	18.61	-	-

IV. Land Deterioration Cycle

The impact of mining on land environment gets reflected in land use pattern on the respective areas because more the land gets exposed to erosion by losing its green cover or by getting disturbed otherwise due to mining (excavation, overburden dumping etc) and related activities, its water resources get damaged, more the damages go on proceeding in accelerated rates and the cumulative effects push the land towards degradation. The process works through a cycle termed as Land Deterioration Cycle.

Mining activities disturb water table, creates water scarcity & effects in drying of greenery thereby temperature rise. The barren land is generated which experiences direct heat/effects of sun, wind and rain that causes more erosion, more siltation, drying of surface water bodies, thereby decreasing irrigation potential. The drying up of land gradually degrades the land which finally leads to gradual desertification. This cycle aggravates land further and forms into desert.

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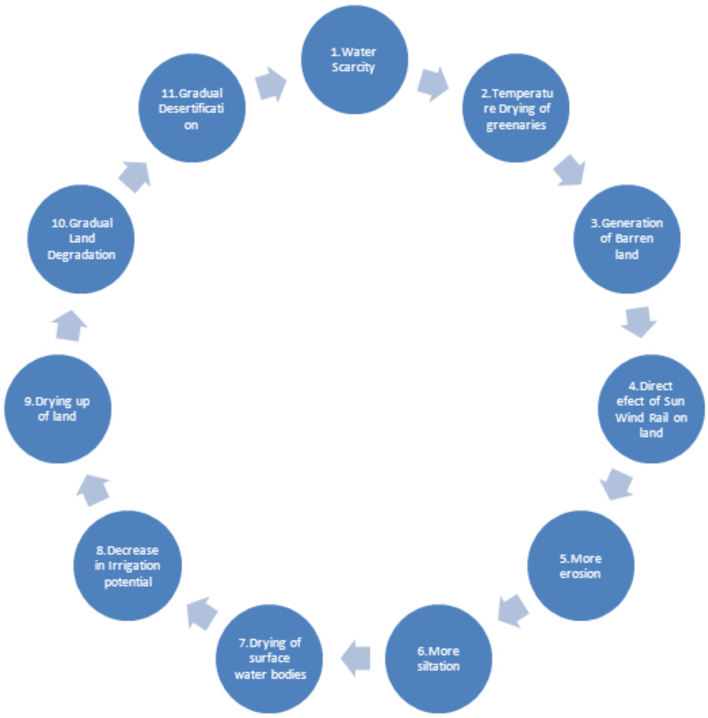
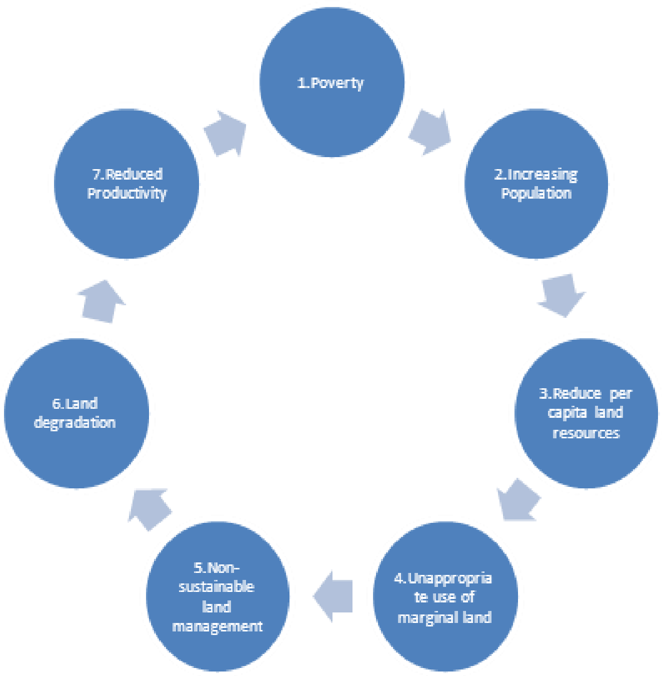


Land Deterioration Cycle

V. LAND DEGRADATION

Greenery bears a pivotal role in protecting the quality of all aspects of environment, also in many cases it is considered as a desired indicator of protector of environmental quality in the region. Regarding desired land use pattern, our National Forest Policy has fixed the national average forest cover at 33%. Though this realization generated long back, the country is still far behind the desired level in this matter. This fact indicates that there is still some drawback in the land-use management system. Strategies need to be developed including policy intervention, promoting research and stakeholder participation, and technological intervention to check land degradation. **Vicious Cycle of land degradation** is depicted in following figure.



Land degradation Cycle

VI. Land Rehabilitation, Reclamation & Restoration

Rehabilitation: The land is returned to a form and productivity in conformity with a prior land-use plan including a stable ecological state that does not contribute substantially to environmental deterioration and is consistent with surrounding aesthetic values.

Reclamation: The site is hospitable to organisms that were originally present or others that approximate the original inhabitants.

Restoration: The condition of the site at the time of disturbance is replicated after the action.

According to these definitions, Rehabilitations usually permits the greatest flexibility in future land use and incurs the least cost. Reclamation infers that the pre- and post disturbance land uses are nearly the same. Restoration allows no land use flexibility and incurs the greatest cost. There are various perspectives regarding the most appropriate goals for land treatment. Generally, the industry favours rehabilitation, regulatory authorities favour reclamation, and many ecologist favour restoration.

The central issue often is future land use requirements and whether returning to the pre disturbance use constitutes the best use of land. Post mining site reclamation and restoration is the final and crucial stage, which requires proper planning. It must be clearly understood that the reclamation should not be confined necessarily towards the decommissioning phase of the project. Rather site reclamation should be progressive such that rate of restoration is more or less similar to the rate of mining. The reclamation process consists of several key features that must be studied carefully for effective land restoration.

Mapping, in order to delineate the areas of direct and indirect environmental degradation with the use of accurate and appropriate techniques, viz. scaled maps, remote sensing and aerial photographs etc. Geological and geotechnical investigations for the strata that is likely to influence restoration, this includes the field and laboratory testing of soils and materials to investigate the parameters that are essential for sustainable restoration. The toxicity of the soil, stability of waste dumps need to be investigated before reclamation is carried out. Meteorological and climatological investigation in order to collect standard data (temperature, amount of rainfall, humidity and wind patterns etc.) is to be carried out and assess their influence on atmospheric and water pollution. Hydrological conditions at a site include the quantity, quality, movement and storage of water above and below the surface. Hydrology is determined by upslope and onsite characteristics of climate, geology, topography, soil and vegetation. Climate provides the water input to the hydrologic system whereas the other parameters determine the movement of water into and across the surface.

Topographic conditions refer to the surface configuration of an area described as rugged, rolling, gentle or smooth. The topography surrounding the disturbed sites also influences reclamation plans and practices. The reconstructed surface must blend with the undisturbed landscape so that matter and energy fluxes smoothly travel through the reclaimed surface. Soil condition including the soil's water holding capacity controlled by the combined factors of texture, aggregation, bulk density and over all depth directly influences plant productivity, leaching potential and ground water replenishment. Vegetative condition particularly the quality, quantity and diversity of vegetation at a site reflect the entire environment setting in addition to the past and present human activities.

VII. Reclamation Planning

The goals for reclamation can be vied wed from theoretical and practical perspectives. Simply put, a reclamation project should aim to produce environmentally sound and stable conditions that ultimately integrate the disturbed area into the general eco-system. Accordingly, a reclamation plan should address the topographic reconstruction, topsoil replacement or substitution, re-vegetation and site monitoring and maintenance.

Topographic Reconstruction: Most natural landscapes are composed of drainage basins which in turn consist of hill slopes and stream channels in an orderly arrangement for effectively conveying water and sediment. These gets disturbed during mining. The character of the post reclamation equilibrium differs from that of the pre-disturbance equilibrium because geologic and soil properties cannot be replicated. Topographic design therefore should be based upon expected properties following reclamation rather than pre-disturbance properties. Care is also to be taken to minimize erosion and runoff where ground cover is temporarily removed. Special flood-control and sediment-control measures are necessary to prevent damage. The importance of topographic reconstruction cannot be neglected because the resulting landforms are the foundation upon which other reclamation practices are executed & eventual land uses take place.

i) Replacement of Topsoil and Soil Reconstruction:

Revegetation of the reclaimed surfaces requires a suitable growth medium. In most cases, top soils have the necessary physical, chemical and biological properties to sustain plant development, although the use of substitute geologic materials is often inevitable. In general top soil layers are higher in organic matter, microbial activity, and nutrients than underlying subsoil or geologic material. Top soils contain significant seed bank that can be used to great advantage in revegetation. Stock piling and reuse of top soil almost always facilitates achievement of reclamation goals. When spoil or other course-textured materials are revegetated without top soil covers, moisture stress induced by compaction, high course-fragment contents, salts, and high surface heat is usually the primary factor limiting growth. Therefore as far as practicable the top soil should be stored at a suitable place with proper precautionary measures so that it could be utilized during reclamation process. Some of the best practices involved in the topsoil management are: Scrap the top soil prior to drilling and blasting, Scrapped topsoil should be used immediately for plantation work, otherwise it should be stacked in a designated area. Stacked topsoil should be surrounded by proper embankments to prevent erosion. Stacked topsoil should be stabilized further by grasses and bush to protect from the wind.

ii) Revegetation:

Revegetation is a principal goal of reclamation and results in many desirable secondary water quality and aesthetic benefits. Revegetation goals are from simple erosion control to the full restoration of complex native communities. The approaches and protocols employed, therefore, are specific for region, site and land use. The development of a permanent vegetation cover should aim to establish a plant community that will maintain itself indefinitely without attention or artificial aid, and support native fauna. To extract better results, some ecological variables must be considered while selecting species for plantation. These are; their capacity to stabilize soil, soil organic matter and available soil nutrients, and under storey development. In the initial stages of revegetation quick growing grasses with short life cycle, legumes and forage crops are recommended. It will improve the nutrient and organic matter content in soil. Plantation of mixed species of economic importance should be done after 2-3 years of growing grasses.

Care and maintenance and Closure Planning

On the cessation of mining, a process of decommissioning with a follow up program of reclamation/rehabilitation should start. This should include adoption of preventive measures against slope failure, managing toxicity of tailings or waste rock which may limit re-vegetation and preventing acid drainage from abundant pits, tailing etc. A participatory management for care and maintenance of the reclaimed area may ensure a process of benefit sharing specially from the forest, that are grown, as a major work component of reclamation plan.

VIII. Environmental Management Services

CIL has a subsidiary CMPDIL which offers Environmental Management services to the mines in CIL and also to other industries e.g. Manganese Ore (India) Ltd., Hindustan Copper Ltd., Hutti Gold Mines Co. Ltd., etc.

CMPDI a subsidiary of Coal India Limited is routinely dealing with multi-dimensional environmental complexities of the coal and mineral sector to promote environmentally benign mining design and mitigation practices in India & abroad. The services include EIA/EMPs (Environmental Impact Assessment / Environmental Management Plan) for mining and coal beneficiation projects, planning & design of Pollution Control Facilities (Industrial & Domestic Effluent treatment Plants), Mine Closure Plan, Slope Stability analysis for dumps & high walls and regular environmental monitoring (air, water and noise level). CMPDI also takes up environmental baseline data required for EIA/EMP studies. The environmental laboratory at CMPDI (HQ) is recognized by Central Pollution Control Board and is accredited with ISO-9001 certification. CMPDI is also accreditated by National Board of Education & Training (NABET), an organ of Quality Council of India (QCI), New Delhi as an EIA Consulting Organization for two sectors namely mining of minerals including opencast / underground mining and Coal washeries as per the requirement of Ministry of Environment & Forests, Government of India.

Following services are offered by CMPDIL:

(1). Environmental Impact Assessment (EIA)/ Environmental Management Plan (EMP)

EIA/EMP studies for Coal Projects & Coal Beneficiation Plant to obtain Environment Clearance from Ministry of Environment & Forests.

The studies undertaken & covered in the EIA/EMP are:

i). Baseline data generation

This covers Base data generation covering recording of meteorological data, measurement of ambient air & water quality, noise level, soil quality, study of land use, flora & fauna and social status of population in core & buffer zone.

ii). Impact Assessment and Management Plan

This includes assessment of impact due to mining on land, air, water and noise levels, hydro-geologic regime, flora & fauna and on the society. Planning of suitable measures to reduce the environmental impact and improve the local environment through air, water & noise abatement measures, land reclamation, green belt development, rehabilitation and resettlement (R&R), subsidence management, waste management, and ecological restoration are also covered.

(2). Environmental Monitoring

The Environmental Monitoring of mining projects and coal beneficiation plants are undertaken in sampling & analysis for compliance of statutory directives of Ministry of Environment & Forests, Government of India and State Pollution Control Boards.

(3). Environmental Statement and Mine Closure Plan

Annual environmental statement of different coal mining projects and Mine Closure Plan (MCP) for safe and sustainable closure of the mines in terms of guidelines issued by Ministry of Coal, Government of India is undertaken on regular basis.

(4). Slope Stability and Soil Conservation Studies.

Slope Stability Analysis of OB dumps (both external & internal) is another area of service rendered. Soil Conservation & Management Plans are prepared for compliance of forestry clearance requirement.

(5). Engineering Services

The ground water studies for mines are also undertaken by CMPDIL.

(6). Land Use Planning

Environment Department, in association with Remote Sensing Cell of Geomatics Department, undertakes land use studies through satellite imagery techniques for the project as well as for urban and regional planning.

(7). Rain Water Harvesting

Roof top rain water harvesting schemes are also planned for conservation / augmentation of precious ground water resource.

IX. CONCLUSION

In principle the areas or resources affected by mining should be returned to a safe and productive condition through rehabilitation, which may or may not involve a return to pre-mining conditions and reclamation, should be an ongoing activity throughout the life of the operation as well as after decommissioning. The mining industry, the government and the local people must work together to care for future generations. There is also a need for better planning of reclamation /restoration system to bring back the derelict land in short time for use. It takes time, money and certain degree of geological good fortune to transform disturbed mined land in to a park, forest, lakeside, farmland or further industrial development etc. Sometimes land value and materials may not support the mining project for land reclamation since the cost of reclamation may be very high. However, the utmost priority has to be give to restore the land.

Mining, more than any other industrial activity tends to leave a strong negative impact on environment and society. However, a complete ban on mineral extraction is not possible as modern society and civilization are heavily dependent on minerals and mineral production. The efforts instead should be to limit the negative consequences of mining through the application of the concept and principles of sustainable development to mining operations.

Hence constant research and development efforts are required to find out newer and latest technologies and methodology to reclaim greenery in protecting environment land for better use since economic development must have respect for environmental integrity.

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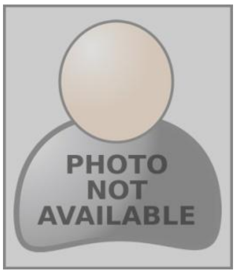
LIST OF ABBREVIATIONS

CIL- Coal India Limited, CMPDI- Coal Mining Planning & Design Institute, EIA-Environmental Impact Assessment / EMP-Environmental Management Plan, MOIL-Manganese Ore (India) Ltd. HCL- Hindustan Copper Ltd, MCP-Mine Closure Plan, OB-Overburden.

AUTHOR(S) PROFILE



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