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IMPLEMENTATION OF ENVIRONMENTAL MANAGEMENT OPTIONS IN CHROMITES MINING REGION OF ORISSA, INDIA

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ABSTRACT: The chromite deposits in Sukinda valley of Orissa, India contain 90 % of total deposits available in India. Chromite ore is mainly used in metallurgical industry. Discharge of chromium containing effluents by chromite mines and associated activities could affect the underground as well as surface water systems in Sukinda valley of Orissa. Water of Sukinda region containing chromite mines are found to be contaminated with chromium-VI discharged through rivers. A study in chromite mining areas of Sukinda district was carried out to look at environment and development options as planner, scientist and environmentalist, and to document these impacts through the process of EIA on regional level. The mines are preparing EIA and EMP reports for environmental clearance and mining plan for approval by Indian Bureau of Mines under relevant Acts and Rules. Under these regulations individual mines implement the environmental management and mineral conservation plans. These mines are located in a cluster and implementation of individual action plans may not become very effective due to mining projects located contiguous to each other and any action at one mine influences the other one. It is concluded that land use planning as a regional scheme and be made for a 10 to 20 plan year period and all the projects should be brought into one management plan. The unscientific OB disposal, discharge of effluents, servicing of automobile components, transport of ore and beneficiation by the projects create huge environmental stress in the region and good practices of environmentally responsible individual projects get nullified without benefiting the environment and the people of the region as there is no plan to address the cumulative impacts. Regional environmental plan may help in balancing such aberrations by combining all projects and impacts at regional scale for implementation.

KEY WORDS: Chromite mining, Cumulative impacts, Sukinda, EIA, REIA, Orissa, Overburden management

INTRODUCTION

The natural world and its environmental setting greatly influence our life sustaining systems. Although the progress in technology and development has brought out improvements in our lives, but these also have created various problems of pollution, rapid urbanization and present day environmental crises. Rapid industrialization and mining activities without sound environmental management options result in deterioration of the quality of the environment. The Environmental Impact Assessment (EIA) is an effective tool in addressing the adverse impact. Environmental Management Plan (EMP) deals with managing the adverse impacts on environment and the health of human beings, plants and animals. Chromium is used in many industrial applications like steels, electroplating, dyes and pigments, photography, wood processing, textiles and tanneries. Chromium poisoning has long been known and the population using the chromium contaminate water and the people working in chrome related establishments have problems of ulcer, dermatitis, lung cancer, liver necrosis, Cr^{+6} in dust affect the people from lung cancer[1]. Increase of hexavalent chromium causes decrease in fecundity and growth in arthropods[2].

In India, there are 37 mining leases spread over approximately 9700 ha area. Total recoverable reserve of chromium is about 97076 thousand tones[3]. Chromite ore production in 2003-04 was 3469 thousand tones worth Rs.504 crore. Total export in the same year from the country was 1098 thousand tones with monetary value of Rs 250 crores[4] for a total quantity of 1098 thousand tones. State of Orissa occupies a prominent place in the country and export of chromite mineral. The state benefits from these mines as high grade minerals are subjected to high rate of royalty. Chromite grade of above 52% Cr_2O_3 attracts highest rate compared to grades of 40-52% and less than 40% Cr_2O_3. Chromite fines are available in all grades except lumps of above 52% grade. Concentrates having highest grade are costliest in the market and also attract maximum royalty[5]. Discharge of chromium containing effluents by chromite

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mines could affect the underground as well as surface water systems in Sukinda Valley of Orissa. Water sources of Sukinda region chromite mines are found to be contaminated with chromium-VI discharged through rivers. Trivalent and hexavalent forms of chromium are common in terrestial environment[6]. The wastes arising from these mining industries contribute to air and water pollution, raising concerns especially due to various health impact implications. Cr^{+6} containing effluents are highly toxic than the effluents bearing Cr^{+3} which is immobile and non toxic to organisms[7,8]. Cr^{+6} is highly soluble in water, mobile and bio available and can be formed in the presence of Oxygen due to oxidation of Cr^{+3} [9,10]. A study in chromite mining areas of Sukinda district was carried out to look at environment and development options as planner, Scientists and Environmentalists and to explore if these impacts could be addressed through the process of EIA at regional level. The study aimed at bringing pertinent issues of these developments so that these can be identified, quantified and attempts can be made to maximize the positive impacts and minimize negative impacts.

LOCATION OF THE STUDY AREA

The chromite mines are located in Sukinda Valley of Jajpur district in Orissa. The area is connected with the nearest railway station, i.e. of Jajpur-Keonjhar road in Howrah-Madras main rail -line and by an all weather road of 55 km on NH 5. The companies like TISCO, FACOR, Jindal, Misrilal, IMFA, OMC etc. are operating in the area and more companies are in the offing due to high demand of chromite in the country and in international market. Chromite ore bodies are intrusive into lower sequence of the basal group of iron ore super group. Chromite ore of various chromite mines is mainly used in metallurgical industry.

TABLE 1 : RESERVES OF CHROMITE IN INDIA AND ORISSA (MILLION TONES)

State	Proved	Probable	Possible	Total
India	27,404	31,210	29,737	88,351
Orissa	27,069	30,662	28,660	86,391

(Source: Indian Bureau of Mines, Government of India, 2005)

SUKINDA VALLEY: ENVIRONMENTAL PERSPECTIVE

The chromite deposits in Sukinda valley of Orissa contain 90% of total deposits available in India (Table 1). Chemical composition of chromite ore of Sukinda Valley is given in Table 2. All the operating mines in the study area are mostly covered under the provisions of Water (Prevention and control of pollution) Act 1974, Air (Prevention and control of Pollution) Act, 1981 and Environment (Protection) Act, 1986. The mining projects located in the Forest areas attract the provisions of Forest (Conservation) Act 1980. The mines are to obtain environmental clearance and approval of mining plan by Indian Bureau of Mines under MMRD Act and Rules. Individual action plans often are not able to generate positive impacts in mining cluster areas as cumulative impacts of all these mining projects located contiguous to each other largely remain unaddressed.

TABLE 2 : CHEMICAL COMPOSITION OF CHROMITE ORE

Constituents	High grade (> +48%)	Medium grade (+42-48%)	Low grade (+30-42%)	Sub grade (<30%)
Chromite Oxide (Cr_2O_3)	54.50	46.12	36.12	14.41
Ferric Oxide (Fe_2O_3)	4.33	12.50	19.04	28.39
Ferrous Oxide (FeO)	9.85	8.60	6.80	1.63
Silica (SiO_2)	6.40	7.64	13.23	29.85
Alumina (Al_2O_3)	9.42	9.44	13.28	1.67
Lime (CaO)	0.49	0.49	0.50	0.62
Magnesia (MgO)	12.74	11.40	7.80	5.49
Phosphorous (P)	0.006	-	0.007	0.014
Nickel (Ni)	0.06	0.053	0.06	0.06
Cobalt (Co)	0.02	-	0.05	0.05

(Source: EIA, EMP reports of mining projects of Sukinda Valley (averaged values for various parameter attributes)

To maintain ecological balance and to check the harmful effects due to chromite mining, environmental control measures are required to be integrated into the provisions of mine planning. Environmental management planning is multidisciplinary in dimension and management parameters are to be regularly reviewed in the light of experience likely to be gained during the progress of mining. Certain schemes may require periodic modification. Assessment of all technical, biological and socio-economic control measures envisaged during study can broadly be grouped into followings:

Solid Waste Management

The mining activity being site specific creates void by open cast methods. Enlarging the size of voids for removing the minerals and the wastes goes several years. Impact by digging of mother earth, creation of large effluent storage pits and beneficiation of ores in the mining area

remain for several decades. Further, post land use plan remains unattended due to fluctuation in mineral and uncertainty of man life. The excavated "Top soil and subsurface soil" are generally stored separately. Protection of top soil nutrients by grass planting may be useful as often these are not used for years together. Spreading of top soil on Overburden wastes (OB) helps plants to derive nutrients from highly rich top soil in early phases of establishment. In order to protect the nutrient value of the top soil, height of the top soil dump should not be made more than one meter. Nickeliferous and non-nickeliferous overburden is dumped separately in projects. Small scattered Nickel dumps are in fact a cause of concern in terms of conserving the nickel metal in these solid wastes. Present nickel conservation issues are not being seriously taken up. However, regulatory mining agencies stipulate separate stacking and for taking all precautionary measures to conserve this precious mineral. Looking at all the environmental issues linked to these dumps, we recommend the followings:

1. All the project authorities must come forward to locate a centralized dumping place for nickel bearing wastes with all inbuilt measures to conserve nickel and reduce runoff.
2. The projects should keep aside some financial resource to initiate studies for development of viable technology for nickel extraction by making a consortium of R and D institutions, ministry of mines and the projects of the region.
3. Till technology for extraction of nickel is available at site, the dumps should be protected by developing green vegetation to cover all surfaces of the dumps. It would be advisable to take up vegetation of shallow rooted plants, grasses and shrubs.

Maintaining proper slope will help reducing the migration of soil and mineral particles through runoff. At present there are huge quantities of scattered dumps of non-nickeliferous OB of which many dumps are active for many years. Small scattered OB dumps may be effectively managed by forming a united large sized regular shaped OB dump with maximum height of 60m and slope not to exceed 28 degree as generally stipulated by regulatory authorities. It is reported that Cr^{+6} bearing spoil dump near Tokyo polluted the underground drinking water sources where the concentration of Cr^{+6} was 2000 times of the permissible standards[11].

As mining progresses, phase-wise scheme of disposal and reclamation of OB is also needed. Back filling is not done in projects on the ground that there are chromite deposits at lower depths. High market value of chromite attracts the projects to do opencast mining at greater depths as opencast is economically cheap and underground operations may be cost intensive. Generally 18% of the OB is nickeliferous overburden which contains 0.6% nickel (average). Feasibility study for beneficiation of this nickel waste is needed.

Generally pioneer species come first at degraded site during secondary succession. The wrong notion of late recovery by following the principle of ecological succession need to be removed. The failure of plantation of tree species in damaged OB areas is because of this ignorance and because the projects want to show culture of fast recovery. The failure of plantation cost too much in financial terms (usually not calculated) which could be a huge monetary loss. The projects taken up in Northern coal-fields limited by proper selection of ecological species is an example which all mining projects in India could replicate. The slow recovery of nutrients and organic matter prompts better natural build up of nutrients and species. The pioneer and late successional species of the region if selected in the regional reclamation plan will have positive impact and resistance to climatic fluctuations. Pressure of cattle grazing can be reduced by making barriers around the dumps. In addition to selecting plantation as a tool in reclamation, holistic strategy for restoration should be emphasized. This includes considering policy measures, direct seed dispersal, rain water harvesting, vegetative cuttings etc. to achieve ecological, economic and social sustainability in such regions. Vegetation growth can be accelerated by making garland drains around the dumps, normal dump height help quicker establishment of vegetation. These measures help in moisture retention in soil.

Land -Use Planning

Land use planning in the region is required to be made for a 10 to 20 plan year period and all projects should be brought into the plan. Mining activities are being carried out mostly in areas of good forest growth. As compared to the present vegetation status, a much better land use could come when the artificial forestry practices will be considered in the reclamation of overburden dumps and other such selected spots and local forest can be improved by converting damaged land area under forest cover. Ore bearing forest areas which will come under mining in future should also be protected to keep natural germ-plasm alive. Afforested dumps should match well with the existing hilly forests in the vicinity. Terraced formation of dumps will form better landscaping. Mining will only be interim land use and substantial greenery shall be mandatory to see that vegetation is sufficiently developed. It is a common practice to revegetate spoiled mine lands to prevent soil erosion and deposition of contaminated soils in streams and nearby lands[12]. A Phytoremediation technique makes use of green plants and their associated micro biota to treat or remove contamination or render these harmless environmental contaminants. There are limited numbers of plants capable of up taking contaminants by plant roots and translocation within the plant parts. A well defined plantation or greenbelt

should aim at achieving ,protection and stability of dumps, prevention of degradation of land and soil, prevention of dust (the leaves acting as a sink) and screening noise, maintaining ecological balance by compensatory afforestation and increasing aesthetic value of the region.

A few suitable locations can be selected for strip plantation. The areas surrounding mines, either side of roads could be suitable for strip plantation with sufficient width and density. As per regulatory norms of the country, a 7.5 m wide area within the periphery of lease boundary inside the lease is to be left out and properly vegetated. These scientific stipulations, if properly complied will benefit the region by adding as a noise border, trapping the dust and reducing the visible grey aesthetic sense among the surrounding population. In order to avoid direct visibility of the open pits and other mining establishment (beneficiation facilities, ETPs, offices and workshops) from a distance and also for screening of dust and noise, peripheral plantation may be carried out. Plantation may be done on vacant lands, inside the colony and also by the side of the roads connecting the queries, dumps, workshops, magazine etc. where it is not possible to take up strip or peripheral plantation. Natural growth of chosen species, rate of survival, and suitability of species for a particular type of area are some of the screening criteria for selection of species. Following points may be considered, while recommending the species for plantation:

a) Biodiversity value of the species and its ecological attributes in terms of acceptability by local population and surrounding bird and other species.
b) Only those herbs, shrubs and tree species may be selected initially which are not grazed. Generally the pioneer species are resistant to grazing, climatic fluctuation and low nutrient and water availability. Apart from these species, the tree species like *Polyalthia, Albizzia lebbeck, Azadiracta indica, Tamarindus, Cassia, Acacia, Pongamia pinnata. Bambusa sps. Ipomea, Delbergia sisso*, etc. may be the promising species for initial stabilization of soil. However, opinion of local ecologists, wildlife and forestry experts may be useful before taking plantation.

Post plantation care is as important as species selection

As the mining activities alter the ecological character of the habitat, all the required input for plant growth may be limiting. Immediately after planting, water harvesting structure for storing the water should be built up in plantation areas during the rainy season which to provide sufficient water to seedlings for subsequent 4-5 months. The afforested area has to be protected from cattle grazing, soil erosion, plant diseases etc. Earth bunds, masonry chutes, protected drains etc. are to be formed to regulate the water wherever required. In order to protect the nutrient values of the top soil height of the top soil dump should not be made more than one meter. Availability of seedlings of the required species is the basic pre-requisite for success of afforestation programme. Depending on the area of plantation, a nursery farm of required capacity should be established at the site of plantation in order to raise saplings of different types of species.

Air Pollution Control

The existing level of air pollution in the region is generally low due to good natural vegetation and forest growth acting as a sink to various kinds of air pollution. Due to increased mining activities the level of air pollutants are to rise definitely. Fugitive dust is generated in drilling, blasting, shoveling (loading) and unloading and in haul roads due to movement of dumpers and trucks. During loading and unloading, dust is prevented to become airborne by water sprinkling. Dust generated due to wind can be reduced by planting grasses and creeper species on the dumps soon after dump formation and tree species are added later. Exhaust fumes generated by the engines of excavators, dumpers, dozers and other machineries can be minimized by ensuring vigorous maintenance and stringent overhaul schedule. "Pollution under control" certificate may be made mandatory for all vehicles being operated for project work.

Water Pollution Control

Most of the mines are drawing ground water for meeting their industrial and drinking water requirement. The region is known to be suffering from ground water depletion. Continuing stressing the ground water for meeting the industrial requirement will pose serious threat to drinking water availability. A large umber of steel and power plants and chromite mining and beneficiation facilities are already in the offing. Central Ground Water Authority constituted under Environment (P) Act 1980 should take up a study immediately to find out the sustained availability and impose restriction/limit for withdrawal of ground water for industrial purposes. Perennial source of Brahmani River of the region may be tapped by projects with mandatory maximum recycling/reuse of treated water. Ground water cess may be imposed and so fixed that industries do not get attracted to underground source. The water recharge and harvesting schemes be made mandatory to be implemented on emergency basis.

The projects should endeavor to regulate the surface water of the mining area for minimum contamination and alteration of drainage system and natural streams or rivers. Treated effluents can be utilized for supplying water to various mining activities, for dust suppression and plantation works. For the monsoon season water management scheme could be made taking in to account to following objectives:

- 'Remediation by reduction' approach can reduce the hazard associated with Cr^{+6} and minimize ecological and health hazards in the region.

- Garland drains should be made around quarry and segregated completely from the garland drains made for dumps and other infrastructures viz. workshop, garage etc.
- Grasses and small bushes developed held back solid particles from draining away and act as filters.
- Stone pitching at suitable locations on the drain sides may regulate the water which otherwise may over flow here and there and drains are cleaned up periodically.
- Hexavalent chromium (Cr^{+6}) can be reduced to Cr^{+3} in presence of a reducing agents like ferrous sulphate. James et al.[8] have suggested Potential Chromium oxidizing score (PCOS) for mobile Cr^{+6} level.
- Certain microorganisms's exudates and reducing agents lower the pH to increase Cr^{+6} reductions[13,14].

Biological indicators of chromium pollution like *Lemna, Spirodela, Scirpus valedelius. Cyperus esculentus, Bacoppa monnieri* are known to accumulate chromium and effective chromium concentration tolerance has been reported by various authors[1]. Monitoring of aquatic plants, plant growth and water quality parameters may help finding out the chromium pollution levels in aquatic ecosystems. Lateral roots of Water hyacinth help reduction of Cr^{+6}. Immobilized bioreactors using Bacillus coagulants, carbon based materials, zero (Ferrgels) and divalent Fe, reduced sulphur containing compounds (Iron sulphites, ditionite, thiols ad hydrogen sulphide) and H_2 gas have been tested for remediation of Cr^{+6} contaminated water and soil. Manures have also been successfully used to reduced Cr^{+6} [15].

Workshop and garage water effluent may be routed through an oil and grease trap. Septic tank is allowed under anaerobic condition in small colonies. Bigger colonies should have full-fledged sewage treatment plants with provisions of using the treated water for industrial purposes and the organic matter is converted to compost.

Noise Control and protection measures

Noise level in the work zone is to be kept below the 90 dBA as far as possible. Blasting in different mines and period of blasting are to be controlled to reduce cumulative impact of blasting. A combination of muffling and maintaining the stemming column length in all holes is adopted for effective control of fly rock. Blistering is a short living phenomenon. However, air overpressure and noise can be contained by using long stemming columns in blast holes and covering the detonating fuse with at least 150 mm thick cover of sand / soil/drill cuttings. The distribution ratio of booster to column charge is kept at prescribed level. Maximum permissible charge should be such applied keeping in mind the distance of structure to be protected from the blasting site and maximum total period of blast. Use of protective devices like acoustic wool, ear plug, ear muffs to workers exposed to noise level of more than 80 db (A) with self-rule to use them needs to be inculcated amongst workers. There are instances that workers do not use the protective devices while at work. Sound proof cabins in machines producing higher levels of noise like dozers, shovels, drills, dumpers, etc for the workers deployed. The reasons behind such practices need to be found out by employing sociologist and psychologists who would better understand and analyze these issues. Many a times the workers feel uncomfortable, hotness by using safety devices including the helmets. Like advances in mining and beneficiation technologies, acceptable occupational safety technologies and improved devices are needed.

Occupational Safety and Health

Occupational safety and health issues are closely related to productivity and good employer- employee relationship. The main factors of occupational health in the region are drinking water quality, dust and noise. The water of Dhamsala river is used by humans and cattle including wildlife of the region. Cr affects humans via skin contact and may cause allergic contact dermatitis[16]. Water quality needs to be ensured. Provisions of rest shelters for mine workers with amenities like drinking water, fans etc., conducting first aid awareness in mines including training and education of workers on sanitation, cleanliness, hygiene and health care are needed. Effort to get certification under OSHAS etc. to help maintaining international standards throughout the life of the mine will achieve the objectives.

Socio-Economic Measures

The mining activities help in enhancing the living conditions of the local population by providing them additional opportunities of employment and bringing the sophisticated medical, education and communication facilities within their reach. Good industry- people relationship could be achieved by extending the above facilities to the community so that public perception about the industry improves. Public image of a industry affect the productivity. The villages located around the Sukinda valley lack many such amenities. Drinking water availability, school and hospital facilities, modern agricultural tools and technology and drought are the major constraints in villages. Projects should take up water harvesting and re-charge systems in all the villages.

CONCLUSION

Many impacts could be addressed at a specific project level for immediate positive results. However, certain measures could only be effective at a regional scale like dealing with cross boundary and cumulative impacts. Implementation and periodical review of provisions of EMP holds the key for sustainable productivity. The following environmental management aspects can be addressed at individual project level:

- Regular monitoring of environmental quality parameters by having Facilities for monitoring of surface run off water, mine discharge water Emissions and air quality.

ENVIRONMENTAL MANAGEMENT OPTIONS

- Regular examination on slope failure on open cast mine faces, dumps and barrier, land erosion in mined out area and dumps. The effectiveness of drainage system depends upon proper cleaning of all drains and sumps.
- Regular testing and inspection of blasting operations in work zone with respect to noise, fly rock, vibration dust and fume generation.
- Revegetation and green belt development at project level and systematic protection, management and utilization of top soil and early use and restoration of all nutrients by reducing leaching and run off.
- Continuous training to workers on occupational safety and environmental awareness among project people and community of surrounding villages; Dust prevention and control for avoiding nuisance in the surroundings and also restricting the potential for transfer of significant impacts to other areas.

There is no legislation in India addressing the impact at regional level. However, Regional EIAs have been prepared for many regions in India. Countries in European Union and International Banking agencies have guidelines for REIA, Strategic Environmental Assessment (SEA), Sectoral EIA. World Bank Directive on Environmental Assessment stipulates use of regional EIAs for potentially cumulative impacts to deal with the interaction among effluents or competition for water/land [17].

Sukinda chromite region is having a peculiar topography. Dhamsala stream, traverses through the mineral zone and all mines are located on both sides of this stream at a length of 5 km. All mine discharges, storm water flow, run off water and leachates get discharged in to this stream. Although individual mines do carry out the effluent treatment yet substantial quantity of untreated water from the region flows down to the stream. The treated wastewater from the mines is not reused or recycled. A consortium of mining companies can show a good environmental standing by putting up a common effluent treatment plant at the last discharge point at Dhamsala stream and make provisions of recycling the treated water in all the projects. Japan has successfully introduced regional industrial planning policies to help limiting the level of pollution sources by limiting factory and establishing Joint Pollution Control Facilities. The Sukinda region is having significantly less ground water availability and extracting huge quantity of groundwater by individual mines is certainly affecting the replenishing potential of ground water. Further, this region being predominantly agriculture zone may face serious problem of drinking water availability and water scarcity may also affect the agriculture productivity. The need of drinking water is met by shallow tube wells in the villages. The scarcity of drinking water and water for agriculture may affect the mineral production also. The population in nearby villages is contributing to production of mines as a daily work force. These populations may not help the mining projects in future due to problem of water availability in villages. The impact of only this factor may be so significant that if ignored for longer periods will affect the ecosystems of the region. Depletion of ground water table and leaching and percolation of chromium laden water in to underground aquifers may increase the problem of availability of safe drinking water. People and animals generally utilize the water of Dhamsala stream for different purposes. The water quality has direct bearing on aquatic life. The Central Ground Water Authority is monitoring the depletion rate of ground water in the country. In many areas deep tube wells are not being permitted due to steep decline of water table. Sukinda valley may be brought into these provisions. It is recommended that this region may take the lead of becoming a near Zero discharge industrial conglomerate which will pave a way to other mining cluster regions of Orissa like iron ore, limestone and coal to adopt similar measures at regional scale. There is a need to establish meteorological laboratory for recording regular data like wind speed and direction, rain fall, temperature, humidity and evaporation. Research is needed to explore other effective Cr^{+6} reduction (biological and chemical) technologies.

A consortium may be made by all mining projects to contribute, implement and monitor various developmental schemes for the surrounding villages. Other such plans for awareness generation among local population be made and monitored. Conservation programme in respect of forest, water, waste and energy must be integrated with mining operations at regional scale for achieving sustainable development in the region.

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