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Indian small-scale mining with special emphasis on environmental management

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Abstract

Although small-scale mining provides a wealth of socioeconomic benefits to the rural inhabitants of developing countries, there is often total disregard for the environment industry-wide. This paper focuses upon some of the key environmental issues in the Indian small-scale mining industry. The geo-environmental factors constraining the mining of the Himalayan limestone, magnetite, phosphate, and polymetallic sulphur ore deposits are discussed, and the environmental impacts of small-scale operations working prospective deposits are detailed. The paper further examines the schematics of the Environmental Management Plan (EMP) adopted for small-scale mines in India. It is concluded, however, that widespread environmental improvement can only be achieved industry-wide if additional mining cooperatives are formed, and the Indian Government, through their Department of Environment, oversees the implementation of effective mitigation practices for small scale-mines, particularly at the university level.

Keywords: Economic development; Geo-environment; Opencast; Waste dump; Soil erosion; Landslides; Deforestation

1. Introduction

Small-scale mining has been the subject of intensive international debate. The socioeconomic significance of operations is often overlooked because when compared to large-scale setups, requirements in terms of reserves, implementation time, and initial investments are minimal, skill and infrastructural requirements are moderate, and employment per unit output is high. However, minimum resource requirements and a short construction period are advantageous in any economic environment, and because activities require minimal capital, skills, infrastructure and labour to flourish, small-scale mining has become an important industry in many developing countries, providing thousands of people with employment, and contributing positively to national mineral outputs [1].

Small-scale mines have also had a significant impact on the environment. Generally, the industry features poor working conditions and its workers have low environmental awareness and totally disregard key issues of health and safety [2]. There is an obvious need to promote effective technology [3], and although a wide range of modular systems can be envisaged, the most practical strategies are those that are both cost-effective and environmentally compatible [4].

This paper examines some of the key environmental issues of small-scale mining, and identifies opportunities for environmental management and clean production in the Indian context.

2. An overview of small-scale mining in India

The role of minerals and metals in economic development, especially in the context of developing countries, has received much attention [5–6]. Characterized by low-income and middle-income economies, developing countries have some 80% of the world's population. Small-scale mines represent a growing and important component of the mineral sector in the developing world in terms of value of output, contribution to the economy and employment [7]. It has been estimated that small-scale mines contribute about one sixth of the value of

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world's non-fuel mineral output, and in many developing countries, the output is significantly higher than this figure. In India, some 3000 small-scale mines account for about 50% of non-fuel mineral production. The employment effects of such activity are considerable, especially in tribal and rural areas; a total work force of about 300,000 is engaged in small-scale mining in the country.

In developing countries like India, small-scale mine owners do not generally have the technical or financial capabilities for proper exploitation, mining development, mineral extraction, or processing. They also often lack sufficient mechanical equipment and adequate maintenance facilities. Safety, health and environmental protection are rudimentary at best, and mine owners usually do not receive near-market places for their products. In spite of these drawbacks, however, the industry provides several benefits. These include the ability to operate in remote areas with minimal infrastructure, thus enabling the exploration of otherwise uneconomic resources, and a high degree of flexibility, due to low overheads. Small-scale mining can also be easily integrated into the existing social structure, particularly if seasonal operations are required because of agricultural production in the same area. The ability of small-scale mines to generate employment, income, and entrepreneurial skills in rural areas can restrain urban migration. In addition, because most are locally owned, small-scale mines can provide a larger net gain to the community and national economy vis-à-vis larger foreign owned mines.

At the same time, however, small-scale mining can be highly inefficient. Poor working conditions, and problems with safety, health and environmental degradation are rampant in prospective mining regions. Much small-scale mining activity is also carried out illegally and is thus difficult to monitor and control.

As already noted, in addition to providing direct employment and real income to the unskilled rural populace, a thriving small-scale mining sector also helps to streamline the rural–urban population [8]. There is a need, however, for adequate economic and social infrastructure at remote sites where activities are being carried out. The Government of India has established special small-scale mining agencies that have helped to create the means to commercialize and legalize artisinal mine production, raise living standards, and create employment opportunities in rural areas.

The creation of miners' cooperatives has successfully stimulated small-scale mining activity in India. Cooperatives have two significant advantages over individual mining activities. First, through their greater financial power and long-term viability, they have easier access to mining and procuring equipment. This, in turn, results in greater production, and increases incomes. Second, a more stable operation helps to regulate the boom and bust cycle experienced in the industry. These operators are more likely to contribute to the development of central processing and transport facilities, which would help to improve the efficiency and productivity of the more informal mining operations.

3. Case study: the environmental impact of mining in the Indian Himalayas

The Himalayan deposits, because of their small size, limited extensions in depth, and problematic geo-technical conditions, are amenable to opencast mining methods [9]. Wastes cover more than 60% of land in the Himalayan mining region of India. This in turn contributes to increased deforestation and environmental degradation [10], and continuous de-watering of these operations disturbs the hydrological regime of the area. Moreover, high strain in host rocks as a result of complex folding, thrust movements, and fault developments, generally induces numerous landslides during and after mining. Steep hill slopes, dips of strata and the vertical planes of the host rocks accentuate such geo-technical hazards.

It is very difficult to stabilize the mine wastes produced in this region [11]. Dispersal of finer mine wastes over steep slopes leads to rapid degradation of agricultural lands downstream [12]. Streambeds are readily silted and frequently flood and degrade larger agricultural areas. The amount of toxic heavy metals and other impervious elements or salts, mine rejects, tailings, and effluents from the beneficiation plants are also generally quite high, which further threatens agricultural land and pollution of surface and ground water.

Unsystematic, unplanned and selective opencast mining of limestone in the Mussoorie Hills has resulted in widespread degradation of the Himalayan environment [11]. Deforestation resulting from mining in this area has accelerated soil erosion over the years, which has seriously affected the stability of hill slopes, frequently causing landslides and debris flows, particularly during the rainy season. Uncontrolled and unabated disposal of waste materials from quarries, and subsequent gravitational transportation and surface run-off has led to siltation and virtual congestion of resident watercourses. Dust, noise and vibration generated during mining and transportation operations have further degraded the fragile ecology and environment of the region. The problems are compounded further by kilns, which are located in the valley along the hillsides.

Opencast mining methods are employed to extract magnesite in the Jhiroli Ridge of the Kumaon Himalayas. Because of talcose materials and interstices of magnetite, the ore must be benificiated in close proximity to mine sites. Geo-environmental constraints imposed upon mining in the region are related essentially to frequent landslides, debris flow, and ground water seepage. Disposal of mine waste on steep hill slopes poses an additional problem. It is currently being managed using

waste dumps, which involves erecting retaining walls and planting trees alongside slopes. However, these dumps often release additional effluents, gases, heat, and dust particles, which further impacts in the ecology and environment of the region.

Deposits of phosphate (17–24% P_2O_5) are being exploited in Mudeotn, Durmal, Talikhol, Masran, and Peritibha in Dehradun, and the Tehri Districts. Calcareous impurities in the phosphate contribute to a lowering of the grade as well as problems with beneficiation. The richness of phosphoric in iron sulphides and carbonate fluor-apatite also poses serious geo-environmental problems. These are further aggravated by the presence of highly permissible horizons constituting geo-hydrological hazards. Apart from deforestation along the slopes of Malderon Mines, phosphoric mining has also caused partial geo-morphological degradation in the area [13]. The basic reason is that the Dumala Mines and some of the Madeota Mines are mostly underground operations. However, landslides are frequent in the open-cast mines of Maldeota and elsewhere because of the exposure of slide prone foot well dolomite after removal of phosphoric ore bodies. A bigger problem, however, is imposed by the continuous degradation of total rock mass rich in iron sulphides, and the resultant pollution of mountainous streams with highly dissolvable solids, SO_4, PO_4 and F [13].

The Zn–Pb–Cu sulphide deposit of Bhotang Hill near Rangpo in southern Sikkim constitutes the only base metal deposit under active exploitation in the Himalayas. It is a part of a significant cluster of cogentic mineralisations [14] that deserves detailed investigations to formulate a common strategy for their exploitation [15]. The ores contain variable proportions of copper, lead and zinc, which constitute over 98% of the metal content of the ores; minor metal and metalloids found in these ores include As, Bi, Sb, Co, Ni, Cd, Ag, Au, Hg, Cr, and Sn [16]. These metals have caused substantial chemical pollution, and deposits are located along weak structural zones and in an earthquake prone area [17]. This has resulted in numerous natural and induced calamities such as landslides, slope failures, grand subsidence and mine inundation. The locations of the Tista River, and the national highway just beside and above the ore body, impose a further problem because significant quantities of rich copper ores remain 'locked up'. Finally, the presence of metal zoning, both along and across the strike, has made grading an impossible task for operating over a limited strike length [18]. Host rocks possess strong potentiality to produce heavy metal toxicants [19], and anomalous concentrations of radioactive minerals in certain zones of the ore body also pose a threat [20].

Fig. 1 provides an overview of the important Himalayan deposits suitable for small-scale mining.

4. Environmental management

India, however, is not a unique case, as it is a well-known fact that most small-scale mining adversely impacts the environment. Several countries have adopted different strategies for tackling pressing environmental problems in the industry. The following sections describe how India is working to address some of the aforementioned impacts.

It is mandatory to draft an environmental management plan (EMP) before commencing such projects in India [21]. An EMP helps to ensure that the potential environmental impact of a project is assessed and incorporated into the early stages of development planning. The procedure of preparing an EMP has been accepted as a statutory requirement for granting a permit from the environmental angle [22]. In India, the Public Investment Board requires an environmental clearance from the Department of Environment (DOE), Ministry of Environment and Forests, Government of India, for sanction for funding all major projects. All such mining projects need to be cleared by DOE to ensure that effective safeguards are in place to prevent environmental hazards [23]. DOE has issued guidelines for the preparation of an EMP report for mining projects. Finally, the Environmental Appraisal Committee for mining projects (EAC-M) formed by DOE examines the EMP report before granting clearance for the project.

The application of efficient pollution control technology is an important means of controlling environmental impacts; sound management, however, must support technology to increase its efficacy [24]. An EMP report describes the pre-project environmental scenario, making specific reference to socio-economic profile, land use pattern, and environmental quality with respect to air, meteorology, water, noise, soil, flora and fauna. Socio-economic impact, land oustees, effect on flora and fauna, solid waste management, the impact of water pollution, and noise pollution are all discussed in the report. More specifically, it addresses following:

1. Land acquisition area
2. Land required for rehabilitation of the land oustees
3. Item-wise details of the rehabilitation package
4. Number of families to be rehabilitated
5. Land required for compensatory afforestation and amount provided
6. Value of compensation for existing forest wealth to be paid to the Forest Department
7. Amount provided for compensatory afforestation
8. Capital provision for land reclamation
9. Capital provided for other environmental protection and antipollution measures at mine site
10. Capital provision for biological reclamation
11. Provision for antipollution measures in township area

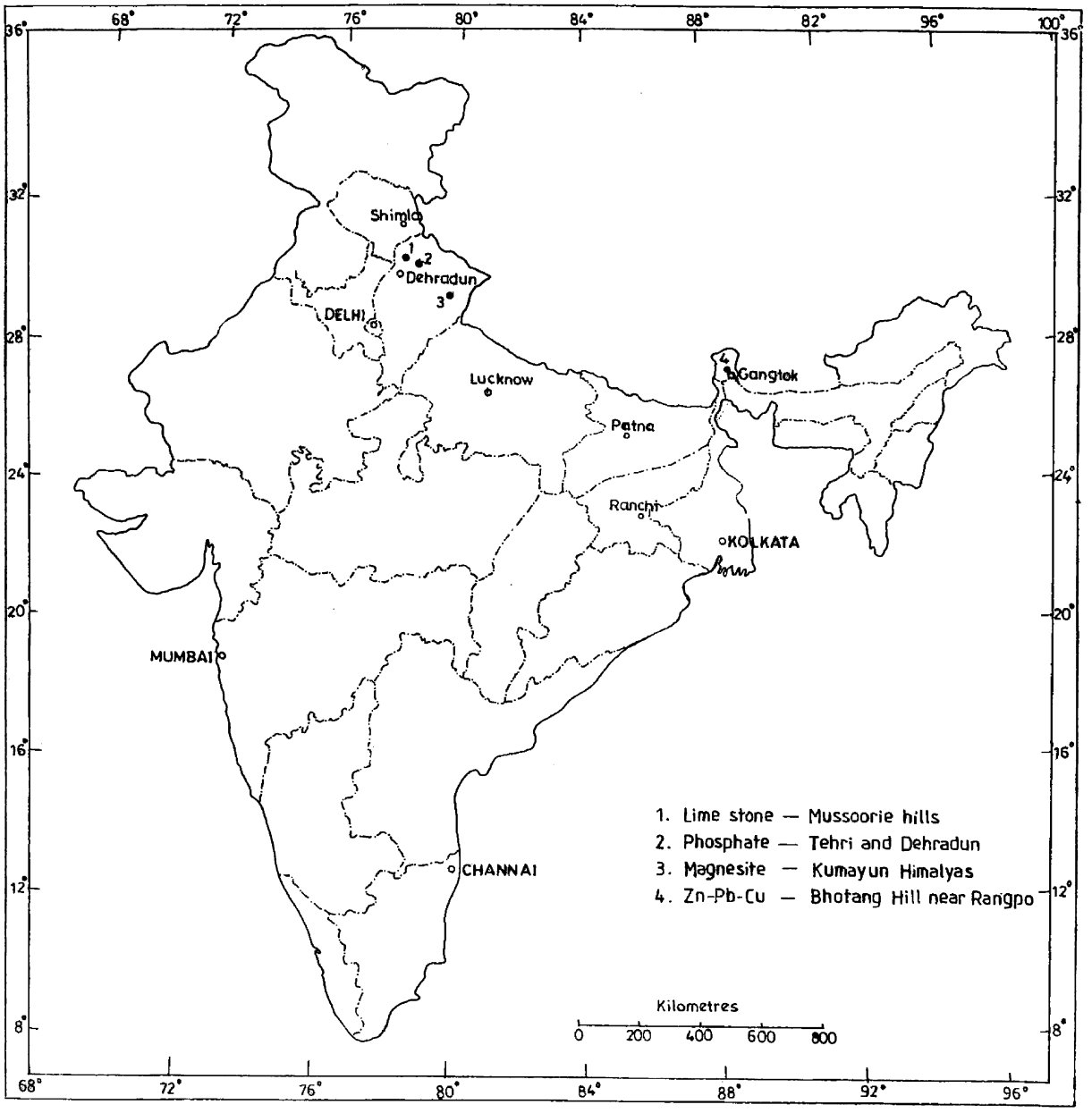

Fig. 1. Himalayan mineral deposits suitable for small-scale mining.

12. Organization for environmental and rehabilitation work
13. Manpower for environmental control and rehabilitation work
14. Recurring expenditure for environmental control and reclamation work

As per DOE, it is also obligatory on the part of a mine, new or old, to prepare an EMP and to get sanctioned, which is why it includes the following four important aspects.

1. Description of pre-mining (existing) environmental setting in the core zone and buffer zone (10 km radius).
2. Identification and prediction of the potential impacts of the project.
3. Evaluation of significant impacts.
4. Mitigation measures to minimize the detrimental effects of negative impacts.

The existing environmental setting within the study area is determined through field surveys, census reports and other secondary sources. For some of the attributes (air, water, noise and soil), continuous monitoring is carried out [25–26]. Predicted impacts are expressed in

appropriate units in order to gain an aggregated picture of the predicted impact of a project. An evaluation of the predicted impact is carried out using a Matrix Methodology, which depicts the causes and effects of environmental attributes. It also helps to identify the environmental impacts of various activities. The magnitude and the importance of the cause–effect interaction in the Matrix is decided subjectively on the lines set by the Environmental Evaluation System (EES).

For effective implementation of an EMP, a mid-term corrective measure is essential, such as a time bound action plan. This includes a programme for land reclamation, afforestation, mine water treatment, surface drainage and check dams, and sewage treatment. A separate department is established to evaluate the performance of the programme, monitoring pollution control equipment, emissions from sources, and the quality of the surrounding environment. The programme also includes safety measures inside the project and a horticulture cell for the development of green belts and afforestation. For this purpose, a multi-disciplinary task force is formed that undertakes the following tasks:

1. Environmental data generation.
2. Evolving environmental management plan for the project in close collaboration with other agencies and consultants.
3. Monitoring of project implementation from the environmental angle, including rehabilitation and compensation.
4. Creation and maintenance of nurseries for timely supply of sapling for afforestation.
5. Coordination of other project activities to ensure effective implementation of the project.
6. Coordination with the Department of Environment, Central/State Pollution Control Board.

The responsibility to improve environmental management rests with the Project Officer of the project. As far as air, water, noise and soil pollution control measures are concerned, samples are collected and tested at strategic locations during all four seasons. The implementing authority is guided and advised as per the data received from the laboratories.

5. Environmental laws in the Indian context

Small-scale mining is considered a potentially environmentally degrading activity, which is why it is imperative that an effective system of legislation is in place for environmental regulation purposes. In India, environmental law is not confined to apportionment of rights and duties and adjudication of disputes arising therefrom. More importantly, it is a policy instrument designed to manage natural resources intelligently, with a view to moderating their use for sustainability, intergenerational equity and avoidance of irreparable consequences. In all these policy goals, it is science and technology that plays a critical role. The focus, legislatively, should be on the *prevention* of harmful effects, and effective management of resources.

Development has environmental costs. Therefore, the role of the law is to see how and where to absorb these costs to keep damages at a minimum. Not only does recently introduced environmental regulations in India not concern mines, but most have been poorly implemented, further underscoring India's reputation for being notoriously soft in this regard. Corruption and a lack of political will also plays its role in non-performance of these and related pollution control measures. The most promising development in India has been the increased constitualisation of environmental actions based on human rights approaches. Recently, the Supreme Court of India ruled that every person has a fundamental right to the enjoyment of pollution-free water and air. A proactive court invented new remedies and evolved convenient procedures to giving meaningful justice where fundamental rights and public interests are involved. Such is a significant development, which will hopefully be sustained for better environmental management in India.

One serious problem in this regard is the veil of secrecy maintained by the Government departments and the general non-availability of information on environmentally sensitive issues. Investigative journalism in Indian print media sometimes results in the generation of sensitive information essential for litigating environmental issues. What seems to be developing is an alliance among academics, NGOs, media and public interest lawyers for the cause of environmental protection. Though an inadequate substitute for an effective regulatory system, it does promise greater compliance of environmental norms and better accountability as far as the environment of the future is concerned. Problems, which are created as a result of industrial activity, deserve to be addressed by political and administrative apparatuses, in which civil society must play a leading role. A convergence of interests needs to be created between economic and environmental goals to increase the probability of compliance with norms and standards. Environmental goals should receive adequate attention in corporate governance and management.

In short, in the context of small-scale mining in India, environmental regulations are not a key to promoting environmental improvement in operations, as most are 'loose' and poorly implemented.

6. Contributions from resident universities

Because of obvious regulatory weaknesses in India, there is urgent need to pursue different strategies for pro-

moting improved environmental management in the small-scale mining sector. One possible avenue is increased research at the university level. In fact, promising research is already being undertaken that could help to facilitate environmental improvements in the sector.

In recognition of the need for environmental research in India's mining industry, the Ministry of Environment and Forests (MOEF) established the Centre of Mining Environment (CME) at the Indian School of Mines (ISM) in Dhanbad in 1987. The Centre seeks to:

- Carry out research in the field of mining environment
- Coordinate the development of academic research programmes (Masters and PhD) in the area of environmental science and mining engineering
- Provide training to mining personnel
- Undertake consultancy and laboratory work to help solve environmental problems in mining and mineral industries.

At present, the Centre is controlled by the Ministry of Human Resource Development (MHRD), although MOEF continues to provide generous grants for R& D activities. It has excellent infrastructure for academic, research and developmental activities, and now has several well-equipped laboratories, a library, and seminar and lecture halls. The Centre offers three semester M.Tech and PhD programmes, and completed a number of R&D projects successfully by establishing linkages with various national and international organizations. MOEF has established an Environmental Information System (ENVIS) at the Centre of Mining Environment to help to disseminate environmental information system in the area of mining. The Centre is also conducting World Bank funded projects to impart training programmes to the executives of mining industries, and Environmental Management Capacity Building Technical Assistance Projects.

In addition to the Centre, the Central Mining Research Institute, Indian Institute of Technology, Benaras Hindu University, Central Mine Planning & Design Institute Ltd. are also actively engaged in mining environmental research. However, as far as small-scale mining is concerned, because R&D activities in the sector are inadequate, the Government of India should provide more funds to resident universities to pursue technology and management-related projects. Although international bodies like the World Bank are providing funding for the coal mining sector, India's small-scale mining sector continues to receive minimal attention from these organisations. With the regulatory regime weak, it is crucial that the Government begins promoting research at the university level and coordinating the efforts of international agencies. Such is the key to improving environmental management in the Indian small-scale mining industry.

7. Conclusion

Because of a poor handling of resources, small-scale mining is causing a negative impact on the environment. This paper, which documented the Indian case, has shown that the mining of India's Himalayan deposits has caused much damage. The system of preparing an EMP report for clearance from the Government of India prior to implementation of a mining project has been a positive step towards minimizing the negative impact but a weak regulatory regime is inhibiting progress in this area. Although improved execution of EMPs would undoubtedly facilitate improvements, promotion of environmental research at the university level could be the key to delivering improved environmental results in the near future. Since resident universities are already actively engaged in promising mining environmental research, a simply rerouting of priorities—namely, increased emphasis upon small-scale mining—could significantly improve environmental performance in the sector.

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