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Review Article

ENVIRONMENTAL IMPACT OF SOIL AND SAND MINING: A REVIEW

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Abstract: Sand is an important mineral for our society in protecting the environment, where this practice of sand and soil mining is becoming an environmental issue as the demand for sand increases in industry and construction. Mining and its associated activities can be responsible for considerable environmental damage. In this article we are discussing about the direct and indirect impacts due to soil and sand mining to the environment in Indian regions. Pollution of the water is evident by the colouration of water which in most of the rivers and streams in the mining area varies from brownish to reddish orange. Low pH (between 2-3), high electrical conductivity, high concentration of ions of sulphate and iron and toxic heavy metals, low dissolved oxygen (DO) and high BOD are some of the physico-chemical and biological parameters which characterize the degradation of water quality. Contamination of Acid Mine Drainage (AMD) originating from mines and spoils, leaching of heavy metals, organic enrichment and silting by sand particles are major causes of degradation of water quality.
Key words: mining, water quality, Acid mine drainage, environmental damage.

1. INTRODUCTION

Sand is an important mineral for our society in protecting the environment, buffer against strong tidal waves and storm, habitat for crustacean species and marine organisms, used for making concrete, filling roads, building sites, brick-making, making glass, sandpapers, reclamations, and in our tourism industry in beach attractions. Sand mining is the process of removal of sand and gravel where this practice is becoming an environmental issue as the demand for sand increases in industry and construction. In almost every mineral bearing region, soil mining and land degradation have been inseparably connected. Unscientific mining has caused degradation of land, accompanied by subsidence and consequential mine fires and disturbance of the water table leading to topographic disorder, severe ecological imbalance and damage to land use patterns in and around mining regions (Ghose, 1989).

Mining is a major contributor (2'nd) to the national GDP (4%) occupying 36 lakh hec. (0.11%) of total land area (329 m ha) and providing employment generation (4 %) for 1.1 million people of the country. In almost every mineral bearing region, soil mining and land degradation have been inseparably connected. India recognizes that mining, unless properly regulated, can have adverse environmental and social consequences. Mining is essentially a destructive development activity where ecology suffers at the altar of economy. Scientific mining operations accompanied by ecological restoration and regeneration of mined wastelands and judicious use of geological resources, with search for eco-friendly substitutes and alternatives must provide sensational revelation to the impact of mining on human ecosystem (Surender Singh Chauhan, 2010).

Unfortunately in most regions of earth, the underground geological resources (minerals) are superimposed by above ground biological resources (forests). This is particularly more prominent in India. Hence mining operations necessarily involves deforestation, habitat destruction and biodiversity erosion. The extraction and processing of ores and minerals also lead to widespread environmental pollution. However, mankind also cannot afford to give up the underground geological resources which are basic raw materials for development. Physico- chemical parameters and concentration of heavy metals Pb^{2+}, Zn^{2+}, Ni^{2+}, Co^{2+}, As^{3+}, Cu^{2+}, Fe^{2+}, Mn^{2+} and Sn^{2+}were analyzed in mined soil areas and found that most parameters and metals concentration exceeds the permissible limit and concluded that ex-mining catchment has a high pollution potential due to mining activities (Ashraf et al., 2010).

2. Acid Mine Drainage- Threat to water resources

The potential for acid mine drainage is a key question. The answer will determine whether a proposed mining project is environmentally acceptable. When mined materials (such as the walls of open pits and underground mines, tailings, waste rock, and heap and dump leach materials) are excavated and exposed to oxygen and water, acid can form if iron sulfide minerals (especially pyrite, or 'fools gold') are abundant and there is an insufficient amount of neutralizing material to counteract the acid formation.

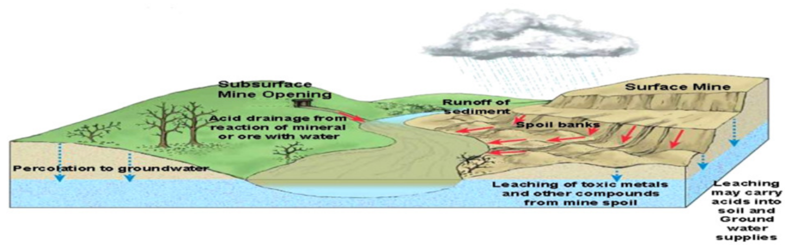

fig. 1 Acid mine drain

"**Acid** mine drainage (fig.1) is considered one of mining's most serious threats to water resources. A mine with acid mine drainage has the potential for long-term devastating impacts on rivers, streams and aquatic life. Acid mine drainage is a concern at many metal mines, because metals such as gold, copper, silver and molybdenum, are often found in rock with sulfide minerals. When the sulfides in the rock are excavated and exposed to water and air during mining, they form sulphuric acid. This acidic water can dissolve other harmful metals in the surrounding rock. If uncontrolled, the acid mine drainage may runoff into streams or rivers or leach into groundwater. Acid mine drainage may be released from any part of the mine where sulfides are exposed to air and water, including waste rock piles, tailings, open pits, underground tunnels, and leach pads. If mine waste is acid-generating, the impacts to fish, animals and plants can be severe. Many streams impacted by acid mine drainage have a pH value of 4 or lower similar to battery acid. Plants, animals, and fish are unlikely to survive in streams such as this.

TOXIC METALS: Acid mine drainage also dissolves toxic metals, such as copper, aluminium, cadmium, arsenic, lead and mercury, from the surrounding rock. These metals, particularly the iron, may coat the stream bottom with an orange-red coloured slime called yellowboy. Even in very small amounts, metals can be toxic to humans and wildlife. Carried in water, the metals can travel far, contaminating streams and groundwater for great distances. The impacts to aquatic life may range from immediate fish kills to sub- lethal, impacts affecting growth, behaviour or the ability reproduce.

3. Environmental Issues of Mining

The role of minerals and metals in economic development, especially in the context of developing countries, has received much attention. The first step in planning is to recognize the environmental issues that need to be faced in designing a feasible mine layout. However, it is often possible to reduce these impacts so that mining is sufficiently compatible with surrounding land uses and preserves acceptable long-term uses of the site itself.

In Tamil Nadu, with a view to drawing the attention of the government to the magnitude of the problem and sensitising people about the risks involved, the Campaign for the Protection of Water Resources-Tamil Nadu arranged a State-level "public hearing" on the impact of sand mining (on river basins, streams, coastal areas and hill regions). After intense studies in different regions and interaction with the affected people, the Campaign for the Protection of Water Resources, Tamil Nadu has identified 15 adverse consequences of sand mining. They include the depletion of groundwater; lesser availability of water for industrial, agricultural and drinking purposes; destruction of agricultural land; loss of employment to farm workers; threat to livelihoods; human rights violations; and damage to roads and bridges. Representatives of victims from 13 of the 28 districts of the State gave evidence on the damage caused to the environment and livelihoods in these districts. The affected river basins included those of the Palar and its tributaries Cheyyar, Araniyar and Kosathalaiyar (Kanchipuram and Thiruvallur districts); the Cauvery (Karur district); the Bhavani (Erode district); the Vellar (Perambalur district); the Vaigai (Madurai and Theni districts); and the Thamiraparani (Tirunelveli district). Victims from the coastal districts of Nagapattinam, Tuticorin, Ramanatha-puram and Kanyakumari.

In Kerala, there has been a significant increase in sand mining since the beginning of the 1990s following a boom in the construction industry, and the activity reached alarming proportions in several areas, particularly in the southern and western regions of the State, after court restrictions on sand mining came into effect in neighbouring Kerala in 1994. Similarly River Bharathapuzha in Kerala has become a victim of indiscriminate sand mining. “Despite numerous prohibitions and regulations, sand mining continues rapidly on the riverbed of the Bharathapuzha. Water tables have dropped dramatically and a land once known for its plentiful rice harvest now faces scarcity of water. In the villages and towns around the river, groundwater levels have fallen drastically and wells are almost perennially dry.

Illegal and excessive sand mining in the riverbed of the Papagani catchment area in Karnataka has led to the depletion of groundwater levels and environmental degradation in the villages on the banks of the river in both Andhra Pradesh and Karnataka. In Karnataka, llegal sand mining from the Papagani river catchment area in Kolar district, been going on for six to seven years. Initially, the Karnataka government gave sand mining rights to some contractors, but due to increased illegal and excessive mining, it has led to environmental degradation and problems for the people by the depletion of ground- water levels in the villages situated on the river banks. Moreover, as these villages are situated in the border between Andhra Pradesh and Karnataka, both the states are affected by this problem.

In Megalaya, pollution of the water is evident by the colouration of water which in most of the rivers and streams in the mining area varies from brownish to reddish orange. Low pH (between 2-3), high electrical conductivity, high concentration of ions of sulphate and iron and toxic heavy metals, low dissolved oxygen (DO) and high BOD are some of the physico-chemical and biological parameters which characterize the degradation of water quality. Contamination of Acid Mine Drainage (AMD) originating from mines and spoils, leaching of heavy metals, organic enrichment and silting by sand particles are major causes of degradation of water quality in the area. Mining operation, undoubtedly has brought wealth and employment opportunity in the area, but simultaneously has led to extensive environmental degradation and disruption of traditional values in the society. Environmental problems associated with mining have been felt severely because of the region's fragile ecosystems and rich biological and cultural diversity. Large scale denudation of forest cover, scarcity of water, pollution of air, water and soil and degradation of agricultural lands are some of the conspicuous environmental implications of coal mining (Swer and Singh, 2004).

The malaise is pretty widespread as many other states like Rajasthan, Gujarat, Karnataka, Tamil Nadu, etc are also victims of unchecked illegal sand-mining the consequences of which are very serious.

4. **Air quality**

The main air quality issue with mining is dust particles (Ghose and Majee, 2000). Large amounts in concentrations of dust can be a health hazard, exacerbating respiratory disorders such as asthma and irritating the lungs and bronchial passages. However, people invariably feel a loss of environmental amenity, due to dust deposits or dust concentration, before their health is affected. Dust deposition is measured with deposition gauges and reported in units of g/m^2 per month of dust fallout. Pre-mining background levels and total amounts of deposited dust are the usual measures against which limits are set. Dust concentrations are monitored with mechanical high volume air samples and limits are placed on average and peak hourly values.

5. Noise and vibration

Noise can be an issue because mines normally operate 24 h a day and sound levels can fluctuate widely. Surface mines mainly generate noise from overburden excavation and transport, while the major noise sources from underground mines are ventilation fans, the surface facilities and product transport. Noise levels generally must be controlled so that they reflect the most stringent requirements during evening hours when nearby landholders wish to relax or sleep. Blast planning must also limit ground vibration to avoid damage to building structures and annoyance to people living in the area. Vibration limits set for environmental amenity are significantly lower than for structural damage. Industrial structures can often withstand up to 50-mm/s ground vibrations without structural damage. For transport noise, average noise exposure is adopted. In many parts of world it is also necessary to allow for noise enhancement caused by atmospheric thermal inversions at night.

6. Water quality

Mines can affect surface runoff and groundwater quality through contamination with dissolved and suspended materials. Perhaps the commonest surface water contaminant is sediment or suspended solids. Sediment can smother the beds of receiving streams, affecting fish and benthic organisms. Apart from runoff from overburden emplacements and stockpiles, storm water can be contaminated from process plants, workshops and vehicle wash-down pads. Drainage from oxidization of sulphur or sulphidic ores is highly acidic and can contain dissolved heavy metals. These are toxic to aquatic life and impact on the surrounding environment. Mine planners must consider how their facilities will cope with floods. Mines can de-water groundwater aquifers some distance from shafts or open pits, which can make nearby wells or groundwater bores run dry. Mine designers must also guard against the release of chemically or radiologically contaminated water.

6. 1 Quality of ground water in sand mining areas of Rajasthan

Ten ground water samples (Table. 1) from different sources like tubewell, hand pumps, and runoff water located on the un-mined and mined soils were collected and analysed using standard laboratory methods to investigate the quality of water for irrigation.

Table 1. Ground water quality in sand mining areas

Sample No	Source,Location and District	Depth (m)	pH	EC (dSm -1)	Na	Ca + Mg	K	HCO_3	Cl	RSC	Fluori-de (ppm)
					---------------------me/l------------------------						
SM-1	Rain water in mine pit Nagla Mirgain, (Karnal)	---	7.8	1.50	5.6	9.0	0.42	7.0	6.8	Nil	0.00
SM-2	Tubewell, Deva Singh, Nagla Mirgain (Karnal)	15	7.5	0.85	1.6	6.5	0.20	2.7	4.5	Nil	0.00
SM-3	Hand pump, Nagla Mirgain, (Karnal)	20	7.4	0.75	2.1	6.0	0.17	4.7	4.0	Nil	0.00
SM-4	Tubewell, Ram Singh, Garhi Chajoo, (Panipat)	22	8.0	0.50	2.0	2.6	0.17	0.9	3.8	Nil	3.09
SM-5	Field Stagnation, VillageBaholi (Panipat)	---	8.2	0.50	1.8	2.7	0.07	2.2	2.5	Nil	0.59
SM-6	Tubewell, village Machhrauli (Panipat)	26	8.0	0.70	3.0	3.9	0.18	5.0	2.3	1.1	2.59
SM-7	Tubewell,Ajit Singh, Harisinghpura, (Karnal)	82	7.9	0.66	2.6	3.9	0.06	3.9	2.8	Nil	0.47
SM-8	Tubewell, Sh.Santkuar Nandnour (Sonepat)	14	8.1	0.60	2.3	3.7	0.17	3.6	2.5	Nil	0.00
SM-9	Tubewell,Sh.suresh Jaurasi, (Panipat)	26	8.1	0.48	2.0	2.5	0.06	1.8	2.5	Nil	1.01
SM-10	Tubewell,Sh.Gulab Singh, Jaurasi,(Panipat)	40	8.0	0.45	1.6	2.5	0.18	1.7	2.8	Nil	0.24

Fluoride was analysed using Specific Ion Meter. The EC value less than 1.5 dSm^{-1} and RSC less than 1.1 make these waters good for irrigation without any detrimental effect on soils and crops. However higher fluoride contents of 3.09, 2.59 and 1.01 ppm in three water samples collected from tube wells in villages, Garhi Chhajoo, Macchrouli and Jaurasi in Panipat district might pose health hazards to humans and animals. Fluoride rich waters were drawn from 22 and 26 meters depth.

7. Land use

The type of mining and the characteristics of the particular mineral deposit both affect the degree to which mining disturbs the landscape. Underground mining usually causes little surface disturbance and rehabilitation is restricted to tailings dumps, removal of buildings and equipment, and making the area safe. Surface mining results in the destruction of the existing vegetation and soil profile. Removal of overburden and waste rock and its replacement in waste dumps or the mined-out pit can significantly change the topography and stability of the landscape. Some overburdens may release salt, or contain sulphide materials which can generate acid mine drainage cumulative efforts of coal production are taken into consideration.

8. Soil quality

By far the greatest impact of mining on the nations soil resources is due to opencast mining, which is having a very much potential for the deterioration of soil quality than underground operations. Topsoil is an essential component for land reclamation in coal mining areas (Kundu and Ghose, 1994). The topsoil is very seriously damaged if it is not mined out separately in the beginning, with a view to replacement for due reclamation of the area. This is particularly necessary due to the scarcity of topsoil in coalfield. Therefore, it is necessary to save topsoil for a latter use in a manner to protect primary root medium from contamination and erosion, and hence in productivity. Sendlein *et al* (1983) indicate, however, that systematic handling and storage practice can protect physical and chemical characteristics of topsoil while in storage and also after it has been redistributed into the regraded area.

9. Flora and fauna

An accepted part of pre-mining investigations is a survey of existing flora and fauna. Cataloguing individual species and grouping these into floral habitats are the first tasks. However, apart from identifying rare and endangered plants and animals, planners must consider the ecological integrity of an area and what role it plays as a part of a regional environment. Relevant questions include how well species and habitats are protected in parks and conservation areas, and the role of the site as a part of a habitat corridor. The species selected for establishment will depend on the future land use of the area, soil conditions and climate. If the objective is to restore the native vegetation and fauna then the species are pre-determined. . Some indigenous species may not thrive in, areas where soil conditions are substantially different after mining: Climate, soils and the rehabilitation strategyare important considerations in minimizing impacts on native flora and fauna.

10. Environmental protection

India, however, is not a unique case, as it is a well- known fact that most mining adversely affects the environment. Several countries have adopted different strategies for tackling pressing environmental problems in the industry. The following describes 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. An EMP helps to ensure that the potential environmental impacts of a project are 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. In India, the Public Investment Board requires an environmental clearance from the Department of Environment (DOE), Ministry of Environment and Forests, Govt. of India, for sanction for funding for 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. DOE has issued guidelines for the preparation of an EMP report for mining projects (Ghose and Kumar, 2004).

11. Conclusions

Weak governance and rampant corruption are facilitating illegal mining posing depletion of water resources. The socio-economic significance of mining operations is often overlooked, and there is a need to protect its economic and social benefits. Because of a poor handling of resources, soil and sand mining cause negative impacts to the environment. The system of preparing an EMP report for clearance from the Government of India prior to implementation of mining project has been a positive step of minimizing the negative impacts.

The government should exercise prudence when it comes to leasing out the riverbed for mining activities and also demarcate areas clearly and monitor mining through a suitable institutional mechanism. A high level lobbying committee must be formed and Laws has to be enforced in an efficient and unbiased way and decisive steps are to be taken for environmental solution.

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