INNOVATIONS IN SAND MINING FOR SUSTANABLE DEVELOPMENT

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ABSTARCT

This paper presents a critical review of various sand mining methods, problems of environmental pollution, some typical problems and issues due to the present sand mining practices in our country along with illustration of scientific design of sand mining methods, mining plans, monitoring plans etc for extraction in a sustainable way. Effects and general guidelines for sand and gravel mining along with action plan in brief are also presented. Emphasis is made on application of suitable river model in determining the locations, period and quantity of sand to be extracted by means of appropriate scientific methods. As an alternative to river sand, it is also suggested to accelerate the efforts to prepare sand from rocks—i.e rock sand mining may be given a good boost by the respective State and Central Governments.

INTRODUCTION

In recent years, rapid development has led to an increased demand for river sand as a source of construction material. This has resulted in a mushrooming of river sand mining activities which have given rise to various problems that require urgent action by the authorities. These include river bank erosion, river bed degradation, river buffer zone encroachment and deterioration of river water quality. Very often, over-mining occurs which jeopardizes the health of the river and the environment in general [1-6]. There is a need for the Concerned Government Agencies To be equipped with the necessary planning and management tools to deal with the problems that arise from river sand mining and this article intends to review some of the present problems and prospects of sand mining with an impetus on preparation of proper guidelines for eco-friendly sand mining. In India, Mineral-wise analysis revealed that building stone had the largest share of 24.5% to the value of minor minerals followed by brick-earth 20.9%, road metals 17.1%, marble 2.1%, ordinary sand 6.4%, quartzite & sandstone 5.2%, limestone 3.6%, gravel 3.3%, murrum 1.8%, kankar 1.5%,ordinary earth 1.4% and ordinary clay 1.1%. The remaining minerals together contributed 1.1% of value of minor minerals. At present, there are no proper statutory provisions for the Mine plan in case of Minor minerals.

SAND AND GRAVEL MINING METHODS

a) Bar scalping or skimming

Bar scalping or skimming is extraction of sand and gravel from the surface of bars. Historical scalping commonly removed most of the bar above the low flow water level, leaving an irregular topography [6-9]. Present method generally requires that surface irregularities be smoothed out and that the extracted material be limited to what could be taken above an imaginary line sloping upwards and away from the water from a specified level above the river's water surface at the time of extraction (typically 0.3 - 0.6 m (1-2 ft)). Bar scalping is commonly repeated year after year (Figure 1). To maintain the hydraulic control provided to upstream by the riffle head, the preferred method of bar scalping is now generally to leave the top one-third (approximately) of the bar undisturbed, mining only from the downstream two-thirds.

b) Dry-Pit Channel Mining

Dry-pit channel mines are pits excavated within the active channel on dry intermittentor ephemeral stream beds with conventional bulldozers, scrapers and loaders. Dry pits are often left with abrupt upstream margins, from which headcuts are likely to propagate upstream.

Fig 1: Bar scalping

c) Wet-Pit Channel Mining

Wet-pit mining (Figures 2) involves excavation of a pit in the active channel below the surface water in a perennial stream or below the alluvial groundwater table, requiring the use of a dragline or hydraulic excavator to extract sand and gravel from below the water surface. In some areas, such as low terraces, some glacio-fluvial deposits, and some ephemeral streambeds, sand and gravel mining may penetrate the water table and may be mined wet or dry. In some geologic settings, wet pits can be made dry by collecting the groundwater in drains in the floor of the pit and pumping the water out of the pit.

Fig 2 : Wet-Pit Channel Mining

d) Bar Excavation

A pit is excavated at the downstream end of the bar as a source of aggregate and as a site to trap sand and gravel. Upon completion, the pit may be connected to the channelat its downstream end to provide side channel habitat. On the Russian River, California, recent proposals for bar mining include leaving the bar margins untouched and excavating from the interior of the downstream part of the bar, but above the water surface elevation, a variant intermediate between bar scalping and bar excavation.

e) In-stream Gravel Traps

Sand or “bed load traps” have been used to reduce sand in downstream channels for habitat enhancement in Michigan. Such traps can also be potential sources of commercial aggregate, provided the amounts so collected are sufficient to be economically exploited. One advantage of the traps as a method for harvesting sand and gravel are the concentration of mining impacts at one site, where heavy equipment can remove sand and gravel without impacting riparian vegetation or natural channel features. Sand and gravel can be removed year after year from the bed load trap.

An idealized trap shown in Figure 3 has short dikes to create a constriction downstream and to hold the resultant higher stages. Sand and gravel are removed from the downstream end of the deposit, and a grade control structure at the upstream end of the trap prevents head cutting upstream from the extraction. There is no hydraulic impact upstream due to the extraction, because the engineered constriction is the hydraulic control during high flows. The concentrated flow scours a deep pool immediately downstream from the constriction, which may be important habitat in aggrading reaches where pool formation is limited by deposition.

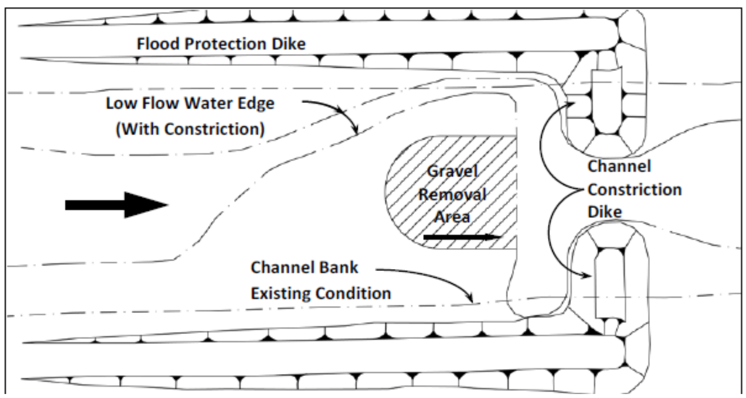

Fig 3: Idealized Sand and Gravel Trap

f) Channel-wide In-Stream Mining

In rivers with a highly variable flow regime, sand and gravel are commonly extracted across the entire active channel during the dry season. The bed is evened out and uniformly (or nearly so) lowered.

EFFECTS OF SAND AND GRAVEL MINING

The effects of sand and gravel mining are listed below:

a) Extraction of bed material in excess of replenishment by transport from upstream causes the bed to lower (degrade) upstream and downstream of the site of removal.

b) Bed degradation can undermine bridge supports, pipe lines or other structures.

c) Degradation may change the morphology of the river bed, which constitutes one aspect of the aquatic habitat.

d) Degradation can deplete the entire depth of gravelly bed material, exposing other substrates that may underlie the gravel, which could in turn affect the quality of aquatic habitat.

e) If a floodplain aquifer drains to the stream, groundwater levels can be lowered as a result of bed degradation.

f) Lowering of the water table can destroy riparian vegetation.

g) Flooding is reduced as bed elevations and flood heights decrease, reducing hazard for human occupancy of floodplains and the possibility of damage to engineering works.

h) The supply of overbank sediments to floodplains is reduced as flood heights decrease.

i) Rapid bed degradation may induce bank collapse and erosion by increasing the heights of banks.

j) In rivers in which sediments are accumulating on the bed (aggrading) in undisturbed condition, gravel extraction can slow or stop aggradation, thereby maintaining the channel's capacity to convey flood waters.
k) The reduction in size or height of bars can cause adjacent banks to erode more rapidly or to stabilise, depending on the amount of sand and gravel removed, the distribution of removal, and on the geometry of the particular bend.
l) Removal of gravel from bars may cause downstream bars to erode if they subsequently receive less bed material than is carried downstream from them by fluvial transport.

APPROPRIATE EXTRACTION SITES

a) Appropriate extraction sites are locations chosen based on knowledge of the local rate of aggradation or scour, a site-specific determination of channel stability and bank erosion and evaluation of riparian resources. Site-specific evaluation is needed to evaluate each proposed operation to minimize disturbance and maximise stability of channel [5]. In-stream extraction sites should be located where the channel loses gradient orincreases in width, and deposition occurs unrelated to regular bar-pool spacing in channel. Particular sites may include sites upstream of a bedrock constriction or backwater, or at deltas created near confluences.

STABLE CHANNEL DIMENSIONS

The stable channel dimensions can be determined from existing sediment transport equations such as Engelund-Hansen and Yang using the flow chart suggested by Chang (1988) as shown in Figure 1. Table 1 gives an example of stable channel dimensions for Sungai Mudaat the existing sand mining pit (CH 33.60) and Sungai Langat (CH 76715) at the upstream [5]. For the selected sediment size, flow discharge and sediment transport rate, the stable channel dimensions can be determined and stable channel cross section can be evaluated (Fig 3).

LEGAL FRAMEWORK FOR ENVIRONMENTAL PROTECTION AND MEASURES FOR IMPLEMENTATION

Present Legal Framework in SAARC Countries Environmental concerns can be translated into action in a variety of ways. Governments can restrict the harmful activities of their citizens through law, they can formulate policies and develop institutions to monitor and implement environrnental programmes and priorities, and they can alter the behaviour of their citizens by building up public awareness bout environmentally sound practices. In the last of these three tasks, they can be assisted by citizens groups and nongovernmental organizations. Environmental legislation in SAARC countries is in a state of evolution, with several countries having enacted environmental laws, many of which have been amended to reflect changing needs and the experience of implementation. In the same period, a variety of environmental institutions have come into existence in the region, with high level environmental institutions emerging in different countries. These perform the tasks of formulating environmental policy and the monitoring of environmental phenomena and activities that affect them. Finally, in most SAARC member countries efforts have begun to try and influence the public in their interaction with the environment.

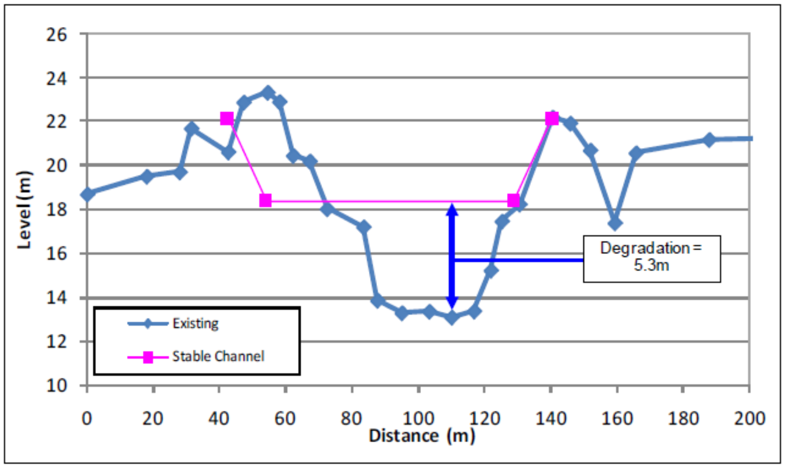

Fig 3: Existing and Stable channel cross section at a typical river section [5]

NATIONAL SCENARIO

Mineral-wise analysis revealed that building stone had the largest share of 24.5% to the value of minor minerals followed by brick-earth 20.9%, road metals 17.1%, marble 2.1%, ***ordinary sand 6.4%,*** quartzite & sandstone 5.2%, limestone 3.6%, gravel 3.3%, murrum 1.8%, kankar 1.5%,ordinary earth 1.4% and ordinary clay 1.1%. The remaining minerals together contributed 1.1% of value of minor minerals.

Under the Constitution of India, it is the duty of both the state and the irtizen to protect and improve the environment. This duty was included in the statutes in 1976. However, the first specific environment related legislation was enacted in 1972, namely, the Wildlife (Protection)A ct. The other specific acts which followed are the Water (Prevention and Control of Pollution) Act, 1914 to protect the quality of water; the Forest(Conservation) Act, 1980 to prevent diversion of forest land for other purposes except where unavoidable; the Air (Prevention and Control and Pollution) Act, 1984 to restrict air pollution; and, the Environment(Protection)A ct, 1985 as an Umbrella legislation to enable government to deal with environmental offenders of any kind. These acts, except for the Forest Conservation Act, are administered by the state governments and their agencies. This leads to a variation in implementation and procedures but uniformity is brought about by establishing national standards. The laws are reviewed periodically and if necessary amended to make them more effective. Rules have recently been ratified under the Environmental Protection Act of 1986f or handling of hazardous substances. Similarly, guidelines for controlling the release of genetically engineered microorganisms have also been issued under the Act.

Apart from Central laws specifically dealing with environment, a host of other enactments have a direct bearing on specific aspects. The Factories Act of 1941 for example, has provisions for ensuring industrial safety and control of effluents and emissions. The handling of toxic insecticides and pesticides is regulated by separate laws. The Explosion Act, Boilers Act, Motor Vehicles Act, Drugs and Cosmetics Act etc. have provisions based on environmental considerations. Many State level acts are also powerful instruments for environment management. For example, legislation related to land seeks to control land use. Town and country planning acts are effective tools for regulating urban and regional development. Municipal Acts have numerous clauses relevant to environmental concerns.

Administrative procedures have also been used to deal with environmental issues. In 1985 the Union government notified 22 types of highly polluting industries which would require environmental clearance from State governments before being granted a license or registration. Public sector investments which are potentially damaging to the environment are now scrutinized by MOEF before clearance. This is in addition to the clearances required under the Forest (Conservation) Act of 1980, the Air and Water Pollution Control Acts, and other statutes and regulations. This environmental assessment procedure is useful for appropriate planning and design of new, large projects. Since the environment issue is so wide in scope, there is no single, comprehensive Environmental policy statement of the government. A national conservation strategy is now under Preparation by a group of experts. The national forest policy was revised in 1988, and reiterates the goal of a 33 per cent forest cover for the country. There are also separate national policies on land use and water.

NEED OF ACCURATE ENVIRONMENTAL DATA

The lack of accurate environmental data at the micro-level is a problem which pervades the environment sector in India. The Indian Meteorological Department has a network of monitoring stations which have developed a strong data base. Climate modeling and weather forecasting is being refined by the Department of Science and Technology(DST). The Department of Space has launched a programme called the Natural Resource Management System(N RMS), which conducts research in aspect such as forest cover, soils, and coastal zones through remote sensing. The DST is executing another programme called the Natural Resource Data Management System which aims at developing methodologies for creating data bases to be used in micro-level planning for example, in mountain areas, semi-arid regions , coastal and offshore regions. The survey of natural resources is a prime input in any environmental information data base. The Botanical Survey of India has completed a survey of the floral wealth over about 60 per cent of the country. The Zoological Survey of India has surveyed about one-third of the country, identifying and collecting about one million specimens. The Forest Survey of India is engaged in analyzing the forests of the country, and publishes the 'State of Forests reports.

Other survey activities are carried out by the Survey of India, the Geological Survey of India, the Groundwater Survey and the National Remote Sensing Agency. Specific monitoring of Environmental indicators is being carried out under the National Water Quality Monitoring Programme. A national network for monitoring ambient air quality was initiated in 1984. The Environmental information System (ENVIS) was started in 1982 by the Indian government. The Network presently consists of 10 centers which concentrate on different issues such as pollution control, toxic chemicals, energy and coastal ecology. Each centre is expected to collect and store data on the subject allotted to it, and disseminate it through publications and in answers to queries. The entire system, however, till needs to draw upon the vast reservoir of environmental data collected by different institutions in the country.

The Council of Scientific and industrial Research (CSIR) carry out research through a Network of laboratories, some of which conduct research directly related to the environment for example, the National Environmental Engineering Research Institute, Nagpur; the Industrial Toxicology Research Centre, Lucknow and, National institute of Oceanography, Goa. Other Laboratories such as the Central Weather Research Institute, Madras, the Central Pulp and Paper Research Institute, Saharanpur, and National Chemical Laboratory, Pune, occasionally carry out Research on specific environment related subjects. In addition, there is a large amount of ongoing research in Indian universities and Institutes of Technology. Useful work is also being done by some NGOs.Research in forestry and wildlife is almost entirely coordinated by the Ministry of Environment and Forests with some support by State governments. The apex body for forestry Research is the Indian Council of Forestry Research and Education, Dehradun. The premier Research body under it is the Forest Research Institute, Dehradun. Wildlife research is conducted by the Wildlife Institute of India, Dehradun.

MOEF has also developed centers of excellence in the fields of environmental education, Ecological research, mine environment, and natural history, and provides them with financial support in priority areas of research. In addition, the Govind Ballabh pant Institute of Himalayan Environment and

Development has recently been established to coordinate and promote Research. There are no statutory provisions for the Mine plan in case of Minor minerals.

The Department of Mines and Geology Rajasthan has formulated the following guidelines for Ecofriendly mining for ***Minor Minerals*** and project proponents shall submit a duly approved Eco- friendly mining plan before applying for the consent.

1. Whenever the lessees dig out the available top soil, they may store it separately in such a manner that it could be utilized for stabilizing of dumps created by depositing overburden, by intensive plantation
2. For minerals like gypsum, brick earth etc. where mining is shallow for very small depths (1m to 5m), waste & overburden generated during mining operations, must be refilled. After leveling, top soil collected must be spread over it and suitable plantation should be done
3. All leaseholders should check the water channels in their mining lease areas and clear/clean them before the rains start. Water should flow in its natural path and there should be no obstruction created by way of unplanned mining activities
4. If some diversion of water channels becomes necessary due to availability of mineral in lease area at a particular location only, new drains following the contours be constructed by lessees, so that water flows un-obstructed to main water bodies/ponds / tanks/natural reservoirs
5. The overburden should not be dumped in such a manner that it flows with water in the nearby tanks, reservoirs and ponds etc. The leaseholders should dump the overburden in such a manner that it does not get washed away to the nearby water tanks and lakes etc. during the rainy season
6. All mining lease holders/quarry license holders are requested to plant a specific number of trees based on their area of lease so that they survive for longer time to come. It has to be ensured here that the mine owners should report the achievement of the target of tree plantation by way of giving number of plants that survive and not by the number of plants planted by them
7. The lessees of major and minor minerals having areas more than 5.00 hectares shall develop thick afforestation zone on the boundary of lease in atleast 10 meter strip. This can be achieved in steps and exact plan should be submitted to ME/AME. The plan must contain yearwise afforestation programme including site and nature of plantation. It shall also be duty of lessee to maintain growth of these plants and survival rate should not be less than 80%. Proper protection of these plantations is also to be ensured by the lessee
8. In all leases that are located adjacent to forest areas, a safe distance as provided in the rules should be left by leaseholders between the actual mining area and the forest boundary. The lessees of such leases should plant a specific number of trees to create a green buffer zone between the mining area and the forest. Such lessees may also construct loose stone/Pakka stone wall showing their working boundaries between the forest and the lease so that there is no possibility of even unintentionally movement towards the forest areas
9. Whenever mining reaches the water table, the leaseholder should dig a separate well in the lease area itself in which water from the mining pit is disposed with the objective of recharging the water table. By doing so, there would be no wastage of ground water due to mining operations close to the water table
10. Water pollution and air pollution clearances, wherever required are duly obtained by the lessees from the **State Pollution Control Board.** The lessees should prepare “Eco-friendly Mining Plan” on the above guideline and submit the mining plan in the prescribed Performa given in **Annexure 5** to DMG of Rajasthan.

GENERAL GUIDELINES FOR SAND AND GRAVEL MINING

The general guidelines based on critical review of global scenario for sand and gravel mining is as follows [5-11]:

a) Parts of the river reaches that experience deposition or aggradations shall be identified first. Operators may be allowed to extract the sand and gravel deposit in these locations to lessen aggradation problem.
b) The distance between sites for sand and gravel mining shall depend on the replenishment rate of the river. Sediment rating curve for the potential sites shall be developed and checked against the extracted volumes of sand and gravel.
c) Sand and gravel may be extracted across the entire active channel (refer Figure 1.2) during the dry season (May to September).
d) Layers of sand and gravel which could be removed from the river bed shall depend on the width of the river and replenishment rate of the river (refer Figure 1.1). e) Sand and gravel shall not be allowed to be extracted where erosion may occur, such as at the concave bank.
f) Sand and gravel shall not be extracted within 1,000 meter from any crucial hydraulic structure such as pumping station, water intakes, bridges, buildings and such structures. The cross-section survey should cover a minimum distance of 1.0 km upstream and 1.0 km downstream of the potential reach for extraction. The sediment sampling should include the bed material and bed material load before, during and after extraction period. Develop a sediment rating curve at the upstream end of the potential reach using the surveyed cross-section. Use both Yang or Engelund - Hansen equations and the measured bed material parameter. Using the historical or gauged flow rating curve, determine the suitable period of high flow that can replenish the extracted volume. Calculate the extraction volume based on the sediment rating curve and high flow period after determining the allowable mining depth.
g) Sand and gravel mining could be extracted from the downstream of the sand bar at river bends. Retaining the upstream one to two thirds of the bar and riparian vegetation is accepted as a method to promote channel stability.
h) Flood discharge capacity of the river could be maintained in areas where there are significant flood hazard to existing structures or infrastructure. Sand and gravel mining may be allowed to maintain the natural flow capacity based on surveyed crosssection history.
i) Alternatively, off-channel or floodplain extraction (see Figure 1.3) is recommended to allow rivers to replenish the quantity taken out during in-stream mining.

The mining of minor minerals has been increasing over the years and this has begun to have significant adverse impact on our ecology. Since there is currently no uniform framework to regulate the mining of minor minerals, Ministry of ENVIRONMENT & FORESTS, GOVERNMENT OF INDIA had constituted a Group under the Chairmanship of Secretary, Ministry of Environment & Forests to evolve guidelines for sustainable mining of minor minerals. Some key recommendations of the group vide D.O. No. Z-l1012/3/2oo9-IA.II (M) dated June 1st, 2010 includes:

• Minimum size of mine lease should be 5 ha
• Minimum period of mine lease should be 5 years.
• A cluster approach to mines should be taken in case of smaller mine leases operating currently
• Mine plans should be made mandatory for minor minerals as well
• A separate corpus should be created for reclamation and rehabilitation of mined out areas
• Hydro-geological reports should be prepared for mining proposed below groundwater table
• **For river bed mining,** leases should be granted stretch wise, depth may be restricted to 3m / water level, whichever is less, and safety zones should be worked out .
• The present classification of minerals into major and minor categories should be re-examined by the Ministry of Mines in consultation with the States.

For sustainable mining of minor minerals, all the chief ministers of the states were also requested by the Minister Of State (Independent Charge) ,Environment & Forests, Government Of India, to examine the report and issue necessary instructions for incorporating the recommendations made in the report (in March 2010). in the Mineral Concession Rules for mining of minor minerals, framed by your Government under Section 15 of the Mines and Minerals (Development and Regulation) Act, 1957.

CONCLUSIONS

In view of the present crisis of sand in Andhra Pradesh and in various states of India, appropriate guidelines should be formulated by suitable committee with the experts from government agencies, academia, researchers etc for use by relevant authorities and update the existing sand and gravel permitting policies or guidelines to achieve the following regulatory and management objectives:

1. to ensure that sand and gravel extraction is carried out in a sustainable way
2. to maintain the river equilibrium with the application of sediment transport principles
3. and suitable river model in determining the locations, period and quantity to be extracted
4. As an alternative to river sand, effort may be accelerated to prepare sand from rocks—i.e rock sand mining may be given a good boost by the respective state and central governments

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