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Environmental Impact of River Bed Mining- A Review

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ABSTRACT

The River plays a most important role in the terrestrial and aquatic ecosystem. Rivers are under immense pressure due to the various kinds of natural and anthropogenic activities among which indiscriminate extraction of construction grade sand and stones, are the major factor. River Bed Mining is the major activity occurring in all over the world for constructing the buildings, urbanization, roads and industries. The demand for the river bed materials increasing day by day due to manmade activities which may led the major environmental effects in and around terrestrial as well as aquatic ecosystem. For the development purposes the natural resources like river bed material (Sand, gravel, Cobbles and boulder) are the major raw material. The development of the country is mainly focused on the growth of urbanization and indusrtization of that country. The increasing demand of river bed materials, the illegal mining (sand mafia) and mining in the agricultural field, floodplain area are increase and its effect the health, physical process and different function of rivers, degradation of the riparian zone, degradation of aquatic and terrestrial biodiversity. There are many environmental effects are generated due to the unscientific and up hazard river bed mining. The present review paper deals with the environmental effects of indiscriminate River Bed Mining from the catchments basin of the river.

KEYWORDS: River bed mining, Environmental impacts, Review

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INTRODUCTION

The most important life nourishing systems of nature are a freshwater ecosystem, in which rivers are important and play a major role in the terrestrial and aquatic ecosystem. It transfers the water and minerals from the terrestrial environment to ocean realm[1, 2]. In India, there are many perennial, annual and seasonal rivers which provide a large amount of natural resources like Sand, Gravel, and Boulder. These materials are beneficial for the development of a country in way of urbanization and industries. River bed mining is the process of removal of sand, gravel and boulders from the river. The name of this raw material is based upon their size like if the size of material >256 mm then it is categorized as boulders and size varies between 64-256 mm Cobbles, Gravel/ Pebbles size varies between (2-64 mm) are divided into 5 types because of their Different Sizes, if size varies between 32-64 mm very coarse gravel, 16-32 mm coarse gravel, 8-16 mm medium gravel, 4-8 mm fine gravel, 2-4 mm very fine gravel[3]. Sand is a movable, non-cohesive granular material whose size varies between 0.063 mm and 2 mm [4]. Sand also divided into 4 types because of the different size, very coarse sand (1-2 mm), coarse sand (0.5-1 mm), medium sand (0.25-0.5 mm), fine sand (125-250 µm), and very fine sand (62.5-125 µm) respectively [3]. The term sand is used to cover almost any rock or mineral, but technically it is limited to quartz sand with a minor impurity of mica, iron oxides and feldspar[5]. Sand and gravel occur as sedimentary beds, lenses and pockets lying on or close to the surface or inter-bedded with other sedimentary formations. They take place in the river channel and floodplain deposits, fluvial glacial deposits, seashore deposits, windblown deposits along and near water bodies, marine and freshwater sedimentary beds and desert sand dune [6].The sand acts as a buffer against strong tidal waves and storm surges by reducing their impact as they reach the shore and it also a habitat for crustacean species and other related marine organisms. Sand is a vital part of beach attractions and hence, is important for the tourism industry[7].

The river bed mining practice is becoming an environmental issue as the demand for sand and gravel increases in industry and construction [6]. However, an increase in population and the rise in industrial and economic developments during the past few decades have aggravated mining of river sand many folds higher than natural replenishments which really made a host of damages to river ecosystems in the world. Individuals and private companies are increasingly demanding sand for construction purposes and this has placed immense pressure on sand and gravel resources[7]. With the increase in the demand of the river bed materials resulted in illegal mining of river materials like sand, gravel and boulder from rivers and in some regions, the river sand mafia came up to dominate the region. The demand for the stone aggregates also has resulted in illegal mining of stones which resulted in deforestation and soil erosion problems[8]. Sand is mined from beaches and inland dunes

and dredged from river beds and ocean beds. The unplanned housing schemes and uncontrolled mining of river bed materials paved way for the destruction of rivers. Exploiting the natural resources for the growing needs and all atrocious and fatal to the very life of humans and other organisms on the globe. Today, the illegal river bed materials miners engage modern machinery in mining sand, which it is against the principles of mining, and destroy the resources at an alarming speed. Of course, there are environmental laws to check the adverse impact of sand and gravel mining and the like on the environment and the social life in India[9].

Unscientific and haphazard river bed mining, in many of the occasions, lead to severe environmental problems like the degradation of the aquatic habitat of river ecosystem that need immediate attention and corrective measures. As the environmental impact of river minerals (sand, gravel and boulder) extraction becomes increasingly well understood in recent years, the practice has received increased scrutiny. The rivers that are harvested at rates in excess of natural replenishments often undergo channel degradation, causing incision of the entire river system including its tributaries. Striking cases of excessive sand and/or sediment removal are summarized by many researchers [10, 11, 12].

SCENARIO OF RIVERBED MINING AROUND THE WORLD

The riverbed mining activity is done in whole the world to construct the buildings, roads and urbanization. The river bed material like sand, gravel, Stone and Boulder are present in all the world rivers. The mining of these material legal and illegal, occurring because these materials are high economic value in all over the world. In the world, total 47 to 59 billion tonnes of material is extracted every year, in which river bed materials (sand, gravel and boulder) share the largest part (68% to 85%) of extracted materials. The mining activity of these materials shows the many environmental effects like air pollution, water pollution, soil pollution, noise pollution, threats to biodiversity (terrestrial and aquatic) and some socioeconomic impacts. Some researcher on all over the world studies the environmental effects created by the riverbed mining activity [10, 11,12,13,14,15,7].

In all the world, the different methods like (Manually and mechanically) is used to collect this material from the natural sources (Rivers, Lake, Floodplain area, Agricultural Field). The removal of material by manual process does not show a high environmental effect in comparison to the mechanically like Joseph Cyril Bamford (JCB**)** tractors are used to collect the material from the river in large scale. In all over the world, many researchers show the different types of environmental effect by the extraction of river bed mining on sea shore, floodplain area, rivers, lake, agricultural field, forest area. The details of the research are given below **Table 1.**

SCENARIO OF RIVERBED MINING IN INDIA:

India is the developing country and it is the 2nd largest populated country in the world. The infrastructure, industries and urbanization are the main key points for a development/ developing country. The main raw materials for construction of these key points are natural material like sand, gravel and boulders which are obtained by the rivers viz. Perennial, seasonal, and annual. India is the mega biodiversity country and in all the states of India, there are many rivers which provide these raw materials in large amount. The perennial river, in the northern region of India, the major rivers are: Indus, Ganga River, Yamuna River, Beas River, Jhelum, Satluj, Ravi, and Chenab provide a large amount of raw material. In central India, the major rivers are the Narmada, Tapi, Son, Indravati, Mahanadi, Waingangā, Betwa, Parbati, Chambal river and in south India the major rivers are Krishna, Periyar, Godavari, Bhima, Tungabhadra, Pennar, Palar, Ponnalyar, Kollidam, and Kaveri River provide the sand and gravel in the large amount for constructing the urbanization and industries for developing the country[8,9,16,17].

The rapid growths of the population across all states of India are affecting the all natural resources in which sand and gravel included. The unscientific mining of these materials shows the many environmental effects in and around the river ecosystem[6]. Some studies are showing the environmental effect due to the mining activities in across India. **Table 2** shows the description of rivers in which mining activities are going and which type of material was provided by the river.

EFFECTS OF RIVER BED MINING ACTIVITY IN AND AROUND THE RIVER ECOSYSTEM:

1. *Effect on River Morphology*

River morphology means the shapes and direction of river channels. The river channel morphology is a combination of many processes and environmental condition in which erodibility and composition of the bed and banks viz. Sand, stone, boulder; erosion by natural and anthropogenic activity, affect the formation of the river path[18].

Some anthropogenic activity like mining of riverbed materials (sand, gravel, stone and boulder) within a river channel causes the erosion and degradation of the river bank. The major effect of river morphology by the riverbed Mining activity is given by many others[19, 20, 10] follows ***Upstream incision:*** the head cutting of the river system for many kilometers by the mining process in the slope of the channel bed stream. The upstream incision causes the lowering of bed material of the main channel also lower the bed material of tributaries, by increasing their slope and causes their rapid erosion. ***Downstream incision:*** The downstream

incision occurs when the sediment mining is excessive and prolonged in river or stream. The excessive mining of sediments in downstream disturbs the sediment transport and its show the sediment deficit in the downstream. ***Lateral channel instability:*** the mining activity shows the channel instability, bank erosion, changing in channel width. ***Bed armoring:*** the excessive instream mining show the sediments deficit leads to washing of finer grains from bed material and it developed the bed armor. ***Effects of gravel bar skimming****:* The changes in the continuity of sediment transport induce downstream incision and lateral it shows instability of the channel. It removes the coarser surface layer of sediment that occurs in many natural rivers, favoring bed erosion and increasing bed load transport[10, 52].

2. *Effect on Water Quality:*

Rivers are the major sources of fresh water ecosystem. The rivers also recharge the groundwater of an area continuously. The quality of water ecosystem (Surface and groundwater) was disturbed due to the riverbed mining activity. ***Effect on Surface-water Quality:*** The riverbed mining effect on the surface water quality of a river due to the removal of materials in the bed of the river. The major effect of mining activity on the surface water of any river is turbidity level, TDS Concentration and conductivity of water had been increased due to the mining. Murray et al., studied some toxic elements like Arsenic, Selenium and zinc in river water are found in high levels after the mining operation[13, 14]. ***Effect on ground water Quality:*** The river bed mining causes the depletion of ground water by lowering the water table and its effect the process of groundwater recharge[21].

3. *Effect on Aquatic Biodiversity:*

Rivers are the habitat of many Aquatic animals, its cover the major portion of fresh water animal's phytoplankton, Zooplankton, Benthos and fishes. The bed material like Sand, stone and boulder are the Habitat of these animals. The riverbed mining activity affects these animals by removing of the sand, boulder and stones from the river. The turbidity of water affects the Phytoplankton and zooplankton. The Benthos are found on the lower side of stones and boulder, by removing the stones and boulder the habitat of benthos destroyed and its effect the population of the benthos in a river system. The riverbed mining activities affect the reproduction and characteristics of spawning nests of fish like salmon and trout[15].

4. *Effect on Riparian Biodiversity*

Riparian biodiversity includes vegetation cover on and near the river banks, which is very beneficial to control the bank erosion and provide the nutrients for the aquatic biodiversity. The mining activity instream and floodplain area of a river destroy the riparian

vegetation of the river and its shows the bank erosion[16]**.** The effect of riparian flora is due to the transportation of the River bed material from the river, floodplain mining and illegal mining near the bank of river. The riparian flora diversity is the interaction zone between the terrestrial and aquatic life. They provide food and other nutrients to aquatic animals, which is beneficial for the growth and development of the aquatic life. But due to the floodplain mining and illegal mining, the riparian floras of the rivers are destroyed like see in **Figure 1.** The degradation of riparian zone is caused by the need to create the space for stockpiles and haul roads. These haul roads created by the vehicle wheels and they formed the bare tracks. In rainy season, when water flows these tracks in contionous flow they causing erosin. After erosion material increase the Sedimentation, Turbidity and deposition of pollutants in the river[22]**.**

Figure1. The effect on riparian flora near the bank of River.

5. *Effect on Soil and Landscape*

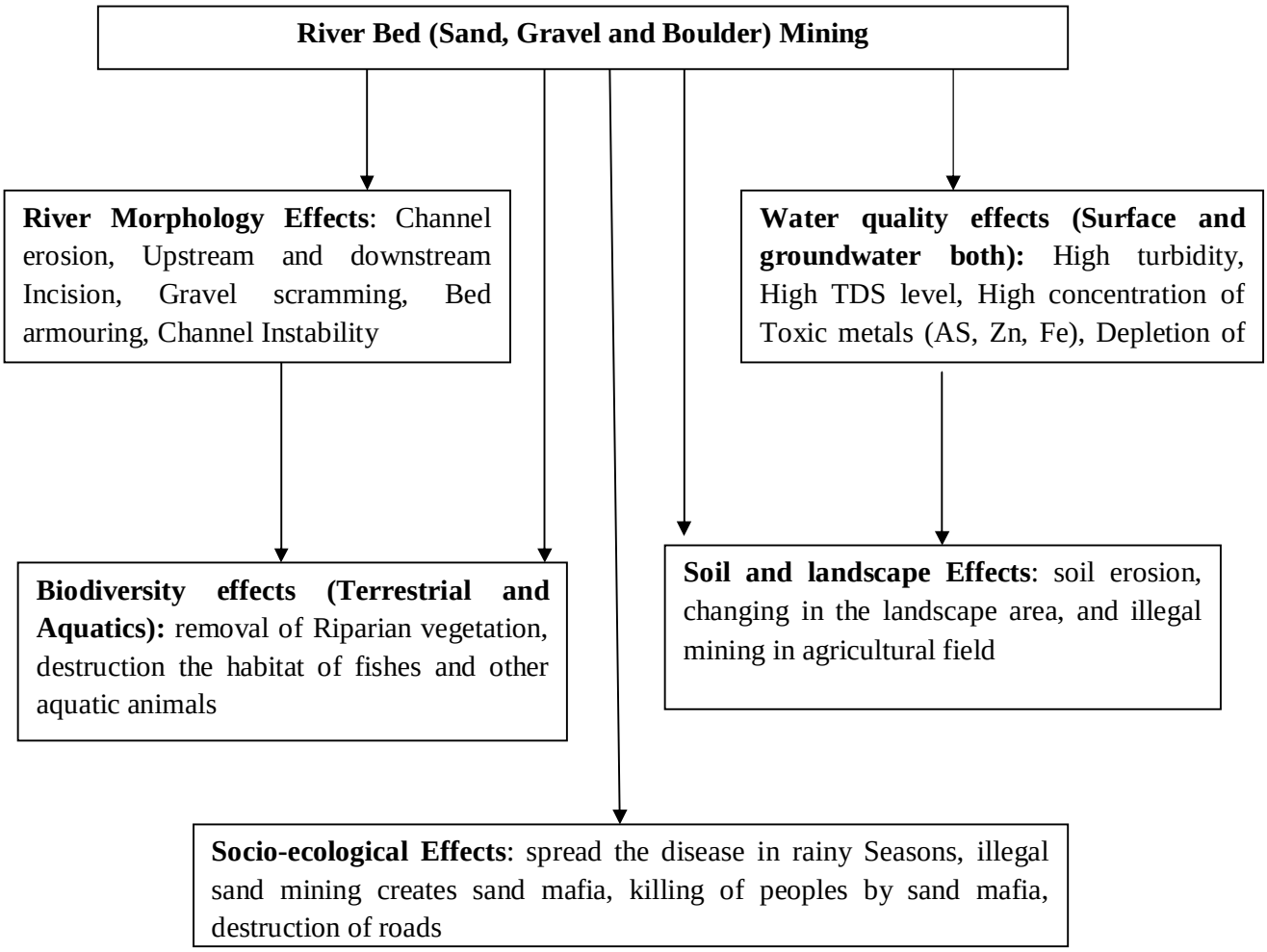
Sand and gravel mining activity responsible for shifting of river channel, degradation of river bank land, loss of fertile land, and changing in the landscape area. The high demand of sand and gravel, illegal mining is increase. In some area, the people remove the fertile soil from the agricultural land and after they take out the boulders from the agriculture land[23, 16,24,8]. The **Figure 2&3** show, how the people remove the fertile soil from the agricultural land for stone and boulder in illegal way. After remove the materials these lands are not use to agricultural purpose because of the remove of fertile soil from the field.

Figure 2. Illegal mining & erosion os sand near the active mining area.

Figure 3. Illegal mining activity in the agricultural field.

6. *Socio-Ecological Impacts*

There are some studies which show the socio-ecological impacts by the river bed mining activity in the form of loss or reduction of farm lands due to illegal mining, mining pits are the breeding habitat of the mosquitoes in rainy seasons, and spread the many diseases in local environment[25,26]. A study is conducted on sand mining and its social impact on local society in rural Bangladesh. In this study, they conclude the impact of sand mining and business utilizing it on local society, old people of the area say, the bank erosion is increase due to the sand mining activity, they lose their houses, agricultural fields. Total 29 households have transferred their main house from mining area for erosion[27].



Flow Chart: The Major Effect of River Bed Mining Activity on Different Environment Variables

GUIDELINES OF RIVER BED MINING (SAND MINING)

The sand mining process is held on all over the world for construction the roads, buildings, urbanization etc. For the high demand for these raw materials, create the many problems for the environment and our society. There are a different source of river bed materials, in which rivers are the most important source. The increasing demand for these materials, it effects on health, physical process and different function of the river. The extraction of river bed materials (sand, gravel and boulder) from river bodies has to be regulated and done with the adoption of required environment safeguards. In view of the scenario of all the country has prepared the sustainable sand mining management guidelines. These guidelines are focused on preparation of the district survey report, Marine Sand Mining and its impact on Biodiversity of Marine, Management plan, issue and management of mining in cluster, mining in agricultural field, management of sand deposited after flood on agricultural field of farmer, monitoring system for sustainable sand mining information

technology system, creation of district level environmental impact assessment authority, district level expert appraisal committee for granting the environmental clearance for mining of minor minerals, exemption of certain cases for environment clearance and standard environment condition for sustainable river bed mining[7].

MAJOR OBJECTIVES OF THE GUIDELINES FOR SAND MINING ACCORDING TO MOEF, 2016 (INDIA) ARE FOLLOWS

- To ensure the River bed mining is done in environmentally sustainable and socially responsible manner.
- To ensure availability of adequate quantity of aggregate in a sustainable manner.
- To improve the effectiveness of monitoring of mining and transportation of mined out material.
- Ensure conservation of the river equilibrium and its natural environment by protection and restoration of the ecological system.
- Avoid aggradations at the downstream reach especially those with hydraulic structures such as jetties, water intakes etc.
- Ensure that the rivers are protected from bank and bed erosion beyond its stable profile.
- No obstruction to the river flow, water transport and restoring the riparian rights and instream habitats.
- Avoid pollution of river water leading to water quality deterioration.
- To prevent depletion of ground water reserves due to excessive draining out of ground water.
- To prevent ground water pollution by prohibiting sand mining on fissures where it works as a filter prior to ground water recharge.
- To maintain the river equilibrium with the application of sediment transport principles in determining the locations, period and quantity to be extracted.
- Streamlining and simplifying the process for grant of environmental clearance (EC) for sustainable mining[7].

CONCLUSION AND RECOMMENDATION

The extraction of river bed materials causes the destruction of in and around the area of a river ecosystem. The extraction of riverbed materials shows many effects on different environment variables. The main effect of the river bed extraction is a change in the river morphology (Upstream and Downstream incision, channel erosion etc.). The changing of river morphology shows the flood condition of a river area. The removal of river bed materials causes the water quality of surface and

ground water. High turbidity and TDS value of any surface water decrease the amount of light intensity and this condition disturb the food chain of any aquatic ecosystem because the primary producers (Phytoplankton) does not survive in the high turbid water. In the bottom of the river, stone and boulders are the major habitat of benthos and fish species. They use the bottom for reproduction and to save their larva from the predators. But Mining activity in the bottom of river depletes the habitat of benthos and fishes. Many other effects are soil erosion and land use land change pattern of an area due to illegal mining. The transportation of raw material from the river to stone crusher also shows the destruction of roads, destruction of river bank and also destruction of riparian vegetation. From the above conclusion, it is recommended that large and small-scale mining activity may be allowed after the scientific study of that area. The mining activity is banned near the ecologically sensitive area. Mining activity allowed only those rivers in which Replacement rate of material is high. Mining should be allowed at a safe distance (buffer areas) away from the road/ rail/ building/ river etc. Research and developmental activities should be strengthened for updating resource database, technologies and management. Estimate the resource availability in the local body/region wise and its extraction to be considered in a sustainable and eco- friendly manner. The mining activity should be done in a sustainable way and according to the guidelines of sand mining.

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Table 1: Show Different Rivers and Locations Where Riverbed Mining Activities Occurring in The World

S.No.	Country/ Area	Name of River/ Tributaries/ Area	Mining Materials	Effects	References
1.	Victoria (Island Creek)	Goulbern River	Sand, Stone, and Gravel	Upstream Undermined, Destroying Road crossing and Red gum vegetation	[28]Carigie, 2012
2.	Western Sydney (Near Chipping Norton)	Georges River	Sand, Stone, and Gravel	Upstream incision, increasing tidal velocities, causing channel erosion	[29]Warner *et al.*, 1997
3.	Bathrust	Fish River	Sand, Stone, and Gravel	Course change through gravel pits	[30]Erskine, 1990
4.	Castlereagh	Nepean River	Sand, Stone, and Gravel	Course change through gravel pits	[30]Erskine, 1990
5.	Louisiana	Tangipahoa River	Sand, Stone, and Gravel	Bed degredation up to 6 m, increased erosion in downstream, highway bridge failed due to the bed degredation	[31]Mossa and Marks, 2011
6.	Southern California	Tujunga Wash	Sand, Stone, and Gravel	Bed degredation, three bridges and seven houses were destroyed	[32]Scott, 1973; [33]Bull and Scott, 1974
7.	California	San Benito River, Stony creek	Sand, Stone and Gravel	Channel widening, loss of bridges, bed degredation upto 3 m ,Change in alinghment of stony creek, bridge damage	[34]Harvey and Smith, 1998; [35]Kondolf and Swanson, 1993
8.	Washington State	Cowlitz River	Sand, Stone and Gravel	River Avulsion by gravel pit	[36]Norman *et al.*, 1998
9.	Clackamas, Oregon	Clackamas River	Sand, Stone and Gravel	Bed degredation upto 2 m and 500 m upstream of the pit	[37]Kondolf *et al.*, 1996
10.	Oregon	Rogue River	Sand, Stone and Gravel	Bank erosion and loss of power line tower near the river	[38]Klingeman, 1998
11.	California	Merced River+	Sand, Stone and Gravel	Changing in river pattern, excavated on floodplain or point bars	[37]Kondolf *et al.*, 1996
12.	Washington, USA	Yakima River	Sand, Stone and Gravel	Threatened an interstate highway, Channel shifted due to gravel p[its	[39]Dunne and Leopold, 1978
13.	Spain	Jarama River	Sand, Stone and Gravel	River Straighten due to the diversion of river through Gravel pits	[40]Uribelarrea *et al.*, 2003
14.	South America	Pilcomayo River	Sand, Stone and Gravel	Heavy metal contamination in water, sediments and macroinvertebrates	[14]Smolders *et* al., 2003
15.	South Africa	Nzhelele Valley, Limpopo province	Sand and Gravel	Land use changes, environment impacts, habitat and aesthetic beauty degredation, river system degredation, floodplain ponding and riparian zone degredation	[22]Kori and Mathada, 2012
16.	Bangladesh	Tangil District	Sand Mining	Social impact on local Society	[27]Khan and Sugie, 2015
17.	United Kingdom		Mining	Impact on fresh water environment	[41]Younger and Wolkersdorfer, 2004
18.	Northeastern Pennsylvania and	Susquehanna River	Coal mining	Impact on microinvertebrates on different river ecosystem	[42]Bruns, 2005

	Southern new York				
19.	China	Poyang Lake	Sand Mining	Impact on Hydrology and ecosystem services of lake	[43]Leeuw *et al.*, 2010
20.	North central Nigeria	Luku, Minna, Nigar state	Sand mining from Land and soil	Environmental effects due to mining activity on soil and land	[21]Ako *et al.*, 20104
21.	Illinois (USA)	Illinois River, Kings River	Gravel mining	Change in morphometry, physical habitat and sediment dynamics	[44]Brown *et al.*, 1998
22.	Southen Monterey Bay (U.S.)	Salinas River, Marina and Sand city	Sand Mining	Shoreline erosion in bay of Southern Monterey	[45]Thornton, 2007
23.	Virginia	Powell River System	Mine drainage	Impact on aquatic biota	[46]Soucek *et al.*, 2003
24.	New Jersey, U.S.A.	Offshores of New Jersey	Sand Mining	Disturbance in physical process (Wave, currents, Sediment Transport, disturbance in Aquatic fauna	[47]Byrnes *et al.*, 2004
25.	Canada	McQuesten River	Placer Mining	Disturb the habitat of sensitive fish	[48]Pentz and Kostaschuk, 1999
26.	Nepal	Tinau River	Riverbed extraction	Higher concentration of nitrate and phosphate, Physic-chemical properties of water	[49]Dahal *et al.*, 2012

Table 2: Show the Different Rivers and Locations Where Riverbed Mining Activities Occurring in India

S.No.	State	Name of River/ Tributaries	Area/ City/ Village	Mining Materials	Geography of nearby area (Plane/ Forest/ Agriculture)	References
1	Uttarakhand	Ganga River and its tributaries	Shyampur Kangri (Haridwar)	Sand, Bajri and Boulder	Forest and Agriculture area	[8]Kamboj *et al.*, (2012)
3	Haryana	Yamuna river	Narnaul, Gumthala	Sand and Stone Mining	Agriculture area	[50]Tejpal *et al.*, (2014)
4	Rajasthan	Banas River, Kantali River	Tonk, SIKAR, Nathdwara,	Sand and bajri Mining		[17]Shekahawat(2013) Report
5	Kerala	Chalakudy,Periyar and Muvattupuzha Rivers, Achankovil,Pamba, Manimala, Meenachil, Vembanad lake, Neyyar River	Kochi, Thiruvananthapuram	Sand mining	Forest and Agriculture area	[6]Sreebha and Padmalal (2011) [9]Padmalal *et al.*,(2008), [51]Shaji and Anilkaur (2014)
6	Tamilnadu	Bharathapuzha River	Chennai	Sand Mining		[9]Padmalal *et al.*,(2008),
7	Himachal Pradesh	Beas, Sutlej, Ravi, Chenab	Bilaspur, Kangra, Chamba Kinnaur, Kullu, Lahaul-Spiti, Solan, Una, Mandi Hamirpur, Shimla, Sirmour	minor minerals like sand, stone and bajri	Forest area	[16]Singh *et al.*, (2016)

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