# Subarnarekha River: The Gold Streak of India

**Chapter** · January 2018

DOI: 10.1007/978-981-10-2984-4_22



**2 authors:**

Abhay Kumar Singh
Central Institute of Mining and Fuel Research


Soma Giri
CSIR-Central Institute of Mining and Fuel Research, Dhanbad

# Subarnarekha River: The Gold Streak of India

**Abhay Kumar Singh and Soma Giri**

## 1 Introduction

The word "Subarnarekha" literally means "*streak of gold*." It is a combination of two words; "Subarna" meaning gold and "rekha" meaning line or streak in Indian languages. Traditionally, it is believed that gold was mined at a village named Piska near the origin of the river. This was the reason for the river being named as Subarnarekha. It has been known that gold particles were found in the Subarnarekha River bed sediments at ancient time. At some places, even today people are searching for the gold particles in the sandy beds of the river. As the tributaries of Subarnarekha flow over gold-bearing rocks of the Panch Pargana plain, they pick up particles of gold from the auriferous rocks for deposition in the bed of Subarnarekha. Still, it carries grains of the glittering metal which is often panned from its sandy bed by the local residents along the middle reaches of the river.

The Subarnarekha is a rain-fed river and ranked as the smallest river basin among fourteen major river basins of India. The Subarnarekha River originates near Nagri village (23° 18′ 02″N and 85° 11′ 04″E) in the Ranchi district and runs through some major cities and towns, i.e., Jamshedpur, Chaibasa, Ranchi, Bhadrak before joining to the Bay of Bengal near Kirtania port (21° 33′ 18″N and 87° 23′ 31″E) in Orissa. The catchment area of the Subarnarekha River basin extends over 19,296 km$^2$ and accounts for 0.6% of the geographical area of India (Roy et al. 2013). The total annual yield of water flowing within the basins is in the order of 7940 million m$^3$. The Subarnarekha River basin is bounded by north latitudes of 21° 33′ to 23°32′ and east longitudes of 85° 09′ to 87° 27′ and flows in the north-east corner of the Peninsular India (Fig. 1). Chota Nagpur plateau bounded the Subarnarekha River basin from the north-west side, while it is

A.K. Singh (✉) · S. Giri
Natural Resources and Environmental Management Group, CSIR-Central Institute of Mining and Fuel Research, Barwa Road, 826015 Dhanbad, India
e-mail: singhak.cimfr@gmail.com



D.S. Singh (ed.), *The Indian Rivers*, Springer Hydrogeology,
https://doi.org/10.1007/978-981-10-2984-4_22

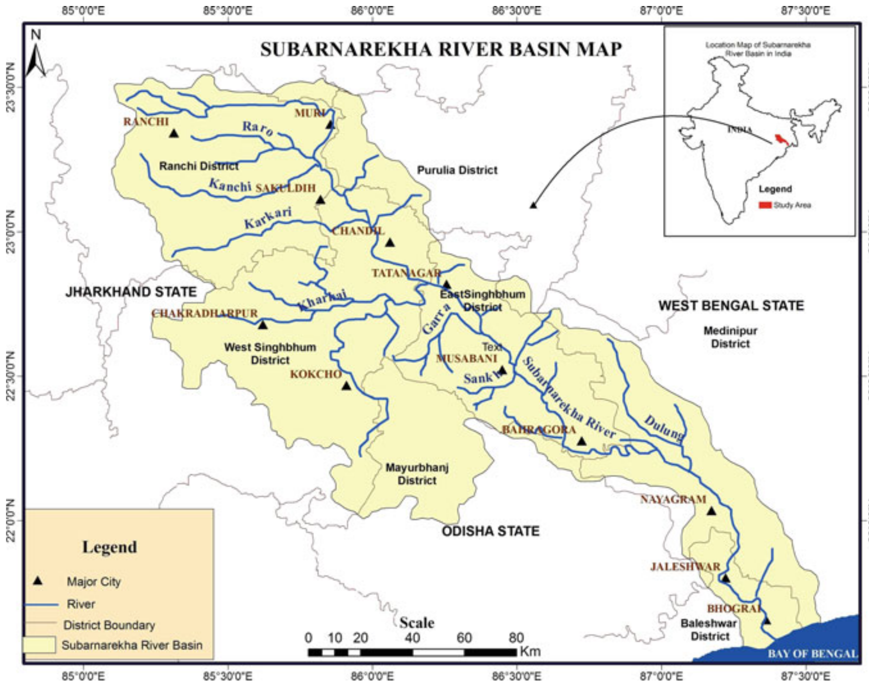


**Fig. 1** Location map of Subarnarekha River basin

**Table 1** State-wise distribution of the Subarnarekha drainage area

| S. No. | Name of the state | Catchment area ($km^2$) | Percentage |
|---|---|---|---|
| 1 | Jharkhand | 13,193 | 68.4 |
| 2 | Orissa | 3,114 | 16.1 |
| 3 | West Bengal | 2,989 | 15.5 |
| | Total | 19,296 | 100 |

*Source* Survey of India (1923–1979), Rao (1975)

restricted by the Brahmani River basin in the south-west, Burhabalang River basin in the south, and by the Bay of Bengal in the south-east side. The Subarnarekha flows through Ranchi, Saraikela, and east Singhbhum districts of Jharkhand, west Midnapore district of West Bengal, and Balasore district of Orissa. It flows a distance of about 395 km from its origin before falling into the Bay of Bengal. Out of the total travel distance of 395 km, river flows 269 km in Jharkhand, 64 km in West Bengal, and 62 km in Orissa (CBPCWP 1986; Giri and Singh 2014a). Subarnarekha is a very important river to satisfy the irrigation, industrial, and municipal water demands of these three states. The state-wise distribution of the catchment area and its percentage in respect to the total river basin drainage area are given in Table 1.

## 2 River Course and Major Tributaries

The River Subarnarekha is originated near the Nagri village, at a distance of about 15 km south-west of Ranchi, the capital of Jharkhand (Fig. 2a). On the Ranchi plateau, the river lazily winds its way for 60 km till its water plunge down a 74-m-high cliff, creating a scenic waterfall known as Hundru Fall (Fig. 2b). The river thereafter flows through a 25-km-long-deep gorge till it emerges out of the Ranchi plateau and debouches on the flatter piedmont plain of Panch Pargana. By now, the river swells fairly big, some 500 m wide. After having travelled through a course of 145 km over the Panch Pargana plain, the river cuts through a narrow defile across the volcanic lavas of Dalma range. After emerging from the range, the river sweeps through a fairly wide floor of the Dhalbhum valley for another 150 km till it finally leaves the rocky granitic terrain of Jharkhand and takes to a more meandering course on the unconsolidated alluvial material in the Medinipur district of West Bengal and Balasore district of Orissa (CBPCWP 1986; Jain et al. 2007). After several turns, the river eventually empties its enormous volume of water along with its rather heavy silt load into the shallow shelf of the Bay of Bengal at Kirtania near Talsari (Fig. 2c).


**Fig. 2** **a** The origin place of the Subarnarekha River at Nagri village, **b** Subarnarekha plunge down a 74 m high cliff at Hundru (Hundru Fall), **c** the river near mouth at Kirtania, **d** confluence of Subarnarekha and Kharkai rivers at Sonari near Jamshedpur

**Table 2** Major Tributaries of the Subarnarekha River

| S. No. | Name of the tributary | Bank | Length (km) | Catchment area (km$^2$) | % of the total basin area | Annual yield (MCM) |
|---|---|---|---|---|---|---|
| 1 | Raru | Right | 50 | 622 | 3.22 | 250 |
| 2 | Kanchi | Right | 80 | 1036 | 5.37 | 750 |
| 3 | Karkari | Right | 120 | 1575 | 8.17 | 950 |
| 4 | Kharkai | Right | 145 | 5825 | 30.19 | 3300 |
| 5 | Garra | Right | 55 | 483 | 2.50 | 200 |
| 6 | Sankh | Right | 30 | 196 | 1.02 | 80 |
| 7 | Other streams of right bank | Right | – | 4812 | 24.94 | 970 |
| 8 | Jumar | Left | 35 | 182 | 0.94 | 70 |
| 9 | Dulung | Left | 75 | 1173 | 6.08 | 500 |
| 10 | Other streams of left bank | Left | – | 4760 | 17.64 | 870 |
| | Total | | | 19,296 | 100 | 7940 |

*Source* Survey of India (1923–1979), Rao (1975)

The Subarnarekha has an asymmetrical catchment basin; the right-bank tributaries draining more than three-fourths of the total basin area, whereas the left-bank tributaries drain hardly one-fourth of the basin. On the right bank, there are four major tributaries, the Raru, the Kanchi, the Karkari, and the Kharkai, draining between them nearly half of the Subarnarekha basin, covering around 9050 km$^2$ area, while on the left side there is only one sizable stream, namely the Dulung, which drains an area of some 1173 km$^2$ (Table 2). The Kharkai is the largest tributary of the Subarnarekha originated on the slopes of the Simlipal massif in Mayurbhanj district and contributing nearly 45% of the total annual flow of the Subarnarekha River. It drains a catchment area of 5825 km$^2$ and flows through a course of 145 km before joining Subarnarekha at Sonari near Jamshedpur town (Fig. 2d). The Kharkai is also a gold-bearing river, some of its tributaries like the Sanjai, Sona Sanhua, and the Bonai are known to have placer gold in their beds.

## 3 Geomorphology and Geology

The Subarnarekha cutting across the Dalma range gives the impression of an antecedent drainage. Such a situation could arise if the main highlands and the Dalma ranges are uplifted sequentially, so that, the river emanating from the central highland is consequent but is antecedent to regions of later uplift as the Dalma ranges. Alternatively, the Subarnarekha may have eroded down its position over the then existing surface over the Dalma Range consequent upon lowering of sea level. In the latter case, it would be superposed river. Detailed work on the geomorphic controls on drainage system may address these questions. The most significant landscape element of the Subarnarekha basin in its eastern course is marked by the presence of river terraces (Mahadevan 2002). The terraces are of two to three generations and vary widely in their extent and relief. Perhaps, representing the oldest are the terraces recognized north of Tatisilwai in the Ranchi plateau region. However, more prominent are the terraces recorded in the downstream, where the river crosses the Dalma ranges. Both bedrock type and alluvial/gravel terraces occur in the tributaries of the Subarnarekha draining the western margins of the Ranchi plateau, such as the Sobha, Raro, Kanchi, Garra Sanjai, Kharkai, and Jamir. Mukhopadhyay (1973) recognizes 3-tier terraces: the upper, middle, and lower; and upper and lower flood plains in the Kharkai and the Subarnarekha near Tata Nagar. In the Sanjai basin, the two terrace levels have diverging relief from the present river floor, implying changes in plantation and deposition patterns. The Sanjai–Kharkai basin itself has features of an etch plain, offering evidences of "inversion of relief."

Prominent developments of terraces have been described from the lower Subarnarekha valley. Niyogi (1968) records 3-level terraces in the areas close to Baharagora–Jamsola on the northern bank of Subarnarekha. These are at elevations of 74, 61, and 49 m above mean sea level (amsl). The most prominent of these is the highest terrace, traceable from SW of Baharagora to near Jamsola. The terrace has a maximum width of some 2.5 km, a prominent natural levee, 2–3 m high, and about 500 m wide. The other terraces are much smaller in their dimensions. All the terraces comprise thin alluvial cover over the lateritized basement of the country rocks (Chaibasa formation).

A prominent erosion surface is described from the western bank of Subarnarekha near Dhalbhumgarh by Dunn and Dey (1942). The surface occurs 110–120 m above the river and exposes coarse gravel beds that are correlated with the Dhalbhumgarh Tertiary gravels exposed to the NE bank of the river. Dunn and Dey (1942) suggest differential warping or uplift along the western flank of the order of 100–120 m, possibly in the Pliocene or even the Miocene age. Presence of terraces was reported in the lower reaches of the river catchment at elevations of 75 m and 66 m amsl, each some of 12 m in height. In places, there are indications of a third terrace also. Niyogi (1968) also records terraces in the downstream of the river at 49 m, 34 m, 12 m, and 9 m amsl separated by modified scarp faces. The development of the terraced surfaces is generally considered to be tectonic uplift of the Chota Nagpur plateau region during the quaternary, particularly in the Holocene period. However, another important factor that may explain the relatively smaller features as the river terraces and flood plain fillings is the eustatic changes in sea levels during the Quaternary, which would have greatly influenced the dynamics of the river systems.

Indian Shield occupies the major parts of the Subarnarekha river basin, and ancient Precambrian igneous and metamorphic rocks are mainly exposed in these areas. The younger geological formation namely, Tertiary gravels, Pleistocene alluvium, and Recent alluvium are exposed only in the lower reaches of the basin at south-east of the Ghatsila. Shallow alluvial formation covers parts of the Shield area, especially in the eastern part of Ranchi district. The geological age of the rock formation of the Subarnarekha river basin is widely ranged. It ranged from 3.8 billion years old older Metamorphic Group of rocks (including tonalite gneiss) in parts of Mayurbhanj district to the most recent deltaic alluvium. Pelitic schist, calc-magnesium metasediments, ortho-amphibolites, tonalite-trondhjemite, banded iron formation, mafic lavas, phyllites, shales, metapellites, quartzite, mafic lavas, soda-granites, granitic gneiss, dolerite dyke swarms, and gravels are the major litho units associated with the geological formations of the basin. The soils in the Subarnarekha basin are derived from diverse parent materials and can be divided into three groups: (i) alluvial soils, (ii) red soils, and (iii) latosols. The red soils cover more than 83% of the basin area mainly in the upper reaches of the basin. River-born alluvial soils cover 11% of the basin area and mostly confined in the lower valleys and coastal plains. The remaining 4% of the basin area are covered by the infertile latosol (mainly laterites).

# 4 Socio-Economic Importance

## *4.1 Water Resource and Its Uses*

Since the basin is located in the moderately heavy rainfall area of Peninsular India, especially along the belt of storm tracks originating in the Bay of Bengal, it receives a substantial quantity of rainwater (about 28,609 million cubic meters) every year (CBPCWP 1986). About 82% of the total annual flow actually occurs over only four wet months (June–September), while in the remaining part of the year, the Subarnarekha River and its tributaries run almost dry. If the total annual flow is taken into consideration, the mean discharge of the river would come around 250 $m^3$/s. At places, especially in the upper and the middle reaches, the river flow during the dry period becomes sluggish, and it behaves like a stagnant pool of water, often highly charged with pollutants. The Subarnarekha and its tributaries are sustaining a large population of Jharkhand, West Bengal, and Orissa and form the main sources of urban water supply. The water resources of the Subarnarekha River basin are summarized in Table 3.

Though Subarnarekha basin is rich in mineral and mineral-based industries, it is still dominated by its agrarian economy. Agriculture, as an economic activity, has not yet been properly developed within the Subarnarekha basin, and necessary inputs including irrigation facilities are still rather inadequate. About 62% of the basin area is classified as cultivable, and nearly 31% is devoted to forests. The forests within the basin are in poor state of maintenance and required rigorous protective measures. The net sown area occupies 40% of the basin, while 22% is left unused as fallow land or as cultivable waste (Table 4).

The Subarnarekha River basin presents a classic example of conflict among competing uses of water both sectorally and across regions. The river water has

**Table 3** Water resource potential of Subarnarekha River Basin

| | |
|---|---|
| Total renewable water resource ($km^3$) | 12.37 |
| Potentially utilizable surface water resource ($km^3$) | 6.8 |
| Potentially utilizable groundwater resource ($km^3$) | 1.7 |
| Total potentially utilizable water resources ($km^3$) | 8.5 |
| Total renewable water resource per capita availability ($m^3$) | 829 |
| Potentially utilizable water resources per capita availability ($m^3$) | 568 |
| Water withdrawal per person ($m^3$) | 374 |
| Net irrigated area (million hectare) | 0.55 |
| Irrigation intensity (%) | 124% |
| Groundwater irrigated area (% of net irrigated area) | 43% |
| Grain crop irrigated area (% of net irrigated area) | 88% |
| Overall irrigation efficiency (%) | 45% |

*Source* CWC (2002)

**Table 4** Land-use pattern of Subarnarekha River basin

| Land use | Area ($km^2$) | Percent of the total catchment area (%) |
|---|---|---|
| Cultivated | 7,719 | 40 |
| Cultivable waste/uncultivated (Fallow) | 4,338 | 22 |
| Forest | 5,934 | 31 |
| Orchard | 350 | 2 |
| Other use | 955 | 5 |

*Source* Das Gupta (1980), CBPCWP (1986)

been used by different agencies for different purposes. It is used by industry as a direct process input and as a disposal agent for the dilution of effluents; by agriculturists for irrigation; and by household sector for drinking and other domestic uses (Jain et al. 2007). A number of irrigation and multipurpose projects were initiated to fulfill the water and energy demand of the eastern region. This includes Subarnarekha Multipurpose Project, an inter-state project in Jharkhand, West Bengal, and Orissa; Kanchi Irrigation Schemes, and ten Medium Irrigation Projects of Jharkhand. The main objectives of the Subarnarekha Multipurpose Project (SMP) are (i) to provide reliable water supply to agricultural lands in Jharkhand, Orissa, and West Bengal, (ii) to supply 740 million $m^3$ water per year for municipal and industrial uses in Jharkhand, (iii) to reduce flood damage in Orissa and West Bengal by constructing 463 million $m^3$ flood-storage capacity dam at Chandil, (iv) to construct embankments by Orissa and West Bengal governments in their respective territories along the flooding reaches of the river, and (v) to generate 30 MW of hydroelectric power through medium, mini-, and micro-hydroelectric projects located at various points of the canal system.

The Subarnarekha Multipurpose Project was initiated in 1982–83 with the objective of irrigation, hydropower generation, and water supply. However, the feasibility and economic viability of the project have decreased due to the attempts to implement all project components simultaneously and the consequent delays. This Multipurpose Project envisaged the construction of two dams, one at Chandil across the Subarnarekha and the other across the Kharkai at Icha near Chaibasa, two barrages at Galudih across the Subarnarekha and the other across the Kharkai at Ganjia near Adityapur and a network of canals from these. Three small storage reservoirs at Haldia, Jambhira, and Baura and a network of canals from these reservoirs are also proposed in Orissa. However, the construction work of Chandil dam and Galudih barrage is only completed, while all other components are either delayed or still incomplete.

A multipurpose reservoir is constructed across the Subarnarekha River at Getalsud (23° 27′N and 85° 33′E), about 40 km east of Ranchi city in 1971 to meet

**Table 5** Water storage/diversion structures of Subarnarekha River basin

| S. No. | Dam/barrage | Completion year | River | Purpose |
|---|---|---|---|---|
| 1 | Hatia Dam | 1963 | Subarnarekha | Irrigation |
| 2 | Sitarampur Dam | 1964 | Kharkai | Irrigation |
| 3 | Getalsud Dam | 1971 | Subarnarekha | Hydroelectric, irrigation, water storage |
| 4 | Kakudajodi Dam | 1976 | Kukudajodi | Irrigation |
| 5 | Nesa Dam | 1978 | Nesa | Irrigation |
| 6 | Kharkai Dam | 1984 | Kharkai | Irrigation |
| 7 | Lorgara Dam | 1985 | Kharkhai | Irrigation |
| 8 | Palna Dam | 1985 | Ranka Jhuria | Irrigation |
| 9 | Haladia Dam | 1985 | Haladia | Irrigation |
| 10 | Rissia Dam | 1986 | Tangana nalla | Irrigation |
| 11 | Jambhira Dam | 1986 | Jambhira | Irrigation |
| 12 | Dimu Dam | 1989 | | Irrigation |
| 13 | Sunei Dam | 1990 | Sunei River | Hydroelectric, irrigation |
| 14 | Torlow Dam | 1990 | Torlow | Irrigation |
| 15 | Sonua Dam | 2009 | Sanjay | Irrigation |
| 16 | Nakti Dam | 2010 | Bijay | Irrigation |
| 17 | Raisa Dam | U/C[a] | Kanchi | Irrigation |
| 18 | Chandil Dam | U/C[a] | Subarnarekha | Hydroelectric, irrigation, water storage |
| 19 | Galudih Barrage | U/C[a] | Subarnarekha | Irrigation |
| 20 | Icha Dam | U/C[a] | Kharkai | Hydroelectric, irrigation |

[a]Under construction
*Source* Water Resources Information System of India (2014)

municipal water demands of Ranchi town, industrial needs of the Heavy Engineering Corporation (HEC), and other industrial units of the adjoining areas. Getalsud dam has a catchment area of 717 $km^2$, dam height of 35.5 m, and water storage capacity of 288.5 $Mm^3$. Two powerhouses of 65 MW capacities each have been also commissioned near to dam site. Both the powerhouses have one unit of 65 MW each (Jain et al. 2007). Some of the major water storage/diversion structures of river basin are summarized in Table 5.

## *4.2 Mining and Industrial Activities*

The upper part of Subarnarekha basin harbors some extensive mineral deposits, and thus, a number of industries have been established along the banks of the river. The mineral resources of Subarnarekha basin are mainly comprises of ores of Cu, Fe, U, Cr, Au, V, industrial minerals including kyanite, asbestos, barytes, apatite, china clay, talc, limestone, dolomite, and building stones (Giri et al. 2013). All these have been exploited for various purposes, some on large scale and some on small scale. The arc-shaped Singhbhum copper belt between Mayurbhanj and Singhbhum districts at the right bank of the Subarnarekha ranked as the one of the richest copper-bearing horizons of India. Rakha, Mushabani, and Surda were historically important centers for the copper mining in this region. Subarnarekha also has to bear country's richest uranium deposits, and mining activities are taking place near Jaduguda areas of Singhbhum district by the Uranium Corporation of India (UCIL). Jaduguda, Turamdih, Batin, and Narwapahar are the major centers of productive uranium mines. Deposits of chromite associated with ultramafic intrusive rocks were reported in the Chaibasa region of Jharkhand. Iron ore deposits occur at Gorumahisani, Badampahar, and Sulaipat areas. There are several deposits of kyanite occur in the Subarnarekha River basin including India's richest deposits at Lapsa Buru. The basin studded with numerous small quarries for building stones and road metals. Slabs of dolerite, Singhbhum granites, Kolhan limestone and sandstone, and Chota Nagpur granite–gneiss are extensively used in building and road constructions.

The Subarnarekha River passes through an industrial rich belt of Jharkhand and Orissa. There are four major industrial areas occur along the bank of the Subarnarekha: (i) Ranchi–Hatia industrial area, (ii) alumina processing plant at Muri, (iii) the iron and steel plant and industrial complex at Jamshedpur, and (iv) Jaduguda–Ghatsila mining and industrial complex. Heavy Engineering Corporation (HEC), Usha Martin Industries, MECON, Steel Authority of India (SAIL), Indian Aluminum Industries, Tata Steel, TELCO, Indian Tube Company, Tin Plate (of India), Tata Pigments, Hindustan Copper Ltd., and Uranium Corporation of India are the major existing industrial units in the basin. Other important small- and medium-sized industries in the basin are tobacco products in Chakradharpur; cement, asbestos sheets, glass, and ceramics at Chaibasa; locomotives and coaches, automobiles, agricultural equipments, wires and cables, iron and steel machinery, metal tubes and conduits, copper and brass, chemicals and caustics, fertilizers, and soaps are the other industries exist at Jamshedpur. Studies have indicated that the water quality of Subarnarekha River has deteriorated mainly due to discharge of untreated, domestic and industrial, and mining effluents at various river stretches (CBPCWP 1986).

### 4.3 Natural and Anthropogenic Hazards

The river "Subarnarekha" is the lifeline for tribal communities inhabiting the Chota Nagpur region and the people of the north Orissa. It does not merely represent a river but means a lot more than that for this region. However, it has also become the death line when it submerges major areas of Balasore such as Bhogarai, Baliapal, Basta, Jaleswar blocks, and some parts of Rasgovindpur block of Mayurbhanj every year during rainy season, causing large-scale devastation in the villages situated on both sides of the river. Every year, people suffer from the same problem; the only change is in the intensity of the flood. Annual average rainfall in the basin is in the order of 1250 mm with the maximum and minimum rainfall recorded as 1420 and 1150 mm, respectively. Out of this, about 90% of this rainfall is recorded during the south-west monsoon season, i.e., June–October (Jain et al. 2007). The water level of the Subarnarekha rose beyond its danger line due to heavy rain in July 2007, and it crossed the previous highest flood level (HFL) of 12.2 m recorded in 1997. Flash floods due to heavy rainfall in the upper catchment areas were also recorded in the Subarnarekha River in year 1973, 1974, 1977, 1978, and 2009 (Maiti et al. 2009). The floods were devastating in nature; it took many lives and submerging thousands of houses and destroyed thousands of hectare kharif crops. Severe deforestation, rapid urbanization, industrialization, and severe soil degradation in the upper catchment of the Subarnarekha basin were the main causes for such ecological disaster.

Throughout the Subarnarekha basin, the soil mantle has been subjected to heavy erosion, and the topsoil is liable to be washed down the river if adequate protection is not provided immediately. Erosion control and soil conservation in the upper catchment are therefore essential for sustainable agricultural development and conservation of the water resources of the Subarnarekha basin. Certain parts of Jumar sub-basin have also been severely affected by gully erosion. There is great fluctuation between the wet season and dry season flows if the total annual flow is taken into account. The fact is that the entire amount of annual flow is actually spread over the four wet months (June–September). During the flood stage, the Subarnarekha turns into a large, turbulent stream of highly turbid water and is charged with sediments of yellow ochre color. The silt load during the rainy season is very high, indicative of heavy soil erosion, especially in the upper catchment zone. While floods occur frequently in the wet season, during the rest eight months, the flow in the Subarnarekha drops down to a mere trickle, leaving the river as a series of fordable pools of water almost throughout its length, barring the tidal and lower estuarine stretch of the course.

Subarnarekha's rich natural resource base has proved to be disastrous for the basin. Large-scale environmental degradation of the basin owes to the unplanned and unregulated mining and mineral processing industries. Unscientific mining practices and unplanned dumping of wastes and mining tailing create many environmental problems in the region. The erosion and transportation of wastes from exposed dumps and mining tailing during the monsoon seasons increase suspended solids and heavy metal loads in the river water and caused siltation in the dams and reservoirs. Mining of construction and building materials, such as granite, basalt, quartzite, dolerite, sandstone, limestone, dolomite, gravels, and river sands, has created many environmental problems and created vast stretches of wasteland in the river basin. The copper mining around Ghatsila and Mosabani has degraded the water quality to a large extent, and in many places, concentration of toxic metals was observed above the prescribed limits. There is also apprehension about water contamination due to seepage of radioactive waste from tailing ponds of the Uranium Corporation of India near Jaduguda areas. Radioactive pollution is a serious health hazard in the water bodies of the region which necessities precautions to be taken. The mine tailing and dumps of injurious minerals must be carefully monitored for assessing their possible impact on the environment in the Subarnarekha basin.

Besides mining, the other factors responsible for pollution in the river are considerable amount of domestic and industrial wastewater generated from the towns which is discharged into the river. For mitigating pollution, proper remedial measures should be adapted in the towns and the industrial units responsible for polluting the surface water and groundwater systems. The locations around Tatisilwai, Muri, Ghatsila, Mosabani, and Jamshedpur indicate severe pollution in the Subarnarekha River (Giri and Singh 2014b). The need of stringent control of the quality of the industrial, mining, and domestic wastewater effluents discharged into the river is utmost important because the total volume of water flows in the river on the whole is on the lower side, especially during the dry season. During the long dry period, the Subarnarekha turns into stagnant brook, and at many places, it losses pollutants diluting capability and totally incapable of washing down the pollutants discharged into it from the urban and industrial centers such as Hatia, Ranchi, Muri, Jamshedpur, Jaduguda, and Ghatsila. The surface water quality in the greater part of the Subarnarekha River is graded as classes D and E on the basis of laboratory measurements of the constituents (CBPCWP 1986). Upgradation of the existing river water quality requires an appropriate treatment. It would be necessary to take up a well-planned pollution control action program not only at different towns and industries, but throughout the basin.

## 5 Conclusions

Subarnarekha is an important inter-state river sustaining about fifteen million people of Jharkhand, West Bengal, and Orissa. However, the environmental condition of the river is deteriorating day by day with the increase in mining and industrial activities of the basin. Considering the great endowment of natural resources in the mineral-rich basin of the Subarnarekha River, it is high time that a well-integrated plan for ecological development and natural resource management along with pollution control measures has to be formulated for the basin immediately. The action plan for prevention of floods and control of water pollution in the Subarnarekha basin must have to be carried out in an integrated manner involving massive programs of reforestation, afforestation, soil protection, water conservation, water storage, and moisture management throughout catchment area, besides controlling the discharge of pollutants from towns, industries, and agriculture fields. The Subarnarekha River which behaves like a mighty river during the monsoons dramatically turns into more or less stagnant pools of water held in hollow and potholes in the river bed during the summer season. At many places, river lost its pollutants washing down capability. To mitigate the pollution load in the river, some effective measures would have to be taken to regulate the monsoon flow and raise the dry season flow to a reasonable level for dilution of the pollutants. The distribution of available water resource in different sub-basins within the Subarnarekha River system and the consequent possible change of water regime both in the dry and wet seasons, after building of adequate number of water storage reservoirs in the upper catchment areas, have to be worked out.

Over the years, the frequency of floods is found to have increased to a considerable degree especially in the lower part of the Subarnarekha catchment. The water-holding capacity, especially in the upper parts of the catchment area, has been considerably reduced due to severe deforestation, rapid urbanization, extensive industrialization, and fast degradation of the soil mantle. Appropriate land and water resource management, massive afforestation, and corrective land-use planning are essential to abate water pollution, to control the soil erosion, and to enhance the forest cover area of the basin. There are large tracts of deforested areas, barren wasteland or inadequately used lands available within the basin for reforestation, afforestation, and effective cultivation. In the action plan for abatement of water pollution, the groundwater sources available within the basin would also have to be fully mobilized for beneficial uses, supplementing the existing surface water potential. Only through judicious conjunctive use of both surface and groundwater, the hydrological cycle can be maintained in a healthy state. Pollution control for the Subarnarekha basin should have to take into consideration the entire water resource available within the basin after making a thorough study of the water balance. If groundwater is properly harnessed and used extensively, the surface flow of the streams, especially in dry months, can be adequately augmented, thus reducing the pollution level to a considerable degree. Formulation of an integrated pollution control and resource development program for the India's smallest but potentially rich Subarnarekha River basin will not only help in pollution load reduction, but it may also serve as an ideal small-scale working model for ecological development of other basins and sub-basin in India.

## References

CBPCWP (1986) Assessment and development study of river basin series ADSORBS/15/1985-86. Basin sub basin Inventory of water pollution: the Subarnarekha River basin, Central Board for the Prevention and Control of Water Pollution (CBPCWP), pp 163

CWC (2002) Water and related statistics. Water Planning and Projects Wing, Central Water Commission (CWC), New Delhi

Das Gupta SP (1980) Atlas of Agricultural Resources of India. National Atlas and Thematic Mapping Organization Plates 9, 10, 18, 19

Dunn JA, Dey AK (1942) The geology and petrology of eastern Singhbhum and surrounding areas. Mem Geol Surv India 69(2):456

Giri S, Singh AK, Tewary BK (2013) Source and distribution of metals in bed sediments of Subarnarekha River, India. Environ Earth Sci 70:3381–3392

Giri S, Singk AK (2014a) Assessment of human health risk for heavy metals in fish and shrimp collected from Subarnarekha River, India. Int J Environ Heal R 24:429–449

Giri S, Singk AK (2014b) Risk assessment, statistical source identification and seasonal fluctuation of dissolved metals in the Subarnarekha River, India. J Hazard Mater 265:305–314

Jain SK, Agarwal PK, Singh VP (2007) Mahanadi, Subernarekha and Brahmani Basins. Water science and technology library. In: Hydrology and water resources of India, vol 57. Springer, Netherlands, pp 597–639

Maiti S, Jana A, Bhattacharya, AK (2009) Generation of a coastal flood hazard zonation map of Midnapur-Balasore Coast in Eastern India using integrated remote sensing and GIS techniques. In: Joint international workshop of ISPRS WG IV/1, WG VIII/1 and WG IV/3 on geospatial data cyber infrastructure and real-time services with special emphasis on disaster management. INCOIS Hyderabad

Mahadevan TM (2002) Geology of Bihar & Jharkhand. Geological Society of India, Bangalore, p 563

Mukhopadhyay SC (1973) River terraces of the Subarnarekha basin. Geogr rev India 35(2): 152–170 Geographical Society India, Calcutta

Niyogi D (1968) Morphology of the terraces of the Subarnarekha River, India. Selected Paper, 21 International Geographic Congress. 1, pp 84–88

Rao KL (1975) India's water wealth, its assessment, uses and protection. Orient Longman, New Delhi, pp 39–70

Roy D, Begam S, Ghosh S, Jana S (2013) Calibration and validation of HEC-HMS model for a river basin in eastern India. J Eng Appl Sci 8:40–56

Survey of India (1923–1979) Topographical sheets no. 73 E, F, G, I, J, K, M, N, O

Water Resources Information System of India (WRIS) Retrieved 06.08.2014. http://india-wris.nrsc.gov.in/wrpinfo/index.php?title=Subarnarekha