MINE WATER AND THE ENVIRONMENT, VOL. 13, JUNE-DECEMBER ISSUE, 1994 PP 1-10

ENVIRONMENTAL POLLUTION FROM COAL MINING ACTIVITIES IN DAMODAR RIVER BASIN, INDIA

R.K. Tiwary and B.B. Dhar
Central Mining Research Institute,
Barwa Road,
Dhanbad-826001
Bihar, India

ABSTRACT

Damodar river basin is a repository of 46% of Indian coal reserve. Exploitation of coal and related industries in this area have exerted a great impact on the environment of the basin. Hydrogeochemical analyses of mine water were carried out for all the major coalfields. The analysis revealed that total dissolved solids, sulphate, hardness and iron content are high. Acid mine drainage problem is not observed in all the coalfields of the basin except in one or two mines. Biological contamination are also observed in terms of MPN in the mine water.

As a consequence of underground mining, huge volume of polluted water, flooded in the mines, are channeled into the stream or river which in turn gets chemically polluted. Activities other than mining like coal beneficiation and preparation plant also generate huge amount of water effluent which affects the aquatic ecosystem and reduces biodiversity.

INTRODUCTION

In the process of development, coal mining is one of the prime industrial sector which is inadvertently causing environmental pollution. Damodar river basin is the repository of 46% of coal reserve of India mainly bituminous to sub-bituminous grade. The basin is credited of first coal mining in India in 1815 (Singh, 1992). The basin lies between latitude 22°45' N and 29°30' N and 84°45' E to 88°30' E longitude. The area with an estimated (1991 census) population of over 1,40,67,000 owes its urban and rural mixed status primarily due to the existence of very large deposits of coal. Its present large population has arisen both due to large nunmber of coal mining and coal based industrial activities expanded during last three decades. In this basin important coalfields are namely Raniganj, Jharia, South Karanpura, North Karanpura, E/W Bokaro and Ramgarh. The quality of coal varies from non-coking to coking coal.

Damodar river is the main source of water in these coal mining areas which is rain fed and thus acute shortage of drinking water occurs in summer period. Another major problem encountered in the supply of potable water is lowering of the groundwater table in the area due to underground coal mining. Acid mine drainage problems is not acute in the coal fields of the basin (Ghosh, Singh and Tiwary, 1984) due to low sulphur content in the coal. Opencast mining also disturbs the aquifers and water table. This causes permanent flow of water into the mine and loss of water from aquifers. Mine water is very hard in nature and has high total dissolved solids (TDS) and bacterial contamination which reduces the potability of mine water and when channelled into streams or rivers that get contaminated or even polluted. Environmental implication in Indian coal mining are already illustrated by Dhar 1993. The major pollutant associated with coal mining are suspended solids, dissolved salts (especially chlorides) acidity and iron compounds (Bell and Karr 1993).

PHYSIOGRAPHY AND GEOLOGY

Igneous, sedimentary and metamorphic rocks of different geological period are found in Damodar river basin. Lower portion of the basin is covered with thick alluvium over the solid rocks of tertiary ages. Archean formations have a general east-west strike. Laterites and lateritic formations of tertiary period are found between Archean foundations and alluvium zone. Other younger geological formations like Gondwana, Vindhyans of later ages are deposited on the Archean basement.

The Gondwana formations were deposited in the tectonic trough with faulted boundaries on the either side of the Damodar river which flows on the faulted trough. There had been repeated cycles of sedimentation and repeated sinking of the Gondwana basins. The strike of the faults is E-W and the strata dips towards the major faults. The coal measures were also intruded by the igneous intrusions i.e. micaperidotites, dolerites or basalt. The granite-gneiss area extends over extensive areas to the westnorth and south of the Gondwana region.

Metamorphic rocks are very restricted in the basin. Metamorphics are comprised of quartzites, quartz schists, quartz mica schists, and are found to the north-east of Koderma town where mica mining is under process. Vindhyan formations occur only in the north-western part of the Hazaribagh district near Tilaiya reservoir. The lithology of the Vindhyan formations are sandstone, shales, and limestone.

The coal bearing Gondwana formation were deposited over the archean basement and plays a vital role in the economy of the whole country. The lower Gondwana comprises of Talchir, Karharbari, Barakar, Barren Masures and Raniganj stages. The lithology of there stages are boulderbeds, shales, sandstone, grits and coal seams. Coal seams are confined to Barakar. The lower Gondwanas are overlain by upper Gondwana and comprise of Panchet and Supra-Panchet stages.

HYDROGEOLOGY

The study area is tropical and experiences three seasons summer, monsoon and winter. Mean annual rainfall is about 1200 mm. The rainy season generally lasts from July to October. The natural vegetation is tropical rain forest type.

Surface Water Hydrology

The basin area is well drained and is spreaded with 40 water sheds out of which 39 are in upper valley and only one in lower region. Main river in the area is Damodar river which arises from the Chhotanagpur hill from 606.0 m above mean sea level. It's tributaries are Barakar, Jamunia, Nalkari, Banjari, Bhairavi and Katri. These rivers are, however, not perennial and get dry in dry seasons. Five major dams are constructed on

Damodar river and Barakar river, to control soil erosion and from devastating floods in lower basin. The drainage pattern is shown in the Figure 1.

Liquid effluents from various underground mines and other coal related industries like coal washeries and coke oven plants are discharged into the rivers thereby polluting them. On contrary to this, the Damodar river is the prime source of drinking water for this region which is continuously deteriorating in terms of quality and quantity.

GROUNDWATER HYDROLOGY

Hydrogeologically, the river basin has two distinct units fissured and porous formations. The Chhotanagpur granite-gneiss, mica schists phyllites and quartzites belong to fissured formations. The groundwater occurs under water table conditions in weathered zone and movement of groundwater depends upon joints, fissures and other planes of structural weakness.

The semi-consolidated Gondwana formations comprising sandstone and related rocks occurring in Damodar valley and alluvial formations in West Bengal i.e. in lower valley are of porous formations. The sandstone are porous and permeable and constitute good repositories of ground water. The occurrence of the sandstone has been found from surface down to 245 m. below ground level and water occurs in confined conditions. Outflow zone are noticed in Karanpura coalfields.

Mine Water Quality and Water Pollution

Surface water and ground water samples of Damodar river basin were analysed during the year of 1992-93. Besides mine water from each coalfield, water samples from various coal washing plant were also collected for the detailed analysis. About 50% of discharged mine water find their way into the Damodar river. About 18 coal washing plants are dotting in this basin which discharge huge amount of fine coal particles into the river. In particular the blanketing effect of coal slurry particles on the bed of a river is unacceptable in terms of appearance and its influence on the flora and fauna in the stream. Various coalfields falling in the Damodar river basin are shown in Figure 2.

Coal mining activities and coal production figures in respective coalfields of the basin are summarised in the Table 1.

Table 1 Coal reserve and coal production in the Damodar River Basin

Serial Number	Name of the Coalfield	Area Sq Km	Reserves B Tonnes	Production M Tonnes	Coal Type
1	Ranganaj Coalfield	1550	22.0	26.0	Non-coking
2	Jharia Coalfield	450	19.4	29.0	Prime -coking
3	South Karanpura Coalfield	194	5.72	5.72	Non-coking
4	North Karanpura Coalfield	1230	13.57	8.14	Non-coking
5	E/W Bokaro Coalfield	444	10.2	15.44	Medium coking
6	Ramgarh Coalfield	98	0.97	2.9	Medium/ semicoking

Table 2 Geochemical characteristics of Mine Water

Parameters	BCCL	ECL	CCL
Discharge rate ML/D	400.0	384.7	205.70
pH	6.50- 9.22	6.98. 8.99	6.7 - 7.3
Temperature ^{o} C	26-32.9	25.5- 32.00	26.00 - 34.00
TSS (mg/L)	240.6 - 1180.0	10.00- 182.0	10.0 - 528.00
TDS (mg/L)	459.0-796.0	348.00- 860.00	200- 670.00
Oil and grease (mg/L)	0.03 - 0.05	0.08 - 4.78	0.1- 1.2
Total Nitrogen mg/L	-	0.03 - 2.3	-
BOD at 20^{o} C (mg/L)	0.6 - 33.42	4.0 - 120.0	0.4 - 4.6
COD (mg/L)	21.05 - 235.20	9.0 - 340	18.0- 53.0
As (mg/L)	Nil	Nil	Nil
Hg(mg/L)	Nil	Nil	Nil
CN(mg/L)	Nil	Nil	Nil
Cl (mg/L)	24.5 - 1009.1	27.0- 73.0	20.0 - 185.00
F(mg/L)	0.1 - 1.5	0.28- 1.3	0.6- 1.4
Sulphates (mg/L)	206.1- 401.2	14.00- 379.4	25.0 - 24.00
Sulphide	-	0.25 - 24.00	-
Coliform (MPH/100L)	17.0 - 2400	920 - 1600	12- 1400
Hardness (mg/L)	600.5 - 711.4	68.0 - 324.00	260.00- 570.0
Iron (mg/L)	1.3 - 3.1	0.28 - 4.2	0.25 - 1.77
Mn (mg/L)	0.015 - 0.06	-	-
Nitrate (mg/L)	40.8- 58.0	-	0.11 - 4.6
Conductivity µs/cm	-	0.26- 1.14	-

BCCL - Bharat Coking Coal Limited ECL - Eastern Coalfield Ltd CCL- Central Coalfield Ltd. MLD - Million litres per day BOD - Biological Oxygen Demand COD - Chemical Oxygen Demand

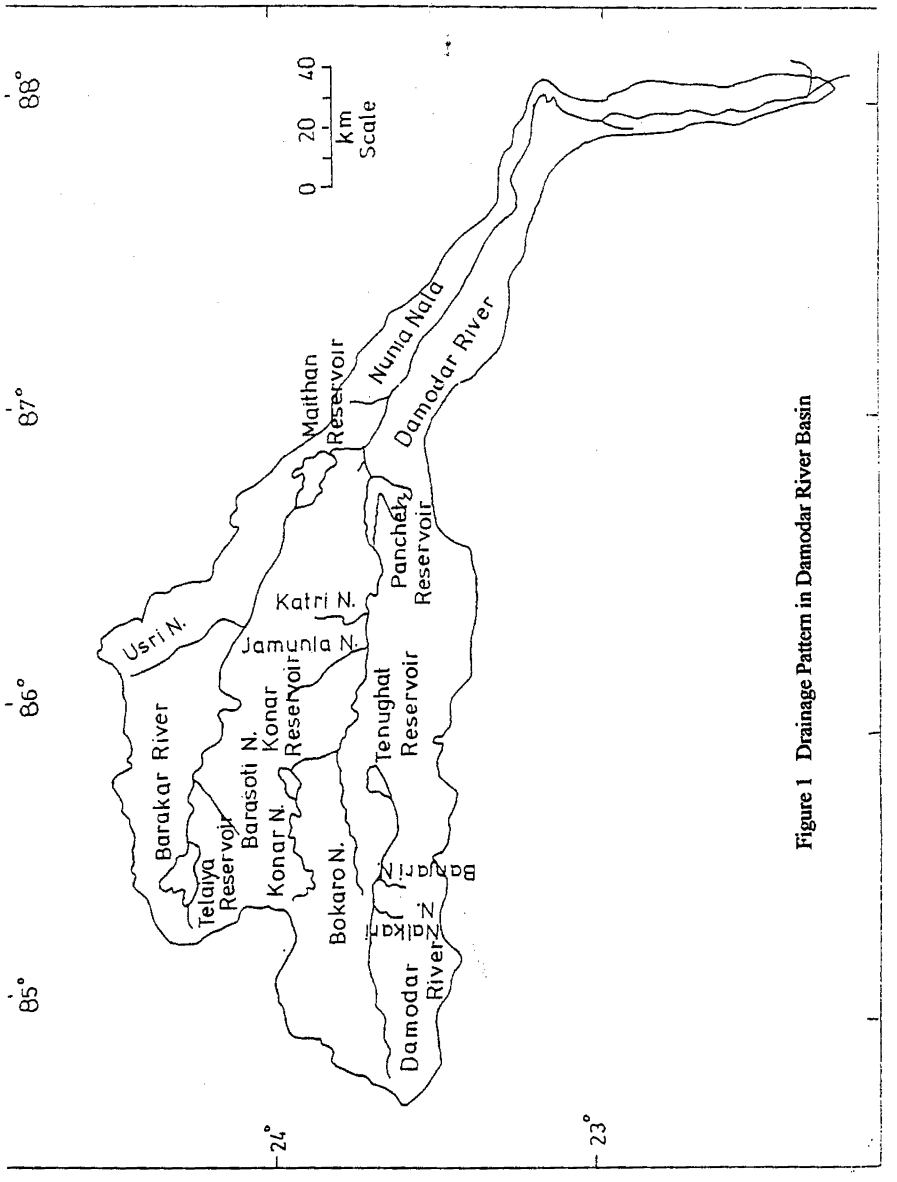

Figure 1 Drainage Pattern in Damodar River Basin

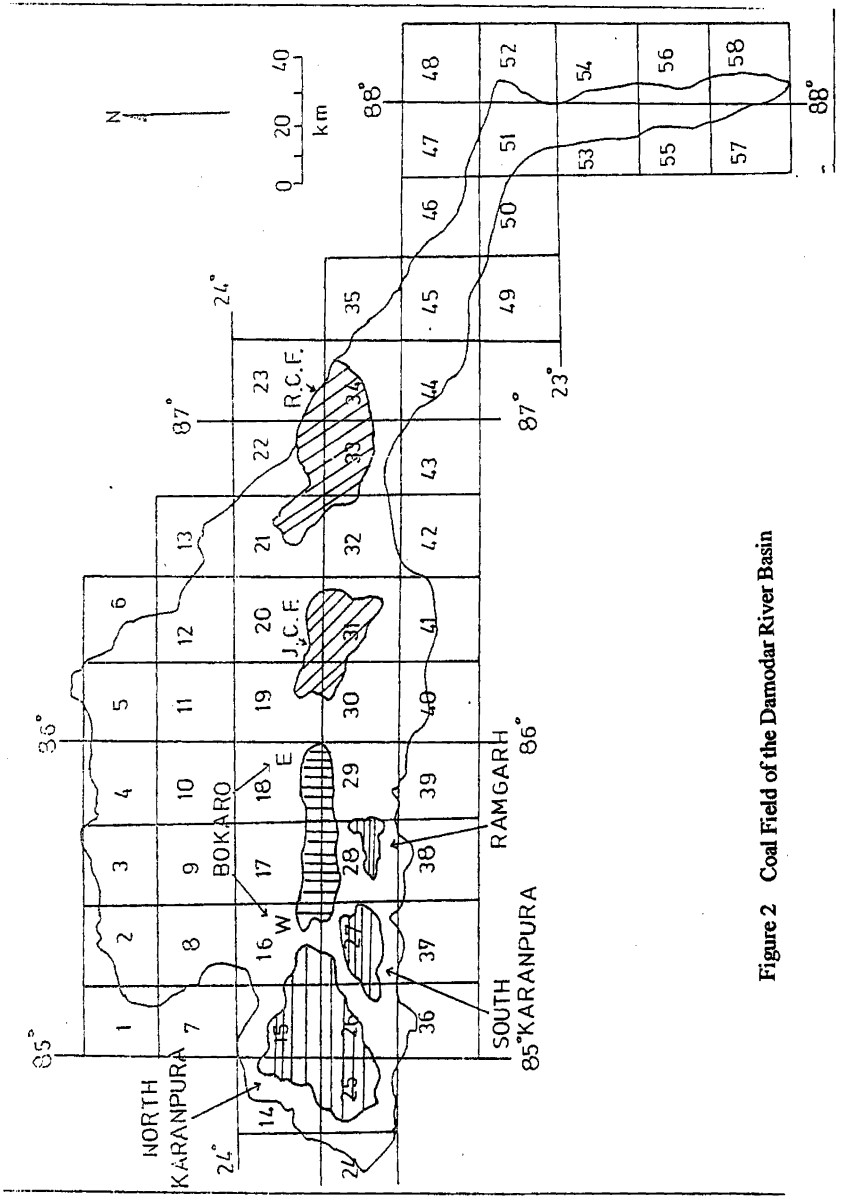

Figure 2 Coal Field of the Damodar River Basin

Out of 23170 sq.km. of basin area, about 4000 sq.km. area is under extensive exploitation for the extraction of coal producing 90.0 mt of coking and non-coking coal every year.

Mine water quality under three subsidiary of Coal India Limited were studied and ranges of different parameters are given in the Table 2. All the coalfields come under Bharat Coking Coal Limited, Eastern Coalfield Limited and Central Coalfield Limited. Results show the quality of mine water of different coal companies. BCCL cover major part of Jharia coalfield, where as ECL covers major part of Raniganj coalfield and others are covered by CCL.

Coal mining in the basin has caused significant degradation in ground water quality. One special peculiarity of these coalfields are that the mine water do not have acid mine drainage problem as coal deposits are not associated with pyrites and sulfur content in the coal are very less. The average sulphur content of Indian coal is around 1 percent (exceptions are Assam and J & K Coalfields). In Bengal and Bihar in which Damodar basin falls, sulphur content varies from 0.2 to 3 percent. Organic sulphurcompounds like mercap-tans, RSH, Sulphide or thioethers RSR or aromatic systems do not exceed more than 1 percent (Rawat, 1982). It is also obvious from the pH ranges of mine water. pH values are found in the range of 6.5-9.2, 6.98-8.99 and 6.7-7.3 for BCCL, ECL and CCL. But pH below 7.0 is a significant cause for leaching action, as a result elevated total dissolved solids (TDS) levels are found in mine water. It ranges from 459-796 mg/l, 348-860 mg/l and 200-670 mg/l for BCCL, ECL and CCL coal mines. Sulphate ions are high in some of coal mines of BCCL and ECL while it is found low in CCL mine water except of few mines. S04 ions are found in the range of 206401.2, 14-379.4 and 25-185 mg/l for BCCL, ECL and CCL mines. S04 ions in excess of 250 mg/l may have laxative effect while the presence of hydrogen sulphide may be toxic (Felter, 1980). Its high solubility favours its increased presence in the water as sulfide concentration are found in the range of 0.25-24.0 mg/l in ECL mine water sample.

Iron concentration in mine water are found in the range of 1.3-3.1, 0.28-4.2 and 0.251.77 mg/l for BCCL, ECL and CCL mines. The ranges are not very high due to less percentage of pyrites. Even then it is mostly found above 0.3 mg/l above which water containing it, stains plumbing fixtures has metallic taste and may be toxic to some aquatic species (Todd, 1980).

Mine water are found very hard. Hardness of water samples vary in the range of 600.5 - 711.4, 68-324 and 260570.0 mg/l for BCCL, ECL and CCL. High hardness in BCCL and CCL mine water reduces its potability for drinking purposes causing acute shortage of drinking water in the basin specially in summer season.

Other factors which reduces its utility in drinking purposes are bacterial contaminated which is obvious from MPN test. MPN vary in the range of 17-2400, 920-1600, 121400 in respective coalfields.

Mine water flooding from the mines are pumped into the nearby streams and rivers thereby polluting them. About 350 MLD mine water are discharged into river from the mines. Besides mine water, greater impact is laid on river water quality by coal washery effluents carrying high TSS (66122310), TDS (291-729), Oil and Grease (1.73-4.62 mg/l), Iron (0.62-212.6 mg/l), COD (192-3840 mg/l). The Damodar river whose water is the main source of drinking water for this industrial region is adequately affect by coal mining and coal based industrial activities (Tiwary 1991). Parameters like pH, TSS, TDS, BOD, COD, Iron are found in the range of 6.9-7.4, 311470 mg/l, 92-437 mg/l, 3-26 mg/l, 156-740 mg/l and 1.0-19.02 mg/l respectively in river water. All the surface water including Damodar river analysed showed high level of bacteriological pollution.

OTHER ENVIRONMENTAL POLLUTION

Other environmental pollution includes high suspended particulate matters in active mining areas especially in opencast mining areas. It also includes devegetation and presence of noxious gases due to land subsidence and mine fire a large portion of land are under fire and thereby enhancing noxious gases like CO, H_2S in the environment. About 90.71 sq. km. area is subsided due to underground mlning, 53.90 sq.km. are abandoned mined out, abandoned external reject dumps are lying in 25.33 sq.km. and area under fire are 25.13 sq.km. Suspended particulate matters, SO2 and NOx are found in the range of 287.1-1911.0 µg/m3, 64.4-129.6 µg/m3 and 75.0-89.0 µg/m3 in mining areas of the basin. CO level are found in the range of 1620-1850 µg/m3 which is partly due to vehicular exhaust from heavy mining equipments. At many sites especially in upper region coal mine spoils are dumped at the bank of the river which pollute river in terms of T.S.S. and metal contents.

CONCLUSION

Mine water and coal washery effluents are affecting the chemical quality of both ground water and surface water into which waters are pumped out. Mine water contain high amount of S04, hardness and bacterial contamination whereas, coal washery effluent consists of high TSS, Iron content and oil and grease. High TSS in the form of fine coal particles in coal washery effluent increases the TSS, TDS and COD values of river water as well as blanketing effect of coal slurry particles on the bed of the river is appeared. Suspended Solids act as a physical pollutant which degrades the beds of receiving streams and eventually reduces biodiversity. The contamination of ground water is a frequent hazard as the remediation of aquifers is rarely successful. Water from the coal mine area may with some treatment mainly involving hardness and bacterial contamination be employed in augmenting the present inadequate water supply in the basin. Mine spoils waste should be disposed in preplanned and well designed disposal site to prevent underground and surface water contamination. Fracture should be properly identified before any effective and efficient dewatering scheme.

REFERENCES

1. Singh, T.N. Underground winning of coal (1992). Oxford & IBH Publishig Co. Pvt. Ltd., New Delhi.

2. Ghosh, S.K., Singh, T.P.N. and Tiwary, R.K. Quality of mine waters in Jharia coalfield. IAWPC TECH. ANNUAL, XI, 25-28 (1984).

3. Dhar, B.B. Environmental scenario of Indian mining industry. Env. Management, Geo-water & Engineering Aspects. Chaudhary & Shiv Kumar (eds) 1993. Balkema, Rotterdam ISBN90 54100990.

4. Bell, F.C. and Kerr, A. Coal mining and water quality with illustrations from Britain Page 607-614, Env. Management, Geo Water and Engineering Aspects, Chaudhary and Shiv Kumar (Eds). 1993 Balkema, Rotterdam.

5. Rawat, N.S. Sulfur occurrences in coal and its relationship to acid formation. Metals and Minerals, Sept. XXI(10), 1982.

6. Felter, C.W. Jr. Applied Hydrogeology London (England). Merril Pub. Co. (1980).

7. Todd, D.K. Groundwater Hydrology, London (England) J. Wiley & Sons (1980).

8. Tiwary, R.K.(1990) Studies on water pollution of Damodar river due to coal mining and other industrial activities in Dhanbad Jharia region. Iandian School of Mines, Dhanbad, Ph.D. thesis awarded in 1991.