Water Quality Assessment and its Management in Opencast Coalmines - A Case Study

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ABSTRACT

Wastewater management in an opencast coalmine is essential not only in preserving the quality of surface water but also for conserving the ground water in the mining complex. Instead of directly disposing of water into nearby streams, it may either be used for a plantation programme on the overburden spoil or it may be collected into a small specially constructed reservoir for fisheries and final overflow may be utilised for spoil irrigation. The studies conducted in Singrauli coalfield have shown that due to disposal of mine effluents, the concentration of suspended soilids, dissolved solids and oil and grease increased considerably downstream of the disposal point in the surface water system.

Usefulness of the effluents of various coalmines have been examined to see their suitability for aquiculture and waste-dump plantation purposes. The study suggests that the effluents of all the coal projects in the area may be directly used for plantation programmes whereas in case of fisheries, effluents of the Gorbi and Jhingurdah mines need pre-treatment for better productivity. If mine water is to be used for such purposes it will not only reduce siltation problems in the reservoir but also conserve the quality of natural water from pollution.

INTRODUCTION

Mining of coal by the opencast method has been undertaken by Coal India Limited (CIL) on a large scale in Singrauli region. Out of eleven mining blocks, Gorbi, Jhingurdah, Bina, Jayant and Kakri projects are producing coal at their targetted capacity. Four projects, Amlori, Dudhichua, Khadia and Nigahi are at different stages of development. Marak block is at exploration stage while Moher block is at planning stage. The coal production in this coalfield is expected to rise from 30.0 million tonne (1993-94) to over 65.0 million tonne per annum by the turn of this Century. Large scale mining operations in this coalfield have deteriorated the quality of the fresh water of the area. Only a small fraction of mine wastewater is being used at present in different mining activities whereas the major part of it is allowed to flow into nearby streams.

Although disposal of wastewater on agricultural and forest lands is common practice in many countries [1-6], information available on fisheries and waste-dump plantation with mine effluents is meagre [7]. The aim of this study was therefore to examine the usefulness of mine effluent for aquiculture and waste-dump plantation purposes so that inspite of directly disposing of it into the receiving stream it may either be used for a plantation programme of the overburden spoil or may be utilised for fishery in the mining area.

WATER QUALITY ASSESSMENT AND ITS MANAGEMENT

The Singrauli area is enriched with surface water resources. It is located in the drainage area of the Son and Rihand rivers. The north flowing streams in the Moher area joins the Bijul river, which is a tributory of Son; and the south flowing streams mostly join the Kachani river, a tributory of the Rihand river. Some surface streams join directly to the Rihand reservoir or to the perennial Balia stream. Among the north flowing streams, Mehrauli stream maintains a perennial flow. Most of the other streams in the area, such as Turra, Mudwani, etc are seasonal. In the south east, there is Rihand dam reservoir, which covers an area of 450 square Km.

Table 1 summarises the quality of the water in the upstream and downstream sections of the surface water in the area. The quality of effluents disposed off in these surface streams from different mines are also included in the table. It is evident from the table that the quality of the effluent of Gorbi mine, discharging its effluent into Bijul stream, is highly acidic in nature. It is also fully loaded with suspended solids and dissolved solids. Among dissolved solids, iron and sulphate are in the higher ranges. The water quality in the upstream section of the Bijul stream is of potable nature but due to the disposal of acidic effluent of the mine, it has been changed considerably in the downstream side. In the case of Chatka nalla, a tributory of Bijul, the effluent of Jhingurdah mine has deteriorated the quality of water to a significant degree. The upstream clear water has been changed to blackish water due to addition of oil, grease and suspended particulate matter. Balia stream receives the effluents from Jayant, Dudhichua, Amlori and Khadia opencast coalmines. The effluents from these mines are either neutral or alkaline in nature and show a lower concentration of impurities compared to the effluents of Gorbi and Jhingurdah mines. The quality of downstream water has therefore been less affected in comparison to Bijul stream. The water qualities of Kachan and Karahia streams are not affected by mining activities since mines (Solan and Moher) in these areas are under development stages. The quality of water in Rihand Dam near the confluencing point of mine effluent is also shown in Table 1. The water quality of the dam is influenced by the effluents of mines and power plants.

From the above observations it is clear that the quality of surface water in the area is influenced by the disposal of effluents from various coal mines. Although a Zero Discharge Policy is the ultimate solution to protect the surface water quality, it may lead to degradation of the landscape by accummulation of salts and toxic compounds. Some toxic constituents may also leach into the groundwater [8]. Effluent quality can also be improved by the application of advanced treatment techniques [9] but may not be economically feasible in such a large opencast coalfield. Quality control of the mine effluent through overburden materials has also been reported in the literature [10]. Studies carried out by authors in this coalfield have shown that neutralisation of acidic effluents of Gorbi and Jhingurdah mines may be achieved successfully if acidic effluents of these mines are passed through Barakar sandstone of the Gondwana formation [11]. The neutralisation will also help in lowering the concentration of dissolved constituents in the mine effluent.

Utilisation of mine effluent is another way of controlling pollution of surface water. Irrigation with effluent is one such method and is also cheaper in comparison to treatment processes [2-4]. The suitability of effluent for such purposes depends on physico-chemical parameters of effluent. High concentrations of sodium and potassium ions lead to salinity trouble in waste-dump and soil. Excess amount of nickel, copper and sulphur also restricts the growth of plants. Some toxic substances such as selenium, boron, arsenic, etc, if present in mine effluent, may get adsorbed into the plants [7]. A close examination of the table reveals that the quality of the effluents of different mines of this coalfield, except Gorbi and Jhingurdah projects, are matching with the values prescribed for irrigation water [7]. In the case of effluent of Gorbi mine, the electrical conductivity , chloride and sulphate ions concentrations are more than their tolerance limits whereas in the effluent of Jhingurdah mine the concentration of chloride ion is on the higher side. From the salinity point of view, although both of these effluents may be grouped under moderately high salinity class due to their low sodium content these effluents may be classed under Good Water Category for irrigation purposes [7].

Effluents of all these projects may therefore be considered suitable for direct use in waste-dump plantation programmes. While framing a reclamation programme, the nature of the waste-dump and the type of plant species should also be given due considerations. Research work is in progress to find the suitable plant species for the overburden spoil of this coalfield [12].

Table 1

Physico-chemical characteristics of effluent and surface waters in Singrauli coalfield

	Bijul Stream			Mehrauli Stream		
Parameters	Upstream	Effluent	Downstream	Upstream	Effluent	Downstream
Temperature °C	27.81	27.31	27.85	31.00	30.10	31.05
pH	8.75	3.14	6.12	7.91	7.44	7.48
Total suspended solids	10.32	648.22	421.40	57.60	397.5	244.70
Total Dissolved solids	363.33	1970.50	602.50	406.00	950.00	580.00
BOD_5 at 20°C	2.46	5.00	2.59	2.03	2.46	1.96
COD	24.00	254.00	45.50	11.40	182.00	31.46
Oil & Grease	BDL	58.24	3.45	BDL	12.14	4.00
Bicarbonate	180.50	6.30	72.46	166.19	352.01	181.04
Carbonate	1.00	BDL	1.80	1.15	4.81	0.05
Chloride	24.00	28.60	26.75	30.10	39.00	35.00
Fluoride	0.09	0.24	0.16	0.08	0.10	0.12
Nitrate	0.11	0.09	0.03	0.07	0.30	0.07
Phosphate	BDL	BDL	BDL	BDL	0.08	B D L
Silicate	17.13	16.80	16.60	18.70	13.80	10.70
Sulphate	16.00	1453.20	531.70	29.00	512.00	108.00
Boron	0.13	0.12	0.09	0.18	0.23	0.14
Calcium	52.60	62.40	52.78	51.30	72.10	94.70
Chromium	BDL	BDL	0.60	BDL	0.73	BDL
Copper	BDL	BDL	BDL	BDL	0.15	BDL
Iron	1.40	189.02	23.10	2.13	42.82	13.19
Lead	0.12	1.04	0.16	0.26	0.30	0.28
Magnesium	10.50	13.50	12.40	9.08	42.46	17.08
Potassium	1.60	1.21	1.87	2.60	2.11	3.26
Sodium	15.30	18.30	16.37	17.00	26.30	23.80
Zinc	1.137	1.79	1.64	1.11	1.32	1.13

Table 1. (continued)

Parameters	Balla Stream Upstream	Balla Stream Effluent	Balla Stream Downstream	Kachani Stream	Karahia Stream	Rihand Reservoir
Temperature °C	29.90	30.00	29.95	27.80	29.30	32.00
pH	7.76	7.01	7.26	8.22	8.51	8.06
Total suspended solids	70.40	386.90	259.40	11.70	9.60	36.50
Total Dissolved solids	143.30	426.65	206.60	155.00	430.05	650.00
BOD_5 at 20°C	2.20	3.39	2.60	1.90	1.70	3.90
COD	11.00	344.00	71.30	13.50	25.00	77.50
Oil & Grease	BDL	51.20	24.60	BDL	B D L	B D L
Bicarbonate	38.40	117.20	76.36	108.40	206.95	276.50
Carbonate	BDL	BDL	BDL	1.95	3.43	B D L
Chloride	7.66	58.66	18.60	29.00	10.33	32.00
Fluoride	0.11	0.11	0.12	0.04	0.26	0.30
Nitrate	0.06	0.01	0.11	0.03	0.03	B D L
Phosphate	0.18	0.12	0.06	B D L	0.15	0.11
Silicate	5.20	4.60	6.03	11.50	14.76	4.25
Sulphate	23.60	107.77	34.30	36.00	13.66	63.00
Boron	0.17	0.11	0.12	0.12	0.03	0.25
Calcium	18.04	61.32	31.10	45.53	55.0	77.07
Cromium	BDL	BDL	BDL	BDL	B D L	B D L
Copper	BDL	BDL	BDL	BDL	B D L	B D L
Iron	1.24	3.20	1.81	1.16	0.98	2.23
Lead	0.09	0.52	0.02	0.01	0.08	0.07
Magnesium	5.62	15.60	6.06	11.22	16.98	20.25
Potassium	1.50	1.66	1.16	2.75	5.16	4.00
Sodium	7.50	11.66	7.86	16.50	22.33	25.50
Zinc	1.41	1.56	1.30	1.61	1.65	2.42

All values are in mg/L except pH & temperature

BDL - Below Detection Limit.

Another effective way of utilising mine effluent is its application for fisheries purposes. In this case, the essential water quality parameters that affect productivity of fish are pH, turbidity, electrical conductance, ammonical nitrogen, dissolve oxygen, carbon dioxide, phosphorous, potassium and calcium salts and trace metals [13-14]. From the table it is evident that most of the toxic trace metals in the effluents are well within the tolerance limits. Only iron and sulphate concentrations are higher in the effluents of Gorbi and Jhingurdah mines. Due to low pH and higher electrical conductivity, effluents of Gorbi and Jhingurdah mines are not suitable for fisheries and requires pre-treatment, whereas effluents of the other mines under reference may directly be used without any pre-treatment [7]. If mine effluents have to be used for such purposes at the time of construction of the pond, physical parameters such as depth and temperature must also be given due consideration. A shallow pond allows sunlight to penetrate into the bottom and increases productivity by photosynthesis. If it is too shallow, the water becomes warmed up rapidly during the summer season, thereby affecting the survival of the fish. Generally, a two metre deep pond is considered suitable for maximum productivity [13-14]. It is therefore obvious that a mine sump can not be used as a fish pond. A separate pond of suitable depth and at a proper location has to be built up in the project to provide a suitable ecological condition essential for productivity of the pond. Selection of fish species and other aquatic life are other aspects which need in depth research for a successful aquiculture programme.

CONCLUSIONS

Contamination and pollution of precious surface water resources due to mining activities have necessitated the use of remedial measures to protect the quality of natural water from pollution. Studies on the effluent qualities of various opencast projects in the Singrauli coalfield reveal that the surface water degradation in the area may be controlled by utilisation of the mine effluents instead of disposing them directly into the nearby receiving streams. The study suggests that the effluents of these coalmine projects may be directly used for plantation programmes whereas in the case of fisheries, the effluents of Gorbi and Jhingurdah mines need pre-treatment for better productivity.

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