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Characterisation of coal mine effluents from jharia coalfields, Bihar, India

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INTRODUCTION

Though underground mining has little direct impact on surface streams but may have profound long term effects on ground water resources. By its nature a mine tends to drain a large area and if soluble minerals are present in the coal and associated rocks, these minerals may enter in the streams draining a mining region and cause a severe degradation of water quality (UNEP 1979). This effect is important both where mines are drained by pumping and in mountanious regions where drainage is by gravity (UNESCO 1979). Contamination caused by both deep and surface mining has substantially altered the water quality of some 17,000 km of stream in Appalachia, U. S. A. Acid drainage has seriously polluted about 10.000 km of streams of the same area reducing or eliminating aquatic life (Nephew 1977). Similarly with greater excavation depths coupled with an increased rate of digging, many coal mines in India have started experiencing water pollution problems. For the progress of work mine water is regularly pumped out from the working seams to the surface above, causing pollution of other water bodies as well as is being utilized by a vast population of mine workers in various ways. The total area of Jharia coalfield of Damodar Valley region of Bihar is about 455 km^2 and out of this only 223 km^2 more than 83 mines are being operated. This data simply provides a picture of severity of the pollution problem in the area due to coal mine drainage. A perusal of literature

TABLE 1

Physico-chemical characteristics of coal mine effluents (minimum, maximum and average)

	SUMMER	RAINY	WINTER	M	SD	CVS	V
Temp°C	26.3–32.5 28.5	25.2–32.3 30.1	27.5–29 5 27.3	28.86	2.678	9.25	7.12
pH	7.5–9.2 8.5	7.2–8.1 7.5	7.6–8.6 8	7 88	0.565	7.17	0.319
D. O.	5.4–7.4 6 42	5 4–7.8 6 55	5.3–7 8 6.35	6 44	0.787	12.23	0.60
Phenol. Alk.	21.2–38.2 26.08	30.5–69.5 51.10	28.7–52.1 38.50	38.55	15 06	39.06	226.80
M. O. Alk.	177.5–280.8 237.45	224.8–3 1.6 291.53	148.2–190.6 164.78	231.25	65.10	28.15	4238.01
Temp. Hard.	102.6–170.7 124.25	124.2–185.3 165.78	210.1–405.2 158.20	149 41	35.81	23.96	1282.35
Perma. Hard.	280.7–300.4 293.35	301 6–315.7 308 80	210.1–405.2 309 78	303.98	42.74	14.06	1826.70

Total Hard	400.1–450.8 417.60	425.8–496.1 474.58	209.1–688.6 467.98	453.38	69.46	15.32	4824.69
Dissolved solids	213.8–515.2 423.77	466.2–598 2 544.8	240.2–558 2 424.7	464.42	121.13	26.08	14672.47
TSS	87.2–207.2 135.85	98.8–243 2 171.57	90.1–292.8 150.35	152.59	68.91	45.16	4748.58
COD	16.8–23.2 20.2	22.8–29.2 26.85	11.6–21.6 15.37	20.80	5 80	27.88	33.67
Chloride	40.9–88.6 65.05	24.8–46.8 34.68	21.3–50.2 40.40	46.71	19.15	40.99	366.72
Sulphate	48.1–117.2 80.15	75.6–101.2 88.98	90.2–143.2 115.45	94.85	25.13	26.49	631.51
Phosphate	111.2–192.7 151.82	82.1–110.6 99.27	87.2–152.8 128 82	126.64	36.84	29.09	1357.18
Iron	1.4–3 5 2.42	1.3–2.6 1.95	1.3 –2.8 2.2	2.27	0.49	21.62	0.240

M = Annual mean, SD-Standard daviation, CV = Co-effieient of variation
V = Variance. All parameters are in mg/litre.

reveals that there is no published account of studies on coal mine effluent from ecological view point.

The present study has been taken up to assess the pollutants level in the coal mine drainage area and collect some useful data helping in remedial measures for pollution control.

MATERIAL AND METHODS

The samples were collected from the discharge points on the surface and were analysed for their physcio-chemical characteristics as per Indian Standard specification of 1968 (IS : 2488) following the standard method (A. P. H. A. 1968), and Trivedy and Goel (1984) during 1984-85.

RESULTS

The results of analysis of coal mine effluents have been shown in Table 1. The maximum and minimum values obtained for different parameters and their average have been shown. Statistically the monthly data of one year has been analysed to find-out the standard deviation (SD), co-efficient of variation (CV) and variance (V) of the different parameters in one year. As the data reveal the maximum coefficient of variation (CV) was 45.16 of total suspended rolids, while minimum (CV) was 7.17 of pH values. Similarly the minimum SD was 121.13 of dissolved solids and the same was minimum of iron (0.491) during the study period. Methyl orange alkalinity was found four to six times higher than phenolpthalein alkalinity. Similarly permanent hardness was recorded more than double of the temporary hardness in nearly all the samples analysed. As the coal mine effluents are not in direct touch with different environmental factors no definite trend of fluctuation from seosonal change or depth variation view point was observed.

DISCUSSION

The various water quality parameters in the Table 1 show that the coal mine drainage are severly polluted. Many parameters of water samples exceed the limiting water quality standards listed in Table 2. The nature of the effluent is controlled by the nature of geogical formations, since the mineralogy of the geologic regime controls to a large extent the chemical quality of water permeating through the system. In general pyrite and calcarious material present in the system have the greatest chemical impact on the aqueous regime. The coal mine drainage samples

under investigation are alkaline in nature. The pH values ranges from 7.2 to 9.2 while the effluent standard for discharging the same in inland surface water specify the range from 5.5 to 9.0 only. Some coal mine drainage of the same area and in, East Bokaro area are acidic (our unpublished data), which pose special problem due to their toxic nature. The temperature of coal mine effluents was found below the permissible limit during the period of study.

Phenolphthalein alkalinity has been found ranging from 21.2 to 67.5 mg/L with coefficient of variation 39.06, while methyl orange alkalinity varied from 148.2 to 351.9 mg/L reflecting high concentrations of carbonate, bicarbonate and hydroxyl ions. Very high hardness values indicate that these waters differ from the more common type of hard water in that sulphate and not bicarbonate is the dominant ion. The sulphate values are less than that of bicarbonate. Many studies from human health view point have indicated a negative correlation between cardiovascular disease and hardness of water. (Shaper et al. 1974). Most hard water of calcium carbonate or calcium–magnesium bicarbonate type are associated with low casdiovascular dlsease rates. The ICMR permissible limit for hardness of water as calcium carbonate is up to 600 mg/L and that of WHO (1971) is 500 mg/L.

The dissolved solids are within limits and the suspended solids cross the specified limit of effluent disposol similar to phcsphate, while chloride and sulphate are below the permissible values. The other parameters determined are within the limit of Indian Standard specification except iron which in its annual average is double of the allowable limit (1 mg/L).

From the above characteristics of coal mine effluents it is clear that it is not safe from pollution view point as per Indian Standard to dispose the same without proper treatment As is the usual case the effluents contaminate the water bodies and result into their eutrophication. Sometimes blankating effect is found due to high concentration of suspended solids which ultimately hinders light penetration and hence normal planktonic growth. If only phosphate content which is a causative nutrient of eutrophication is considered alone the effluent needs 4220 times dilution to reach the critical value 0.03 mg/L (Sawer et. al 1945) Thomas (1969) pointed out that the addition of phosphate brings about an eutrophication mechanism by increasing bacterial content, increase in reproduct-ion and growth of algae. Reid (1961) showed that the mean phosphate content of natural waters of most lakes ranges from about 00.1 to 0 03 mg/L.

The above information suggests that the treatment of coal mine effluent should be given paramount importance, of the water bodies in the local area one thuman health is to preseved.

TABLE 2

IS toleraucе limits for the sewage (A) and industrial effluents (B) and that of inland surface water (C).

Characteristics	A	B		C
	IS : 4764–1973	Inland surface water IS : 2490–1973	Public sewers IS 3306–1974	IS : 2296– 974
BOD (5 day 20°C) mg/L	20	30	500	3
COD, mg/I	–	250	–	-
PH	–	5.5–9.0	5 5–9.0	6. 0. 9. 0.
Total suspended	30	100	100	-
solids, mg/L	–	40	45	–
Temperature, °C	–	10	100	0.1
Oil and Grease, mg/L	–	1.0	5	0.005
Phenolic compounds, mg/L	–	0.2	2.0	0.01
Cyan·des (as CN), mg/L	–	2 0	–	--
Sulphides (as S), mg/L	–	2.0	–	1.5
Fluorides (as F), mg/L	–	1.0	–	--
taloT residual chlorine mg	–	Zero	–	Zero
Insecticides, mg/L	–	0.2	–	0.2
Arsenic (as As), mg/L	–	2.0	-	--
Cadmium, hexavalent (as Cr),mg/L	–	0.1	-	0.05

				(Total chromium)
Copper, mg/L	–	3 0	3 0	--
Lead, mg/L	–	0.1	1.0	0.1
Mercury, mg/L	–	0 01	-	--
Nickel, mg/L	–	3.0	2	--
Selenium, mg/L	–	0.05	–	0.05
Zinc, mg/L	–	5.0	15.0	--
Chloride (as Cl), g/L	–	-	600	600
Sulphates, mg/L	–	–	--	1.00
% Sodium	–	-	60	--
Ammoniacal Nitrogen, mg/L	–	50	50	--
Nitrates (as NO), mg/L	–	--	--	
Radioactive meterials : emitters, uc/ml	–	10–7	--	50 10–9
B-emitters, uc/ml	–	10–6	--	10–8
Dissolved Oxygen, mg/L	–	--	-	40% of sacuration value, or 3 mg /1, whichever is higher.
Coliform organism (monthly average) -MPN per 100 ml	–	-	–	should not exceed 5,000 (should not exceed 20,000 with less tnan 5% samples, and 5.000 with less than 20% samples)

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