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MINE WATER POLLUTION STUDIES IN CHAPHA INCLINE, UMARIA COALFIELD, EASTERN MADHYA PRADESH, INDIA

by

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ABSTRACT

Mining affects physical and chemical changes in the mine environment resulting in water pollution. Based on the geological distribution the coal mines in the state of Madhya Pradesh, the Coalfield can be categorised into three basins Northern, Southern and Satpura. The Northern belt lies along the Sone Valley whilst the Southern one lies within Mahanadi Valley and the Satpura basin lies south of the alluvial tract. Mine water pollution study reported in this paper is concerned with Chapha Incline, Umaria Coalfield in Eastern Madhya Pradesh. The water analysis was carried out on representative samples obtained from the site on pre- Monsoon and post- monsoon seasons, and reference samples were obtained from the area in the vicinity of the site of investigation. The samples were analysed in the laboratory for determining water quality parameters including trace element detections and microbial analyses. The chemical analysis results of mine water are presented in the form of Durov diagrams.

INTRODUCTION

Madhya Pradesh is one of the important Coal-producing state in India. Until recently, no systematic studies have been carried out with respect to mine water pollution associated with coal mining operations in the state. This paper is an attempt to carry out preliminary study to identify the range of problems.

EXPERIMENTAL WORK

Sampling by random selection was undertaken so that the composition of the sample was identical to that of the parent water body. The water samples (around 3000 ml in volume) were collected from the site of investigation before the Monsoon period as well as after the Monsoon period corresponding to low and high water table conditions. Reference samples during pre-monsoon and post-monsoon period were also analysed as control samples from the vicinity of the mine.

Table 1. Water quality index (WQI) of chapa incline (Umaria) coal mine waters, Eastern Madya Pradesh

Parameters	VALUES							
	PRE MONSOON				POST MONSOON			
	Coal mine				waters			
	value	qi	wi	qiwi	value	qi	wi	qiwi
TDS	296.6	100	0.09	9.0	316.2	100	0.09	9.0
Turbidity	11.4	60	0.09	5.4	6.2	80	0.09	7.2
Total Hardness	131.1	100	0.04	4.0	62.1	100	0.04	4.0
Chlorides	77.6	80	0.04	3.2	24.7	100	0.04	4.0
BOD	4.6	40	0.13	6.2	4.1	40	0.13	5.2
DO	9.8	100	0.18	18.0	9.2	100	0.18	18.0
Total Alkalinity	175.0	0	0.04	0.0	142.5	0	0.04	0.0
pH	6.2	0	0.18	0.0	7.3	100	0.18	18.0
Bacterial Colonies	4.0	80	0.18	14.4	3.0	80	0.18	14.4
			Σwi = 0.97	Σqiwi = 59.2 WQI = 61.03			Σwi = 0.97	Σqiwi = 79.8 WQI = 82.26
	Reference water							
	value	qi	wi	qiwi	value	qi	wi	qiwi
TDS	303.1	100	0.09	9.0	280.5	100	0.09	9.0
Turbidity	5.1	80	0.09	7.2	3.1	100	0.09	9.0
Total Hardness	190.0	100	0.04	4.0	132.5	100	0.04	4.0
Chlorides	115.0	60	0.04	2.4	177.5	80	0.04	3.2
BOD	6.0	0	0.13	0.0	5.2	0	0.13	0.0
DO	11.2	100	0.18	18.0	10.0	100	0.18	18.0
Total Alkalinity	91.0	40	0.04	1.6	110.0	40	0.04	1.6
pH	6.4	0	0.18	0.0	7.3	100	0.18	18.0
Bacterial Colonies	2.0	80	0.18	14.4	1.0	100	0.18	18.0
			Σwi = 0.97	Σqiwi = 56.6 WQI = 58.35			Σwi = 0.97	Σqiwi = 80.8 WQI = 83.29

The physico-chemical analyses of water comprised determination of the following parameters; Turbidity, pH, Total Hardness Total Alkalinity, Total Dissolved Solid (TDS), Dissolved Oxygen (DO) , Biochemical Oxygen Demand (BOD), Chloride, Bacterial Colonies for calculating water quality index (WQI).

To calculate WQI, an approach similar to Horton (1965) has been followed. Trace elements (Cu, Pb, Fe, Mn, Co and Zn) were determined by Atomic Absorption Spectroscope Model Perkin Elmner 3280. Microbial analysis was conducted by using two types of Media.

(1) Potato Dextrose Agar Media (Pelczar, Reid , 1986)

(2) Enrichment media (Temple and Colmer ,1951 and Leathen et el, 1951)

RESULTS AND DISCUSSIONS

As the coal mine water does not come in direct contact with the surface environment, no definite trend of fluctuation due to seasonal change was observed. Similar observations were noted with respect to the reference sample. The various physicochemical parameters in table 1 clearly show that coal mine water is severely polluted. Many parameters like Turbidity, BOD, Alkalinity and Bacterial Colonies are not within the permissible limits as compared to standards (Punmia 1977) , Table 2 and 3. High anionic and cationic concentration is also noticed. This may be due to heavy mining operations which are continuously taking place in coal mines.

TABLE 2. Calculation of water quality index (WQI), water quality parameters, their standard values (I.C.M.R.) and assigned weights

Water quality parameters	I.C.M.R. permissible	Standards * Excessive	Weight (wi)	Unit weight (Wi)
T.D.S	500+	1000+	2	0.09
Turbidity	5	25	2	0.09
Total Hardness	300	600	1	0.04
Chlorides	250	1000	1	0.04
BOD	< 5+	-	3	0.13
DO	> 6	3.6	4	0.18
Total Alkalinity	< 120+	-	1	0.04
pH	7 - 8.5	6.5 - 9.2	4	0.18
Bacterial Colonies	< 1	> 10	4	0.18

* All values except for pH and Bacterial Colonies are in ppm.

+ U.S. public health servicevalues (I.C.M.R. standards are not available).
I.C.M.R. - Indian Council of Medical Research.

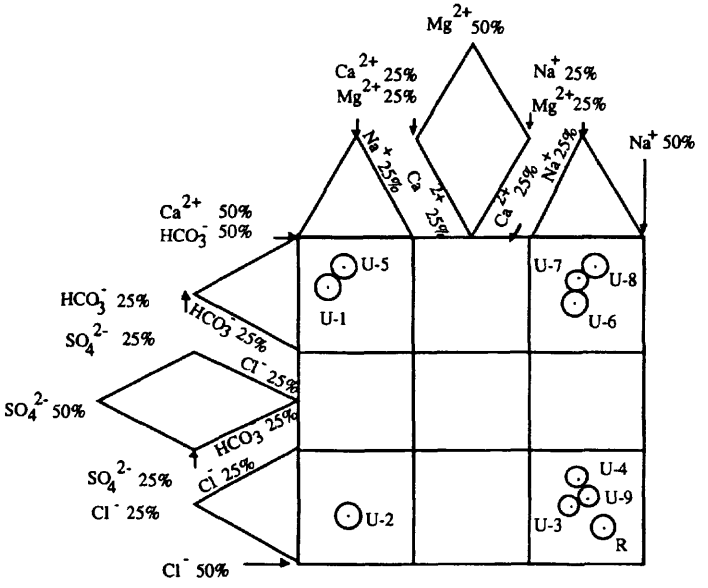
TABLE 3. Calculation of water quality index (WQI), rating scales for water quality parameters

Parameters	Range of Values				
TDS	< 500	500 - 700	701 - 900	901 - 1000	> 1000
Turbidity	< 5.0	5.0 - 10.0	10.1 - 17.5	17.6 - 25.0	> 250
Total Hardness	< 500	300 - 400	401 - 500	501 - 600	> 600
Chlorides	0 - 50	51 - 100	101 - 150	151 - 250	> 250
BOD	0 - 1.0	1.1 - 3.0	3.1 - 4.0	4.1 - 5.0	> 5.0
DO	> 7.0	5.1 - 7.0	4.1 - 5.0	3.0 - 4.0	< 3.0
Total Alkalinity	21 - 50	16 - 20, 51 - 70	11 - 15, 71 - 90	5 - 10, 91 - 120	> 120, < 5.0
pH	7.0 - 8.5	8.6 - 8.7, 6.9	8.8 - 8.9, 6.8	9.0 - 9.2, 6.5 - 6.7	> 9.2 < 6.5
Bacterial Colonies	≤ 1	2 - 4	5 - 7	8 - 10	> 10
Rating qi	100	80	60	40	0
Extent of Pollution	Permissible	Slight	Moderate	Excessive	Severe

TABLE 4. Plot of water logging profile - Chapha incline (Umaria) : Relevant water quality parameters

Parameters	pH	Total Anions	Total Cations	Total Hardness	Total dissolved solids	Heavy Metals
Levels			PRE	MONSOON	SAMPLES	
0	6.4	190.0	272.9	125.0	280.5	14.0
2	6.3	125.0	216.8	110.5	330.3	12.0
19	6.2	139.0	255.8	109.5	266.9	20.0
26	6.2	148.0	257.2	109.0	253.3	15.0
27	6.2	153.0	326.8	124.0	357.4	13.0
28	6.2	148.0	332.9	92.5	325.7	14.0
32	6.3	178.0	214.1	134.0	271.4	22.0
59	6.4	152.0	304.6	129.0	294.1	12.0
			POST	MONSOON	SAMPLES	
0	7.7	74.5	181.5	68.5	262.4	16.0
24	7.5	79.5	118.3	48.5	361.9	21.0
52	7.2	89.4	201.1	69.0	366.5	0.0
57	7.3	129.1	169.7	45.0	352.9	30.0

The WQI of coal mine water was fluctuating from 60.03 to 83.26 in the pre-monsoon and post- monsoon periods respectively. Similarly, the reference samples indicate WQI of 58.35 and 83.29 for pre-monsoon and post-monsoon perids respectively indicating excessive to moderate pollution, (Kudesia, 1980)



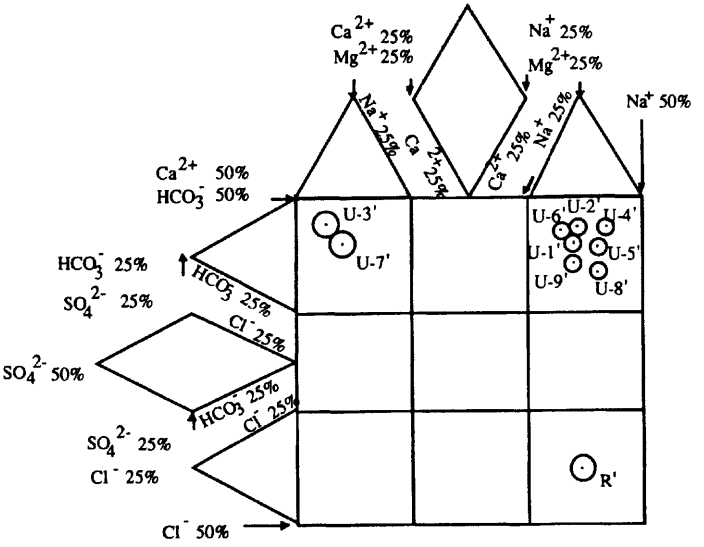
U-1 to U-9 - Coal mine waters (pre monsoon)
R - Reference water (pre monsoon)

Fig. 1 Durov's diagram of samples - Chapha incline (Umaria)

Except for Copper, Lead, Iron, Manganese, and Cobalt other elements could not be detected by Atomic Absorption Spectroscopy. This may be due to the Chemical affinity of trace elements under basic conditions (Jones, 1974)., as total dissolved heavy metals form insoluble precipitate in basic water.

In microbial studies no usual micro-organisms were noticed in the PDA media (Pelczar et al 1986) except Acetomycetes and fungus (Aspergillus niger) while in enrichment media (Temple and Colmer, 1951) bacterium Thiobacillus ferrooxidians was noticed. Although the pH of the samples is not very much favourable for thriving of the bacterium (pH 6.2 to 8.3 alkaline range). This may be due to the fact that the sample may belong to a class of mine waters with abundance of Fe^{2+} ion. More acidic medium probably existed in the microzones where the Thiobacillus ferrooxidans developed and when the pH is in alkaline range it ceases to grow and when again inoculated in a favourable medium [5,6] i.e. in acidic medium the bacterium becomes active and shows a normal growth which implies that bacterium has propensity for adaptation[10].

Based on the observed physico-chemical parameters hydro=chemical diagrams have been plotted.



U-1' to U-9' - Coal mine waters (post monsoon)
R' - Reference water (post monsoon)

Fig. 2 Durov's diagram of samples - Chapha incline (Umaria)

Durov's diagram (Fig.1,2) reveals that HCO_3 and Na^+ions are predominating in both the seasons (pre and post monsoon).

The water logging profile which gives the distribution of particular parameter in relation to depth reveals that fluctuation is very much distinct at 22nd to 30th levels. The cause is the intense mining operations in the mine (Table 4, Fig. 3).

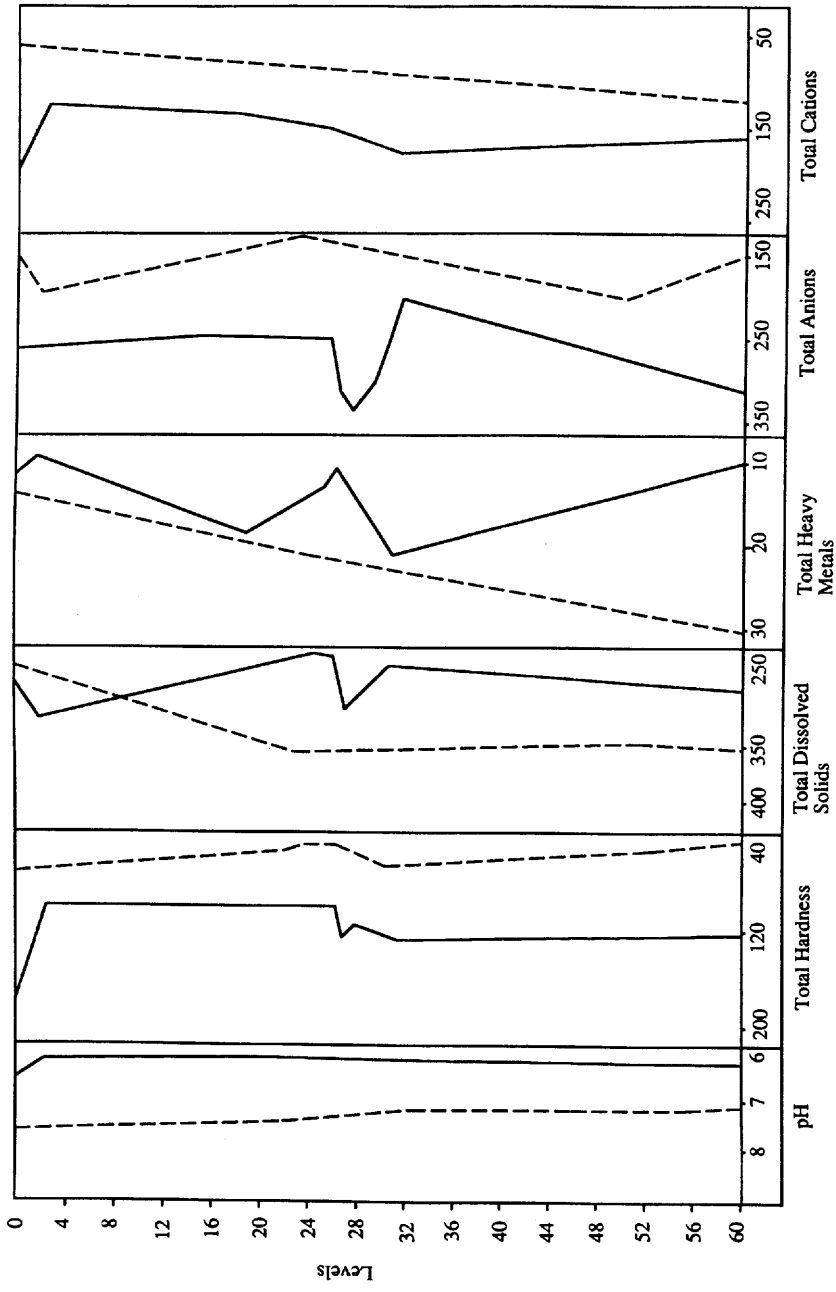


Fig. 3 Water logging profile (pre and post monsoon) : Chapha incline (Umaria)

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