PREDICTION OF WATER QUALITY DRAINAGE IN COAL MINES - A CASE STUDY

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ABSTRACT

The physico-chemical characteristic of water depends upon physico-chemical properties of overburden and waste dumps and weathering and erosional factors prevailed in that mining area. Mining makes the availability of rocks at or near the earth surface. These rocks and associated ores are vulnerably attacked by both physical and chemical processes; and accelerates the movements of mineral and other degraded product into hydrological cycle. The determination of concentration of various cations and anions in water before or during different stages of mining would provide a solid base in order to adopt mitigative measures for improvement of mine drainage quality.

In this paper a case study of one major issues of mining industry, in water quality prediction is presented. For prediction of water quality in a coal mine, a physical model has been designed and developed in order to determine what rock or spoils/water interaction will occur in mine, either in working face (sump water) or in waste dump (leachates). The study has been conducted in mine D of Northern Coalfields Limited in Madhya Pradesh. Acid production potential (APP) and acid neutralization potential (ANP) of coal and coal associated rocks samples collected during coring have also determined. Model test has been performed to quantify the acidic or alkaline nature of each strata.

The above study reveals that water quality of sump will be acidic (4.9 to 5.2) in initial stage of mining operation. with lapse of time, it will become more acidic when coal will be excavated. To validate the above finding further, APP and ANP of each litho-unit have determined and computed. These value also confirm the occurrence of acid drainage in mine D during exploration stage. Pyritous shale and coal show high APP and are the main cause of acidity in mine.

Now after a couple of years, during the mining operation, when the coal production started; quality of sump water in mine D have monitored in different seasons. The pH value ranges from 4.7 to 5.8. Other parameters have also analysed.

It may be concluded from above investigations that occurrence of acidic or alkaline mine drainage may be predicted even at planning/exploration stage in order to formulate or propose the mitigative measures during mining operations.

INTRODUCTION

Prediction of mine drainage quality at the exploration stage is of prime importance to plant the water quality management. Prediction of drainage quality became of most importance in mines containing pyritous coal. Since such mines would suffer with acid mine drainage problem. Hence, prediction of water quality at even at exploration stage not only help in formulation of AMD management programme in advance but also help in protecting the water quality in a better way.

Mining operations make the availability of rocks at or near the earth surface. These rocks are vulnerable to attack by both physical and chemical processes and accelerates the movement of minerals, degraded products into hydrological cycle. The quality of drainage in coal mines is generally governed by the mineralogical composition of rocks and many other factors (e.g. chemistry of ground water, volume of water, geological structures and relative proportion of each rock type.

The ratio of acid producing (pyritous rocks) and acid neutralizing (carbonate containing rocks) rocks ultimately decides the fate of sump water, quality (acidic or alkaline) in a mine.

This paper is an attempt to predict the mine drainage quality even at exploration stage with the help of bore hole samples and physical model. The core samples has been collected from field to make the laboratory investigations. The laboratory investigation has been correlated with field data.

STUDY AREA

The study area (Mine D) in Singrauli is located in Madhya Pradesh. The Singrauli coalfields stands as a high plateau over the surrounding plane covered by a Talcher sediments. The Barakar is the main formation covering the plateau and hills in the area. The maximum elevation of landscale is over 500 m above mean sea level. The landscale has step like scrap faces and represent different stages of peneplanation.

The Mine D is located in the drainage area of Sone and Rihand rivers. Kachani river, a tributary of Rihand, receives the effluent of Mine D. The mine D experience a tropical monsoon climate. The area enjoys a rather heavy monsoon and the annual rainfall varies between 125 cm and 150 cm. The mine D lies at the northern extremity of the Sone - Mahanadi master Gondwana basin. The detailed geological sequence is given below with thickness :

Strata	Thickness in meter
Coal seam	2.42 to 13.24
Shale, sandstone, shale	0.00 to 13.25
Coal seam	5.06 to 19.04
Fire clay, shale, sandstone, shale,	27.05 to 68.00
Coal seam	10.05 to 26.66
Clay, sandstone, shale	15.24 to 28.32
Coal	0.24
Shale	2.59
Coal	0.34 to 1.0
Shale, sandstone, shale	26.62 to 41.16
Coal	0.30
Clay	2.75
Coal	1.75 to 2.10

It may be observed from description that the dominant rocks exposed in the area are sandstone, shale, clay, fireclay and coal. These are severely attacked by weathering agent in presence of water (surface and underground water) during various opencast coal mining operations. The annual production of coal from this mine is about 10 million tonnes.

STUDY METHOD

A simple physical model has been fabricated to assess the impact of various rocks types on water quality (Fig. 1) . The containers in the model are numbered as 1,2,3,4,5,. The height of each container is correspond to thickness of each strata in the field. The total height of model represent the total height of all benches in the mine i.e. the total thickness of each strata.

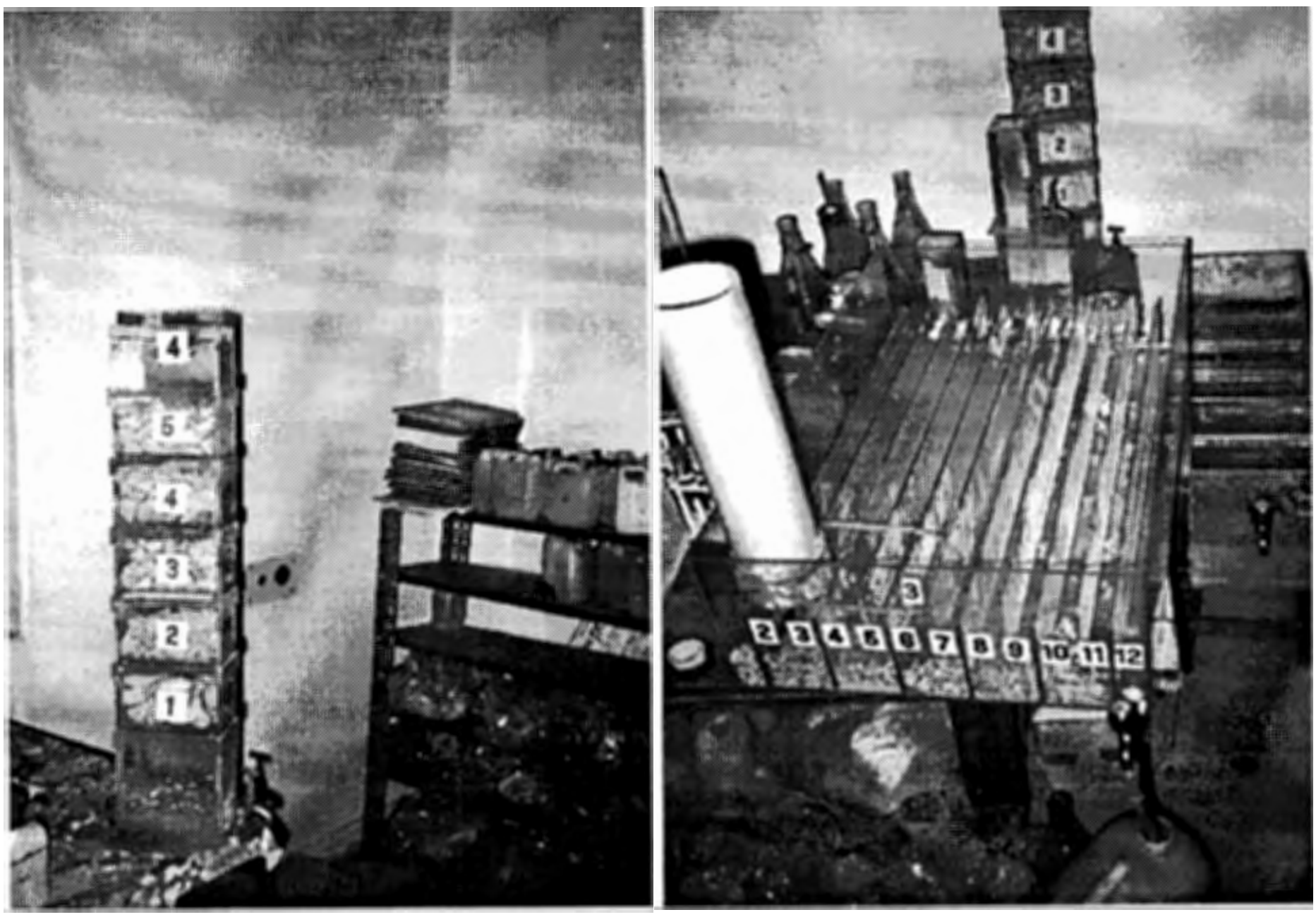

Fig. 1. Water quality prediction models

The rock types found in mine D were collected from bore holes. The actual thickness of coal and associated rocks were calculated from lithological profile and working forces. These rocks were filled in each container accordingly to match with the thickness of strata occurring in the field. The lithological sequence in container were also maintained to that found in field.

The actual thickness and its relative proportion to other has been taken into consideration while filling the container with corresponding rocks in lose form. The uppermost (top) container numbered as S_1 is used for water to be percolated through various rocks at a particular rate of flow. The base of top container is perforated to pass water at a particular rate of flow. The bottom-most container has been kept vacant to receive leached water from overlying containers filled with strata

in a sequence actually occurred in filled in this leached water has been tested on water analysis kit for temperature, pH value, total dissolved solids, D.O. and conductivity. The results are summarised in Table 1.

Sump water samples both near coal and overburden face has been collected and analysed in the field. The results of detailed analysis is summarised in Table 2.

RESULTS AND DISCUSSIONS

Impact of various rocks and coal on water quality

In coal mine D, the stripping ratio ranges from 2.8 to. 4.2. Hence, arkosic sandstone plays a Table 1. Impact of sedimentary rocks on water quality, rate of flow of water - 200 ml/minute dominant role in degrading or upgrading (acidic water) the water quality in mine. sandstone is an acid neutralizing rocks, producing slightly alkaline water, with a low total dissolved solids (TDS) concentration (165 - 185 mg/L) (Table 1).

Table 1. Impact of sedimentary rocks on water quality
(rate of flow of water - 200 ml/minute)

Parameters	**Blank water**	**Sandstone**	**Fireclay + clay**	**Shale + coal**	**Sandstone + Fire clay + clay + shale + Coal**
Temperature °C	32.8-32.9	33.8-33.9	32.9-33.1	33.9-33.7	33.0-33.62
pH Value	6.97-7.01	7.80-7.94	7.02-7.64	2.92-3.68	5.67-5.81
Total dissolved solids (mg/L)	130-132	165-185	140-165	230-242	210-252
Conductivity ms/cm	20	21-23	22-23	35-40	30-31
D.O. mg/L	3.4-3.9	2.8-3.2	1.9-2.2	2.102.7	4.4-4.9

The impact of clay and fire clay is least on water quality, a slight increase in pH value (7.64) and TDS has been observed.

Shale and coal are acid producing rocks in this mine and a very low pH value (2.92 - 3.68) has been observed.

In a rock simulated model, the cumulative impact of all rocks types on water quality is not significant, right now. Under the present working condition, when the stripping ratio is high and hence a slightly acid water would be produced from mine (Table 1).

This result is correlated with analytical result of sump water collected from mine (Table 2).

It is clear from Table 1 and also from geological setting that when the stripping ratio decreases, the severity of the acidic water problem will be increased. Hence the mine is expected to suffer with acid mine drainage problem.

Table 2. Sump water quality in mine D

Parameters	Sump Water	
	Coal Face	Sandstone Face
Temperature °C	32.6-32.8	33.4-33.8
pH Value	5.69-6.80	7.63-7.92
TSS mg/L	380-730	920-1130
TDS mg/L	125-130	115-1450
BOD_5 at 20 °C mg/L	2.6-3.2	1.2-1.9
Oil and Grease mg/L	Nil-1.2	Nil-0.6
Bicarbonate mg/L	Nil-26.8	103-118.2
Carbonate mg/L	Nil-14.0	10-15.8
Chloride mg/L	34-42	34-57
Fluoride mg/L	0.3-0.9	0.2-0.4
Nitrite mg/L	3.0-6.5	2.8-12.2
Nitrate mg/L	3.8-9.2	7.9-12.2
Phosphate mg/L	0.8-1.8	Nil-1.2
Silicate mg/L	6.8	12.6
Sulphate mg/L	80-123	10.0-27.0
Boron mg/L	2-9	3-7
Calcium mg/L	8.2-12.3	7.3-9.2
Chromium mg/L	BDL	BDL
Copper mg/L	BDL	BDL
Iron mg/L	0.214-0.436	0.2004-2144
Lead mg/L	0.2114	0.1213
Magnesium mg/L	0.6-8.5	5.0-8.2
Potassium mg/L	6.0-6.25	6.0-7.8
Sodium mg/L	12.0-15.2	8.0-11.6
Zinc mg/L	Nil	-
Conductivity ms/cm	12.6	11.6

CONCLUSIONS

1. A slightly alkaline water (pH more than 7) leached out from sandstone, fireclay and clay confirm that these rocks are not acid producing horizon in mine D. To some extent, they help in mitigating the acidity of acidic sump water. Hence, these rocks act as an acid neutralizer.
2. It is known from the very low pH value of leached water from shale and coal that these are acid generating strata and pyrite occurrence is the only cause of acidity in mine D.
3. The sump water of mine D is slightly acidic and it is proved by laboratory model also. In coming years, the mine may suffer with AMD problems with decreasing stripping ratio (overburden/coal ratio).
4. Sandstone is the aquifer in the area. The pH value of ground water in the range of 7.5-8.6 further confirm the presence of neutralizing constituents in sandstone.

ACKNOWLEDGEMENT

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