Suitability of Irrigation with Barapukuria coal mine water.

Joydeb Kumer Dutta, Mohammad Ismile Molla

ABSTRACT

In Bangladesh, coal has been extracted from Barapukuria Coal Mine (BCM) by underground method since 2005. Coal mining authority dewaters the mine continuously by water pump to keep the mine in working condition. Drainage from the mine is treated by primary methods before releasing it into ditch system and local farmers use that treated mine water to irrigate their crops by collecting it from the ditch system. So, the study was undertaken to investigate the suitability of coal mine water as irrigation water. A number of water samples were collected from the subsurface mine sump, abandoned & active coal faces while a few water samples were taken from drains at the surface. Mine water samples were analyzed for major & minor ions and also for trace element concentrations. The coal mine water is of low to medium salinity water having almost neutral pH and is classified as 'normal chloride', 'normal sulfate', 'normal carbonate' and 'very hard' types. From the physical and chemical aspects of mine water it is inferred that mine is not producing Acid Mine Drainage (AMD). When compared to international irrigation water quality standard BCM water is found suitable for irrigation.

Keywords — Acid Mine Drainage, Barapukuria Coal Mine, FAO, Physico- Chemical, pH, Trace elements.

1 INTRODUCTION

Bangladesh has a great coal mining potential in its north western parts & Barapukuria mine is the sole producing coal mine in the country. Mining related impacts upon the natural water environment are reported in many parts of the world throughout the life cycle of a mine and even long after mine closure. Disposal of mine water is a worldwide problem, occurring wherever operating mines, both underground and opencast workings are found. The quality of the mine water depends largely on the chemical properties of the geological materials that come into contact with it (Thompson, 1980). Barapukuria coal mine is facing water inrush problem since the very beginning. Mine authority dewaters the mine continually by underground water pumps to keep the mine in operation. Produced mine drainage is treated by primary methods to settle the suspended solids (which are mainly fine coal particles). 30 -40 % of the treated water is then resent into underground facilities for various purposes and rest is released into surface ditches. Local farmers utilize that water as a source of free irrigation. Some undocumented reports complaining about mine water quality was published in the local newspaper. Thus purpose of the study is to find the suitability of Barapukuria Coal Mine (BCM) water as irrigation water.

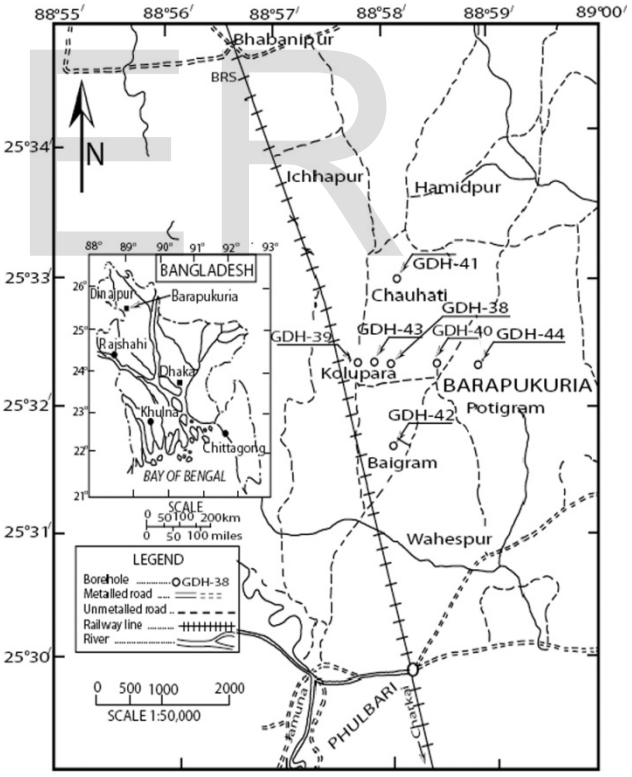

Fig. 1. Location map of the Barapukuria coal field.

Ex- Post Graduate student, Geology & Mining Department
Rajshahi University, Rajshahi. Bangladesh.
E-mail: duttajoydeb@yahoo.com

2 METHODOLOGY

The methodological procedures of the present study involve mine visits and field survey, sample collections, preparations of samples for analyses, field measurements and laboratory analyses. Mine water samples were collected from the subsurface mine sump, abandoned & active coal faces while a few samples were taken from drains at the surface. Standard guidelines were followed during water sampling. Some physico-chemical parameters of the mine water such as pH, Electrical Conductivity (EC), color and temperature were measured in the field by portable digital meters & then Total Dissolved Solids (TDS) were calculated from those EC values. Total Suspended Solids (TSS) was measured in the laboratory by filtration method. Major cation such as Na+, K+, Ca2+ & Mg2+; anion such as Cl-, SO42-, CO3--, HCO3- & NO3-; and different trace element concentrations in the mine water were measured by Flame Photometer, Atomic Absorption Spectrometer, UV- Visible Spectrophotometer, Ion Chromatograph and Titration methods in the laboratories.

3 RESULT & DISCUSSIONS

There are appreciable variations in chemistry of mine water collected from different locations of the Barapukuria Coal Mine. Minimum EC and TDS values are found in gob coal face water (i.e., relatively unmixed and fresh) while that of maximum values in underground sump water (i.e., accumulation of dissolved matter from a variety of sources). The coal mine drainage is of low to medium salinity water having almost neutral pH. Near neutral or greater pH values of coal mine water strongly deny generation of any Acid Mine Drainage (AMD) . Very low TDS, iron, manganese, sulfate and heavy metal concentrations in mine drainage also corroborate the non-existence of AMD. Though carbonate concentration in mine water is slightly higher than that of usual range for irrigation standard (FAO,1985). All major anions, cations and trace elements levels in the mine water are within usual range for irrigation (FAO, 1985) standard. TDS, pH & hardness values of the mine water are within acceptable range for irrigation. Total Suspended Solids(TSS) of the mine water are also within acceptable range according to standard set by Ministry of Agriculture, Forestry and Fisheries, Japan, 2008 for irrigation water.

Table 1
Physico-Chemical Characteristics of BCM water

Parameters	Units	Sites of Sampling			
		Gob coal face 1101	Production coal face 1108	Underground Sump	Surface drain
Depth	m	-260	-420	-430	Surface
pH		7.02	6.96	7.58	7.52
EC	µS/cm	183	403	501	360
TDS	mg/l	117	258	321	230
Temp.	°C	35	38	36	37
TSS	mg/l	Trace	20	40	98.4
Color		Colorless	Colorless	Dark black	Black
Hardness	mg/l	245	237.79	233.47	228.49

Table 2
Concentrations of major anions, cations & trace elements in BCM water

Parameters	Units	Sites of water sampling			
		Gob coal face 1101	Production coal face 1108	Underground sump	Surface drain
Na^{+}	mg/l	22.6	19.1	18.7	24.7
Ca^{++}	mg/l	87.1	75.6	74.2	76.2
Mg^{++}	mg/l	6.71	11.9	11.7	9.27
K^{+}	mg/l	4.74	6.26	6.65	6.26
Cl^{-}	mg/l	3.73	3.45	2.51	3.72
SO_4^{2-}	mg/l	3.72	89.4	71.3	46.2
CO_3^{2-}	mg/l	23	10.5	8.36	9.41
HCO_3^{-}	mg/l	172	148	131	143
NO_3^{-}	mg/l	0.07	0.11	1.71	1.43
Fe^{Total}	mg/l	0.74	7.17	4.95	1.47
Mn	mg/l	0.103	0.415	0.308	0.15
Zn	mg/l	< 0.1	< 0.1	< 0.1	< 0.1
Cu	mg/l	< 0.01	< 0.01	< 0.01	< 0.01
As	mg/l	< 0.005	< 0.005	< 0.005	< 0.005
Pb	mg/l	< 0.01	< 0.01	< 0.01	< 0.01
Hg	mg/l	<0.001	<0.001	<0.001	<0.001
Cd	mg/l	< 0.01	< 0.01	< 0.01	< 0.01
B	mg/l	0.53	0.46	0.65	0.41
Co	mg/l	< 0.01	< 0.01	< 0.01	< 0.01
Mo	mg/l	< 0.01	< 0.01	< 0.01	< 0.01

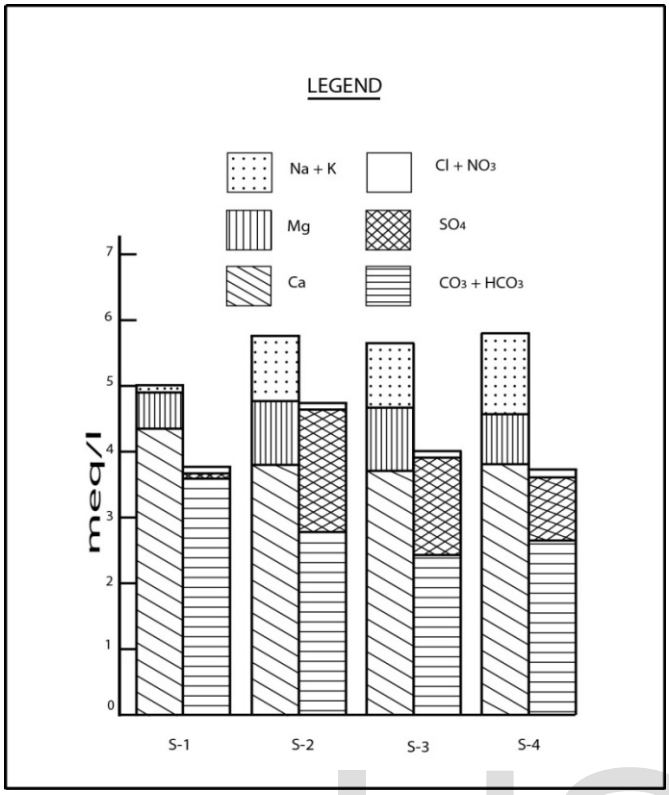

Fig. 2. Collin's (1923) vertical Bar graph showing quality variation in four(S-1,S-2, S-3 & S-4) BCM water samples.

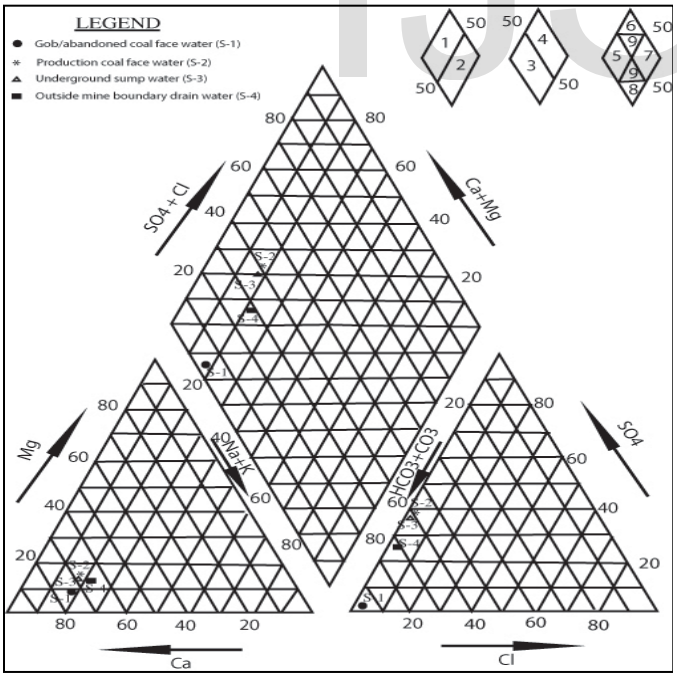

Fig.3. Piper's trilinear diagram shows hydrochemical characteristics of BCM water

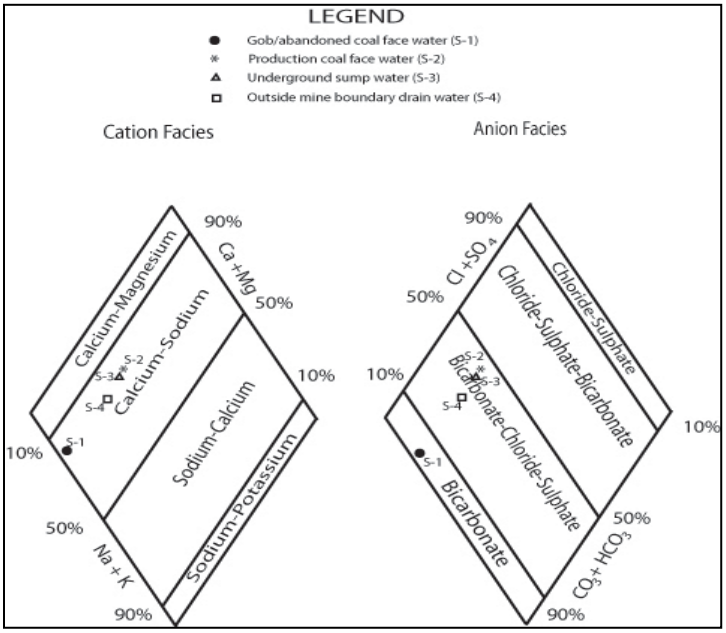

Fig. 4. Facies mapping approach of BCM water

Table 3
Distribution of samples in Piper's Trilinear Diagram

Field No.	No. of samples	Interpretation (After Lloyed et al., 1985)
1.	All samples	Alkaline earth exceeds alkalis
2.	Nil	Alkalis exceed alkaline earth
3.	All samples	Weak acids exceeds strong acids
4.	Nil	Strong acids exceed weak acids
5.	All samples	Carbonate hardness (secondary alkalinity) exceeds 50%, that is chemical properties dominated by alkaline earth and weak acids

Table 4
Classification of groundwater based on hardness & its suitability for irrigation by (Raghunath, 1987 & University of Tennessee Institute of Agriculture, 1999).

Water Class	Ranges of hardness in mg/l as CaCO3	Range in BCM water (mg/l)	Hardness range in irrigation water (mg/l) from University of Tennessee Institute of Agriculture, 1999
Soft	0-55	(228.5 – 245) Very Hard	Desirable is (100-150 mg/l) but acceptable level can be higher
Slight hard	56-100		
Moderately hard	101-200		
Very hard	201-500		

Table 5
Comparison of parameters of coal mine water with that of usual irrigation water set by FAO, 1985.

Water parameter	Unit	Usual irrigation water		BCM water	
Electrical Conductivity (EC)	dS/m	0 – 3	dS/m	0.18 - 0.50	dS/m
Total Dissolved Solids (TDS)	mg/l	0 – 2000	mg/l	117 - 321	mg/l
Acid/Basicity (pH)	1–14	6.0 – 8.5		6.96 - 7.58	1–14
Cations and Anions					
Ca^{++}	meq/l	0 – 20	meq/l	3.71 - 4.35	meq/l
Mg^{++}	meq/l	0 – 5	meq/l	0.56 – 1.0	meq/l
Na^{+}	meq/l	0 – 40	meq/l	0.81 – 1.07	meq/l
CO^{--}_3	meq/l	0 – .1	meq/l	0.28 - 0.77	meq/l
HCO_3^-	meq/l	0 – 10	meq/l	2.15 - 2.82	meq/l
Cl^-	meq/l	0 – 30	meq/l	0.07 - 0.11	meq/l
SO_4^{--}	meq/l	0 – 20	meq/l	0.08 - 1.9	meq/l
NUTRIENTS					
Nitrate-Nitrogen (NO_3-N)	mg/l	0 – 10	mg/l	0.07 - 1.71	mg/l
Potassium (K^+)	mg/l	0 – 2	mg/l	4.74 - 6.65	mg/l
Boron (B)	mg/l	0 – 2	mg/l	0.41 – 0.65	mg/l

Table 6
Comparison of trace element concentrations in coal mine water with that of recommended maximum levels in irrigation water set by FAO, 1985.

Elements	Recommended Maximum Concentration (mg/l)	Concentrations in BCM water (mg/l)
As	0.10	< 0.005
Cd	0.01	< 0.01
Co	0.05	< 0.01
Cu	0.20	< 0.01
Fe	5.0	0.74 - 7.17
Mn	0.20	0.10 - 0.41
Mo	0.01	< 0.01
Zn	2.0	< 0.1

4 CONCLUSIONS & RECOMMENDATION

Barapukuria coal mine water is of low to medium salinity water having almost neutral pH and is classified as 'normal chloride', 'normal sulfate', 'normal carbonate' and 'very hard' types. From the physical and chemical aspects of mine water it is inferred that mine is not producing any Acid Mine Drainage (AMD). When compared with international irrigation water quality standars, BCM water is found suitable for irrigation. Despite primary treatments coal mine water still contains some very minutle coal particles & which may contain heavy metals. Thus regular monitoring on mine water quality is recommended.

ACKNOWLEDGEMENTS

The authors are grateful to the authorities of Barapukuria Coal Mininig Co. Ltd. for their permission to visit the mine & take water samples. The authors also wish to thank Mr. Aminul Ahsan, Senior Scientific Officer of Bangladesh Council of Scientific & Industrial Reserch for his cordial support in analyzing water samples.

REFERENCES

[1] Collins, W.D. 1923. Graphic representation of analyses: Industrial and Engineering Chemistry., v.15, 394p.

[2] FAO, 1985.Water quality guidelines for maximum crop production.Food and Agricultural Organization/UN.www.fao.org/docrep/T0551E.2006/9/13.

[3] Lloyd, J.W. and Heathcote, J.A. 1985.Natural inorganic hydrochemistry in relation to groundwater: An introduction, Claredon Press, Oxford, 291p.

[4] Ministry of the Environment, Japan, 2008.EnvironmentalQuality Standards for WaterPollution, http://www.env.go.jp/en/water/

[5] Piper, A.M. 1944. A graphic procedure in the geochemical interpretation of water analyses: American Geophysical Union Transactions., v.25, p. 914-923.

[6] Raghunath, H.M. 1987. Groundwater.Wiley Eastern Ltd., Delhi, India, 563p..

[7] Thompson, J.G., 1980. Acid mine waters in South Africa and their amelioration. Water SA ., v.6, p.130-134.

[8] University of Tennessee Institute of Agriculture, 1999.Agricultural Extension Service, PB1617-1M-2/99, p.3-5.