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Full Length Research Paper

Water Characterization of Coal Mining Areas of Lakhra, Sindh

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Coal mining is causing adverse effects on water in the vicinity of mining areas throughout the world. Discharged water from mines shows alteration in the physical properties and may be acidic depending upon the concentration of heavy metals and sulfate ions which in turn depends upon the pyrite contents of the coal. It degrades the water quality by lowering pH value, increasing turbidity and total suspended and dissolved solid contents which pose hazardous effects on groundwater and ecosystem. This paper deals with the characterization of water being affected by coal mining in the Lakhra area of Sindh. Total eleven samples were collected from different water sources including groundwater, mine outflows, mine inflows and surface water in the vicinity of coal mine. All samples except that of groundwater showed higher turbidity, lower pH values and higher total solid contents. Higher concentration of Fe and Cu in all samples indicate higher acid mine drainage (AMD).

Keywords: Water pollution, Mine water characterization, Effect of mining on water

INTRODUCTION

Mining industry plays a prime role in the development of any country; particularly it acts as a backbone for developing countries. Everything we use today, either directly or indirectly is acquired from this industry. Despite all of the benefits which the mining industry offers to society, it adversely affects the environment during its all stages of working, even after completion of mine operation. Its major negative impact includes changes in hydrology, lithology, topography, ecology, land-use distribution and visual degradation, socio-economic statistics and atmosphere. Probably the most severe damage occurs to the groundwater regime of the area. Once the mining activity is started, hydrology of the area begins to pollute almost infinitely due to the addition of dissolved or suspended particles. Generally water is

altered either physically or chemically by embracing impurities. Once the water is entered the mine, it becomes inevitable to prevent it from getting contaminated. This contaminated water is normally entered the water cycle and causes hazardous effects on living things, land and atmosphere. Extent of water contamination is primarily dependent upon composition of ore deposits and its surrounding geology, structural features of the area, hydrology and climate of the mining region. It also depends upon how the water is entered a mine, how it interacts with host rocks and ore body, in which way it is utilized in mining processes and the way it is pumped out of the mine (Dold and Fontbote, 2001).

Water contamination in coal mines is primarily dependent upon the coal contents/ impurities, nature of

Table I. Physical Characteristics of water samples collected from in and around the vicinity of Lakhra coal mine

Sample	Odor	Temperature (on-site) (°C)	pH	Conductivity (mS)	Turbidity (ftu)	TS	TDS
Limits*	---	---	6-9	--	5**	(200***+ 3500)	3500
G1	Earthy	16	6.35	7.72	1.151	530	460
G2	Earthy	16	6.46	7.33	1.152	760	530
O1	Weedy	21	2.23	66	4.85	6530	5130
O2	Weedy	21	2.31	67	4.77	6800	4500
O3	Weedy	21	2.31	71	4.7	5730	5000
I1	Light pungent	23	2.27	20.37	5.12	5060	4500
I2	Light pungent	23	2.32	6.64	5.29	6130	4500
I3	Light pungent	17	6.29	403	0.882	830	460
S1	Not detected	19	2.36	396	2.76	3260	2200
S2	Not detected	19	2.34	493	2.82	3200	2460
S3	Not detected	19	2.43	592	2.87	3530	1730
C1	Similar to coal	22	5.63	412	1.039	2630	860

Table II. Elemental analysis of water samples collected from in and around the vicinity of Lakhra coal mine

Sample	Ca (ppm)	Mg (ppm)	Fe (ppm)	Zn (ppm)	Cu (ppm)	SO ₄ ²⁻ (ppm)
Limits*	--	--	8.0	5.0	1.0	600
G1	153	1.0	60	0.00	1.28	207
G2	415	7.0	60	0.00	0.72	207
O1	14	12.5	63	0.11	11.75	215
O2	14	5.0	60	0.06	11.75	207
O3	0	0	63	0.08	10.53	215
I1	56	0	63	0.03	10.53	215
I2	56	0	63	0.01	10.53	215
I3	0	6.0	74	0.50	4.48	254
S1	0	5.0	80	0.97	7.58	267
S2	0	7.0	74	1.13	6.91	254
S3	0	10.0	74	0.86	7.22	254
C1	0	12.5	88	0.03	11.75	302

* After National Environmental Quality Standards (NEQS, 2001).

** After Pakistan's drinking water standards (PEPA, 2008)

*** Total Suspended Solid Limit

the country rock, mining method, rate of extraction, inflow rate of water and the amount of water used in mine (Gomes et al., 2011). Acid generation through oxidation of sulfur bearing minerals such as pyrites in coal mines is one of the major causes of water contamination (Tiwary, 2000). The amount of acidity produced from a coal mine mostly depends on the sulfide contents, age of the deposit, alkalinity producing minerals and waste volumes (Gomes et al., 2011). Mn, Fe, and Al are found to be the major elements which constitute acidity in coal mine drainages (Skousen et al., 1998). The reduced pH values cause further dissolution of various minerals and toxic

metals into water (Tiwary, 2000). Pb, As and Ni are frequently found toxic metals in coal mine drainages (Younger and Sapsford, 2004).

The aquatic life is adversely affected by the acid-generation. Not only the lower pH value harm organisms but release of heavy metals into water severely damages the aquatic biota, wild life and land fertility for vegetation (Tiwary, 2000). Amount of copper, zinc, calcium, nitrates and phosphates also affects the organism growth. Besides acid mine drainage, inappropriate physical conditions like temperature, turbidity etc. of water play significant role in limiting the growth of living things

(Kumar & Kakrani, 2000). This study aims to characterize the water samples collected from different sources around coal mines in Lakhra area, Sindh. These samples were particularly evaluated for their acidity due to contamination in the form of dissolved metal contents. Moreover, a passive treatment method was proposed for reducing the contamination level of coal mine water.

Experiment:

MATERIALS AND METHODOLOGY

Water samples were collected in pre-cleaned air tight bottles washed by nitric acid prior to sampling. The bottles were sealed immediately to avoid oxidation and other atmospheric effects on contained constituents. Each sample bottle was labeled and sample codes were employed to make the proper log of collected samples.

Total eleven water samples were collected from different sources including mine inflows (I1 and I2), mine outflows (O1, O2, O3), groundwater outlets (G1, G2) and surface flows (S1, S2, S3). Each sample from a particular source was collected from different locations. I1 and I2 were collected from two different points within the mine while I3 was sampled from a little inrush of water in the midway of the main incline. O1, O2 and O3 were collected from sump-1 situated down the main incline, discharged water by pump and sump-2 located in midway of the incline respectively. G1 is collected from a well nearby to the mine portal while G2 was sampled from a well far away from mine. S1, S2 and S3 were collected from three different surface sources located in different directions to the mine. In order to find out the potential of coal to pollute water, a sample C1 was prepared in the laboratory by adding 7 liter distilled water in 2 kg crushed coal having particle size less than 4 mm. The mixture was allowed for 24 hours and then the infected water was filtrated through a 150 micron sieve to get the desired water sample.

Color of all water samples was noted before and after exposure of 24 hours to fresh air to get an idea of oxidation. Odor of the samples was recorded after getting the opinion of 4 to 5 observers as it varies with the individual sensitivity. Mercury thermometer calibrated in degree Celsius was used to measure on-site temperature of the water samples. pH and turbidity (haziness of a fluid due to invisible suspended particles) of all samples were measured by using ELE pH meter and ELE turbidity meter respectively. The Lovibond Sesnso Direct Con. 200 electrical conductivity meter was used to determine the electrical conductivity of water samples in μS and mS (micro and milli Siemens). Total solid (TS) and total dissolved solids (TDS) were determined by using conventional heating methods. ELE Paqualab Photometer was utilized to find out concentrations of metal such as Fe, Ca, Mg, Zn, and Cu etc. and sulfur.

RESULTS AND DISCUSSIONS

Groundwater samples showed a slight increase in turbidity while a very high increase in turbidity was observed for mine outflows, surface water and mine inflows. All samples except groundwater showed yellow colored precipitates after exposure of 24 hours to fresh air. The yellowish colored of the water was primarily due to the formation of iron hydroxide $[\text{Fe}(\text{OH})_3]$ which is commonly found in the water bodies near coal mining areas. Generally when iron is introduced into the natural water, it becomes hydrolyzed and forms precipitate of iron hydroxide. Iron in coal mines normally results from pyrite contents in the coal (Sewer and Singh, 2004).

The results of odor, temperature, pH, turbidity, total solids, total dissolved solids, and metal and sulfur concentrations are shown in the Table-I. pH values of the water samples varies between 2.27 and 6.46. All samples except groundwater samples showed acidity or low pH values which indicate acidity of the water. Acidic water is injurious for living bodies. This water may flow to rivers or streams where it can be hazardous to aquatic life since it facilitates leaching of toxic metals into the water (Sewer and Singh, 2004). Moreover, high acidity limits the amount of nutrients in the water which are required for vegetation (Ezeigbo and Ezeanyim, 1993).

Mine outflows and inflows revealed higher total solid (TS) and total dissolved solid (TDS) beyond the standard limits. These solid materials may be present in the form of insoluble suspended mineral particles and soluble ions of metals, sulfate, chloride, phosphate and nitrates etc. The suspended particles are harmful for aquatic life as they reduce the availability of light and dissolved oxygen in water which is necessary for photosynthesis.

Although sulfur ions in all water samples are found to be within limits which vary between 207 and 302 mg/l, they may combine with water to form sulfuric acid or can attach to calcium ions to form gypsum sludge. Cu and Fe concentrations vary from 0.72 to 11.75 mg/l and 60 to 88 mg/l respectively. These concentrations are very high which are responsible for acidity of water. Concentration of Ca, Mg and Zn vary from 0 to 415, 0 to 12.5 and 0 to 1.13 mg/l respectively in Table-II. Higher concentration of Ca and Mg are the root causes of water hardness which may affect health of living bodies if used for drinking purposes.

As the discharged water is pumped out to the surrounding fields and local water drains, it may be very hazardous to the surrounding water bodies and land soil which can severely affect the aquatic and wild life and ecosystem of the area. Therefore, this acidic water should be treated before its drainage to local water bodies. Since the mine site geology is mainly limestone, which is naturally remediating the affected water, therefore a passive treatment method may serve the purpose. For passive treatment of water, construction of two or three small settling ponds would be required to

settle suspended particles which may be followed by a number of small ditches normally 3-6 feet deep in surface limestone. These ditches can be filled with gravels of limestone for treating dissolved acid producing metal contents through ion exchange method.

CONCLUSIONS

Most of the water samples were found to be fairly affected by impurities. These impurities appeared in the form of suspended and dissolved solids. Elevated concentrations of Fe, Cu and SO_4^{2-} in most of the water samples had caused considerable reduction in pH value of water making it highly acidic. However, it was found that groundwater was not much affected yet as it had the pH value in the prescribed safe limits (6.5-7.8). It was concluded that geological formations such as limestone present in the study area was naturally treating the mine discharged water. This was confirmed by the presence of large amount of Ca ions and relatively low concentrations of iron, copper and sulfur ions in the groundwater samples.

Lower pH values and large concentrations of dissolved metals and sulfate ions in the inflow water samples showed that the surrounding geology is also contaminating the water to some extent, thus causing acid generation. Moreover, characteristics of the water extracted from coal samples in the laboratory clearly revealed that the coal seam had fair tendency to produce acid mine water.

REFERENCES

- Dold J, and Fontbote L (2001). Element Cycling and Secondary Mineralogy in Porphyry Copper Tailings as a Function of Climate, Primary Mineralogy and Mineral Processing. *J Geochem Explor*, 74, 3-55.
- Ezeigbo HI, and Ezeanyim BN (1993). Environmental Pollution from Coal Mining Activities in the Enugu Area Anambka State Nigeria. *Mine Water and Environment*, 12, 53-62.
- Gomes CJ, Mendes CA, Costa JF (2011). The Environmental Impacts of Coal Mining: A Case Study in Brazil's Sangao Watershed. *Mine Water Environment*, 30, 159-168.
- Ibrahim SM (2009). "*Stratigraphy of Pakistan*", Geological Survey of Pakistan, pp-25-39, 2009.
- Kumar U, Kakrani B (2000). *Water Environment and Pollution*. Jodhpur: Agrobios (India).
- Skousen J, Rose A, Geidel GJG, Evans R, Hellier W (1998). *Handbook of Technologies for avoidance and remediation of Acid Mine Drainage*. Morgantown. West Virginia Water Research Institute, Virginia University.
- Swier S, Singh OP (2004). Status of Water Quality in Coal Mining Areas of Meghalaya, India. *Proceedings of the National Seminar on Environmental Engineering with Special Emphasis on Mining Environment, NSEEME-2004*, 19 – 20, march 2004.
- Tiwary RK (2000). Environmental Impact of Coal Mining on Water Regime and its management. *Water, Air and Soil pollution*, 132, 185-199.
- Younger PL, Sapsford DJ (2004). *Evaluating the Potential Impact of Opencast Coal Mining on Water Quality (Groundwater Regulations 1998): An Assessment Framework for Scotland*. Newcastle Univ, Newcastle upon Tyne: Scottish Environment Protection Agency (SEPA).