Present status of acid mine drainage in coal mines of secl and its prevention

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Abstract
Acid Mine Drainage (AMD) is a very common environmental pollution problem which occurs worldwide in mining region. AMD forms when sulfide minerals in rocks are exposed to oxidizing condition in coal and metal mining, highway construction and other large scale excavations. During mining, the exposed wall rocks come in contact with the oxygenated water, interaction between these causes generation of AMD. Bacterial activity also plays an important role in acid formation. Coal has a crucial role in meeting current needs and is a resource bridge to meet future goals. Through the enhancement of knowledge and technology the challenge is to apply the right technology in the most efficient and environment friendly way. The biggest environmental challenge facing the coal industry is the issue of greenhouse gases and acid rain. The aim of this project is to investigate the water quality parameter in relation to acid mine drainage for the Indian coal fields that includes possibilities for control, minimization and optimal feasibility for the implementation of control method. In Chhattisgarh region S.E.C.L., division of CIL plays a major role for coal extraction. The AMD management practices followed by SECL were not found adequate owing to the technological, environmental and natural water resource management problems. Thus there is an urgent need of research regarding control and abatement of AMD. Depending upon site characteristics, so improved reliability and efficiency is required. An attempt is made to view the status of acid mine drainage in Indian coal mine and to study about its preventive measures is an issue of further research.

Keywords: AMD, CIL, Coal, Mines

INTRODUCTION
NCPH colliery is situated in the eastern part of chirimiri coalfields. Latitude- 23°11'36" Longitude- 82°21'5". Premises of R-6 colliery starts after 1 km from Chirimiri railway station in north. Direction

Table 1. Details of R6 colliery, Chirimiri area, SECL.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>1st seam</th>
<th>2nd seam</th>
<th>3rd seam</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness</td>
<td>1.6-2.3 m</td>
<td>1.2-3 m</td>
<td>4.0-7.0 m</td>
</tr>
<tr>
<td>Gradient</td>
<td>1 in 45</td>
<td>1 in 40</td>
<td>1 in 45</td>
</tr>
<tr>
<td>Max depth</td>
<td>200 m</td>
<td>230 m</td>
<td>260 m</td>
</tr>
<tr>
<td>Gassiness</td>
<td>Degree-1</td>
<td>Degree-1</td>
<td>Degree-1</td>
</tr>
<tr>
<td>Area</td>
<td>230 acre</td>
<td>780 acre</td>
<td>1010 acre</td>
</tr>
<tr>
<td>Reserve</td>
<td>5.28 mt</td>
<td>5.8 mt</td>
<td>7.56 mt</td>
</tr>
<tr>
<td>Production/day</td>
<td>450 te</td>
<td>230 te</td>
<td>450 te</td>
</tr>
</tbody>
</table>

Sampling of mine water
Water samples from 6 different locations were collected and tested, corresponding locations are as follows

Table 2. Location from where samples were collected

<table>
<thead>
<tr>
<th>Sample no</th>
<th>Spot from where sample was collected</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Working face water</td>
</tr>
<tr>
<td>2</td>
<td>Goaf area</td>
</tr>
<tr>
<td>3</td>
<td>Discharge at surface (through drainage, near water treatment plant)</td>
</tr>
<tr>
<td>4</td>
<td>Sump</td>
</tr>
<tr>
<td>5</td>
<td>Main return (near temple through pumping)</td>
</tr>
<tr>
<td>6</td>
<td>Sealed off area</td>
</tr>
</tbody>
</table>

Tests of water samples for various parameters with respect to standards of ‘General Standards For discharge of Environmental Pollutants [INS. by GSR 422 (E) and 801 (E), dated 19th May 1993]’ have been carried out in Applied Chemistry Laboratory of NIT Raipur and results are given below.

Status of industrial pollution.

Table 3. Results of laboratory chemical tests

<table>
<thead>
<tr>
<th>Physical Properties</th>
<th>Sample no.</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>Supernatant</td>
<td>6.46</td>
<td>7.62</td>
<td>7.1</td>
<td>4.33</td>
<td>8.29</td>
<td>6.62</td>
</tr>
<tr>
<td>Turbid</td>
<td></td>
<td>7.33</td>
<td>7.41</td>
<td>6.75</td>
<td>4.47</td>
<td>7.90</td>
<td>6.07</td>
</tr>
<tr>
<td>TDS (in ppm)</td>
<td></td>
<td>1990</td>
<td>1655</td>
<td>1210</td>
<td>930</td>
<td>1085</td>
<td>855</td>
</tr>
<tr>
<td>TSS (in ppm)</td>
<td></td>
<td>1620</td>
<td>915</td>
<td>549.5</td>
<td>320</td>
<td>895</td>
<td>865</td>
</tr>
<tr>
<td>TS (in ppm)</td>
<td></td>
<td>3610</td>
<td>2770</td>
<td>1795.5</td>
<td>2250</td>
<td>1980</td>
<td>1720</td>
</tr>
<tr>
<td>Total hardness (in ppm)</td>
<td></td>
<td>975.65</td>
<td>924.3</td>
<td>916.4</td>
<td>1224.5</td>
<td>622.125</td>
<td>513.5</td>
</tr>
<tr>
<td>Chloride conc. (in ppm)</td>
<td></td>
<td>7.09</td>
<td>24.815</td>
<td>31.905</td>
<td>28.36</td>
<td>14.18</td>
<td>17.725</td>
</tr>
<tr>
<td>Calcium conc. (in ppm)</td>
<td></td>
<td>167.5</td>
<td>287.5</td>
<td>160</td>
<td>302.5</td>
<td>157</td>
<td>262.5</td>
</tr>
</tbody>
</table>
FINDINGS

Working face (sample no 1, R6 mine)

Total dissolved solids' is found to be highest in water sample no 1. In the working face, different production and auxiliary operations are being carried out that is why TDS amount is highest here.

As the water near working face is subjected to iterative mixing of dust and agitating action due to movement of machinery and workmen, the amount of total suspended solids is found to be highest in working face sample.

pH value is found to be a little bit acidic and is 6.46, which shows that, coal is containing FeS$_2$ which is main contributor of AMD production. Total solid content is 3610 ppm, total hardness is 975.65ppm, Chlorid concentration is 7.09 ppm, Calcium concentration is 167.5ppm, Magnesium concentration is 40.87 ppm, Iron concentration is 16.95 ppm, Sulphate concentration is 1205.45 ppm.

GOAF Area (sample no 2)

pH value is 7.62, total solid content is 2770 ppm, total hardness is 924.3 ppm, Chloride concentration is 24.815 ppm, Calcium concentration is 287.5 ppm, Magnesium concentration is 83.57 ppm, Iron concentration is 11.3 ppm, Sulphate concentration is 1464.145 ppm.

Discharge at the surface (sample no 3)

It contains highest concentration of Iron, but water sample no 4 is found to be most acidic, this is due to the fact that formation of acid merely depends upon available contact time between water, iron and oxygen, and for sample no 3 contact time is less than contact time for samples no 4.

pH value is 7.1, total solid content is 1759.5 ppm, total hardness is 916.4 ppm, Chloride concentration is 31.905 ppm, Calcium concentration is 157 ppm, Magnesium concentration is 29.28 ppm, Iron concentration is 43 ppm, Sulphate concentration is 1092.31 ppm.

Mine sump

pH value of water taken from sump is found to be most acidic among all other water samples, it can be concluded that contact time of water with rock and mixing of samples leads the water sample to lower pH.

Sample no 4 contains highest sulphate concentration, that shows the concentration of acid formed, and least pH value.

pH value is 4.33, total solid content is 2250 ppm, total hardness is 1224.5 ppm, Chloride concentration is 28.36 ppm, Calcium concentration is 302.5 ppm, Magnesium concentration is 74.42 ppm, Iron concentration is 16.95 ppm, Sulphate concentration is 2145.5 ppm.

Main return (sample no 5)

Sample collected from main return is found to be of most alkaline nature among all samples collected. Iron concentration is least in this sample and also Sulphate concentration is least among all, that leads to its low acidity and high alkalinity. Proper pumping is also a reason for reduced acidity.

pH value is 8.29, total solid content is 1980 ppm, total hardness is 622.125 ppm, Chloride concentration is 14.18 ppm, Calcium concentration is 157 ppm, Magnesium concentration is 72.59 ppm, Iron concentration is 5.65 ppm, Sulphate concentration is 814.605 ppm.

Sealed off area (sample no 6)

Sample collected from sealed off area is of a little bit acidic nature and is 6.62, total solid content is 1720 ppm, total hardness is 513.5 ppm, Chloride concentration is 17.725 ppm, Calcium concentration is 262.5 ppm, Magnesium concentration is 32.94 ppm, Iron concentration is 11.3 ppm, sulphate concentration is 1692.98 ppm.

Adverse effects of acid mine drainage

- It supports only limited type of flora like acid resistant moulds and algae. It goes on increasing and forms a mat over the water and when this algae decomposes, produces toxic material.
- Because of decreased pH, the solubility of heavy metals such as Fe, Mn, Zn, Cu etc increases. The metal consumes the oxygen present in water for their oxidation. As a result oxygen dissolved in water reduces and it can no more support life.
- Water becomes corrosive and cannot be used for industrial purpose.
- It also leads the water body unacceptable for recreation.
- This water is not suitable for agricultural and drinking purposes.

Acid mine drainage control measures

- Modified mining methods like long wall mining
- Mine sealing.
- Surface reclamation.
- Water diversion.
- Control of ground water flow system by well fields and other methods.
- Deep well injunction for containing polluted water.
- Subsurface dams and ground curtains.
- Dilution of AMD to achieve acceptable effluent quality.
- Spraying bacteriophage viruses in to mines to kill acid forming bacteria.
- Chemical grouting to make rock impermeable and to bind sulphur by using plastic bubbles to fill abandoned mines.
Recommendations

Workout plan

After this practical observation and theoretical study on various parameters of occurrence, causes, prediction and prevention of AMD, following measures are being recommended for control of Acid Mine Drainage at underground coal mine R6, Chimiri area -:

(1) Pumping arrangement:- Sufficient pumping arrangements should be installed, enough for complete and efficient pumping the accumulated acid water. Pump fittings, impellers, supply pipes should be made of corrosion resistant material.

(2) Application of biotechnology: Use of bactericides should be preferred so that, production of acidic water will be minimized. Sodium Laurel Sulphate (SLS), Alkyl Benzene Sulphonate (ABS), Sodium Benzoate (SBZ) can be used for abatement of AMD economically.

(3) Proper stowing: - Stowing practice should be forced to minimize the percolation of water through water feeders and also it cuts the contact time between water and oxygen and retards the formation of AMD.

(4) Treatment method :- Concerning the chemical analysis in the previous chapter which have been carried out it is recommended that in NCPH R-6 colliery acid water can be treated by wetland method after it is discharged to the surface either by pumping or by drainage.

(5) pH Control :- Limestone channel or combination of channels will be suitable for treatment of acid water to increase pH value before discharging it to any stream or river feasibly and also terrain of the area is suitable for this method.

(6) Drainage control in rainy season:- Proper drainage of surface water in rainy season can reduce percolation of water through cracks to underground and thus will reduce availability of water for AMD formation.

(7) Protective devices: like Shoes, hand gloves should be used for prevention of skin diseases in workers.

(8) Diversion wells: It can be efficiently used for treatment of acid mine water which is coming out of the R6 mine.

(9) Control method suggested- open limestone channels: Under these conditions the best suitable method for acid mine drainage treatment will be “open limestone channel”. Where AMD must be conveyed over some distance prior to or during treatment, use of open channels lined with limestone has been shown to be an effective mechanism for removing and generating small amounts of alkalinity.

The acidic water is allowed to flows through these channels. The water treated after this treatment must be randomly checked through lab test.

CONCLUSION

Coal mining, despite the very substantial benefits they bestow on society, stir strong Emotions. A great ongoing social challenge for the mining industry is sustainable development and community acceptance of its role in society. The problem of mining-induced displacement and resettlement (MIDR) poses major risks to societal sustainability.

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