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Removal of Iron and Sulphates from Acid Mine Drainage and Neutralisation of pH Using Chemical Process

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Abstract

Acid mine drainage refers to the outflow of acidic water from a mining site. A significant number of coal mines suffer from acid mine drainage. It is a worldwide problem, leading to ecological destruction in watersheds and the contamination of human water sources. The increased acidity caused by acid mine drainage has a range of negative effects depending on the severity of the pH change. AMD ia normally having high amounts of sulphur and iron also. Limestone, dolomite and slag have been tried for the removal of iron and sulphates from acid mine drainage water. It has been found that these chemicals can be successfully used for the removal of iron and sulphates and to neutralise the pH of acid mine drainage water.

Keywords: Acid mine drainage water, limestone, dolomite, slag.

Introduction

The problem of acid mine drainage (AMD) is a global issue and it is one of the most serious, challenging and still partly solved problem. AMD is an acidic, iron and sulphate water that forms under natural conditions when geologic strata conditioning pyrite are exposed to the atmosphere or oxidizing environments. AMD can form from coal mining both in surface and in underground mines. Among its adverse impacts, degradation of surface and sub surface water quality is of major concern. In coal mining areas, water pollution is caused particularly by seepage through mine, generally erosion and increased sediments input case of surface mining. Releases of AMD have low pH (generally, the pHdrops to values below 4, which causes toxic metals todissolve), high specific conductivity, high concentrationsof metals such as Fe, Al, and Mn, and smalleramounts of toxic metals like Cd, Pb, Cu, and Ni (Goldani et.al, 2013).

The problem becomes more severe where coal has high percentage of pyritic sulphur (more than 1%) and such mines suffer with Acid Mine Drainage (AMD) problem when water comes in contact with such coal. The factors responsible for acie mine drainage are geological factors, geo-textural factors, climatic factors, and microbiological factors.Table 1 gives the characteristics of acid mine drainage.

Parameters	Limits
pH	<6.0
Acidity	>3mg/L
Alkalinity	Normally 0
Iron	>0.5mg/L
Sulphate	>250mg/L
TDS	>500mg/L
TSS	>250mg/L
Hardness	>250 mg/L

Table 1. Characteristivs of acid mine drainage (Source by: MOEF)

There are two broad classes of methodologies available for AMD remediation: one that use natural chemical and biological reaction (passive treatment) and other that consist in the mechanical addition ofalkaline chemicals to raise pH and precipitate metals (active treatment; Gaikwad and Gupta 2008).Cadmium, copper, iron, lead, mercury, nickel, and zinc are some of the metals that will precipitate as metal sulfides. In addition, arsenic, antimony, and molybdenum form more complex sulfide minerals (Figueroa, 2005). Metals such as manganese, iron, nickel, copper, zinc, cadmium, mercury, and lead may also be removed to some extent

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by co-precipitation with other metal sulfides. Sulfate reduction also consumes acidity, raising the pH. Increasing the pH facilitates the above precipitation reactions and creates suitable conditions for precipitation of metal hydroxides.

This paper focusses on chemical treatment using limestone, slag and dolomite for the removal of iron and sulphates in acid mine drainage and also to neutralise the pH.

Study Area Description

The Singareni Collieries Company Limited (SCCL) is the only coal producing company in South India having operations in Andhra Pradesh. The Singareni Collieries Company Limited (SCCL) has been producing coal for more than 110 years. Out of 470 km long pranahita Godavari valley coalfield, 350 km stretch is laying mostly in the south India state of Andhra Pradesh, wherein the SCCL is performing coal mining activities. 80% of coal is supplied to thermal power plants operating in Andhra Pradesh, Karnataka & Maharashtra and remaining quantity is supplied to several medium and small industries including cement, paper, textiles, tobacco, ceramic, pharmaceutical and brick kilns. The sample for water for laboratory investigation was collected from OC-III mine which is underground mine is shown in Figure 1.

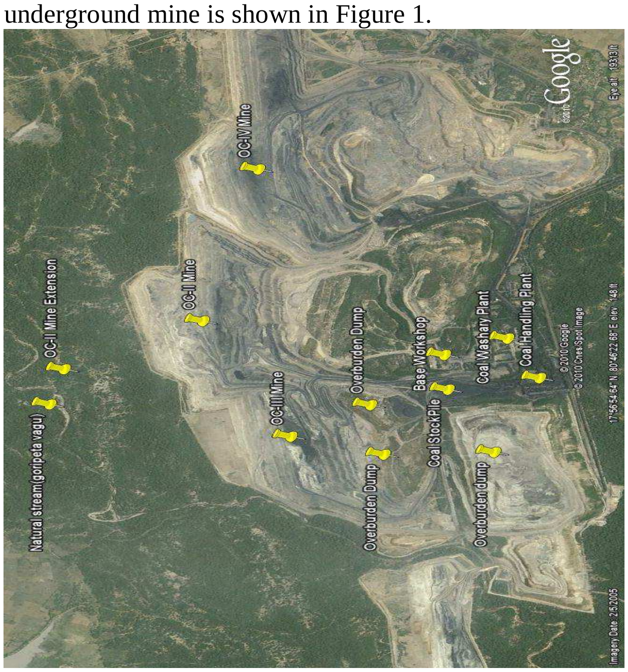

Figure 1. Sample collection OC-III mine

Materials and Methods

Collection and sampling of acid mine drainage

The experiments are performed by initial testing of acid mine water taken from SINGARENI coal mine. The analysis were carried out according to the procedure outlined in standard method (APHA, 2005).

The collection of water samples has been done as per Indian standard, water samples were taken in preheated sampling bottles. Plastics bottles were used as container, because they can be easily handled, inorganically in active and durable. Manual sampling has been done during water quality survey, representative sampling has been carried out with all possible care. The water sample were collected to ensure that it must be both homogenous and representative physico- chemical properties of water should not be changed during collections and analysis. Due to this reason care was taken during sampling and transportation of these samples.

The time of sampling of mine water is also important factor because the nature of water samples in mine varies due to working schedule and machinery used in underground mine for drilling change the water quality. However investigation, the water samples were collected between 10am to 12.30pm during the day. Samples were taken from inside underground and from seepage. The water quality parameters of the sample is given in Table 2.

Water quality Parameters	Water sampling sites OC-III mine	Tolerance limits as per GSR(general discharge of effluent in inland surface water)
Colour	Colourless	Shall be colourless
Odour	Odourless	Shall be odourless
Temp(^{0}C)	33.2-34	Shall not exceed 5^{0}C above receiving water temperature

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pH	3.03-3.34	5.5-9.0
TDS	2.745	10
Conductivity	4.5	-
DO	6.9	-
Alkalinity	BDL	BDL
Iron	1.187	0.3-1
Acidity or mineral acid test	46.96	>3
COD	0.0145	-
Hardness	15200	150-300
Sulphate	11730	200-400
Chloride	14.042	250-1000
Bicarbonate and Carbonate	BDL	-
MPN	NR	-
Na and k	33.91, 14.8	-

Table 2- Water quality parameters of acid mine drainage sample water

The phsico- chemical parameter tested for SCCL water samples in which acidity came more than tolerance limit together with sulphate and iron which came more than limit. The sulphate content was 11,730 mg/l after thousand dilution and iron content was 1.187 which are higher than standard limits. Hence focus was done on removal methods for sulphate and iron and also to increase the pH using some chemicals.

Minerals Used for Treatment

The chemical testing is done by using slag, limestone and dolomite taken from KIOCL (Mangalore). **Limestone** is a rock that contains a significant quantity ofcalcium carbonate ($CaCO_3$, calcite).The remaining constituents may include other carbonateminerals such as dolomite magnesite, ($CaMg(CO_3)_2$ and lesscommonly aragonite ($CaCO_3$). Limestone is usuallynot very hard, and its strength depends upon the degree ofcementation or recrystallisation.

Dolomite is generally formed from limestone bydolomitisation, a digenetic process involving replacementof calcium in the calcite with magnesium.

Technically, **slag** is nearly a solid which melts and forms a silicate glass during a metal refining process.Slag is called "Calcium alumina silicate oxide".The neutralization potentials of steel slags range from 45 to 70%. Slag is waste coming from iron Ore Company.

The above three chemicals have been tried in different dosages, time and sizes for the treatment of acid mine drainage water. The normal composition of the chemicals is shown in Table 3.

	Slag %(m/m)		Dolomite%(m/m)		Limestone%(m/m)
SiO_2	34.21	SiO_2	3.3	SiO_2	0.5
Al_2O_2	20.03	Al_2O_3	0.9	Al_2O_3	0.3
CaO	34.03	MnO	1.0	MnO	0.5
MgO	8.94	TiO_2	<0.1	TiO_2	<0.1
FeO	0.42	CaO	29.1	CaO	55.3
K_2O	0.77	MgO	17.6	MgO	0.8
Na_2O	0.35	P_2O_5	<0.1	P_2O_5	<0.1
S	0.9	K_2O	<0.1	K_2O	<0.1
Mg	0.25	Na_2O	<0.1	Fe_2O_3	0.1

Table 3. Composition of neutralizing agents (KIOCL)

Chemical Treatment by Neutralizing Agents

Aliquiots of 500 ml freshly acid mine were placed in 1000ml round plastic beaker and conditioned by agitation for few minute as shown in Figure 2. The amount of dosing agents, well as their respective particle sizes, were varied while solution was sufficiently, stirred for a specific chosen period of time. All the experiments were conducted five times. Each solution was left to settle, filtered through whatsmann No 41 and filterate, analyzed for pH, total iron, sulphate by standard method procedure.

Limestone, dolomite and Slag obtained from KIOCL Mangalore were in solid form was made into powder form. In all cases the particle size of dosing agents was passed through < 150µm sieve

Figure 2. Mixing of chemicals with acid mine drainage

The efficiency of dosage and type of neutralizing agents depends on several factors; usually cost and health consideration. Other selection criteria of neutralizing agents include reaction rate, sludge production an disposal, safe and ease of handling, total costs and effect of an over dosage.

Results and Discussions

The neutralization reaction rate was investigated by determining the change in pH as a function of dosage and particle size.It was determined that a minimum dosage of 10g/500ml of limestone with120 min contact time was required to reach pH of 5.58. Larger dosages of limestone stone ensured a reduction in contact time such as 100g/500ml with 30 min of contact time. For dolomite the minimum dosage required was 40g/500ml and 240 min contact time, while for the slag a minimum dosage 22.2g/500ml and 30 min contact time was necessary. The minimum dosage required by slag, limestone and dolomite to reach particular pH, iron and sulphate removal are shown in graphs.

Removal Using Slag

The slag testing started with 10g, 12.5g, 15g, 17.5g, 20g and 22.2g dosage with contact time 5, 10,15,20,25 and 30 minute. The pH started increasing with contact time and amount of dosage applied. The pH increased from 3.38 to 6.21. Iron and sulphate showed good removal rates with increasing dosage and contact time. The amount of iron reduced to 0.237mg/ml and amount of sulphate reduced to around 5.072mg/ml. Neutralisation of pH and iron and sulphate removal using slag is shown in Figures 3,4 and 5.

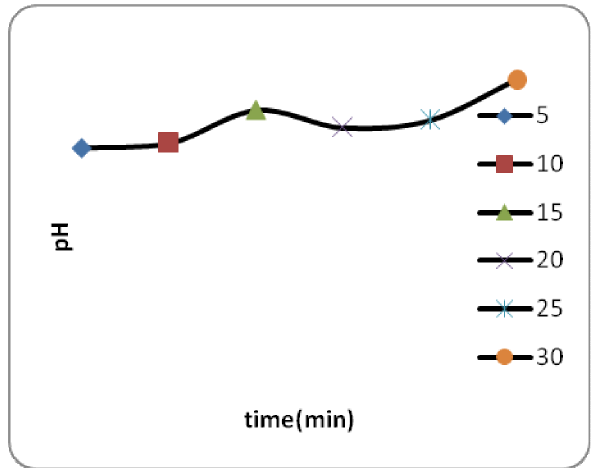

Figure 3 Neutralisation of pH using optimum amount of slag(22.2g/500 ml)

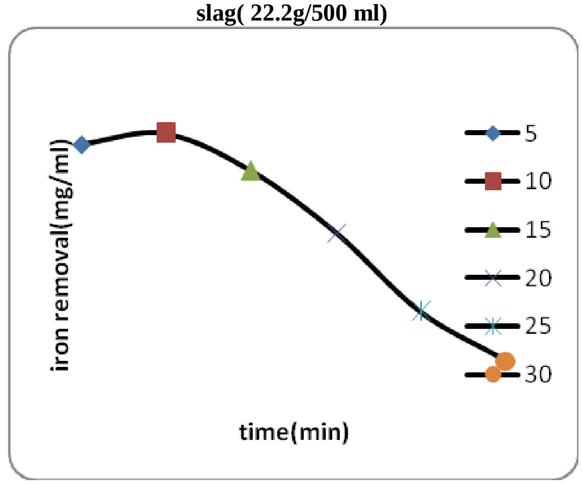

Figure 4. Iron removal using optimum quantity of slag (22.2g/500 ml)

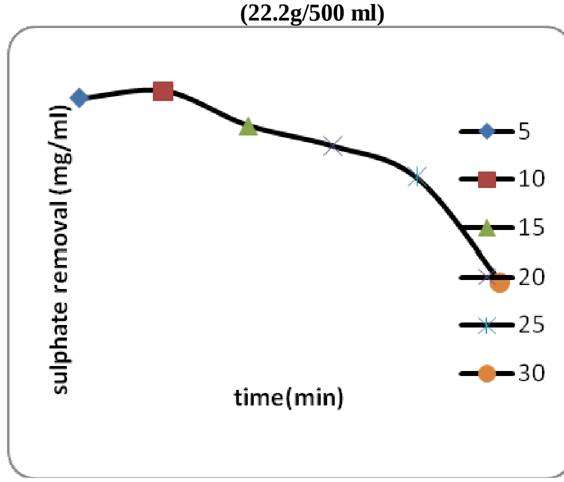

Figure 5.Sulphate removal using optimum quantity of slag (22.2g/500 ml).

Removal Using Dolomite

The dolomite testing started with 5g,10g,15g,20g,30g,35g and 40g dosage with contact

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time starting from 30,60,90,120,150,180,210 and 240 minute. The pH started increasing with contact time and amount of dosage applied. The pH increased from 3.35 to 5.52. But after particular dosage it started decreasing.

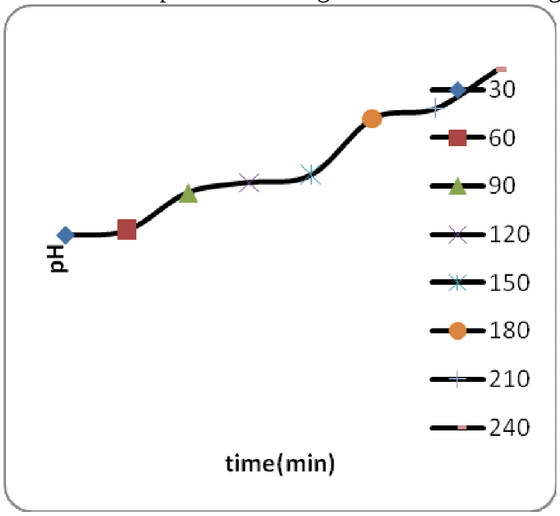

Figure 6. Neutralisation of pH using optimum amount of dolomite(40 g/500 ml)

Iron and sulphate removal was high with increasing dosage and contact time. The iron content reduced to 0.114 mg/ml and sulphate content reduced to around 8.322 mg/ml. Neutralisation of pH and iron and sulphate removal using dolomite is shown in Figures 6,7 and 8.

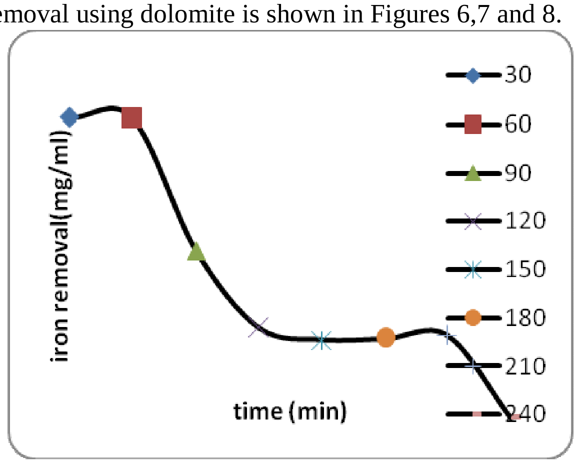

Figure 7. Iron removal using optimum quantity of dolomite (40g/500 ml)

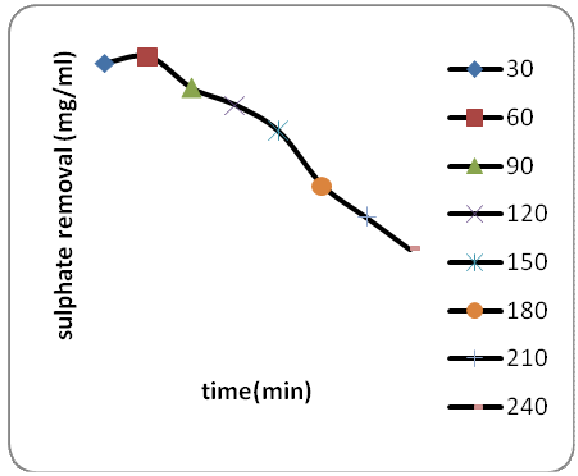

Fig 8.Sulphate removal using optimum quantity of dolomite (40g/500 ml).

Removal Using Limestone

The treatment started with 2g, 4g,6g,8g and 10g dosage with contact times 15,30,60, 90 and 120 minute. The pH started increasing from 3.32 to 5.58 with contact time. A larger dosage 100g<150µm limestone is required to neutralise 1000ml of acid mine water with contact time of 6 hour to reach a pH value 7.4. The iron and sulphate removal removal came around 0.07 and 6.211 mg/ml.

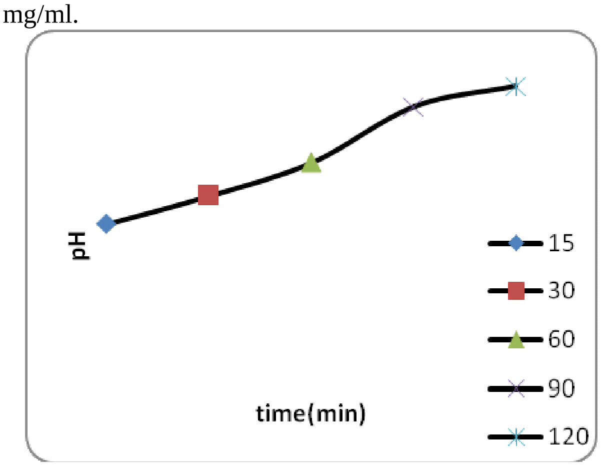

Figure 9. Neutralisation of pH using optimum amount of limestone (10g/500 ml)

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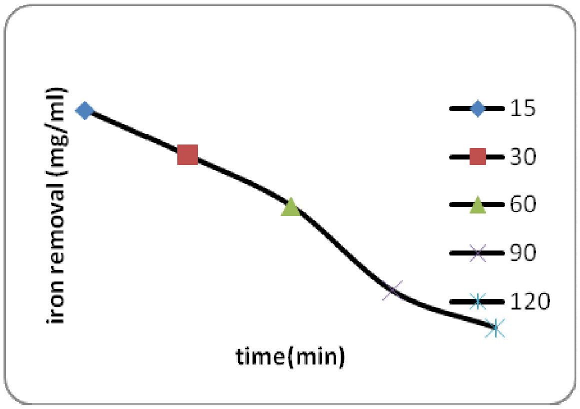

Figure 10. Iron removal using optimum quantity of limestone (10g/500 ml)

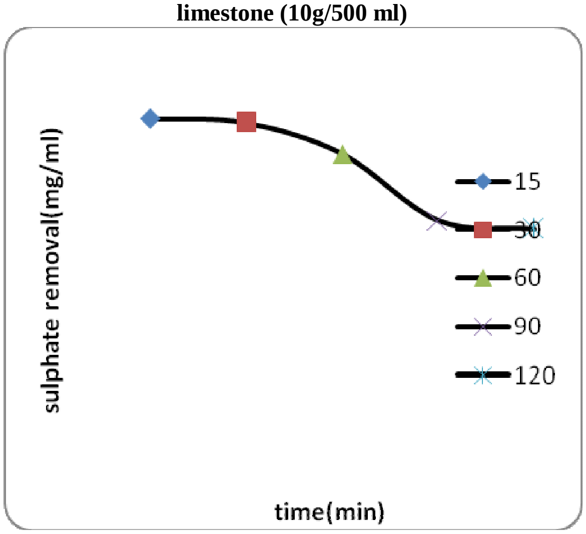

Figure 11. Sulphate removal using optimum quantity of limestone (10g/500 ml)

Although significant removal of sulphates upto 70% of the original concentration was achieved, the level is still higher than the maximum allowed level for discharge into sewerage systems.Neutralisation of pH and iron and sulphate removal using limestone is shown in Figures 9,10 and 11.

Conclusion

The acid mine water and industrial effluent usually affect the underground water pollution, ecological significance and detrimental effects necessitate investigations. Although several acid mine water treatment techniques and method exist, they all have certain disadvantages. Lime treatment is most common approach but in this investigation, limestone, dolomite and slag were selected as pre-treatment agents based on their low cost. The results of investigation shown that the quality of water improved with the chemical treatment using limestone, dolomite and slag.

References

[1] APHA (2005). "Standard Methods for the Examination of Water and Wastewater," 21st ed. American Public Health Association, Washington, DC.

[2] Aube (2000). "The science of treating acid mine drainage and smelter effluents". Vol 2, pp 33-46.

[3] Bayrakdar Alper(2009). "Performance of sulfogenic anaerobic baffled reactor (ABR) treating and Zinc containing waste water", Bio resource technology, 4354-4360.

[4] Chan, Y. J., Chong, M. F., Law, C. L., Hassell, D.G. (2009). "A review on anaerobic-aerobic treatment of industrial and municipal wastewater." Chemical Engineering Journal, 155, 1–18.

[5] Division of water, environmental and forestry (2000). "The effect of reactor type and residence time on biological sulphate and sulphide removal".

[6] Gaikwad, R. W., & Gupta, D. V. (2008). Review on removal of heavy metals from acid mine drainage. Applied Ecology and Environmental Research, 6(3), 81–98.

[7] Goldani, E, Camilo Moro, C, Maia.S.M., (2013), "A study employing different clays for Fe and Mn removal in the treatment ofacidmine drainage," Journal of Water, Air, Soil pollution, 224:1401

[8] Motsi Tafadzwa (2010). "Remediation of acid mine drainage using natural zeolite" Journal chemical engineering, 24, 245-258.

[9] Mccarthy.T.S,TuTu.H(2008)."The chemical characteristics of AMD with particular references to source distribution and remediation", Applied Geochemistry, 23, 3666-3684.