UGC Approved Journal

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

ISO 3297:2007 Certified

Vol. 4, Issue 9, September 2017

Utilization of Coal Mine Waste Material as Low Cost Adsorbent for Removal of Heavy Metal from Synthetic Water

H. L. Yadav[1] and A. Jamal[2]

Department of Mining Engineering, Indian Institute of Technology, (Banaras Hindu University), Varanasi, India[1,2]

Abstract: Present study shows the removal of metal ions from mining wastewater using mine discarded waste materials as an effective and economical low-cost adsorbent. Obtained discarded waste material was categorized by using BET, XRD and FTIR analysis. This study was performed to remove the heavy metals from synthetic water sample similar to the AMD obtained from Gorbi abounded mine NCL, MP, India, by using sandstone channel. Continuous flow experiments were used to find out the most encouraging circumstance like pH, flow rates, size of sandstone as low-cost adsorbent materials. In this study experimentally obsessed that the sandstone has better adsorption ability for the removal of metal ions. Percentages of metal removal were 96% from a synthetic water sample. Also, in all tests neutralization process is occurred and the pH of the final solution increased TDS and electrical conductivity decreases during experimental analysis also. For the industrial aspects, the real mining influence water from mining industry was characterized by its quality standards and practical applicability of sandstone as low-cost adsorbent material for the removal of heavy metals.

Keywords: acid mine drainage, Neutralization, synthetic water, heavy metals, Sandstone.

I. INTRODUCTION

Nowadays in the present world, mining of coal and mineral producing Acid rock drainage (ARD) OR Acid mine drainage (AMD), this is a serious environmental issue. AMD is created as a result of geochemical reaction; when sulfide minerals(mostly pyrite) present in coal/ metals mines exposed during different mining operation in the surrounding atmosphere, which reacts with oxygenated water release acid mine drainage(Rios et al.,2008; Yadav and Jamal, 2015,2016,2017). Acid mine drainage having low pH, high acidity, a high concentration of sulfate and numerous of hazardous toxic metals ions depends on the quality of host rocks in different concentration. If acid mine drainage released in a natural environment without proper treatment can have a stern bad impact on the vital natural environmental resources. Thus, ADM can cause injury to human health (Cui et al., 2012; Maicaneanu et al., 2013; Yadav and Jamal, 2017. 2017a), plant, animals and natural ecosystem.

There is numerous method are available for the treatment and management of acidic water released from different mines, these are chemical precipitation, oxidation, and hydrolysis, reverse osmosis, solvent extraction, ion exchange, neutralization, electrochemical remediation, adsorption and biosorption (Tolonen et al., 2014, Yadav and Jamal, 2015, 2016, 2017).

Among them, adsorption process receives significant importance in acidic water neutralization and toxic metals removal due to its high removal efficiency, simple in materials handling, the simplicity of operation cost-effective, and the accessibility of different adsorptive materials and not require any chemical substances and produced very less sludge during treatment.(Feng et al., 2004; Lin and Juang,2002; Bhattacharya et al ,2006] Absorption process is a very successful technique for the treatment and management of acidic water released from mines (Zhang, 2011).This study was performed to uptake heavy metals from synthetic water by sandstone.

II. MATERIALS AND METHOD

This study was carried out at room temperature using sandstone in channel technique. The adsorbent used in the study were collected from NCL coal mines which are located in the MP, India. First obtained sandstone crushed using jaw crusher in the departmental laboratory, and then sieved and a particle size between +20mm to -40mm were selected for experimental study purposes.

All chemical used in this study were analytical grade and obtained from Merck. Sample water (Acid mine drainage) collected (shown in figure.1) from the abounded Gorbi coal mine Northern Coal Fields Limited, MP, India. For experimental analysis, the similar water sample was prepared in the laboratory.

UGC Approved Journal

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

ISO 3297:2007 Certified

Vol. 4, Issue 9, September 2017

Table .1. Shows the chemical composition of Sandstone

Characteristic of Sandstone			
Oxides	Content %	Oxides	Content %
Alumina (Al_2O_3)	25.43	Nickel(II) oxide(NiO)	0.21
Calcium oxide (CaO)	1.70	Potassium oxide (K_2O)	0.56
Chromium(III) oxide(Cr_2O_3)	0.63	Silica (SiO_2)	67.87
Ferric oxide (Fe_2O_3)	2.27	Titanium dioxide (TiO_2)	0.09
Manganese oxide (MnO)	0.22	Vanadium(V) oxide V_2O_5	0.005

Figure 1. The current status of water pollutions and soil quality around the Gorbi mines (abandoned), MP . India

Experimental procedure

To assess the suitability of sandstone as a neutralizer and adsorbent for the neutralization of acid mine drainage and removal of metal ions, a laboratory experiment was designed at laboratory scale and Conducted in a laboratory continuous flow in a physical channel of Length,18 m., width 0.10 m. and depth 0.08 m. In order to increase the contact period between acidic water and sandstone in the channel, many bends are given in the channel model. For maintain the suitable flow rate of discharge in physical channel model, a rotameter was attached with the channel model. The sandstone of different sizes (+20mm to -40mm) is placed 2.5cm Thickness. Synthetic mine water prepared in the laboratory, which characteristics are given in the table3. During this experimental study, synthetic water was allowed to pass over sandstone of different sizes (+20mm to -40mm) laid down in the channel. The rate of flow of synthetic water was varying from 1L/min to 3L/min for18 meter distance. The observations were made at the fixed distance (at the 3meter interval) along the sandstone channel at the fixed interval of time and the effectiveness of sandstone in the neutralization of acidic mine water laden with metals ions was assessed at varying rate of discharge..

III. RESULTS AND DISCUSSION

Effect on the pH Value

Increase in the pH level is as presented in fig.2, 6, 8, that pH value of water is increased as the distance travel by water in sandstone channel is increases. It may be noted that at different points (at an interval of 3.0 m) the pH value increases 2.48 to 3.58. After 2 hours and 3 hours study with the same flow rate. It may be noted that at the different point. The pH value increases 2.48 to 3.52 and 2.48 to 3.51. However, flow through the sandstone channel, pH increased with increasing sandstone amount; it finally reaches 3.51 to 5.5 by at the 1L/min flow rate in the sandstone channel. However, final pH achieved by sandstone channel was slowly decreased as the flow rate of sample increases in sandstone channel. The pH value of water sample was enhanced due to the composition (SiO_2+Al_2O_3 + Fe_2O_3) of the sandstone and the calcium content 6,7,24-27. This composition increases the pH value of the solution.

Effect of flow rate

Now as the rate of discharge in the sandstone channel increases there are marginal decreases found in the pH value and removal of metals from the synthetic solution. The pH value at 1L/min, 2L/min and 3L/min rate of discharge is 3.58, 3.51 and 3.20 respectively. The studies also show that at a higher rate of discharge its pH decreases and researched only 3.30 from its initial values of 2.48.

Removal of iron ions

The removal of iron ions in the sandstone channel is shown in Fig.3,7,9. It was observed from the results' data removal capacity of sandstone increases with increases the solution travel distance in the channel 12.5mg/L to 1.2mg/L. During this study, total dissolved solids and electrical conductivity also decrease from, 635 mg/L, 1270 µS/cm to, 420 mg/L,

IARJSET
ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
ISO 3297:2007 Certified
Vol. 4, Issue 9, September 2017

840 µS/cm respectively shown in Fig.4, 5, 10, 11. The treatment of aqueous solution in sandstone channel is very effective due to the composition of sandstone dominated (67.87%) by silicon oxide (SiO2), (25.43%) Alumina (Al2O3), Ferric oxide (Fe2O3), (2.27%) and Calcium oxide (CaO) (1.70%), which provides better metal removal efficiency from metal-laden effluents

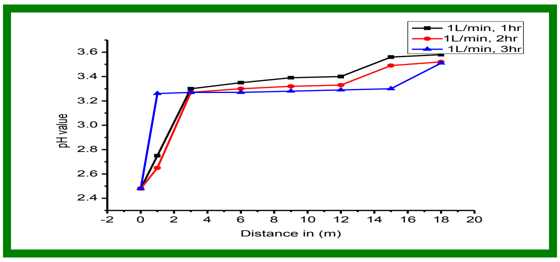

Fig.2. pH increase in sandstone channel

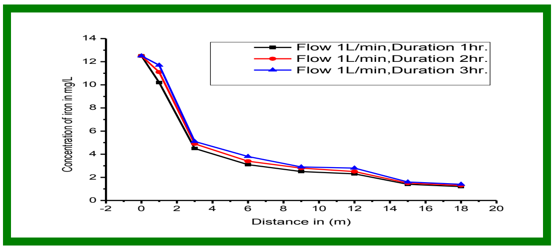

Fig.3.Removal of iron in sandstone channel

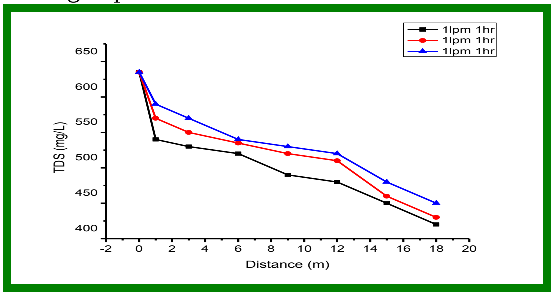

Fig.4. Removal of TDS in sandstone channel

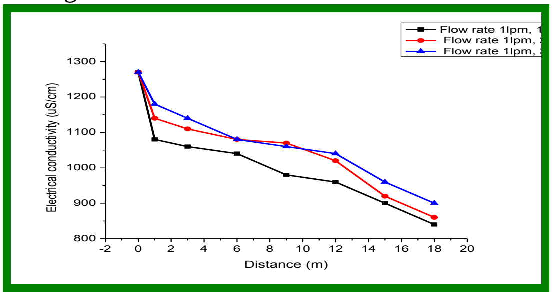

Fig.5. Removal of Electrical conductivity in sandstone channel

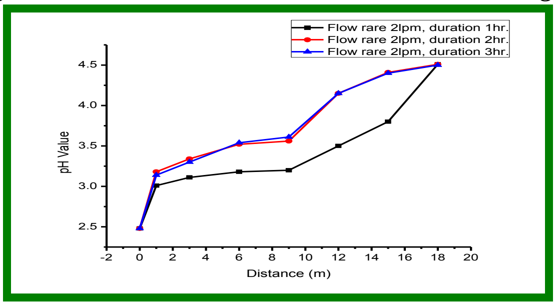

Fig.6. pH increase in sandstone channel

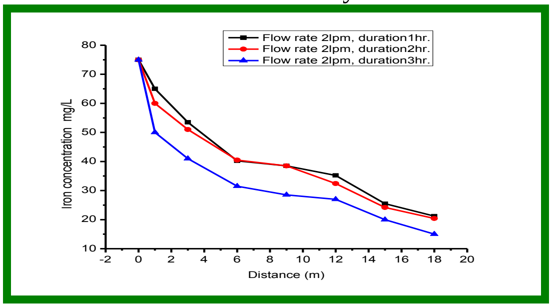

Fig.7.Removal of iron in sandstone channel

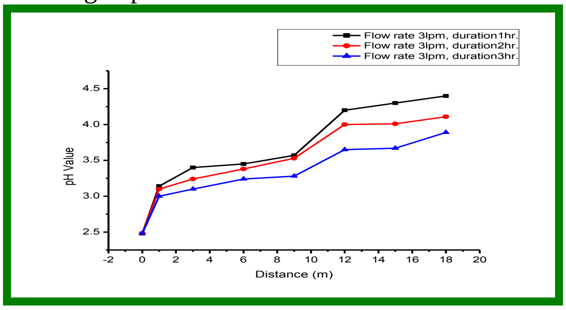

Fig.8. pH increase in sandstone channel

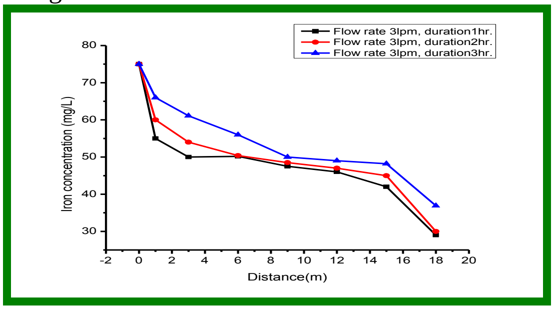

Fig.9.Removal of iron in sandstone channel

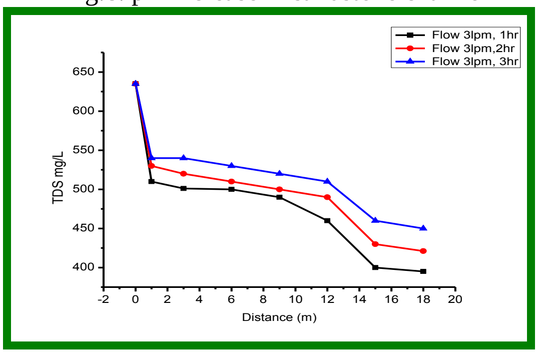

Fig.10. Removal of TDS in sandstone channel

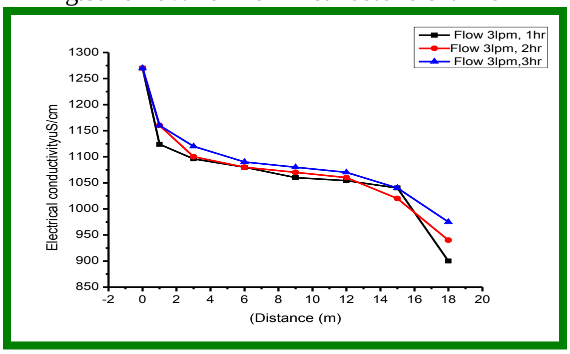

Fig.11. Removal of Electrical conductivity in sandstone channel

IARJSET
ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
ISO 3297:2007 Certified
Vol. 4, Issue 9, September 2017

Application studies on mining waste water

The characteristics of mine water; collected from inactive mine sites are shown in table3. The proposed method was applied for the removal of iron ions from the real mine water. The experiment results show 96% removal of iron ions for a sandstone size +20 and -40 mm. Results show that the sandstone successfully decreases the concentration of metal ions, thus the method is eventual for the treatment of mining effluent.

Table 3: Characteristics of mining effluent.

S.No.	Parameters (units)	Values	Permissible limits of drinking water
		Sample	WHO
1	pH	2.48	6.5-8.5
2	Conductivity (μS/cm)	1780	-
3	Total Dissolved Solids (mg/L)	1750	500-2000
4	Dissolved Oxygen (mg/L)	0	-
5	Cr (VI)	Nil	0.05
6	Nitrate (NO3-) (mg/L)	0.2	45
7	Iron (mg/L)	73.48	0.1-0.3
8	Lead (mg/L)	0.066	0.05

IV.CONCLUSION

In this research continuous process at low flow rates were studied for the deletion of iron ions from synthetic solutions using sandstone as low cast economical and efficient coal mine waste materials. At the low flow rate, 1L/min. Iron elimination capacity of sandstone was found comparatively higher in sandstone channel due to higher precipitation rate and was found 96% from the synthetic water sample, it also reduced the total suspended solids, electrical conductivity, and salinity, 66%, 66%, 80% respectively. It is an effective low-cost adsorbent material, which has the potential for cutting out iron ions from mining wastewater.

ACKNOWLEDGMENT

The authors wish to thank, Department of Mining Engineering, Indian institute of Technology, (Banaras Hindu University) for providing helpful and valuable information for the study and for giving permission to use their laboratory facilities during research works.

REFERENCES

1. M.Cui, M. Jang, SH.Cho, J. Khim and F.S. Cannon (2012). A continuous pilot-scale system using coalmine drainage sludge to treat acid mine drainage contaminated with high concentrations of Pb, Zn, and other heavy metals, J Hazard Mater., 215-216, 122-8.
2. Măicăneanu , H. Bedelean, M. Ardelean, S. Burcă and M. Stanca (2013). Haneş and Valea Vinului (Romania) closed mines Acid Mine Drainages (AMDs) Actual condition and passive treatment remediation proposal, Chemosphere, 93, 1400-1405.
3. H.L. Yadav, and A. Jamal, (2015). Impact of Mining on Water Resources in India, International Journal of Advanced Research Volume 3, Issue 10, pp.1009 -1015
4. H.L. Yadav, and A. Jamal (2016).Waste water in mines and status of utilization.Int. J. of Advance. Res.,4 (6),310-315.
5. H.L. Yadav, and A. Jamal (2016). Treatment of Acid Mine Drainage: A General Review Int. Adv. Res.J. in Sci. Engg. and Tech.,3(11),116-122.
6. H.L. Yadav, and A. Jamal (2017).Treatment Of Acid Mine Drainage Using A Sandstone Column Rasayan J. Chem., 10(3), 891-896.
7. H.L. Yadav, and A. Jamal, (2017).Removal of Lead (II) from synthetic solution by adsorption onto coal mining waste material. Rasayan J. Chem., 10(3), 1062-1067.
8. C.A.Rios, C.D. Williams and CL. Roberts (2008).Removal of heavy metals from acid mine drainage (AMD) using coal fly ash, natural clinker and synthetic zeolites, J Hazard Mater., 156, 23-35.
9. E-T., Tolonen, A .Sarpola, T. Hu, J. Ramo and U Lassi. (2014).Acid mine drainage treatment using byproducts from quicklime manufacturing as neutralization chemicals, Chemosphere, 117, 419-424.
10. D.Feng, J.S.J. Van Deventer and C. Aldrich (2004). Removal of pollutants from acid mine wastewater using metallurgical by-product slags, Separation and Purification Technology, 40, 61-67.
11. S.H. Lin, R.S. Juang (2002).Heavy metal removal from water by sorption using surfactant-modified montmorillonite. Journal of Hazardous Materials. 92(3):315-326.
12. A.K. Bhattacharya, S.N. Mandal, S.K. Das. (2006). Adsorption of Zn (II) from aqueous solution by using different adsorbents. Chemical Engineering Journal.123(1-2):43-51.
13. N. Atar, Olgun and S.Wang (2012). Adsorption of cadmium (II) and zinc (II) on boron enrichment process waste in aqueous solutions: Batch and fixed-bed system studies, Chemical Engineering Journal, 192, 1-7.