Water Research Institute

Annual Technical Report

FY 1999

Introduction

Research Program

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Improving the Recycle of Class C Steel Slag by Treatment of Acid Mine Drainage
Project Number	WRI26
Start Date	03/01/1999
End Date	06/30/2000
Research Category	Water Quality
Focus Category #1	Acid Deposition
Focus Category #2	Acid Deposition
Focus Category #3	Acid Deposition
Lead Institution	West Virginia University

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Eung Ha Cho	Professor	West Virginia University	01

Problem and Research Objectives

The West Virginia coal industry generates acid mine drainage (AMD). The State's steel industry generates large volumes of slag which in turn generate much alkalinity. The neutralization potential of steel slags ranges from 45 to 78%. Thus, the AMD can be treated with steels slags instead of conventional alkaline chemicals such as sodium hydroxide, lime and limestone. The merit of the treatment of AMD with steel slags may lie in utilization of this waste material which the U.S. produces

at 13 million tons annually. However, the problem with the utilization of steel slags is that ferric iron contained in the AMD is precipitated as ferric hydroxide which tends to cover the surface of the steel slag particles, and making the dissolution of alkaline content of the slag particles difficult. Also, the precipitation of ferric hydroxide in the interstitial space between slag particles hinders the diffusion of hydroxl ions produced by the dissolution of alkaline content from the slag particles, thus making the neutralization of AMD very difficult. These difficulties is called armoring effect and has been a focus area for the treatment of AMD with limestone. The objective of this project conducted to date is to investigate the armoring effect of AMD treatment with steel slag samples. The armoring effect has been measured as change of flow rate of the AMD in a bed of steel slag.

Methodology

Principal Findings and Significance

Materials AMD samples which was taken from TNT site, near Morgantown, West Virginia were used in the experiments. The pH of the AMD sample was 2.64 and had 935 mg (CaCO3 equivalent)/liter. Iron was 90 ppm, manganese 2.3 ppm and zinc 1.3 ppm in the AMD sample. Almost 100% of iron existed as ferric iron instead of ferrous iron. Steel slag samples used were from Weirton Steel, West Virginia. A size fraction of 4 by 18 mesh was used for the experiments. The chemical analysis for the sample in the size fraction shows that the alkaline content in the slag was 32% and the content of the Ca (OH)2 equivalent was 70%. Bed Experiments Experiments were conducted in a bed of C slag. There were three different versions of bed information. The first one was that AMD flows on top of a flat bed with a constant hydrostatic height; the second one was that AMD flowed through a whole bed horizontally; and the third one was that two perforated tubes, one near the top and the other at the bottom of the bed were used to flow the AMD through. The bed dimension was 18.5" long x 1.5-5" high depending on the version of the bed. There were two reservoirs attached to the bed, one was delivery one and the other was collection one. The lengths of the reservoirs were 2 and 2.5", respectively. The first version was a delivery of AMD on top of a bed with the constant hydrostatic height of 1.5". The bed height was also 1.5". The constant hydrostatic height was maintained by a level sensor combined with a peristaltic pump. The flow rate was 26 ml/min. Table 1 provides the variation of pH of the effluent AMD as a function of time. Table 1. pH of Effluent AMD as a Function of Time in the Constant AMD Head Bed. Time, hour pH 0 2.64 0.25 3.15 3.25 2.85 13.75 2.89 The pH increases in the beginning and then decreases, suggesting that the AMD treatment is retarded. This may be due to the armoring effect of the slag. It is also seen that the bed length of 18.5" is not long enough to treat AMD The second version was set up with a bed of 3" height. A 3"-height of AMD in the delivery reservoir was maintained by the level sensor and the peristaltic pump. The results are given in Table 2. Table 2. pH and Flow Rate of Effluent AMD as a Function of Time through a Slag Bed Time, hour pH Flow rate, ml/min 0.1 12.52 13.5 4.5 12.44 7.83 22 12.35 6 32.4 12.1 4 44.25 12.16 2.5 50.4 12.10 2.15 56.5 12.03 2 72.15 12.01 .93 There are two phenomena that can be observed from the data of Table 2. One is that the flow rate of AMD through the bed decreases drastically as time proceeds. The flow rate was 13.5 ml/min at 0.1 hour but it decreased to 0.93 ml/min, or 14.5 times less after 3 days later. This decrease of flow rate is undoubtedly due to the armoring effect; that is the precipitate of ferric hydroxide which clogged up the interstitial voids between slag particles. Another phenomenon is that pH of the effluent AMD are very high, suggesting that the retention of time of the AMD through the bed is very high. In conclusion, this type of slag bed can not be used for the treatment of AMD. The third version of the bed used two perforated tubes, one near the top with 0.25" diameter and the other at the bottom with 0.5" diameter. The bed heigh was 5" and the AMD height was slightly less than 5" diameter. The AMD height in the delivery reservoir was maintained by the level sensor at the peristaltic pump. The results are given in Table 3. Table 3. pH and Flow Rate of Effluent AMD as a Function of

Time through a Bed with Two Perforated Tubes. Time, hour pH Flow rate 0.15 12.20 36.7 3.2 11.19 11.8 15.45 11.75 8.12 28.25 12.10 8 39.05 12.2 6.6 57.2 12.25 6.5 It can be sen from the data of Table 3 that this bed with perforated tubes generates high flow rates than the bed in the second version. However, the flow rate decreases as time goes on as in the case with the bed of second version, despite the lesser degree. This decrease in flow rate is undoubtedly due to the armoring effect on the slag bed. The high pH of the effluent AMD in this bed is also undoubtedly due to the low flow rate or the high retention of time of the AMD. In conclusion, this type of bed with perforated tubes, although is slightly better than the bed of second version, can not be used for the treatment of AMD. Recently, a similar bed to the first version has been designed and used to determine the armoring effect on the Weirton slag and then to compare with that of limestone. Thus, unless this armoring problem with steel slag is solved, the steel slag can not be utilized for the treatment of AMD. Recent discovery using some type of bacteria in depressing the armoring effect on limestone has received much attention of many interested people. The long term effect of the treatment is yet to know because bacteria is generally vulnerable to many factors such as temperature and some chemicals. An alternative as a means of depressing armoring effect is to use a ultrasonic wire. With this device, the wave tends to detach ferric hydroxide precipitate from the slag particle and also accelerate the diffusion of hydroxyl ion through the precipitate. The detached ferric hydroxide precipitate may be carried along by the flow of AMD and may be collected in a swamp. This can be studied in a future project(s).

Descriptors

Acid Mine Drainage Treatment Steel Slag Recycle

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

A master's thesis is in preparation from the work of this project. Also, a paper is in preparation to publish in a referred journal.

Information Transfer Program

Information Transfer Program In addition to the WVWRRI Newsletter, ECHO and our website, the WVWRRI focuses on transferring information directly to stakeholders and agency personnel. West Virginia is a small, rural state and water use stakeholders are accustomed to public meetings and personal contact as the appropriate forum for addressing their information needs. In addition, we at the WVWRRI work closely with the WV Division of environmental protection to transfer information directly through working meetings and through technical assistance on specific water quality problems. Following is a listing of such activities for fiscal 2000. 8 Feb 99 Meet with WVDEP and Coastal Corporation regarding remediation of acid mine drainage from the T&T Mine. 10 Feb 99 Presentation to Northern WV Sierra Club regarding our work on mine pool flooding in the Pittsburgh Coal

Basin. 16 Feb 99 Meet with federal agencies in Charleston to develop remediation plan for AMD in the Hiser/Manilla Watershed. 22 Feb 99 Meet with WVDEP and Coastal Corporation regarding remediation of acid mine drainage from the T&T Mine. 16 Mar 99 Presentation to Dunkard Creek Watershed Association regarding our work on mine pool flooding in the Pittsburgh Coal Basin. 6 Apr 99 Presentation to Friends of the Cheat regarding progress on the Sovern Run and Big Bear Lake projects. 14 Apr 99 Presentation to the WV Acid Mine Drainage Task Force on innovative watershed remediation techniques. 18 May 99 Meet with WVDEP and Coastal Corporation regarding remediation of acid mine drainage from the T&T Mine. 18 Jun 99 Meet with WVDEP and Coastal Corporation regarding remediation of acid mine drainage from the T&T Mine. 19 Jun 99 Presentation to the Pennsylvania Watershed Conference regarding innovative AMD treatment methods. 29 Jun 99 Assist organization and tours for the WV Interagency Reclamation Tour. 12 Jul 99 Presentation in State Capital press conference re findings of WVWRRI Poultry Waste Project. 28 Jul 99 Field inspection of WVDEP Alton to develop remediation plans. 30 Jul 99 Presentation in Moorefield WV press conference re findings of WVWRRI Poultry Waste Project. 26 Aug 99 Meet with WVDEP and Coastal Corporation regarding remediation of acid mine drainage from the T&T Mine. 7 Sep 99 Meet with WVDEP and Coastal Corporation regarding remediation of acid mine drainage from the T&T Mine. 8 Sep 99 Meet with WVDEP in Oak Hill WV to begin planning for remediation of the Royal Scott Mine. 14 Sep 99 Royal Scott Mine Site visit with WVDEP. 21 Oct 99 Meet with Cheat River Stakeholders to discuss TMDL implications. 19 Nov 99 Meet with WVDEP in Oak Hill WV to begin planning for remediation of the Royal Scott Mine. 16 Dec 99 Conduct tour for Trout Unlimited Chapter of AMD remediation project at Big Bear Lake. 21 Dec 99 Assist WV Mining and Reclamation Association in developing policy regarding mountaintop mining and valley fill issues. 12 Jan 00 Chair mountaintop mining/valley fill conference for USEPA. 26 Jan 00 Meet with USEPA region III staff to discuss improved process for TMDLs in Appalachia. 16 Feb 00 Meet with USEPA staff and WV stakeholders re TMDL issues in West Virginia. 7 Mar 00 Assist WV Public Television in developing program: West Virginia After Coal. 22 Mar 00 Assist WV Mining and Reclamation Association in developing policy regarding mountaintop mining and valley fill issues. 27 Mar 00 Public meeting with the Hiser/Manilla Watershed Association. 28 Mar 00 Presentation to the Allegheny Watershed Association regarding our project on flooding of underground mines in the Pittsburgh Coal Basin.

USGS Internship Program

Student Support

Student Support					
Category	**Section 104 Base Grant**	**Section 104 RCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	N/A	N/A	N/A	N/A	N/A
Masters	1	N/A	N/A	N/A	N/A
Ph.D.	N/A	N/A	N/A	N/A	N/A
Post-Doc.	N/A	N/A	N/A	N/A	N/A
Total	N/A	N/A	N/A	N/A	N/A

Awards & Achievements

Publications from Prior Projects

Articles in Refereed Scientific Journals

Carpenter, M..W. and D.J. Gardner. 1993. Fixation/leaching of CCA in selectedhardwoods at two temperatures. In: Chromium-containing waterborne wood preservatives: Fixation and Environmental Issues. J. Lang, Production Coordinator pp. 52-55. Kuhlman, John M. and Lyell, M.J. "The Development of a User-Friendly Planning Software Planning Tool to Assess the Effect of Biofilm Activity on Contaminant Reduction in Streams" Network and Computer Applications, Vol. 19, 1996, pp. 249-64.

Book Chapters

Dissertations

Mullenbach, R.A. 1995. M.S. Thesis. Evaluation of methods for detection of coliforms in rural groundwater supplies. West Virginia University, Division of Plant and Soil Sciences, Morgantown, WV. Field of Study: Environmental Microbiology Carpenter, Deborah. MA Department of Geology and Geography, West Virginia University. "Exploring the River Continuum Concept: General Theory vs. Context Variation". Strager, Michael P. 1995. Prioritizing Acid Mine Drainage Affected Watersheds: A Compromise Programming Approach, unpublished MS thesis, West Virginia University, Division of Resource Management, Morgantown, WV. 119 pages. Brian E. Mace, 1998, "Emissions Testing of Two Recreational Marine Engines with Water Contact in the Exhaust Stream", West Virginia University, Department of Mechanical and Aerospace Engineering, Morgantown, WV. 51 pages. Todd J. Vanyo, 1997, "Determination of Airborne and Waterborne Marine Engine Exhaust Contaminant using Chromatographic Methods of Analysis", West Virginia University, Department of Chemistry, Morgantown, WV. 81 pages.

Water Resources Research Institute Reports

Lyell, M.J. and Kuhlman, J.M. "Development of Planning Tools for River/Stream Bioremediation" Final Report. Submitted to the WV WRRI.

Conference Proceedings

Gardner, D.J. and J. Slahor. 1994. Fixation of chromated cooper arsenate (CCA)in selected Appalachian Hardwoods. In: 1994 Hardwood Research Council Annual Meeting Proceedings Vanyo, T.J., Morrison, R.W., Remcho, V.T., Mace, B.E., Nine, R.D. and Clark, N.N., "Development of Analytical Tools for the Determination of Airborne and Waterborne Marine Engine Exhaust Contaminants", 19th International Symposium on Capillary Chromatography and electrophoresis, Wintergreen, VA. 1997. Mace, B.E., Nine, R.D., Clark, N.N., Vanyo, T.J., Remcho, V.T., Morrison, R.W., and McLaughlin, L.W., "Emissions from Marine Engines with Water Contact in the Exhaust Stream", SAE International Congress, Detroit, Feb. 1998, SAE Paper 980681. Nine, R.D., Clark, N.N., Mace, B.E., Morrison, R.W., Remcho, V.T., Lowe, P.C., and McLaughlin, L.W., "Use of Soy-Derived Fuel for Environmental Impact Reduction in Marine Engine Applications", American Society of Agricultural Engineers Meeting, Orlando, Fl., July 1998. ASAE Paper 986083

Other Publications