

# ASSESSMENT OF ECOTITE™ FOR USE IN ACID ROCK DRAINAGE TREATMENT<sup>1</sup>

T. W. Schmidt,<sup>2</sup> and B. R. Shultz<sup>3</sup>

**Abstract:** Limestone or limestone-based products are often the materials of choice for passively treating acid rock drainage (ARD) when site and discharge characteristics are favorable. However, limestone treatment may require long detention times, large quantities of material, and significant land area for implementation. This condition may result in limited applicability due to the size of treatment areas needed for limestone contact and capture of metal precipitates. In addition, use of limestone materials for passive treatment may be limited by discharge characteristics of the ARD such as high metals and acidity concentrations. ECOTITE™ is a material composed of approximately one-third iron by weight including the minerals ackermanite, magnetite, hematite, goethite, monoxides (e.g., wustite), metallic iron, and iron sulfides. ECOTITE™ has demonstrated an ability to generate alkalinity through dissolution of calcium-silicate minerals with relatively short contact times. In addition, ferric oxides within ECOTITE™ provide adsorption capacity for metal retention. Laboratory and on-site bench scale tests have been conducted to evaluate ECOTITE™ materials for ARD treatment, particularly at sites where conventional passive treatment techniques posed significant challenges. ECOTITE™-based treatment has been tested successfully on a variety of discharge water characteristics. Use of ECOTITE™-based treatment technology may broaden the range of ARD water quality characteristics and flow rates able to be passively treated.

**Additional Key Words:** acid mine drainage, passive water treatment, iron rich material, adsorption, AMD, ARD

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<sup>2</sup> Terry W. Schmidt, P.E., Vice President, Engineering, Skelly and Loy, Inc., 2601 North Front Street, Harrisburg, PA 17110. e-mail: [tschmidt@skellyloy.com](mailto:tschmidt@skellyloy.com) <sup>3</sup> Bradley R. Shultz, Water Quality Scientist, Skelly and Loy, Inc., 2601 North Front Street, Harrisburg, PA 17110 e-mail: [bshultz@skellyloy.com](mailto:bshultz@skellyloy.com)

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## **Introduction**

Limestone is often the material of choice for alkalinity addition in passive treatment systems for acid mine drainage and acid rock drainage (ARD) due to broad availability and relatively low price. However, limestone-based passive treatment is limited based on discharge characteristics of the ARD (such as high metals and acidity concentrations), limestone dissolution rate, and/or land area required for system construction. ECOTITE™ is a co-product of zinc recovery from electric arc furnace dust and has demonstrated an ability to generate alkalinity with relatively short contact times dependent upon water chemistry characteristics. In addition, ECOTITE™ also provides adsorption capacity for metal retention. Laboratory bench scale tests and pilot scale tests have been conducted to evaluate ECOTITE™ materials for ARD treatment at sites where conventional passive treatment techniques posed significant challenges. ECOTITE™-based treatment has been successfully tested on a variety of discharge water characteristics. Use of ECOTITE™ may broaden the range of ARD water quality characteristics and flow rates able to be passively treated.

The Pennsylvania Department of Transportation (PennDOT) is responsible for treating ARD seeping from waste and fill areas within the Interstate 99 (I-99) construction site located in Patton and Huston Townships, Centre County, Pennsylvania. PennDOT requested that Skelly and Loy research potential passive treatment systems capable of treating the severe ARD emanating from the fill areas. Skelly and Loy's initial suggestion was to consider a Sulfate Reducing Bioreactor. However, due to concerns related to release of hydrogen sulfide gas, PennDOT requested that Skelly and Loy also consider new and innovative processes that may be on the cutting edge. The objective of this study was to evaluate ECOTITE™ as a component of a passive treatment system at the I99 site which provides a significant challenge with respect to water chemistry due to a combination of high acidity and high metal concentrations. If ECOTITE™ passes this screening test, it will be subject to a more rigorous testing process.

## **Background**

ECOTITE™ was identified as a potential component of a treatment media during a literature search conducted by Skelly and Loy for innovative treatment technologies for ARD. Horsehead Corporation generates ECOTITE™ material during recycling and zinc recovery from Electric Arc Furnace (EAF) Dust. More specifically, ECOTITE™ is an iron rich material collected from Waelz kilns where EAF Dust is mixed with a carbonaceous reductant and heated to liberate a Crude Zinc Oxide (CZO) product and ECOTITE™. The CZO is separated from the combustion gases and captured in fabric filter collectors, while the ECOTITE™ is a granular solid discharged from the Waelz kiln. The Waelz kiln process is designated by the U.S. Environmental Protection Agency (USEPA) as representing the Best Demonstrated Available Technology (BDAT) for the processing of EAF Dust and the ECOTITE™ material meets or exceeds the BDAT limits established by the USEPA and adopted by Pennsylvania Department of Environmental Protection (PA DEP).

ECOTITE™ exhibits unique properties that are favorable for passively treating water that is characterized as acidic and containing dissolved heavy metals. Bowers (1998) and Dutrow (1998) considered the mineralogy of ECOTITE™ and identified its potential use in treating

contaminated water at the manufacturer's site in Palmerton, Pennsylvania. Both experts, one a geochemist and the other a mineralogist, determined that the various phases of iron present in the material and the presence of several calcium-silicate minerals allow ECOTITE™ to liberate alkalinity and simultaneously adsorb dissolved heavy metals from water. Dutrow (1998), through the use of optical microscopy, x-ray diffraction, and electron beam analyses characterized the chemical and mineral composition of ECOTITE™ and indicated the relativity of this information to the application of the material for use in water treatment. Dutrow (1998) found calcium-silicate minerals to make up a significant portion of the ECOTITE™ material, including akermanite ( $\text{Ca}_2\text{MgSi}_2\text{O}_7$ ), merwinite ( $\text{Ca}_3\text{MgSi}_2\text{O}_8$ ), monticellite ( $\text{CaMgSiO}_4$ ), and larnite ( $\text{Ca}_2\text{SiO}_4$ ). Bowers (1998) indicated that the calcium-silicate mineralogy of ECOTITE™ is crucial to its ability to provide long-lasting pH buffering capacity. The pH buffering capacities of the four primary calcium-silicate minerals found in ECOTITE™ are higher than calcite ( $\text{CaCO}_3$ ), the alkalinity-producing component found in limestone. Bowers (1998) explained that the ECOTITE™ buffering capacity, which is reliant on the sparingly soluble calcium-silicate minerals, is long lasting and not ephemeral.

Iron composes approximately one-third of ECOTITE™ by weight including the minerals magnetite, hematite, goethite, monoxides (e.g., wustite), metallic iron, and iron sulfides. Air and/or water contacting the iron minerals oxidize and form hydrous ferric oxide, which is an amorphous material forming a surface coating on the particles. It is these hydrous ferric oxides that present an opportunity for heavy metals adsorption. However, the adsorption process is dependent on the pH of the water, with adsorption increasing as the pH increases. Therefore, as the calcium-silicate minerals slowly hydrolyze during contact with water, hydroxyl ( $\text{OH}^-$ ) ions are released that increase the pH of the water and promote the adsorption of heavy metals. Gao et al. (1995) conducted several fixed-bed column experiments using ECOTITE™ for heavy metals removal in metal-laden synthetic water. Gao et al. (1995) identified two important characteristics about ECOTITE™ as a water treatment media. First, the performance of ECOTITE™ to remove heavy metals was essentially independent of solution pH above roughly 3.5. Second, ECOTITE™ is as effective as ion-exchange resins at removing dissolved heavy metals from water.

Horsehead Corporation's Palmerton Plant has been a long-term case study of ECOTITE™ use for passive water treatment as documented by Brown (2006). Prior to Horsehead Corporation's operation of the facility, a contaminated discharge was identified in the 1980's from an area of the site known as the Cinder Bank. Effluent water from portions of the Cinder Bank had zinc concentrations as high as 190 mg/L. ECOTITE™ was placed at the toe of the Cinder Bank in a permeable reactive barrier style layout to treat the discharge. ECOTITE™ dropped the dissolved zinc concentrations below 1 mg/L and increased the pH levels from a low of 5.0 to over 8.0. Since installation, Brown (2006) indicated ECOTITE™ treatment has maintained an average dissolved zinc concentration effluent below 1.0 mg/L with additional ECOTITE™ material added periodically.

### **Materials and Methods**

The PennDOT I99 site provided a significant passive treatment challenge with respect to water chemistry. An ARD source from this site was used to evaluate the use of ECOTITE™ as a

passive treatment media. In the spring of 2006, Skelly and Loy and PennDOT acquired and installed equipment to conduct the bench scale testing efforts. After evaluating the various ARD sources at the site for quantity and quality, water from the Siebert basin was determined to provide the most consistent source of highly contaminated ARD with high acidity and high metals concentrations. A flat area near the Siebert basin was selected for placing the bench scale testing equipment and materials.

In the winter of 2006, Skelly and Loy obtained the necessary approvals from PennDOT and Pennsylvania Department of Environmental Protection (PA DEP) to conduct on-site bench scale tests of ECOTITE™. The testing equipment included three 1,500-gallon chemical-grade plastic tanks to serve as temporary storage vessels for the raw source ARD from the Siebert basin. The ARD was fed from these three vessels by gravity to a PVC distribution line that connected to each of three test cells. The distribution line was equipped with additional ports and control valves with the ability to add additional test cells and sample raw ARD. The bench scale test cell containers were 55-gallon plastic drums with lids. Each test cell was plumbed with an inlet and outlet port, one at the top and the other at the bottom of the cell, allowing for evaluation of up-flow or down-flow introduction of the ARD into the test cell materials. Both the inflow and outflow ports of the cells contained valves to regulate the flow of water. Perforated pipes and tubing were installed inside each test cell on the inflow and outflow ports to reduce potential water channeling through the test cell media. Figure 1 is a cross section of a typical test cell used in this study.

Following installation and set-up of the water supply and test cell equipment, material mixtures were developed for placement into the cells. Approximately 50 gallons (190 liters) of material mixtures were placed in each test cell. Table 1 summarizes the percent by volume quantities of materials used in the test cells. Test cell materials included ECOTITE™, AASHTO 67 limestone, and wood mulch. There was no source of bacteria added to any of the test cells. Therefore, no sulfate reduction was anticipated. Each material was weighed and measured to determine approximate dry densities and estimate the percent by weight and volume of each treatment media. Table 2 provides the measured densities of each material.

Table 1. Phase II Test Cell Material Compositions – Percent By Volume.

<b>Test Cell</b>	<b>AASHTO 67 Limestone</b>	<b>ECOTITE™</b>	<b>Wood Mulch</b>
1	35	35	30
2	20	60	20
3	0	100	0

Table 2. Test Cell Material Measured Dry Densities

<b>Material</b>	<b>Density (lb / gal)</b>
AASHTO 67 Limestone	11.75
ECOTITE™	12
Wood Mulch	1.75

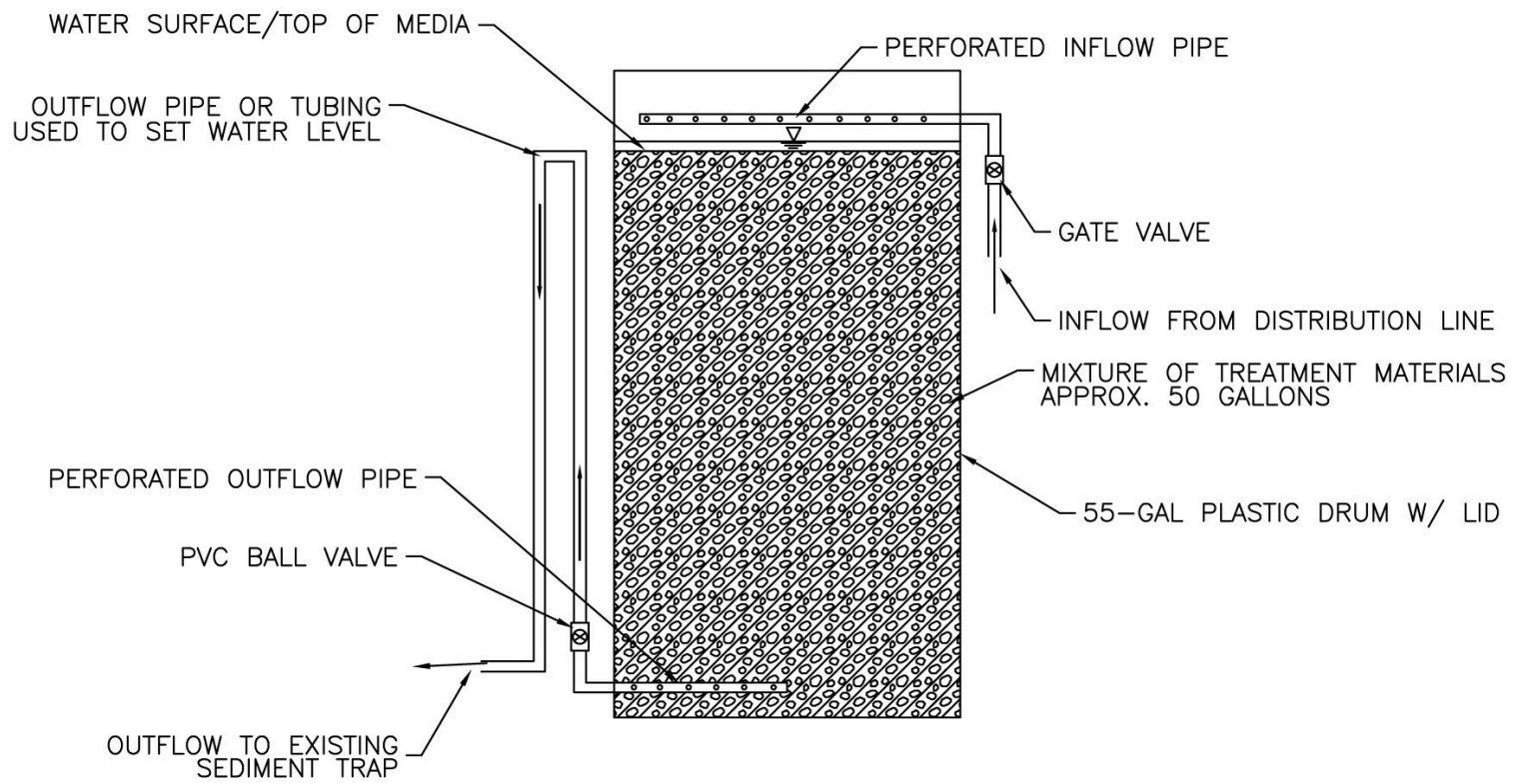


FIGURE 1 - TYPICAL TEST CELL CROSS-SECTION

Each material mix was volumetrically measured and thoroughly mixed in small batches prior to placement in the cells. Resulting test cells contained approximately 50 gallons or 190 liters of treatment materials. The void space of test cell #3 was measured at 35% (after settling) while the void space of test cell #1 was 40%. Test cells 1, 2, and 3 were evaluated for their ability to neutralize acidity, generate alkalinity, and retain metals. Samples collected for water chemistry analysis were tested for the following parameters:

- **Total Metals (EPA Method 200.7):** Al, As, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, V, and Zn;
- **Conventional Chemistry Parameters (SM / EPA Methods):** Acidity (SM 2310B), Total Alkalinity (SM 2320B), pH (EPA Method 150.1), Total Dissolved Solids (SM 2540C), Total Suspended Solids (SM 2540D), Sulfide (SM 4500-S2-F), Total Organic Carbon (SM 5310C), and Dissolved Silica (SM 4500-SIO2C); and
- **Anions (EPA Method 300.0):** Chloride, Fluoride, and Sulfate.

The evaluation focused on treatment effectiveness of the materials through detailed chemical analyses of the treatment cell effluents. The tests were continued until the treatment media became spent with respect to alkalinity addition and/or metal retention. After the treatment media was spent, samples of the spent materials were collected and analyzed for Toxic Characteristic Leaching Procedure (TCLP) Metals (EPA Method 6010B, except for Mercury which was performed using EPA Method 7470B) and Synthetic Precipitation Leaching Procedure (SPLP) Extracted Analyses (EPA Method 1312). This testing was completed to determine if heavy metals or anions may re-dissolve from the spent treatment media. The spent treatment media was analyzed for the following parameters grouped by EPA Method:

- **TCLP Metals (EPA Method 6010B):** Ag, Al, As, B, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Mo, Na, Ni, Pb, Sb, Se, Ti, Tl, and Zn;
- **TCLP Metals (EPA Method 7470A):** Hg;
- **Conventional Chemistry Parameters (SM / EPA Methods):** Sulfite (SM 4500-SO3-B);
- **Anions (EPA Method 300.0):** Chloride, Fluoride, and Sulfate;
- **SPLP Extracted Analyses (EPA Method 1312):** SPLP Final pH; and
- **TCLP Extraction (EPA Method 1311):** TCLP Final pH.

## Results

In April 2006, the test cells were installed and tested for proper operation and leaks. Table 3 below illustrates the typical quality of the source ARD water from the Siebert basin. The acidity was reported by the laboratory using Standard Method 2310B. The calculated acidity based on the metal acidity and pH acidity (including metals not listed on Table 3) is approximately 1200 mg/L.

Table 3. Siebert Basin ARD – Typical Water Chemistry

<b>Parameter</b>	<b>Siebert Basin – 5/23/06</b>
<i>Total Aluminum (mg/L)</i>	131.0
<i>Total Iron (mg/L)</i>	2.6
<i>Total Manganese (mg/L)</i>	11.0
<i>Total Zinc (mg/L)</i>	3.3
<i>pH</i>	3.4
<i>Acidity (mg/L)</i>	2000
<i>Sulfate (mg/L)</i>	5590

After completing preliminary tests of cell operation, three test cells were developed for detailed water chemistry evaluation as identified on Table 1. Test cells 1 and 2 used ECOTITE™ combined with limestone and wood mulch in varying percent volumes. Test cell 3 contained pure ECOTITE™.

Each test cell received identical source water supplied by individual containers. Raw ARD source water was introduced to the test cells approximately eight hours per day. This method of raw water introduction allowed for a high level of visual monitoring and accurate estimation of total water treated by the test cells. Average flow rates for the test cells are provided in Table 4. The flow rates shown on Table 4 correspond to contact times of 28 to 48 hours as water remained in contact with the material overnight between source water introduction periods.

Table 4. Average Test Cell Flow Rates

<b>Test Cell</b>	<b>Average Flow Rate (mL/min)</b>
1	85
2	122
3	70

The test period began on June 14, 2006, and continued through August 10, 2006. Detailed water chemistry data was collected on June 26 and August 4, 2006. Water chemistry data was also collected for the raw water and test cell #3 on July 12, 2006. Samples were not collected from test cells 1 and 2 on July 12, 2006, due to clogging of the material. The cells were subsequently mixed on a weekly basis to promote flow and a final sample was collected August 4, 2006. Table 5 and Table 6 summarize selected data collected from the detailed water chemistry analysis. Field data included daily collection of pH, conductivity, test cell outfall flow rates, and temperature. Figure 2 and Fig. 3 graphically illustrate the pH and flow data during the evaluation period.

Table 5. Water Quality Results for Selected Metals (mg/L)

Sample	Sample Date	Al (T)	Ca (T)	Fe (T)	Mn (T)	Zn (T)	Ni (T)
Raw Water	6/26/2006	142	114	1.71	30.4	3.66	1.75
	7/12/2006	144	120	1.78	12.0	3.69	1.66
	8/4/2006	161	123	1.91	31.3	3.85	1.91
Test Cell 1	6/26/2006	<0.250	823	0.708	0.397	<0.05	<0.05
	8/4/2006	97.6	284	72	42.3	3.77	1.16
Test Cell 2	6/26/2006	<0.250	766	0.0643	0.594	<0.05	<0.05
	8/4/2006	156	301	49.9	22.5	4.97	1.01
Test Cell 3	6/26/2006	<0.1	685	<0.02	<0.02	0.0399	<0.02
	7/12/2006	0.612	754	2.51	9.03	0.184	0.0532
	8/4/2006	94.5	253	13	12	2.96	0.827

Table 6. Water Quality Results for Selected Parameters (mg/L)

Sample	Sample Date	Acidity	Alkalinity	pH*	Sulfate	TDS
Raw Water	6/26/2006	2600	<10.0	3.38	5520	6510
	7/12/2006	2100	<10.0	3.47	7960	5500
	8/4/2006	2500	<10.0	3.22	11700	6640
Test Cell 1	6/26/2006	-30	180	9.64	2050	3460
	8/4/2006	1200	<10.0	4.22	4640	5380
Test Cell 2	6/26/2006	-10	124	10.5	1800	2910
	8/4/2006	1400	<10.0	4.04	5930	4920
Test Cell 3	6/26/2006	-14	138	11.3	1900	2950
	7/12/2006	38	<10.0	7.23	2330	2990
	8/4/2006	990	<10.0	3.97	4890	4160

\*pH expressed in Standard Units

Based on the pH and water chemistry data in early August 2006, test cells 1, 2, and 3 appeared to be spent and operation of the cells was discontinued on August 10, 2006. In the weeks leading up to the decision to terminate operation of the test cells, the treatment material was stirred to ensure that treatment capacity of the material was reached and the material was spent. This stirring occurred on a weekly basis from July 12 through cessation of testing. The cessation of treatment was due to the chemical and physical changes in the substrate. Based on the mineralogy of the material, less than 10% of the available alkalinity had been expended.

Challenges for use of raw ECOTITE™ as a passive treatment media include the high resultant pH as observed in test cell 3. Based on these data, it is likely that ECOTITE™ will only make up a portion of the treatment media at ratios similar to test cells 1 and 2 or lower. In addition, a release of iron was noted in each test cell after the treatment material became



ineffective. This increase was attributed to the dissolution of iron primarily from the source material as low pH water continued to contact the material.

At the completion of the testing effort, several analyses were conducted to characterize the spent treatment materials. Composite samples of the treatment materials from test cells 2 and 3 were collected and analyzed for TCLP and SPLP. These test methods were recommended by Pennsylvania Department of Environmental Protection Waste Management Section to aid in determining potential beneficial use option for spent material. Table 7 summarizes the results of these laboratory analyses. Based on these data, the primary metals of concern are not easily leached from the spent treatment media.

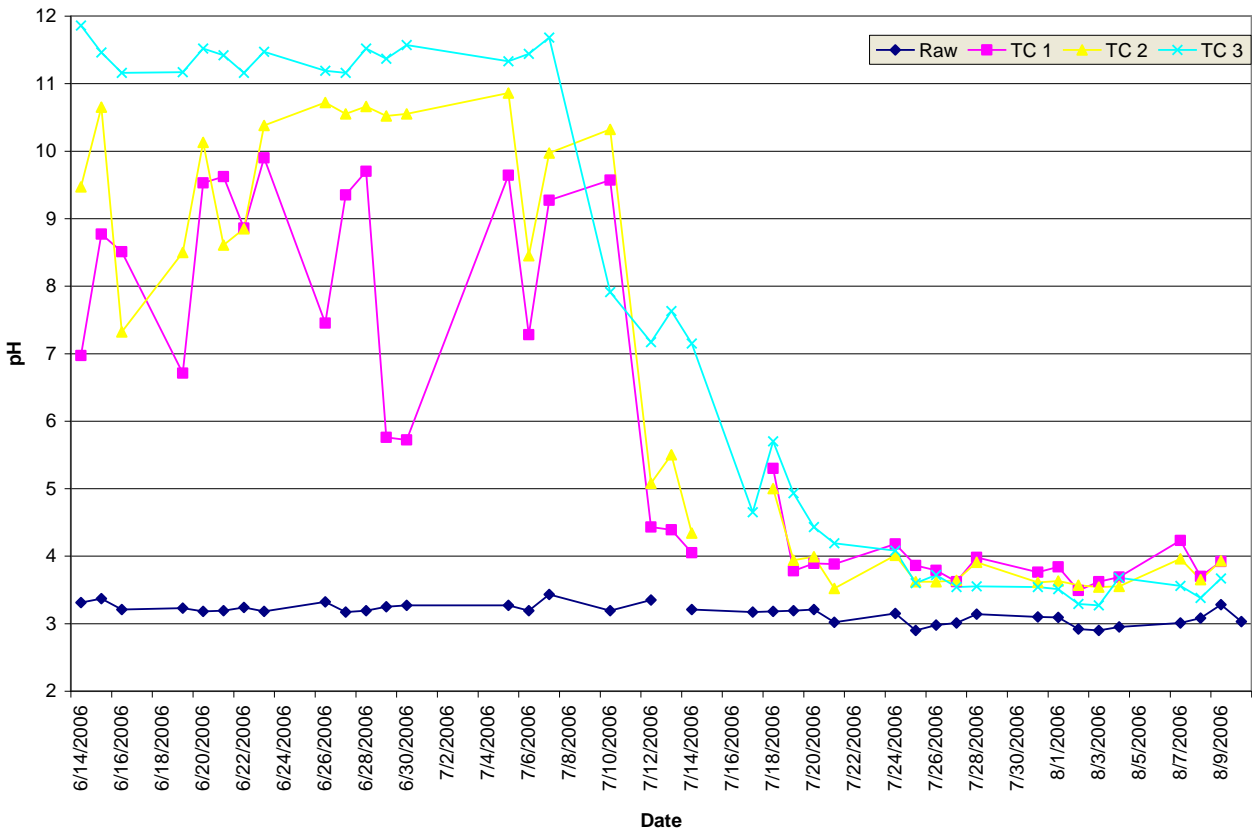


Figure 2. Raw Water, Test Cell 1 (TC1), Test Cell 2 (TC2), and Test Cell 3 (TC3) pH Readings in Standard Units

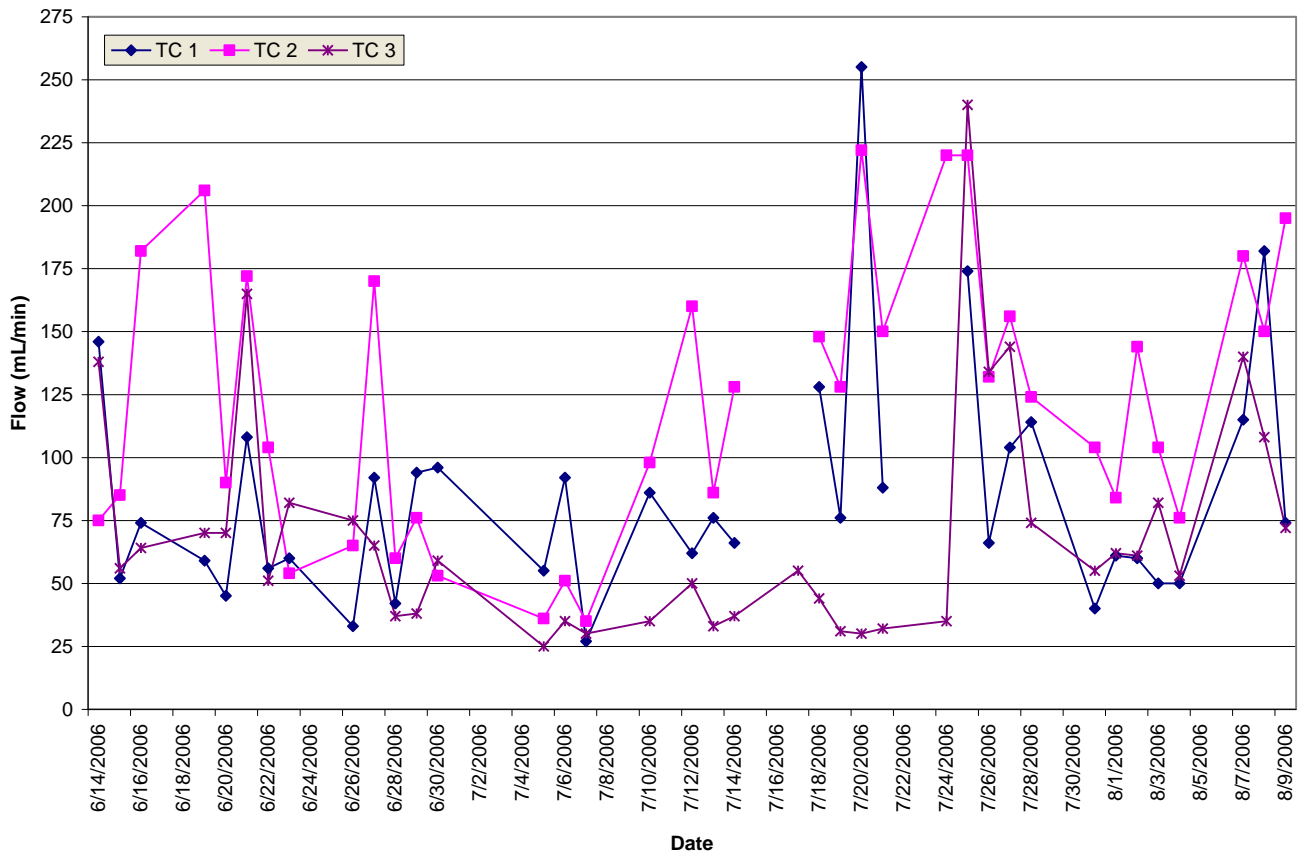


Figure 3. Raw Water, Test Cell 1 (TC1), Test Cell 2 (TC2), and Test Cell 3 (TC3) Flow Measurements

Table 7. Results of TCLP and SPLP Analyses for Test Cell 2 and Test Cell 3 Spent Material\*

<b>Parameter</b>	<b>Test Cell 2</b>	<b>Test Cell 3</b>
Silver	<0.020	<0.020
Aluminum	<0.250	<0.250
Arsenic	<0.020	0.0373
Boron	<0.50	<0.50
Barium	0.0933	0.102
Beryllium	<0.005	<0.005
Calcium	1000	827
Cadmium	<0.010	<0.010
Cobalt	<0.050	<0.050
Chromium	<0.005	0.0174
Copper	<0.050	<0.050
Iron	<0.050	<0.050
Mercury	<0.0002	<0.0002
Potassium	1.83	1.42
Magnesium	98.3	110
Manganese	8.11	33.5
Molybdenum	0.0957	<0.050
Sodium	1990	1970
Nickel	<0.050	0.0947
Lead	<0.250	<0.250
Antimony	<0.010	<0.010
Selenium	<0.020	<0.020
Titanium	<0.005	<0.005
Thallium	0.0223	<0.020
Zinc	<0.050	<0.050
Sulfite	<1.00	<1.00
Chloride	<1.00	<1.00
Fluoride	2.94	1.72
Sulfate	1130	1140
TCLP Final pH	7.85	7.70
SPLP Final pH	9.83	10.40

\*All units are mg/L except for the TCLP Final pH and SPLP Final pH, which are pH Standard Units (S.U.). The SPLP test techniques were used for anions sulfite, chloride, fluoride, and sulfate while TCLP test techniques were used for cations.

## Discussion and Conclusions

Utilizing ECOTITE™ in a treatment media for acidic metal-laden discharges such as acid mine drainage and ARD requires preliminary bench scale testing to select the appropriate mixture of materials best suited to treat specific water chemistry and flow characteristics. Because of its small grain size, ECOTITE™ can be susceptible to plugging and must be considered during the design process.

This evaluation included one source water and three treatment media mixtures containing ECOTITE™. Two test cells contained mixtures of limestone, wood mulch, and ECOTITE™ while the third cell contained pure ECOTITE™. The limestone, wood mulch, and ECOTITE™ mixtures were chosen in order to promote greater permeability, prevent large-scale agglomeration of the ECOTITE™ material, and provide additional buffering capacity through limestone dissolution. No source of bacteria was added to the cells and no indication of hydrogen sulfide gas was noted. Therefore, it is unlikely that sulfate reduction occurred within the cells. All test cell mixtures did produce some level of agglomeration or clumping of the ECOTITE™ material.

Test cells 1 and 2 contained different mixtures of ECOTITE™, AASHTO 67 limestone, and wood mulch. The pH values in test cell 1 started dropping below 7.0 about one month after test initiation. Despite having more ECOTITE™ material than test cell 1, test cell 2 pH results were similar to test cell 1. Test cell 1 pH results stayed in a more neutral range. During the first three weeks of testing (6/14 to 7/5), the pH levels in test cell 1 varied between 5.72 and 9.90, with an average of 8.32. In comparison, the pH values of test cell 2 were more alkaline ranging from 7.32 to 10.86, with an average of 9.84 for the first three weeks. Test cells 1 and 2 effectively removed acidity and metals based on the 6/26/06 sample of the effluents. Test cell 1 produced a net alkaline discharge with very low metals concentrations, usually below 1.0 mg/L. Test cell 2 had very similar outfall characteristics including a net alkaline discharge with very low metals concentrations. Both test cells showed a significant decrease in sulfate concentrations of approximately 65%. It is hypothesized that this was due to gypsum formation ( $\text{CaSO}_4$ ) and/or ion exchange and adsorption of the dissolved ion onto ECOTITE™. This hypothesis was confirmed by subsequent X-ray diffraction and mineralogical evaluation performed by Dr. Barry Sheetz of Penn State University based on verbal communications and internal reports. The third sampling event (8/4/06) indicated that test cells 1 and 2 were no longer effective at removing metals, acidity, or sulfate.

Test cell 3 contained pure ECOTITE™ and exhibited a very strong alkaline affect on the pH of the ARD, averaging a pH value of 11.4 during the first three weeks. The pH of test cell 3 dropped on 7/10/06 and averaged 7.5 during the week. On 7/17/06 the pH level dropped further and averaged 4.8 during the week. Following this downward trend in pH, the cell pH eventually dropped to a level near the raw ARD pH and the test was discontinued on 8/10/06. ECOTITE™ in test cell 3 exhibited the highest level of agglomeration in any of the test cells. The surface of the material became crusted and an accumulation of iron precipitates was evident on the surfaces. The longer the test was continued, the lower the permeability of test cell 3 became as the treatment media became plugged with iron precipitates and the bed became more agglomerated. The lower permeability was observed based on the level of water accumulation above the surface of the treatment media and inability of the water to pass through the media.

Water chemistry for test cell 3 during the first sampling event displayed the metals removal capacity expected for ECOTITE™ and surprisingly lowered the sulfate concentration by 66%. However, by the second sampling event on 7/12/06, the metals removal effectiveness began deteriorating. Even though most of the acidity was removed or neutralized (final outfall acidity was 38 mg/L), the iron and manganese levels began to increase. By the third sampling event, the test cell became ineffective for alkalinity addition and metals retention. However, sulfate concentrations were still lowered by nearly 58%.

It is difficult to compare ECOTITE™ to other more conventional passive treatment techniques due to the extreme nature of the raw water tested. Limestone-based treatment would generally not be attempted with similar source water quality. Sulfate Reducing Bioreactors may be a viable, more conventional passive treatment technique. However, the treatment location was not amenable due to the potential generation of hydrogen sulfide gas near businesses and residential areas. Further testing of ECOTITE™ is underway to confirm results of this evaluation under controlled laboratory conditions where external factors and flow rates can be managed and controlled. Future evaluations are also planned and/or underway comparing ECOTITE™ to steel slag, a pellet form of Bauxal known as Viromine, and cells promoting sulfate reduction. This evaluation of ECOTITE™ continued for approximately one month. Evaluations currently underway include methods to utilize the material to take advantage of both the alkalinity generating potential and metal adsorption to maximize the life of the treatment system. Based on our estimate of the ECOTITE™ mineralogy, less than 10% of the available alkalinity was expended.

The use of ECOTITE™ as a system component for treating acid mine drainage and ARD is promising. Of particular interest is the manner that ECOTITE™ distinguishes itself from other passive treatment materials based on its mineralogy. One mole of the principal iron silicate mineral, ackermanite has the ability to neutralize 6 moles of acidity. ECOTITE™ has been successfully used for water treatment at the generation location at Palmerton, Pennsylvania. The bench scale tests conducted as part of this evaluation added to existing information on the ability of ECOTITE™, alone and in combination with other components, regarding its ability to raise pH, add alkalinity, remove heavy metals, and provide some reduction in sulfate from ARD. It also became apparent that the method of flow introduction, hydraulic conductivity of the treatment media, and agglomeration and metal precipitation within the treatment beds must be considered for ECOTITE™ treatment systems.

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