Abandoned Mine Drainage

Formation, Impacts, Treatment, and How You Can Help!

For details on the information contained in this packet, or lessons you can teach using this information please contact Rebecca Holler at rholler@tu.org or by phone at 570-748-4901.

Information contained in the pamphlet was developed by Trout Unlimited's Eastern Abandoned Mine Program. Some materials were adapted from the Western Pennsylvania Coalition for Abandoned Mine Reclamation's AMD Clearing

What is AMD?

Abandoned Mine Drainage (AMD) is water that has become contaminated as a result of historic coal mining. Some people call AMD “acid” mine drainage because it is commonly acidic, however it can be alkaline in nature so the more proper term is “abandoned”. Prior to 1977, the laws governing coal mining operations were less stringent concerning their environmental impacts. It was a common practice to simply abandon mining operations following the exhaustion of the coal reserve, then declare bankruptcy. This allowed the mining operators to walk away from liabilities, including environmental devastation.

The nature of AMD contamination varies greatly from site to site, as its formation is dependent on a variety of factors. AMD often lowers water quality and impairs aquatic life, and is most often characterized by one or more of the four major components:

- Low pH (high acidity), i.e., acid mine drainage
- High metal concentrations (iron is the most common, but aluminum and manganese are also commonly found)
- Elevated sulfate levels
- Excessive suspended solids and/or siltation

A) Aluminum precipitate is seen in a stream. Aluminum is toxic in the dissolved and precipitated form. B) Iron sediment is seen coating a small stream. Along with the iron precipitate is algae which can coat impaired streams. C) A kill zone is an area of land where no vegetation grows. This is due to polluted water running over the surface. D) A polluted stream enters the West Branch of the Susquehanna. Iron and aluminum can be seen.

How is AMD formed?

AMD is created when water and oxygen comes in contact with certain minerals which contain acidic material. In the case of AMD this happens in the mining process, but these minerals can be exposed in other ways. The mineral responsible for the vast majority of AMD formation is pyrite, often called fool's gold. Pryite's chemical formula is FeS_2 and is also called iron sulfide or iron pyrite. While in actuality a series of chemical reactions occur to form contaminated water, the net result of these reactions can be summarized as follows:

Pyrite + water + oxygen = sulfuric acid + yellow boy

$$FeS_2 + H_2O + O_2 \rightarrow H_2SO_4 + Fe(OH)_3$$

Sulfuric acid (H_2SO_4) is a strong acid capable of having devastating environmental consequences for plants and animals. Yellow boy ($Fe(OH)_3$), also known as iron hydroxide, can form an orange or yellow sludge coating the bottoms of streams, effectively smothering aquatic life.

The acidity generated by this reaction can further dissolve other minerals and leach metals from the soils where the water flows. These metals most commonly are aluminum and manganese. These pollutants in sufficiently high concentrations can have a variety of negative effects.


A


B


C


D

A) Pyrite is naturally found in the soils and near coal. As coal was mined Pyrite was exposed and has lead to AMD. B) Historic deep mines such as this one can fill with water and contribute large amounts of pollution. C) Surface mines were often left as open pits, and steep cliffs. These contribute pollution and are also a risk to people who may be injured in them. D). Unwanted rocks and low grade coal were often times piled up and can still be found. These piles produce polluted water, as well as being eye sores.

How does AMD impact streams?

AMD is responsible for degrading over 7,500 miles of streams throughout the Appalachian region, and has been identified by the Environmental Protection Agency as the single largest threat to the environment. This acid along with the metals in the water degrade water quality and affect life in the streams. Streams generally have very low pH (2-4) and high metal concentrations (iron aluminum and manganese) which leave streams discolored. Sulfates are also present which produce an un-

Impacts to Stream Life

- Low pH affects the ability of aquatic organism's cells to regulate how much water is contained in them. This leads to cell death especially in the gills .
- Dissolved and some precipitated metals, especially aluminum are toxic to life. When theses metals are combined with low pH they are more toxic. (Photo C shows aluminum)
- Metals coat stream bottoms leaving no habitat for macroinvertebrates, and smothering the eggs of fish and macros. (Photo D shows precipitated metals coating the stream bottom)
- Precipitated metals coat and clog gills. (Photo A shows a fish gill coated with iron)
- Aquatic plants are lacking in these streams, limiting the food for macroinvertebrates. As invertebrates die off food for fish is limited.
- Coldwater fish (Trout) are especially affected since small coldwater stream generally do not have naturally occurring buffering capacity. (Photo B shows a small stream which should contain trout but has been polluted)

Impacts to the Economy

We are dependent on clean water, just as trout are. AMD impacts the water resources at our disposal and thus has massive impacts on human life around these streams. AMD also clogs pipes, and damages concrete structures in water. The following figures are a summary of the results of a 2009

Recreational Spending

$22.3 million in sport fishing revenue was lost in one year with-in the West Branch watershed. This does not include the losses in revenue from other eco-tourism and recreation.

Property Values

In one small subwatershed of the Susquehanna $4 million dollars was lost in property values. Homes with-in 200 feet of an impaired stream lost approximately $2,500 per acre.

Drinking Water Supplies

Actual assessments of how much money is spent treating AMD so it can be used in drinking water are difficult to assess. It is know that in the West Branch $11 million has already been spent to provide drinking water to contaminated wells, much more has been spent by public water companies to treat water.

Job Creation

The restoration of streams will generate local jobs during the remediation process, and more jobs are generated with restoration of the area. Many areas where AMD impacts streams are economically depressed with little industry remaining.

How can we fix this problem?

Despite the vast scale and massive devastation that AMD has caused there are ways to restore streams so they can support life. Volunteer groups, state agencies, and other non-profit groups are working to install treatment systems which remove the pollution and restore streams. Treatment involves increasing the pH of the water, which limits the ability of metals to be dissolved. Once the metals become solid they can be removed. We also can remove the source of the pollution through land reclamation.

Passive Treatment

Passive treatment involves using limestone, microbes, wetlands and other means to increase pH and remove metals. As the pH is increased by limestone (a very basic mineral) the metals become solid. These can then be settled in large ponds, and removed. Plants and microbes assist with this process. Each discharge is different so multiple different technologies are often times used. While these are called passive, they still require monitoring and maintenance every few months.

A) Large treatment systems like this one contain multiple "cells" which treat water. If one of them is damaged or needs work, water can be diverted to the other cells allowing treatment to continue. B) In this system pipes are placed at the bottom of the pond, with limestone over top. Mushroom compost is placed on top of to promote bacterial growth. Water must flow vertically through all the layers to the pipes on the bottom, so these types of systems are called vertical flow ponds. C) Systems are often times quite large and utilize multiple types of treatment . D) This type of passive treatment is call a limestone cell and raises the pH of water.

How can we fix this problem?

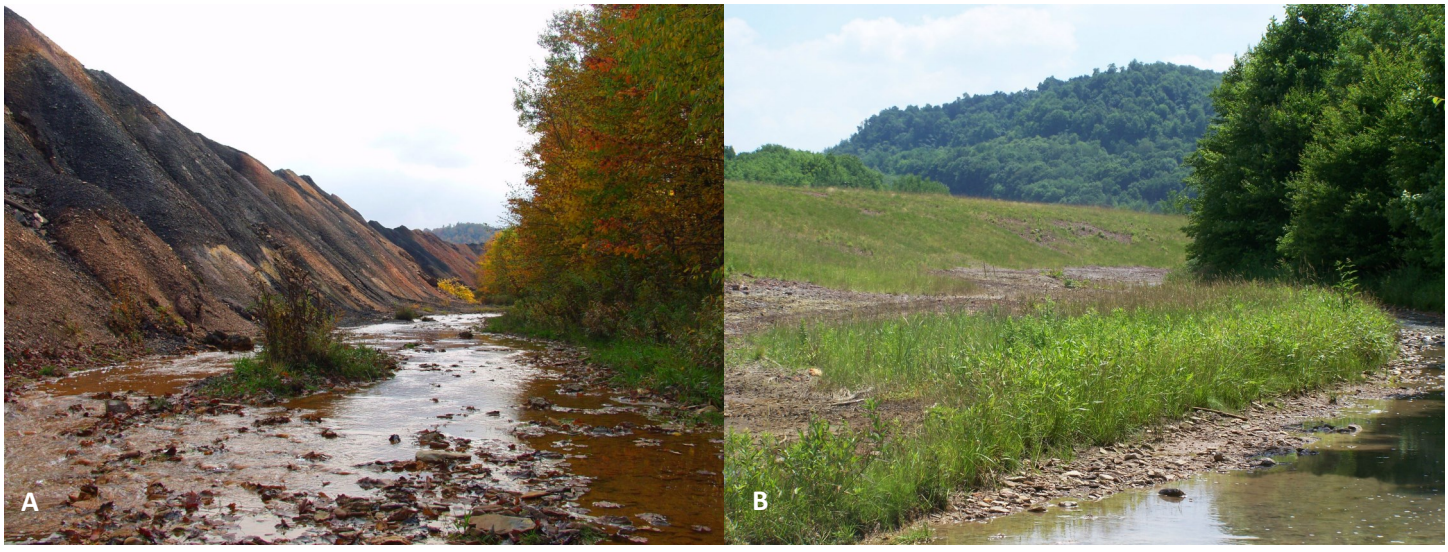
Active Treatment

Active treatment involves adding basic chemicals to AMD to treat the pollution. These systems then allow the precipitated metals to settle and the clean water to enter the stream. These systems can be large water treatment plants, or just small “dosers” which add the chemicals. Active treatment involves continuous additions of chemicals, and requires monitoring and new chemicals to be added often. This generally means someone needs to be at the site at least once a week.

A) This is an example of a large water treatment facility. This facility cost $14.4 million, and requires a full time employ to maintain.
B) A “lime doser” is really just a silo filled with basic chemicals that regulates how much of this chemical is added at a time.

Land Reclamation

Land Reclamation involves removing the source of pollution by re-grading and redirecting the water flow so that pyrite is not exposed. Basic material is also added to treat and acid that is formed. Sometimes coal that was not removed during the original mining process is also removed and sold to decrease costs, this is called remining. Land Reclamation permanently removes the source of pollution and requires little maintenance. It also improves the land habitat.



A) The Barns Watkins refuse pile and mine prior to reclamation. B) The same site after land reclamation. The water flowing here is the West Branch of the Susquehanna.

What is TU doing about AMD?

TU builds water treatment facilities, and complete other treatment. We also work with volunteers to support their treatment work. TU also works with legislators, and others to ensure funding remains to treat AMD.


TU completes many assessments of impacted streams, as well as monitors streams that are being restored. TU also takes part in research projects for AMD restoration and trout conservation


In order to sustain our work, TU provides youth and adult education about AMD, streams, and treatment. This encourages others to become involved in this work as well.


What can you do?

Join your local TU chapter, and/or another volunteer group working to restore streams! Plant trees and improve habitat so trout populations are strong, and can repopulate areas as they are cleaned up from AMD. Monitor and help complete work on AMD restoration. Many volunteer groups complete AMD treatment systems. And most importantly share your passion for fishing and the outdoors with others!!