Chapter 8 ~
ACID MINE DRAINAGE

Chapter Purpose

In this session we will study acid mine drainage and learn about the impacts abandoned coal mines have on the water quality of streams throughout Pennsylvania. We will learn how abandoned mines have the potential to affect plants, water resources, and human health.

Key Terms In This Chapter

- ✿ **Abandoned Mine Reclamation**
- ✿ **Erosion**
- ✿ **Oxidation**
- ✿ **Passive Treatment**
- ✿ **Pyrites**
- ✿ **Solubility**
- ✿ **Subsidence**

Chapter Concepts

After completion of this chapter, students will have a thorough understanding of what acid mine drainage is and what affects it can have on the environment. Students will also learn about the significance of this problem particularly in Pennsylvania. All pertinent terminology will be discussed throughout the chapter.

Outline

This session can be taught in one science period. The time includes teaching the lesson, answering student questions, and assigning the chosen homework. A class exercise is included at the end of this session and should be covered in class.

Acid Mine Drainage Facts

Facts:

As of 1977, Pennsylvania had produced 1/3 of all the coal mined in the entire United States.

Approximately 3,000 miles of streams have been affected by acid mine drainage.

The estimated cost of solving Pennsylvania's acid mine drainage problems is $15 billion.

Acid mine drainage is the major source of stream degradation in the state.

58% of the electricity used by Pennsylvanians is generated by coal.

Today, active coal miners in Pennsylvania pay 35 cents per each ton of surface-mined coal in Pennsylvania in order to fund future mine reclamation activities.

Due to recent laws passed regulating mining operations, over 97% of the mining operations started in the last five years have not caused water pollution.

8-1 IMPORTANT CONCEPTS

Acid Mine Drainage: What is it?

Acid mine drainage is one of the major by-products of the coal mining industry. As coal mines have been abandoned across the state over the last century, water has been able to seep into the massive holes which remain either from heavy rains or flooding. As water comes into contact with coal remaining in the mine as well as other minerals present in the bedrock, several chemical reactions occur. The reactions occur when the water touches the **pyrites** in coal which cause the water to become acidic. Pyrites are any group of minerals which are made up of primarily metallic sulfides. Metallic sulfides contain sulfates which can easily create sulfuric acid when they come in contact with water. The acid contaminated water then drains out of the mine into nearby streams. The water, referred to as drainage, is heavily laden with acid and minerals which have the ability of turning the water many different colors. In addition, when the water is acidic in streams, it increases the **solubility** of certain metals such as copper, nickel and cadmium which are all toxic to plant and animal life. When metals are

soluble, they are able to be dissolved in liquids.

What Causes Acid Mine Drainage?

Coal Mining

In order to fully understand how acid mine drainage is formed, a short lesson on the different methods of coal mining is necessary. There are two ways for coal to be mined from the earth, including surface mining and deep mining.

Figure 8-1, Erosion resulting from surface mining

Surface mining is generally safer for miners, but is much more destructive to the landscape. The general process of surface mining is to dig a strip or trench along an area where coal is known to be present. The coal is then dug out of the earth using heavy machinery. In the past, mining companies often left the gaping holes in the earth once they had removed all the coal. No effort was made to fill in the trenches or to revegetate the land. As a result, massive amounts of soil **erosion** occurred. The erosion process occurs when bare soil is left exposed to the elements such as wind and rain. During heavy rain or wind storms, individual soil particles may become loose and either enter the air as dust or enter nearby streams as silt and sediment. This process is both damaging to the soil surface and to streams. Valuable nutrients are lost from the topsoil and sediment in streams clogs fishes gills and also blocks out precious sunlight needed to support plant and algae growth.

Figure 8-2 Heavy Equipment used for Surface Mining

The other method of mining is known as deep mining. Not all coal is located close to the earth's surface. In many cases it lies deep below the surface and intricate tunnels and caverns are required to be dug into the earth in order to reach the coal. This often presents major dangers to miners because the tunnels create unstable conditions in the earth. In the past, many miners were killed when tunnels collapsed on top of them. Once the miners had reached the coal, it was either dug out by hand or explosives were used to loosen it from the earth.

Pennsylvania has long been known as one of the leading producers of coal throughout the country. Coal mining has occurred in the state since the mid-1800's when it was used to heat homes and to fuel heavy industries such as iron and steel mills. As time progressed, alternate sources of energy were discovered (mainly fossil fuels such as oil and natural gas) and the coal mining industry gradually declined. As a result, thousands of mines, essentially open pits, were left abandoned across the state.

Abandoned Coal Mines

Due to the many numbers of abandoned mines across the country and particularly in Pennsylvania, acid mine drainage has become a prevalent problem. Acid mine drainage occurs when water from heavy rains or flooding seeps into the abandoned mines and comes into contact with any remaining coal present in the mine as well as minerals present in the bedrock. Chemical reactions occur as a result of this contact which cause the water to gain acidity and pick up minerals such as iron, manganese and aluminum. When this water comes to the surface and mixes with oxygen in the air, the metals become deposited onto rocks and gravel in streams and along stream banks. This process is known as **oxidation**. In most of the water discharged from abandoned mines, iron is the mineral which is most prevalent in addition to the acid. As a result, when the iron mixes with oxygen it becomes iron oxide. It is the iron oxide which is what so often turns streams and other water bodies orange in color. The color of the water affected by abandoned mine drainage depends on what mineral is most prevalent in the mine. If aluminum is the most prevalent mineral, the water will stain the rocks and water in the stream white. When manganese is present, the result will be a black streambed.

The degree to which mine drainage becomes acidic depends largely on an areas geology. The mine drainage will be more likely to neutralize any acidity if it flows over certain types of rock such as limestone. The limestone will help the drainage become more alkaline and buffer itself from the acidity. When acidity is present in streams, it increases the solubility of certain metals such as copper, nickel, and cadmium and the metal is dissolved in the water.

8-2 MAJOR CONCERNS ASSOCIATED WITH ACID MINE DRAINAGE

Major concerns associated with acid mine drainage include what effects it may have on the natural balance of the environment. When acid mine drainage enters a stream, it often turns the water an orange-red color due to the presence of iron. However, just because a stream is not orange or red in color does not mean that it has not been contaminated with acid mine drainage. As we learned in the Acid Rain Session, the acidity in the water is toxic to aquatic life, even in moderate concentrations. In addition, the acid present in the water has the ability to erode bridges and piers which are located within the streambed, just as acid in the air can erode at buildings and statues.

The abandoned mines across the state have also become a nuisance to the people who reside near them. Not only do the old mines cause the water in local streams to become polluted and turn strange colors, but residents living near them also use them as dumping grounds. In addition, sites are also dangerous due to the possibility for underground fires and **subsidence**. Subsidence may occur when the majority of the rock and/or soil is removed from a particular area. This leaves the land and ground cover remaining unsupported and open to collapse.

8-3 WHAT CAN BE DONE TO MINIMIZE THE EFFECTS OF ACID MINE DRAINAGE?

Realistically, acid mine drainage will continue to be a problem as long as there are abandoned mines. However, the more we can do to close up abandoned mines and make them less of a hazard, the greater chance we will have to reduce the effects of acid mine drainage. The process of closing up abandoned mines and reclaiming the land is referred to as **abandoned mine reclamation**. There are many benefits to abandoned mine reclamation such as elimination of hazards to health, safety and general welfare of citizens residing near old mines. In many cases, old mine sites become popular dumping grounds for garbage. In addition, children are attracted to the mines to explore and play without realizing the great danger due to subsidence.

Some of the benefits to the environment of abandoned mine reclamation include restoration of the land for future use, improved water quality and enhanced wildlife habitat. The restored land can be used for a variety of uses ranging from pasture land to recreational areas.

There are several things which can be done to reduce the number of abandoned mines which include closing and backfilling mine openings, backfilling open pits, eliminating dangerous high walls, and extinguishing or halting the advancement of underground fires. In addition, subsidence can be minimized by stabilization and filling, stream channels can be reestablished and water quality restored, dilapidated buildings associated with mine activities can be removed, and abandoned sites can be regraded and revegetated.

One way scientists are attempting to treat acid mine drainage is with **passive treatment** methods. Experts on stream pollution have realized that water contaminated with acid mine drainage does not have to be sent to an expensive chemical-based, water treatment plant in order to be pollutant free. Passive treatment methods rely on chemical and biological processes that naturally decrease metal concentrations and neutralize acidity. The basis for passive treatment is to let nature purify itself over time through a slow moving system of linked ponds which allow the toxins attached to particles of sediment to gradually filter to the bottom of the pond. In addition, the ponds are lined with limestone which is able to neutralize acidity levels. One disadvantage to passive treatment methods is the amount of land required to establish such a large system of ponds.

There are, however, several advantages to using passive treatment methods. Once constructed, passive systems can treat the water for 15 to 25 years with minimal routine maintenance costs. They generally require less operational attention than a technical water treatment plant which must be carefully monitored by qualified employees. Some of the maintenance required is the removal of any iron or mineral deposits which have accumulated on the pond floor. These deposits are normally removed and sent to a landfill approximately every two years. With a passive treatment system in place, life as it once was in the stream will gradually return. Some studies have shown streams returning to their original state within one year of utilizing passive treatment methods.

Pennsylvania law makers were the first to adopt regulations governing the coal mining industry. These regulations tell mine operators where and how they can mine and set requirements for restoring the land in and around mines once mining is completed.

8-4 HOMEWORK QUESTIONS

1) Define the words in the "Key Terms in this Chapter" box.

2) What are the two main methods of mining coal and briefly describe each one.

3) What is soil erosion?

4) Briefly describe how acid mine drainage is formed.

5) What are three of the minerals which are commonly present in abandoned mines?

6) What causes many streams contaminated with acid mine drainage to turn orange-red in color?

7) What are some of the benefits of abandoned mine reclamation?

8) What are three things which can be done to reclaim abandoned mines?

9) What is passive treatment of acid mine drainage?

10) What are some of the benefits of passive treatment as opposed to chemical treatment of acid mine drainage?

8-5 ACTIVITY

This activity will consist mostly of research. Students will be responsible for researching in more detail the two major types of mining which occur in Pennsylvania, surface and deep mining. Students should describe the types of equipment used for each mining method. In addition, descriptions of the specific effects to the environment which are associated with each type of mining should also be discussed. Students should present their findings in a short paper approximately 1-2 pages in length. The teacher can then select two or three of the top papers to be read aloud by the students who wrote them.