Title: Clean-up Cost: Acid Mine Drainage
Level: Intermediate, Middle School
Time: 1 hour prepare cabbage indicator Lesson -- 1-2 days
KERA Goals -- 2.1, 2.2, 2.4
Objective: Practice real life problem solving as the student determines the amount of base (the chemical treatment) needed to neutralize an acid (the mine drainage) in order to calculate the cost of mine drainage clean-up.
Materials:
1. Vinegar (white)
2. Ammonia
3. Red (purple) cabbage (head)
4. 3 Baby food jars or clear plastic cups for each group of students
5. 2 Eyedroppers for each group of students

Background Information: To make the purple cabbage indicator, boil ½a head of torn red/purple cabbage in one liter of water for approximately 20 minutes. Remove the cabbage from the indicator, the purple cabbage-juice water.

Activity:
1. Place 30 ml (approximately 1 oz.) of white vinegar (acid) into baby food jar or clear plastic cup.
2. Using an eyedropper, add four to five drops of red cabbage juice (the indicator) to the vinegar.
3. Observe any color change. A few more drops of red/purple cabbage juice can be added to brighten the color.
4. Using the second eyedropper, add the ammonia (base) one drop at a time to the vinegar and cabbage juice until the solution appears to be colorless. Swirl the solution periodically as you add the base for more accurate results. Record the number of drops of ammonia needed to neutralize the vinegar here:_____.
5. Answer the following questions and place the answers in the appropriate boxes in the data table below. Assume, for your calculations, that 1ml=20 drops of ammonia.

a. Determine both the amount of base needed and the cost to neutralize the amount of vinegar (acid mine drainage) in the above procedures.

b. Determine the amount of base needed and the cost to neutralize one liter of acid mine drainage. (1 l=1000 ml).

c. If a stream flows at a rate of 75 l per hour, determine the amount of base needed and the cost to neutralize the flow of acid mine drainage for a 24 hour period.

d. Using the same stream as an example, determine the amount of base needed and the cost to neutralize the flow of acid mine drainage for one year.

Amount of acid (ml)	Time	Amount of base (ml)	Cost/ml of base	Total cost

	0		$0.0012	
	0		$0.0012	
	24 hours		$0.0012	
	1 year		$0.0012	

Provided by Pittsburgh Energy Technology Center