Science Unit: ***Renewable & Non-renewable Resources***

Lesson 4: ***Mining & Bacterial Remediation***

School Year:	2009/20010
Developed for:	Dr. R. E. McKechnie Elementary School, Vancouver School District
Developed by:	Linda Hanson (scientist); Judi Burley and Theresa Lopetrone (teachers)
Grade level:	Presented to grade 4/5; appropriate for grades 2-7 with age appropriate modifications
Duration of lesson:	1 hour and 20 minutes

Objectives

1. Learn about the processes involved in mining.
2. Gain experience running a simple experimental activity.
3. Discuss the environmental implications of some mining practices.

Background Information

The idea for this lesson arose from research being conducted by Dr. Sue Baldwin at the University of British Columbia. Dr. Baldwin's lab is investigating how bacteria can help clean up mining related pollution. In particular, her research studies how particular communities of bacteria can be used to remove toxic heavy metals from streams and other aqueous environments. More information on her research can be found at <http://www.chbe.ubc.ca/faculty-staff/baldwin.php>

Vocabulary

Ore:	Rocks containing enough minerals or metals to make mining them profitable.
Waste rock:	Rock that is harvested during the mining process but does not contain enough minerals to make it worth processing.
Milling:	Crushing and grinding ore into very small pieces.
Slurry:	A mixture of water and very fine particles of crushed ore.
Concentrating:	Separating the minerals in the slurry from the waste rock so that they can be collected. Usually requires chemicals, some of which can be very toxic.
Mine tailings:	All of the waste products that result from the separation of the minerals from the ore. Usually a slurry.

Materials

- 1% starch solution
- 2-5% solution of amylase
- iodine solution
- spotting plates for testing (1 per group)
- disposable droppers (5 per group)
- test tubes or Petri dishes (1 per group)
- test tube rack (1 per group)
- sand and small gravel
- ore samples (1 per table group) or 5-6 per class

In the Classroom

Introductory Discussion

1. Hand out ore samples to each group. Discuss what mineral each sample contains. Have students guess if time allows.

- Once we have removed the ore from the earth (by blasting, digging, etc.) what do we do with it? How do we get the minerals/metals separated from the ore? Record student suggestions on the board.

Steps in the Mining Process

- First the ore must be milled – crushed/ground into very small pieces. The ore is mechanically crushed into gravel sized pieces and then water is added to help the machines grind it into very fine particles. The resulting slurry of rock and water is called slurry.

- Concentration: Separation of minerals from the rest of the slurry can be done by a variety of methods including flotation, amalgamation and dissolution. In flotation chemicals are added to the slurry and the slurry is bubbled with air. The chemicals cause the slurry to froth and the minerals become associated with air bubbles and float to the surface where they are skimmed off (e.g. lead mining). In amalgamation chemicals are added to the slurry that join with the minerals and make them easier to collect (e.g. mercury used in gold mining). In dissolution chemicals are added to the slurry which cause the minerals to dissolve. The resulting liquid with the dissolved ore is then treated transform the mineral back into a solid form (e.g. cyanide and gold mining or sulphuric acid and copper mining). After concentration the product is referred to as a mineral concentrate. All of the waste products that result from the separation of the minerals from the ore are known as mine tailings.

- Smelting: The mineral concentrate contains both pure mineral particles as well as particles in which the mineral is “trapped” with other non-target minerals. Various methods are used to free the trapped minerals depending on the ore and mineral in question. Some of the most common are roasting (pyrometallurgy), chemical/wet leaching (hydrometallurgy) and biological leaching (biometallurgy). The resultant product contains fewer impurities but is still not pure enough for commercial use.

- Refining: Purification of the final smelting product.

- So now that we have our pure minerals, what do we do with all of the mining waste? The mine tailings are usually contaminated with chemicals and toxic metals. We obviously can’t put this stuff back into the environment so how do we clean it up? If time allows ask for suggestions and record them on the board. If time is limited just introduce the activity.

- Today we are going to do an activity that looks at one method of cleaning up mine tailings. Scientists, including some at UBC are currently studying how some kinds of bacteria can be used to clean up mine tailings. Special bacteria have been found that can help remove toxic metals and chemicals from the water. We are going to try “cleaning” some mine tailings with bacteria.

2. Short description of other items to discuss or review.

- Discuss the need to prevent cross contamination during the experiment.

- Discuss the need for controls such as the pre-test of the solution and the timing of the experiment.

3. Briefly describe science experiment/activity.

- The students will simulate the detoxification of environmentally harmful mine tailings. The mine tailings will be comprised of a mixture of sand, small gravel and a starch solution. The starch will be the proxy for the toxins.
- Iodine will be used to test for the presence of toxins (starch). If starch is present the iodine solution will turn from brown/orange to blue.
- The students will add an amylase solution to their mine tailings and test for the continued presence of toxins (starch) over time. The amylase will convert the starch into sugar. When all of the starch is converted the solution will no longer test positive for starch (i.e. adding iodine will not result in the solution turning blue, it will just stay brown/orange)

4. Briefly describe the processes of science that the students will focus on: For this experiment the students will focus on recording their observations, following procedures and recording results
5. Briefly describe safety guidelines.

- Iodine can stain. When using the iodine be careful not to spill it on the desk, or on your clothing, or on your hands.
- Iodine is toxic if ingested. Wash your hands with soap when you are finished the activity.

Science Activity

Activity Title: Bacteria to the rescue

Purpose of Activity: To simulate the detoxification of environmentally harmful mine tailings.

Methods and Instructions:
Set-up prior to experiment: Mix a 1% solution of cornstarch or potato starch in water (1 g per 100 mL). To dissolve the cornstarch heat the solution until just before boiling. Allow to cool to room temperature before using. Each group will need approximately 3-5 ml.
Preparing a test tube of “mining waste” for each group. Add approximately 5 ml of a sand/rock and starch solution slurry to each test tube or Petri dish.
Prepare a 2-5% solution of amylase (depends on what type/grade of amylase you are using and how long you want the experiment to last). Portion the amylase solution in 1 ml aliquots. One per group.

Students will work in groups of two (depending on class size and availability of materials).

1. Each group will receive one test tube of “mine tailings,” one spotting plate, one tube of amylase solution, one bottle of iodine solution, 4 disposable droppers and one timer.
2. See detailed instructions on worksheet.
3. Briefly, the students will start by testing the mine tailings for the presence of toxic material (starch). To do this they will place 3 drops of mine tailings into one section of the spotting plate and add one drop of iodine. If starch is present the solution will turn blue.
4. Have the students predict how quickly the bacteria will clean up the “toxins.”
5. To simulate adding beneficial bacteria to the tailings pond the students will add the amylase solution to their test tube of mine tailings. They should start the timer as soon as they do this. (or if the entire class starts together the teacher/scientist can time the entire class at once)
6. Every 5-10 minutes have the students test the tailings for toxins. They should use a new dropper and a new section of the spotting plate each time.
7. Students will record their prediction, observations and results on worksheets. While they are waiting to run each test they can draw a picture of their experimental set-up.

Closure Discussion

1. How long did it take for the bacteria to clean up the mine tailings (in the simulated experiment)?
2. What factors might influence the speed at which this could happen in a real tailings pond?
3. What other wastes do mines generate? What other impacts do they have on the environment? Discuss the problem of acid rock leaching on streams and ground water and/or the problems associated with escaped tailings pond water.
4. How can mining companies prevent some of these problems? What practices could they change? How can they reduce the potential environmental impacts?

References

1. Kesler, Stephen E. 1994. Mineral Resources, Economics and the Environment. MacMillan College Publishing.
2. <www.bcminerals.ca> Mineral Resource Education Program of British Columbia. Accessed February 27, 2010.

Scientist: _____

Date: _____

Bacteria to the rescue

Materials

- Mine tailings
- Bacteria (simulated with 2-5% solution of amylase)
- Spotting plate
- Plastic droppers
- Iodine solution

Prediction

I predict it will take _____ minutes for the bacteria to clean up all of the toxins in the mine tailings.

Procedures and Observations

1. Use one of the plastic droppers to transfer 3 drops of the liquid mine waste into one well of the spotting plate.

   What colour is the liquid mine waste?

   _____

2. Add one drop of iodine to a clean well of the spotting plate.

What colour is the iodine solution?

_____

The iodine will show us if there are toxins in the mine tailings.

3. Add 1 drop of iodine to the well of the spotting plate that contains the mine tailing liquid.

   What colour did the mine tailings turn when they contained toxins? (record your answer in the table below too)

   _____

4. When the teacher or scientist says “go” carefully add the tube of bacteria (simulated with amylase solution) to your container of mine tailings.

5. Carefully and gently stir the tailings for 5 minutes.

6. After 5 minutes use a new plastic dropper to add 3 drops of the mine tailings to a clean well of the spotting plate.

7. Add one drop of iodine to the same well. Record your observations in the table below.

Time since bacteria were added to mine tailings	Colour of mine tailings after iodine was added	Are toxins present? (yes or no)
0 minutes		
5 minutes		
10 minutes		
15 minutes		
20 minutes		

8. Repeat steps 5, 6 and 7 every 5 minutes. Remember to use a clean dropper for every test! Record your results in the table.

How long did it take for the bacteria to clean up the mine tailings?

_____