Instructor Notes

Pollution or Prevention?

In this lab, participants perform extractions on a sample to achieve a specified allowable concentration limit. They relate their results to the economics of cleaning up polluted sites.

The activity is written for workshop participants and may need modification for classroom use.

Suggested Background Reading

- Principles of Environmental Site Assessment

National Science Education Standards for Grades 5–12

Science as Inquiry

- Abilities Necessary to Do Scientific Inquiry
  Conduct scientific investigations. Students conduct a multi-step extraction procedure to simulate the steps necessary to clean up water pollution created by a mining operation. During the extraction, a contaminated water sample is purified to an allowable concentration.

  Use mathematics to improve investigations. Students use mathematics to calculate and compare contamination prevention costs and pollution cleanup costs for the 5-year operation of a theoretical mine.

- Understandings about Scientific Inquiry
  Scientific explanations must adhere to specific criteria. Students present their findings during a class discussion on pollution control that leads to a logically consistent conclusion based on the rules of evidence and current scientific knowledge.

Science in Personal and Social Perspectives

- Environmental Quality
  Natural ecosystems provide an array of basic processes that affect humans. Students understand that mining operations and other industrial activities change many of Earth's natural ecosystems and that these changes may be detrimental to humans.

  Many factors influence environmental quality. Students realize that many factors influence how humans view and control environmental quality, including the role of economics and the capacity of technology to solve pollution problems.

Safety

As the instructor, you are expected to provide participants with the necessary safety equipment (including personal protective equipment such as goggles, gloves, aprons, etc.) and appropriate safety instruction to allow them to work safely in the laboratory. Always follow local, state, and school policies. Read and follow all precautions on labels and MSDSs provided by the manufacturer for all chemicals used.

Materials

Per group

- test tube rack
- 4 small test tubes, 13 mm x 100 mm
- 5 small Beral pipets
- 1 mL tincture of iodine
- 15 mL mineral oil
- distilled water
- marker
- labels
- (optional) Parafilm®

Procedure Notes and Outcomes

Give participants specific safety information and provide any necessary personal protective equipment, including goggles, gloves, and aprons. After participants have completed the Procedure, have them answer the Questions, and then have the class discuss their results.

Plausible Answers to Questions

These sample calculations show the values participants should come up with if it takes five extractions to purify the water. Most participants will carry out the extraction procedure four to six times.

1. Calculate the costs to prevent contamination for 5 years of the mine's operation. Assume that it costs $1.5 million to construct a proper barrier against this contamination and an additional $500,000 per year to operate and monitor the prevention process.

   $\$1{,}500{,}000 + (\$500{,}000 \text{ per year} \times 5 \text{ years}) = \$4{,}000{,}000$

2. Calculate the pollution cleanup costs for 5 years of operation. Assume that each extraction costs $5,000. The extraction process must be performed a number of times weekly in order to maintain the water quality equal to or better than the allowable concentration amount. How many times per week equals the number of extractions it took you to effectively clean up the released contamination (step 6).

If five extractions:

$5,000 per extraction × 5 extractions per week = $25,000 per week

$25,000 per week × 52 weeks per year × 5 years = $6,500,000

3. Compare the costs of the prevention and pollution cleanup over a 5-year period. Which method is more economical?

   It is much more economical to initially construct the pollution barrier. A significant difference in cost of prevention versus cleanup exists after 5 years. This gap will increase every year the barrier is in operation.

Reference

"Consider Some Economics," *The Daily Planet.* Center for Chemistry Education: Middletown, OH, March 26, 1999.

Activity Instructions

Pollution or Prevention?

Whenever a new industrial process is to be implemented, concerns are raised over the potential contamination of the local environment due to the products and by-products of the process. The company in question must decide how they will control this pollution—will they prevent the contamination before it happens, or will they attempt to clean up contamination after the fact? This lab explores the economic differences between the choices of pollution cleanup and prevention.

Safety

In a laboratory setting, you are ultimately responsible for your own safety and for the safety of those around you. It is your responsibility to specifically follow the standard operating procedures (SOPs) which apply to you, including all local, state, and national guidelines on safe handling, storage, and disposal of all chemicals and equipment you may use in the labs. This includes determining and using the appropriate personal protective equipment (e.g., goggles, gloves, apron). If you are at any time unsure about an SOP or other regulation, check with the course instructor.

Procedure

1. Use a Beral pipet to place 10 drops of tincture of iodine solution into a small test tube. Using a clean pipet, add 30 drops of distilled water to the iodine solution and mix well by gently agitating the tube. (To avoid splattering, you may wish to use a piece of Parafilm to cover the test tube when agitating it.) Label this sample "contaminated."
2. Use a clean Beral pipet to place 1 drop of the "contaminated" mixture into a clean test tube. Dilute it by adding 19 drops of distilled water, mix, and set it aside for future comparisons. The dilution solution is 1/20 of the original contaminated sample concentration. Label this sample "allowable concentration." This will provide a visual reference of the maximum allowable concentration of pollutant. Set it aside for future comparisons.
3. Place 20 drops of the "contaminated" sample into a third clean test tube.
4. Add 40 drops (2 mL) of mineral oil, and label this test tube "extraction." Mix well. Allow layers to form and settle. You may need to tap on the side of the tube to remove any bubbles. Note the colors of the two layers. Once the layers have separated, use a Beral pipet to carefully remove the mineral oil (top) layer without disturbing the water (bottom) layer. Place the oil layer into a clean test tube labeled "oil waste."
5. Compare the remaining water layer with the allowable concentration sample saved in step 2.

6. Repeat steps 4 and 5 on the "extraction" sample until the color closely resembles the color of the allowable concentration sample. This is the point at which the contaminated water is considered cleaned up. Keep track of the number of times you carry out the extraction procedure (step 4).

The number of extractions it takes to reach the allowable concentration will be considered the number of extractions per week used in question 2.

Questions

1. Calculate the costs to prevent contamination for 5 years of the mine's operation. Assume that it costs $1.5 million to construct a proper barrier against this contamination and an additional $500,000 per year to operate and monitor the prevention process.
2. Calculate the pollution cleanup costs for 5 years of operation. Assume that each extraction costs $5,000. The extraction process must be performed a number of times weekly in order to maintain the water quality equal to or better than the allowable concentration amount. How many times per week equals the number of extractions it took you to effectively clean up the released contamination (step 6).
3. Compare the costs of the prevention and pollution cleanup over a 5-year period. Which method is more economical?