Activity name: Environmental Risk–Fluorescent Lights: Risky or Not?

Goals

- to build students' knowledge and skills about releases of polluting materials into the environment
- to apply knowledge and skill in the community context.

Activity	Objectives
Fluorescent Lights: Risky or Not?	• Analyze data on amount of mercury released from broken fluorescent lights • Calculate the volume of air used and needed in the classroom • Analyze data to determine degree of risk from broken lights

This activity allows students to use the process of risk assessment. It provides a real-world application of the math, science, technical, and critical thinking knowledge and skill concepts identified by ATEEC Fellows as necessary preparation for environmental technology occupations.

Appropriate for which course(s)? : High school and community college technology ed, science

Concept/skill learned (i.e. from K/S Tables: unit conversions using dimensional analysis, apply ratios and proportions to solve problems

SCANS skills addressed: Interprets and communicates information

Cognitive Level: Comprehension, analysis, and evaluation

Learning objectives–Students will be able to:

- Use the methodology of risk assessment to determine the risk involved from possible exposure to mercury in light fixtures

Approximate time to complete activity: 50 minutes

Materials/resources needed (equipment, print media, electronic media, videos, supplies, etc.):

- Calculators
- Access to the Internet (optional—numbers can be given to students)
- Balloons, water, graduated cylinders, metersticks

General Description of Activity:

Most schools use fluorescent light fixtures in their classrooms and hallways. Fluorescent lights contain a small amount of mercury that may be released if they are broken. The students will analyze data on the amount of mercury released from a broken bulb. They will calculate the volume of their classroom and use their lung capacity to calculate how much air is available and how much air they breath in and out. Then they will take their data on the dose available via breathing air contaminated with one light bulb and compare it to the standards for exposure to mercury. They will analyze their data and decide if this type of exposure is a risk in their classroom.

Teaching Procedure:

Introduce the topic of Risk Assessment using the Risk Assessment web page on this site or your own sources. Be sure to include the four steps of risk assessment. These steps are: identifying hazards, dose/response assessment, exposure assessment, describing (characterizing) risk. Students will be doing each of these 4 steps in their activity. Go over the activity ahead of time to be sure all required parts are available. For an extension, you may want to ask the students to discuss the risks involved in the practice of smashing fluorescent light tubes for disposal. This was done to minimize waste volume. What were the benefits and the drawbacks of such a practice?

Student Procedure:

1. Students will work in pairs. They will do a 'minilab' to calculate their lung capacity. Give each group 2 balloons and have one student blow up a balloon using one breath. The lab partner will then fill the 2nd balloon to the same volume with water. (Note: Nozzles may be required for some lab sinks in order to fill the balloons with water.) The two students will then measure the amount of water in the water filled balloon using the graduated cylinder and record their data on lung capacity. Most students will record their lung capacity in milliliters (cubic centimeters). Students will change these numbers to more appropriate units later.
2. Next have the students use a meterstick to measure the dimensions of the classroom. Perhaps one group can be assigned this task All groups will need to record the length and width of the classroom. The height of the classroom can be given to the class by the teacher. Students will need to calculate the air volume in the classroom by using the formula volume = length x width x height. Check student units to be sure they have written down their answer with the correct units—cubic meters or cubic centimeters. (cubic meters are recommended)
3. Students can either look up the amount of mercury in one fluorescent light bulb or they can be given this information by the teacher. Light bulb information can be found at: http://www.nesllc.com/lightnelect.htm however it is deeply embedded.

Most high school students should be given the information that T8 mercury containing fluorescent lights have 15 mg of mercury. T12 bulbs have 20-30 mg mercury and low mercury T8 bulbs have less than 10 mg of mercury. To be thorough, the teacher can look at the particular bulbs in the room for the bulb size or a bulb size can be assumed.

4. Have the students calculate how much mercury would be in the room if one tube broke. Sample calculation; 15mg mercury from a T8 bulb divided by 210 m^3 room air volume gives 0.071 mg Hg/m^3 in the room.
5. The National Institute of Occupational Safety and Health has determined that the maximum "safe" air exposure to mercury is 0.5 mg/m3. Are your students being exposed to the maximum levels (or more)?
6. Your students should calculate how much mercury they are breathing in. They will need to convert the measurement for lung capacity they made in step one to m^3. Sample calculation: 1800ml x 1 cm^3/1mL x 1m^3 / 1 x 10^6 cm^3= 0.0018 m^3 breathed in for every breath. Then they can take the volume they breath in (ex. 0.0018 m^3) and multiply this by the mercury content (ex. 0.071 mg Hg/ m^3) to find out how much mercury they are breathing in for each breath. (ex. 0.00013 mg Hg)
7. The National Institute of Occupational Safety and Health has determined that the maximum skin exposure level is 0.05mg/m3. Students will need to calculate their lung volume in this section. While a person is not exercising, they only use about 1/20th of available lung capacity. Students should take their lung capacity measured in step one with the units of m^3 and multiply it by 20 to calculate an approximation of lung volume. (Ex. 0.0018 m^3 x 20 = 0.036 m^3). Have your students divide the mercury they breathed in by the total lung volume just calculated. (Ex. 0.00013 mg Hg/0.036 m^3 = 0.0036mgHg/m^3). Are your students being exposed to a hazardous amount of mercury from one broken tube when they breath in? This calculation is more of an estimate than the others since lung tissue is not "skin" but hopefully the students will get the point of the activity as appropriate lung tissue studies are difficult to find.
8. Students can then write a conclusion about how "risky" this scenario is. Suggested required parts are: identify the hazard (one broken fluorescent light containing mercury – a toxic element), discuss the dose they could receive and their possible personal exposure based on their calculations, and then discuss how much risk is involved. Is there such a risk involved that there should be no T8 fluorescent lights? (Explain) Should there be a switch to low mercury T8 lights? How much would the low mercury T8 lights help? (They could recalculate their numbers using the low mercury T8 10 mg value). What societal values are involved in this situation? (economics, the probability of a light actually breaking and other issues and values could be discussed in the conclusion) The students should come up with a statement saying the use of the fluorescent light bulbs is or is not an acceptable risk and they should back up their statement with the data and reasoning they used.

Resources:

- http://www.britannica.com/
- http://www.nesllc.com/lightnelect.htm
- http://www.epa.gov/
- http://www.cdc.gov/

Student Worksheet:

Fluorescent Lights: Risky or Not? Name_____

Background: Most schools use fluorescent light fixtures in their classrooms and hallways. Fluorescent light bulbs contain a small amount of mercury that may be released if they are broken. You will analyze data on the amount of mercury released from a broken bulb. You will calculate the volume of the classroom and your lung capacity. You will then use your data on the dose available via breathing air contaminated with one light bulb and compare it to the standards for exposure to mercury. You will analyze your data and decide if this type of exposure is a risk in our classroom.

1. Find a lab partner. Obtain 2 balloons. One student should blow up a balloon using one breath. The lab partner will then fill the 2^{nd} balloon to the same volume with water. Measure the amount of water in the water filled balloon using the graduated cylinder. Record your data on lung capacity.
2. Use a meterstick to measure the dimensions of the classroom (length and width). Your teacher will give you the height in meters. You will need to calculate the air volume in the classroom by using the formula: Volume = length x width x height. Record your room volume.
3. T8 mercury containing fluorescent lights have 15 mg of mercury. T12 bulbs have 20-30 mg mercury and low mercury T8 bulbs have less than 10 mg of mercury. Calculate how much mercury would be in the room if one regular T8 tube broke by dividing the amount of mercury by your room volume. Record your answer.
4. The National Institute of Occupational Safety and Health has determined that the maximum “safe” air exposure to mercury is 0.5 mg/m3. If one T8 tube breaks in the room, are you being exposed to “risky” levels? Explain.
5. To calculate how much mercury you are breathing in, you will need to convert your experimental data from step one to m^3. Some units you may need are: 1 cm^3 = 1mL and $1m^3 = 1X\ 10^6\ cm^3$. Record your results in the data table.
6. Multiply the volume you breath in times the mercury level in the room. Record.
7. The National Institute of Occupational Safety and Health has determined that the maximum skin exposure level is 0.05mg/m3. You will need to calculate your lung volume in this section. While a person is not exercising, they only use about $1/20^{th}$ of available lung capacity. Take your lung capacity measured in step one with the units of m^3 and multiply it by 20 to calculate an approximation of lung volume. Record.
8. Divide the mercury you breathed in by the total lung volume just calculated. If one tube breaks in the room, are you being exposed to a hazardous amount of mercury when you breath in?

9. Write a conclusion about how "risky" this scenario is. Required parts are: identify & discuss the hazard, discuss the dose you could receive and your possible personal exposure based on your calculations, and then discuss how much risk is involved — is it OK to use these light bulbs based on your calculations? Defend your point.

Data: Record the appropriate units for your data.

1) Lung capacity _____

2) Room volume _____

3) Mercury amount/room volume_____

4) Answer to question in #4.

5) Lung capacity in m^3 _____

6) Mercury mg breathed in _____

7) Lung volume _____

8) Mercury/lung volume _____

9) Answer to question in # 8

Conclusion:

Activity submitted by: Robin Ritter

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