PHYTOREMEDIATION:
CONTROLLING POLLUTION WITH PLANTS

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Phytoremediation Lesson Plan

Grades 9-12 Duration 2-5 sessions

WHAT IS PHYTOREMEDIATON?

Phytoremediaton is the process using plants to clean up the environment. The word **phytoremediation** comes from the Greek word *phyto*, meaning "plant" and the the Latin word *remediare*, meaning "to remedy". This word is generally used to describe any system where plants are introduced into an environment to remove contaminants from it. **Phytoremediation** is done in a variety of ways. The plants can be introduced into an environment and allowed to absorb contaminants into its leaves and roots. These plants can then be harvested and treated as hazardous waste. There have even been studies where these plants have turned the contaminant into a harmless substance and then once harvested can be used for mulch, animal feed, paper, etc. In some instances (especially if trees are being used) the plants are left in the environment and allowed to grow and mature as normal.

WHERE DID PHYTOREMEDIATION COME FROM?

The concept of using plants to clean up their environment is not a new one, but most research in this area was strictly in studying those few wild plants that actually grew in waste infested areas. It wasn't until Dr. Ilya Raskin, a Russian born US educated scientist, came along that phytoremediation was actually born. Dr. Raskin, who not only came up with this new technology involving plants, but also named it: came to the United States in 1976. In 1989, he encountered a company called Envirogen Inc. which using micro-organisms to degrade and clean up oils and chemicals in soil. Dr. Raskin became interested in finding a similar technology to clean up heavy metals, one this micro-organisms just can't do. It was at this point that Dr. Raskin remembered some reading he did back home. He states: "I remembered reading Russian papers from the 1930's and 1940's about geobotany, in which they prospected for minerals by looking at the plants. Some plants have a high capability of accumulating metals from the soil." These plants gave a clue to what minerals were under the surface, but couldn't these same plants to used to absorb the metals from the soil? It was then that phytoremediation was born. Dr.

Raskin spent many hours finding those plants that best took metals from their environment.

APPLICATIONS OF PHYTOREMEDIATION

Phytoremediation can and has been used to clean up metals, pesticides, solvents, explosives, crude oil, polyaromatic hydrocarbons, land fill leachates, agricultural runoff, acid mine drainage, and radioactive contamination.

WHY USE PHYTOREMEDIATION?

Phytoremediation is an environmentally friendly, safe, cheap way to clean up contaminants. Early estimates on the costs have shown that plants could do that same job as a group of engineers for one tenth of the cost. The plants are also more pleasing to look at than many such operations are. The soil or water need not be gathered in and stored as hazardous waste, requiring large amounts of land, money, and manpower. Plants can be planted, watered, and then harvested with less manpower. If need be, the storage of the harvested plants as hazardous waste would be a far smaller amount. The main drawback on the use of this technology is that it isn't good for all sites. If the contamination runs too deep or the contaminant concentration is too great, the plants alone can't efficiently remediate the contaminated site.

SITES WHERE PHYYTOREMEDIATION HAS BEEN USED

Phytoremediaton has been used in many different locations. It is being used in Chernobyl with sunflowers to remove cesium 137 and strontium 90. Hybrid poplars have been used in Whitewood Creek in South Dakota to absorb arsenic from mine wastes and in Aberdeen , Maryland to remove trichloroethylene and polycyclic aromatic compounds from groundwater.

OBJECTIVES

- Describe the plant contamination process
- Define phytoremediaton
- Demonstrate how phytoremediation works through class experiment
- List the benefits and limitations of phytoremediaton

SKILLS AND KNOWLEDGE YOU WILL LEARN

- Introduction and use of the scientific method
- How to read and interpret a chart
- How to record data, analyze results, and draw conclusions

WORDS YOU WILL LEARN

phytoremediation - the use of plants and trees to clean up contaminated soil and water

contaminants – anything that creates an unclean environment
rhizosphere – area surrounding the root system
transpiration – loss of water from a plant by evaporation
contaminant transport – how any waste moves from the generated site to a new site
translocation- a change in location
migration - movement of the contaminant from one location within the ground to another location. Migration can occur within the soil and /or groundwater.
leaching – the dissolving, by a liquid solvent, of soluble material from it's mixture with An insoluble solid; leaching is an industrial separation operation based on mass transfer
leachate – a solution formed by the leaching of contaminants through soil layers.
uptake- absorption of a contaminant into the surface of a medium (medium can be soil, plants, etc.)
in situ- within the ground
ex situ- external to the ground (surface)

MATERIALS

Tomato plant (6 week old)
Plastic 2 liter bottle
Pipettes or Eye Dropper with milliliter markings
Red food coloring (only **red**)
Water

Acrostic

Potentially marketable by- products
Low impact & passive
Appeals to multiple constituencies
Natural plants can aid in site restoration
Trees improve site appearance
Saves money – cost effective solution

PROCEDURE

1. Use acrostic to introduce lesson.
2. Review plant processes
3. Define contaminants and pollution.
4. Class discussion (hot links)
5. Cooperative groups.
6. Start with clear plastic soda bottle
7. Add tap water to bottle
8. Place tomato plant in bottle
9. Apply copious amounts of red food coloring in water with pipette
10. Observe on the first, third, and fifth day

Question: *What do you think causes the tomato plant to die within 5 days?*

LOOKING BACK

This activity has led you through a series of steps. You found out how and why phytoremediaton is used. You then modeled the process of phytoremediaton with a tomato plant.

Phytoremediaton is one possible answer to contaminants and pollution, but not the only solution. Perhaps you can think of ways to clean pollutants from soil and water.
Possible class discussions: Pump-and-treat, soil vapor extraction, filtration methods

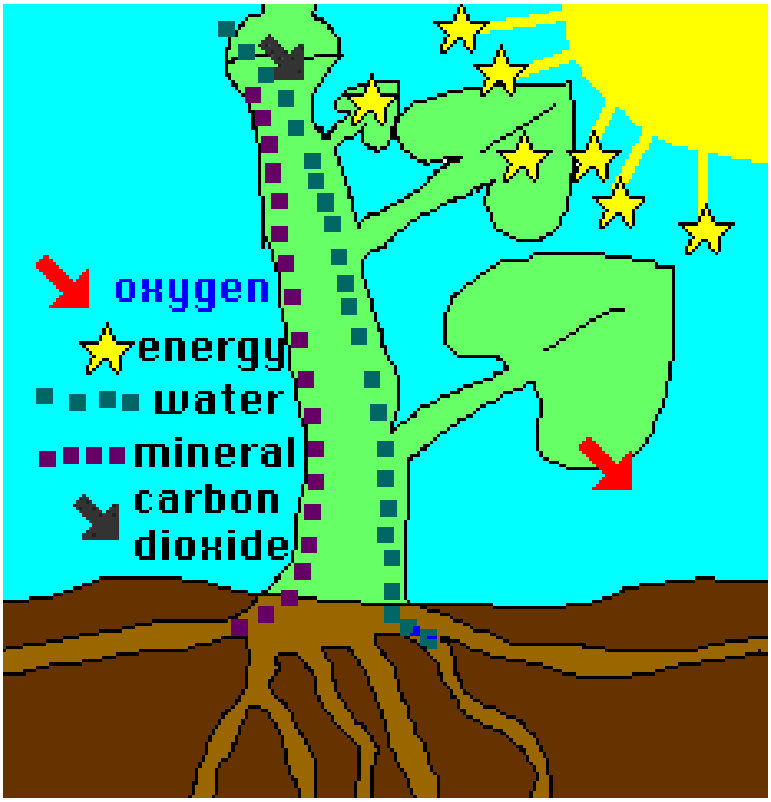
CHECK FOR UNDERSTANDING

Lab Activity Sheet
Word Search

TEACHER RESOURCES

Plant Contamination Process
Study Guide
Lab Activity Sheet
Word Search

PLANT CONTAMINATION PROCESSES



PHOTOSYNTHESIS
Plants take in CO_2 and H_2O and produce sugar for food and gives off O_2 in the presence of light.

TRANSPIRATION
Plants ability to take up nutrients and H_2O, and give off H_2O.

ABSORBTION
Roots take up minerals and water.

Phytoremediation Study Guide

Name_____ Date_____

1. The use of green plants to remove pollutants from the environment is called _____.

2. List three benefits of phytoremediation:

_____
_____
_____

3. Phyto is Greek word for _____ and remediare is Latin for _____..

4. _____ is the uptake of minerals and water.

5. Plant ability to take up nutrients and water and give off water is _____.

6. _____ is the process in which plants take in CO_2 and H_2O for food and gives off O_2 in the presence of light.

7. _____ is anything that creates an unclean environment.

8. Movement is _____.

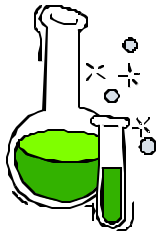
9. A solution formed by leaching is called _____.

10. The area surrounding the root system is called the _____.

11. _____ is the dissolving, by a liquid solvent, of soluble material from its mixture with an insoluble solid.

12. Illustrate and describe plant contamination processes:

LAB ACTIVITY SHEET



PREDICTION:

_____
_____
_____

PROCEDURE:

1. Start with clean soda bottle.

2. Add tap water to the bottle.

3. Place tomato plant in bottle.

4. Apply 10 ml of red food coloring in bottle using pipette.

5. Observe physical plant changes and color of water on the first, third, and fifth day.

OBSERVATIONS:

DAY	TOMATO PLANT	WATER
1		
2		

3		

CONCLUSION:

PHYTOREMEDIATION

T E P T S T M C N M E J T V T X
T R T K R G A U S I K S R W S B
O E A A B A T H I G A H A L H Z
O H F N H I N W X R T V N L G X
U P A H S C Q S M A P R S M T X
B S I N J P A Z P T U N L N O J
P O I U K B O E G I Y Y O U A V
U Z Y P A P Q R L O R O C K Z Z
I I E X S I T U T N E A A T Q N
P H Y T O R E M E D I A T I O N
A R A B S O R P T I O N I I F W
S T N A N I M A T N O C O M O M
U H G N I H C A E L A X N A L N
G D P H G V U A E X E E G I H Y
S W C T D L B B W O A M W Z Y E
O T E G K G R T D W W P Q L H C

PHYTOREMEDIATION TRANSLOCATION

CONTAMINANTS	MIGRATION
RHIZOSPHERE	LEACHING
TRANSPIRATION	LEACHATE
TRANSPORT	UPTAKE
ABSORPTION	IN SITU
EX SITU	

APPENDIX

RESOURCES AND RELATED WEB SITES

Scientific American – Technology & Business "Toxic Cleanup"
http://www.sciam.com/1297issue/1297techbus4.html

Phytoremediation- "Using trees, grasses and other plants to clean up our environment"
http://www.engg.ksu.edu/HSRC/phytorem/home.html

EPA Environmental Protection Agency : A Citizen's Guide to Phytoremediation
http://clu-in.org/products/citguide/phytoz.htm

Verdant Technologies- "About Phytoremediation"
http://www.verdanttech.com/phyto.hmtl

Phytoremdiation: "Plants that Consume Hazardous Waste"
http://www.ecological-engineering.com/phytorem.html

Phytoremediation: "Using Plants to Remove Pollutants from the Environment
http://www.aspp.org/pubaff/phytorem.htm

Phytoremdiation- Technology Evaluation Report
http://www.gwrtac.org

STUDENT SEARCH SITES

EPA's Environmental Quiz
http://www.epa.gov/oms/quiz

U.S. EPA Environmental Education Center
http://www.epa.gov/teachers/curriculum_resources.htm

CONTACTS

Federal Energy Technology Center's Web Site
http://www.fetc.doe.gov

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