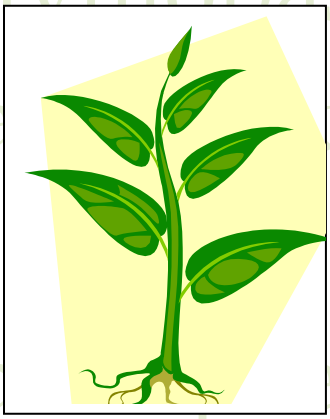
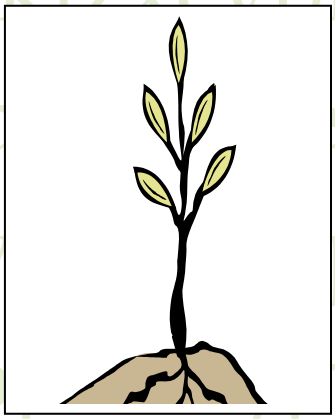
EFFECTS OF SOIL CONTAMINANTS ON THE GROWTH OF PLANTS





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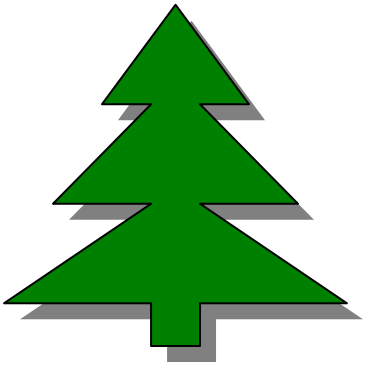


Goals and Objectives

The main objective of this project is to teach students how to design and conduct investigative experiments.
Students become ecologists and investigate the effects of soil contaminants from the perspectives of their hazards. They study some common soil contaminants and learn about their effects on the growth of plants and relate the consequences on their local environment and on the ecosystem in general. Scientific methods will be taught through experiments using plant seedlings in which variables are manipulated. Teachers give students the opportunity to reflect and make some predictions on what will happen if any of the variables are manipulated. The students are expected to completely set up an experimental design that incorporates a research question, hypothesis and parameters to measure in a chosen variable. It is also aimed at helping students acquire or enhances their scientific measuring skills as well as the accurate use of some common measuring tools. In the final stage, students will conduct a controlled experiment using seedlings to study effect of each contaminant on their growth.

The project enables students to set up an experimental design, collect and analyze data and the present what they have learnt through the lens of an ecologist.

Thus this project will seek to address the following questions:

What are soil contaminants?
What are the types and sources of soil contaminants?
What happens when plants grow in contaminated soil?
What is their effect on primary producers?
How do they affect a food chain or web?
What is an experimental design?
What are the components of a good experimental design?
How do I collect and analyze data?

Sunshine State Standards

The Processes that Shape the Earth

SC.D.2.3.2: The student knows the positive and negative consequences of human action on earth's systems.

How Living Things Interact with their Environment

SC.G.2.3.4: The student understands that humans may deliberately or advertently alter the equilibrium in ecosystems.

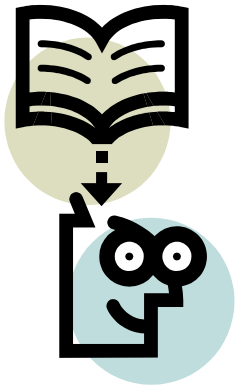
SC.G.2.3.2: The student knows that all biotic and abiotic factors are interrelated and that if one factor is changed or removed, it impacts the availability of other resources within the ecosystem.

The Nature of Science

SC.H.1.3.4: The student knows that accurate record keeping, openness, and replication are essential to maintaining an investigator's credibility with other scientists and society.

SC.H.1.3.5: The student knows that a change in one or more variables may alter the outcome of an investigation.

SC.H.1.3.7: The student knows that when similar investigations give different results, the scientific challenge is to verify whether the differences are significant by further study.



Course Outline/Overview

This project introduces students to soil contaminants and their effects on plant life and the ecosystem in general by using seedlings in a laboratory/classroom setting.
Soil contamination is caused by the presence of man-made chemicals or other alteration in the natural soil environment. This type of contamination typically arises from the rupture of underground storage tanks, application of pesticides and percolation of contaminated surface water to subsurface strata, oil and fuel dumping, leaching of wastes from landfills or direct discharge of industrial wastes to the soil. The most common chemicals involved are petroleum hydrocarbons, solvents, pesticides, lead and other heavy metals. The occurrence of this is correlated with the degree of industrialization and intensity of chemical usage. Another source of soil contamination could be water that washes contaminants from an area containing hazardous substances and deposits these contaminants in the soil as it flows over or through it. The effect of soil contaminants includes the impact on human beings, the inhibition on growth of farm products and plants, and other effects on the ecosystems. Not unexpectedly, soil contaminants can have significant deleterious consequences for ecosystems. The effects can be virtual eradication of some of the primary food chain, which in turn have major consequences for predator or consumer species.

The key question that students will be facing in this project is **"What happens when plants grow in contaminated soil?"** Primarily they will also be reflecting on what happens when these plants are eaten by organisms higher in the food chain?
Working in groups, students set up an experimental design that include the question, hypothesis, prediction, control group and the parameters to measure in the seedlings. The experimental procedure emphasizes the use of scientific method or inquiry and conceptual understanding. Through a hands on activities, students manipulate variables (different contaminants) using seedlings and collect data over a 2-3 week period. By so doing, they become familiar with scientific methods of measuring plant growth using simple measuring tools. The different groups then put together a cumulative comparative data to find out which of the treatments has the most effects. This small group and whole class approach enable students to share ideas and skills.

Students then analyze and communicate their results, drawing conclusions that relate to or explain natural phenomena.

Lesson 1: Setting the stage/Background knowledge

This serves as the preparatory phase of the project involving both the teacher and students. The benchmarks that help understanding the concepts in this project are covered mostly in the 7th grade. However the project can be implemented at any grade level provided the teacher makes an introduction or review of contaminants/pollutants, their sources and effects on living organisms.
The teacher also determines what the students know about scientific inquiry or scientific method. The concept of variables versus control should be emphasized and well explained to the students.

Materials/Resources

- Seeds (bean/pea)
- Gloves
- Internet
- Library/textbooks
- Notebook
- Tray
- Water

Procedure

1. Start the lesson by explaining to the students that they will be investigating the effects of soil contaminants on the growth of plants for the next five weeks. Also that they will need some background information about soil contaminants, sources and effects on living organisms.
2. Introduce these unit and content questions:
    - What are soil contaminants?
    - What are the types and sources of soil contaminants?
    - What are the most common soil contaminants in my community?
    - What happens when plants grow in contaminated soil?
    - How do they affect a food chain?
    - What is an experimental design?
    - What are the components of a good experimental design?
    - How do I collect and analyze data?

    Give these questions as an assignment for the students to do a literature search that addresses the questions.

3. Let the students present and discuss their findings in a facilitated class session. Try to know from the students which are the most common contaminants in their local environment, sources and how they can be controlled.
4. **(Optional)** Make a field or site visit to an accessible area where the source of a contaminant can be observed. **Note: *A simple walk to a parking lot to observe oil droppings from cars might be an option*.** Explain to the students or elicit from them what will happen if the oil in greater quantity is washed onto the lawns or flower beds. Then discuss and relate the effects to other types of contaminants.
5. Let the students know at this point that will be investigating the effects of types of contaminants on the growth of bean plants. **Note: depending on your class size and how much data you wish to cover, you can choose 2 or all three types of contaminants – hydrocarbon, acid and detergent.**
6. Divide the class into research groups based on the number and choice of contaminants or variables (detergent, hydrocarbon and acid). **Note: the following reagents will be used for the different variables:**
    - Detergents: Use a liquid detergent.
    - Hydrocarbon: Use motor.
    - Acid: Use vinegar.
7. This last step in the preparatory phase involves the sowing of bean seeds that will be used for the research. At this point the teacher will instruct and guide the students to perform the following:
    - ✓ Fill a tray with potting mix and add water to let it soak
    - ✓ Using a forceps sow about 100 bean seeds in the potting mix.
    - ✓ Place the tray under light

    Note: These seeds need to be kept moist by adding water to the soil when necessary until they reach the seedling stage. This usually takes about a week but could change depending on other factors. Care must be taken to maintain the health of seeds by making sure that the cotyledons sprout upright. Light is provided using a fluorescent lamp or 34 -40 watts bulbs placed in a box at least 50 cm above the plants.

    Steps 1-6 can be completed in first week and step 7 in the second week.

    Assessment

    - ❖ The information gathered, presented and discussed on the literature search on contaminants and experimental design.
    - ❖ Students' reflections from the field visit

Lesson 2: Experimental Design (3rd week)

Objectives

- Students review and understand steps in a scientific process
- Students understand how to state a hypothesis based on a prediction
- Students learn the difference between a treatment group and a control group
- Students determine parameters to measure in an experimental design.

Materials

- Stakes
- Cups
- Measuring tape
- Syringes
- Plant labels
- Detergent (liquid)
- Water
- Vinegar
- Soil (potting mix & topsoil)
- Motor oil
- Fluorescent lamp or bulbs (34/40 watts)
- Boxes
- Soil pH tester (optional)

Procedure

1. Open a discussion on how a research sequence (scientific method) works and set an expectation that reflects the following:

- Question or hypothesis.
- Research design.
- Data collection method.
- Results.
- Analysis and interpretation.
- Presentation / communicating results

2. Let students move into their assigned research groups. Then distribute the experimental design sheets to each group. **See experimental design sheet**.
3. Model and explain to them that each group will have to formulate a test question, state a hypothesis and make a prediction for their chosen variable.
4. Allow time for them to discuss and write down their ideas.

5. Explain to the students that they will have to set up a treatment group and a control group. Treatment group will be the group of plants on which the variable is applied. So each group research group will have equal number of plants for the treatment and control group.
6. Then distribute the **experimental procedure work sheets**.
7. Give out 10 plastic cups to each research group. They will use 5 for the treatment group and 5 for the control group. **Note: The required quantities of contaminants and water will be added only to the treatment and just the same amount of water will be added to the control group.**

Distribute the appropriate contaminants and the rest of the materials to the different research groups. Explain to them that they will use the syringe to measure the contaminants and the beaker to measure the water. Demonstrate the use a syringe and a beaker in taking accurate measurements.

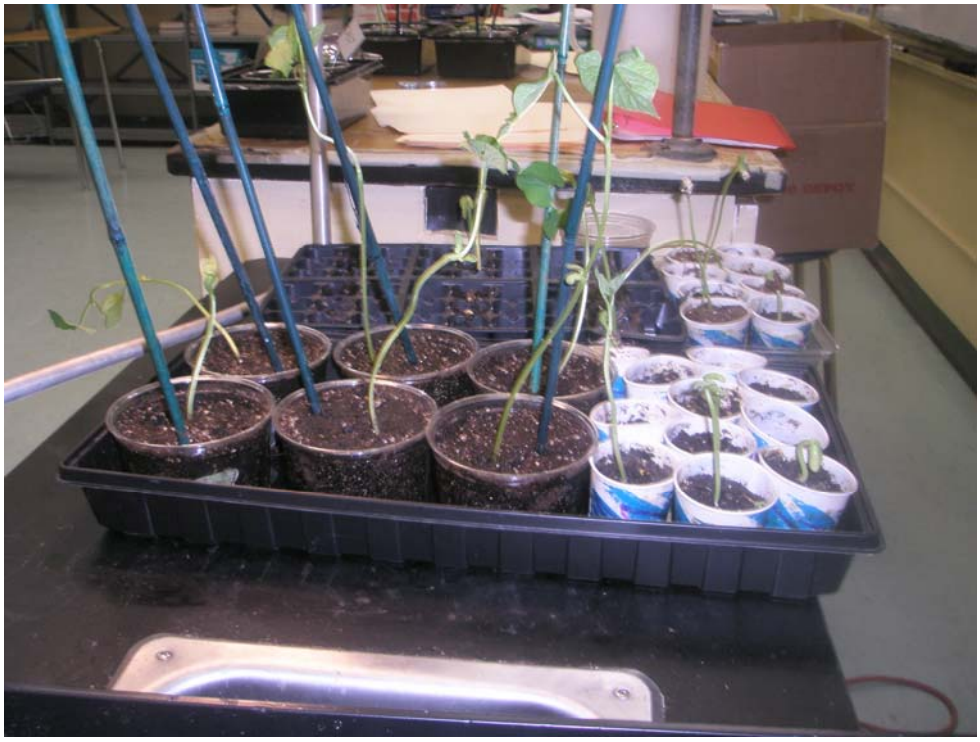
Note: These treatments could be added directly into the cups with the seedlings or into the container so that they can then be absorbed by the plants through the holes. But whichever method that is chosen, should be maintained throughout the experiment.

8. Supervise them as they add the required quantities. At this point, each group of students should have equal number of treatment (seedlings with contaminant added) and control (seedlings without contaminant added) groups.
9. Use the board to demonstrate how the labels and how the initial data for each group of plants should be recorded. The label should carry the plant number, the variable and the date. The stem length is measured from the top soil level to the tip of the plant in an upright position.
10. Distribute the **experimental data sheets** and also demonstrate how to fill in the information.
11. Then supervise them as to pin a stake into each cup to support the seedling.
12. Finally guide students to transfer their set of plants (treatment and control groups) to the boxes and ensure that they receive equal amounts of light.

This data will be collected for 3 weeks.

Assessment

- Experimental design sheet (hypothesis well stated, treatment and control groups well described and parameters identified.
- Quality of data on data sheet (units of measurement used appropriately and accurately).



Experimental Design Sheet

Group Members/Name:_____

What is the question you are asking? _____

_____

What is your hypothesis? _____

_____

What is your prediction? _____

_____

How will your control group be set up? _____

_____

How will your treatment group differ from your control group? _____

_____

What parameters will you measure in the seedlings? _____

_____

Experimental Procedure work sheet

Group name/members…….

Directions: Carefully perform the following tasks as a group. Get approval from your teacher before you proceed from one task to the next.

Your teacher will provide the materials as needed as the experiment proceeds.

1. Use a nail to make about 8 – 10 holes at the base of each cup.
2. Carefully transfer seedlings from the tray onto each of the cups (1 seedling per cup).
3. Fill the cup containing the seedling with potting mix to about $\frac{3}{4}$ full. Make sure that the seedling is about half way submerged in the soil.
4. Place the cups containing the treatment and control groups into separate plastic containers.
5. Add water into each of the cups until the soil is completely soaked. **Note:** Some of the water will leak out through the holes into the container. Take out the cups containing the seedling, empty the water from the container. Place the cups back into the container.
6. Leave this set up for 2 days to allow the seedlings to get established.
7. Add the contaminants to the different experimental samples in the following proportions:
   Detergent: Add 5ml of detergent and 100ml of water onto test sample.
   Motor oil: Add 5ml of motor oil and 100ml of water.
   Vinegar: Add 5 ml of vinegar and 100 ml of water.
8. Fill out the labels and place on each seedling.
9. Record initial data for each group of plants as outlined on the data sheet. This includes number of leaves, length of stem and any observations such as leaf color, color of stem, etc. Stem length is measured from the top soil to the tip of the seedling.
10. Carefully pin a stake into each cup to support the seedling.
11. Place each set of treatment group alongside its control group in the same location such that they receive same amount of light.
12. Collect data 2 times a week (usually within an interval of 2 -3 days). Use 1 data sheet per day of data collection. This data will be collected over a three week period.
13. Add water when necessary. Make sure water is added to all the treatments and control at same time. Also respect the proportion outlined in step 7 above when adding water to the treatment groups.

EXPERIMENTAL DATA SHEET

Group name/members…… **Date:**

Variable: _____

Treatment				**Control**			
Plant number	**Number of leaves**	**Length of stem (cm)**	**Comments**	**Plant number**	**Number of leaves**	**Length of stem (cm)**	**Comments**


ACID
4
ACID
2

Lesson 3: Data analysis (5th week)

Objectives

- Students understand the rationale for graphical display of information.
- Students learn how compute and represent comparative data.
- Students learn how to interpret non-quantifiable information.

Materials

- Completely filled out experimental data sheets.
- Graph paper
- Calculator
- Students' notebooks.
- Weekly cumulative data sheets.

Procedure

1. Explain to the students that will be required to create graphs to represent the data collected. Highlight the appropriate axes for which variables.
2. They will analyze for the death/survival rate. By calculating or making comparison of how many plants in each treatment were dead or alive after a certain period of time. This information will be drawn from their data collected.
3. They will also calculate the growth rate: By making a comparison of the average change in length or rate of production of new leaves over a certain period of time.
4. **Optional.** Guide the students to use the information on the experimental data sheet to fill in the weekly cumulative data sheet for the treatment groups and control. This is information can then be used to analyze the data to show changes on a weekly basis. **See weekly cumulative data sheet.**
5. The non-quantifiable information (observations) will be reported for each treatment group compared to the control. This includes changes in leaf color, stem color, shapes of leaves, etc.

Assessment

- Steps in the calculations are clearly shown.
- Accuracy and appropriate units of measurement used
- Graphical display of data
- Observations analyzed

Weekly cumulative data sheet for treatment group

Group name/members:……

Variable:……..

	Week 1		Week 2		Week 3	
Plant number	Nos. of leaves	Length of stem (cm)	No. of leaves	Length of stem (cm)	Nos. of leaves	Length of stem (cm)

Weekly cumulative data sheet for control group

Group name/members:……

Variable:……..

	Week 1		Week 2		Week 3	
Plant number	Nos. of leaves	Length of stem (cm)	No. of leaves	Length of stem (cm)	Nos. of leaves	Length of stem (cm)

Lesson 4: Report writing and presentation (5th week)

Guide students write up their final report following the scientific method format:

- Title
- Hypothesis
- Materials
- Procedure
- Results
- Conclusion
- Discussion and recommendations.

Assist each group in finding resources to address the content questions and other needs in response to the results obtained.
The whole class will cooperatively to create a power point or make a poster for presentation.

Assessment

- Scientific report
- Presentation.

Extensions

1. Students can investigate the effects of just one contaminant on the growth of different species of plants.
2. Students can measure the effects of variable levels of one contaminant on the growth of a plant.
3. Students investigate the effect of soil salinity (using table salt) on the growth of plants.

Resource list

Supplemental materials (suppliers)

- Ward's Natural Science (www.wardsci.com)
- Carolina Biological Supply (www.carolina.com)

Alan D.B. 1994. Soil Salinity, Salt Tolerance, and Growth Potential of Horticultural and Landscape plants. Department of Plant and Soil and InsectScience.UniversityofWyoming.
http://ces.uwyo.edu/PUBS/WY988.PDF

Blankenship D. W. and Larson R. A. 2005. Plant growth inhibition by the water extract of a crude oil. Water, Air and Pollution 10:4
http://www.springerlink.com/content/p0wx700538301663/

Kristen E. P., Nikos J. Warren J. and Baunder J. W. 2003. The Basics of Salinity and Sodicity Effects on Soil properties. Department of land and Environmental Sciences. University of Montana.
http://waterquality.montana.edu/docs/methane/basics_highlight.shtml

Wyszkowski M., Wyszkowski J. and Zoilkowska A. 2004. Effects of soil contamination with diesel oil on yellow lupine yield and macroelements contents.
Plant soil Environ 50: 218 – 226

http://www.bio.miami.edu/ecosummer/lectures