Increasing High School Students' Environmental and Scientific Literacies Through Outdoor Investigations

by

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Project Summary

Ever since I began teaching my AP environmental class I have thought of ways I can incorporate more hands-on learning for my students while increasing their environmental and scientific literacies. This has always been a struggle for me due to the limited time, limited materials, or just any issue that was presented to me. Through the dozens of articles I researched, I found that getting students involved in nature is one of the best ways to not only increase their environmental literacy, but to also help instill a passion for nature that would lead them to a more environmentally friendly lifestyle. To do this I first had to find an answer to my research question, *how can high school science teachers improve students' environmental and scientific literacy and help them understand their environmental impact through outdoor investigations?*

The best way to achieve this is simply getting the students outside into nature. I began by creating/remodeling three different outdoor investigations of labs I have done in the past but did not involve getting the students outside. I chose three different concepts that I believe are fundamental to developing someones' environmental literacy. Each concept will have a lesson plan that provides an overview of what the students will be learning and doing, material list, safety concerns, and teacher notes that will help an instructor perform the lab to best support the students. Besides the lesson plan, the lab write up will be provided that includes step-by-step instructions, data tables for results, and follow-up analysis questions. Additional resources are also provided if needed for the labs.

The first investigation that is provided focuses on water quality testing of a freshwater stream or river. This is a fundamental environmental skill that all students should understand the process for since our freshwater sources are getting more and more polluted. This lab involves the students traveling to a local stream and performing various water quality tests to determine how beneficial the stream is at supporting aquatic life and if it meets safe water drinking standards. The second investigation involves students comparing soil at two different local ecosystems. I chose soil for the second investigation because soil is the base of all living organisms. Producers which are at the bottom of the food chain depend on soil for nutrients. In this investigation students will be conducting different tests on both samples of soil to determine which soil is better for plant growth. The third and last investigation that my students conducted is looking at air quality. Air pollution has been directly linked to an increase in many respiratory conditions. It is critical that students understand how human activities are releasing pollutants into the air that are harmful to humans. This investigation has two different activities for students. The first is an activity that requires students to develop their own experimental design to test the levels of particulate matter in two different spots around school or their homes. The second investigation involves students testing the exhaust emissions from vehicles to see which car produces the most carbon dioxide.

Through all three of these outdoor investigations, teachers can hold that the knowledge and skills that the students learn can help increase their overall understanding of the world around them. Just like any teaching resource, the application might have to be adjusted to fit the needs of your students. No lab will benefit all students the same. Educators know their students the best and will have to adapt the following lesson plans and investigations to achieve the results they want that best support their students.

TABLE OF CONTENTS

Water Quality Testing Lesson Plan

Class: AP Environmental Science

Grade: 11th and 12th

College board Unit: Unit 8 - Terrestrial and Aquatic Pollution

Next Generation Science Standards:

HS-ESS3-1: Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and construct changes in climate have influenced human activity.

HS-ESS3-6: Use a computational model to illustrate the relationship among Earth systems and how those relationships are being modified by human activities.

HS-ESS2-5: Plan and conduct an investigation of the properties of water and its effect on Earth materials and surface processes.

Learning Objectives:

Students will be able to use information from various water quality tests to determine the overall health of a river/stream.

Students will be able to develop a hypothesis about the quality of a body of water by observation.

Students will be able to conduct various water quality tests.

Essential Vocabulary

Clean Water Act - Establishes the basic structure and standards for regulating discharges of pollutants into the nation's waterways.

Safe Drinking Water Act - Set of regulations and standards that aim to protect the nation's public drinking water.

Eutrophication - Process by which a body of water becomes enriched with minerals and nutrients, primarily nitrogen and phosphorus.

Nitrates and Phosphates - Both are limiting nutrients that are needed for plant growth. Occur naturally but human activities have increased the amount of runoff into bodies of water.

Turbidity - The cloudiness or haziness of a fluid caused by suspended particles in a body of water.

Dissolved Oxygen - Gaseous oxygen that dissolves in water. Essential for aquatic life.

Flow Rate - How much water/liquid flows through an area over a period of time.

pH - Potential of hydrogen, scale used to measure the acidity or alkalinity of a substance

Timeline Two 50-minute class periods or all day field trip

Required Materials:

Lab handout, water quality test instructions, dissolved oxygen test kit, nitrate test kit, phosphate test kit, pH test kit, three tennis balls, basic field first aid kit, turbidity tube, waders/boots, tarp, thermometer, tape measure, and a waste bottle.

Activity: Students will be going outside to a local stream and conducting various water quality tests.

Lesson Implementation:

- Students will be split into groups of 4-5 before going outside. During this time the teacher will explain the contents of each group's water quality box and how the different steps of the lab handout. All the tests that the students will be conducting will be located in this box, along with any other random material that they will need.
- Once students get outside, show them their predetermined locations along the stream. First initial steps should be laying out the contents of the water quality box on the tarp that is given. Students will record a hypothesis in their lab sheets about where they believe the water will be safe for human consumption and aquatic life. After that students then begin to take measurements of their stream location, taking pictures of upstream and downstream, measuring flow rate, and stream discharge.
- After the initial observational tasks are completed the students will conduct the other water quality tests (temperature, pH, dissolved oxygen, amount of phosphates and nitrates, turbidity, salinity, and conductivity.) Students will record their findings on their lab data sheet while looking at their water quality index sheets to determine if levels of their findings are safe for aquatic organisms and meet legal drinking water standards. All waste material and liquids from the tests will be disposed into the waste bottle and placed back into the water quality bin.
- After all tests have been conducted, the students will clean up their site location and bring all materials back into the classroom or bus. Back with their groups, they will review their data and work on the conclusion of the lab.

Safety: General aspects of safety. Students will be supervised at all times and monitor students closely when they are taking quality tests in the water using waders/boots. Strongly advised to review location many days before bringing the students to conduct the investigation. Warn students not to ingest any of the chemicals needed for the water quality tests. Each water quality bin will contain a basic first aid kit with gauss, band-aids, etc.

Teacher Notes: Carefully monitor and assist the students during the water quality tests. This lab could be done almost anywhere in the curriculum and ties into many different aspects of the class. Investigation could also be conducted in the classroom if students bring in their own water samples from ponds or streams near their homes if the class is unable to go outside during school hours. Step by step directions will be provided to the students in their water quality bins. Students should already be comfortable with the essential vocabulary and explanation of each test will be included in the water quality guide that is included in the water quality bins.

Evaluation/Assessment of Learning: Students will complete their lab worksheets that contain a conclusion. In the conclusion, students will explain if their hypothesis was correct or incorrect using results from what they observed during the lab. Students will also describe any errors that they faced during testing that could have thrown off their results. The main assessment will be the AP collegeboard exam that students take at the end of the school year. This will see how their scientific and environmental literacy has improved.

Name: ________________________________ Date: _______________Period: ____

AP Environmental Unit 8

Water Quality Testing

<u>Introduction</u>

A **watershed** is the entire area of land whose surface runoff and groundwater drains into a particular river or body of water, such as the Fox River or the Gulf of Mexico. Both naturally-occurring and human-caused events within the watershed can affect the quality of the water and the health of the organisms within that aquatic ecosystem. Several different **abiotic (non-living) factors** are monitored in many aquatic ecosystems to determine their overall health and to determine possible detrimental effects of human activities. Various tests can be performed to determine the overall health of the body of water and thus the entire ecosystem. Today in your groups you will be conducting these water quality tests to get a better understanding of the process and all the factors that can cause unacceptable water quality.

- Write a hypothesis about whether you think this stream is healthy for aquatic organisms. Why or why not?

- Write a hypothesis about whether you think this stream is healthy for human consumption and will meet safe drinking water standards. Why or why not?

<u>Part One - Water Chemistry Tests</u>

Information about each test is located in the water quality bin. In the table below, write in the results for the test and if the test meets standards for human consumption and aquatic life.

Temperature Test

What is the reading of the creek/water sample? _______________________________

pH Test

What is the reading of the creek/water sample? ___________________________________

Is this reading acceptable for aquatic life? Explain. _________________________________

____

Is this reading safe for human consumption? Explain. ______________________________

____

Dissolved Oxygen Test

What is the reading of the creek/water sample? ___________________________________

Is this reading acceptable for aquatic life? Explain. _________________________________

____

Is this reading safe for human consumption? Explain. ______________________________

____

Turbidity Test

What is the reading of the creek/water sample? ___________________________________

Is this reading acceptable for aquatic life? Explain. _________________________________

____

Is this reading safe for human consumption? Explain. ______________________________

____

Nitrate Test

What is the reading of the creek/water sample? ___________________________________

Is this reading acceptable for aquatic life? Explain. _________________________________

____

Is this reading safe for human consumption? Explain. _____________________________

____

Phosphate Test

What is the reading of the creek/water sample? ______________________________

Is this reading acceptable for aquatic life? Explain. ____________________________

____

Is this reading safe for human consumption? Explain. ___________________________

____

Part Two - Geological Features

A) Site Survey

CHECK ALL THAT APPLY

Stream Habitat
_____ Riffle
_____ Run
_____ Pool
_____ Undercut banks
_____ Snags
_____ Exposed rocks

Inorganic Substrate
_____ Boulders
_____ Cobble
_____ Gravel
_____ Sand
_____ Silt

Water Odors
_____ Normal
_____ Sewage
_____ Petroleum
_____ Chemical
_____ Fishy
_____ Other

Surface Oils
_____ None
_____ Some
_____ Lots

Bank Vegetation
_____ Bare ground
_____ Turf grass
_____ Unmowed grasses
_____ Woody shrubs
_____ Decidous trees
_____ Conifer trees
_____ Other

Local Land Use
_____ Urban
_____ Suburban
_____ Agriculture
_____ Park (turf)
_____ Park (woods)
_____ Other

CHECK MOST PREDOMINANT

Bank Stability
_____ Stable
_____ Slightly eroded
_____ Moderately eroded
_____ Severely eroded

Bank Slope
_____ Slight
_____ Moderate
_____ Steep

CHECK MOST PREDOMINANT

Current Weather
_____ Sunny/Clear
_____ Overcast
_____ Showers (intermittent rain)
_____ Rain (steady rain)
_____ Storm (heavy rain)

Past Weather (48 hours)
_____ Sunny/Clear
_____ Overcast
_____ Showers (intermittent rain)
_____ Rain (steady rain)
_____ Storm (heavy rain)

B) Site Map

In the space below draw a detailed picture of the site location. Label all parts.

C) Other Geological Testing

- Air Temperature = _________________ Time Recorded = _______________
- Flow Rate of Stream = _______________________________ m/s
    - *Repeat three times to get an average. Instructions are in the bin.*
- Width of Stream = _____________________________________ m
- Depth of Stream = _____________________________________ m
- Stream Discharge Rate = _______________________________ m^3/s
    - *Flow Rate x Width x Depth*

D) Site Photos

Your group needs to take three different photos and share/email them to your teacher.

1) Facing cross section of the area you have monitored
2) Facing upstream of the are you have monitored
3) Facing downstream of the area you have monitored

<u>Lab Conclusions</u>

Write the following for your conclusion. Answers need to be typed or written on a separate sheet of paper and stapled to this document.

1) Introductory statement with purpose and explain both hypotheses.
2) Summary of the experiment and explain whether your results confirmed or refuted both hypotheses.
3) Explain any experimental error that you or your group encountered, and note how this error could have influenced your results.

Water Quality Bin Contents

Your water quality bin contains the items listed below. Please use the equipment carefully and make sure all pieces make it back. Choose a location at your site, spread out the tarp, and use this as your basecamp. All items should be rinsed and accounted for BEFORE you leave and head back to the rest of the class.

- Tarp
- Dissolved Oxygen Test Kit (Prope and Vanier Tablet)
- Nitrate Test Kit
- Phosphate Test Kit
- Turbidity Test Kit
- pH Paper Strips
- Three Tennis Balls
- Thermometer
- Tape Measure
- Waste Bottle
- Basic First Aid

Water Quality Tests Reference Sheet

Use this information to accurately gather results

Temperature

Temperature is an important factor for all aquatic life. Species are adapted to various temperature ranges and sudden changes in temperature can be harmful.

No standard for drinking water - humans can consume hot or cold water

There is no standard for all aquatic species because different species have different ranges.

Place the thermometer at one inch depth for one minute.

pH Test

pH (potential of hydrogen) is the measure of H+ and OH+ ions. Higher H+ ions means the solution is acidic <7 on pH scale. Higher OH+ ions means the solution is basic >7 on pH scale. All organisms are adapted to a particular pH range. Extreme pH changes can kill aquatic life (dissolves the shell in mollusks). Humans need a stable pH for our functions to work properly.

Aquatic organisms need a pH of around 6.5 - 8.5

Drinking water needs to be close to neutral 6.5 - 7.5*

*Carbonated drinks have a pH of 2.5 - 3.5, although these are safe for consumption they are not recommended everyday.

Tear off an inch of the pH testing paper and dip it in the stream. Match the color to the index image that is on the box.

Turbidity

Turbidity is the measurement of suspended solids and clarity of the water. Turbid waters can be caused by soil erosion, urban runoff, algal blooms, sediment disturbances, etc. Higher turbidity levels are often associated with higher levels of disease causing microorganisms.

Measured in JTUs

Too much turbidity (>40 JTUs) is not healthy for aquatic life. Limits photosynthesis because it blocks light which may reduce the number of plants and food.

No standard for turbidity for human drinking water. Microorganisms can be in clear or turbid water.

Follow the step by step instructions in the turbidity test box found in the bin.

Dissolved Oxygen (DO)

Measure of dissolved oxygen present in the water. All aquatic animals need oxygen to surface. Aquatic environments with high levels of DO can support copious amounts of organisms creating a very diverse ecosystem.

Colder waters can hold more DO than warmer waters.

Aquatic organisms need DO to be between 3 mg/L and 5 mg/L for optimum results. Anything less than 3 mg/L can lead to death.

DO in water does not affect humans.

Take the DO probe found in the bin and connect it to the vanier tablet device. Once the device is turned on the setting should automatically be calculating DO. Place the probe in the water for two minutes, and once the reading is steady - document your result.

Nitrates and Phosphates

Nitrates and phosphates are a nutrient needed by aquatic plants and animals to build protein. Decomposition of aquatic organisms and excretions of living animals release nitrates into the ecosystem. Excess nitrates can cause increased plant growth and decay - eutrophication.

Nitrate levels should be lower than 50 ppm for aquatic life and less than 10 ppm for human consumption.

Phosphate levels should be between 0.5 and 1.0 ppm for aquatic life and less than 40 ppm for human consumption.

Follow the step by step instructions found in both the nitrate and phosphate testing bin.

Flow Rate

Is the amount of water that flows through a given point.

Select a section of moving water that is 10 meters in length.

Position one person upstream at the start of the 10 meter section.

Position another person at the end of the 10 meter section.

Person at the start of the 10 meter section drops a tennis ball. A third person will be timing how long it takes the ball to reach the person downstream.

Do three trials and average the time. Convert to meters/second.

Soil Testing Lesson Plan

Class: AP Environmental Science

Grade: 11th and 12th

Collegeboard Unit: Unit 4 - Earth's Systems

Next Generation Science Standards:

HS-ESS2-6: Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.

ESS2.A: Earth, Materials, and Systems.

Learning Objectives:

Students will be able to conduct various soil tests.

Students will be able to determine soil texture and health from various properties

Essential Vocabulary

Bedrock - Solid rock underlying surface material (soil).

Parent Material - General physical and chemical composition of the unconsolidated material, mineral, or organic matter that helps form soil.

Sediment - Small pieces of rock that get broken down by weathering. Three main sizes are largest to smallest, sand, silt, and clay.

Weathering - Break down of larger rocks into smaller sediments through physical, chemical, or biological processes.

Erosion - Transport of sediment from one place to another through water, wind, or gravity.

Soil Texture - Proportion of sand, silt, and clay sized particles that make up the mineral fraction of the soil.

Porosity - Amount of space between the particles in the soil.

Permeability - How easily water will filter and percolate through the soil.

Water Holding Capacity - The ability of a certain soil texture to physically hold water against the force of gravity.

Nutrients - A substance that provides nourishment essential for growth and maintenance of life.

Timeline Three 50-minute class periods

Required Materials:

Ruler, Rapitest soil nutrient test kits, pipette, distilled water bottle, 100 mL graduated cylinder, 50 mL graduated cylinder, 250 mL beaker, 50 mL beaker, small shovel, a tray, seran/cling plastic wrap, and two clear plastic cups.

Activity: Soil investigation comparing regular lawn soil and soil from a forest.

Lesson Implementation:

- This lesson will be split into two different parts. The first part will deal with students going outside to gather the soil.
- For this part in the lab the teacher will pass out the lab worksheets along with the soil gathering bin. This bin will contain two plastic cups, a tray, plastic wrap, and a small shovel. Students in their groups will first hypothesize which location will contain the most nutrient rich soil (the front lawn of the school or soil from the forest/grassland nearby.) Once the students have their hypothesis they will venture outside to the two sites. At the sites, the students will first take detailed measurements of their locations, along with taking pictures and drawing sketches. The students will shovel out a cup's worth of soil and spread it on the tray. Students will pick out larger sediments like rocks or organic matter such as worms, sticks, etc. Anything that is picked out will be recorded on the lab sheet. Once students have done this for both sites they will head back into the classroom.
- The second part of the lab will be conducting the soil tests in the classroom. The students will use their two plastic cups of soil for the tests. The teacher will pass out the soil testing bins to each of the groups along with a soil test manual that contains detailed instructions for each test. Students will record their results from the various soil tests (nutrients, soil texture, porosity, and permeability.) Students will then use the soil triangle to determine the texture of their soil, and then analyze their data to complete their conclusions. Soil testing will most likely take two days because the soil texture test requires soil to sit in a jar full of water and settle out before measuring the different layers.

Safety: Carefully supervise the students when they are outside; especially in the woods or other type of ecosystem besides the front lawn. Basic first aid kit will also be included in the soil gathering bin. Safety goggles will be required for the students when they are doing the second part of the experiment since they will be using glassware.

Teacher Notes: Simple lab to administer, directions for each stage of the experiment will be inside the soil gathering bins. Lab could also be done inside with students gathering soil from their own homes. They would need to do the sketching and measurements outside of the classroom. Students should already be comfortable with the essential vocabulary and explanation of each test will be included in the.soil gathering bins.

Evaluation/Assessment of Learning: Students will complete the lab worksheet that will contain a conclusion where they will explain if their hypothesis was correct or incorrect. They will be comparing the soil quality of each of their sites and using the results gathered to construct a concrete agreement to support their conclusion. Students will take the AP Collegeboard exam at the end of the school year. This exam will be a good indicator of the students' scientific and environmental literacy.

Name: ________________________________ Date: _______________Period: ____

AP Environmental Unit 4

Soil Testing

Introduction

Soil is a complex mixture of sediments, mineral nutrients, decaying organic matter, air, water, and countless living organisms. Soil first originated as rock before getting weathered by a physical, chemical, or biological process. Without soil there would be no life since producers that are the base of our food chains get their nutrients and food from the soil. Soils can also help decompose and recycle biodegradable waste while also filtering out pollutants that are in our water as the water percolates through the soil. Filtered water will reach our aquifers while the pollutants get trapped in the soil. Carbon dioxide is sequestered by our soil which helps regulate Earth's climate. Unfortunately, since the Green Revolution, human activities have accelerated natural soil erosion which can convert this renewable resource into a nonrenewable one.

The size and type of nutrients of soil can change from region to region. The parent rock that gets weathered is a huge factor on the mineral nutrients that are present. The size of the particles, sediments, influences how water will flow through the soil. The ranges of sizes go from the smallest, clay (<0.002 mm) to silt (0.002 mm - 0.05 mm) to the largest, sand (0.05 mm - 0.2 mm). Each type of sediment (clay, silt, and sand) have their own pros and cons. However, a mixture of all three is considered the best soil for plant growth. The breakdown is 40% sand, 40% silt, and 20% clay. Today we will see what type of soil we have available to us in our very own backyards.

Hypothesis

Create a hypothesis on whether you believe the grass ecosystem or the grassland/forest ecosystem will have more nutrient rich soil that is optimal for plant growth. Explain why you made your selection.

Part One - Soil Gathering

Materials for Part One (Located in Soil Gathering Bin)

- Two clear plastic cups
- Thermometer
- Shovel
- Measuring Tape

Using your soil gathering bin, collect two soil samples from two different ecosystems.

1) First ecosystem - Maintained Lawn
2) Site information
   a) Take two photos of your dig site. One up close to where you will be digging and another photo taken 3 meters away. Photos will be shared/emailed to the teacher.
   b) Use the spot below to record any anthropogenic features in a 10 meter distance from your dig site.

3) Before digging the soil sample, take a reading of the temperature. Leave the thermometer in the soil for 1 minute.
   a) Soil temperature ______________________________
4) Using the equipment in the testing bin shovel soil into the plastic cup. Dump soil into the tray and begin to remove any organic matter (worms, leaves, etc.) and inorganic matter (rocks, sticks, etc.). Record anything you remove below.
   a) <u>Organic Matter</u> <u>Inorganic Matter</u>

5) After all large organic and inorganic matter is removed, dump the soil back into the plastic cup and seal it with the serene wrap.

6) Second ecosystem - Grassland or Forest (Circle which one you selected)
7) Site information
    a) Take two photos of your dig site. One up close to where you will be digging and another photo taken 3 meters away. Photos will be shared/emailed to the teacher.
    b) Use the spot below to record any anthropogenic features in a 10 meter distance from your dig site.

8) Before digging the soil sample, take a reading of the temperature. Leave the thermometer in the soil for 1 minute.
    a) Soil temperature ______________________________
9) Using the equipment in the testing bin shovel soil into the plastic cup. Dump soil into the tray and begin to remove any organic matter (worms, leaves, etc.) and inorganic matter (rocks, sticks, etc.). Record anything you remove below.
    a) <u>Organic Matter</u>   <u>Inorganic Matter</u>

10) After all large organic and inorganic matter is removed, dump the soil back into the plastic cup and seal it with the serene wrap.

Part Two - Data Gathering Day One

Materials for Part Two

- 100 mL graduated cylinder - 50 mL graduated cylinder - coffee filter and funnel
- 250 mL beaker - Rapitest Soil Nutrient Kit - water (sink water)

- Pipette
- 2 clear plastic cups (new ones)
- ruler

Procedure for day one

1) Using the small beaker, measure 25 mL of soil and place it in your clear cup.
2) Add 125 mL of water to the soil and mix well.
3) Repeat steps 1-2 for the second soil sample. Label the cups with your group name and which location the soil is from. This will be used for the nutrient tests.
4) Using the small beaker, measure 25 mL of soil and place it in the 100 mL graduated cylinder.
5) With the soil in the graduated cylinder, add water to the 75 mL line. Shake well and put the graduated cylinder off to the side next to the nutrient cup.
6) Repeat steps 4-5 for the second soil sample.

Porosity and Permeability Tests

<u>Porosity</u>

1) Take the 250 mL beaker and add about 75 mL of soil.
2) Fill the 50 mL beaker with water and slowly start pouring the water into the 250 mL beaker. Stop adding water when the soil is saturated with water. Do Not get to the point where there is standing water on top of the soil.
3) Measure the porosity by dividing the total amount of water used by 50 mL record porosity below.
4) Repeat steps 1-3 for the second soil sample.

Porosity of 1st soil sample grass, grassland, or forest ____________________%

Porosity of 2nd soil sample grass, grassland, or forest ___________________%

<u>Permeability</u>

1) Place a coffee filter into the funnel. Place the funnel on top of the 50 mL graduated cylinder.
2) Take 25 mL of soil and put it inside the filter.
3) Measure the distance from the bottom of the filter to the bottom of the graduated cylinder in cm (this will be your distance traveled)

4) Gently pour 50 mL of water into the soil sample. Start a watch when the water starts to drop out into the graduated cylinder.
5) Stop recording when the water level reaches the 25 mL mark in the graduated cylinder.
6) Use this equation to calculate permeability. Distance traveled divided by total time.
7) Repeat steps 1-6 for the second soil sample.

Permeability of 1st soil sample grass, grassland, or forest
____________________ cm/s

Permeability of 2nd soil sample grass, grassland, or forest
___________________ cm/s

Soil Testing Day 2

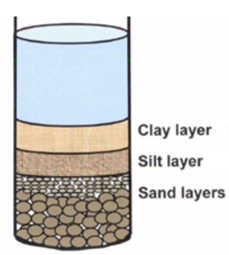
Nutrient Tests

1) Start off by getting the two clear plastic cups that you set aside yesterday.
2) Use the instructions provided with the Rapitest Soil Nutrient Kit.
3) After each test, dump the water and left over soil into the bucket that the teacher has designated.

	Potassium (K - Test)	Nitrogen (N - Test)	Phosphorus (P - Test)	pH Test
Maintained Lawn Soil				
Grassland/Forest Soil				

Soil Texture Triangle

1) Retrieve both of your graduated cylinders containing 25 mL of soil and 75 mL of water.
2) Record the following information for both cylinders.
   a) Use the picture to the right for help.



Soil Sample	Total Volume of Settled Soil	Volume of Sand Layer	Volume of Silt Layer	Volume of Clay Layer
One				
Two				

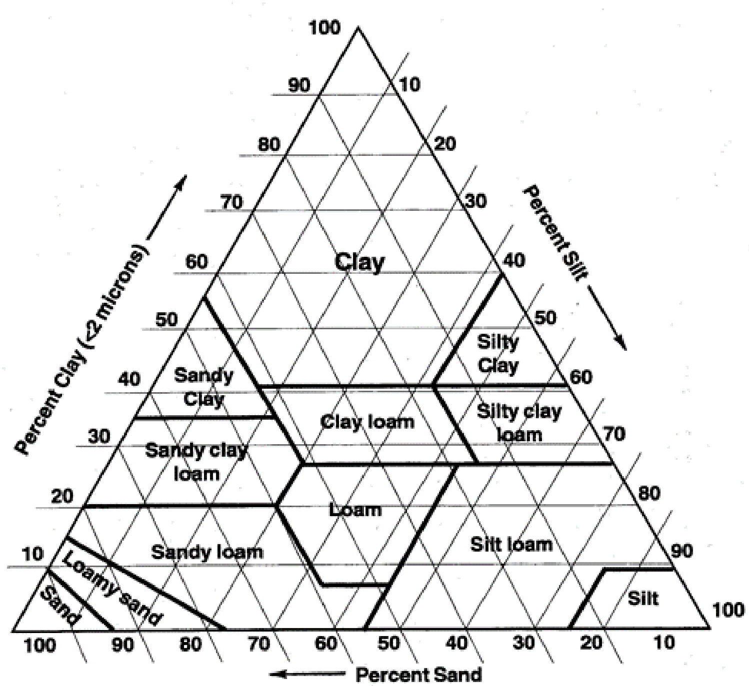
3) Calculate the percentages of sand, silt, and clay present in your soil sample. Example for sand. Take sand volume/the total volume x 100

Soil Sample	Percent of Sand Layer	Percent of Silt Layer	Percent of Clay Layer
One			
Two			

4) Use the Soil Texture Triangle to determine the soil texture of your samples.

Soil Sample 1 (Maintained Lawn) ________________________________

Soil Sample 2 (Grassland or Forest) ______________________________



Lab Conclusions

Write the following for your conclusion. Answers need to be typed or written on a separate sheet of paper and stapled to this document.

- Introductory statement with purpose and explain your hypothesis.
- Summary of the experiment and explain whether your results confirmed or refuted your hypothesis.
- Explain any experimental error that you or your group encountered, and note how this error could have influenced your results.

Outdoor Air Pollution Lesson Plan

Class: AP Environmental Science

Grade: 11th and 12th

Collegeboard Unit: Unit 7 - Air Pollution

Next Generation Science Standards:

4-ESS3-1: Obtain and combine information to describe that energy and fuels are derived from natural sources and their uses affect the environment.

HS-ESS2-6: Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.

Learning Objectives:

Students will be able to design a proper scientific experiment.

Students will be able to compare carbon dioxide emissions from different vehicles.

Essential Vocabulary:

Clean Air Act - Law defines EPA's responsibilities for protecting and improving the nation's air quality.

Corporate Average Fuel Economy - Regulations that improve the average fuel economy of motorized vehicles.

Particulate matter - Tiny microscopic particles of solids that are suspended in the air.

Carbon Dioxide - Greenhouse gas that is emitted from the burning of fossil fuels. Has two oxygen atoms for every carbon atom.

Carbon Monoxide - Odorless gas that is the result of incomplete combustion of organic matter.

BromThymol Blue (BTB) - Solution that helps detect the concentration of carbon dioxide.

Fossil Fuels - Formed from the decomposition of carbon-based organisms that died millions of years ago.

Hydrocarbons - Organic compound consisting entirely of hydrogen and carbon.

Timeline: Three 50-minute class periods

Required Materials:

Three petri dishes, vaseline, microscope, BTB solution, clear plastic ziplock bags, access to different vehicles, autoclave glove, filter paper, file folders, stopwatch, tape, and marker.

Activity: Airborne Particulate and Car Exhaust Labs

Lesson Implementation:

- First part of the lab will be conducted inside the classroom. First the teacher will hand out the airborne particular experimental design lab to the students. From there, the students will be tasked with designing their own lab that measures the amount of particulates comparing two different sites. For example they could be testing the proximity to a busy street by placing a petri dish next to a busy street and then another petri dish further away. Once the teacher gives the okay that the experiment is designed properly with all variables accounted for; the students will begin creating their three petri dishes. To create these the students will put a small layer of vaseline on the bottom of one side to collect any particulates that fall into the dish. Two dishes will be placed in the testing locations, while the last dish is covered and will remain closed for the duration of the experiment to serve as the control. Students will wait a full 24 hours before gathering their petri dishes from the field to begin analyzing the data.
- The following day after the students placed their petri dishes they will begin conducting the car exhaust lab. This lab will be done as a full group since it involves a small number of vehicles and the students will not have access to start them on their own. Students will create the exhaust bags by adding 2mL of the BTB solution in a bag full of 200mL of water. Mix the contents around until the bags are a light blue. Keep the bags sealed until ready to test. The students will then create a funnel from the file paper and attach the larger end to the exhaust pipes of the testing vehicles. While the vehicle is running, the students will hold the bag with the funnel attached to the tail pipe for one minute. After a minute has passed, quickly seal shut the bag to avoid excess gas into the bag to alter the results.
- After the students have collected all the data from the vehicles, they need to gather their petri dishes from the testing locations. They will bring all materials back into the classroom.
- While comparing the colors of the car exhaust ziplock bags; the students will also be viewing their petri dishes under a microscope to examine all the particulate

matter they captured. Once all data is gathered and transferred to the lab sheets, they will begin their analysis and conclusions.

Safety: For the first part of the lab, carefully monitor the locations that students are placing their petri dishes. Not on the roof, in the roadways, etc. For the second part of the lab, the student/teacher who is removing the file folder funnel from the car will need to wear an autoclave glove to protect their skin from the hot metal. Student/teacher who is holding the plastic bag behind the vehicle will need to position their body so they are not directly behind the exhaust pipe and off to the side.

Teacher Notes: Pay attention to the weather forecast, petri dish experiment will not work in the rain. If rain is in the forecast, students can easily change their experimental design and turn the petri dish lab into an indoor air quality assessment. They could compare their kitchen vs. their bedroom as an example, and find the amount of air particulates that the petri dishes have accumulated. Getting enough vehicles for the car exhaust part may be difficult. Benefit is that AP environmental students are typically juniors and seniors who drive to school. Use their vehicles to test. These cars are sometimes better for the lab because some students drive older vehicles that have been passed down. Talk to the building administration about using a school bus or other district owned diesel vehicles. The data gathering phase of the petri dish investigation requires the students to use microscopes. Demonstrate the proper way to hold and transport by having one hand underneath the base and the other hand holding the stem of the device.

Evaluation/Assessment of Learning: Students will be completing two different lab worksheets, one for the petri dish investigation and another for the car exhaust investigation. Students will be writing about the quality of their experimental design in the petri dish lab while explaining their results. Students will be comparing which type of vehicle had the most and least carbon dioxide emissions and researching the laws and regulations that achieved these results. Students will also be taking the AP environmental collegeboard exam at the end of the year.

Name: ___________________________________ Date: _________________Period: ____

Outdoor Air Quality Particulate Matter Investigation

Introduction

Airborne particulates are among the unhealthiest components of air pollution to humans Small particulates can travel deep inside lung tissue. Sources of particulates can either be natural or anthropogenic.

Task

Design an experiment to test the levels of particulates in the air outdoors. Could test proximity to street, distance from trees and plants, etc.

Materials

3 petri dishes
Vaseline
Ruler
Microscope

Design Your Experiment

Think about what you want to test. Remember, you can only test one question at a time. After you have decided, fill in the information below.

Problem/Question You Are Testing

____

____

____

Hypothesis

____

____

____

Experimental Design

Where is each petri dish going to be placed?

____

____

____

List of Variables

Independent Variable ________________________________

Dependent Variable _________________________________

Control Group ____

Experimental Group _______________________________________

List of Constants ____

____

Once your experimental design has been approved by your teacher; you can begin to create your petri dishes.

1) Grab three petri dishes.
2) On the bottom spread a thin layer of vaseline on all three of the petri dishes
3) Label the three different petri dishes (1 being the control while the other 2 will be placed where you have decided).
    a) The control will remain with the lid taped shut in the classroom.
4) Wait for the teacher to instruct when to place the petri dishes outside.

Data Gathering

Gather the petri dishes from their locations and use the microscopes to observe the particulates.

Petri Dish	Location	# of Particulates	Qualitative Data
1 - Control	X		
2			
3			

Lab Conclusions

Write the following for your conclusion. Answers need to be typed or written on a separate sheet of paper and stapled to this document.

- Introductory statement with purpose and explain your hypothesis.
- Summary of the experiment and explain whether your results confirmed or refuted your hypothesis.
- Explain any experimental error that you or your group encountered, and note how this error could have influenced your results.
- Describe a way that you can change the experiment to gather different results.

Name: ________________________________ Date: _______________Period: ____

Outdoor Air Quality Car Exhaust Investigation

Introduction

One of the most common greenhouse gasses is carbon dioxide, which can be found in every sphere of the Earth. It is found in the atmosphere, water, soil, and produced from virtually all living organisms. Since the Industrial Revolution, humans have been burning fossil fuels, which are remains of ancient organic matter. Since these remains are carbon based, they release carbon dioxide once they are combusted into the atmosphere. Essentially every aspect of human life releases carbon dioxide in some factor. Today we will be investigating the carbon dioxide that is emitted from the exhaust of several different vehicles. To test this, we will use an indicator solution, such as BromoThymol Blue (BTB) which monitors the concentration of carbon dioxide. Besides carbon dioxide, we will also be testing how much particulate matter is produced by the combustion of gasoline. To do this, we will use a simple filter paper and weigh the mass before and after combustion.

Materials

- Ziploc Bags
- 10 mL Graduated Cylinder
- 100 mL Graduated Cylinder
- BTB Solution
- File Folder
- Tape
- FIlter Paper
- Stopwatch/Phone
- Marker
- Vehicle Exhaust

Problem

What type of vehicle produces the most carbon dioxide and how much particulate matter is produced?

List of vehicles that will be used

In this experiment your team will measure the amount of CO_2 released by the vehicles described below. The specifications of each vehicle are listed in the table below.

Vehicle Type and Make	Year	Model	Diesel or Gasoline Engine	Number of Cylinders

Hypothesis

Generate a hypothesis with your group about which vehicle will produce the most carbon dioxide and/or particulate matter. Explain why you selected your vehicle.

____

____

____

Procedure

Preparation

1) Label the bag according to the vehicle type.
2) Measure 200 mL of water into your bag.
3) Measure 2 mL of BTB solution and add it to your bag.
4) Seal the bag and gently mix the solution and water until the color is light blue. Remain sealed until ready to collect exhaust.
5) Roll the file folder into a funnel.
6) Measure and record the mass of the filter paper before testing. (On the next page is a table where you can record the initial mass)
7) Insert the filter paper into your funnel.

Sample Collection

8) Samples will be collected outside in the parking lot.
9) Hold the larger side of the funnel at the end of the vehicle's tailpipe. Position your body so you are not standing directly in front of the exhaust pipe.
10) Partially open your ziplock bag and insert the small end of the funnel into the bag and into the solution.
11) Make sure you have a good seal around the bag and funnel, try to keep outside air out of the bag as much as possible.
12) Let the car idle for 1 minute to collect as much exhaust as possible. After 1 minute, remove the bag and seal it asap.
13) Turn the vehicle off.
14) As soon as all bags are full of exhaust, follow your teacher's instructions to return to the classroom.

Data Analysis

1) Compare the color of the BTB solution in the bags by taping them to the front board.
2) Rank the basks based on the color of the BTB solution and amount of CO_2 produced. (Bluer the solution the less CO_2 present).
3) Record your data.

Rank from least to greatest	Vehicle Type and Make	Year	Model

4) Record the mass of the filter paper again after testing.

Vehicle Make and Model	Initial Mass	Final Mass	Percent Change

Conclusions

1) Which vehicle produced the most carbon dioxide? ________________________
2) Which vehicle has the largest percent change of particulate matter?

   ____

Answers need to be typed or written on a separate sheet of paper and stapled to this document.

- Introductory statement with purpose and explain your hypothesis.
- Summary of the experiment and explain whether your results confirmed or refuted your hypothesis.
- Explain any experimental error that you or your group encountered, and note how this error could have influenced your results.

REFERENCES

"Home Page: Next Generation Science Standards." *Home Page | Next Generation Science Standards*, www.nextgenscience.org.