Curriculum Units by Fellows of the Yale-New Haven Teachers Institute
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Environmental Chemistry

Curriculum Unit 93.05.05
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This unit is designed to be used with an eighth grade science class. It addresses the expected learning outcomes of New Haven's science curriculum and uses the basic textbooks "Concepts and Challenges in Physical Science" by Globe Book Company and "Matter-Building Blocks of the Universe" by Prentice-Hall, which were adopted by the science department, as a guide to cover this topic. As this unit is designed for the student to do critical thinking about issues that will face them today and tomorrow, the first topic to be presented to them is the Scientific Method. We use this system of problem solving everyday but are unaware of the steps we follow. Therefore, we will start by having the student list the steps in the scientific method from our textbook and relate the steps to everyday situations.

These steps are:

1. Identify and State the Problem.

2. Gather Information

3. State a Hypothesis

4. Design an Experiment

5. Make Observations and Record Data

6. Organize and Analyze Data

7. Suggest Future Experiments and New Hypothesis

If you have access to the computer program "Discovering the Scientific Method" by Focus Media, Inc., you will find this a good way to evaluate their ability to use the scientific method to solve problems. They give the student 3 problems to solve, which are progressively harder to organize and evaluate using data. They enjoy the challenge and usually solve the problems by working together.

Basic Chemistry topics will be discussed and studied at this time so that the student will have some insight with the chemical reactions that take place in the environment.

GENERAL PROPERTIES OF MATTER

General properties of matter are properties that are common to all matter. Mass, the amount of matter in an object, will be the first property to be investigated. Introduce the student to the balance and have them weigh various objects to become comfortable with the basic units of mass(grams) and also provide an opportunity for a hands-on activity. If you would like to have the student do some graphing of information, this will provide a good opportunity to achieve this objective. I have found that using 10 marbles is one way to accomplish this task. I have the students weigh 1, 3, 5, 7, & 9 and record the results on a graph of # of marbles vs mass of marbles. I then have them interpolate the graph for the mass of 2, 4, 6, 8, & 10 marbles. After this I have them mass the 2, 4, 6, 8, & 10 marbles and figure the per cent error for each.

Ask the students to list some reasons why the actual mass and the interpolated masses differ.

actual mass—mass from graph % error = —— ———————————— actual mass Volume can be investigated in a similar manner. Introduce the student to the graduated cylinder and the displacement method of measuring volume. Use the same marbles and find the volume for 1, 3, 5, 7, & 9 marbles. Plot this information on a graph of # of marbles vs volume of marbles. Again interpolate the graph for the volume of 2, 4, 6, 8, & 10 marbles and actually measure the volume. Find the per cent error by using the per cent error formula.

Again ask them to list some reasons for per cent error.

Measuring various objects with the meter stick and/or metric ruler will allow the student to become familiar with the metric unit of length. If you have vernier calipers, they can be used by the students to test some volume formulas. I have found they enjoy finding the volume of a coffee can and checking their accuracy by using the graduated cylinder and water.

Density activities are performed first by finding the mass and volume of different numbers of rubber stoppers. Most appear surprised when the answers end up about the same. After these activities have been completed, the idea of density can be reinforced by using different substances of the same volume and constructing a bar graph to visually show the difference in their densities.

STATES OF MATTER

The student should have an understanding of the three states of matter and what is involved in a change of state. A good explanation of the molecular motions in the various states is found on page 324 in “Physical Science” by Ramsey, Gabriel, McGuirk, Phillips, and Watenpaugh published by Holt, Rinehart, and Winston 1986.

People in a theater are used to show the difference in molecular action between each state. I start by having people sitting in their chairs watching a performance. (solid) When the performance is over the people begin to leave their seats. (liquid) Finally, they leave the theater and head for home. (gas)

This activity gives them a better understanding of what is happening when they heat ice water to the boiling point. Plotting a graph with time vs temperature is also fun to plot and discuss.

PHYSICAL AND CHEMICAL CHANGE

Because we are going to study various changes in our environment, we must know the difference between a physical and a chemical change. They should understand that in a physical change nothing new is formed. There are a variety of ways to reinforce this for the student. One way is to heat water to it's boiling point and then have it condense on a cooler object. The student will then realize that a change in state is a physical change.

Chemical changes result in something new being formed. A good way to demonstrate this is to use iron filings and sulfur. Mix the two together and use a magnet to separate the mixture. Remix the sulfur and iron filings, heat and repeat trying to separate the two by using the magnet. This shows that the iron and sulfur have combined to create a new substance iron sulfide. This reaction is an example of a chemical change.

ELEMENTS, MIXTURES, COMPOUNDS, AND SOLUTIONS

Because there are differences in matter, it has been classified into four main categories. Because taking proper care of our environment involves matter in all these categories, the student must have a basic understanding of each category before we begin to use the CEPUP modules.

The basic make-up of matter is the element. The student should realize that all matter is made from a little over 100 elements and each has a one or two letter abbreviation to represent it when showing chemical reactions. They should think of these elements as letters of the alphabet combining or staying alone to make everything that exists. The should also realize that like letters of the alphabet, you cannot combine all letters to make words and the same is true for elements. Not everything will combine. This will be cleared up when you talk briefly about the periodic table.

A mixture is two or more substances mixed together in no specific ratio. The substances are not chemically combined. This means that they can be separated by simple physical means. We classify mixtures as heterogenous (different-sand & water) or homogeneous. (same-soda pop)

Compounds are combinations of two or more elements chemically combined. We use formulas to tell us what makes up the compound and subscripts to tell the amount of each element. How compounds are formed will be discussed and demonstrated when we talk about the periodic table.

Solutions are homogeneous substances formed when one substance is dissolved in one another. The substance that is dissolved is called the solute and the substance doing the dissolving is called the solvent. There are nine type of solutions and most can be separated by simple physical means.

FOUR FUNDAMENTAL FORCES IN NATURE

The basic structure of the element is the atom. The atom can be broken down into the proton, neutron and electron. At this stage in their education it is not necessary to break down the atom any further. The atom is kept together by four fundamental forces:

a. electromotive force—keeps electrons in orbit around the nucleus of the atom.
b. strong force—opposes electromotive force of repulsion in the nucleus.
c. weak force—responsible for radioactive decay
d. gravity—force of attraction exerted between all objects in nature.

THE PERIODIC TABLE

The periodic table is a chart that organizes all the elements according to their atomic numbers (# of protons) by groups—columns that have similar physical and chemical properties, and periods—rows which have the same number of energy levels.

We will use the "A" group elements to help the student get a basic understanding of how and why a chemical reaction occurs. I have found that having the student think of the symbols for the elements as letters of the alphabet to be very useful. I explain that just as there are rules for making words there are also rules for chemical reactions. There are a limited number of letters justs as there are a limited number of elements.

The electrons in the outer shell are responsible for chemical reactions. The atom wants to have a complete outer shell of eight electrons. This is accomplished by lending or borrowing 1 to 4 electrons. Let's see how this is accomplished.

We will use the (+) for the tendency to give up electrons and the (-) sign for the tendency to borrow electrons. The roman numeral in front of the letter "A" indicates the number of electrons in the outer shell called valence electrons.

++++

IA = + IIA = ++ IIIA = +++ IVA = or

- - - -

VA = - - - VIA = - - VIIA = - - VIIIA = 0

In order to have a chemical reaction, we need something to lend electrons and something to borrow electrons. The number of (+) must equal the number of (-) in a completed chemical reaction.

At this point we can combine some elements using this method.

Li = + Cl = - rxn = LiCl
H = + O = - - rxn = H O
H = + 2
Al = +++ O = - - rxn = Al O
Al = +++ O = - - 2 3
0 = - -

Now that we have a basic understanding of what is happening during a chemical reaction, we will begin to investigate various problems in our environment.

ENVIRONMENTAL CHEMISTRY

We are now ready to concentrate on our mission of learning to become responsible people. We will discover that issues concerning our environment are not in black or white. Grey areas exist and they must be investigated to learn how various laws might impact the lives of people as well as the environment.

To begin, we should discuss with the students the meaning of the word “threshold” since different elements in the environment have different thresholds. The CEPUP kit “Determining Threshold Limits” has activities to help the student with this concept.

The 6 activities include processes and societal issues.

1. Processes:

Observe threshold of taste for salt solution.

Analyze data using a bar chart.

Societal Issues:

Can the quality of our drinking water be determined by taste and smell?

2. Processes:

Conduct qualitative analysis.

Societal Issues:

> What are the policy implications of the presence of potentially harmful chemicals in our drinking water?

3. Processes:

Extrapolate and interpolate from experimentally determined graphed data.

Societal Issues:

What is the proper method of disposing of a harmful substance?

4. Processes:

> Use simulated animal experiments to study acute and chronic effects of a potentially toxic substance.

Societal Issues:

How are toxicity levels for potentially toxic substances determined?

5. Students are exposed to the realities of using animal experiments to determine toxic levels for humans.

6. Using given experimental data students in this activity explore the difference between acute and chronic toxicity.

We can now talk about the various areas on earth and how various forms of pollution effects them.

THE ATMOSPHERE

We live in the layer of the atmosphere called the troposphere. This layer contains a mixture of gases which include nitrogen, oxygen, carbon dioxide and water vapor.

When other substances enter the atmosphere, they cause a change in its composition. Sometimes these changes can be harmful and have a long term effect. These substances are called pollutants. Since most pollutants in the atmosphere are the result of human activity, we must find ways to curb these activities without affecting our quality of life.

An activity that you might use to show the various particles in the air can be found in a number of textbook activities. As the materials you will use must be left out for several days, you should look at a long range forecast and choose a time when no precipitation is expected to perform this activity.

You perform this activity by taping graph paper underneath petri dishes. You then coat the inside of the petri dish with white petroleum jelly and place the lids on each dish.

Decide on several locations where you would like to place each dish to investigate different particles. Some places of interest might be near the railroad station, the airport, the Q-bridge, and even have some teachers who live in different communities take one home for you. But you must make sure they will be placed in an area that will not be disturbed once you have them in place.

After you have placed the petri dishes in position, remove the lids and allow to remain for three days undisturbed. After the three day period, label the location on the lid, cover and return to school for observation.

Decide on how you will record your data and what benefits, if any, can be gained from the collection of these data.

Another activity that you may want to perform is found in HANDS-ON SCIENCE by Dorothea Allen. This activity allows the student to see how burning puts pollutants into the atmosphere and how they travel, once in the atmosphere by using a covered 10 gallon glass aquarium tank and burning wood chips.

The greenhouse effect is important to life on earth as it prevents the earth from becoming a frozen planet. When the sunlight strikes the earth, radiant energy is transformed into heat energy. The carbon dioxide in the atmosphere then absorbs this heat energy and does not allow it to escape back into space. This results in the earth staying warmer than if it did not have carbon dioxide.

An increase in the population and more industrialization has caused an increase in the carbon dioxide level. Some scientists and environmentalist fear that if this trend continues the amount of carbon dioxide in the air will increase so much that heat will not be able to escape and the earth will warm up more than it should, causing many disasters.

A way to show the greenhouse effect is to take a glass container with a lid and place a thermometer inside. Next to the jar have another thermometer exposed to the air. Record their temperatures and then place both in the sunlight and observe the temperature changes. You may also use one glass container and use the same procedure twice. The first time you measure the temperature of the container uncovered. You remove the container from the light and allow the temperature to return to the original temperature and repeat the procedure but this time you will cover the container.

Another problem pollutant in our atmosphere is sulfur dioxide. This product is introduced into our atmosphere mainly by the burning of coal. As sulfur dioxide dissolves in rainwater very easily, it forms an acid and is called acid rain.

Acid rain is harmful to living and non-living things. It damages buildings by causing them to corrode and high level of acids in water cause living things to die and disrupt the food chain. We will work with and understand acids better when using the Chemical Survey & Solution and Pollution Module.

The ozone layer is getting plenty of attention these days. Ozone is a form of oxygen gas and is important because it absorbs harmful ultraviolet radiation from the sun. This radiation is not only harmful to humans but can weaken the immune systems of animals.

Refrigerators, air conditioners, and aerosol spray cans are man’s contribution to the destruction of the ozone layer. The chlorofluorocarbons released into the atmosphere eventually combine with the ozone to form an oxygen molecule and a molecule of chlorine monoxide. The chlorine monoxide then reacts with a free oxygen atom setting the chlorine atom free to attack another ozone molecule. It has been estimated that each chlorine atom that is released in these reactions can change as many as 10,000 molecules of ozone to oxygen. At this rate, you can see that eventually there will not be enough ozone to effectively block the ultraviolet radiation.

To give the student a better understanding of the ozone layer and the effects of CFC’s, an activity in HANDS-ON SCIENCE by Dorothea Allen might be useful. The activity is entitled PROBING WAYS TO PROTECT THE OZONE LAYER. They research information on the ozone layer then analyze and discuss their findings.

Before we have the students start giving suggestions on how to reduce air pollution, we should have them read articles on air pollution from newspapers, magazines and textbooks. One source for articles is from the series “Science, Technology, & Society.” The text “Resources” has several articles with activities taken from newspapers and magazines on this subject.

We can evaluate the effectiveness of this section by listening to the discussions the students have and the suggestions they make to improve our air quality.

THE HYDROSPHERE

Looking at the earth’s surface from above would lead one to think that it is not necessary to worry about a water supply.

Although most of the earth is covered with water, only a small portion is in a form that can be used by humans and other land dwellers. The oceans cover about 70% of the earth’s surface and contain about 97% of the water. As we all know this water contains salt which prevents our using it directly for life functions.

Icecaps contain about 2% of the available fresh water leaving the last 1% for our use in a natural state.

As water dissolves more substances than any other single substance and with our living in a closed system, we must therefore conserve our fresh water supply and prevent it from becoming polluted.

At this time, introduce the water cycle to the students. We might also do an electrolysis of water demonstration to show the chemical composition of pure water.

After the water cycle has been discussed, the CEPUP MODULE—CHEMICAL SURVEY & SOLUTIONS AND POLLUTION will be used to gain an understanding of water pollution.

This module begins by having the student answer a survey form on chemicals. They also ask people over the age of 18 to answer the same survey questions. When both are completed they tally the results and write a report comparing their response to adult responses. Upon completion of this exercise they are made to realize that everything that has mass is made up of chemicals.

Activity one has the student explore the water solubility of various substances learning about solutions and the terms solute, solvent, dilute and concentrated.
Activity two teaches the student parts per million (ppm) through a visual demonstration using successive dilution of food coloring.
Activity three has the student explore the reactions of an acid, a base, water and universal indicator when mixed together in various quantities.
Activity four has them explore the question of whether dilution is the answer to pollution.
Activity five has the student study neutralization quantitatively.
Activity six has the student determine the concentration of household vinegar relative to a known acid solution.
Activity seven has the student use their knowledge to solve a simulated water pollution problem.

We now can use the water cycle chart and our knowledge of an acid to review acid rain.

Using our water cycle chart, we can now discuss groundwater fits into the water cycle. The CEPUP MODULE—INVESTIGATING GROUNDWATER: THE FRUITVALE STORY will be used to gain a better understanding of groundwater.

Activity one deals with factors that affect the movement of groundwater, how groundwater gets contaminated and how contamination is spread.
Activity two deals with dilutions of parts per million (ppm) and parts per billion (ppb).
Activity three has the students read the Fruitvale story and using a map, decide where more test wells should be drilled to discover the source and extent of contamination.
Activity four has the group deciding on a plan of action, carrying out a simulation of well testing and recording their results on the Fruitvale map.
Activity five has the students use the information and draw a plume showing the boundary of safe concentration of the pesticide.
Activities five and six are optional role playing activities.

We are now ready to read and discuss water pollution problems in the real world. Have the students bring in articles from papers and magazines on these problems to be shared and discussed with the class. You might also want to use the the textbook RESOURCES, mentioned earlier as source of articles. There are nine articles with activities on this subject in the book.

The type of discussions and suggestions for handling the water pollution problem can be a way to evaluate the effectiveness of the section.

THE LITHOSPHERE

The lithosphere refers to the solid portion of the earth's surface that we live on. Increased populations are causing many problems. We are removing areas of natural vegetation to make room for this expansion upsetting the balance of nature. Along with this increased population comes an increase in solid waste. Many cities and towns landfill areas are full and they must look for alternative sites to rid this waste.

Recycling programs are now being mandated to help alleviate this problem and also to help save some of our natural resources.

We as a people must be willing to give up some of our conveniences for the betterment of our planet especially things that cause toxic waste.

We can use the CEPUP MODULE—TOXIC WASTE: A TEACHING SIMULATION to give the student a better understanding of a toxic waste.

Activity one has the student do an electroplating activity and then he/she is confronted with the problem of disposing of the toxic used copper chloride solution.
Activity two has the student use the dilution method as a treatment procedure for waste disposal.
Activity three introduces the student to the reclamation process.
Activity four has the student examine cost and safety factors for reclamation.
Activity five introduces the use of precipitates for securing toxic waste.
Activity six has them converting toxic waste to a solid producing products that will resist leaching of the toxic.
Activity seven has them reviewing the various processes for handling toxic waste. They then compare the advantages and disadvantages of each method to the ultimate fate of the material.

When people go to the super market, they are asked if they want their groceries in a plastic or paper bag. The CEPUP MODULE—PLASTICS IN OUR LIVES will help the student to realize some of the factors that go into this decision.

Activity one: The student become aware of common plastic products.
Activity two: The student examines the physical properties of four common plastics.
Activity three: Polymer molecules are synthesized from monomers.
Activity four: The student constructs a model of a polymer molecule and then relates physical behavior to molecular structure.
Activity five: The student compares properties of natural and synthetic polymers.
Activity six: Students examine issues relating to the disposal of plastics.
Activity seven: Explores the use of alternatives to using plastic products.
Activity eight: Students reconsider their decision of whether to use plastic of paper bags

Again there are some good articles for the student to read from the test RESOURCES. There are nine articles and activities on managing solid waste and nine articles and activities on land use.

This unit has covered many topics and is not expected to be an end all unit on environmental topics. It has hopefully motivated some students to think more critically about the environment and possibly think about a career in science.

PROBLEM:
What effects does an acid have on some monuments and buildings?

GOAL:
Upon completion of this investigation, the student will know that acid rain effects buildings and monuments made of marble.

PROCEDURES:
1. Weigh 5.0 grams of marble chips.

2. Place the chips into a 250 ml. beaker.

3. Add 50 ml. of a dilute sulfuric acid solution into the beaker.

4. Observe the reaction for several minutes.

5. Stir and wait for the reaction to stop.

6. Pour the mixture through filter paper.

7. Rinse and dry the marble chips.

8. Weigh the dry marble chips.

OBSERVATIONS:
1. What happens when the marble chips and acid are mixed?

2. What happens when you stirred the mixture? Why?

3. What happened to the weight of the marble chips?

CONCLUSION:
How can you connect this activity to what is happening in our environment?

PROBLEM:
What effects do air pollutants have on plants.

GOAL:
Upon completion of this exercise, the student will realize that the greater the concentration of a pollutant, the greater the damge to the environment.

PROCEDURES:

1. Have the student groups design an experiment, using one type of plant and one pollutant to carry out the investigation.
2. Have the student groups explain the needs for a control.
3. Have the students set up standards so that they can share and compare results.
4. Carry out the investigations.

OBSERVATIONS:

1. How do the plants compare with the control plants?

2. What other things might cause the same reaction?

CONCLUSIONS:

What can you conclude from doing this investigation?

How realistic is it to compare this study to our environmental problems?

BIBLIOGRAPHY

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Globe Book Company, 190 Sylvan Avenue, Englewood Cliffs, New Jersey 0732 Third Edition 1991

Basic text for the New Haven School System.

Physcial Science topics covered for the average student.

This material will help the student understand chemical and physical environmental changes.

MATTER: BUILDING BLOCK OF THE UNIVERSE

Prentice Hall, Englewood Cliffs, New Jersey 07632 1993

Basic text for the above average student.

Physcial science topics covered in greater depth.

This material will help the student understand chemical and physical changes in the environment.

ECOLOGY: EARTH'S LIVING RESOURCES

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Good ecology units.

FAST I THE LOCAL ENVIRONMENT

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College of Education University of Hawaii, 1978

Good activities on field ecology and air pollution.

ISSUEORIENTED SCIENCE USING CEPUP MODULES
Reagents of the University of California 1993

Overview of CEPUP modules.

POPULATIONS
Globe Book Company, Englewood Cliffs, New Jersey 07632 1993

Good articles on human impact on the environment.

IMPACTS OF TECHNOLOGY
Globe Book Company, Englewood Cliffs, New Jersey 07632 1993

Good articles on hazardous substances.

RESOURCES
Globe Book Company, Englewood Cliffs, New Jersey 07632 1993

Good articles on water resources, air quality and managing solid waste.