Environmental Aspects

Nancy Rose
Lindsey Buehler

Middle School
General Science, Environmental Science, Physical Science, Biology, Ecology

For the Teacher

The project ideas proposed in this section are applicable for science fairs, but they could also be modified and performed as classroom activities or demonstrations to introduce or reinforce basic environmental science concepts such as ecosystem balance, nutrient cycling, and energy transformations. Project ideas can also be easily adjusted to fit levels of student knowledge and ability.

Before students begin a science fair project or before a project idea is introduced as a classroom activity, students will need background information on environmental aspects of energy production and use. We have included several resources that can help familiarize students with the environmental aspects of energy. Students should be familiar with the use fossil fuels for energy, the different forms of pollution created by the continued use of fossil fuels, and why renewable resources may be a better alternative.

At the National Renewable Energy Lab (NREL), scientists not only focus on the production of energy from various renewable resources, but also the elimination of hazardous wastes produced in biomass fuel generation. They work to discover efficient industrial and/or bioremediation methods to reduce or eliminate the need for waste storage, making the production process more efficient and environmentally friendly. The following projects are aligned with the National Science Education Standards and support the mission of NREL

National Science Education Standards by the National Academy of Sciences

Science Content Standards: 5-8

Science As Inquiry
– Content Standard A:

"Abilities necessary to do scientific inquiry"
"Understandings about scientific inquiry"

Physical Science
- Content Standard B:

"Properties and changes of properties in matter"
"Transfer of energy"

Life Science
- Content Standard C:

"Diversity and adaptations of organisms"

Science and Technology
- Content Standard E:

"Abilities of technological design"
"Understandings about science and technology"

Science in Personal and Social Perspectives
-Content Standard F:

"Populations, resources, and environments"

History and Nature of Science
- Content Standard G:

"Science as a human endeavor"
"Nature of science"

Technology Description

With human population growing exponentially, the demands for energy resources have increased dramatically. The energy needed for our everyday lives is creating environmental concern throughout the world. In all energy changes, there is a loss of energy in the form of heat or other waste, which can pollute the environment. In fact, in some places, we are actually poisoning ourselves with wastes from human activities.

Pollution is anything in the environment that does not normally belong there. Much of the pollution in our world is linked directly to energy use. Combustion of fossil fuels such as coal, oil, and natural gas in our vehicles, homes, industries, and power plants creates several types of harmful emissions. The harmful pollutants end up in our air, water, and soil, which cause damage to the earth and its organisms, to property, to our health, and to our quality of life. In addition, combustion of fossil fuels releases excess carbon dioxide into the atmosphere, which scientists believe could possibly lead to dramatic changes in the world's climate.

Not only does using fossil fuels as sources of energy create pollutants, but their supplies are also limited. Fossil fuels take millions of years to form from decaying organic matter. We are using them up at an ever-increasing rate, and they will not be replenished in our lifetime. Finding and using alternative energy resources, such as wind, solar, and biomass, makes sense. Renewable energy resources produce fewer wastes overall and are continuously available because of our sun.

Although we can't always undo the environmental damage, sometimes there are ways to clean up the pollutants. One method to clean wastes from the environment is called **bioremediation.** In the process of bioremediation, microorganisms break down harmful substances and use them as food. A good example of bioremediation that you may be familiar with is the use of microorganisms to help clean up oil spills. New research focuses on the use of microorganisms to clean up wastes so that the earth is a friendly place for all organisms.

The following project ideas focus on the environmental aspects of energy usage. The topics examine environment quality, air, water, and soil pollution, and bioremediation. Most projects can be done with a limited amount of supplies, but the time invested in the projects will vary. By taking a more critical look at the impacts energy usage has on the environment, you will develop a greater appreciation for Earth's balance and its complexity. We hope you become more aware of your own energy consumption and need

References for the environmental aspects of energy use:

Books:

E. McLeish, *Energy Resources: Our Impact on the Planet.* Austin, TX: Raintree Steck-Vaughn, 2002.

T. Cook, *Environment*. Danbury, CT: Grolier, 2002.

M. Maslin, *Global Warming: Causes, Effects, and the Future.* Stillwater, MN: Voyageur, 2002.

K. M. Miller, *What If We Run Out of Fossil Fuels?* Danbury, CT: Children's Press, 2002.

Web Resources:

University of Wisconsin, Board of Regents, "The Why Files: The Science Behind the News," [site] 2003, Search: Energy, Environment and pollution, and Micro world, Available: http://whyfiles.org/

US Geological Survey, "Bioremediation: Nature's Way to a Cleaner Environment," [Online document] 1997 Apr 1, Available: http://water.usgs.gov/wid/html/bioremed.html

Web Content Producer: Patricia Noel Williams, Site design: Crabtree + Company, "Microbeworld," [site] Available: http://www.microbeworld.org

Michigan State University. Communication Technology Laboratory and the Center for Microbial Ecology, "Microbe Zoo," [site] 1995, 1996, 2000 Available: http://commtechlab.msu.edu/CTLprojects/dlc-me/zoo/

Office of Fossil Energy, U.S. Department of Energy, "Fossil Fuels…Future Fuels," [Site] Available: http://www.fe.doe.gov/education/

U.S. Department of Energy, "Energy Efficiency and Renewable Energy," 2003 Jul. 2, Available: http://www.eere.energy.gov/

U.S. Department of Energy, search "Energy Sources" and "Environment," Available: www.energy.gov

The U.S. Environmental Protection Agency, "Browse EPA Topics," [Site index] 2003 June 11, Available: http://www.epa.gov/epahome/topics.html

National Oceanic and Atmospheric Administration, "NOAA Education Resources," [site] 2003 June 16, Available: http://www.education.noaa.gov/

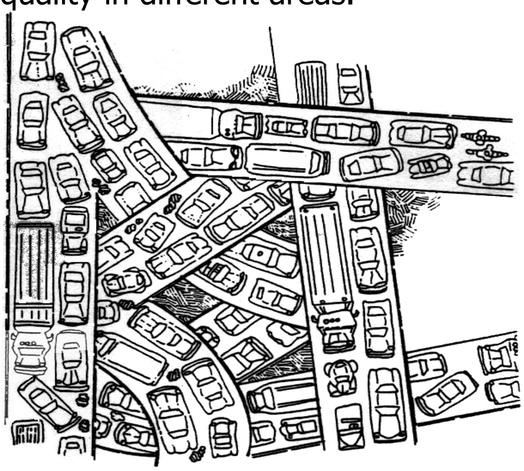
Website curator: Robert B. Schmunk Responsible NASA official: James E. Hansen, "Institute of Climate and Planets," [site] 2003 May 7, Available: http://icp.giss.nasa.gov

Materials Resources:
* Indicates materials that can be purchased through any science supply company. Possible science supply companies include:
Carolina Biological- www.carolina.com
Sargent-Welch– www.sargentwelch.com
Frey Scientific – www.freyscientific.com

Project Ideas

1 How clean is your community?

Learning Objective: Did you ever wonder if the water or air in your home or around your community was polluted? In this project you will collect samples of the water or air in and around your home, school, or community over time and compare/contrast the water or air quality in different areas.



Control and Variables:
Control – For water monitoring, distilled or drinking water; for air monitoring, filtered air
Variables – collection site or source, time of day, season of the year, day of the week

Materials and Equipment:
pH paper; thermometers; water and air testing strips and/or titration kits (science supply company* $33-300); air collection kits, ozone monitoring (science supply company*, approximately $125); muffler collection demonstration kits (Carolina Biological, $100)

Safety and Environmental Requirements: Wear goggles when using testing kits with solutions and wash hands when completed. Follow all directions and safety precautions that are included with the kits.

Suggestions:
- Collection sites should be checked regularly
- Organisms present in water can be monitored, and particulates in the air can be collected using index cards covered with petroleum jelly.
- Data from global monitoring organizations, like NOAA, can also be compared and analyzed.

2 What are the effects of air pollutants on plants?

Learning Objectives: Have you ever wondered how pollutants from burning fossil fuels affect organisms in the environment? In this project you will monitor pollutant(s) derived from the combustion of fossil fuels and analyze their effect on plants.

Control and Variables:
Control – Unexposed plants
Variables – plant variety, type of air pollutant (e.g. sulfur dioxide, ozone, carbon monoxide, nitric acid), length of exposure, concentration of pollutant

Materials and Equipment: Pollution monitoring kits (science supply company*, starting at $30); aquaria or plastic bags for individual treatment chambers; plants, seeds, soil, and containers can be purchased from local stores.

Safety and Environmental Requirements: Follow all safety instructions when generating gases. Initial testing should occur in the presence of an adult with supervision. This should occur under a fume hood or in adequate ventilation. Goggles should be worn when producing gas. Gloves and masks may be worn.

Suggestions

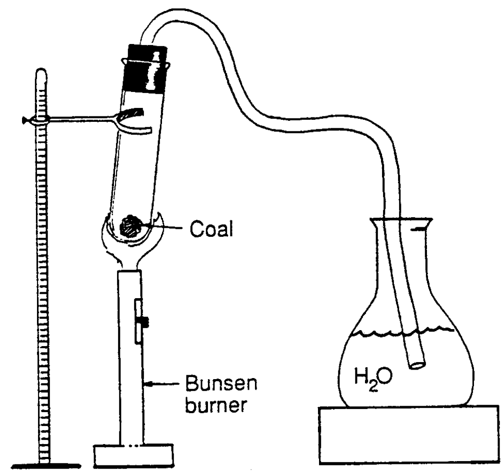
- Old aquaria can be sealed with plexiglass and silicon seal. This allows for an accurate measurement of pollution concentration. Valves can be installed in plexiglass so that air plus pollutant can enter or exit.
- Plastic bags can be used in place of aquaria for "one shot" applications.
- Seeds can be planted and germination rates determined or seedlings planted and growth rates can be monitored.
- Carbon dioxide can be generated and the effects of excess gas can be monitored in plants to simulate increased carbon dioxide in the atmosphere.

3 What types of energy sources produce substances that cause acid rain?

Learning Objective: Do all fuels produce acid rain? In this project you will discover how acid rain can be produced by gas wastes from the combustion of energy sources and evaluate if some fuel sources produce more acid rain than others.

Control and Variables:
Control – Liquid without gases being introduced.
Variables– fuel source, combustion time

Materials and Equipment:
Combustion set-up (from classroom or high school chemistry lab); water or lime water (calcium hydroxide, science supply company*, $4) or liquid indicator (cabbage juice or other organic indicators from a science supply company*); solid fuel sources (charcoal, coal, paper, dried cornstalks, wood chips); balance; pH paper;



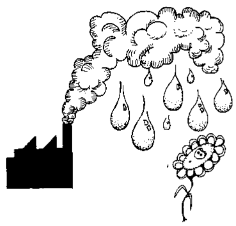
Safety and Environmental Requirements: Perform burnings under a fume hood or in a setting with adequate ventilation. Wear goggles and be careful to avoid burns. Do not leave the experiment unattended. Do not allow water to suck back into hot test tube.

Suggestions:

- Heat equal volumes/weights of biomass from different sources over the same time period.
- More advanced students can quantify the concentration of the pollutant and identify the pollutant.

4 How does acid rain affect the growth and survival of plants?

Learning Objective: Do you know how acid rain affects organisms in an ecosystem? In this project you will discover what effect acid rain has on the growth and survival of plants and infer how that may disrupt the health of the entire ecosystem.



Control and Variables:
Control – Unexposed plants
Variables – Plant variety, age of plant, rain pH, exposure time

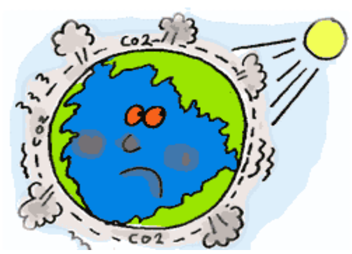
Materials and Equipment: pH paper; spray bottle; various concentrations of dilute acids (school chemistry lab or kitchen products); seeds, plants, soil, and containers can be purchased from local stores. Optional: acid rain kit (science supply company*, $30 and up).

Safety and Environmental Requirements: Be careful when spraying the "acid rain" on plants and do not point toward your face. Gloves and goggles should be worn during preparation and application.

Suggestions
- Compare plant species, test and select members of the same species with greater tolerance to lower pH.
- Compare germination rates or effects on seedling development.
- Monitor other organisms, such as microorganisms or small aquatic invertebrates, in ponds and streams.
- Monitor nutrients in the soil to see how pH levels affect them.

5 What is the effect of an increase in water temperature on the amount of dissolved oxygen in water?

Learning Objective: You have probably heard the term "global warming." Do you know what it is, what causes it, and what it may do to the organisms on earth? Why would it be a big deal for factories to discharge clean, but warm water into a stream? In this project you will investigate the effects of global warming and thermal pollution on organisms living in the water.



Control and Variables:
Control – sample water tested at "normal" temperature (the temperature normal for the environment)
Variables – varying the temperature of water sample, source of water, the amount of oxygen in the water, living organisms in the water

Materials and Equipment: Water samples; thermometer; individual dissolved oxygen kit or chemicals to perform dissolved oxygen tests (science supply company*, $43).

Safety and Environmental Requirements: Be sure to follow all directions in the kit. Use goggles when testing with chemical solutions in the laboratory or field.

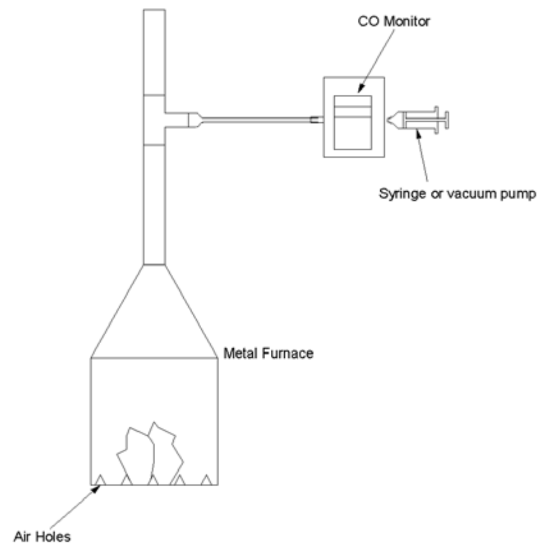
Suggestions:
- Take water temperatures first.
- Test samples directly in the field, or test samples as quickly as possible after gathering from a water-sampling site.
- Fill all bottles to the top and cap tightly so that no air enters.
- A water bath could be used to slowly heat water samples to measure the effects of varied temperature.
- Range of oxygen requirements could be investigated for invertebrate organisms by observing physiological responses in varying water temperatures.

6 How does the amount of oxygen affect the quality of air when different fuels are burned?

Learning Objective: You already know that oxygen is needed to burn fuel sources. Did you know that burning with low oxygen concentrations also effects the types and amounts of air pollutants? Did you also know that some fuel sources contain more pollutants than others? In this project you will analyze the carbon monoxide emissions from burning solid energy sources.

Control and Variables:
Control – room air
Variables – Amount of oxygen (size or amount of openings in furnace), solid energy source (wood, charcoal, natural gas, coal, paper, old cornstalks, etc.)

Materials and Equipment:
Small metal furnace (see diagram), carbon monoxide detector (purchase from local hardware store, $30), soild fuel sources, igniter, optional starter fluid



Safety and Environmental Requirements: Wear goggles and perform only with adult supervision. Perform combustions under a fume hood or in well ventilated areas outdoors (cemented areas, inside grill). Be careful of burns.

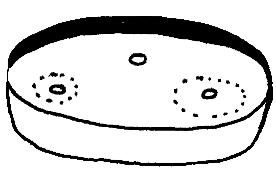
Suggestions:
- Allow the fuel source to burn entirely within the furnace.
- Compare burning temperatures or calculate the number of joules of energy produced by each fuel source.
- Monitor and/or analyze the buildup inside the furnace or ash remains.
- Investigate possible uses for the ash waste.

- Compare the burning of alcohol with gasoline in furnace and in modified internal combustion engines.

7 How can pollutants in the soil affect the organisms that live there?

Learning Objective: Did you ever wonder what affects spilling or leaching of energy-generating products have on the organisms in the soil? In this project you will investigate the effects common energy products have on microorganisms in the soil.

Control and Variables
Control – "unexposed" soil
Variables – fuel product, amount of fuel, soil type, soil site, amount of soil, exposure time, culture media, respiration conditions (with or without air)
Materials and Equipment: Liquid media: culture tubes or bottles with caps and media ; Solid media: petri plates, media, and filter disks; (media available from science classroom or science supply company, $7-$50); soil samples, balance, fuel sources/products (gasoline, motor oil, alcohols, engine cleaners, coolants); spectrophotometer for liquid media (high school or university).



Safety and Environmental Requirements: Store soil sample in refrigerator when not in use. Wear goggles when adding fuels or products to cultures. Wash your hands after setting up cultures. Do not open lids of petri plates. Follow directions when using the spectrophotometer.

Suggestions:
- Solid or liquid media can be used to culture soil microorganisms.
- Respiratory conditions can be compared.

-Anaerobic conditions can be obtained by filling all tubes/bottles full. Plates can be placed in bags or containers with an oxygen scavenger ($20-35 Camp Micro Inc. www.campmicro.com)

-Aerobic cultures should be agitated to increase oxygen dispersion.

- Solid media should be inoculated with liquid cultures.
- Small filter disks may be used or colony growth can be visually inspected for zones of inhibition.

8 How can microorganisms help clean up pollutants from the environment?

Learning Objective: Did you know that some microorganisms can use pollutants as "food"? Pollutants that some microorganisms can degrade are oils, such as those from oil spills. In this project you will see if microorganisms are capable of bioremediation and examine what conditions are needed for successful "cleanup".

Control and Variables:
Control – no microorganisms
Variables – type of oil, temperature, type of soils, source of soil, amount of soil, respiratory conditions, light

Materials and Equipment: Soil samples; different oils (motor, machine, vegetable, mineral, available from grocery or auto store); jars and lids; inorganic nutrients (chemistry classroom); balance; brown paper for oil test.

Safety and Environmental Requirements: Wear goggles when setting up and collecting data. Oils are FLAMMABLE! Keep set up away from open flame.

Suggestions

- Aquaria pump and lid alterations can be used to monitor the effects of aeration on rate of degradation.
- Paper is used to check for degradation. Let oil/water spot on paper dry before you make conclusions.
- pH may be monitored.
- Nutrients can be limited, or added in excess, to monitor affects.
- Advanced students may want to design assays for metabolites or design a cleanup method for potential use in their community.

Appendix

SCIENCE FAIR JUDGING GUIDELINES

Science Project Evaluation Criteria

Judging is conducted using a 100-point scale with points assigned to creative ability, scientific thought or engineering goals (II a and b respectively), thoroughness, skill, and clarity. Team projects have a slightly different balance of points that includes points for teamwork. A chart of these point values is located at the end of these criteria. Following is a list of questions for each criterion that can assist you in interviewing the students and aid in your evaluation of the student's project.

I. Creative Ability (Individual – 30, Team – 25)

1. Does the project show creative ability and originality in the questions asked? the approach to solving the problem? the analysis of the data? the interpretation of the data? the use of equipment? the construction or design of new equipment?

2. Creative research should support an investigation and help answer a question in an original way. The assembly of a kit would not be creative unless an unusual approach was taken. Collections should not be considered creative unless they are used to support an investigation and to help answer a question in an original way.

3. A creative contribution promotes an efficient and reliable way to solve a problem. When judging, make sure to distinguish between gadgeteering and genuine creativity.

II.a. Scientific Thought (Individual – 30, Team – 25)

1. Is the problem stated clearly and unambiguously?

2. Was the problem sufficiently limited to allow plausible attack? One characteristic of good scientists is the ability to identify important problems capable of solutions. Neither working on a difficult problem without getting anywhere nor solving an extremely simple problem is a substantial contribution.

3. Was there a procedural plan for obtaining a solution?

4. Are the variables clearly recognized and defined?

5. If controls were necessary, did the student recognize their need and were they correctly used?

6. Are there adequate data to support the conclusions?

7. Does the student recognize the data's limitations?

8. Does the student understand the project's ties to related research?

9. Does the student have an idea of what further research is warranted?

10. Did the student cite scientific literature, or only popular literature (i.e.: local newspapers, Reader's Digest)?

II.b. Engineering Goals (Individual – 30, Team – 25)

1. Does the project have a clear objective?

2. Is the objective relevant to the potential user's needs?

3. Is the solution workable? Unworkable solutions might seem interesting, but are not practical. acceptable to the potential user? Solutions that will be rejected or ignored are not valuable. economically feasible? A solution so expensive it cannot be used is not valuable.

4. Could the solution be utilized successfully in design or construction of some end product?

5. Does the solution represent a significant improvement over previous alternatives?

6. Has the solution been tested for performance under the conditions of use? (Testing might prove difficult, but should be considered.)

III. Thoroughness (Individual – 15, Team – 12)

1. Was the purpose carried out to completion within the scope of the original intent?

2. How completely was the problem covered?

3. Are the conclusions based on a single experiment or replication?

4. How complete are the project notes?

5. Is the student aware of other approaches or theories concerning the project?

6. How much time did the student spend on the project?

7. Is the student familiar with the scientific literature in the studied field?

IV. Skill (Individual – 15, Team – 12)

1. Does the student have the required laboratory, computation, observational and design skills to obtain supporting data?

2. Where was the project done (i.e.: home, school, laboratory, university laboratory)? Did the student receive assistance from parents, teachers, scientists, or engineers?

3. Was the project carried out under adult supervision, or did the student work largely alone?

4. Where did the equipment come from? Did the student build it independently? Was it obtained on loan? Was it part of a laboratory where the student worked?

V. Clarity (Individual – 10, Team – 10)

1. How clearly can the student discuss the project and explain the project's purpose, procedure, and conclusions? Make allowances for nervousness. Watch out for memorized speeches that reflect little understanding of principles.

2. Does the written material reflect the student's understanding of the research? (Take outside help into account.)

3. Are the important phases of the project presented in an orderly manner?

4. How clearly are the data presented?

5. How clearly are the results presented?

6. How well does the project display explain itself?

7. Is the presentation done in a forthright manner, without cute tricks or gadgets?

8. Did the student do all the exhibit work or did someone help?

VI. Teamwork (Team Projects only - 16)

1. Are the tasks and contributions of each team member clearly outlined? How did you delegate responsibilities between each of the team members?

2. Did you designate one person to be the team leader? If so, what were his/her responsibilities? Do you feel that a team leader is a necessary component for a team project? Why or why not?

3. Was each team member fully involved with the project, and is each member familiar with all aspects? How did you approach other team members to make sure the work got done?

4. Did you find it difficult finding the time to work together? What actions did you take to assure that you met as often as necessary to complete the project?

5. Does the final work reflect the coordinated efforts of all team members?

Evaluation Criteria	Individual Projects	Team Projects
Creative Ability	30 points	25 points
Scientific Thought/Engineering Goals	30 points	25 points
Thoroughness	15 points	12 points
Skill	15 points	12 points
Clarity	10 points	10 points
Teamwork	- - - - -	16 points
TOTAL POSSIBLE SCORE	100 points	100 points