

How Acid Rain Affects Pittsburgh and Its Rivers *by Bethany Foster-Wilhelm*

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Overview

Pittsburgh has a serious problem with acid rain, with Pittsburgh's acid rain pH being the worst in the country. Nitrogen oxides and sulfur dioxides are being introduced into the air from a variety of sources. These two gases mix with water vapor to form sulfuric and nitric acids known as acid rain. All rain is acidic, but acid rain has a lower pH .

A FACETS unit on Acid Rain was adopted by the Pittsburgh Public Schools in 2000. This unit was originally approved for the 8th grade, but a year later was designated to the 6th grade. Although the subject matter is very pertinent and interesting, this presented a challenge to the abilities of our 6th grade Science students. First, our students lacked understanding of what acids and bases are. Secondly, our students lacked the library research skills needed to conduct self-guided research. Also, our students lacked computer research skills. In addition, the labs were not written to reinforce the students use of the scientific method. Finally, the lab directions were not teacher or student friendly in that many were too material intensive and the procedures were unclear.

The modifications I made do not deviate from the original standards and key concepts to be taught. I provided needed background information for my students on what an acid and a base were, and knowledge about the pH scale and pH indicators. They needed to understand this before we could even start talking about acid rain.

To address the lack of library research skills, I made adaptations to guide the students through a research paper through the use of a teacher-made outline, criteria and rubric. All three of these documents were given to the students before

the report was researched in the library so that they would have clear expectations. The librarian also addressed how to use a bibliography and how to take notes on index cards entitled with the key concepts. The students were assigned homework to find a book or article on acid rain, and then were shown how to take this information and fill in the bibliography and note cards.

Since our students lacked computer research skills, they were first guided to specific sites on acid rain in Pittsburgh. This is so that they would understand that their own city has the worst acid rain problem in the country. In order to fill in any gaps in their research, they were then provided with web addresses for more general information on acid rain. They were to finish this research on their own, and bring their completed notes to Communications class to get help in writing their research paper.

To supplement their research, two guest speakers from local universities were brought in to talk about acid rain. This served to clear up any persistent misconceptions, demonstrate some chemistry of acid rain and give a forum for students to ask their own questions. I feel that this provided the students with better understanding than the books and web sites did.

To address the issue of the FACETS labs not guiding the students through the scientific method, I retyped the labs to include a problem, hypothesis, control and variable. The materials were numbered and included exact amounts. The procedures were rewritten in short command statements that could easily be replicated. A data table was provided for collecting data while doing the experiment. The conclusion required students to analyze their data for patterns, and tell whether their hypothesis was correct and why or why not.

Finally to address the issue of being teacher and student friendly, I modified the materials to use items easily purchased in a supermarket and used less of the items. I rewrote many of the materials and procedures to include these new items. I also broke the procedures down into smaller, clearer steps.

Rationale

Introduction to Acid Rain

The first serious acid rain fall may have occurred about 65 million years ago when a six-mile wide asteroid impacted the Earth. This asteroid would have created a layer of dust that surrounded the Earth and therefore caused highly acidic rain. This and other factors may have led to the extinction of two thirds of Earth's species, including the dinosaurs (Rosenberg, 1999).

The first person to coin the term “acid rain” was Robert Angus Smith, an English scientist in 1856. “It has often been observed that the stones and bricks of buildings crumble more readily in large towns where much coal is burnt. I was led to attribute this effect to the slow but constant action of acid rain.” (Encyclopedia of the Atmospheric Environment, 2003).

Acid rain occurs when pollutants combine with water vapor. There are two forms of acid rain, wet and dry deposition. Wet deposition can fall in any form of precipitation such as rain, sleet, hail, snow, mist and fog. Dry deposition is microscopic sulfate and nitrate particles in the forms of dust, sand, ash, soot, smoke, pollen and exhaust.

These pollutants are often carried long distances, so the pollution you create affects someone downwind of you. The prevailing winds blow from the west to the northeast. The acid rain problem is the worst in Eastern Europe in areas such as Germany’s Black Forest. In the US, it is the worst in northwest Pennsylvania due to pollution in Ohio, Kentucky and Indiana. Pennsylvania has actually sued these states for the impact upon our own state (Schroth, 2003).

Causes of Acid Rain

Acid rain is caused by a variety of sources; some are natural causes such as lightning, volcanoes, rotting vegetation and forest fires, but humans cause most acid rain. A common misconception among my students is that acid rain comes from polluted water. They believe this because they know about the water cycle. But only the water evaporates back into the atmosphere, not the acids because the acids are too dense. The natural causes have not contributed to our more acidic rain, but man-made activities have.

My students also believe that very strong acids, 0-to1 pH, cause acid rain. All rain is slightly acidic with a pH of 5.6, but the pH of acid rain can range from 2 to 5.5. The two main gases that cause acid rain are sulfur dioxide and nitrogen oxides. Because of their solubility, when they combine with water vapor they become sulfuric acid (SO_2) and nitric acid (NO_x).

The early causes of sulfuric acid being produced in Pittsburgh were from the use of coal in industrial furnaces, trains, steamboats and fires burned within peoples’ homes (wqed, 2003). Later, nitric acid increased with the use of internal combustion engines in cars. Today, in the United States, 70% of sulfur dioxide emissions come from power plants that burn coal, while 43% of nitrogen oxides are from cars. These figure are different in Canada, with 61% of sulfur dioxides coming from industry and 60% of nitrogen oxides coming from cars (Encarta, 2001). Ammonium, carbon

dioxide, methane and propane also contribute to acid rain, but to a much lesser extent (Farnham, 1999).

The range of pH of acid rain in Pittsburgh is from 3.9 to 5.5, with an average pH of 4.26 in 2001, as measured by the Penn State monitoring device. The areas 50 to 75 miles downwind from a coal burning power plant have the worst problem with acid rain. Although we have the worst acid rain in North America, the numbers are improving. Sulfate emissions from utilities have decreased due to the Clean Air Act of 1970 (Carr, Schroth and Warnock, 2003).

Effects of Acid Rain

The causes and effects of acid rain interact with other environmental problems to produce synergistic effects, such as trees dying from a combination of acid fog, insects and acidic soil. A common misconception among my students is that acid rain burns your skin as a strong acid would. They also believe that the effects are immediate to both living and nonliving things. Acid rain does affect living creatures and man-made materials, but over a period of time. It affects the health of people, birds and aquatic life, as well as plants.

Acid rain can change soil pH, which can erode into streams, killing plants including crops and trees. When soil pH is changed, the nutrients plants need are taken away and toxic metals can accumulate. Trees on mountaintops are especially vulnerable since they sit in acid fog. First the acids attack the protective waxy layer on the needles, and then the needles turn yellow and fall off. Other factors may get involved, eventually killing the trees. In Pittsburgh, Mt. Washington was stripped of vegetation in the early 1900's due to sulfuric acid. It was known as Coal Hill in those days.

The acids from acid rain and acid mine drainage cause metals, particularly aluminum and mercury, to be leached from the streambeds and surrounding banks. These metal particles can accumulate in fish bodies and stick to fish gills and fish eggs. Mucus sticks to the fishes' gills preventing them from absorbing oxygen. It causes smaller fish and lower body weights, making fish less able to compete for food. At a pH of 5, most fish eggs will not hatch. These effects can lead to a decrease in biodiversity.

Heavy snow melts and heavy rainfalls can lead to episodic acidification with a pH as low as 2. Although it is temporary, it can lead to "fish kills", particularly in the sensitive lakes of the Adirondacks and Appalachians. This can affect the whole food chain. Water sources least affected by acid rain are seawater because salt is a natural buffer (epa.gov/airmarkets, 2002). Some other natural buffers are wetlands and beaver dams, as well as limestone-lined riverbeds.

Some other ways that acid rain can affect the environment are reducing visibility, and preventing plants from photosynthesizing because they are covered by a layer of dust. It has diminished our beautiful displays of foliage in the fall (Schroth,2001). I always believed that the diminished color was due to weather changes from a lack of rain or unseasonable temperatures, but in our case, it is also due to the acid rainfall.

Acid rain can affect human health, but not by burning your skin, swimming in it, or drinking it, as some of my students thought. The dry deposition or small particles can get into your lungs. It is believed to contribute to asthma, bronchitis, emphysema, influenza and other respiratory illnesses. I wonder if the increase in childhood asthma is caused in part by acid rain.

The affects acid rain has on man-made materials are it damages buildings, statues, bridges and car paint. Acid rain can rust bridges, which has a serious effect on Pittsburgh with our 1800+ bridges. The dry deposition from acid rain can still be seen on our buildings as filth. Limestone, marble and sandstone are especially vulnerable stones due to their softness. These devastating effects can be seen on the Parthenon in Greece, the Taj Mahal in India and the Mayan ruins of Chichen Itza , as well as other irreplaceable cultural artifacts (Earwood, 1998).

One positive effect of acid rain may be the slowing down of global warming due to the sulfates in the upper atmosphere that reflect some sunlight back to space. It is believed that this may have delayed warming by several decades in the middle of the 20th century (Encarta, 2001).

Solutions to/ Prevention of Acid Rain

Whether we make the environment a priority or not depends upon what is going on in the world at that time. Historically, wars take financial precedence over the environment. In 1939, Pittsburgh developed the Smoke Control Commission to improve both health and the economy. But when World War II broke out in 1941, the environment was put on the back burner. The industries that were producing for the war effort made additional pollution (PA Air and Water Pollution, 1996-1998).

My students wanted to know what the statistics were for acid rain in Pittsburgh during the time that steel mills were most active. But Environmental Science is a fairly new science, so there are not many acid rain statistics before the 1960s (Schroth, 2003). We do know this: in the post war years, new legislation was enacted. In 1947, smoke control laws were in effect for the entire county. By 1954, the Weather Bureau reported a 94%

reduction of the hours of “heavy smoke”, although steel mills were running at full capacity. Also, plants began to grow again on hills and riverbanks (wqed, 2003).

Another factor that determines whether the environment is a priority is the standard of living within that country. Solutions to acid rain and other environmental concerns are a luxury that third world nations cannot afford to fix (Schroth, 2003). Yet there is funding for third world countries to limit pollution and provide alternative energies. One such program is SELF, or the Solar Energy Light Fund. They empower rural people without electricity to self-finance solar panels. This eliminates the undesirable burning of limited wood, kerosene and diesel (Cleaner Times, 2003).

Since coal is the leading producer of sulfur dioxides, I will focus here on some solutions to reducing SO₂ emissions. We can use low sulfur coal (Pittsburgh has high sulfur coal deposits), clean the coal before burning it, and attach scrubbers to the smokestacks. Scrubbers work by using water and powdered limestone to dissolve sulfur, which is highly soluble. This dissolved sulfur can be recycled and reused.

Other forms of electricity can be used besides coal burning power plants. Some alternative forms of electricity are solar energy, hydropower, wind energy, nuclear energy and geothermal energy. Of these energies, nuclear and hydropower are the most widely used in this country. Nuclear, hydropower and coal are currently the cheapest forms of energy (epa.gov/airmarkets, 2002). Burning the methane produced by natural materials found in landfills, creates a source of renewable electricity (Cleaner Times, 2003). This is an exciting way to reduce organic waste in landfills and create cleaner energy.

Since cars are one of the leading sources of nitrogen oxide emissions, I will focus here on alternative ways to power cars and other forms of transportation. The introduction of unleaded gas, the catalytic converter and emissions inspections all helped to reduce the amount of nitrogen oxides given off. Instead of the gas powered internal combustion engines we use now, we could use natural gas powered vehicles, battery powered cars, fuel cells and liquid hydrogen powered vehicles. Two alternative fuels that are still being researched are the grease from french fry makers at fast food restaurants and diesel made from soybeans.

The alternative form of transportation most of my students were most familiar with was electric and hybrid cars. My students also suggested walking, riding bikes, scooters, skateboards and carpooling. Many of the students did not understand that mass transit was a solution because they just see buses and trains as giving off more pollution than a car. I explained that many more people could be in one bus or one train than one car. Trains are the most environmentally

sound form of transportation because they are fifteen times more fuel efficient than a car (Corson, 2003).

Some other steps that average citizens can take to conserve energy is to insulate their homes, buy energy-efficient appliances, turn down their thermostats and turn off electricity when it is not in use. In addition, they can stay informed and elect government officials who can make a difference. Some Pittsburgh Public School students take part in Creek Connections, which tests the water quality of local waterways. This makes the students more aware of water and air pollution issues.

Some preventative legislation was the Clean Air Act of 1970, which reduced automobile and factory emissions. Amendments in 1990 set stricter limits on emissions and allowed public utilities to sell or bank unused pollution credits. The Federal Clean Water Act of 1999 includes an “anti-degradation policy”, which promotes maintaining and protecting existing waterways. This fund collects money from those that violate these laws (creekconnections, 2003). When the Acid Rain Program is fully implemented in 2010, public health benefits of \$50 billion dollars a year are expected to be saved due to reduced deaths, hospital stays and emergency room visits (epa.gov/airmarkets, 2002).

Since acid rain crosses national boundaries, international cooperation was needed. The Long-Range Transboundary Air Pollution Agreement of 1988 was sponsored by the United Nations to reduce nitrogen oxide levels. Other international laws were passed which all helped to reduce sulfur dioxide emissions. Changes have been seen in the reduction of acidic lakes and streams in Europe, but not in Canada and the United States (Encarta, 2001).

Once the environment is harmed, there are ways to reduce the effects of acid rain. Lime can be added to waterways and soil to reduce acidity. Fertilizer can be added to nutrient-poor soil. Statues made of limestone or marble can be painted with a protective coating to prevent erosion. The latest technology in bridge building is to use plastics instead of metals to prevent corrosion. Engineers are still in the experimental phases of this new material (Rehak, 2003). Stainless steel and aluminum are the least vulnerable metals.

Summary of Acid Rain

The main causes of acid rain are cars with internal combustion engines, factories and coal burning power plants. There many viable alternatives, but we must be willing to change and to monetarily invest in our future. At the outset, these solutions are more expensive, but over the long run, we save money.

Acid rain affects our quality of life with decreased health and increased medical bills. It affects our aesthetics with reduced visibility of skylines and sunsets, fall foliage that is less spectacular, the destruction of mountaintop forests, the creation of rust, dirty buildings, eroded statues and the destruction of cultural antiquities.

Because of acid rain, our food chain is also affected. It is risky to eat fish because of the toxic metals that can accumulate in their bodies. Acid rain affects the soil, making nutrients less available to plants and allowing toxic metals to accumulate in the soil. This makes me wonder if our vegetables are less nutritious than they used to be and if the animals that eat them are less nutritious as well. Is this one of the causes of all the cancer that is occurring at such an alarming rate?

Acid rain is an international problem, yet you don't hear much about it in the news. My role as a citizen and a teacher is to conserve energy and teach the next generation of policymakers about this problem and its solutions. My students are now empowered by their knowledge to make informed decisions about how their actions affect the environment. Their sharing of this knowledge with their families may even impact the behaviors of their parents and siblings.

Objectives

First, students will get a background on acids and bases before they learn what acid rain is. Students will learn that the pH scale is from 0 to 14, with the strongest acid being a 0, the weakest acid being 6.9, neutral being 7, the strongest base being 14 and the weakest base being 8. Through labs, they will learn how to determine if a liquid is an acid or a base by using litmus paper, cabbage juice, bromothymol blue or phenothalien. They will learn how to determine the strength of an acid or a base by using pH paper or a pH meter. They will learn that we eat many weak acids, and that many bases are used for cleaning. Also, students will discover that acids and bases can cause physical and chemical reactions. These concepts will address Science standard #1, 2 and 6: All students explain and demonstrate basic science concepts and principles. All students apply skills of the scientific method.

Then, students will learn that acid rain is not just rain, but all forms of precipitation and dry deposits. Students will learn that all rain is slightly acidic, but acid rain is more acidic therefore it is harmful. They will learn that acid rain is caused by man-made sources, as well as nature. They will learn that acid rain affects living things as well as man-made materials. Students will discover that acid rain in Pittsburgh is the worst in the country, but that it is improving. They will also learn that acid rain can be prevented, and that they can play a role in this prevention. These concepts will address Science standard #4 and Environmental standard #5: All students explain the relationship among science, technology and

society. All students demonstrate an understanding of the local, national and international implications of environmental and ecological issues.

Finally, students will conduct research and write a report on the causes, effects and solutions to acid rain. They will illustrate two out of these three ideas with an environmental art project. These concepts will once again address Science standard #4 and Environmental standard #5. In addition it will cover Communications standard #4: All students write for a variety of purposes in all subject areas.

Strategies

As the teacher, you will need to have a solid background on the causes, effects and solutions to acid rain in your area. I have provided some necessary background information within the previous section entitled “Rationale”. You can also find additional information, both general and specific to Pittsburgh, by using the sources from my “Annotated Bibliography”.

First you need to assess your students’ prior knowledge of acids and bases and acid rain. One way is to have students do a web map with a partner. Then discuss what your students believe, but do not correct their misconceptions as this curriculum is inquiry based. It is hoped that they will correct their own misconceptions over time through class readings and discussions, performing labs in cooperative groups, asking questions of guest lecturers and finally through conducting independent research.

Before your students begin their research paper, provide them with an outline of the research paper, 4 index cards (one for each number on the outline), a criteria, rubric and a format for the bibliography. Then guide them through one of their printed sources about acid rain that they found for their homework.

Give homework related to the key concepts to reinforce the information. To assess your students understanding, give biweekly written assessments on such topics as acids and bases, physical and chemical changes and the causes, effects and solutions to acid rain.. By writing their own lab on acid rain, you will be able to determine their ability to follow the scientific method and show their understanding of the causes and effects of acid rain.

As a culminating activity, the students created art through the use of photographs, drawing or computer-generated pictures to illustrate the causes, effects and solutions to acid rain. Two images were simultaneously presented on folded mat board so that if you looked from one direction you would see a cause of acid rain. But if you looked from the other direction you would see a solution to acid rain.

For example, exhaust from cars produces acid rain. Riding a bike would be a solution to acid rain. These pictures were presented to their peers along with a brief explanation, and then were displayed as environmental art in venues where other children could view them and learn about acid rain.

Classroom Activities

Day One

Objective: SWBAT share their prior knowledge about acids. (Science #1 and 2)
Have students work in pairs to create a web map on acids. Start by brainstorming. At this point, they may not know that bases exist and they may fail to mention acid rain. You will also hear some misconceptions, but do not correct them.

Day Two

Objectives: SWBAT use a Venn diagram to compare acids and bases. (Science #1 and 2)
Teacher preparation: Create and make copies of Venn diagram templates. Provide page numbers for background information on acids and bases from “Science Interactions”.

Have students work in the same pairs to create a Venn diagram. Using the supplemental text, “Science Interactions”, students will gather information on acids and bases. They will compare and contrast the differences of acids and bases with the similarities being listed where the two circles overlap.

Day Three

Objective: SWBAT sort common acids, bases and neutrals into their correct categories by using the pH number. (Science #1 and 2)
Teacher preparation: Create and make copies of acid, base and neutral chart templates. Create an overhead with a variety of common acids, bases and neutrals with their pH numbers.

Read about and discuss the pH scale. Write the pH of common items on an overhead, and have the students sort them into the correct categories of acids, bases and neutrals on a chart that you provide. Put a copy of the chart on the overhead, and determine as a class if the items were written in the correct categories.

Day Four/ Five

Objective: SWBAT test the pH of common household items. (Science #6)
Teacher preparation: Prepare lab kits with 8 dropper bottles of a variety of acids, bases and neutrals and add litmus and pH paper. Make copies of the lab.

Periods needed: 2 days

Lab procedures: On the first day, have students predict the pH of each item and then test each item with litmus and pH paper. On the second day, have students complete conclusion questions and discuss them as a class.

Day Six/ Seven

Objective: SWBAT determine which samples are acid rain. (Science #6)

Teacher preparation: Fill 3 separate bottles with a base, acid and a neutral. Fill 3 more bottles with varied combinations of distilled water and vinegar to simulate rain. Provide each group with BTB and pH paper. Make copies of the lab.

Periods needed: 2 days

Lab procedures: On the first day, have students test each liquid with BTB and pH paper and record data. On the second day, compare and discuss the results.

Day Eight/ Nine/ Ten

Objective: SWBAT determine how acid reacts with marble and steel. (Science #5 and 6)

Teacher preparation: Set up lab kits with marble or steel, distilled water or vinegar and a balance.

Periods needed: 4 days

Lab procedures: On the first day, have students familiarize themselves with how to use a balance by finding the mass of different common items. On the second day, have students find the mass of marble or steel in distilled water or vinegar. Then they will predict what the masses will be two weeks from then. Most students will predict that the masses will be less due to evaporation. On the third day, they will share their results with the other lab groups, and record them in their data table. Two weeks later, they will see that the masses are the same and record the masses of the other lab groups in their data table.

Day Eleven

Objective: SWBAT observe the rates of chemical reactions. (Science #1, 2 and 6)

Teacher preparation: Prepare lab kits with baking soda, water, vinegar, measuring spoons and a beaker.

Periods needed: 2 days

Lab procedures: Students pour different amounts of vinegar into the same amount of baking soda. They time the reaction and measure the foam. On the second day, they compare their results and answer conclusion questions.

Day Twelve/ Thirteen

Objective: SWBAT conduct research on acid rain and write a report about it. (Science #1, 2 and 4; Environmental and Ecology #5; Communications #4)

Periods needed: 2 days of library research

Teacher preparation: Make copies of a criteria, rubric and outline for acid rain research. Create and make copies of a bibliography template.

Materials: 4 index cards per student, 1 folder per lab group, criteria, rubric and outline.

Day Fourteen/ Fifteen

Objective: SWBAT use provided Internet sites to find information on acid rain. (Science #4)

Teacher preparation: Familiarize yourself with the information on the web sites that I provided in the appendices.

Periods needed: 2 or more days of computer research

Day Sixteen/ Seventeen/ Eighteen

Objective: SWBAT write own lab on acid rain. (Science #6)

Materials: Copies of previously completed labs, criteria for creating own acid rain lab

Periods needed: 3 days

Procedure: In lab groups, write a problem, hypothesis, control and variable. On day two, write the materials and procedures. On the third day, finish any uncompleted sections.

Day Nineteen/ Twenty/ Twenty One/ Twenty Two

Objective: SWBAT create art that shows the causes, effects or solutions to acid rain. (Science #4)

Teacher preparation: Make an example of the art project. Score a piece of cardboard for every pair of students so that the cardboard forms an accordion. Make copies of criteria to give to each student.

Materials: images of causes, effects and solutions to acid rain, rulers, scissors, glue sticks, paper, mat board, sample project, criteria

Periods needed: 4 days

Procedure: In the computer lab, have students print out two colored pictures depicting causes, effects or solutions. The combinations they could have are cause and effect, cause and solution or effect and solution. On the second day, measure and draw a line at every inch along the back of the pictures. Cut out the

strips. On the third day, put your strips in order, and then intersperse your strips with your partners. Paste the strips onto the mat board. Write a brief caption to explain the meaning of the pictures. On the fourth and final day, students present their pictures and captions to the class. The teacher grades the project based on the criteria in the “Appendices”.

Annotated Bibliography

Books and Pamphlets

Aldridge, A. et al. Science Interactions. Glencoe McGraw-Hill. Columbus, OH, 1995 (pp.186-202).

This is a supplemental textbook for Pittsburgh Public School Middle School Science, which includes a chapter on acids and bases.

“Cleaner Times”. Green Mountain Energy. Eastern Edition, Spring 2003.

A quarterly newsletter that provides energy saving tips and explores the latest research on new solutions to saving energy.

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Advances in scientific understanding since the passage of the 1970 and 1990 Clean Air Act Amendments.

Rosenberg, M. The Handy Geography Answer Book. Visible Ink Press. Canton, MI, 1999.

Provides explanations of a variety of areas related to geography and world cultures.

Websites and Online Sources

Corson, Stephanie. Private Transportation vs. Mass Transit: The Environmental Aspects. Access on 3 Feb. 2003.

<http://www.cas.usf.edu/philosophy/mass/Stephanie.html>

Extols the virtues of mass transportation over the use of cars to reduce acid rain.

Earwood, Aaron. Acid Rain’s Monumental Effects. Spring 1998. Access on 1 March 2003.

<http://ga-mac.uncc.edu/faculty/haas/geol3190/termpap/earwood/>

Discusses how acid rain forms and its affects upon man-made structures.

Encarta. “Acid Rain”, Microsoft Corporation, 2001.

Gives information on the worldwide causes, effects and solutions to acid rain.

Encyclopedia of the Atmospheric Environment. Access on 2 Feb. 2003.

<http://www.doc.mmu.ac.uk/aric/eae/english.html>

Gives an overview of the causes, effects and solutions to acid rain worldwide, as well as information on weather and air pollution.

Environmental Health & Safety Online. Acid Rain Information. Access on 1 March 2003.

<http://www.ehso.com/AcidRain.htm>

Provides an overview of the EPA Acid Rain Program.

EPA's Clean Air Market Programs. Updated 28 Oct. 2002. Access on 3 Feb. 2003.

<http://www.epa.gov/airmarkets/acidrain>

Discusses causes, effects and solutions to acid rain in the US.

Farnham, Shayne. Acid Rain. Updated 26 April 1999. Access on 1 March 2003

<http://www.ems.psu.edu/info/explore/AcidRain.html>

Focuses on the meteorology of acid rain and the affects of acid rain on minerals and aquatic life.

Pittsburgh History Series: Rivers and Valleys: Cleaning Up After Ourselves. Access on 2 Feb. 2003.

<http://www.wqed.org/erc/pghist/units/rivers/rivers5.html>

Discusses the history of air and water pollution in Pittsburgh.

Southwestern Pennsylvania Waterways. Access on 2 Feb. 2003.

<http://creekconnections.allegheny.edu/SouthwestPAWaterwayInfo.html>

Information on water quality from a group that sponsors grants for teachers and students to conduct local water quality testing.

Other References

Acid Rain Workshop. Conducted by Carr, H., Schroth, E and Warnock, G. Carnegie Mellon University, 15 February 2003.

Provides background material, mentions causes and effects specific to Pittsburgh and includes experiments.

“PA Air and Water Pollution”. Sponsored by Pennsylvania Environmental Council and Duquesne Light, 1996-1998.

Documentary on the historical evolution of air and water pollution in Pittsburgh.

Rehak, D. Lecture at CMU about bridges. April 2003.

PTI seminar presentation of the history and architecture of Pittsburgh bridges.

Schroth, E. Personal interview of Duquesne professor. April 2003.

Research from a local authority on the causes and effects of acid rain in Pennsylvania.

Appendices

Outline for Acid Rain Report

- I. Introduction**
 - A. Definition**
 - 1. prevailing winds
 - 2. chemicals
 - B. Interesting fact**
 - C. Focus**

- II. Causes**
 - A. Factories**
 - B. Car exhaust**
 - C. Power plants (electricity)**
 - D. Natural**
 - 1. lightening
 - 2. volcanoes
 - E. Relevant to Pittsburgh**
 - F. Other**

- III. Effects**
 - A. Health**
 - B. Water and aquatic life**
 - C. Plants**
 - D. Man-made materials**
 - E. Relevant to Pittsburgh**

- IV. Solutions**
 - A. Scrubbers**
 - B. Catalytic converters**
 - C. Alternative transportation**
 - D. Stricter laws**
 - E. Other sources of electricity**
 - F. Other**

- V. Conclusion**

- A. Short summary of key points**
- B. Statement or question**

Completed Outline for Teacher to Check Acid Rain Note cards and Report

VI. Introduction

A. Definition

- 1. prevailing winds**
 - a. travels from west to the northeast**
- 2. chemicals**
 - a. nitrogen oxide a.k.a. nitric acid a.k.a. No_x**
 - b. sulfur dioxides a.k.a. sulfuric acid a.k.a. SO_2**
- 3. any from of precipitation and dry deposits**
- 4. pollutants combine with moisture to form acid rain**
- 5. pH is more acid than normal rain (5.6)**
 - a. ranges form 2 to 5.5**

B. Interesting fact

- 1. Pittsburgh has the worst acid rain in the country.**
- 2. The water in Sweden is so acidic it can turn your hair green.**

C. Focus

VII. Causes (*not from evaporation or acid mines*)

A. Factories

B. Car exhaust

- 1. tail pipes give off nitrogen oxides**

C. Power plants (electricity)

- 1. burn coal which gives off sulfur dioxide**
- 2.**

D. Natural

- 6. lightening
- 7. volcanoes
- E. Relevant to Pittsburgh
 - 1. mostly car exhaust, power plants and factories
 - 2. pH of 3.9-5.5
 - 3. pollution comes from the west
 - 4. PA coal is high in sulfur
- F. Other
 - 1. power tools
 - 2. pleasure boats
 - 3. decaying plants
 - 4. sea spray
 - 5. forest fires

VIII. Effects (*does not burn skin*)

- A. Health
 - 1. contributes to respiratory problems
 - a. asthma
 - b. bronchitis
- B. Water and aquatic life
 - 1. makes water more acidic (lowers pH)
 - 2. kills fish eggs as well as grown fish
 - 3. leaching or dissolving of toxic metals
- C. Plants
 - 1. acid mist or fog coats entire leaf
 - 2. burns leaves
 - 3. can kill plants
- D. Man-made materials
 - 1. corrodes or rusts metals
 - 2. eats away car paint
 - 3. erodes or wears away buildings and statues
 - a. limestone
 - b. marble
- E. Relevant to Pittsburgh
 - 1. rusts bridges

2. reduces visibility

IX. Solutions

A. Scrubbers

- 1. put on top of smokestacks of factories**
- 2. traps pollutants in water**

B. Catalytic converters

- 1. put on tail pipes of cars**
- 2. traps bad gases and lets out good gases**

C. Alternative transportation

- 1. carpool**
- 2. buses, trolleys, trains**
- 3. ride bikes, scooters, skateboard**
- 4. walk, jog**
- 5. electric or hybrid cars**

D. Stricter laws

- 1. emission testing**
- 2. Clean Air and Clean Water Acts**

E. Other sources of electricity

- 1. solar energy**
- 2. hydro energy or water**
- 3. geothermal energy**
- 4. nuclear energy**
- 5. wind power**

F. Other

- 1. turn off electricity when not in use**
- 2. coat statues to prevent erosion**
- 3. clean coal before it is used**
- 4. use coal with less sulfur**
- 5.**

X. Conclusion

A. Short summary of key points

B. Statement or question

Criteria for the Acid Rain Report

- 1. Within the introductory paragraph, define acid rain, include an interesting fact and establish the focus of the paper.**
- 2. Explain at least 5 causes of acid rain.**
- 3. Explain 5 effects of acid rain.**
- 4. Explain at least 5 solutions, or ways to prevent acid rain.**
- 5. Within the conclusion, summarize the key points. Bring the report to a close by making a statement or asking a question.**

Rubric for the Acid Rain Report

Advanced	Proficient	Basic	Below Basic
Introduction includes a detailed definition, interesting fact and establishes a clear focus for the report	Introduction includes a definition, fact, and establishes a focus for the report	Includes a limited definition, fact and focus for the report	Most of the important information is missing, unclear, or incomplete
Clearly explains more than 5 causes	Explains 5 causes	Limited explanation of 3 or 4 causes	Most of the important information is missing, unclear, or incomplete
Clearly explains 5 effects	Explains 5 effects	Limited explanation of 3 or 4 effects	Most of the important information is missing, unclear, or incomplete
Clearly explains 5 solutions/ preventions	Explains 5 solutions/ preventions	Limited explanation of 3 or 4 solutions/ preventions	Most of the important information is missing, unclear, or incomplete
Conclusion includes a clear and accurate summary of key points and statement/ question	Conclusion provides a sense of closure that fulfills its stated purpose	Conclusion is limited and may not provide a sense of closure	Conclusion is incomplete with little or no sense of closure
Few, if any errors in conventions	Few errors in conventions	Errors in conventions disrupt reading	Many errors in conventions seriously disrupt reading

Relevant information is drawn from 3 or more sources.	Relevant information is drawn from at least 2 sources.	Information is drawn from 1 source.	No reliable sources were provided.
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Criteria for Creating Own Acid Rain Lab

Circle the number of points for the criteria that you followed.
Write your total points.

1. State where you got the idea. (If it is from a book, include the title and author. If it is from a previous lab, include the lab title. Or maybe it's your own idea.) 10 pts.
2. State the problem in the form of a question. 10 pts.
3. The hypothesis should answer the question, and include a what and a why (because) statement. 10 pts.
4. State the controls and variable. 10 pts.
5. Materials are numbered with exact amounts and are specific for later replication. 10 pts.
6. Procedures are numbered and easy to read and are specific for later replication. 10 pts.

Total 60 pts.

Your Total

Criteria for Creating and Presenting the Acid Rain Art Project

- ❖ shows a correct cause, effect or solution to acid rain
10 pts.**
- ❖ clear written description of the picture
10 pts.**
- ❖ neatness
10 pts.**
- ❖ presenting picture to the class
10 pts.**

Standards

The following standards have been adopted by Pittsburgh Public schools in accordance with the Pennsylvania State Standards on Communications, Science and Technology and Environment and Ecology.

The Communications Standard that is covered is #4: All students write for a variety of purposes. The Science and Technology standards that are covered are #1, 2, 4 and 6: All students explain and demonstrate basic science concepts and principles. All students explain the relationship among science, technology and society. All students apply skills of the scientific method.

The Environmental and Ecology standard that is covered is #5: All students demonstrate an understanding of the local, national and international implications of environmental and ecological issues