**DEP Environmental Education Curricula**

**Lesson Plan**

**GRADE/LEVEL: Middle School**

**LESSON TITLE: Air Pollution - Acid Rain**

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| **Next Generation Science Standards** |  |  |
| **MS-ESS3-3** | **MS-ESS3-3** | Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. |
|  | **Science and Engineering Practices** | [**Constructing Explanations and Designing Solutions**](http://www.nap.edu/openbook.php?record_id=13165&page=67) **-** [Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.](http://www.nap.edu/openbook.php?record_id=13165&page=67) |
|  | **Disciplinary Core Ideas** | [**ESS3.C: Human Impacts on Earth Systems**](http://www.nap.edu/openbook.php?record_id=13165&page=194) **-** [Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth’s environments can have different impacts (negative and positive) for different living things.](http://www.nap.edu/openbook.php?record_id=13165&page=194)[Typically, as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.](http://www.nap.edu/openbook.php?record_id=13165&page=194) |
|  | **Crosscutting Concepts** | [**Cause and Effect**](http://www.nap.edu/openbook.php?record_id=13165&page=87) **-** [Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation.](http://www.nap.edu/openbook.php?record_id=13165&page=87) |
| **Objectives** |
|  |  | **Objective 1:** Determine the natural and manmade contributions to acid rain formation.**Objective 2:** Demonstrate understanding of the pH scale.**Objective 3:** Determine the effects of acid rain on the environment and human health.**Objective 4**: Explore options for reducing manmade contributions to acid rain formation. |
| **Background** |  |  |
| **Teacher Version**Selected Materials from … | **Source:** Learning About Acid Rain: https://www3.epa.gov/acidrain/education/teachersguide.pdf |
| **Vocabulary** |  |  |
|  | **Acidic** | Describes a substance with a pH less than 7. |
|  | **Acid Rain** | Rain that has become acidic by contact with air pollution. Other forms of precipitation, such as snow and fog, are also included in the term acid rain or wet acid deposition. |
|  | **Basic** | Describes a substance with a pH greater than 7. Also described as alkaline. |
|  | **Buffer** | A substance, such as soil, bedrock, or water, capable of neutralizing either acids or bases. |
|  | **Carbon Dioxide** | A naturally occurring gas made of carbon and oxygen. Sources of carbon dioxide in the atmosphere include animals, which exhale carbon dioxide, and the burning of fossil fuels and biomass. |
|  | **Causation** | The act of causing something. |
|  | **Correlation** | A mutual relationship or connection between two or more things. |
|  | **Deposition** | When chemicals like acids or bases fall to the Earth’s surface. Deposition can be wet (rain, sleet, snow, fog) or dry (gases, particles). |
|  | **Ecosystem** | All the living and nonliving things in an area, as well as the interactions between them. |
|  | **Haze** | When particles of dust, pollen, or pollution make the air less clear, and limit visibility. |
|  | **Hydrologic Cycle** | The movement of water from the atmosphere to the surface of the land, soil, and plants and back again to the atmosphere. |
|  | **Nitrogen Dioxide** | A family of gases made up of nitrogen and oxygen commonly released by burning fossil fuels. |
|  | **Ozone** | Chemical that is made up of three oxygen atoms joined together, and found in the Earth’s atmosphere. “Good” ozone is found high in the Earth’s atmosphere; “Bad” ozone is found low to the ground. |
|  | **Particulate Matter** | Tiny solid particles or liquid droplets suspended in the air. |
|  | **pH Scale** | The range of units that indicate whether a substance is acidic, basic, or neutral. This scale ranges from 0 to 14. |
|  | **Sulfur Dioxide** | A naturally occurring gas made of sulfur and oxygen that is also released when fossil fuels are burned. |
| **Introduction**Acid rain forms when clean rain meets pollutants in the air, like sulfur dioxide (SO2), carbon dioxide (CO2), and nitrogen oxides (NOX). Although sulfur dioxide and carbon dioxide occur in the air naturally, burning fossil fuels adds more of these chemicals to the air. When these pollutants are released into the air, they mix and react with water, oxygen, and other chemicals to form acid rain. Acid rain then falls to the Earth where it can damage plants, animals, soil, water, and building materials.Despite its name, acid rain does not burn and cannot directly harm people. However, the pollutants that cause acid rain, especially SO2 and NOX, can react with other pollutants in the air, forming substances like Particulate Matter and ground level Ozone, which can sometimes make people sick.The consequences of air pollution are important to understand because air pollution can be carried long distances and affect large areas. This means that pollution from towns hundreds of miles away may be affecting your community.**Acid and Base**A substance that is neither acidic nor basic is neutral. The pH scale measures the acidic or basic level of a substance. The pH scale ranges from 0 to 14. A pH of 7 is neutral, while a pH less than 7 is acidic and a pH greater than 7 is basic. Pure water is neutral. However, when chemicals are mixed with water, the mixture can become either acidic or basic.Acid rain is rain that is more acidic than it should be. Acid rain is a complicated problem affecting soil and water chemistry, as well as the life cycles of plants and animals on land and in the water.**Air Pollution and Acid Rain**Scientists have discovered that air pollution from the burning of fossil fuels is the major cause of acid rain. Power plants and factories burn coal, oil, and natural gas to produce the electricity we need to do all kinds of things, like light our homes. Cars, trucks, and airplanes also run on gasoline, a fossil fuel.Burning fossil fuels sends smoke and fumes into the atmosphere, or the air above the Earth. In the air, these pollutants combine with moisture to form acid rain. The main chemicals in air pollution that create acid rain are sulfur dioxide (SO2) and nitrogen oxides (NOX). Acid rain usually forms high in the clouds where SO2 and NOX react with water and oxygen. This forms sulfuric acid and nitric acid in the atmosphere. Sunlight increases the speed of these reactions, and therefore the amount of acid in the atmosphere. Rainwater, snow, fog, and other forms of precipitation then mix with the sulfuric and nitric acids in the air and fall to Earth as acid rain.**Acid Precipitation**Water moves through the air, streams, lakes, oceans, and every living plant and animal in the hydrologic cycle. When water droplets form and fall to the Earth they pick up particles like the dust and chemicals that float in the air. Even clean, unpolluted air contains particles such as dust or pollen. Clean air also contains naturally occurring gases such as carbon dioxide (CO2). The interaction between the water droplets and the CO2 in the atmosphere gives rain a pH of 5.6, making even clean rain slightly acidic. However, when rain contains pollutants, especially SO2 and NOX, the rainwater can become very acidic.About half of the acidity in the atmosphere is deposited onto buildings, cars, homes, and trees as particles and gases. This process is called dry deposition.Dry deposition (gases and particles) is sometimes washed from trees and other surfaces by rainstorms. When that happens, the runoff water contains acid from acid rain and dry deposition, making the combination more acidic than the falling rain alone. The combination of acid rain (wet deposition) plus dry deposition is called acid deposition.**Natural Acids**There are also natural sources of acids such as volcanoes, geysers, and hot springs. Nature has developed ways of recycling these acids by absorbing and breaking them down. These natural acids contribute to only a small portion of the acidic rainfall in the world today. In small amounts, these acids actually help dissolve nutrients and minerals from the soil so that trees and other plants can use them for food. Unfortunately, the large amounts of acids produced by human activities overload this natural acidity and throw ecosystems off balance.**Acid Rain Effects on Ecosystems**Acid rain and the air pollution that causes it can severely damage ecosystems. Every ecosystem is very interconnected, and the organisms that live there rely heavily on each other. For example, ecosystems have food webs, where species depend on one another for food. If any animal is affected, so are several others. This is how acid rain can affect entire ecosystems. Acid rain may only damage a few organisms in an ecosystem, but everything else is indirectly affected. The damage acid rain causes can also take years, or even decades to reverse.**Forests**Acid rain causes significant damage to forests.If trees and plants are damaged by acid rain, the effects are felt throughout the entire ecosystem.Acid rain causes trees in forests to grow more slowly, and in some sensitive species it can even make the leaves or needles turn brown and fall off. Red Spruce and Sugar Maple, two species of trees found mainly in the East and in New England, are very susceptible to acid rain damage. Acid rain damages trees by dissolving the calcium in the soil and in the leaves of trees. This hurts the tree, because calcium is a mineral that trees need to grow. Once the calcium is dissolved, the rain washes it away so the trees and other plants cannot use it to grow. Acid rain washes other minerals and nutrients from the soil in a similar fashion, causing nutrient deficiency. This is why acid rain can cause trees to grow more slowly.Adirondack forest**Sugar Maples**Nutrient deficiency causes other problems for trees and plants. The lack of nutrients weakens the trees, and makes them more sensitive to the cold. A well-nourished tree in healthy soil will survive even a very cold winter with little difficulty, but a tree already weakened by a mineral deficiency can die during a cold winter. The weakened trees and plants are also more sensitive to insects and disease. At the same time, acid rain causes the release of substances such as aluminum from the soil. Aluminum can be very harmful to trees and plants. Once released into soil, aluminum can end up in streams, rivers, and lakes, where it can harm or even kill fish. Less aluminum is released when the rainfall is cleaner.The pollution that causes acid rain also causes haze by scattering light back towards the sky. Haze reduces the amount of light available for plants to use in photosynthesis. Since photosynthesis is the base of the food chain, acid rain can cause problems with the movement of nutrients to other organisms in ecosystems that are already impacted.A spring shower in the forest washes leaves and the rain falls through the trees to the forest floor below. Some of the water soaks into the soil. Some trickles over the ground and runs into a stream, river, or lake. Soil sometimes contains substances, like limestone, that buffer acids or bases. Some salts in soil may also act as buffers. The soil may neutralize, or make less acidic, the acid rainwater. This ability of the soil to resist pH change is called buffering capacity.**Ponds, Lakes, and Streams**The effects of acid rain are most clearly seen in aquatic environments such as streams, lakes, and marshes. Acid rain flows to streams, lakes, and marshes after falling on forests, fields, buildings, and roads. Acid rain also falls directly on aquatic habitats.Most lakes and streams have a pH between 6 and 8, because the buffering capacity of soil usually neutralizes slightly acidic, clean rain. Lakes and streams become acidic (pH value goes down) when the rainwater itself is so acidic that the surrounding soil cannot buffer the rain enough to neutralize it. For this reason, some lakes in areas where soil does not have a lot of buffering capacity are naturally acidic even without acid rain.As lakes and streams become more acidic, the numbers and types of fish and other aquatic plants and animals that live in these waters decrease. Some types of plants and animals are able to tolerate acidic waters. Others, however, are acid-sensitive and will leave or die as the pH declines.**pH tolerance of various species****Effects on Humans**Acid rain looks, feels, and tastes just like clean rain. Walking in acid rain, or even swimming in an acid lake, is no more dangerous for humans than walking or swimming in clean water. However, breathing air that contains the pollutants that cause acid rain can damage human health. Sulfur dioxide (SO2), nitrogen oxides (NOx), particulate matter, and ozone all irritate or even damage our lungs. These effects are mostly seen in people whose lungs have already been weakened by respiratory illness, but even healthy people can sometimes have pain or difficulty breathing because of air pollution.SO2 and NOX, the pollutants that cause acid rain, can also reduce visibility, limiting how far into the distance we can see. These pollutants form small particles in the atmosphere. These particles reduce visibility by scattering light. Reduced visibility is most noticeable in places like National Parks, where people go to see some of the nation’s most beautiful landscapes.**Visibility in Acadia National Park****Effects of Acid Rain on Manmade Materials**Acid rain eats away at stone, metal, paint—almost any material exposed to the weather for a long period of time. Human-made materials gradually deteriorate even when exposed to unpolluted rain, but acid rain speeds up the process. Acid rain can rust metals and cause marble statues carved long ago to lose their features. This happens because marble is made of a compound called calcium carbonate, which can be dissolved by acids. Calcium carbonate is also found in limestone. Many buildings and monuments are made of marble and limestone and are damaged by acid rain. Repairing acid rain damage to buildings and monuments can cost billions of dollars.**What is Being Done to Reduce Acid Rain?**The Acid Rain Program was established by Congress as part of the 1990 Clean Air Act Amendments. It requires the electric power industry to lower emissions of sulfur dioxide (SO2) and nitrogen oxides (NOx), the pollutants that cause acid rain.Experts from EPA, states, universities, and other agencies have set up air quality and deposition monitoring stations across the country. These monitoring stations contain equipment that constantly collects air quality data and samples. These devices measure many things, including the amount of pollution in the air, the pH of rain, the amount of rainfall, and the surrounding temperature. There are several networks made up of many stations taking samples in different areas. The Clean Air Status and Trends Network (CASTNET) takes samples from mostly rural areas around the United States. CASTNET measures dry deposition and collects atmospheric data. The National Atmospheric Deposition Program (NADP) has sites around the United States and focuses on precipitation and meteorological monitoring.EPA also requires power plants to use Continuous Emissions Monitoring Systems (CEMS) to keep track of the amount of pollution they release into the air. A CEMS is a monitoring device that each unit must place on their smokestack. These monitors take samples of the air traveling through the smokestack, and measure the amount of pollutants traveling through it. Then, the monitor sends the recordings to EPA. CEMS allows EPA to keep track of emissions to make sure that the power companies are following the laws to reduce pollution.**What Can I Do to Reduce Acid Rain Generation?**1. Conserve electricity by turning off lights, appliances, and computers when no one is using them.
2. Lower your energy consumption by using other Energy Star® products and appliances, including TVs, computers, refrigerators, washing machines, air conditioners, furnaces, etc.
3. Try to reduce the amount of time you spend in the car by walking, biking, or taking public transportation.
4. Shrink your “carbon footprint” and reduce greenhouse gas emissions by turning the thermostat down a little bit in winter, or up a little bit in the summer.
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| **Topic source** | Source Material taken from EPA Acid Rain Program | https://www.epa.gov/airmarkets/acid-rain-program |
| **Overview**The Acid Rain Program (ARP), established under [the 1990 Clean Air Act (CAA) Amendments](https://www.epa.gov/airmarkets/acid-rain-program-laws-and-regulations), requires major emission reductions of sulfur dioxide (SO2) and nitrogen oxides (NOx), the primary precursors of acid rain, from the power sector. The SO2 program sets a permanent cap on the total amount of SO2 that may be emitted by electric generating units (EGUs) in the contiguous United States. The program was phased in, with the final 2010 SO2 cap set at 8.95 million tons, a level of about one-half of the emissions from the power sector in 1980. NOx reductions under the ARP are achieved through a program that applies to a subset of coal-fired EGUs and is closer to a traditional, rate-based regulatory system. Since the program began in 1995, the ARP has achieved significant emission reductions.The ARP was the first national cap and trade program in the country and it introduced a [system of allowance trading that uses market-based incentives to reduce pollution](https://www.epa.gov/airmarkets/market-based-mechanisms). Reducing emissions using a market-based system provides regulated sources with the flexibility to select the most cost-effective approach to reduce emissions, and has proven to be a highly effective way to achieve emission reductions, meet environmental goals, and improve human health. |

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| **Demonstration Project** Measuring The pH Of Natural Water | **Materials taken from Source:** https://www3.epa.gov/acidrain/education/teachersguide.pdf |
| **Materials** * pH paper and color chart or pH meter (range pH 2 to 7)
* clean cups or beakers
* 2 clean, empty, water or soda bottles
* notebook and pencil
* A map of the pH in the United States, which can be found at <http://nadp.sws.uiuc.edu/maplib/pdf/2015/pH_2015.pdf>

**Instructions** 1. Label a clean, empty water or soda bottle “rainwater,” and leave it outside of your classroom to collect water on a rainy day.
2. After you have collected at least a tablespoon of water, cap the bottle to prevent evaporation and bring it inside.
3. Locate a local stream, river, lake, or pond. Go with an adult. Depending on where you live, you may choose to gather water samples from many sources, including different creeks, lakes, ditches, ponds, and rivers.
4. Scoop some of the surface water into a clean, empty water or soda bottle. Label the bottle “surface water,” and cap the bottle to prevent evaporation and spilling while you bring it home.
5. Do you think the rainwater you collected will be acidic? What about the different surface water samples? Why? Take a moment to write down your hypotheses.
6. Pour the rain water into a cup and measure the pH of the rainwater using pH paper or a pH meter and record the result.
7. Pour the surface water into a cup and measure the pH of the surface water using pH paper or a pH meter and record the result.
8. Repeat steps 6 and 7 two more times so you test and record the pH results a total of three times for each sample.
 |
| **Questions for Discussion**1. What is the pH of the rainwater? Compare your results to the map. Is it what you expected?

*Answers will vary.*2. What is the pH of the surface water? *Answers will vary.*1. How does the measured pH compare to the pH levels that affect plants and animals in aquatic habitats?

*Check your values with the figure titled pH tolerance of various species.*4. Was one of your samples more acidic than the other? Which one? If they are different, what do you think the reason for the difference is? *The rainwater should be more acidic than the surface water from the pond or stream. This is because most surface water travels through soil and is buffered, or made less acidic, before reaching a pond or stream.*1. Were your hypotheses correct?

*Answers will vary.* |
| **Crosscutting Concepts**  | Cause and Effect - Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation. |
| Discuss how pollution in the air can contribute to the formation of acid rain in the atmosphere. Notice that different species tolerate pH levels differently, and as the pH level drops typically less and less species are able to thrive and/or survive. |
| **Teacher Prep**  |
|  | **Advanced Preparation Steps &****Duration** | 1. Read and consider associated background material, demonstration procedures, and questions for discussion. (1 hour)
2. Review Fuse School video clip (5:36 minutes)
3. Review Acid Rain PowerPoint (15 minutes)
4. Assemble Demonstration Materials & Practice Demonstration (2 hours)
 |
| **Needed Materials**  |  |   |
|  |  | Fuse School – Chemistry for All - Video Clip – Acid Rain <https://www.youtube.com/watch?v=Nf8cuvl62Vc&t=59s> (5:36 minutes)1. A map of the pH in the United States, which can be found at <http://nadp.sws.uiuc.edu/maplib/pdf/2015/pH_2015.pdf>
2. pH paper and color chart or pH meter (range pH 2 to 7)
3. clean cups or beakers
4. 2 clean, empty, water or soda bottles
5. notebook and pencil
6. internet connection
 |
|  | **Duration of activities** | ~ 50 minutes |
|  | **Safety notes** | Always handle materials with care. Do not drink or ingest materials.  |
| **Procedures for instruction** |  |  |
|  |  | Introduce the class to the idea of acid rain.  | ~2 minutes |
|  |  | Fuse School – Chemistry for All - Video Clip – Acid Rain | 5:36 minutes (YouTube Film) |
|  |  | Acid Rain Presentation | ~15 minutes(PowerPoint) |
|  |  | Measuring The pH Of Natural Water Demonstration | ~15 minutes(Class Demonstration) |
|  |  | Discussion | ~10 minutes |
| **Student Materials** |  |  |  |
|  | Background Informational Sheet | Reading assignment prior to the demonstration day. |
|  | Vocabulary List | Available for clarification of terminology as students read their Background Informational Sheet and Demonstration Procedure |

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| **Student Background Information Sheet – Air Pollution - Acid Rain** |
| **Source:** Learning About Acid Rain: https://www3.epa.gov/acidrain/education/teachersguide.pdf**Introduction**Acid rain forms when clean rain meets pollutants in the air, like sulfur dioxide (SO2), carbon dioxide (CO2), and nitrogen oxides (NOX). Although sulfur dioxide and carbon dioxide occur in the air naturally, burning fossil fuels adds more of these chemicals to the air. When these pollutants are released into the air, they mix and react with water, oxygen, and other chemicals to form acid rain. Acid rain then falls to the Earth where it can damage plants, animals, soil, water, and building materials.Despite its name, acid rain does not burn and cannot directly harm people. However, the pollutants that cause acid rain, especially SO2 and NOX, can react with other pollutants in the air, forming substances like Particulate Matter and ground level Ozone, which can sometimes make people sick.The consequences of air pollution are important to understand because air pollution can be carried long distances and affect large areas. This means that pollution from towns hundreds of miles away may be affecting your community.**Acid and Base**A substance that is neither acidic nor basic is neutral. The pH scale measures the acidic or basic level of a substance. The pH scale ranges from 0 to 14. A pH of 7 is neutral, while a pH less than 7 is acidic and a pH greater than 7 is basic.**Air Pollution and Acid Rain**Scientists have discovered that air pollution from the burning of fossil fuels is the major cause of acid rain. Power plants and factories burn coal, oil, and natural gas to produce the electricity we need to do all kinds of things, like light our homes. 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When that happens, the runoff water contains acid from acid rain and dry deposition, making the combination more acidic than the falling rain alone. The combination of acid rain (wet deposition) plus dry deposition is called acid deposition.**Natural Acids**There are also natural sources of acids such as volcanoes, geysers, and hot springs. Nature has developed ways of recycling these acids by absorbing and breaking them down. These natural acids contribute to only a small portion of the acidic rainfall in the world today. **Acid Rain Effects on Ecosystems**Acid rain and the air pollution that causes it can severely damage ecosystems. Every ecosystem is very interconnected, and the organisms that live there rely heavily on each other. For example, ecosystems have food webs, where species depend on one another for food. If any animal is affected, so are several others. This is how acid rain can affect entire ecosystems. 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Sulfur dioxide (SO2), nitrogen oxides (NOx), particulate matter, and ozone all irritate or even damage our lungs. These effects are mostly seen in people whose lungs have already been weakened by respiratory illness, but even healthy people can sometimes have pain or difficulty breathing because of air pollution.SO2 and NOX, the pollutants that cause acid rain, can also reduce visibility, limiting how far into the distance we can see. These pollutants form small particles in the atmosphere. These particles reduce visibility by scattering light. Reduced visibility is most noticeable in places like National Parks, where people go to see some of the nation’s most beautiful landscapes.**Visibility in Acadia National Park****Effects of Acid Rain on Manmade Materials**Acid rain eats away at stone, metal, paint—almost any material exposed to the weather for a long period of time. Human-made materials gradually deteriorate even when exposed to unpolluted rain, but acid rain speeds up the process. Acid rain can rust metals and cause marble statues carved long ago to lose their features. This happens because marble is made of a compound called calcium carbonate, which can be dissolved by acids. Calcium carbonate is also found in limestone. Many buildings and monuments are made of marble and limestone and are damaged by acid rain. Repairing acid rain damage to buildings and monuments can cost billions of dollars.**What is Being Done to Reduce Acid Rain?**The Acid Rain Program was established by Congress as part of the 1990 Clean Air Act Amendments. It requires the electric power industry to lower emissions of sulfur dioxide (SO2) and nitrogen oxides (NOx), the pollutants that cause acid rain.Experts from EPA, states, universities, and other agencies have set up air quality and deposition monitoring stations across the country. These monitoring stations contain equipment that constantly collects air quality data and samples. These devices measure many things, including the amount of pollution in the air, the pH of rain, the amount of rainfall, and the surrounding temperature. There are several networks made up of many stations taking samples in different areas. EPA also requires power plants to use Continuous Emissions Monitoring Systems (CEMS) to keep track of the amount of pollution they release into the air. A CEMS is a monitoring device that each unit must place on their smokestack. These monitors take samples of the air traveling through the smokestack, and measure the amount of pollutants traveling through it. Then, the monitor sends the recordings to EPA. CEMS allows EPA to keep track of emissions to make sure that the power companies are following the laws to reduce pollution.**What Can I Do to Reduce Acid Rain Generation?**1. Conserve electricity by turning off lights, appliances, and computers when no one is using them.
2. Lower your energy consumption by using other Energy Star® products and appliances, including TVs, computers, refrigerators, washing machines, air conditioners, furnaces, etc.
3. Try to reduce the amount of time you spend in the car by walking, biking, or taking public transportation.
4. Shrink your “carbon footprint” and reduce greenhouse gas emissions by turning the thermostat down a little bit in winter, or up a little bit in the summer.
 |
| **Source:** https://www.epa.gov/airmarkets/acid-rain-program**Acid Rain Program Overview**The Acid Rain Program (ARP), established under [the 1990 Clean Air Act (CAA) Amendments](https://www.epa.gov/airmarkets/acid-rain-program-laws-and-regulations), requires major emission reductions of sulfur dioxide (SO2) and nitrogen oxides (NOx), the primary precursors of acid rain, from the power sector. Since the program began in 1995, the ARP has achieved significant emission reductions.The ARP was the first national cap and trade program in the country and it introduced a [system of allowance trading that uses market-based incentives to reduce pollution](https://www.epa.gov/airmarkets/market-based-mechanisms). Reducing emissions using a market-based system provides regulated sources with the flexibility to select the most cost-effective approach to reduce emissions, and has proven to be a highly effective way to achieve emission reductions, meet environmental goals, and improve human health. |
| **Student Vocabulary List– Acid Rain**  |
| **Acidic** | Describes a substance with a pH less than 7. |
| **Acid Rain** | Rain that has become acidic by contact with air pollution. Other forms of precipitation, such as snow and fog, are also included in the term acid rain or wet acid deposition. |
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| **Buffer** | A substance, such as soil, bedrock, or water, capable of neutralizing either acids or bases. |
| **Carbon Dioxide** | A naturally occurring gas made of carbon and oxygen. Sources of carbon dioxide in the atmosphere include animals, which exhale carbon dioxide, and the burning of fossil fuels and biomass. |
| **Deposition** | When chemicals like acids or bases fall to the Earth’s surface. Deposition can be wet (rain, sleet, snow, fog) or dry (gases, particles). |
| **Ecosystem** | All the living and nonliving things in an area, as well as the interactions between them. |
| **Haze** | When particles of dust, pollen, or pollution make the air less clear, and limit visibility. |
| **Hydrologic Cycle** | The movement of water from the atmosphere to the surface of the land, soil, and plants and back again to the atmosphere. |
| **Nitrogen Dioxide** | A family of gases made up of nitrogen and oxygen commonly released by burning fossil fuels. |
| **Ozone** | Chemical that is made up of three oxygen atoms joined together, and found in the Earth’s atmosphere. “Good” ozone is found high in the Earth’s atmosphere; “Bad” ozone is found low to the ground. |
| **Particulate Matter** | Tiny solid particles or liquid droplets suspended in the air. |
| **pH Scale** | The range of units that indicate whether a substance is acidic, basic, or neutral. This scale ranges from 0 to 14. |
| **Sulfur Dioxide** | A naturally occurring gas made of sulfur and oxygen that is also released when fossil fuels are burned. |

**Project Assessment**

**Project Title:** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Instructor/School/Grade: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_/\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_/\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Instructor Contact Information: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Date assigned: \_\_\_\_\_\_\_\_\_\_\_\_\_ Number of Students Participating \_\_\_\_\_\_\_\_\_\_\_\_**

The following questions are intended to help us understand your feelings regarding the presentation and materials. Your sincerity in answering these questions is appreciated. Please feel free to use the space at the end of the form for any additional comments that you may have. *This form has been left in Microsoft Word format so that you may fill it in electronically. Please fill out the form completely and email your assessment to* david.madore@maine.gov.

**Ranking System**

 1 ~ Excellent / Strongly agree

 2 ~ Good – Above average / Moderately agree

 3 ~ Average – ok / Neutral in agree or disagree

 4 ~ Poor – below average / Moderately disagree

 4 ~ Very poor – not acceptable / Strongly disagree

 NA / not applicable

*Please continue on the second page…*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **1** | **2** | **3** | **4** | **5** | **NA** | **Questions** |
|  |  |  |  |  |  | **Course Content** |
|  |  |  |  |  |  | 1. Value of course content to you.
 |
|  |  |  |  |  |  | 1. Importance of course content given your teaching topic.
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|  |  |  |  |  |  | 1. Overall rating of course content.
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|  |  |  |  |  |  | 1. Ease of implementing materials into daily lessons.
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|  |  |  |  |  |  | **Materials/Project** |
|  |  |  |  |  |  | 1. Movie (if applicable) was easy to present.
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|  |  |  |  |  |  | 1. Student worksheet was useful and easy to follow.
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|  |  |  |  |  |  | 1. Student project stimulated thinking & conversation.
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|  |  |  |  |  |  | 1. The project put ideas across effectively.
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|  |  |  |  |  |  | 1. Teacher materials were useful and easy to follow.
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|  |  |  |  |  |  | 1. The method of material presentation encouraged students feel free to ask questions, disagree, express ideas, etc.
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|  |  |  |  |  |  | **Self-Evaluation (Instructor)** |
|  |  |  |  |  |  | 1. What was your level of knowledge concerning this topic prior to this presentation?
 |
| **Please share any recommendations you feel would be helpful.** |

**Thank you for providing your feedback!**

Please email your assessment to david.madore@maine.gov.