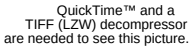
Acid Rain: Is It In Your Neighborhood?

A Teaching Unit Designed For The High School Mathematics Teacher That Examines Global Change



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Acid Rain: Is It In Your Neighborhood?
Table of Contents

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Acid Rain: Is It In Your Neighborhood?
Unit Overview

Target Grade: 9th grade

Subject: Mathematics / Algebra

Unit Overview:

Students will develop an understanding of acid rain and the application of the logarithmic scale. They will use technology to algebraically model, analyze, and report acid rain data via spreadsheets, charts and graphs, graphing calculators, and PowerPoint. Students will create presentations that indicate an understanding for the complexity of human advancement and the affects on the local and global environment.

Lesson 1 Overview: Students will brainstorm and share their beliefs and opinions as what constitutes acid rain. Students will investigate the pH scale and determine the pH of substances to gain a better understanding of what constitutes as acidic, basic, and neutral.

Lesson 2 Overview: Students will determine the mathematical mean of pH readings from substances measured in class from Lesson 1. They will learn and apply the logarithmic pH scale as a base-ten scale where a pH of 6 is 10 times more acid then a pH reading of 7. They will develop an understanding for the range in acid rain on a logarithmic scale, which has greater variance in numeric values then a linear scale. Students should realize that small changes in measured readings of acid rain are not linear scale differences but exponential.

Lesson 3 Overview: Students will learn that normal rainwater is slightly acidic, how this slight acidity is beneficial and what pH levels of rainfall constitutes as 'acid rain'. Students will use pH probes and graphing-calculators to measure the pH of local rainwater that has precipitated from varied approaching storm fronts. (i.e. storm fronts from the west, east, north, and/or south). Students will have the opportunity to discuss what ecological factors might contribute to the variance of the pH readings of the rainwater gathered from the different storm fronts. Finally, the students will have to the opportunity to hypothesis and make correlations between the acidity of collected rainwater samples from varied fronts and contour maps showing Ozone levels of the United States.

Lesson 4 Overview: Students will add their pH measures of local rainfall from Lesson 3 to other pH measures of rainfall for the same area that has been recorded since 1999 by the National Atmospheric Deposition Program (NADP) listed on the Internet. They will graph the pH readings on a spreadsheet and determine a linear equation to model the pH levels over time. They will calculate the residual of their model and make predictions about the acid rain level in their area as well as discuss the validity of their predictions.

Lesson 5 Overview: Provided with a rubric students work in groups to analyze and summarize all they have learned in the unit by preparing a presentation on Acid Rain in their neighborhood. The report should include mathematical support for their hypothesis whether they believe the levels of acid rain are increasing or not. Additionally, students will include in the report the effects acid rain has on their environment and suggest some of the point sources. The student will need to think about and include in the report what opportunities are available to the local citizen to minimize the affects of ozone and acid rain. The student presentation will utilize various forms of technology: computers, Internet access, PowerPoint, video equipment, cameras, telephones, as well as local community environmental specialist.

Overall Unit Assessment: Using a provided Student Presentation Rubric the teacher may evaluate the student presentations. To help student develop an effective presentation provide in advance copies of the Student Presentation Rubric page, Overall Unit Assessment Outline page, and Student Resource page. Presentations should indicate an understanding for the complexity of human advancement and the affects on the local and global environment supported mathematically.

Current Curriculum Need: The curriculum need is not only to develop algebraic models to represent a real world situation, but also to have students evaluate the validity of their algebraic model and use it to make future predictions. In this unit the students will have the opportunity to explore the validity of their algebraic model using relevant and current data of pH levels in their local area. Consequently, the student will have the opportunity to be engaged in meaningful mathematical content while developing and expanding their skills of environmental science and global issues, chemistry, social science, language arts, as well as interpersonal communication skills.

Acid Rain: Is It In Your Neighborhood?
Learning Objectives

Teaching and Learning Objectives:

The student will:

Lesson 1:

-Develop a group-generated list of what they know about acid rain and to list any questions about it.

-Test the pH levels of various substances to learn about the pH scale: acids, bases, and neutrals.

-Gain practice and familiarity with the concept and measurement of pH, the use of Universal Indicator solution, and the Universal Indicator color chart.

-Develop the scientific background and terminology necessary for understanding the range of acidity of acid rain.

Lesson 2:

-Apply logarithmic scales and understand it as a base ten scale.

-Determine the mean (average) of measured values on logarithmic scales.

-Develop the scientific background and terminology necessary for understanding the range of acidity of acid rain.

Lesson 3:

-Test samples of rainfall from opposing precipitation fronts and determine its current pH level utilizing the graphing calculator to measure pH levels.

-Formulate a hypothesis about what makes rainwater acidic.

-Develop the understanding of pH levels and what constitutes as acid.

Lesson 4:

-Create a graphic model of the local pH levels since 1999 by National Atmospheric Deposition Program (NADP) listed on the Internet and student-measured pH levels of local rainfall using spreadsheet technology.

-Find a line of best fit to represent the graphical model of pH levels.

-Determine an algebraic model (linear equation) from the line of best fit and use it to make future predictions about pH levels (acid rain) in the environment.

-Determine the independent and dependent variables of the algebraic model representing the pH readings.

-Analyze what the algebraic model indicates about short-term and long-term levels of pH and reflect on its potential impact to the surrounding environment as acid rain.

-Calculate and analyze the residual of the algebraic model using spreadsheet technology.

Lesson 5:

-Prepare a report using technology to convey their resulting data/calculations, what the data indicates along with suggestions as to the potential impact on the local environment as well as global environment.

-Develop an understanding for the complexity of human advancement and the affects on the local and global environment.

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Acid Rain: Is It In Your Neighborhood?
Michigan Content Benchmarks Addressed

Correlating Michigan Content Standards:

Mathematics / High School

Standard: Numerical and Algebraic Operations and Analytical Thinking

Students analyze problems to determine an appropriate process for solution, and use algebraic notations to model or represent problems.

Benchmark 1: Identify important variables in context, symbolize them and express their relationships algebraically.

Benchmark 2: Represent algebraic concepts and relationships with matrices, spreadsheets, diagrams, graphs, tables, physical models, vectors, equations and inequalities; and translate among the various representations.

Benchmark 3: Solve linear equations and inequalities algebraically and non-linear equations using graphing, symbol-manipulating or spreadsheet technology; and solve linear and non-linear systems using appropriate methods.

Benchmark 4: Analyze problems that can be modeled by functions, determine strategies for solving the problems and evaluate the adequacy of the solutions in context of the problems.

Benchmark 5: Explore problems that reflect the contemporary uses of mathematics in significant contexts and use the power of technology and algebraic and analytic reasoning to experience the ways mathematics is used in society.

Science / High School

Standard: Constructing New Scientific Knowledge

All students will ask questions that help them learn about the world; design and conduct investigations using appropriate methodology and technology; learn from books and other sources of information; and communicate findings of investigations, using appropriate technology.

Standard: Ecosystems

All students will explain how parts of an ecosystem are related and how they interact; explain how energy is distributed to living things in an ecosystem; investigate and explain how communities of living things change over a period of time; describe how materials cycle through an ecosystem and get reused in the environment; and analyze how humans and the environment interact.

Standard: Geosphere

All students will describe the earth's surface; describe and explain how the earth's features change over time; and analyze effects of technology on the earth's surface and resources.

Standard: Hydrosphere

All students will describe the characteristics of water and demonstrate where water is found on earth; describe how water moves; and analyze the interaction of human activities with the hydrosphere.

Standard: Atmosphere and Weather

All students will investigate and describe what makes up weather and how it changes from day to day, from season to season and over long periods of time; explain what causes different kinds of weather; and analyze the relationships between human activities and the atmosphere.

Social Science / High School

Standard SOC.II.2

All students will describe, compare, and explain the locations and characteristics of ecosystems, resources, human adaptation, environmental impact, and the interrelationships among them.

Standard SOC.V.1

All students will acquire information from books, maps, newspapers, data sets, and other sources, organize and present the information in maps, graphs, charts and timelines, interpret the meaning and significance of information, and use a variety of electronic technologies to assist in accessing and managing information.

Standard SOC.V.2

All students will conduct investigations by formulating a clear statement of a question, gathering and organizing information from a variety of sources, analyzing and interpreting information, formulating and testing hypotheses, reporting results both

orally and in writing, and making use of appropriate technology.

Standard: Group Discussion

All students will engage their peers in constructive conversation about matters of public concern by clarifying issues, considering opposing views, applying democratic values, anticipating consequences, and working toward making decisions.

Language Arts / High School

Standard: Meaning and Communication: Reading

All students will read and comprehend general and technical material.

Standard: Meaning and Communication: Writing

All students will demonstrate the ability to write clear and grammatically correct sentences, paragraphs, and compositions.

Standard: Meaning and Communication in Context

All students will focus on meaning and communication as they listen, speak, view, read, and write in personal, social, occupational, and civic contexts.

Standard: Ideas in Action

All students will apply knowledge, ideas, and issues drawn from texts to their lives and the lives of others.

Standard: Inquiry and Research

All students will define and investigate important issues and problems using a variety of resources, including technology, to explore and create texts.

Acid Rain: Is It In Your Neighborhood?
Teaching Unit Sources Consulted

Sources Consulted and Use of Books:

Australian Greenhouse Office. Global Warming Cool It. *Ten Easy Ways to Cool Global Warming.* Students can use this resource to explore what they can do to make a difference regarding Global Warming. Retrieved August 24, 2005, from: http://www.greenhouse.gov.au/gwci/ten.html

Consumers Energy. (2002). *A Close up Look at Our Environmental Commitment.* Students can use this resource to explore what local businesses are doing regarding Global Warming. Retrieved August 24, 2005, from:
http://www.consumersenergy.com/welcome.html?/ocompany/Index.asp?SSID=43

EPA-Air Quality Guide for Ozone. (2005). This web site provides students the opportunity to hypothesis and make correlations between the acidity of collected rainwater samples from varied storm fronts and contour maps showing Ozone levels of the United States. The EPA determines daily ozone level contour maps and they are archived on the Internet at EPA-Air Quality Guide for Ozone at this Web site. Retrieved August 24, 2005, from
http://cfpub.epa.gov/airnow/index.cfm?action+airnow.main

Ford Motor Company. *Global Climate Change.* Students can use this resource to explore what local businesses are doing regarding Global Warming. Retrieved August 24, 2005, from:
http://www.ford.com/en/company/about/publicPolicy/globalClimateChange.htm

General Motors. *GM Reduced US Greenhouse Gases 72% from 1990to 2003.* Students can use this resource to explore what local businesses are doing regarding Global Warming. Retrieved August 24, 2005, from:
http://www.gm.com/company/gmability/environment/news_issues/news/ghg_report_101204.html

Online Calculators:
Students will complete one of these online calculators for their contributions to Global Warming:

American Forests. Determines the number of trees a family needs to plant to offset the negative effects that has family on the climate. Retrieved August 24, 2005, from:
http://www.americanforests.org/resources/ccc/index.php

Carbon Footprints. Determines the carbon footprint for their family. Retrieved August 24, 2005, from: http://safeclimate.net/calculator/

Emissions and Pollution. Determine the Emissions/ Pollution a family contributes to the atmosphere. Retrieved August 24, 2005, from: http://www.airhead.org/Calculator/

Greenhouse Emissions. Determines the Greenhouse Emissions for their family. . Retrieved August 24, 2005, from:
http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterToolsGHGCalculator.html

Lawrence Hall of Science: University of California. *GEMS: Acid Rain Grades 6-10*. Ph. 510-642-7771. This resource was referenced for Lesson 1 and 2. This reference includes students resource pages about the effects of acid rain. This resource has a teacher reference section providing background information and definition of terms related to the pH scale and acid rain.

National Atmospheric Deposition Program, (NADP). (2005). The web site features maps of rainfall pH and other important precipitation chemistry measurements. Retrieved August 24, 2005, from http://nadp.sws.uiuc.edu

Ozone Damage. (2005). This site has pictures of ozone damage to plants. Retrieved August 24, 2005, from http://www.ces.ncsu.edu/depts/pp/notes/Ozone/ozone.html

Senk, Sharon L., Thompson, Denisse R., and Viktora, Steven S. *The University of Chicago School Mathematics Project: Advanced Algebra.* Illinois: Scott, Foresman and Company. 1993. This resource is a secondary mathematics textbook. It was referenced for the creation of Lesson 2 Additional Practice Worksheet. This resource may serve as an additional reference for calculation of common logarithms and the teaching of it to students.

Top Ten Things You Need to Know about Global Warming. Students use this site to explore the facts of Global Warming. Retrieved August 24, 2005 from, http://hdgc.epp.cmu.edu/teachersguide/teachersguide.html

United States Environmental Protection Agency. *Climate Change and Waste: Reducing Waste Can Make a Difference*. Retrieved August 24, 2005, from: http://www.epa.gov/epaoswer/nonhw/muncpl/ghg/folder.html

Lesson: 1

Investigation Overview:
Students will brainstorm and share their beliefs and opinions as what constitutes acid rain. Students will investigate the pH scale and determine the pH of substances to gain a better understanding of what constitutes as acidic, basic, and neutral.

Objectives/Purpose:
The student will:
-Develop a group-generated list of what they know about acid rain and to list any questions about it.
-Test the pH levels of various substances to learn about the pH scale: acids, bases, and neutrals.
-Gain practice and familiarity with the concept and measurement of pH, the use of Universal Indicator solution, and the Universal Indicator color chart.
-Develop the scientific background and terminology necessary for understanding the range of acidity of acid rain.

Lesson Plan / Day I:

Anticipatory Set:
Arrange students in groups to develop a list of what they recall about acid-rain, what they may have heard about acid-rain and/or any questions about acid-rain. From group reports, teacher compiles a classroom-generated list of statements and questions about acid rain. Post this list in the classroom to serve as a useful tool for students to sort out the scientific validity of hearsay information, and, as the unit progresses, to factual information from statements more related to social values and global change. An optional extension of the posting could be to post another classroom-generated list Titled*: What We Don't Know About Acid Rain.*

Activity:
Overview: First, students will observe a teacher demonstration to learn how to test solutions for pH levels. Second, they will participate in an activity to test the pH of various substances.

Advance Preparation: Prepare in advance for each group a tray with a set of labeled plastic cups containing: Tap Water, Normal Rain (*Distilled water that has been exposed to the environment for at least a week*), Lemon Juice, vinegar, and Baking Soda Solution (4 tablespoons /500 ml tap water). Additionally, each group will need a squeeze bottle labeled "Universal Indicator", Universal Indicator color chart, 2 egg cartons, safety goggles and the Lab Sheet. (Lab Sheet Master is at the end of this Lesson I Outline)

Teacher Discussion: Draw out and discuss the pH scale. Point out on the 1-14 pH scales that scientist classify chemical into three groups according to how they react: ***acids, bases (alkaline),*** and chemicals that are neither of these are called ***neutral***. Discuss some of the shared properties of "acids": sour-taste, breaks-up proteins, dissolves metals, conduct electricity. Discuss some of "bases": Baking Soda, Soap, Toothpaste, ammonia, drain-cleaner, and milk of magnesia. You may also mention other substances with weaker acidicity and alkalinity strength to show substances can be all along the scale. (Lawrence, pg. 124-137) Explain they will be testing a variety of substances to see where the substances belong on the pH scale, but first you (the teacher) will model for the class the testing of normal rain (distilled water) to see where it belongs on the pH scale. Explain and show how to use the Universal Indicator Solution and plot the pH of the normal rainwater. The

directions for the students is on the lab sheet. (Teacher Note: pH paper is always another option in testing the pH of a substance…in the next lesson students will use pH probes and their graphing calculator to determine the pH of substances as well as examine the powers of ten on the pH scale.)

Student Activity: Have students make predictions about the substances they will test and record those predictions on their lab sheet before they conduct the pH level for each substance. After they have made their predictions, have the students conduct the pH test on the various substances. If the students find the color of the test too faint, too dark or cloudy have them enter more Indicator Solution. Have them read and complete the lab sheet.

Teacher Activity: Pool from the class groups the measured pH data from the Tap water, Baking Soda solution, Lemon Juice, Normal rain, and vinegar from groups as they finish their testing.

(Teacher Note: Save that this class pooled data. You will use it as part of tomorrow's follow-up assignment…to average the pH for each substance. ***)***

When all the results are posted, ask general questions about the results:
Which substances were the most acidic, basic, etc. What substances if any varied extremely in the measured pH level? You may also inquire if they have any questions and other personal observations. Finally, poll the class for their predicted pH values of given substances on part B of the Lab-sheet. Ask students to justify their thoughts and findings. You may want to have some of these optional substances on hand to test the pH of as well. These pH levels of these substances are listed in the box below.

Answer Key to Part B on Lab-sheet:

Battery acid –pH 1	Drain Cleaner-pH 13	Cola- pH4
Ammonia-pH 11	Milk-pH 6.5	Stomach Acid-pH 1
Orange Juice –pH 5 *(may vary)*		

**At this point, you may start to discuss the pH scale as a Logarithmic Scale, time permitting.

Materials Required:

Class Materials:

Butcher Block Paper / Markers
Masking Tape
Drinking straws
2-clear wide mouth cups
Approximately 125mls of Universal Indicator solution with charts
Approximately 500 ml of:
- -Lemon Juice
- -Vinegar

Approximately 1 Liter of:
- - Distilled water
- - Tap water

One half liter of container for making the baking soda solution
Baking Soda (approx. 4 Tablespoons)
Assess to sink for washing and rinsing

Optional: Battery acid, Drain Cleaner, Cola, Ammonia, Milk, Orange Juice

Group Materials:

1 cafeteria tray
5 clear plastic wide-mouth cups
5 medicine droppers
1 small squeeze bottle for the indicator solution
2 Styrofoam egg cartons or some reactive tray
1 Universal Indicator Color Chart
2 pH data sheets
Safety goggles

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Lab Sheet / Lesson 1

Name_____

A. Testing pH of Substances

Date_____ Hr___

1. Choose a test solution.
2. Record your prediction of that solution's pH on this sheet.
3. Squirt a small amount of test solution into a compartment in test tray.
4. Carefully add 2 drops of Universal Indicator to the liquid in the tray and gently swirl the mixture.
5. Match each color of the mixture to the pH chart and decide what pH the test solution is.
6. Record your test result (pH number) on this sheet.
7. Repeat this procedure until you have tested all five solutions.
8. When you have finished, go on to predict the pH of the other substances listed below.

Test Solutions	
Your prediction	***Your result***
Tap water	
Baking soda solution	
Lemon juice	
Normal rain	
Vinegar	
Other Substances	
Substances	***Your Prediction***
Drain cleaner	
Battery Acid	
Stomach Acid	
Milk	
Ammonia	
Orange Juice	
Cola	

B. Recording the pH of Substances

Write the name of each solution ***you tested*** where it belongs on the pH scale below.

Very Acidic			Slightly Acidic				Neutral			Slightly Basic				Very Basic
0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**

Acid Rain: Is It In Your Neighborhood?

Lesson: 2

Investigation Overview: Students will determine the mathematical mean of pH readings from substances measured in class from Lesson 1. They will learn and apply the logarithmic pH scale as a base-ten scale where a pH of 6 is 10 times more acid then a pH reading of 7. They will develop an understanding for the range in acid rain on a logarithmic scale, which has greater variance in numeric values then a linear scale. Students should realize that small changes in measured readings of acid rain are not linear scale differences but exponential.

Objectives/Purpose:
The student will:
-Apply logarithmic scales and understand it as a base ten scale.
-Determine the mean (average) of measured values on logarithmic scales.
-Develop the scientific background and terminology necessary for understanding the range of acidity of acid rain.

Lesson Plan / Day 2:

Anticipatory Set:
Have students create the pH logarithmic scale on their own paper. The teacher should create a classroom ph scale on butcher-block paper for reference during today's lesson and future lessons. Ask if anyone is familiar with the Richter scale and what it measures. Note the Richter scale was named after its inventor Charles Richter (1900-1985), a seismologist at the California Institute of Technology. (Senk, pg. 499) Discuss that the Richter scale is a logarithmic scale, a base ten scale, which measures the amount of ground movement in an earthquake. For example, a tremor of 5.0 on the Richter scale is ten times more powerful than one measured at 4.0. Additionally, a tremor of 5.0 is 100 times more powerful than a tremor measured at 3.0. Ask students to compare various tremor readings. For example, how much more powerful is a tremor reading of 6 than a reading of 4 or 3, etc. You may also want to ask how much weaker is a reading of 2 compared to a reading of 5? [1000 times weaker] Students should understand that every number movement on the scale is a multiple of ten is strength, an exponential movement with a base of ten.

Activity:
Overview:
Students will find mathematical means of pH readings. They will learn the pH scale is a logarithmic scale, a base ten scale.

Teacher Discussion:
Explain and draw out the pH scale as logarithmic, a scale representing powers of ten. The pH scale actually measures the amount of positive hydrogen ion concentration (H_3O^+) in a substance. A zero pH measure represents 10^{0} and the calculated equivalent 10 to the power of zero is 1 the measured amount of positive hydrogen ion concentration (H_3O^+) in the substance. A pH measure of 1 represents ten to the power of negative one, written as 10^{-1}, or calculated is the equivalent 0.1 positive hydrogen ion concentration (H_3O^+) in the substance, and 2 represents concentration levels of 10^{-2} (or 0.01), and 3 is 10^{-3} (or 0.001), etc. Substances that measure pH levels between 2

and 3, for example, on the logarithmic scale would be calculated in the same manner. A substance with a pH level of 2.5 would be $10^{-2.5}$ or using a calculator 10 to the power of negative two point five is equivalent to 0.00316 of positive hydrogen ion concentration (H_3O^+) in the substance. So, to calculate the average of pH 4 which is 10^{-4} and pH 5 which is 10^{-5} would be to take pH 4 at 0.0001 and pH 5 at 0.00001 and divide the sum by two. Shown as:

$\frac{(10^{-4}+10^{-5})}{2}\frac{(0.0001+.00001)}{2}=\left(\frac{.00011}{2}\right)=0.000055$. **Now** to determine the pH of the substance explain that 10 to some power has to equal 0.000055. It can be written as $10^{?} = 0.000055$. Students can use trial and error. You can then explain logarithms. (Senk, pg. 504) Or you may simply at this point show common log $10^{n} = m$. And, that $n = \log_{10} m$ can be used to find the exponent of ten if you know the calculated value, *m*. For example, from above we wanted to find the exponent in $10^{?} = 0.000055$, so calculate (using the key *log* on the calculator) log 0.000055 and enter. The calculator should display -4.2596… as the pH level. Consequently, the average of pH 4 and pH 5 is **not** pH 4.5 but rather pH 4.2596. This will surprise students because they will expect the average of pH 4 and pH 5 to be pH 4.5 and it is not such on the logarithmic scale. Students should be able to calculate the mean pH of the substances tested in class yesterday.

Utilizing the class data of pH levels of substances from Lesson 1. However, again demonstrate how to calculate the pH mean of a chosen substance. For example, perhaps for orange juice the readings recorded may have been a pH of 5, 5.5, and 6. The average pH for the juice would be:

$\frac{(10^{-5}+10^{-5.5}+10^{-6})}{3}=\left(\frac{0.00001+0.000003162+.000001}{3}\right)\approx 4.721x10^{-6} = 0.000004721$, which is then converted to a pH level reading by taking the common log of this number. So, log 0.000004721 is calculated to be -5.3256 or pH level 5.3256, which is between pH 5 and 6. You may also want to show the three readings you averaged and the resulting answer as decimals and correlate to a number line for students to see decimal placements. They may have difficulty-believing 4.721×10^{-6} is actually between 0.00001 and 0.000001 (pH of 5 and 6).

Advance Preparation: Locate the pH data collected during Lesson 1.

Student Activity: Assign groups a substance to calculate its mean pH level from data collected during Lesson 1.

Teacher Activity: Have students plot the pH for the assigned substances on the posted classroom pH scale. Discuss and explain that logarithmic scales are exponential scales because it is calculated using exponents of numbers with the same base, in this case a base of ten. The word *logarithm* literally means "ratio of number". Logarithmic scales are different from linear scales. On a linear scale the units are spaced so that the differences between successive units is the same. Whereas, on a logarithmic scale the units are spaced so the *ratio* between successive units is the same. Logarithmic scales are often used to model data with a very 'wide range' of values. Other logarithmic scales include radio dials and a Decibel-scale, which measures the intensity of sound. (Senk, pg. 500) The worksheet titled Additional Practice Lesson 2 following this Lesson may be assigned.

Materials Required:

Class Materials: Butcher Block Paper
Group Materials: Calculators, pH data from Lesson 1Activity.

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(adapted: Advanced Algebra, Scott Foresman)

Additional Practice / Lesson 2

Name_____

Date_____ Hr___

Directions: Complete the following questions justifying any calculations.

1. A logarithmic scale is a scale calculated using what numbers?

2. An increase of one unit on the Richter scale corresponds to multiplying the energy of a quake by what number?

3. To what factor does an increase of two units on the Richter scale correspond?

4. How many times more intense is an earthquake with a Richter magnitude of 6.7 than one with magnitude 4.2?

5. What is the major difference between a linear scale and a logarithmic scale?

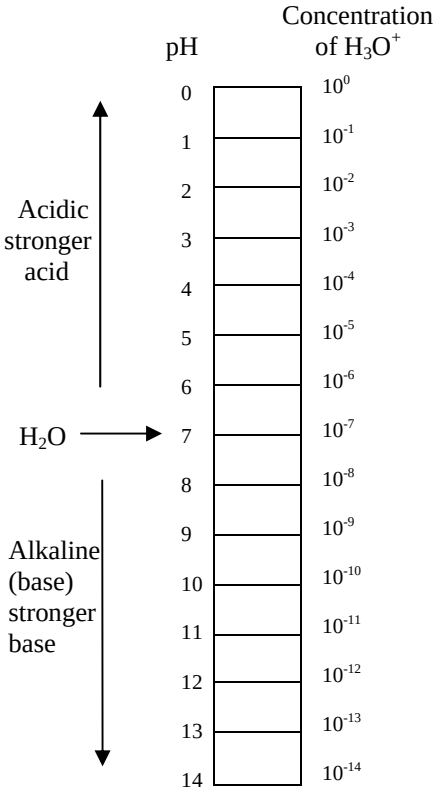
6. How are the Richter-Scale and pH-scale alike?

7. What does the pH scale measure?

6. Why is a logarithmic scale better than a linear scale for illustrating the data below?
$4x10^{-34}\,kg$; $1.89x10^{-24}\,kg$; $10^{-19}\,kg$; $3.64kg$; $1.42x10^{6}\,kg$

7. Find the average of the following pH values.
   a.) pH measures of 4 and 5.
   b.) pH measures of 3 and 6.5.
   c.) pH measures of 2.5, 4, and 5.
   d.) pH measures of 5, 6, and 7.

In **8-10**, refer to the pH scale below. The pH scale is a logarithmic scale that is used to measure how acidic or alkaline a solution is. Measuring the concentration of hydronium ions, H3O+, determines the pH of the solution. The concentration is expressed as a power of 10 and is then converted to a pH value as shown in the graph at the right. Pure water has a pH of 7. Alkaline (basic) solutions have pH values greater than 7.



8. The gastric juice in your digestive system has a pH of 2.0 and many soft drinks have pH of 3.0.

    a. Which is more acidic, gastric juice or soft drinks?
    b. What is the concentration of H_3O^+ ions in the more acidic solution?

9. Seawater has pH of 8.5.

    a. Is seawater acidic or basic?
    b. What is the concentration of H_3O^+ ions in seawater?
    c. Rewrite your answer to part b in scientific notation.

10. An acidic solution is increased in strength from pH 5 to pH 1. How many times more concentrated is the solution?

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Acid Rain: Is It In Your Neighborhood?

Lesson: 3

Investigation Overview: Students will learn that normal rainwater is slightly acidic, how this slight acidity is beneficial and what pH levels of rainfall constitutes as 'acid rain'. Students will use pH probes and graphing-calculators to measure the pH of local rainwater that has precipitated from varied approaching storm fronts. (i.e. storm fronts from the west, east and south). Students will have the opportunity to discuss what ecological factors might contribute to the variance of the pH readings of the rainwater gathered from the different storm fronts. Finally, the students will have to the opportunity to hypothesis and make correlations between the acidity of collected rainwater samples from varied fronts and contour maps showing Ozone levels of the United States. Note that the EPA determines daily ozone level contour maps and they are archived on the Internet at EPA-Air Quality Guide for Ozone.

Objectives/Purpose:
The student will:
- Develop the scientific background and terminology necessary for understanding the range of acidity of acid rain.
-Measure pH levels of rainfall from opposing fronts and determine its current pH level utilizing the graphing calculator and pH probe.
-Formulate a hypothesis about what makes rainwater acidic.
-Continue to develop an understanding of pH levels in the environment and what constitutes as acid rain and recognize some of the point sources.

Lesson Plan / Day 3:

Anticipatory Set: From Lesson 2 students should understand that the pH scale is logarithmic and differences in pH readings are a multiple of ten. Conduct a class demonstration to focus on the pH of normal rainwater. Ask students why rainwater is slightly acidic, as compared with 'pure water'. Explain that pure water should have a pH of 7.0, which can change depending on what else the water contacts. Complete the following in class demonstration showing the acidifying effect of air on water.
Demonstration: Show two cups of the rainwater. (You can make your own normal water by taking distilled water you have exposed to the classroom atmosphere at least a week or two.) Measure the pH of one cup. Emphasize the water in both cups are the same. Either pour them from the same container into two cups or measure the pH of both. Have a student blow through a straw for approximately fifteen seconds into the cup to yet be measured for pH. The student may take breaths as the class counts off fifteen seconds. Explain that this process very roughly simulates rain

falling through carbon dioxide in the atmosphere. Measure the pH of this cup of rainwater that has been exposed to student blowing. You may want to pose questions like, "What change took place in the water?" [It became more acidic] "Does anyone have any ideas about why this took place?" "What is in the air we breathe out that might cause water to change this way?" Point that when carbon dioxide gas dissolves in water and reacts with it, it becomes more acidic. The acid that is form in the water is carbonic acid. Similarly, pure water raining through the sky mixes with some of the gases in the air, such as carbon dioxide, and becomes acidic. Normal rain is therefore slightly acidic and has a pH of 5.6. Point out that this small amount acidity in rainwater is good, since 5.6 is acidic enough to react with minerals from rocks and soils so they dissolve. These minerals trickle down to nourish the roots of plants. You may record the range of normal rain as 5.6-6.0 on the class pH chart. Explain that, while normal rain is slightly acidic, it is **not** what is referred to as "acid rain". Explain that scientists have defined **acid rain as anything below pH 5.6**. Acid rain is formed when the atmosphere is filled with gases and particles that come from factories, power-generating plants, and cars. These human-made pollutants in the air react with sunlight and moisture to form acids. These acids dissolve into the rainwater as it falls, and makes it more acidic than carbon dioxide by itself does. How *acid* the rain becomes as it falls depends on how much of each of these pollutants there are. Mark the class chart showing acid rain range of pH 5.6 and below.

Activity

*Overview***:** Students measure the pH level of pre-collected rainwater from varied local storm fronts to determine the acidity of local rainfall. The students will hypothesis why rainfall from different storm fronts has different acidity. They will have access to Ozone contour maps of the United States for this analysis. Students should see a correlation between high ozone areas and rainfall coming from those areas to be more acidic.

Advance Preparation: Place dated pre-collected rainfall in cups for students to test the pH. This rainfall should be from different approaching storm fronts. The day the rainfall was collected needs to be documented. Students will need this date to find air quality maps for the same day the rainfall was collected to correlate pH readings against. You will need to watch the weather in your area via weather channel or web site before starting this unit and set out a collection device to catch the rain from storm fronts approaching from different directions. Several large funnels (handmade or purchased) taped to the top of a collection container may be a method to collect the rainfall. You may assign a student to do this in advance of the unit as well. Once collected tightly close the collected rainfall until ready for usage. If stored for over a week…you may try freezing the collection to keep the sample stable.

Teacher Discussion: Poll the class for pH readings for each of the storm front samples. Show students where to compare these reading with contour maps of Ozone levels at Web site http://cfpub.epa.gov/airnow/index.cfm?action+airnow.main . Once at the site click on *archives* and choose the *month* to examine ozone levels. Next choose the *day* from the calendar that the rainfall was collected. Students should see a correlation between high ozone areas and rainfall coming from those areas to be more acidic.

Student Activity: Students complete the investigation of correlating pH reading to Ozone readings for the days of rainfall collection. The idea is to let them discover and seek any relationships themselves.

Teacher Activity: Discuss any apparent relationship between the pH readings and the air quality maps. Students should see a correlation between high ozone areas and rainfall coming from those areas to be more acidic. You may ask students what they think might be in the areas of poor air quality contributing to acid rain. [Fossil fuel burning, car emissions…] Next, guide students through the web site http://nadp.sws.uiuc.edu . This site has a contour map of pH reading across

the United States. The map is titled 'Hydrogen ion concentration as pH from measurements made at the Central Analytical Laboratory, 1994'. The National Atmospheric Deposition Program (NADP) measures wet deposition, and the web site features maps of rainfall pH and other important precipitation chemistry measurements. The map shows the pH reading of rainfall for the entire United States. It is very clear to see the areas currently being affected by acid rain. For comparison and relevance to the day's activity, students will be able to easily correlate their own gathered pH readings done in class of local rainfall pH with what is indicated as laboratory pH readings on the map. They should understand that differences are greater than they appear *since* the pH scale is a logarithmic scale and not a linear scale. Discuss some of the impacts acid rain is having on the current surroundings and where the point source areas are as indicated on the air quality maps.

Some resources to share with students:

Acid Rain East and West (Lawrence, pg.113)

-EPA-Air Quality Guide for Ozone @ following web site:
http://cfpub.epa.gov/airnow/index.cfm?action+airnow.main

-Pictures of Ozone damage @ following web site:
http://www.ces.ncsu.edu/depts/pp/notes/Ozone/ozone.html

-Pollution, Acid Rain and You (Lawrence, pg. 49)

-Scientific Responses to the Startling Statement Questions /Acid Rain (Lawrence, pg. 47)

-The National Atmospheric Deposition Program (NADP) measures wet deposition maps of rainfall pH and other important precipitation chemistry measurements @ following web site: http://nadp.sws.uiuc.edu

-Top Ten things You Need to Know about Global Warming @ following web site:
http://hdgc.epp.cmu.edu/teachersguide/teachersguide.html

Assignment:

Have students choose to complete one of the following explorations as homework and be prepared to discuss their results tomorrow when they return to class.

1. Determine the carbon footprint for their family. The web site: http://safeclimate.net/calculator/
2. Determine the Greenhouse Emissions for their family. The web site: http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterToolsGHGCalculator.html
3. Determine the Number of trees your family needs to plant to offset the negative effects your family has on the climate. The web site: http://www.americanforests.org/resources/ccc/index.php
4. Determine the Emissions/ Pollution your family contributes to the atmosphere. The web site: http://www.airhead.org/Calculator/

Class Materials: 1-2 straws, cups, rain water (distilled water that has been set aside)

Group Materials:
-Pre-collected rainwater from different approaching storm fronts. (Several large funnels [handmade or purchased] taped to the top of a collection container may be a method to collect the rainfall. You may assign a student to do this in advance of the unit as well. Once collected tightly close the collected rainfall until ready for usage. If stored for over a week…you may try freezing the collection to keep the sample stable.)
-Computer access to attend web sites.
-Graphing calculators and pH probes to measure acidity of local rainfall

Lisa Lesser / Pinckney High School

Acid Rain: Is It In Your Neighborhood?

Lesson: 4

Investigation Overview: Students will add their pH measures of local rainfall from Lesson 3 to other pH measures of rainfall for the same area that has been recorded since 1999 by the National Atmospheric Deposition Program (NADP) listed on the Internet. They will graph the pH readings on a spreadsheet and determine a linear equation to model the pH levels over time. They will calculate the residual of their model and make predictions about the acid rain level in their area as well as discuss the validity of their predictions.

Objectives/Purpose:
The student will:
-Create a graphic model of the local pH levels since 1999 by National Atmospheric Deposition Program (NADP) listed on the Internet and student-measured pH levels of local rainfall using spreadsheet technology.
-Find a line of best fit to represent the graphical model of pH levels.
-Determine an algebraic model (linear equation) from the line of best fit and use it to make future predictions about pH levels (acid rain) in the environment.
-Determine the independent and dependent variables of the algebraic model representing the pH readings.
-Analyze what the algebraic model indicates about short-term and long-term levels of pH and reflect on its potential impact to the surrounding environment as acid rain.
-Calculate and analyze the residual of the algebraic model using spreadsheet technology.

Lesson Plan / Day 4:

Anticipatory Set: Discuss the student explorations completed for the assignment for Lesson 3. Refer to the classroom-generated list of students beliefs and questions from Lesson 1 Anticipatory Set about Acid Rain. Discuss any changes additions or deletions to the list since this unit has progressed.

Activity:
Overview: Students will need to go a web site and record the pH data levels for their local area since 1999. They will then enter the values into a spreadsheet and find the line of best fit, determine the independent and dependant variables, determine an equation for this line, use the equation to make predictions about pH levels in the near and long-term future.
Advance Preparation: Students will need to have their pH readings of local rainfall from Lesson 3.
Teacher Discussion: Direct students to the web site http://bqs.usgs.gov/acidrain/index.htm . This site is posted by the National Atmospheric Deposition Program and has pH levels for the whole United States as well as many other Deposition readings. Once at the site have students click on the map for their local area. For example, for my area I would have students click on Michigan and location MI52. From here scroll down and click on weekly data. Choose starting month and year and give a brief description as to the reason for data retrieval, which the site requires. (For example I chose K-12 and my personal description for data retrieval is 'classroom education'.)
Student Activity and Teacher Activity: Students should record the Lab pH values for the retrieved data and enter them along with their own data readings from Lesson 3 into a spreadsheet (Excel) and create a scatter-plot. Once the scatter-plot is created they can double click on any data point and choose trend line. The spreadsheet program will automatically determine the line of best fit.

Ask students to determine the independent variable [weeks/time] and dependant variable [pH level]. The linear equation y = mx + b should be determined by the student where *x* will represent the independent variable (weeks/time), *y* will represent the dependant variable (pH level), *m* the slope or change in pH over time, and *b* the arbitrary starting value (the y-intercept). If students are not familiar with calculating the slope from any two chosen points and determining the equation of a line you may need to assist them through this part of the activity. Students may also enter two points from the line of best fit into the graphing calculator (lists) and choose y = ax + b and the calculator will determine the equation/model to represent the pH levels shown on the spreadsheet as well.

Students should use this algebraic model to predict pH levels in five years, ten years, twenty years, and one hundred years. Note they must change year values to weeks to enter into the equation since the independent variable is measured in weeks. Discuss as a class the validity or reasonableness of the predictions by the equation/model for the time spans indicated. It is likely a positive slope (increasing incline in the line) will exaggerate the pH readings over time. The readings of acidity can only vary as far as zero, the limits of the logarithmic scale. Additionally, perhaps over time the level of pH in rainwater may level to a near constant value. You may wish to discuss why this might occur and what environmental factors would contribute to this effect.

Class / Group Materials:
-Students will need to have their pH readings of local rainfall from Lesson 3.
-Students will need access to the Internet and spreadsheet programs.
-Graphing calculators.

Assignment:
Assign students to repeat the process done in class using the 'field' readings of pH data from the same web site (http://bqs.usgs.gov/acidrain/index.htm) they obtained the laboratory pH readings. They should enter the field pH values into a spreadsheet and find the line of best fit, determine the independent and dependant variables, determine an equation for this line, use the equation to make predictions about pH levels for five years, ten years, and fifty years.

Lesson: 5

Investigation Overview: Provided with a rubric students work in groups to analyze and summarize all they have learned in the unit by preparing a presentation on Acid Rain in their neighborhood. The report should include mathematical support for their hypothesis whether they believe the levels of acid rain are increasing or not. Additionally, students will include in the report the effects acid rain has on their environment and suggest some of the point sources. The student will need to think about and include in the report what opportunities are available to the local citizen to minimize the affects of ozone and acid rain. The student presentation will utilize various forms of technology: computers, Internet access, PowerPoint, video equipment, cameras, telephones, as well as local community environmental specialist.

Objectives/Purpose:
The student will:
-Prepare a report using technology to convey their resulting data/calculations, what the data indicates along with suggestions as to the potential impact on the local environment as well as global environment.
-Develop an understanding for the complexity of human advancement and the affects on the local and global environment.

Lesson Plan / Day 5:

Anticipatory Set: Discuss the pH levels indicated as a result of Lesson 4 assignment. Ask what these pH levels indicate about on site testing of acid rain levels for the local area.

Activity:
Overview / Teacher Discussion: Distribute and discuss the Student Presentation Rubric, the Overall Unit Assessment Outline, and the Student resources page. The students will need to make reference to these pages as they analyze and summarize what has been learned in the unit and prepare a presentation on Acid Rain in their neighborhood. They will include in the report mathematical support for their hypothesis whether they believe the levels of acid rain are increasing or not. They will include the effects of acid rain on the environment and suggest some of the point sources. The report should discuss what opportunities are available to the local citizen to minimize the affects of ozone and acid rain. Assign presentation time limits and days of presentation for groups. Groups of three should provide opportunity for accountability by all members in the group.
Advance Preparation: Make sure all the equipment and resources are readily available for students to work on their presentations. This may include but not be limited to: computers, Internet access, PowerPoint, video equipment, cameras, telephones, poster board, writing instruments, overhead projectors, transparencies, etc. A list of web sources for consulting and copies of materials discussed and used in class. Local community environmental specialist and phone books for researching contacts may also be included.
Student Activity: Students meet in their group and start creating their report.

Class / Group Materials:
- Copies of the Student Presentation Rubric
- Copies of the Overall Unit Assessment Outline page
- Copies of Student Resources Page
- Computer access with PowerPoint, Excel, Internet Browser
- Video Equipment/ CD's
- Camera Equipment/ CD's
- Access to Telephones and Phone book
- Overhead Projector / Transparencies and Writing instruments
- Poster board and Writing instruments

Acid Rain: Is It In Your Neighborhood?

Student Resources:

The following resources may help you start your research for your group presentation. You may utilize your own resources you locate yourself and are not limited to those listed here.

Acid Rain East and West / news article (Lawrence, pg.113)

Australian Greenhouse Office. Global Warming Cool It. *Ten Easy Ways to Cool Global Warming.* @ web site: http://www.greenhouse.gov.au/gwci/ten.html

Consumers Energy. A Close up Look at Our Environmental Commitment @ web site: http://www.consumersenergy.com/welcome.html?/ocompany/Index.asp?SSID=43

EPA-Air Quality Guide for Ozone @ following web site: http://cfpub.epa.gov/airnow/index.cfm?action+airnow.main

Ford Motor Company. Global Climate Change @ following web site: http://www.ford.com/en/company/about/publicPolicy/globalClimateChange.htm

General Motors. GM Reduced US Greenhouse Gases 72% from 1990to 2003 @ web site: http://www.gm.com/company/gmability/environment/news_issues/news/ghg_report_101204.html

Pictures of Ozone damage @ following web site: http://www.ces.ncsu.edu/depts/pp/notes/Ozone/ozone.html

Pollution, Acid Rain and You / News Article (Lawrence, pg. 49)

Scientific Responses to the Startling Statement Questions: Acid Rain
News Article (Lawrence, pg. 47)

Top Ten things You Need to Know about Global Warming @ following web site: http://hdgc.epp.cmu.edu/teachersguide/teachersguide.html

United States Environmental Protection Agency. *Climate Change and Waste: Reducing Waste Can Make a Difference.* @ web site: http://www.epa.gov/epaoswer/nonhw/muncpl/ghg/folder.html

Internet Calculators:

-Greenhouse Gas Calculator @ web site:
http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterToolsGHGCalculator.html
-Climate Change Calculator @ web site:
http://www.americanforests.org/resources/ccc/index.php
-Emissions Calculator @ web site:
http://www.airhead.org/Calculator/

Overall Unit Assessment Outline:

Using the following rubric and a copy of this page the student will create a presentation using technology to convey their resulting data/calculations about acid rain levels for their community. The presentation should include the potential impact on the local environment. The presentation should indicate an understanding for the complexity of human advancement and the affects on the local and global environment.

The Student Should Develop and Include in the Presentation:

-Terms to define:
- pH and the Logarithmic scale
- Acid Rain

- Mathematical evidence:
- Algebraic models of Acid Rain for the local area developed from local data
- Graphical models showing levels of Acid Rain over time for the local area
- Graphical models showing Air Quality/ Ozone levels for the local area

- Analysis of the following topics:
- Current Acid Rain Levels for the local area
- Probable point sources of the Acid Rain
- Affects of Acid Rain on the current local environment
- Citizen opportunities to minimize the effects of Acid Rain

- Supporting material:
- Resources cited
- Photos or supporting evidence of Acid Rain

For example: Pictures on the web or photos you have taken yourself showing acid rain damage, and/or items you have gathered yourself from the local area to share during the presentation that shows acid rain damage.

Optional: As always you have the opportunity to explore more! The following are only two suggestions of personal projects you may develop and present to the class for extra credit. Please share with me individually your intentions and ideas that I might assist you in your project. Be creative!
-Conduct your own experiment to determine the effects low pH / Acid Rain has the environment.
-Explore the graph of temperature verses pH readings for rainfall collected from varied storm fronts.

Student Presentation Rubric

Points Received	Points Possible (100)	Criteria
	Project Design (20 points)	The method the group uses to explore and develop all parts of the presentation is well designed and equally distributed among group members. The main ideas to be discussed in the group are included in the presentation. (See the *Overall Assessment Sheet* provided for these main ideas. The main topic areas included: Terms to Define, Mathematical Evidence, Analysis of Selected Topics, and Supporting Material.)
	Draws on Body of Existing Knowledge (20 points)	A variety of informational sources **are included** in the presentation and cited: • Websites • Experts: scientists, consultants, faculties • Reports, books, journals, etc.
	Data Collection (20 points)	Collects data useful in examining acid rain and its effect on the environment: • Data collection is relevant to understanding the current level of acid rain in the local area • Data is collected from current and relevant scales • Predictions for long-term data across multiple years was determined using algebraic models • Utilized data available from other sources to support ideas and conclusions about the effects of acid rain and its point sources • Includes photos or other visual evidence indicating the effects of acid rain on the environment
	Data Analysis and Conclusions 30 points	Uses data to communicate the effects of acid rain: • Creates appropriate graphics or tables from the data • Uses visuals to facilitate comparisons and draw conclusions for the investigation • Investigation outcomes illustrate what acid rain is and it's local impact on the environment • Discusses the citizens opportunities to minimize the effects of acid rain
	Organization 10 points	The report and presentation are: • Demonstrated shared accountability among group members • Clear and well-organized • Uses visual aides • Utilizes technology to explain and convey understanding of material learned during the unit