



Lesson # 4

Water Quality: pH

Student Handouts

Draft January 2011



Developed by the Lake Roosevelt Forum to support "The River Mile" National Park Service Program



LESSON # 4

Water Quality: pH

Suggested duration:
90 minutes to
optional multi day

Inquiry Questions:
How does pH impact
water quality? What
causes pH to change?

Inquiry Process:
Data comparison &
presentation

Standards:
PS2

Formative Assessment:
Graphing Data

Materials:
pH Power point
Data presentation
examples
pH paper
pH meter
liquids of pH range
(vinegar to baking soda
solution)
Lake or pond water

Handouts:
Science Journal
EPA Acid Rain

Credits/Citations:
Globe pH Lab
www.ecy.gov/
http://www.ecy.wa.gov/programs/eap/fw_riv/rv_main.html

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

INTRODUCTION:

pH - How acidic or basic something is measured by its pH factor. pH is measured on a scale from 0 to 14, with 7 being neutral. Fresh water generally has a pH between 6.0 and 8.5. If the pH of water becomes too high (basic) or too low (acidic), aquatic organisms begin to die. At extremely high or low pH levels all aquatic life will die. Pure water has a pH of 7.0. However, normal rain is slightly acidic because carbon dioxide (CO₂) dissolves into it forming weak carbonic acid, giving the resulting mixture a pH of approximately 5.6 at typical atmospheric concentrations of CO₂. pH is probably the single most important factor initiating all chemical reactions in water.

Acid rain is a broad term referring to a mixture of wet and dry deposited material from the atmosphere containing higher than normal amounts of nitric and sulfuric acids. Emissions of [sulfur dioxide \(SO₂\)](#) and [nitrogen oxides \(NO_x\)](#) result from fossil fuel combustion. In the United States, roughly 2/3 of all SO₂ and 1/4 of all NO_x come from electric power generation that relies on burning fossil fuels, like coal. Acid rain occurs when these gases react in the atmosphere with water, oxygen, and other chemicals to form various acidic compounds. The result is a mild solution of sulfuric acid and nitric acid. When sulfur dioxide and nitrogen oxides are released from power plants and other sources, prevailing winds blow these compounds across state and national borders, sometimes over hundreds of miles. As of 2000, the most acidic rain falling in the U.S. has a pH of about 4.3.

STUDENT WORK AND ASSESSMENT

Presenting data graphically and selecting an appropriate format to compare data from different locations.

QUESTIONS TO EXPLORE/INSTRUCTIONS/PROCEDURE

1. Students reflect on experiences with turbidity and overview of WQ indicators. Introduce pH power point. Discuss acid rain and the impact on plants, buildings air and water quality.
Option 1: Test & record the pH of a variety of common liquids.
Option 2: Conduct GLOBE pH Investigation lab **Note:** *Full lab details are provided in the unit appendices*
Option 3: Test a water sample before and after dry ice is added.
Example at <http://www.stevespanglerscience.com/experiment/dry-ice-bubbling-acid>
Also <http://www.epa.gov/teachers/water.htm>
2. Use a variety graphs for the Ecology data from Grand Coulee & Hawk Creek (e.g., bar, line, radar; mean, median, mode). What are the strengths & weaknesses of each format?
3. Analyze the Ecology data for Grand Coulee and Hawk Creek. What do the data tell about pH levels and LR WQ?
4. Which plants & animals are most likely to be impacted by the changing pH levels?

WATER QUALITY: PH AND ACID RAIN

Name: _____ Date: _____

Essential Questions:

What does pH tell us about water quality?

Inquiry Questions:

What causes pH to change? In how many ways can we compare and present the data collected?

What are the strengths and weaknesses of each presentation format?

Objective:

You will:

- Take notes on pH as a water quality indicator
- Measure the pH of a variety of water samples and common household liquids
- Gather data into a data table (excel spread sheet) and create graphical presentations

Preparation from Lesson 3:

Think about your experience in Lesson 3 of measuring turbidity & conductivity from water run-off and soil erosion. Today we will explore the impact of pH (acid /base) on water quality and some of the factors that can cause pH to change.

Think Time:

Things I already know about pH and some questions running around in my mind....

Record Notes: Identify key points about pH

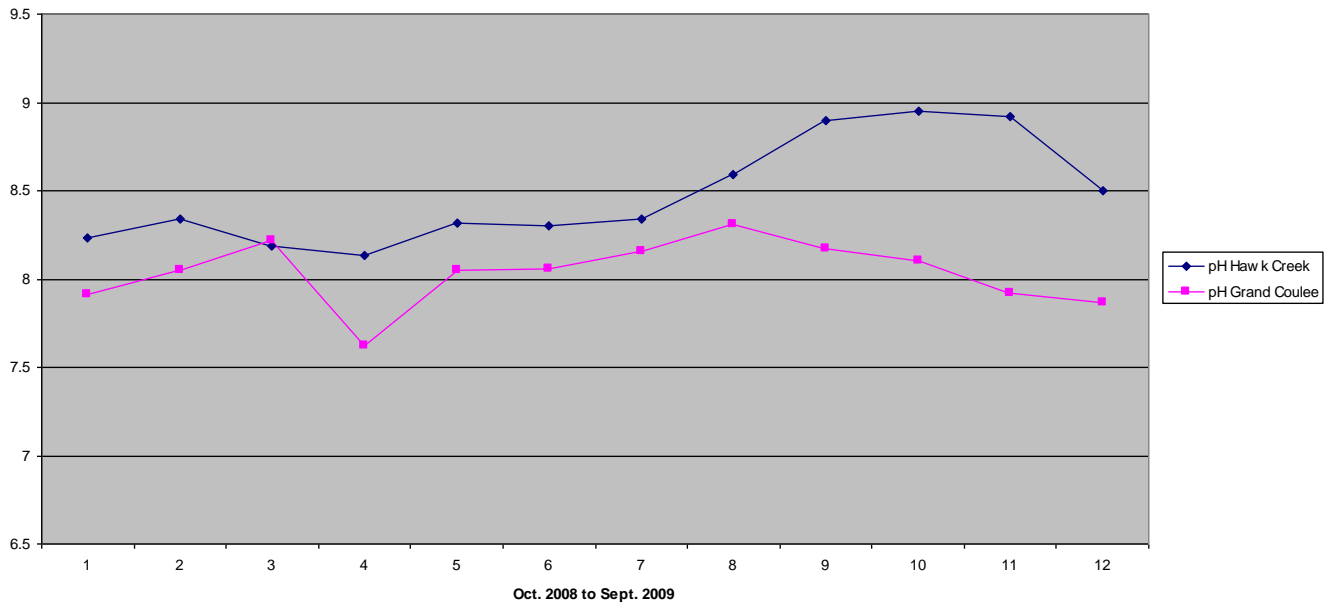
	Grand Coulee	Hawk Creek	Statistical Comparison
10/6/2008	7.91	8.23	
11/3/2008	8.05	8.34	
12/1/2008	8.22	8.19	
1/5/2009	7.62	8.13	
2/2/2009	8.05	8.32	
3/2/2009	8.06	8.3	
4/6/2009	8.16	8.34	
5/4/2009	8.31	8.59	
6/1/2009	8.17	8.9	
7/6/2009	8.1	8.95	
8/3/2009	7.92	8.92	
9/14/2009	7.87	8.5	
Calculate the Mean/AVE			
Calculate the Mode			

In what ways is the mean or mode pH potentially useful information?

2. Analyze the Ecology data for Grand Coulee and Hawk Creek. What do the data tell about pH levels and LR WQ?

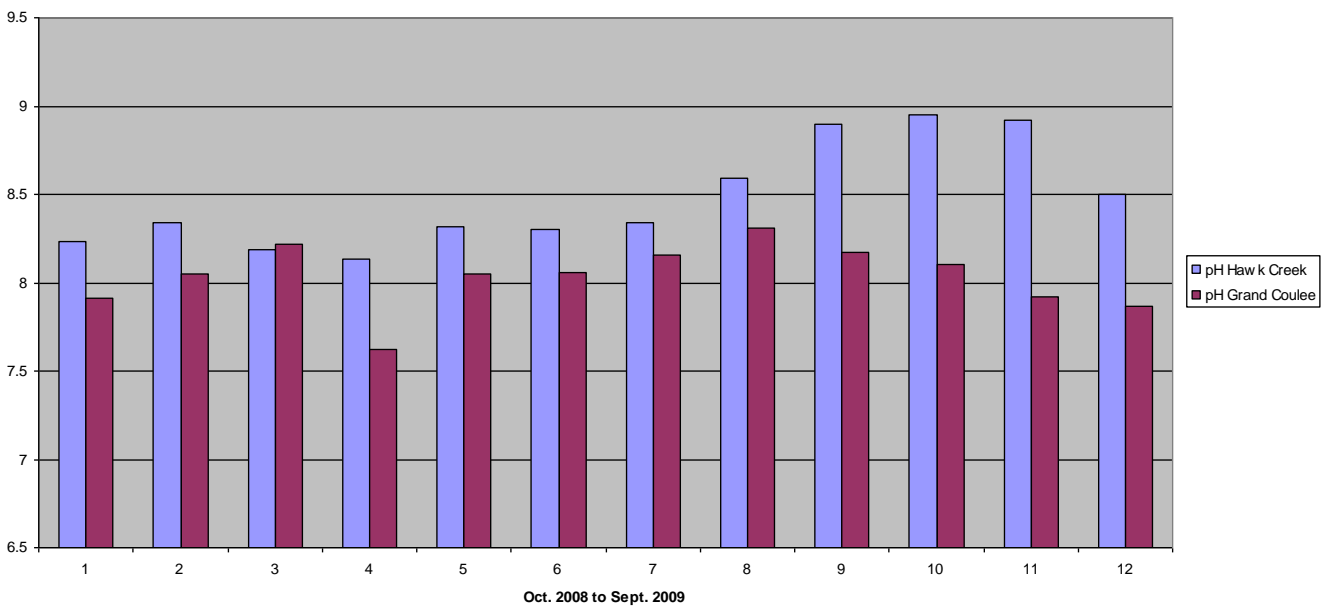
Line Graph

Grand Coulee & Hawk Creek pH Comparison

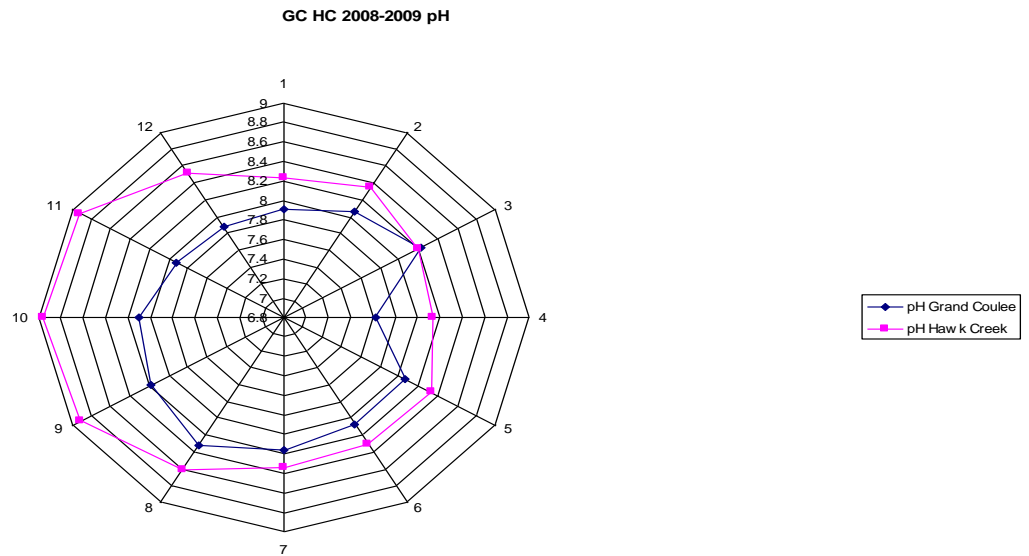


Bar Graph

Water Quality: pH Comparison Grand Coulee & Hawk Creek



Radar Graph



2. What are the strengths and weaknesses of each data presentation format? What do they reveal about pH and water quality?

DATA TABLE:

LINE GRAPH:

BAR GRAPH:

RADAR GRAPH:

3. Which plants & animals are most likely to be impacted by the changing pH levels at Grand Coulee? At Hawk Creek? Explain your choices.



Investigating Water Quality

How is water quality affected by changes in pH?

pH – A Water Quality Indicator

- **pH** – Is a measurement indicating how acidic or basic something is.
- pH is measured on a scale from 0 to 14, with 7 being neutral.
- Fresh water generally has a pH between 6.0 and 8.5. If the pH of water becomes too high (basic) or too low (acidic), aquatic organisms begin to die.
- At extremely high or low pH levels all aquatic life will die.
- pH is probably the single most important factor initiating all chemical reactions in water.

pH and Water Quality

- The pH of the water plays an important role in determining chemical solubility (how much can be dissolved in water). The pH of water can also determine the chemical bioavailability (how much can be used by organisms). The chemicals can be nutrients necessary for life or pollutants that can poison living organisms. For example, many metals are more toxic at a lower pH because they are more soluble.
- Low pH (acid) can result during hypoxic and anoxic (low to no oxygen) conditions. In addition to the stress on organisms from low oxygen, low pH will also damage living organisms. Many species have trouble surviving if the pH drops below 5.0.

pH - Measuring the Concentration of Hydrogen Ions (H+) in Water

- The definition of pH is the negative log of the hydrogen ion concentration.
- Values of pH are based on a logarithmic scale, each 1.0 change in pH represents a factor of ten change in acidity. This means that a pH of 3.0 is 10 times more acidic than a pH of 4.0.

pH Range 0-14

Name	Example	pH Scale
14	lye	14
13	bleach	13
12	ammonia	12
11	milk of magnesia	11
10	borax	10
9	baking soda	9
8	sea water	8
7	distilled water	7
6	milk	6
5	corn	5
4	boric acid	4
3	orange juice	3
2	vinegar	2
1	lemon juice	1
0	battery acid	0

- All fish die (9)
- Best level for fish (6.5-8.5)
- Snails & Tadpoles begin to die
- Bass & Trout begin to die
- Salmon eggs die
- Caddisflies & Mayflies die
- All fish die (4)

Chart provided by EPA

pH Ranges that Support Aquatic Life

Organism Group	Minimum pH	Maximum pH
Bacteria	1.5	13.5
Plants	6.5	12.0
Carp, suckers, catfish	6.0	9.0
Bass, crappies	6.5	8.5
Snails, clams, mussels	7.5	9.0
Trout, aquatic invertebrates	6.5	7.5

(most mayfly, stonefly, and caddisfly nymphs)

<http://wupcenter.mtu.edu/education/stream/Macroinvertebrate.pdf>

pH Ranges for Fish & Aquatic Organisms

	pH 6.5	pH 6.0	pH 5.5	pH 5.0	pH 4.5	pH 4.0
TROUT	Yes	Yes	Yes	No	No	No
BASS	Yes	Yes	Yes	No	No	No
PERCH	Yes	Yes	Yes	No	No	No
FROGS	Yes	Yes	Yes	Yes	Yes	Yes
SALAMANDERS	Yes	Yes	Yes	Yes	Yes	Yes
CLAMS	Yes	Yes	Yes	Yes	Yes	Yes
CRAWFISH	Yes	Yes	Yes	Yes	Yes	Yes
SNAILS	Yes	Yes	Yes	Yes	Yes	Yes
MAYFLY	Yes	Yes	Yes	Yes	Yes	Yes

- Generally, the young of most species are more sensitive to environmental conditions than adults. At pH 5, most fish eggs cannot hatch. At lower pH levels, some adult fish die. Some acid lakes have no fish. The chart above shows that not all fish, shellfish, or the insects that they eat can tolerate the same amount of acid; for example, frogs can tolerate water that is more acidic (i.e., has a lower pH) than trout.

< pH range 6.5-7.5

Aquatic insects that are generally intolerant to water pollution.

- Mayfly Nymphs
- Stonefly Nymphs
- Caddisfly Larvae
- Salmonfly Nymphs
- Riffle Beetle
- Penny Beetle Larvae
- Dobsonfly Larvae

WE CAN TELL HOW HEALTHY A STREAM HAS BEEN OVER TIME BY STUDYING THE DIVERSITY OF ORGANISMS THAT LIVE IN IT.

Aquatic insects that are generally **tolerant** to water pollution.

pH range 2.5 – 9.0

- Crane Nymphs
- Damselfly Nymphs
- Crayfish
- Midge
- Dragonfly Nymph
- Sideswimmer
- Leech
- Snail
- Aquatic Worms
- Mosquito Larva
- Bivalves

www.see.org/Power_of_Learning/100_Teachers_Resource/100_Kids_in_the_Creek/100

9

How to Measure pH Using pH Paper

When measuring pH with pH paper, dip the end of a strip of pH paper into each mixture you want to test. After about two seconds, remove the paper, and immediately compare the color at the wet end of the paper with the color chart provided with that pH indicator. Write down the pH value and color.

Always use a clean, unused strip of pH paper for each mixture you test.

www.carolina.com/.../detail/894720_chm.jpg

10

Hand Held pH Meters

11

Aquatic Plants & Animals Impact pH

- During photosynthesis, hydrogen atoms are used by phytoplankton and the pH will rise, becoming more basic.
- Respiration and the breakdown of organic matter will lower the pH, making the water more acidic.

12

Emissions Impact pH

- "Acid rain" is a broad term referring to a mixture of wet and dry deposited material from the atmosphere containing higher than normal amounts of nitric and sulfuric acids.
- Acid rain formation results from both natural sources, such as volcanoes and decaying vegetation, and man-made sources, primarily emissions of **sulfur dioxide (SO₂)** and **nitrogen oxides (NO_x)** resulting from fossil fuel combustion. In the United States, roughly 2/3 of all SO₂ and 1/4 of all NO_x come from electric power generation that relies on burning fossil fuels, like coal.

13

SO₂ & NO_x Impact pH

- Acid rain occurs when (SO₂ & NO_x) gases react in the atmosphere with water, oxygen, and other chemicals to form various acidic compounds. The result is a mild solution of sulfuric acid and nitric acid.
- When sulfur dioxide and nitrogen oxides are released from power plants and other sources, prevailing winds blow these compounds across state and national borders, sometimes over hundreds of miles.

14

Acid Rain Dry & 'Wet Deposition

<http://www.epa.gov/acidrain/index.html>

15

Effects of Acid Rain on Forests & Soils

- Acidifies (decreases the pH) in lakes, streams & sensitive soils
- Damages trees at high elevations (e.g., red spruce trees above 2,000 feet)

<http://static.howstuffworks.com/gif/acid-rain-3.jpg>

16

Effects of Acid Rain on Humans

- Accelerates decay of building materials and paints, including irreplaceable buildings, statues, and sculptures.
- Contributes to visibility degradation and harms public health (e.g., airborne sulfur dioxide (SO₂) and nitrogen oxide (NO_x) gases and their particulate matter derivatives—sulfates and nitrates).



www.dec.ny.gov/environment/dec18654.html

Effects of Acid Rain on Surface Water



- Most lakes and streams have a pH between 6 and 8, although some lakes are naturally acidic even without the effects of acid rain. Acid rain primarily affects sensitive bodies of water, which are located in watersheds whose soils have a limited ability to neutralize acidic compounds (called "buffering capacity"). Lakes and streams become acidic (i.e., the pH value goes down) when the water itself and its surrounding soil cannot buffer the acid rain enough to neutralize it. In areas where buffering capacity is low, acid rain releases aluminum from soils into lakes and streams; aluminum is highly toxic to many species of aquatic organisms.
- The ecological effects of acid rain are most clearly seen in the aquatic, or water, environments, such as streams, lakes, and marshes. Acid rain flows into streams, lakes, and marshes after falling on forests, fields, buildings, and roads. Acid rain also falls directly on aquatic habitats.

18

date	pH	
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pH DATA TABLE

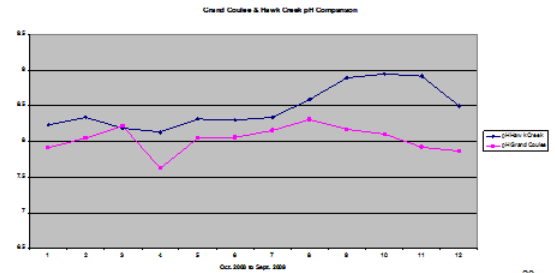
What do the data tell you about pH & water quality in each location?

Data collected by Department of Ecology

19

Compare 2008-2009 pH Data for Grand Coulee & Hawk Creek

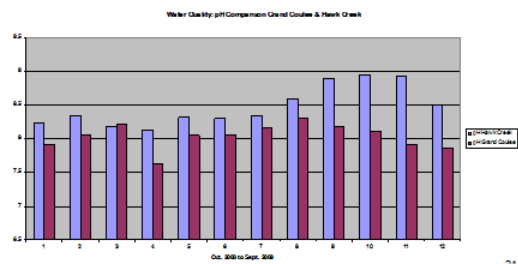
What does the **line graph** show about pH data in each location?



20

Compare 2008-2009 pH Data for Grand Coulee & Hawk Creek

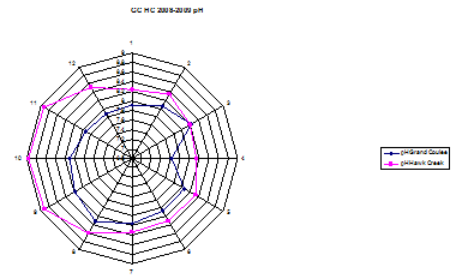
What does the **bar graph** show about pH data in each location?



21

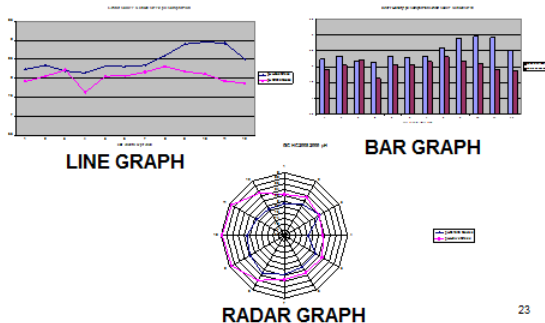
Compare 2008-2009 pH Data for Grand Coulee & Hawk Creek

What does the **radar graph** show about the pH data in each location?



22

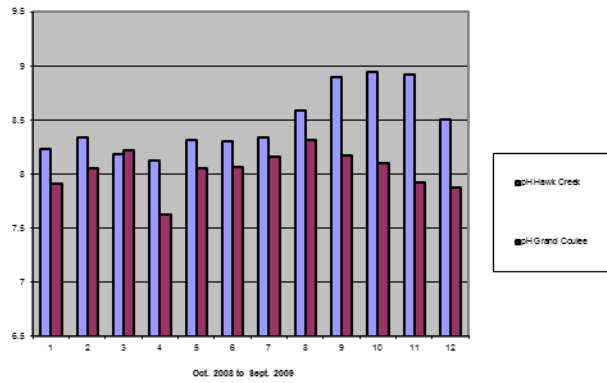
What is the advantage of each graph for analyzing pH data?



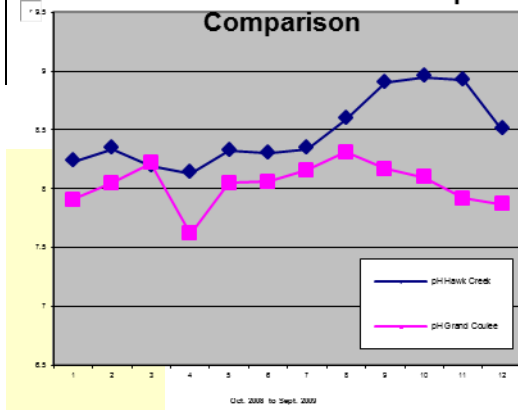
23

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Water Quality: pH Comparison Grand Coulee & Hawk Creek



Grand Coulee & Hawk Creek pH Comparison



GC HC 2008-2009 pH

