New Jersey School of Conservation
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Water Chemistry

Minimum time requirement: Two class periods (approx 3 hours)
Minimum age requirement: 5th grade
Activity level: Moderate
Travel: 1 mile over uneven terrain

Water Chemistry is an outdoor activity where students will focus their observations, curiosity and creativity using the scientific method and experimental engineering design to study the chemistry of water in a stream, lake and river on the New Jersey School of Conservation (NJSOC) campus. Water tests will be conducted and analyzed. Chemistry factors affecting temperature and runoff will be determined to give structure to observations and help form important questions about chemistry, engineering and climate change.

OBJECTIVES

Students will:

- conduct a pre-trip "thought" experiment with a provided challenge.
- conduct water testing at various locations.
- collect, record and discuss data and any findings as to water location, temperature, test results, and effects on flora, fauna and habitat with regard to climate change.
- hypothesize, conduct an experiment, collect, record and analyze data, and discuss findings in changes in temperature, volumes, and runoff rate in relation to substrate material and color.
- explain expectations and findings in terms of chemical structures and functions.
- relate all findings to engineering solutions for water runoff from impervious and permeable surfaces at their school and at NJSOC.
- improve the ability to make useful connections between seemingly unrelated things, increasing creativity.
- engage in individual reflection and small team summarizing.
- give appropriate and timely feedback on engineering design and the impact of chemistry principles.

Pre-trip "thought" experiment Challenges:

Challenge 1: Think about how you would measure the change in temperature, volume or turbidity in a sample of water runoff on different substrates? What tests and data would show a successful experiment? Why is it important to study water runoff?

Challenge 2: After studying the graphs in the EPA article, "Urbanization and Stream Temperature", what is the most critical factor impacting the temperature of rain-water runoff?

MATERIALS

- Copies of EPA article for Pre-trip Challenge & for during experiments
- First Aid kits (2)
- Data Table for Water Testing, Clip Board and Pens
- Watering Testing Kits (LaMotte Water Monitoring Kit or similar kit) (in backpack)
- Salinity Test Probe (in backpack)
- Waste Container for disposal of completed water samples
- Petri dishes (20)
- Whole Milk (1 quart)
- Food coloring (4-dropper bottle box, 8-10 boxes)
- Toothpicks
- Dish liquid detergent (Dawn)
- Chemistry Molecular Model Student Kits (Swpeet 179 Piece Organic Chemistry Molecular Model Student and Teacher Kit: https://www.amazon.com/gp/product/B07GSTZPMH/ref=ewc_pr_img_1?smid=A3NIEYL6KEKEDV&th=1) (2 kits)
- Large beaker or clear container (2), small rock, ice, oil (for Demonstrations)
- Data Table for Experiments, Clip Board and Pens
- Plastic ramps (9: 4 White, 4 Black, 1 Green)
- Small collection containers (10)
- 250 mL metric graduated cylinders (5)
- Thermometers (Digital probes with Laptop)
- Timers (stopwatch on smartphone)
- Calculators (on smartphone)
- Trowel
- Funnels (3)
- 1-Liter bottles (marked for 250 mL, prefilled with 250 mL of H_2O) (10)
- Pail with water (to fill bottles)
- Parking Lot Grid Sample (1)
- Spray Bottle

GENERAL PROCEDURE

Part I - Water Testing - Stream, Lake and River Sampling
(Note for NJSOC Instructor: Be sure to keep data tables or photographs of same.)

Conduct Water Testing and record data.

Locations:

1. Red Fox Trail - before stream water enters Lake Wapalanne
2. Spillway - Lake water exits
3. Water Ecology Bridge - before stream water enters the Flatbrook River
4. Orange Wood Lily or Brown Creeper Trail - Flatbrook River shoreline

Tests to be conducted at each location (LaMotte booklet pages listed):

1. Temperature (affects solubility of matter, particularly gases*****, and impacts the rate of photosynthesis and sensitivity of organisms to toxic wastes, parasites and disease; thermal pollution threatens the balance of aquatic systems) (pages 26 - 27)

   *****As temperature decreases, the solubility of gases increases. As temperature increases, the solubility of gases decreases. It's an inverse mathematical relationship.

2. Dissolved Oxygen (DO) (affected by natural and human-induced changes to aquatic environments; indicates health and stability of natural water environments and diversity of organisms) (pages 15 - 17)

   Inverse relationship between temperature and DO: Cold water increases DO; warm water decreases DO. (Water at 8°C can hold up to 12 ppm DO before it is 100% saturated. Water at 28°C will be 100% saturated with 8 ppm DO).

3. Nitrate (NO_3^{-1}) (affects available proteins for plants and animals; excess from sewage, fertilizer and agricultural runoff increases growth and decay) (pages 20 - 21)

4. pH (measures acidity (from 0) or basicity (to 14); healthy natural water levels measure from 6.5 to 8.2; impacted by industrial waste, agricultural runoff or drainage from mining) (pages 22 - 23)

5. Phosphate (PO_4^{-3}) (fundamental for metabolic reactions; increased levels from human and animal waste, industrial pollution and agricultural runoff cause overgrowth of plants, bacterial activity and decreased DO levels) (pages 24 - 25)

6. Turbidity (measures the clarity of water (not the color); caused by suspended and colloidal matter (clay, silt, organic and inorganic matter, and microscopic organisms);

influenced by soil erosion, urban runoff, algal blooms and bottom sediment disturbances) (pages 28 - 29)

7. Salinity (Optional) (changes in salt concentration impact water quality for drinking and irrigation purposes, affect aquatic life, and indicate potential pollution sources from human activity)

Divide students into groups for each individual test (6-7 tests at each site) to be performed. Within each group, designate the following roles for students:

1. Water Testing Manager (1)
2. Test Conductor(s) (2 for each test)
3. Test Recorders and Reporters (1 for each test)

Read directions for “Collecting a Water Sample”, LaMotte page 10.

Students conduct tests and record data. Discard all water samples in waste container.

Compare results to the “Ranking Test Results” table, LaMotte pages 30 - 31.

Within their testing groups, discuss any trends discovered and how those results relate to Climate Change, especially effects of temperature and testing in different water locations, possible habitat destruction and flora and fauna disruption.

As individuals, ponder the environmental impact of man-made Lake Wapalanne with regard to its relatively shallow depth and runoff thermal influence. Then share those thoughts with the larger group.

Part II - Chemistry Activities and Ramp Experiments

Conduct Chemistry Activities/Demos and Ramp Experiments — Effect of Substrate and Color on Changes in Temperature, Volume and Runoff

Location: Research Lab and outside area (utilize steps to elevate the ramps):

The Chemistry of H_2O

1. Introduction: Report on Water Testing Part I — collection of critical data on water quality.

2. Student activity - Students follow verbal directions to conduct an activity to demonstrate the molecular structure of water.
   Activity: Working in teams of 2, a Petri dish is filled with whole milk, 4 drops of food coloring are added (at 3, 6, 9 and 12 “o’clock”), a drop of liquid soap is placed on the

tip of a toothpick and then the tip is lightly dipped into the center of dish (all students dipping the toothpick at the same time. Observe!

3. Structure - Use molecular models to explain the non-linear shape of water and show its polar structure. (Valence Shell Electron Pair Repulsion Theory (VSEPR). Demonstrate the linear vs angle 3-atom molecules caused by outer electrons (negative pair repulsion)

4. Students build the water molecule model using the kit materials (teams of 2 or 3).

5. If times permits, students connect all water molecule models demonstrating hydrogen bonding on the center lab table.

6. Discussion and Demo:
   Functional effects of the H_2O molecule's angular structure:
   a. polarity and solubility (hydrogen bonding and "like dissolves like")
   b. crystal formation and resulting density of solid vs liquid H_2O and the effect on freezing lake habitats
   c. Demonstration of ice and rock in water vs oil in water

7. Ask students to explain the milk/food coloring activity in terms of above information. (Polarity!)

Discussion of goals:

1. Experimental goals (to measure changes in temperature, volume and rate of runoff with respect to substrate material (impervious vs. permeable) and surface color; independent and dependent variables.

2. LeChatelier's Principle (systems returning to equilibrium)

3. Engineering design of ramp for experiment; material and equipment flaws and decisions.

Explain to students that, ideally, we would have preferred to give them total control of experimental design, but time constraints and materials acquisition would not allow for that.

Demonstration: Ramps (3) (White, Black and Green) with no substrate (simulating impervious surface):

1. Add 250 mL of H_2O through funnel
2. Measure temperature change (Digital temperature probes)
3. Measure volume change and runoff (milliliters, mL)
4. Time the runoff (seconds, s)
5. Calculate the rate of runoff (= Change in Volume (Water prevented from running off) / time, milliliters/second, mL/s

Student Experiments: Students collect substrate materials from the area surrounding Long House. They form hypotheses, conduct the 3 experiments, recording and analyzing data.

Discuss the following before students begin the experiment:

1. Experimental design and set up
2. Possible substrate materials around Long House area and search boundaries (pine needles, leaves, grasses, gravel, pine cones, mulch, sand, etc)
3. Water source (large bucket of water from tap or lake)
4. Safety

Additional rules:

1. The level of substrate filling the ramp can be no higher than the inner fold line in the ramp.
2. Each ramp receives 250 mL of water, poured from the 1L water bottle through the funnel, at a steady rate at the top of the ramp.

Divide students into 3 experimental teams:

Team 1 - Temperature Change, 3 ramps: White, Black and Green, with identical substrates
Team 2 - Temperature Change, 3 ramps, All Black, with different substrates
Team 3 - Volume Change, 3 ramps, All White, with different substrates; to calculate runoff rate.

Within each group, designate the following distinct roles:

1. Ramp manager
2. Substrate manager
3. Water supervisor
4. Time recorder (will need access to stopwatch feature of smartphone)
5. Temperature recorder (will need to work with data logging sensors)
6. Volume recorder
7. Data Recorder/Runoff Calculator/Team Reporter

Discussion:
Each team shares their data and findings to the larger group.

What is the impact of the findings on surfaces at the school and at NJSOC campus (especially at the spillway from Lake Wapalanne and the runoff thermal impact)? What effect would this have on possible design solutions to minimize runoff at all locations?

Show the plastic Parking Lot Grid sample and ask students for possible uses for this product..

Part III - Summary

1. We would be excited if interested students could revisit the data and then share their findings and experiences with NJSOC in the form of a Google slideshow. Doing so would provide a meaningful post-field experience. We would be eager to use their product as an exemplar for future schools with other academically-motivated students, should they give us permission to do so.
2. We had also previously mentioned that ideally, we would have preferred to give them total control of the experimental design. Had we been able to do so, what variables would they have chosen to investigate and what materials would have been necessary to conduct such an investigation.
3. Ask students for any recommendations on changing the surfaces of areas prone to thermal change or large volume runoff. How is this related to Climate Change?
4. Do students have any strong opinions, based on today's activities, as to the future of Lake Wapalanne? as to the future of surfaces in man-made areas, such as school buildings?
5. Your teacher presented you with the following Problem-based Learning Challenge: "Design a solution for how to reduce the impact of warm runoff from the impervious school grounds on the local stream." What did you learn from today's activities that will assist you in solving that challenge? How would you modify your runoff project with the knowledge you gained today?
6. Discuss EPA Article, page 1, regarding urbanization.

Graphs from "Urbanization and Stream Temperature EPA Study"
(https://www.epa.gov/caddis/urbanization-temperature)

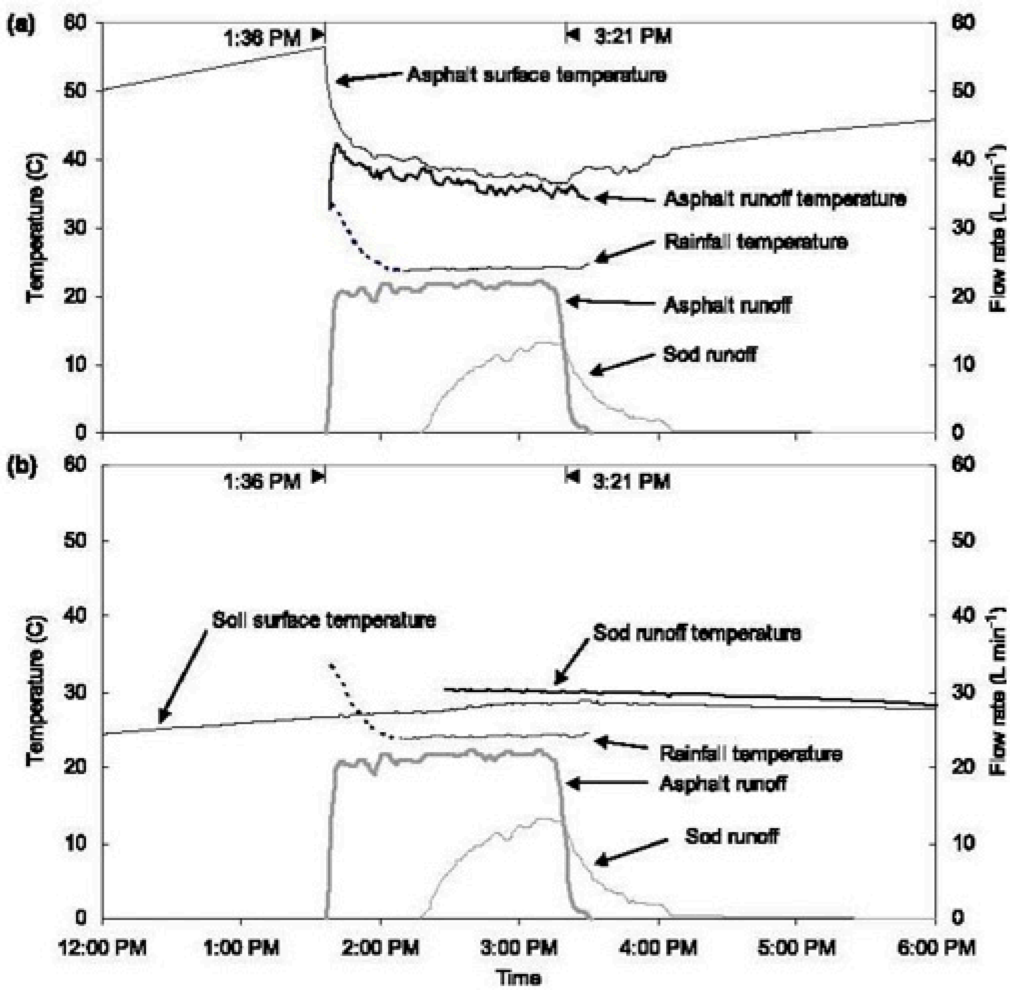

Figure 28. Temperature of (a) asphalt and (b) sod surface and runoff during July 15, 2005 rainfall simulation; asphalt and sod runoff and rainfall temperature are shown in both (a) and (b).

From *Thompson AM et al. 2008a. Thermal characteristics of stormwater runoff from asphalt and sod surfaces. Journal of the American Water Resources Association 44(5):1325-1336*. Reprinted with permission.

NEW JERSEY STANDARDS

New Jersey High School Science Standards, Chemistry

Unit 1: Structure and Properties of Matter
HS-PS2-6: Molecular-Level Structure of Designed Materials

Objectives: Communicate scientific and technical information about why the molecular structure is important in the functioning of designed materials (Structure and Function)

Clarification Statement: Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.

Assessment Boundary: Assessment is limited to provided molecular structures of specific designed materials.

Unit 2: The Chemistry of Abiotic Systems
HS-PS3-4: The Second Law of Thermodynamics

Objectives: Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics). (Systems and System Models)

Clarification Statement: Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.

Assessment Boundary: Assessment is limited to investigations based on materials and tools provided to students.

Unit 3: Bonding and Chemical Reactions
HS-PS1-6: Increased Products Design Solution

Objectives: Refine the design of a chemical system by specifying a change in conditions that would produce increased amount of products at equilibrium (Stability and Change)

Clarification Statement: Emphasis is on the application of Le Châtelier's Principle* and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products.

Assessment Boundary: Assessment is limited to specifying the change in only one variable at a time. Assessment does not include calculating equilibrium constants and concentrations.

*Le Châtelier's principle states that if a dynamic equilibrium is disturbed by changing the conditions, the position of equilibrium shifts to counteract the change to reestablish an equilibrium.

Unit 6: Human Impact: The Chemistry of Sustainability
HS-ESS2-4: Energy Variation and Climate Change

Objectives: Use a model to describe how variations in the flow of energy into and out of earth's systems result in changes in climate. (Cause and Effect)

Clarification Statement: Examples of the causes of climate change differ by timescale, over 1-10 years: large volcanic eruption, ocean circulation; 10-100s of years: changes in human activity, ocean circulation, solar output; 10-100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and 10-100s of millions of years: long-term changes in atmospheric composition.

Assessment Boundary: Assessment of the results of changes in climate is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution.

Comprehensive Health and Physical Education

• 2.2.8.MSC.7 Effectively manage emotions during physical activity (e.g., anger, frustration, excitement) in a safe manner to self and others.

Social and Emotional Learning

All of our field lessons integrate the concepts of self-awareness, self-management, social awareness, responsible decision-making, and relationship skills found in the New Jersey's Core Social and Emotional Learning (SEL) Competencies.

REFERENCES

NJ High School Science Standards for Chemistry:

https://thewonderofscience.com/new-jersey-hs-course-model

Urbanization and Stream Temperature EPA Study:

https://www,epa.gov/caddis/urbanization-temperature

L. Lyons, M. Roche, 2/15//2025, New Jersey School of Conservation