Solar and SODIS: Creating Clean Water for the World

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DESCRIPTION: According to Nobel Laureate Richard Smalley, the number one and two challenges for humanity are energy and clean water. This classroom activity will introduce students to a low cost, renewable technique that connects these two issues. During the activity, students will learn about the risks of contaminated water as part of the spring microbe/microscope unit. They will then be introduced to the SODIS technique (solar UV water disinfection) and learn about the different energy sources in sunlight and how they can be used to kill microbes in water. Students practice the scientific method as they choose which two variables they would like to test (bottle vs. plastic bag, reflective surface vs. black tarp, wind cover vs. exposed, angled roof vs. ground, etc.), create a hypothesis on how these variables will affect coliform levels in the water sample (collected from the Willamette River in our case), collect data on agar plates and then share their findings with the class.

GRADE LEVEL(S): 5, 6, 7, 8

SUBJECT AREA(S): Science, social studies, biology, life science, solar energy

ACTIVITY LENGTH: 1 hour, 30 minutes

LEARNING GOAL(S): Students will be introduced to the range of microbes in the environment, understand the risks of “dirty water” and be able to explain how energy from the sun can purify water through the SODIS technique.

STANDARDS MET:

Next Generation Science Standards:

- 5-ESS3-1. Obtain and combine information about ways individual communities use science ideas to protect the Earth’s resources and environment.
- 3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- 3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- 3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.
- 5-PS1-1. Develop a model to describe that matter is made of particles too small to be seen.

Student Background:

- Prior knowledge of the scientific method
- Prior knowledge of the light spectrum including ultraviolet (UV), infrared (IR) and the visible light spectrum

Educator Background:

- Solar Water Disinfection: Guide for the Application of SODIS http://www.sodis.ch/methode/anwendung/ausbildungsmaterial/dokumente_material/manual_e.pdf
- The Water School: http://www.waterschool.com/
- The Water School Program PowerPoint presentation: waterinstitute.unc.edu/files/2011Entebbe_Day1_08_Mukalere.pdf
- SODIS - Solar Water Disinfection: Water Quality Improvement at Household Level with Solar Energy: www.hedon.info/docs/BP53-Aristanti-12.pdf

Other Materials List:

- "How to Build a SODIS Table" student handout
- "SODIS Worksheet: The Sun and Clean Water"
- "Microbes, Microbes Everywhere" PowerPoint presentation
- (2) 3M Petrifilm Coliform detection boxes - 25 plates/box
- IR temperature gun
- Thermometer (for measuring ambient air temperature)
- 100 disposable 1.0ml pipettes
- 96 4oz. wide-mouth glass jars with plastic lids
- Box sandwich baggies, 100 baggies
- Box of aluminum foil
- Black garbage bag/tarp
- File box
- Basic woven cotton fabric - 1/4 yard
- Rubber bands
- Optional: (1) 8 ft. metal corrugated roof panel, (2) 2" x 4" x 8' pressure treated wood, (8) lag screws

Vocabulary:

- SODIS
- Water-borne illness
- Microbe
- Dehydration
- Sari Filtration

- Solar radiation
- Infrared (IR)
- Ultraviolet (UV)
- Variables
- Control
- Coliforms
- Fecal coliforms
- E. coli

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Lesson Details:

Classroom Prep

1. Collect water from local river: 4L for 30 student class
   - Use smaller plastic bottles (1L or less) so the student teams can collect the water from a main container and add the cotton filter to the top themselves.

2. Designate an area with direct sunlight for 6 hours a day for the experiments.

3. Print class worksheet from website: repasky-jamie-SODIS-worksheet.pdf.

4. Optional: Create SODIS table as an example of the types of roofs that are used in these countries and how they can be used to store SODIS bottles/baggies during the day, see file on the website: repasky-jamie-how-to-build-SODIS-table.pdf.

Day 1: Monday

Time needed: 1 hour, 30 minutes

Materials:
- 96 4oz. wide-mouth glass jars with plastic lids
- box sandwich baggies, 100 baggies
- box of aluminum foil
- black garbage bag/tarp
- File box
- Basic woven cotton fabric, 1/4 yard
- Rubber bands
- IR temperature gun
- Optional: SODIS table

Guiding Questions:
1. If there are microbes all around, how do we know that our tap water is clean?
2. How do you clean water?

3. How does solar radiation kill microbes?

Activity Plan:

1. Hand out the activity packet.

2. Go through the power point presentation with your class.

3. Ask the students to list microbes that are in our environment.
   - Which are good, which are harmless, which are bad for us?
   - Optional extension: microbes in the news
   - Optional extension: how much of your weight is bacteria? (Answer: 1/10 of the dry weight of the human body is bacteria and contains 10 times more bacterial cells than human cells.)

4. Introduce the state of clean water in the world.
   - Optional extension: clean water access in developing countries, disaster areas.

5. Introduce the SODIS technique to the class.
   - Review prior knowledge about solar radiation - IR, visible light, UV.

6. Tell the students that they will be able to test the SODIS technique with water from a local river.
   - Review the scientific method.
   - Ask the students to brainstorm variables that they could test.
     - Direct the brainstorming by allowing them to see the materials available for use.
   - Break the class into teams and ask them to pick a question for their scientific project.
     - They should write the question, one or more hypotheses, and what supplies they will need.
     - If students get stuck picking a question, offer a few options.
       - Does SODIS work better in a bottle or a baggie for water from river X?
       - What happens if a SODIS bottle is on a black surface instead of the reflective surface?
       - What happens if a baggie is left standing up instead of flat on the SODIS table?

7. Ask the class, what should be our class control (Answer: tap water)? Why is a control important?

8. The students should:
   - Write two to three observations about their water sample (Where is it from? What color is the water? And so on…)
   - Label their bottles/baggies with their name and sample number (tip: attaching labels on masking tape will make it easier to reuse the glass bottles)

- Bottle or bag their three samples and label them as follows:
  - River Control – water from the river filtered with the cotton cloth that will not be in the sun (known as "Sari-filtered")
  - Variable 1 (V1) =
  - Variable 2 (V2) =

9. Have the students place their samples outside - on the aluminum foil, tarp, SODIS table, and file box and record the temperature of the sample.

Day 2, 3, 4: Tuesday, Wednesday, Thursday

Time needed: 15 minutes each day after lunch

Materials:
- IR temperature gun
- Thermometer for measuring air temperature

Guiding Question:
Why is or isn't their sample warmer than the air temperature?

Activity Plan:
Have the students use an IR temperature gun to record the temperature of their samples each day and take a reading of the air temperature for comparison.

Day 5: Friday

Time needed: 1 hour

Materials:
- (2) 3M Petrifilm Coliform detection boxes, 25 plates/box
- (100) disposable 1.0mL pipettes

Guiding Questions:
1. What will the agar plates identify in the samples?
2. What do you think the results will look like?

Activity Plan:
1. Have the students bring the samples into the classroom.

2. Ask the students to wash their hands before the lesson.

3. Explain how to use the pipettes correctly. Review how each sample should use a new pipette to avoid contamination.

4. Demonstrate how to use the Petrifilm with the class control (i.e. tap water).

5. Explain how the Petrifilm works.

6. Hand three Petrifilms to each team. Ask the students to label the films with their team name and the sample name.

7. When the teams have plated their samples, collect them and store in a warm location (not in the sun or near water).

8. Have the students wash their hands at the conclusion.

Day 6: Monday

Guiding Questions:

1. What did the agar plates identify in their samples?
2. Did the SODIS technique work in all of their samples? Why or why not?
3. What would they test next time? Why?

Time needed: 1 hour, 30 minutes

Activity Plan:

1. Review how to read the results on the Petrifilm.

2. Ask the students to draw what they see on their plates and record the data in the activity packets.
   - Optional extension: have the student calculate how many total coliforms (TC) and fecal coliforms (FC). Compare the percentages of FC/TC from different water sources

3. Have the students spend 10 minutes writing down their conclusions
   - These conclusions can be used for a mini class presentation - 2 minutes per team:
     - What was the question they asked?
     - What did they think would happen?
     - What did they observe on their plate
     - What does their data make them think happened?
     - What would they do differently if they were to try again?

4. Have each team present their project to the class.

5. Optional extension: Debate pros/cons of SODIS glass bottles vs. bags

6. Optional extension: Design a perfect SODIS bottle

7. Activity wrap up:
    - Create a class definition of “dirty water”
    - Who are the “good, bad, and the ugly”?
    - Create list of different variables that were tested
    - Create a graph or chart of class results

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