Water Purification with Fish Tanks

(4-6 weeks)

Authors

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SUBJECT/GRADE LEVEL

Subject Area: Science and Math
Grade Level: High School

Materials

- Small fish tanks (preferably 10 gallon)
- Filtering system
- Any decorative items for fish tank
- Testing kit to include pH, Nitrate, Nitrite, Ammonia (API company or Chewy.com - for test kit. $36 Use Vernier probe for pH.)
- Computer with Internet

STANDARDS

Next Generation Science Standards

- HS-PS1-4: Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.

Mathematics Standards | Common Core State Standards

- **CCSS.MATH.CONTENT.HSA.CED.A.2** Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.
- **CCSS.MATH.CONTENT.HSF.LE.A.1** Distinguish between situations that can be modeled with linear functions and with exponential functions.
- **CCSS.MATH.CONTENT.HSS.ID.B.6.A** Fit a function to the data; use functions fitted to data to solve problems in the context of the data. Use given functions or choose a function suggested by the context. Emphasize linear, quadratic, and exponential models.

English Language Arts Standards | Common Core State

- CCSS.ELA-LITERACY.SL.11-12.1.A: Come to discussions prepared, having read and researched material under study; explicitly draw on that preparation by referring to evidence from texts and other research on the topic or issue to stimulate a thoughtful, well-reasoned exchange of ideas.

LESSON OBJECTIVE(S)

Students will be able to

1. Demonstrate water purification process by quantitative data from water sources through absorption and adsorption processes.
2. Observe techniques used by water and sewage departments for water purification as well as have an understanding of the filtration process for fish tanks.
3. Make predictions of water levels based on the line of best fit for a set of data.

CAREER CONNECTION(S)

Mentor Background: Luke Gurtoski, Research Chemical Engineer

Mr. Luke Gurtowski, P.E., is a Research Chemical Engineer in the U.S. Army ERDC's Environmental Engineering Branch. He leads research toward materials science and environmental treatment at bench and field (prototype) scales to support the Military and Civil Works missions. His primary focus involves utilization of nanomaterials and novel technologies/strategies for a variety of applications. Namely, Mr. Gurtowski investigates separation techniques in addition to chemical degradation for water treatment related to traditional and emerging contaminants. Mr. Gurtowski has also led research to support materials development for sustainable infrastructure.

Mr. Gurtowski earned a Bachelor of Science in Chemical Engineering and Master of Science in Civil and Environmental Engineering from Mississippi State University. Mr. Gurtowski is a licensed Professional Engineer in the state of Mississippi. He is also an active member of the American Society of Civil Engineers (ASCE) and was named 2019 Young Engineer of the Year by the organization's Mississippi Section.

STEM Careers: **Manufacturing Engineering, Process Engineering, Project Manager, Production Manager, Chemical Product, Quality Assurance**

ENGAGEMENT

Brief Description: This activity will include a video and/or an article of a crisis situation (Mississippi Water Supply, Flint, Michigan water supply, or something that is relevant to your area.

- North Eastern Connection: Train Derailment in East Palestine, OH
- Jackson, Mississippi Water Crisis: NBC News Clean Water
- Flint, Michigan Deadly Water: Flint's Deadly Water

Procedures:

Day 1:

First, the teacher will draw a K-W-L on chart paper titled "Water Crisis". Students will write on post-it notes what they know about the water crisis and stick their post-it notes under the "K" column. The teacher will lead the discussion around what students have shared they know about the water crisis.

Next, students will turn and talk for 5-7 minutes and discuss what they are wondering or what they

want to know regarding the water crisis. Each student will write on a post-it note two points they have discussed with a partner regarding what they want to know about the water crisis.

Then, the teacher will share with students that they will be viewing the video, U.S. states struggle to share dwindling waters of Colorado River

The teacher will explain the following instructions to students for watching the video: As you watch the video, write at least two things you are wondering or have questions about and at least three things you found interesting or learned while watching the video.

After viewing the video, the teacher will ask students to summarize in their own words the information they heard in the video. Then, the teacher will have the students go into a group of three to share the three interesting facts they wrote from the video. After sharing with each other, the teacher will ask each group to write the two things they are wondering or questioning from the video under the "W" column of the K-W-L. The teacher will lead the discussion on what the students found interesting or learned and place it under the "L".

Day 2:

First, the teacher will review the K-W-L chart notes from the previous day. The teacher will guide students through a discussion of the reasons a clean water supply is essential. Students will watch the video, Why American cities are struggling to supply safe drinking water. When students watch the video the first time, students will write a summary of the video in 10 sentences or less.

Next, the teacher will pair students with a partner. The class will rewatch the video, Partner A will write down the problems or issues with the water and Partner B will write down the why and locations of the water crisis.

Day 3: After learning about cities struggling with safe drinking water, students will individually research which local water source provides the drinking water for the area. If available, students can test this water for use in exploration.

EXPLORATION

Brief Description: Science class: This activity will include students researching absorption, adsorption and desorption as a way to purify water. The process of defining actions for sustaining a fish tank to include how commercial filters work.

Length: 1 week for this part of the lesson. This section is set up so that students explore content thoroughly. The science portion is set up to take 2 days for the activities, but could use an extra day to wrap up all the information

Procedures:

Math Class: Students obtain test data from local water source (Ex: Youghiogheny River) for a given time period. Sample data may be PH, Water Temperature, Nitrates, Nitrites, Ammonia. Students will then create a scatter plot of the data and discuss which type of equation would be best for the data. Then, students will test the water fountains/water bottle fill stations in the school for the same data and repeat the process.

- Extension: The teacher can review central tendencies (mean, median, mode), and box and whisker plots. Group the students so that one group is assigned for each variable tested. Each group should create a box and whisker plot using all the drinking water locations in the school. If the students need a review, the teacher should demonstrate with one of the variables. The teacher should use the box and whisker plots to show how the size of a box varies, even though it

represents 25% of the data. This learning is cross-curricular to the idea of precision and sources of error in the science classroom. This is also a good time to demonstrate how outliers greatly affect the results (both the linear pattern on the scatter plot and the length of each of the quartile boxes).
    - Students can individually test the drinking water for a series of days and create their own box and whisker plots to conclude the precision in their measurements. They can compare this to the data from the local water source to determine if there is more or less variability.
- Field Trip Opportunity: Students can go to a local river or water treatment plant to test these variables and/or learn more directly how local water sources are prepared to create safe drinking water.

Science Class:

Students will watch the video to get an understanding. Difference between absorption and adsorption - video As students go through the video, have them write down words (key terms) they are unfamiliar with so they can define those ket terms. To better understand the key terms, the following activities are available.

Energy Absorption at School - Activity

Materials:

Absorption: Students will better understand absorption, adsorption, and desorption through activity concepts. Using the video listed, students will be able to define and have a better understanding of absorption and adsorption. Students will follow the lesson listed above for their school.

Adsorption using activated carbon - Activity

Adsorption: Students will follow the activity above and discover how carbon adsorbs materials.

Students will gather all their research information along with their observations from the activities and keep a record in their science or lab notebooks. This includes all data collected.

EXPLANATION

Brief Description: Science Class: This activity follows the exploration research and students will collect data to support their findings.

Procedures:

Math Class: Lesson Topic: Rate of Change, Slope and Regressions

- Using data collected during the exploration, the teacher will plot the sample data points to demonstrate a relationship between two quantities (example: PH and time). This can be done on a white board, tablet. Demonstrate the connection between results and “steepness” of the slopes. Have students calculate unit rate using two poin ts from their data.
- After students have graphed and determined equations by hand, have students use technology such as a spreadsheet software or TI Nspire to graph and compare different regressions. At this

point, the teacher should explain what the coefficient of determination (R^2) is and how it is used to determine the line of best fit.
- Students will then use their equations to make predictions about future water testing values.

Science Class:

Students will collect different samples of water around the school (or teacher can provide sample water from different nearby sources). Students will test water for pH, nitrogen, chlorine, and ammonia levels. Discussions will take place as the relevenceStudents will prepare their presentation material for the evaluation portion of the unit. Students will gather information from engage lesson and explore lesson to put together the connection between absorption, adsorption and desorption as they relate to purifying water. The work gathered is recorded in their science notebooks/lab books. Key terms are to be defined and explained. Pictures/sketches need to be clean and clear of the process.

ELABORATION

Article: **Importance of Imperviousness**
Article: **Impervious cover to prevent flooding**
Student Work**: Student work will be recorded in their science/lab notebook.**

Brief Description: This activity will demonstrate the sustainability of the purification process by testing and measuring the fish tank system. Students will set up a fish tank and maintain water chemicals by collecting daily chemical levels. Students will also demonstrate and make connections between runoff water from an impervious area and a permeable area through activity and calculations.

Procedures:

Fish tank activity:

1. Be sure to select a sturdy table or stand on which to place the tank and to position it near an electrical outlet and away from direct sunlight, heaters, and air conditioners.
2. Every tank needs a lid to keep out dust and a light for easy viewing of the fish.
3. Clean all items including the rocks before placing them in the tank.
4. For older students, the fish tank can be set up much earlier and allow the water to become cycled before adding fish (see note at the end of the procedures for cycling information). For younger students, once adding water, chemicals can be added and monitored to allow the water to be cycled in order for fish to be ready for the tank.
5. Students will test the water chemicals and temperatures daily for their data collection. (Students will test pH, nitrites, nitrates, and ammonia levels, and record the water temperature daily.)

Natural areas Filter water activity:

1. Have students consider the proportion of runoff from a parking lot compared with a grassy meadow. About 95 percent of rain falling on a parking lot ends up directly in drains and gutters. Only about 5 percent of rain falling on a meadow drains off the field. In terms of development, areas differ

considerably in the proportions that are impervious. In a residential zone, the impervious area may range from 20% to nearly 50%. The differences are determined largely by the layout of streets and parking, and sizes of lots compared with houses.

2. Time allowing, more advanced students can engage in an exercise to quantify and compare the amounts of vegetative cover versus impervious surface.

3. Have students find their school, residence or other suitable location on Google Maps. Switch to Satellite view. Use the zoom tools until the area of interest covers an area about 7 x 10 inches on the screen. Take a screen shot of the area. Using a color printer, print out the screen shot. You should now have an image of the area.

4. Using the marker, students draw a 1cm grid on the acetate sheet.

5. Lay the acetate sheet over the satellite photo image. Count squares accordingly, categorizing surfaces depicted in each one as "soil" or "impervious." If a square includes both surfaces, record the surface that occupies the larger part of the square. If it's hard to tell which surface occupies the larger part of the square, record that square in both categories.

6. Count the number of squares in each category and derive the proportion of total area covered with impervious surface. Have students discuss their findings in context of the impact of impervious surfaces. (See article The Importance of Imperviousness)

Note: Aquarium cycling is creating a biological safe environment for the fish. This is done by introducing nitrifying bacteria into the aquarium to regulate the nitrogen cycle. These bacteria curb the effects of ammonia buildup caused by the breaking down of fish waste. The nitrogen cycle can take 2-6 weeks when adding fish in small amounts. Opting to cycle the tank quicker will take adding beneficial bacteria from the onset (can be from a cycled tank already or by adding bio-balls, a wet/dry filter, or other biological filter media)

EVALUATION

Brief Description: This activity will demonstrate success with mathematical graphs and calculations of sustainability and science development of a purification process.

Procedures:

Science Class: Students will present their observations and connections of having clean (purified) water for humans and how the purification process is embedded in nature and what it takes to purify water for sustainability. Student observations will be assessed through their lab notebooks and presentations. Presentations can be in the format of powerpoint, google slides, or video of their process.

Math Class: Using the data gathered from either the fish tanks or the river data, students can make predictions as to what the water levels would be like if they were left untreated. (The teacher can pick a desired time frame for the independent variable, such as a week. Note: The teacher may want to test a value so that students do not get an impossible result with their trendlines. For example, a month or

year might result in impossible values for pH depending on what the lines of best fit looked like.) Students will use their lines of best fit to make these predictions. If desired, students can write conclusions about how water levels like these could be detrimental to aquatic/human life and the importance of purification for sustainability.

REFERENCES

- Freshwater Aquarium in the Classroom
- How Natural Areas Filter Water