Curriculum Units by Fellows of the Yale-New Haven Teachers Institute
2018 Volume II: Engineering Solutions to 21st Century Environmental Problems

Water Filtration Engineering in the Elementary Grades

Curriculum Unit 18.02.06
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Introduction

As a primary-level teacher in a self-contained classroom at Edgewood Magnet School in New Haven, I find the neighborhood/magnet setting a rewarding environment, with students coming to school each day from a variety of home circumstances and with differences in academic levels. Because of these variables, the children have differing levels of background knowledge and life experiences. The classroom is a mixture of varied ethnicities, economic strata and social and emotional strengths and weaknesses. Edgewood provides an S.T.E.A.M. curriculum, an educational approach that uses Science, Technology, Engineering, the Arts, and Mathematics as access points for guiding student inquiry, dialogue and critical thinking.

The purpose of this unit is to begin to expose my students to the use of scientific inquiry, which inherently allows everyone to learn in a differentiated environment. Students will spend time learning new concepts and experiencing laboratory and field demonstrations as they move through this curriculum unit on environmental engineering and specifically, water filtration. The students will research and design projects to submit to the annual Science Fair that show the experiments that helped them learn about filtering and making potable water of different quality. This unit supports the place-based learning that Edgewood Magnet school encourages. Trips to the Edgewood Park to visit the ponds and the West River for hands-on investigation and experimentation are modeled on experiences from the seminar.

This unit builds an appreciation for the outdoors in my students, impart an understanding of how many people in the world struggle to find clean water, and empower them to solve a problem. Humans are spending increasingly more time indoors. As much as 96% of our day is spent inside, so consequently we are experiencing the natural environment less and less. This is an unfortunate and unhealthy trend. Nature deficit disorder, a term coined by Richard Louv in his book, Last Child in the Woods, identifies a result of this extreme amount of time spent indoors. Children are not being exposed to nature on a regular basis and are not making a connection to their natural world. He points out that the children who play outside are less likely to get sick, to be stressed or become aggressive, and are more adaptable to life's unpredictable turns. [1]

My students most certainly fall into this demographic. They travel to school inside a bus or car; spend many hours in school; many go to after-school programs; frequently sports and activities occur inside buildings: basketball courts, soccer "fields," and swimming pools. While these are all important parts of a child's day, we need to think about moving them to the outside world. New Haven, CT offers tremendous opportunities for outdoor experiences to learn about the water within our community and how we have access to what we need. I want to get my students outside where they can become comfortable exploring and investigating.

The outdoors provides significant ecosystem services to humans. For example, when we're thirsty, we reach for a glass of water. We turn on the tap and fill our glass, open a bottle of water, or go to the refrigerator's water dispenser. Whatever method we use to get a drink, we don't have to consider the environmental and water quality engineering underlying clean water. Living in a fully industrialized country, like the United States, we are fortunate - we don't have to worry about the quality of our drinking water. Our communities have the means to clean and provide water to the residents. But in many parts of the world, people don't have this luxury.

Whether due to war, poverty or underdevelopment, the lack of clean water leads to many health and social problems. In fact, 780 million people do not have access to an improved water source. Towns or villages might not have a well nearby, and family walk for miles to get the daily requirement of water. Or if there is water nearby, it might be contaminated. Contaminated water can be a source of deadly diseases, such as cholera and dysentery. According to the World Health Organization, every year approximately 1.6 million people die from illnesses (usually severe diarrhea) due to drinking unsafe water. Most are children under the age of five. About 4,500 people—again mostly children—die every day because they drank unsafe water. [2]

An additional aspect of lack of access to clean water is gender inequality. The chore of gathering water for the family generally rests upon the shoulders of female family members, especially girls. If girls are gathering water all day, that leaves limited time for school. Access to clean water can result in a population that is not only healthier, but that is better educated, and more able to help improve their community. [3]

Unit Description

The New Haven Public School Science Curriculum includes a focus on Earth's Materials for second graders, specifically how materials cycle through the Earth's systems. This unit supports this area of study and begins with *The River Ran Wild: An Environmental History* by Lynne Cherry as a foundation text. The story begins when native people first settled on the banks of the river now called the Nashua but, unfortunately, by the 1960s, the river valley had been destroyed by many years of serious pollution. Fish, birds, and other animals were no longer seen in the area. This book shows the negative impact that unregulated and irresponsible industry can have on the environment and highlights the difference one determined person can make. With this as a prompt for each one of us participating in problem-solving, my students will learn to design solutions to sets of issues within our classroom and school.

An additional introductory resource is the picture book, *The Water Princess* by Susan Verde, a story based on the childhood of supermodel Georgie Badiel and her dream to bring clean drinking water to her African village. As a child in Burkina Faso, Georgie and the other girls in her village had to walk miles each day to collect clean water for their families. This story will help shed light on the struggle that exists around the world, clearly defining a problem that my students can address, and instilling hope in the future of access to clean water for children everywhere. From these two resources, my students will develop fundamental vocabulary and conceptual understanding to begin the hands-on work that will come later in the unit.

Environmental Engineers

I will introduce the field of environmental engineering to the class as a framework for addressing these water issues. Environmental engineering is the branch of engineering that is concerned with protecting people from the effects of adverse environmental effects, such as pollution, as well as improving environmental quality. They use the principles of engineering, soil science, biology, and chemistry to develop solutions to environmental problems and are involved in efforts to improve recycling, waste disposal, public health, and water and air pollution control. The practice of environmental engineering dates to the dawn of civilization. Ever since groups of people began living in semi-permanent settlements, they have had to deal with the challenges of providing clean water and disposing of solid waste and sewage. With the growth of cities and the advent of large-scale farming and manufacturing, people have also had to worry about air quality and soil contamination. [4]

Key U.S. Federal Regulations and Water Treatment Processes

During the nineteenth and twentieth centuries, acute waterborne diseases such as cholera and typhoid fever prompted the need for the development of drinking water and wastewater treatment to improve water quality. The regulations that govern for our water treatment today are based on both health concerns and aesthetics. [5] The health concerns include two categories: acute effects such as gastroenteritis from microorganisms and chronic effects, including cancer, caused by disinfection by-products. Aesthetics concerns are hardness, color, turbidity, taste, and color. [6]

Prior to the 1970s, many of the major waterways in the United States were degraded because of unchecked pollutants released into lakes and rivers. This led to the passage of two important pieces of water quality legislation: the Clean Water Act (CWA) in 1972 and the Safe Drinking Water Act (SWDA) in 1974. The CWA and the SDWA are complementary. The SDWA prescribes approaches for treating water that is used for human consumption. This water typically comes from groundwater, rivers, and lakes. The CWA, in turn, protects all U.S. bodies of water by prescribing water quality standards and limits for pollutant discharges into eventual drinking, fishing or recreational water sources. Both are necessary and are aimed to achieve the same goal, to ensure high-quality water for human consumption, use, and recreation.

The CWA regulates the discharge of pollutants, mostly from wastewater treatment plants into rivers, lakes, estuaries, and wetlands by means of permits and standards. The main objective is to protect the surface water at a level that is considered “swimmable and fishable.” In addition, the CWA established a separate standard, the National Pollution Discharge Elimination System (NPDES), which is administered by states. This serves as a mechanism managing for the quantity and quality of wastewater effluents for each individual discharger. Because each watershed is different and has different functions for the local populations, states make determinations about the level of protection that is appropriate for the specific ecological condition, water use and pollution. For example, waterways that are used as reservoirs for drinking water will have more regulations than those used for shipping and transport. [7]

The SDWA, enacted in 1974 and amended in 1986 and 1996, establishes water quality standards for all public water systems that serve an average of 25 or more people daily. These standards include the national primary drinking water standards and the national secondary drinking water standards. (fed reg 301). Primary standards are based on the protection of human health, setting acceptable levels of contaminants allowed in drinking water. These are identified under two categories: enforceable maximum contaminant levels (MCLs) and nonenforceable maximum contaminant level goals (MCLGs). MCLs are the maximum levels of contaminants in water delivered to any user; MCLGs are the maximum level of contaminants in drinking water that have no known or anticipated adverse health effects. [8] Secondary standards include potential cosmetic effects, such as skin discoloration and laundry staining, and aesthetic effects such as taste, odor, and color.

Drinking water treatment plants that use surface water (lakes and rivers) as a source must also follow the Surface Water Treatment Rule (SWTR) to protect humans from the risk of waterborne infectious disease. The SWTR prescribes treatment technologies including some combination of disinfection and filtration to achieve a minimum of 99.99 percent of viruses killed or inactive; the maintenance of strict turbidity levels; and the absence of fecal coliform bacteria. [9]

Turbidity is the measure of relative clarity of a liquid based on the amount of light scattered by material in the water when a light is shined through the water sample. The higher the intensity of scattered light, the higher the turbidity. Examples of material that causes water to be turbid include clay, silt, finely divided inorganic and organic matter particles, algae, soluble colored organic compounds, and plankton, bacteria and other microscopic organisms. [10]

Coliform bacteria are a group of organisms found in soil, surface water and on plants. Fecal coliforms bacteria are a subgroup and are present in the intestines and feces of animals and humans. The presence of these bacteria indicate that the water is contaminated with the waste from animals or humans and has the potential to cause disease. Some strains of *Eschericia coli* , a subgroup of fecal bacteria found in warm-blooded animals, cause illness. Through disinfection, filtration and turbidity standards, SWTR works to manage this health threat.

Many treatment technologies are designed to imitate natural processes, with the goal of functioning in an even more efficient manner. Promoting and expanding the use of proven designs are generally good practice for water quality engineering in that if a technique works in one place, it will likely work elsewhere.

Water is delivered to the drinking water treatment plant through a pipe or aqueduct. The water passes through coarse screens to remove large objects such as logs and fish. A pump or gravity them pushes it through an aeration stage to saturate the water with oxygen and to remove gases. Next, chemicals are added and rapidly mixed such as alum or ferric chloride. These two compounds cause particles to coagulate so that they are easier to remove in the following. Activated carbon may also be added to remove taste- and odor-causing molecules. The next stage is flocculation where the water is gently mixed to promotes collisions between coagulated particles, allowing them to adhere and form larger particles. In the sedimentation stage, the coarse particles are separated by gravity. In addition, the water may pass through sand filtration units for the removal of fine particles. At this point, the activated carbon is removed. If activated carbon was not added earlier, the water may be passed through a fixed bed of granular activated carbon. The treated water now passes through one more stage of chemical addition – a disinfectant such as chlorine is added to the water to kill or inactivate pathogenic microorganisms. Fluoride may be added and chemicals to adjust the pH to help prevent corrosion of pipes. The following section describes these water treatment processes in more detail. [11]

Principles of Filtration

Drinking water supplies in the United States are among the safest in the world. However, even in the U.S., drinking water sources can become contaminated. The central concern is waterborne pathogens including but not limited to *Cryptosporidium parvuum* , *Eschericia coli* , Hepatitis A, *Legionella pneumophila* , *Mycobacterium* spp., and *Giardia lamblia* .

Drinking water sources are subject to contamination from agriculture, discharge of human waste and require appropriate treatment to remove disease-causing agents. Public drinking water systems use various methods of water treatment to provide safe drinking water for their communities. Today, the most common steps in water treatment used by community water systems (mainly surface water treatment) include the following:

Coagulation and Flocculation

Coagulation and flocculation are often the first steps in water treatment. Chemicals with a positive charge (Al^{3+} or Fe^{3+}) are added to the water. The positive charge of these chemicals neutralizes the net negative charge of dirt, clay and other small dissolved particles in the water that cause turbidity. When this occurs, the particles bind with the chemicals and form larger particles, called floc.

Sedimentation

During sedimentation, floc settles to the bottom of the water supply through gravitational settling

Filtration

Once the floc has settled to the bottom of the water supply, the clear water on top will pass through rapid filters of varying compositions (sand, gravel, and charcoal) and pore sizes, to remove particles, including small flocs, dust, parasites, bacteria, viruses, and chemicals.

Disinfection

After the water has been filtered, a disinfectant (for example, chlorine or chloramine) may be added to kill any remaining parasites, bacteria, and viruses, and to stabilize the water against microbial growth as it is piped to homes and businesses. [12]

Water in the Developing World

Water safety and quality are fundamental to human development and well-being. Providing access to safe water is one of the most effective instruments in promoting health and reducing poverty. As the international authority on public health and water quality, World Health Organization (WHO) leads global efforts to prevent transmission of waterborne disease. [12] In 2010, the UN General Assembly recognized access to safe and clean drinking water and sanitation as a human right and called for international efforts to help countries to provide safe, clean, accessible and affordable drinking water and sanitation. [13]

In 2015, 71% of the global population (5.2 billion people) used a safely managed drinking-water service – that is, one located on premises, available when needed, and free from contamination. As much as 89% of the global population (6.5 billion people) used at least a basic service, characterized as an improved drinking-water source within a round trip of 30 minutes to collect water.

Yet still, poor access to treated water remains a global problem. As many as 844 million people lack even a basic drinking-water service, including 159 million people who are dependent on surface water. By 2025, half of the world's population will be living in water-stressed areas. [14] Conditions are most severe in sub-Saharan Africa, where 42% of the population is without improved water, 64% is without improved sanitation, and deaths due to diarrheal diseases are greater than in any other region. [15]

The health toll caused by the lack of access to treated water affects millions. Inadequate management of urban, industrial, and agricultural wastewater means the drinking-water of hundreds of millions of people is dangerously contaminated or chemically polluted. At least 10% of the world's population is thought to consume food irrigated by wastewater. Poor sanitation is linked to transmission of diseases such as cholera, diarrhea, dysentery, hepatitis A, typhoid and polio. [16] Diarrhea remains a major killer but is largely preventable. Approximately 842,000 people in low- and middle-income countries die each year because of inadequate water, sanitation, and hygiene each year, representing 58% of total diarrheal deaths. Poor sanitation is believed to be the main cause in some 280,000 of these deaths. [17]

Since 1990, the number of people gaining access to improved sanitation has risen from 54% to 68% but some 2.3 billion people still do not have toilets or improved latrines. In low- and middle-income countries, 38% of health care facilities lack an improved water source, 19% do not have improved sanitation, and 35% lack water and soap for handwashing. Globally, 15% of patients develop an infection during a hospital stay, with the proportion much greater in low-income countries. [18]

There are several obstacles to overcome for these conditions to improve these circumstances:

Economic and social effects

When water comes from improved and more accessible sources, people spend less time and effort physically collecting it, meaning they can be productive in other ways. This can also result in greater personal safety by reducing the need to make long or risky journeys to collect water. Better water sources also mean less money spent on health, as people are less likely to become sick and have medical costs and can remain at work. With children most vulnerable to water-related diseases, access to clean water can result in better health and better school attendance, with positive longer-term consequences for their lives.

Challenges to Implementing Water treatment in the Developing World

Climate change, increasing water scarcity, population growth, demographic changes and urbanization already pose challenges for water supply systems. Re-use of wastewater, to recover water, nutrients, or energy, is becoming an important strategy. Many countries are using wastewater for irrigation – in developing countries this represents 7% of irrigated land. Safe management of wastewater can yield multiple benefits, including increased food production. [19] Options for water sources used for drinking water and irrigation will continue to evolve, with an increasing need to use groundwater and alternative sources, including wastewater. Climate change will lead to inconsistency in harvested rainwater. Management of all water resources will need to be improved to ensure quality. Certainly, a major set of obstacles continue to the lack of financial and political investment and the difficulty in maintaining appropriate services. Governmental and financial instabilities do affect the movement forward in this endeavor for clean water for everyone. Collaboration between water, health and education groups involved in community-based research can demonstrate cost efficient, locally manageable options for water and sanitation services. [20]

Water Treatment Methods for Developing Countries

Many rural residents and people living in low- and middle-income countries still collect water from rivers, lakes, ponds and streams contaminated with human and animal waste, whether from open defecation or other problems such as seepage from septic tanks and pit latrines. [21] People with access to cleaner water from common wells, collected rainwater or centralized sources face the risk of pollution - even when a water source is deemed “safe,” poor hygiene during collection, storage and handling of water results in contamination. [22]

A focus for researchers should be in developing strategies on the sustainability of water and sanitation services regarding the environment, culture, and economics of the area and attempting to provide implementation of long-term solutions for water treatment systems. Solutions could include low-cost household technologies as opposed to centralized systems.

Centralized treatment systems are generally difficult and expensive to maintain. Because of the many issues involved in not only implementing but affording and managing these systems, groups such as UNICEF and the WHO have long recognized that the most practical immediate strategy for improving rural drinking water quality is to provide solutions at the household level. Household water treatment and safe storage (HWTS) technologies are designed to improve water quality at the point-of-use (POU). The WHO published specifications for evaluating the microbiological performance of different HWTS systems in 2011, which established target performance levels for bacteria, virus and protozoa in POU water treatment, providing a benchmark for measuring effectiveness of the designs. [23]

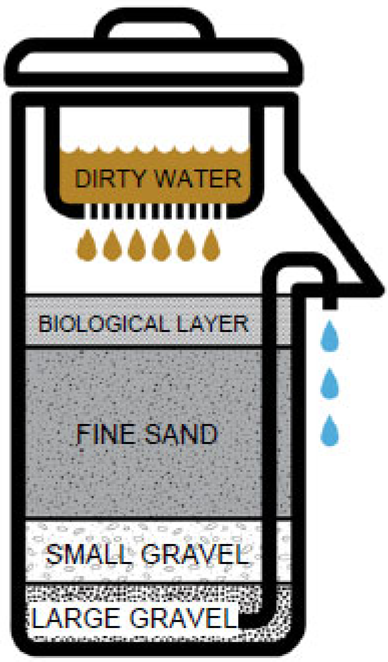
One common POU solution involves chlorination — essentially the same treatment used to disinfect public water supplies in the early 1900s. Under this model, diluted sodium hypochlorite is manufactured locally, bottled and added to water by the capful for disinfection. The water needs to be agitated and then sit 30 minutes before drinking. [24]

Another household water treatment is solar disinfection. This approach requires users to fill plastic soda bottles with low-turbidity water, shake them for oxygenation and place them on a roof or rack for six hours in sunny weather or two days in cloudy conditions. Ultraviolet (UV) light from the sun works together with increased temperature to inactivate microbial pathogens in the water.

The pros for each of these methods include ease of use, virtually no cost and effective pathogen reduction. The cons include the need to pretreat even slightly turbid water, long treatment times, especially in cloudy weather, the need for a large supply of clean bottles and the limited volume of water that can be treated at one time.

Most other POU options involve some form of filtration designed to remove pathogens by passing water through a variety of natural materials. Clay-based ceramic filters, for example, remove bacteria through micropores in the clay and other materials such as sawdust that are added to improve porosity. The best-known design in this category is a flowerpot-shaped device that holds eight to 10 liters of water and sits inside a 20- to 30-liter plastic or ceramic receptacle, which stores the filtered water. [25]

Slow sand filters remove pathogens and suspended solids through layers of sand and gravel. One common household design, the Biosand filter, consists of a concrete container incorporating layers of large gravel, small gravel and clean medium-grade sand. Prior to use, users fill the filter with water every day for two to three weeks until a bioactive layer resembling dirt grows on the surface of the sand. A diffuser plate is used to prevent disruption of the bioactive layer when water is added. Microorganisms in the bioactive layer consume disease-causing viruses, bacteria and parasites, while the sand traps organic matter, particles, and any remaining pathogens. Users simply pour water in the top and collect water out of an outlet pipe. The flow rate can be maintained by cleaning the filter by agitating the top layer of sand and by pretreating turbid water before filtering. [26]



Basic diagram of a concrete Biosand filter from ohorizons.org

Teaching Strategies

Experiential Learning: The major strategy for this unit is to engage the students in hands-on learning. I want them to be actively participating as inquisitive scientists and engineers. The water filtration activities and engineering projects are designed to be exploratory for the students, so they are engaged in the enjoyment of the inquiry and design as well as the process, successfully "cleaning" water.

Differentiated Instruction: The students will use a variety of approaches, working sometimes individually and sometimes in small groups, determined by the complexity of the activity. Because these are young children with variance in levels and background, guidance and pacing are adjusted to ensure that all students are engaged and active throughout the learning experiences. Students will have opportunities work with a variety of peers as they explore design ideas using a variety of materials.

Cooperative Learning: The students will be given opportunities to work as cooperative groups to complete assignments and activities. This strategy will allow students to work collaboratively taking on various roles necessary to complete the experiments and journal work, with a focus on success for all. A culminating activity will be the “fundraiser” that includes their families as they determine how they would like to support an area of need that we identify as a class.

Classroom Activities

Throughout this unit, students will be handling water. Although these experiments are safe to conduct, it is important that the students know that the water is **not** for drinking. They will be doing visual assessments of the success or failure of the filtering processes, not taste tests!

Activity One: Introduce the unit with mentor texts

Part One

Materials: *The River Ran Wild: An Environmental History* , t-chart on chart paper with question, chart to track content from text (examples below), and student science journals.

To introduce the unit on the need for environmental engineering in the field of safe and clean water, students will learn about the need for clean water for our health and safety. They will hear the story, *The River Ran Wild: An Environmental History* by Lynne Cherry as a foundation text. The story talks about the native people who lived on the Nashua river which, by the 1960s, showed the negative impact of industry on the environment. It shows one way that water is affected and needs to be treated.

Begin by asking some questions to activate background knowledge: Have you ever been to a river or a stream? What kinds of things did you see there? What kinds of benefits do people get from rivers? Have you ever seen evidence of pollution at a river or a stream?

Ask students the question posted on the chart, “How do we keep our water clean?” Record any answers and ideas on the left side titled “What We Know.” Read aloud *The River Ran Wild: An Environmental History* .

Prepare T-Chart

How do we keep our water clean?	
What We Know	What We Have Learned

Prepare text content chart

The River Ran Wild: An Environmental History		
Positive water qualities	Negative water qualities	Changes to the river

On the 2 nd chart, track the positive and negative aspects of the river with the third column for recording changes in the water quality of the river and how they occurred.

Return to the t-chart of responses and on the right-side section titled "What We Have Learned." In their science journals, students should transfer the information from each completed chart.

Part Two

A second introductory resource is the picture book, *The Water Princess* by Susan Verde. This story will help shed light on the struggle that exists around the world, clearly defining a problem that students can address, and instilling hope in the future of access to clean water for children everywhere. This story is based in an African village and illustrates the issue of girls in the village having to walk miles each day to collect clean water for their families. Students will use this story as foundation in Activity Five of this unit.

Questions to ask before reading:

Why do we need water?

What would happen if you drank dirty water?

Questions to ask after reading:

Why do you think these children need to travel so far for water?

What happens if the children and their families can't get water?

How do you think Gie Gie feels about traveling so far each day for water?

What do you think is Gie's Gie's wish?

Compare your day with Gie Gie's day. How is your day different?

Does Gie Gie have time to play? Why or why not?

Is Gie Gie happy in the story? Why or why not?

Do you think Gie Gie gets to attend school on daily basis? If not, please explain why.

At the end of the book, there is an informational section with photographs about the girls and women of Goundi in the village in Burkina Faso who take long walks to collect water from the well. The photographs show the women and children collecting the water (that still needs further cleaning), walking with it back to their village which is far away and others celebrating with their new well that was recently built in their village by the Georgie Badiel Foundation.

From these two resources, my students will develop fundamental vocabulary and conceptual understanding to begin the hands-on work that will come later in the unit.

Activity Two: Environmental & Engineering Terms

Students will be using a new set of vocabulary to discuss the concepts within this unit and it is important to have this available through anchor charts. Prepare two charts (or word walls) to ensure the students will have access to these Tier 3 words they discover throughout the unit. This will be an ongoing, interactive process.

Engineering, design process, observation, problem, solution, improve, data, materials, create, form, shape, model, analysis, investigate, control, diagram, patterns, predict, reflect, evidence, filter

Water, pollution, health, conserve, climate, sanitation, recycle, protect, plant, pond, river, green, regions, desert, evaporate

Activity Three: Experiments with Student Ideas

Students will use inquiry and experimentation to design a water filter.

Materials: trays with raised edges or cookie sheets, tubs, buckets, pitchers, funnels, cups, jars, scoops, various of types of paper, cheesecloth, coffee filters, scissors, beads or small stones, spoons, several 12-oz plastic cups

The goal is to filter the small stones or beads out of a 12-oz cup of water. Students will use what they have learned from their previous activities in this unit. Additional challenges could include using silt, which mimics the particle size necessary to remove bacteria or using water from a river or pond to see if the water can be made clearer with their filtration models.

Prepare bins of materials for groups of students to use to build a water filter. With a collection of materials, the students will design their filter on a tray or in a bucket to collect spills. They work as teams to create and test their design and document their findings. Students will "go back to the drawing board" and try a new design. They will use one of their "successful" models in Activity Five.

Activity Four: Transporting Water

Students will practice carrying water from one location to another. The objective is to demonstrate to work involved some people need to do to provide clean water for their families. Students should have selection of several different sized containers, some with handles, some without.

The goal will be to fill a five-gallon bucket, a total of 40 pounds of water! Teams of five students will work to find the best method to complete the task. Each group will keep track of the vessels they use and how many trips it takes to go from the water source to the bucket.

In their science journals, students will document, through writing and drawing, their experience compared to Gie Gie's experience in *The Water Princess.*

Activity Five: Comparing Filtering Systems

Polished stones, large and small; clean gravel; play sand; various containers; funnel;

glass jars, several coffee filters, several liters of "dirty" water, plastic cups with a hole in the bottom, commercial filter system such as Brita pitcher

Begin with a jar of dirty water. This can be tap water that has some added debris.

In the plastic cup, line the bottom with the coffee filters. Then place a layer of clean sand followed by a layer of gravel and topped with a layer of polished stones. Place the cup into an empty jar. Pour the dirty water into the cup so it can filter down through the stones, gravel, sand and coffee filters. Have students describe what they see and what they think happened. Repeat this process several times to see if the results are consistent. Students can use this process to compare tap water with bottled water to determine any differences in the results.

With the same water (control), pour water into the top of the pitcher and observe what happens as the water is filtered. Have the students notice the similarities and differences between the two filtering systems. The students should document both examples of filtering and answer the following questions through writing and drawing.

What does the water look like before filtering?

Why do we use the same water for both experiments?

Why don’t we have to do this every time we want a drink?

Activity Six: Visit Edgewood Park

Adjacent to our school is an amazing and accessible resource, a 120+- acre city park with six ponds and the West River running through it. These water sources will be the focus for student inquiry and research. Students will collect samples to bring back to the classroom for filtering. They will use systems they have designed as well as the commercial systems used for comparison in Activity Five.

Activity Seven: Host a Fundraiser to Support Area in Need

The students will invite their families and students in our building to participate in a fundraiser. The students will share their work from the unit on water filtration and present an argument for the raising money to send to an organization that supports water issues in developing countries. List of suggestions include: Georgie Badiel Foundation, Ryan’s Well Foundation, The Water Project.

Endnotes

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1 Louv, 3.

2 www.epa.gov/.

3 https://thewaterproject.org.

4 https://www.bls.gov/.

5 www.epa.gov

6 Ibid.

7 www.epa.gov/laws-regulations n.d.

8 Ibid.

9 Ibid.

10 https://water.usgs.gov/edu/turbidity.html

11 www.epa.gov/laws-regulations n.d.

12 https://www.cdc.gov/healthywater/drinking/public/watertreatment.html

13 http://www.who.int/water_sanitation_health/water-quality

14 Ibid.

15 Montgomery, 18.

16 www.epa.gov/laws-regulations n.d.

17 http://www.who.int/water_sanitation_health/water-quality

18 Ibid.

19 Ibid.

20 www.epa.gov/laws-regulations n.d.

21 www.watertechonline.com/providing-clean-water-to-the-developing-world/

22 Montgomery, 21.

23 http://www.who.int/water_sanitation_health/water-quality

24 Montgomery, 21.

25 Robeson.

26 Robeson.

Resources

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https://www.bls.gov/home.htm

https://www.cdc.gov/healthywater/drinking/public/watertreatment.html

https://www.epa.gov/laws-regulations n.d.

https://thewaterproject.org/water-scarcity/water_stats

https://water.usgs.gov/edu/

http://www.who.int/water_sanitation_health/water-quality

Montgomery, Maggie A., and Menachem Elimelech. "Water and Sanitation in Developing Countries: Including Health in the Equation." *Environmental Science & Technology* 41, no. 1 (2007): 17-24.

Robeson, Michael. “Providing Clean Water to the Developing World” https://www.watertechonline.com/

"Safe Water System." Centers for Disease Control and Prevention. May 02, 2014. https://www.cdc.gov/safewater/sand-filtration.html.

Appendix – Implementing District Standards

Next Generation Science Standards for K-2

K-ESS3-3 Earth and Human Activity

Communicate solutions that will reduce the impact of humans on the land, water, air, and/or other living things in the local environment.

Students will be learning about human impact on the water systems and determining some solutions that work to reduce that impact.

K-2-ETS1-1 Engineering Design

Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.

Students will use the inquiry approach to design a water filtration system. They will use a collection of common materials to create a new tool to filter large and small objects and debris from “polluted” water.

K-2-ETS1-2 Engineering Design

Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.

Throughout this unit, students will be documenting their ideas and sketching their designs in their science journals, which will also serve as an ongoing informal assessment.

K-2-ETS1-3 Engineering Design

Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.

Student groups will be comparing their water filtration designs by analyzing system construction and resulting “clean water.”

New Haven District Inquiry Standards

A INQ.1 Make observations and ask questions about objects, organisms and the environment.

A INQ.2 Use senses and simple measuring tools to collect data.

A INQ.3 Make predictions based on observed patterns.

A INQ.4 Read, write, listen and speak about observations of the natural world.

In conjunction with the NGSS, this unit will satisfy the district inquiry standards as students design, document and create a system that will filter objects and debris from dirty water.