The Clean-up Crew: Filtration

Subject Area(s) **Environmental Science, Chemistry**

Associated Unit **Drinking Water Treatment Process**

Associated Lesson **Drinking Water Treatment: Filtration and Disinfection**

Activity Title **The Clean-up Crew: Filtration**

Header

Image 1

Image file: water_Activity2.png

ADA Description: Water pouring from a faucet.

Source/Rights: By Anynobody [CC-BY-SA-3.0 (http://creativecommons.org/licenses/by-sa/3.0) or GFDL (http://www.gnu.org/copyleft/fdl.html)], via Wikimedia Commons

URL: http://commons.wikimedia.org/wiki/File:Water1.png

Caption: Where does the water come from? The water that comes from the tap goes through each step of the drinking water treatment process before it is stored or distributed to your home.

Grade Level 10 (9-12)

Activity Dependency

Lessons:

- Introduction into Drinking Water Treatment
- Drinking Water Treatment: Coagulation, Flocculation, and Sedimentation

Activities:

- First Steps to Treating Surface Water

Time Required 45 minutes

Group Size 2-3 students

Expendable Cost per Group US $ 0

Summary

In this activity the students learn about the final steps of the conventional drinking water treatment process from filtration to disinfection and finally storage to distribution. They discover how engineers have designed filters to work on both large scale and small to meet the needs of many or a few. Finally, students learn about the materials used to build filters and the theories behind the construction and layering of the materials, after which they use that knowledge to create their own filters.

Engineering Connection

Civil, Environmental, and many other types of engineers play an important role in the entire drinking water treatment process. Engineers must properly account for the water consumption in a particular area when designing the scale of the treatment facility. They need to understand the interactions between particles in the water and the filter media in order to choose the most

effective materials for efficient filtration. Engineers need to identify the best method for disinfection, storage, and distribution of the water after it has been filtered. Without the expertise of many different types of engineer's, drinking water treatment plants would not operate with near the efficiency or quality they do today.

Engineering Category = #2

Choose the category that best describes this activity's amount/depth of engineering content:

1. Relating science and/or math concept(s) to engineering
2. Engineering analysis or partial design
3. Engineering design process

Keywords

clean water, drinking water treatment, filters, filtration, purifying, water purification, water treatment

Educational Standards

National and State

Texas Essential Knowledge and Skills for Science, 2009, Environmental Systems 5(B): Identify source, use, quality, management, and conservation of water.

ITEEA Educational Standard(s)

ITEEA, Standard 1, Grades 9-12, J. The nature and development of technological knowledge and processes are functions of the setting.

ITEEA, Standard 9, Grades 9-12, K. A prototype is a working model used to test a design concept by making actual observations and necessary adjustments.

Pre-Requisite Knowledge

Learning Objectives

After this activity, students should be able to:

- Identify and explain the last three steps of the drinking water treatment process.
- Evaluate the design of a filter compared to large scale filters in water treatment plants
- Explain the importance of filtration for water quality

Materials List

Each group needs:

- One 2-Liter Bottle
- Marker/Pen
- Masking Tape
- 1.5 Liters bayou water or other water from a source with high turbidity

    - If students participated in the TeachEngineering activity labeled: First Steps to Treating Surface Water they should filter the water that they prepared the day before using coagulation, flocculation, and sedimentation.
- Pre-drilled Plastic Cup
- Small Clear Plastic Cup
- Safety Equipment: Goggles and Apron
- The Clean-up Crew: Filtration Notes and Activity Guide WKS (one per person)

To share with the entire class:

- Aqua Culture Small Pebbles Aquarium Gravel, 5 lb. (11kg)
- Crystal Clear Polish AC with Mesh Bag – Activated Carbon – 5 gallon bucket (18.95 L)
- Mason Sand (course grain) – 1 bag
- Catchment Container (used to catch water as students filter the test water)

Teacher needs:

- Extra Trash Cans
- Spectrometer
- Spectrometer Test Tubes

Introduction / Motivation

Has anyone ever used a filter before? What are some examples of filters that individuals might use on a daily basis? Do water treatment plants use similar devices for water filtration?

There are many water treatment plants around the world which purify millions of gallons of water a day from lakes, rivers, and reservoirs to be used for drinking and other purposes. How can these treatment plants take dirty water and make it safe enough to drink? Scientists and engineers have developed a method for treating water that we will call the conventional drinking water treatment process because it's the most common and widely accepted process. It consists of six main steps: coagulation, flocculation, sedimentation, filtration, disinfection, and finally storage. In today's activity we will be focusing on the last three steps of the process.

(Teacher follows the Drinking Water Treatment PowerPoint to introduce the last three stages of water treatment and the activity procedure.)

(Have Drinking Water Treatment PowerPoint ready: Start at slide 40)

What is diffusion? How is diffusion related to filtration? What is the purpose of filtering water and is the water drinkable after this stage in the process? Filtration is related to diffusion because it is one way in which filters remove flocs formed during the flocculation stage from the water. As flocs pass over the filter media they stick to the collectors either by diffusion, interception, or by gravity. What is filter media? Filter media are the materials used in the filter to collect the flocs. The media in the filter are also called collectors because they stick to and "collect" the remaining particles in the water. The most common filter media used today are sand, gravel, and possibly a charcoal based material layered on top of each other. The order of the layers is important so that all the filtration does not just occur at the top but throughout the

entire filter. Engineers have discovered that by putting gravel on the bottom, the sand in the middle, and the charcoal material on top, filters perform at maximum capacity and depth filtration can be achieved. Filters must also be monitored, maintained, and periodically cleaned in order to keep them functioning at a high efficiency. There are three main stages of filtration called ripening, pseudo-steady state, and backwashing which is determined by the length of time and amount of water the filter has processed. Ripening occurs just after the filter has been cleaned and is considered a conditioning stage in which water is run through the filter to waste. A filter does not immediately begin working with maximum efficiency so water is passed through during ripening until the filter begins collecting a sufficient amount of particles. Once the filter begins operating effectively it is considered in pseudo-steady state. This is the stage is which the water that passes through the filter can be collected and disinfected. Over a period of a couple days the filter becomes saturated with particles and must be cleaned through a process called backwashing. In this stage water is pushed in the reverse direction through the filter until the particles are removed from the filter media and ripening can begin again. The final step in removing the particles from the water after it has gone through coagulation, flocculation, and sedimentation is filtration.

Filters are the last step in separating the flocs and any remaining particles from the water before it is disinfected and stored or distributed. It is extremely important to have an efficient, well-functioning filter because it is the last line of defense in particle removal. Once the water is filtered it's still not safe to drink because filters are not able to remove microorganisms which might still be in the water. The final step of the treatment process before the water is clean and safe enough to drink is the disinfection stage. Chlorine, Ozone, or UV radiation is used during disinfection to kill any remaining microorganisms making the water safe enough to drink. The only thing left to do once the water has been disinfected is to store or distribute the water for use as needed. By the end of today's activity we will be able to design, construct, and critique the filters we built as well as explain the final stages of the water treatment process and their purpose.

Vocabulary / Definitions

Word	Definition
backwashing	cleaning the filter media by pushing water through the filter in the opposite direction
coagulation	adding a chemical agent to the water to destabilize the particles
collector	the filter media (each particle)
diffusion	particle movement from high concentration to low concentration
filtration	removing remaining flocs by passing the water through a media filter
filter media	material used in the filter. Ex. sand, activated carbon, gravel
flocculation	mixing the water to allow the particles to collide and form flocs
pseudo-steady state	stage in which the filter is functioning at maximum capacity; optimal floc removal
ripening	stage in which the filter is being conditioned by filtering to waste
disinfection	adding a chemical agent (Chlorine) to kill any remaining microorganisms

Procedure

Before the Activity

- Pre-wash all the filter media (pebbles, sand, and activated carbon) until wash water is clear.
- Pre-drill the plastic cups with four holes at the bottom.
- Collect water the kids will use for filtration
    - If this activity is being completed in conjunction with the TeachEngineering activity: First Steps to Treating Surface Water, they should filter the water treated the previous day.

- Setup stations with the sand, activated carbon, and pebbles in buckets that kids can easily scoop the materials from and transfer to their filter cups.
    - Pre-fill cups sitting next to each station modeling the maximum amount of sand, activated carbon, and pebbles the kids can use.
- Setup catchment containers around the room to collect the water as kids filter their test water (lab sinks will also work).
- Safety Equipment: Aprons and Goggles
- Ready two large trash cans: One trash can will be used to dispose of 2-Liter bottles and plastic cups and the other will be used for disposing of the wet filter media.
- Make copies of the Clean-up Crew: Filtration Notes and Activity Guide WKS (one per person)

With the Students

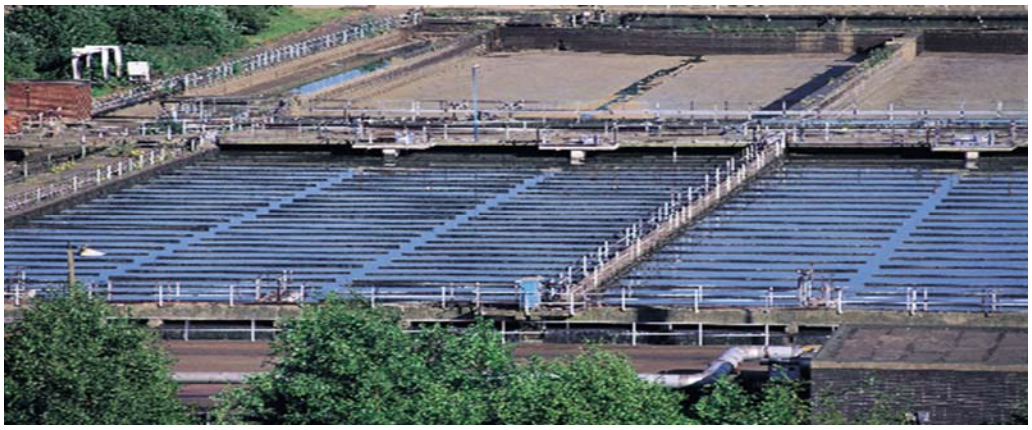
1. Teacher starts with question: What is diffusion?
2. Teacher presents the section of the PowerPoint entitled Drinking Water Treatment Processes: Filtration, Disinfection, Distribution – Slides 40 to 48.
    - Student's complete fill - in notes (The Clean-up Crew: Filtration Notes and Activity Guide WKS) as teacher presents (15 min).
3. Teacher divides the class into groups of 2-3 (material availability may determine group size)
    a. Students should remain in the same groups if this activity is being used in conjunction with the TeachEngineering activity: First Steps to Treating Surface Water.
4. Teacher poses challenge question: Is it possible to design a filter that works with the materials setup around the room?
5. Teacher will briefly explain to the students the setup of the room and the order of the procedure for making their filters. Also show the students the models for the maximum amounts of sand, activated carbon, and pebbles they can use in constructing their filter.
6. Students will get safety equipment (Aprons and Goggles) and sit back down with their groups.
7. Students discuss and plan the design of their filter. Before students actually construct the filter they need to draw out their design on the Clean-up Crew: Filtration Notes and Activity Guide WKS.
8. Teacher advances PowerPoint to slide 50.
9. Students follow directions on slide 50 and record observations on the Clean-up Crew: Filtration Notes and Activity Guide WKS.
10. Teacher continues advancing the slides and students continue to follow step-by-step instructions. Stop at slide 52.
11. Make sure students properly dispose of all materials and accurately recorded their observations, procedures, and transmittance of their filtered water on the Clean-up Crew: Filtration Notes and Activity Guide WKS.

Image file: sand_filter_Activity2.jpg

ADA Description: Sand filter at a raw water treatment plant.

URL: http://commons.wikimedia.org/wiki/File:Sand_filter.jpg

Caption: The picture shows a sand filter in a sand filtration plant for treating raw water.



Attachments
Lesson3_guided_notes_and_Activity2.docx

Safety Issues
- Students should wear Aprons and Goggles.
- Make sure the students do not drink the filtered water.
- Make sure all spills get cleaned up immediately because the floor will be slippery.

Troubleshooting Tips
- Teacher needs to rinse all filter media before filter construction otherwise the dirt from the media will run through and dirty the filtered water.
- Teacher needs to have extra trash cans for the plastic cups, 2-Liters, and all the used filter media.

Investigating Questions

Assessment

Pre-Activity Assessment

Brainstorming: Challenge Question: Is it possible to design a filter that works with the materials setup around the room?
- The challenge question can first be open for class discussion but allow the students to discuss their answers to the class with more detail in their small groups.

Activity Embedded Assessment

Lab Notation: As the students participate in the activity they should be recording every step of the procedure with enough detail that it can be reproducible by another scientist.
- Students should record enough detail and accuracy in their lab documentation to submit a lab write-up at the end of the activity.

Lab Write-up: This activity and assessment corresponds to the TeachEngineering Activity titled: First Steps to Treating Surface Water. This lab write-up assessment can be completed separately or in conjunction with the First Steps to Treating Surface Water Activity but the student's methodology section should reflect both activities if completed in conjunction with each other. Following the activity the students will

be asked to create an official lab write up including a background, methodology, and conclusion section.

Write up Requirements:

General Requirements:

- Each section of the paper needs to be at least one paragraph in length (Each paragraph should be minimum 5 sentences).
- Grammar and spelling should be correct.
- Typed or hand written in pen.
- (Optional) No use of personal pronouns.

Background Suggestions:

- What percentage of Earth's water is usable for drinking water treatment and where does it come from?
- What are the pros and cons of using ground and surface water?
- What are the main types of water contaminants?
- What are some different techniques engineers and scientists have developed for treating water?
- Why is water treatment important?

Methodology Suggestions:

- Use vocabulary when describing each step of the water treatment process.
- Include enough detail in each step of the procedure so that the reader could repeat the each step of the experiment exactly as the original.

Conclusion Suggestions:

- Restate the hypothesis and describe whether or not it was supported or refuted.
- Discuss results (transmittance after completion of one or both of the water treatment activities) and any limitations or successes that led to the irregular or expected outcome.

Post-Activity Assessment

Summative Assessment: Following the completion of the TeachEngineering Unit: Drinking Water Treatment Processes the students will be given the attached summative assessment, Drinking Water Treatment Quiz.

Activity Extensions

Activity Scaling

- For lower grades, ___?
- For upper grades, ___?

Additional Multimedia Support

References

Other

Redirect URL

Contributors
Brad Beless and Jeremy Ardner

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Acknowledgements

Classroom Testing Information
The testing for this curriculum was conducted individually on a paper test at the end of the unit. The test was given in May at Galena Park High School to 183 juniors and seniors.