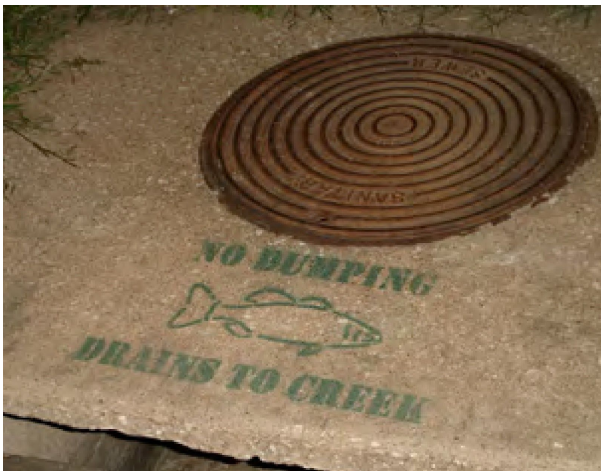
Waste, Water, and Wastewater

Setting the Stage

Wastewater contains solids, chemicals, and microorganisms, and can be a challenge to clean before it is released into a neighboring body of water. If the water is not properly cleaned, it can lead to environmental disaster such as the Cuyahoga River Fire. In this lesson students design a wastewater treatment facility that effectively removes contaminants. Students should be familiar with properties used for separating mixtures such as size, solubility, density, magnetism, and so on. In this lesson, they will apply what they know about how to separate a mixture.



No Dumping, Drains to Creek. Photo credit: Mary Elise Ewing

Lesson Overview

- *Activity 1 – Engagement (15 minutes) How much water do we use?*
  Students brainstorm ways in which water is used and compare current usage to past usage.
- *Activity 2 – Exploration (45 minutes) What's in our water must come out*
  Students hear about the Cuyahoga River Fire and wonder about how disasters like that can be prevented. They use this tragedy to begin thinking about how to design a wastewater treatment facility.
- *Activity 3 – Explanation & Evaluation (60 minutes) Modeling the Wastewater Treatment Process*
  Students create models of wastewater treatment facilities, peer-review each other's work, and compare their designs to that which is used in their hometown.

Instructional Overview	
Grade Level	Middle School
Instructional Time	120 minutes *(total time needed)*
NGSS Standards Alignment	This lesson builds proficiency towards the following Performance Expectations: MS-ESS3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. MS-ESS3-4: Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.
Anchoring Phenomenon	Wastewater includes many components.
Driving Question	● How is wastewater purified?
Learning Goals	Students design a solution to separate the components of wastewater.
Materials	❏ Butcher or poster paper ❏ Colored pencils ❏ Masking tape ❏ Sticky-notes ❏ Internet access for research
Material Preparation	Research the following topics: ❏ Cuyahoga River Fire incident ❏ Clean Water Act ❏ Wastewater treatment in your school community
Vocabulary	A mixture is a combination of different substances that can be separated using physical properties.

Activity 1 (Enage) How much water do we use? (15 minutes)

Brainstorm with the students the many ways water is used by people across the United States. The list will include obvious household uses and less obvious (hidden) uses which include the water used to create their everyday products. Ask students if the water use across the country is the same now as it has been in the past? Show them the table below, and ask them to create a bar chart comparing the usage during the two time periods. Discuss the differences, and ask them what they think are the implications for the quantity and quality of available water.

Additionally, there are tools online for students to estimate their daily water use. Suggested resource: Water Science School (usgs.gov)

Table 3. Water data for students to practice graphing. Modified from the *Clean Water Curriculum: Wastewater Pilot* by West and Kavanaugh and developed through a grant from HRSD Environmental Improvement Fund.

Daily Water Usage in Gallons *(Family of Five)*	**Present Day**	**1880s**	**Difference**
Toilet v. outhouse	15	0	15
Shower v. scrub bath	175	1	174
Dishwasher v. dishes by hand	30	2	28
Drinking water	25	25	0
Washing clothes v. hand washing	60	5	55
Watering garden v. lawn	75	20	55
Watering livestock v. washing car	180	114	66

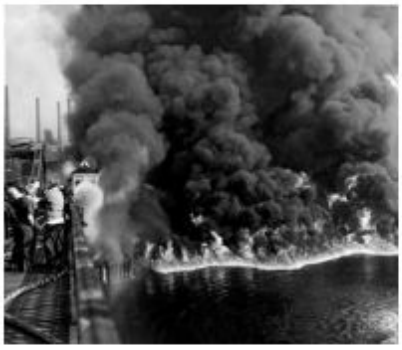
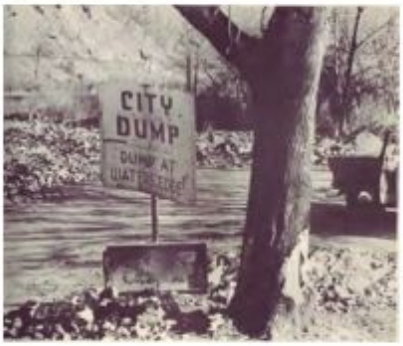
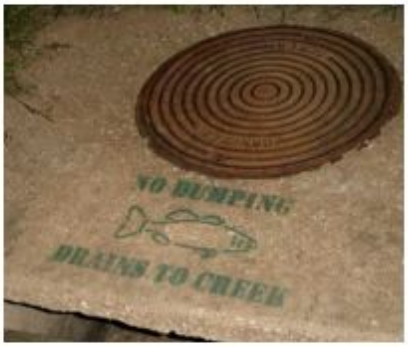
Remind the students that every gallon of water that goes down the drain is a gallon of water that must be cleaned. Tell them that in the rest of the lesson they will focus on the water purification process to ensure everyone has safe water.

Activity 2 (Explore) What's in our water must come out (45 minutes)

Begin by telling the story of the Cuyahoga River Fire of 1969. Many resources are available online. Suggested resource: [Cuyahoga River Fire | Cleveland Historical]

After sharing this story with the students, show old photographs of signage declaring city dump sites at water's edge as well as present day photographs of signage declaring no dump sites at storm drains. These photographs give students a visual image of the contrasting problems and policies associated with waste, water, and wastewater before and after the EPA's Clean Water Act of 1972 (Table 1).

Table 1. Photographs of historical problems and policies regarding waste, water, and wastewater.

Cuyahoga River Fire Cleveland, Ohio	"City Dump: Dump at Water's Edge!"	"No Dumping: Drains to Creek"
		
Cleveland Press Collection	*Photo Credit Unknown*	*Mari Elise Ewing*

After this brief history lesson, discuss the components of wastewater. Guided by the teacher, students will generate a list of common items found in wastewater. Divide the items on the list into the three major components of wastewater – physical (solids), chemical (liquids), and biological (microbes such as bacteria).

Review methods of separating mixtures using properties such as size. Divide students into small groups (ideally three students per group). Each group is responsible for designing a wastewater treatment facility. The students should include the following in their designs:

- multiple steps to separate the physical, chemical, and biological components
- diagrams and descriptions to illustrate and explain each step of the process
- an explicit end goal stating how clean is “clean enough”

Provide students with approximately 15 minutes to begin their brainstorming. Check in with each team to hear their ideas and to challenge their thinking to ensure they are including each step of the wastewater treatment process.

Activity 3 (Explain & Evaluate) Modeling the Wastewater Treatment Process (60 minutes)

In this part of the lesson, students create a model (poster) of a wastewater facility designed to remove solids, chemicals, and microorganisms. Their model should include labels and an explanation of how each component of the wastewater is removed.

Students should be encouraged to consider features of good design such as:

- Scale of operation
- Efficiency
- Aesthetics
- Environmental impact

After students have completed their models, ask them to hang them up for everyone to see. Visit each model as a class, and ask students to share their ideas. Allow time at each model to share ideas. After all the teams have shared, provide students with sticky-notes to leave messages on each of the models. After students have left notes on the models, the groups should reconvene and make changes to their models based on the feedback from the teacher and peers.

In the final step of this peer-review process, ask the students to independently visit the models again, and use an evaluation sheet similar to the one below to identify the models that best fit the evaluation criteria.

Table 2. Peer evaluation sheet for students to complete while walking from poster to poster.

Student Name:	Group #
_____**Which design is most effective?** *Which design best cleans the water?*	
_____**Which design is most efficient?** *Which design best cleans the water for the least amount of energy or expense?*	
_____**Which design is most aesthetic?** *Which design looks the coolest?*	
_____**Which design is the easiest to understand?** *Which design has the best diagrams and descriptions of each step?*	
_____**Which design is your favorite? Why?** *Give 3 specific reasons why you like the design. What is the best feature of the design?*	

Wrap up this lesson by explaining how the wastewater treatment facility in their hometown works. Show the students aerial photographs of their local facility and then explain each step at the treatment process, allowing time for questions. This explanation gives students the opportunity to compare and contrast their designs to an actual facility.