Title of Lesson: Waste, Water, and Wastewater

NSF GK-12 Fellow: Mari Elise Ewing

Grade Level: Middle School

Type of Lesson: Physical Science

Objectives: From BVSD 6th Grade Science Curriculum Essentials Document: "Students can (a) identify properties of substances in a mixture that could be used to separate those substances from each other and (b) develop and design a scientific investigation to separate the components of a mixture." Nature of Discipline #2: "Evaluate and critique experimental procedures designed to separate mixtures."

Background Information: Students will need to become familiar with properties used for separating mixtures such as size, solubility, density, magnetism, and so on. A simple lesson on separating different varieties of beans according to size or color might be a nice introduction to the topic of mixtures. It will also help to explain other real-life processes such as the separation of crude oil into its component parts or the separation of single-stream recycling prior to teaching this lesson on wastewater treatment.

References:
America's Sewage System and the Price of Optimism. *Time Magazine*. August 1, 1969.
"Cuyahoga River Fire." *Ohio History Central*. July 1, 2005.
Maag, C. "From the Ashes of '68, a River Reborn." *The New York Times.* June 20, 2009.
U.S. EPA Office of Wastewater Management. Online at www.epa.gov/owm/
Wastewater Treatment Division. Broomfield, CO. Online at www.broomfield.org/wastewater/

Lesson Vocabulary:
Mixture: A mixture is a combination of different substances that can be separated using physical properties.

Materials Required: Butcher (or poster) paper, colored pencils, masking tape

Preparation: This lesson is designed for three one-hour periods or one longer (lab or block) period. The first hour helps ***engage*** the students in the lesson; the second hour gives the students time to ***explore*** the lesson in small groups; and the third hour allows for the teacher and students to collectively ***explain*** the lesson.

Safety Information: There is no special safety information necessary for this lesson.

Engagement: The first hour of the lesson introduces and engages the students in the lesson. Begin by telling the story of the Cuyahoga River Fire. A complete description of this incredible event can be found at various online sources including *Time Magazine* and *The New York Times*. 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). 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). Ask the students to copy the information into their science notebooks. Review methods of separating mixtures using properties such as size. Finally, in the last fifteen minutes, divide the students into small groups (ideally three students per group) and explain the exploration activity. Each group is responsible for designing a wastewater treatment facility. The students should include the following in their designs: (1) multiple steps to separate the physical, chemical, and biological components; (2) diagrams and descriptions to illustrate and explain each step of the process; and (3) an explicit end goal stating how clean is "clean enough". The students will use the remaining time to brainstorm and draft their ideas.

Exploration: The second hour of the lesson gives the students an opportunity to actively explore the wastewater treatment process by designing a wastewater treatment facility using the information shared with them earlier in the unit (*Background Information*) as well as during the first part of this lesson (*Engagement*). Students should be encouraged to consider features of good design such as scale of operation, efficiency, aesthetics, and environmental impact.

Explanation: The third hour of the lesson allows the students to evaluate and critique their peers' designs. Tape the posters in the hallway outside of the classroom. Give each student an evaluation sheet (Table 2). Encourage the students to spend about fifteen minutes walking from poster to poster. Once the students reconvene in the classroom, ask them questions about the designs. For example, why were some designs more effective than others? Then explain 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.

Extension: Using water usage data (Table 3), ask students to graph the average water usage per U.S. household in the 1880s compared to present day. Remind the students that every gallon of water that goes down the drain is a gallon of water that must be cleaned. This extension activity serves two purposes. First, students become familiar with Excel, using the program to graph data and complete simple equations. This helps them better visualize data. Second, students are challenged to critically think about their own water usage. This helps them understand how their actions contribute to problems such as water

shortages in the semi-arid state of Colorado. Another possible extension involves a discussion on the use of restored or constructed wetlands to filter wastewater. Complete this extension by discussing the benefits of using wetlands (e.g., creating wildlife habitat, decreasing municipality expenses, and increasing public awareness of ecosystem services).

Evaluation: The classroom teacher can explicitly test understanding of this lesson by asking students to apply the information they learned to a new situation. For example, the teacher at Broomfield Heights asked the students this question on the mixtures exam (*Standard 5b*):

Recycling: Design a system that could be used to separate different items that need to be recycled. You should include diagrams and explanations to describe how your design will work.

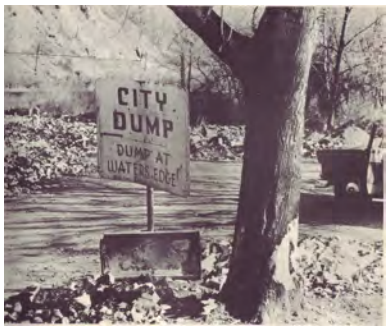
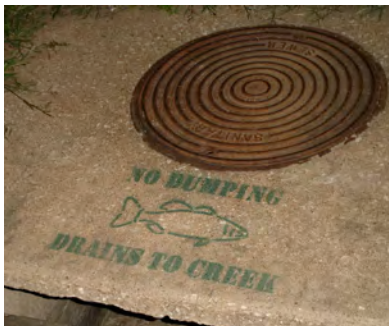
Items to be separated:

Aluminum cans (not attracted to magnets)	Paper
Tin cans (attracted to magnets)	Plastic
Glass bottles	Cardboard

Wrap-Up: The objective of this lesson is to engage students in a real-life example of how and why we separate mixtures. Conclude by asking the students to share one important lesson they learned from the wastewater project.

Waste, Water and Wastewater Tables

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*

Waste, Water and Wastewater Tables

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?*

Waste, Water and Wastewater Tables

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