



Image via iStock.com/Alex_Dobovitsky



Anchoring Phenomenon

Sewage water is consumed by people, but they do not get sick.



Lesson Concept

Compare multiple design solutions and their merit for separating substances from a mixture.



Identified Problem

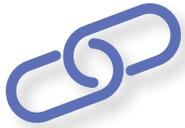
Water collected from a town may be contaminated. The town officials are requesting help to design a process that will identify the particles in the water and then clean the water.



Standards

Refer to Appendix 5.5 for NGSS, CCSS–ELA, and California ELD standards.

5.5 Separating Mixtures



Storyline Link

In the last lesson, students investigated filtration and evaporation as two processes that could clean the town water samples. Students began to use an engineering design process which included defining criteria and constraints.

This lesson focuses on students using all the information they have gathered regarding the properties of matter to build a process or system to identify and separate the materials in a town water sample.

Students will also evaluate their processes for success in meeting the criteria and constraints and compare their results to the results of other teams' processes. By the end of this lesson, students will be closer to understanding the anchoring phenomenon that sewage water can be processed so that it is drinkable.

TEACHER NOTE

The intent of this lesson is to allow students to determine their own design for separating the mixture. Their plan should include these components:

- iron filings can be separated with a magnet.
- sand will not dissolve in water so it can be filtered out of the mixture.
- salt dissolves in water and thus it can be removed through evaporation.

Discussions should include:

- How do we know if we got it all? (with references to what they did in Lesson 3: Properties of Matter using weight as a property of matter)
- How do we know if it's sugar or salt? (with a focus the idea that they should research how they might separate the two if they are both in the mixture)



Time

4 hours 35 minutes

30 minutes	Engage
60 minutes	Explore Plus overnight—or longer—for evaporation
60 minutes	Explain 1
45 minutes	Explain 2
45 minutes	Elaborate
35 minutes	Evaluate

5.5 Separating Mixtures



Materials

Whole Class (same materials as Lesson 4: Cleaning Water)

- Chart paper
- Town Water Samples (from Lesson 1: Town Water Samples)
- 20 paper bowls
- 20 8-oz. clear plastic cups
- 20 4-in. screen squares
- 20 4-in. pieces of cheesecloth
- 20 small shallow plastic bowls
- 2 1-quart water containers
- 20 plastic spoons
- 20 1-in. round magnets
- 20 coffee filters
- 1 paper towel roll
- 30 hand lenses
- 12 3-oz. cups
- 4 digital kitchen scale
- 15 tablespoons (kitchen measuring type)
- 5.5.C1: Criteria for Observations

Group (Groups of 2)

- 1 16-oz. plastic or paper cup
- $\frac{1}{8}$ cup of sand
- $\frac{1}{8}$ cup of salt
- $\frac{1}{8}$ cup of iron filings
- 3 3-oz. cups
- 2 tsp. sand
- 2 tsp. salt
- 2 tsp. iron filings
- 2 whiteboards

5.5 Separating Mixtures

Individual

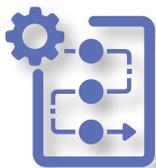
- Science notebook
- 5.4.H3: Environmental Engineer Design Plan (from Lesson 4: Cleaning Water)
- 5.4.H5: Rubric (from Lesson 4: Cleaning Water)



Advance Preparation

1. For each set of partners, mix $\frac{1}{8}$ cup of each substance (sand, salt, iron filings) in the large plastic cup; add $1\frac{1}{2}$ cups of water and stir well. (This is the mixture to be separated.)
2. Set up a side table or counter with the supplies for the Explore (hand lenses, magnets, water, 3-oz. cups, and spoons).
3. For each set of partners, set up 3 cups (3-oz.). In one cup, have 1 tsp. of sand, in another cup have 1 tsp. of salt, and in the third cup have 1 tsp. of iron filings.
4. Make a chart similar to **5.5.C1: Criteria for Observations**.

5.5 Separating Mixtures



Procedure

Engage (30 minutes)

Define a simple design problem to identify and separate materials based on their properties.

1. Hold up Town Water Sample #2 and explain that this is the sample the town wants cleaned first. Ask students to work with a partner to review their science notebook entries from all of the lessons. What do they know about Town Water Sample #2? *ESRs: From our models in Lesson 1: Town Water Samples and Lesson 2: Finding Impurities in Water, we know that there are observable particles in the water: sand and black things which we now think are iron filings. From our exploration in Lesson 3: Properties of Matter where we used the indicator, we know that there are other particles too small to be seen. We also know that the police found empty bags of iron filings, sand, salt, and sugar. So, there may be particles that are too small to be seen such as salt or sugar or even something else.*
2. Ask table groups to discuss this question: “Based on what you think might be in Town Water Sample #2, what properties of matter might you use for your design? Ask several groups to share their thinking and give groups a moment to add any new ideas to their plan.
3. To help you in your design, you can review some of possible contaminants in the water sample. Distribute the 3-oz. cups so that each table has one of sand, one of salt, and one of iron. Give students time to review each of the substances and their properties. Make a 3-column table on the board with these headings: Sand, Salt, and Iron. Have students review in their science notebook the properties of the substances and record their ideas regarding the basic properties in each of the columns.

Sand	Salt	Iron
Does not dissolve in water	Dissolves in water	Does not dissolve in water
Grainy, gritty	Grainy	Grainy
Not magnetic	Not magnetic	Magnetic

4. Ask the students to review their table group’s plan recorded on **5.4.H3: Environmental Engineer Design Plan** to get the matter separated and identified. Now that they know the Town Water Sample is #2, does their plan still work? How will knowing the properties of the materials affect the engineer design plan? Does it still meet the criteria and constraints?
5. After their discussion, ask partners to share any ideas they have about changing or refining their plan.
6. Ask the class if they have any questions and record the student questions so that everyone can see them on the Class Question Board.

5.5 Separating Mixtures

TEACHER NOTE

Facilitate student discussion and push students to “Ask questions to clarify and/or refine a model, an explanation, or an engineering problem.”

Explore (60 minutes plus overnight to allow evaporation)

Apply scientific ideas to solve design problems and to gather data on substances based on their unique properties.

7. Review with the students the materials on the table that are available for creating their solution.
8. Ask partners to use a whiteboard to draw their “plan of action.” What will they do first? What materials will they use and why? What will they do next? What materials will they use and why?
9. Ask each set of partners to share with another set of partners their diagram and explanation of their plan.

TEACHER NOTE

Facilitate the student planning and discussion by asking specific questions about the materials they are using, what might happen if a different material was used, and why they think the material they have chosen is the best for a specific purpose. Provide these sentence frames:

We will use _____. It is the best choice because _____. If we use _____ instead, then _____.

This will facilitate the discussion with another set of partners when they share their plans.

10. After sharing, ask partners to make any final changes to their design and record it in the box labeled #6 Revised Plan on **5.4.H3: Environmental Engineer Design Plan**.
11. Ask student to gather materials and set up their design solution. When the design is complete and ready for testing, give the students the large plastic cup containing the Town Water Sample (Step 1 in Advance Preparation). Ask students to record their observations and results in the box labeled #7 on **5.4.H3: Environmental Engineer Design Plan**. Ask partners to refer to **5.5.C1: Criteria for Observations** to support their recording of their observations.

TEACHER NOTE

The student design should include evaporation of the remaining liquid. Allow time for the liquid to stay out at least overnight and preferably over the weekend.

5.5 Separating Mixtures

Explain 1 (60 minutes)

Generate and compare multiple solutions to a problem using the properties of matter to clean a water system.

12. Have partners return to their table group. Ask them to compare their observations and results with the criteria and constraints and complete the box labeled #8 on **5.4.H3: Environmental Engineer Design Plan**. Post these questions on a doc camera to help them with their discussion:
 - Why did you use this particular material? How did it work? What is your data?
 - What might be a better material to use?
 - Please explain to me how your design system works.
13. Have a whole-class discussion of these questions.
14. Challenge the class to think about:
 - a. "Is the residue from the evaporation salt or sugar? What information is needed to answer this question?" Chart their ideas.
 - b. "How efficient was their separation? Did they get back everything they started with? What information is needed to answer this question?" Chart their ideas.

TEACHER NOTE

Efficiency means how well the substances were separated. Efficiency can be evaluated by determining which team recovered the most of each substance separated with the least amount of impurities.

Reflecting on Lesson 4: Cleaning Water, efficiency should include the idea that the separated weight and volume for each type of matter removed is the same as the starting weight and volume of the Town Water Sample.

- c. Select a question from the Design Solutions Question Board or Class Question Board that would be interesting for student to discuss. What information do they need to answer this question? Chart their ideas.
15. Allow students to select the question they want to work on from either question board, and provide time for students to research how they might answer that question. After they have recorded their ideas in their science notebook, have them assemble in groups (based on those who worked with the same question) to share their ideas.
16. Ask each group to make a brief presentation of their findings to the whole class.

5.5 Separating Mixtures

Explain 2 (45 minutes)

Generate and compare *multiple solutions to a problem using the properties of matter to clean a water system.*

17. Ask students to individually write in their science notebook reflecting on the different design processes created by their peers and the data showing how each design worked in separating the various matter in the water samples. Based on the comparison of different designs, ask students to write ideas for a best design solution for separating the substances and describe why they propose the plan, tools, and materials for separating the substances.
18. Students share ideas as a class and add evidence to the Class Question Board and Design Solutions Question Board.
19. ► (Self-assessment) Ask table groups to reflect on their process for their design by referring to **5.4.H5: Rubric** (from Lesson 4: Cleaning Water). Ask them to reflect on the last four components (planning and carrying out investigations, analyzing and interpreting data, using mathematics and computational thinking, and designing solutions).

Elaborate (45 minutes)

Compare solutions used to separate substances based on their unique properties.

20. Provide the class with Town Water Samples #1 and #3. Ask students to think about what they learned about matter separation in sample #2. Then, in their science notebook, ask them to pick either sample #1 or #3 and describe how they would separate the matter from the water.
21. Divide the class into sample #1 and sample #3 groups and then into smaller groups of four. Have students discuss their ideas for separating their mixture. Ask them to choose the best idea.
22. Ask groups from #1 and from #3 to share their ideas with the class, explaining which process would be the best and why.

Evaluate (35 minutes)

Make a claim about the merit of a solution and communicate solutions to clean and identify matter in contaminated water.

23. Have students work in pairs to discuss what they learned from separating the mixture in Town Water Sample #2. Based on that information, they must develop an explanation that describes how a water filter works. They should include their understanding of:
 - particle size
 - the properties of materials that are used to identify them
 - the scale of the filter, water, and contaminants

5.5 Separating Mixtures

24. Have each pair make a poster to display outside the classroom, so that others can understand how a water filter works. Hang the posters around the school to make other students aware that contaminated water can be cleaned.
25. ▶ Ask students to reflect in their science notebook how understanding the properties of matter and identification of matter helps them understand the anchoring phenomenon that sewage water can be made drinkable. They should state that water filtration makes sewage water safe.

TEACHER NOTE

- ▶ Use the posters to assess students' understanding of water filtration.

Toolbox Table of Contents

5.5.C1 Criteria for Observations

5.5.11

Criteria for Observations

- Uses as many senses as appropriate to make observations.
- Uses qualitative characteristics (e.g., color, shape, texture, smell).
- Uses quantitative measurements with the appropriate tools and units of measure (non-standard or standard) such as pH, temperature, time, and Moh's hardness scale.
- Based on facts, not opinions.
- Contains no inferences or explanations.
- Uses appropriate vocabulary related to content.

Appendix 5.5

Separating Mixtures

Next Generation Science Standards (NGSS)

This lesson is building toward:

PERFORMANCE EXPECTATIONS (PE)	
5-PS1-3	Make observations and measurements to identify materials based on their properties. <i>[Clarification Statement: Examples of materials to be identified could include baking soda and other powders, metals, minerals, and liquids. Examples of properties could include color, hardness, reflectivity, electrical conductivity, thermal conductivity, response to magnetic forces, and solubility; density is not intended as an identifiable property.]</i> <i>[Assessment Boundary: Assessment does not include density or distinguishing mass and weight.]</i>
3-5 ETS1-1	Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
3-5 ETS1-2	Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

NGSS Lead States. 2013. Next Generation Science Standards: For States, By States. Washington, DC: The National Academies Press.

SCIENCE AND ENGINEERING PRACTICES (SEP)
Asking Questions and Defining Problems
<ul style="list-style-type: none">Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on material, time, or cost.
Planning and Carrying Out Investigations
<ul style="list-style-type: none">Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution.Test two different models of the same proposed object, tool or process to determine which better meets criteria for success.
Analyzing and Interpreting Data
<ul style="list-style-type: none">Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and /or computation.Compare and contrast data collect by different groups in order to discuss similarities and differences in their findings.
Constructing Explanations and Designing Solutions
<ul style="list-style-type: none">Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution.Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design solution to a problem.Identify the evidence that supports particular points to an explanation.Apply scientific ideas to solve design problems.

Appendix 5.5

DISCIPLINARY CORE IDEAS (DCI)

PS1.A: Structure and Properties of Matter

- Measurements of a variety of properties can be used to identify materials.
- Matter of any type can be subdivided into particles that are too small to see, but even then the matter still exists and can be detected by other means.

ETS1.A: Defining and Delimiting Engineering Problems

- Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.

ETS1.B: Developing Possible Solutions

- At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs.

CROSSCUTTING CONCEPTS (CCC)

Systems and System Models

- A system is a group of related parts that make up a whole and can carry out functions its individual parts cannot.

Patterns

- Similarities and differences in patterns can be used to sort, classify, communicate and ~~analyze simple rate of change for natural phenomena and designed products.~~

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Common Core State Standards (CCSS)

CCSS ELA SPEAKING AND LISTENING

CCSS.ELA-LITERACY.SL.5.1

Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 5 topics and texts, building on others' ideas and expressing their own clearly.

- Follow agreed-upon rules for discussions and carry out assigned roles.
- Pose and respond to specific questions by making comments that contribute to the discussion and elaborate on the remarks of others.
- Review the key ideas expressed and draw conclusions in light of information and knowledge gained from the discussions.

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Appendix 5.5

California English Language Development (ELD) Standards

CA ELD		
Part 1.5.6a Reading/viewing closely		
EMERGING	EXPANDING	BRIDGING
a) Explain ideas, phenomena, processes, and text relationships (e.g., compare/contrast, cause/effect, problem/solution) based on close reading of a variety of grade-level texts and viewing of multimedia with substantial support.	a) Explain ideas, phenomena, processes, and text relationships (e.g., compare/contrast, cause/effect, problem/solution) based on close reading of a variety of grade-level texts and viewing of multimedia with moderate support.	a) Explain ideas, phenomena, processes, and text relationships (e.g., compare/contrast, cause/effect, problem/solution) based on close reading of a variety of grade-level texts and viewing of multimedia with light support.
In addition to the standard above, you may find that you touch on the following standard as well: P1.5.1 Exchanging information and ideas with others through oral collaborative discussions on a range of social and academic topics		

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