Finding Impurities in Water

5.2

Image via iStock.com/greenaperture

Anchoring Phenomenon

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

Lesson Concept

Develop and use models and recognize patterns to describe the materials that are in the Town Water Samples.

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 5.2 for NGSS, CCSS–ELA and Math, and California ELD standards.

Storyline Link

In the previous lesson, students were introduced to the problem that the town water might be contaminated. Students created a model of possible contaminated water and created questions to help them understand more about the contamination and to generate an engineering design to fix the contamination.

In this lesson, students use their investigation questions to identify the presence and amount of contamination, reinforcing the idea that particles that are too small to be seen exist in the water. They continue to revise their models and create new ones to explain their understanding. Students also review and add to their design questions about ways to clean the water.

In the next lesson. students explore their investigative questions about the properties of the material. This will assist them in designing their plans for cleaning the town water.

TEACHER NOTE

There are multiple models used in this lesson. To help keep track of them, this is a list of how they are used. During:

Step 1: Review their table group models of the Town Water Samples from Lesson 1.

Step 4: Create an initial model of cups A and B.

Step 9: Revise the models of cups A and B to include unseen particles identified with the indicator.

Step 14: Revise table group models of the town sample jars showing unobservable particles in jars #1, #2, and #3 but ***not*** #4.

Step 26: Investigate parts per billion (ppb) and develop new models on the worksheet showing parts per billion.

Step 27: Revise table group models of the town sample jars now showing parts per billion.

Step 30: Assess students' development and use of models for understanding parts per billion.

Step 32: Develop models for their evidence in board presentation.

Time

4 hours 5 minutes

Part I	20 minutes	Engage
Part II	30 minutes	Explore 1
Part III	30 minutes	Explore 2
Part IV	25 minutes	Explore 3
Part V	50 minutes	Explain
Part VI	60 minutes	Elaborate
Part VII	30 minutes	Evaluate

Materials

Whole Class

- Town Water Samples (from Lesson 1: Town Water Samples)—see Advance Preparation
- Chart paper
- 2 clear water glasses (Step 4 in Advance Preparation)
- 'A Tragedy' video (https://www.nbcbayarea.com/news/local/a-tragedy-hundreds-of-thousands-of-california-residents-exposed-to-contaminated-water/43932/)

For classroom demo

- Distilled water (see Advance Preparation)
- 2 large clear glasses
- ⅛ cup phenolphthalein (see options in Advance Preparation Step 5)
- ⅛ cup bleach (see options in Advance Preparation Step 5)
- 2 eyedroppers
- How to Make Orange Juice from Concentrate video (https://www.youtube.com/watch?v=0OD6gxbeAtA&feature=youtu.be) (Optional)

Groups of 4 (Explain)

- 1 eyedropper or plastic pipette (1 or 3 mL)
- Tap water
- 10 mL plastic graduated cylinder
- 5 2-oz. condiment clear plastic cups (or something similar)
- Masking tape or blue painter's tape
- Marking pen
- Blue or red food coloring
- Whiteboard
- Whiteboard markers

Individual

- Science notebook
- Writing tool
- Sticky notes
- 5.2.H1: Analyze This
- 5.2.H2: How Much is One Part per Billion?
- 5.1.H1: Town Water Samples (return student copies from Lesson 1: Town Water Samples with your comments)

Advance Preparation

1. Review the 'A Tragedy' video. Key the video up to play from 2:08–3:08 (https://www.nbcbayarea.com/news/local/a-tragedy-hundreds-of-thousands-of-california-residents-exposed-to-contaminated-water/43932/)
2. Review the How to Make Orange Juice from Concentrate video (https://www.youtube.com/watch?v=0OD6gxbeAtA&feature=youtu.be) (Optional)
3. For each student, print one copy of:
   5.2.H1: Analyze This
   5.2.H2: How Much is One Part per Billion?

> **TEACHER NOTE**
>
> If local water district data and reports are available for your location, you could substitute local data for **5.2.H1: Analyze This.** Another option would be to invite a guest speaker from your local water district to present the data to your students.

4. Prepare a tray for each group containing the following items: 1 eyedropper; 5 small condiment containers; a 10 mL plastic graduated cylinder; about 10 cm of masking tape or blue painter's tape; 1 marker; a cup of water; and 1 container of dark food coloring (or have the food coloring in one location that groups can access).
5. Get ready for the classroom demonstration in Explore by filling the glasses halfway with water. Use distilled water because tap water may be basic and will turn pink in phenolphthalein.

   Add 1 tsp. bleach to one glass and test with 3 drops of phenolphthalein. If the water does not turn bright pink, discard and redo with more bleach. Once it turns bright pink, discard and set up again with the appropriate amount of bleach. Label a glass of tap water without bleach A and a glass of tap water with bleach B.

> **TEACHER NOTE**
>
> If bleach and phenolphthalein are not available, you can substitute using the materials in this table.

Ingredient	Cup A	Cup B
Vinegar + Bromothymol blue	Water = blue	Water + Vinegar = green/yellow
Bleach + Cabbage juice	Water = red/purple	Water + Bleach = green

6. Based on which materials you are using for Explore 1, add one tsp. bleach (or vinegar) to Town Water Sample jars # 1, #2, and #3, but *not* to jar #4.

Procedure

Part I

Engage (20 minutes)

Communicate information and identify patterns in the materials that are in the Town Water Samples.

1. As a table group, ask students to review their models of the Town Water Samples from Lesson 1. Ask them to discuss which samples they would be willing to drink and why. Conduct a class discussion about their reasoning. *ESRs: I would not drink from jar #1 because it has black things in it (iron filings); I would not drink from jar #2 because it has sand in it; not sure about #3 and #4—we know from our models that there could be things in there that we can't see.*
2. Ask students to think about how they could find out if jar #3 and #4 are contaminated. Have students record ideas in their science notebook, then discuss ideas with their table group or a partner. Ask students to write any new questions they have concerning the Town Water Samples. Share questions with the class and explain why or why not the questions should be added to the Design Solutions Question Board.
3. Review the Design Solutions Question Board categories from Lesson 1. Remind students that their questions are driving the lessons with the goal to develop a plan to help the town clean the water in the sample jars. Read several of the questions listed in the category related to determining how much matter is in the jar water. For example: *How do we know if the water is clean and safe to drink? How much matter is in the water? Is any amount of contaminating matter safe to drink?*

Part II

Explore 1 (30 minutes)

Conduct an investigation using an indicator (cause and effect), to *determine if there are contaminants in the water.*

4. ▶ Show the two glasses of water, one marked A and one marked B, that you prepared in the Advance Preparation. Ask student pairs to use what they know about making models to draw in their science notebook a model of what they see in the two glasses. As students draw their models, look for them to depict these ideas:
   - a single shape that represents a water particle
   - particles loosely drawn in the glass to represent a liquid
   - parts labeled

> TEACHER NOTE
>
> **Differentiation strategy**
>
> Based on the scaffolding needs of the students, you may need to provide a template for the model which includes the glasses already drawn and a checklist of the items to be included on the model (shown in the bulleted list above).

5. Explain that scientists use *indicators* to help identify things they cannot see, and give the definition of *indicator*: a substance used to visually show (often by the change of color) the presence of a particular material in a solution. Remind students that in their models, they drew unobservable particles. Indicators can help them confirm if those particles are really there.

> TEACHER NOTE
>
> Glass A will remain clear while glass B will turn bright pink. If vinegar and bromothymol blue are used, the glass A will turn blue and glass B will turn green/yellow. If bleach and cabbage juice are used, the glass A will be red/purple and glass B will be green.

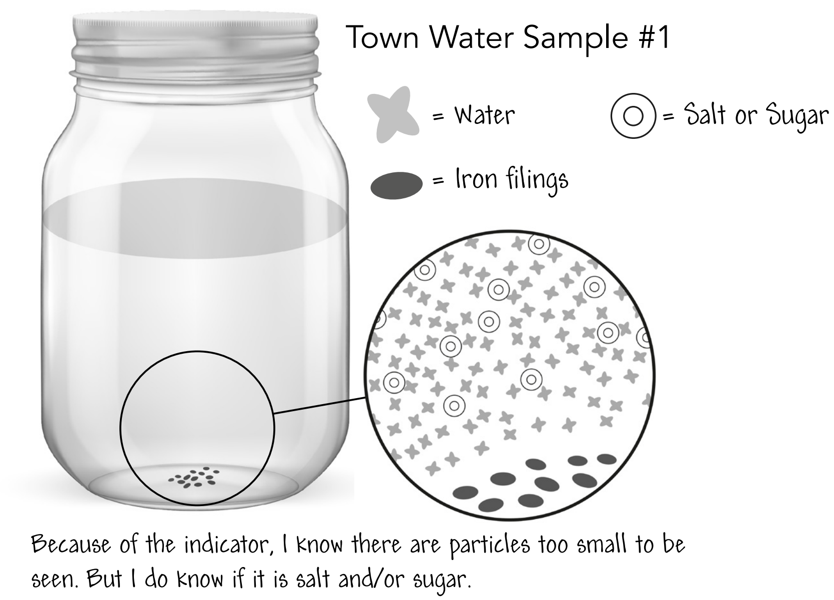
6. Ask two students to come to the front of the classroom to participate in a demonstration. Have one student carefully add 3 drops of phenolphthalein into glass A. Explain that the drops that were added are an indicator. Ask the class, "What do you notice?" *ESR: Nothing; the water looks the same as before. We still don't know if anything is there.*
7. Then ask the other student to carefully add 3 drops of phenolphthalein into glass B. Explain that the drops that were added are an indicator. Ask the class, "What do you notice?" *ESR: The water turns bright pink. It is not the same as glass A, so something we can't see must be in there.*
8. Ask students to enter their ideas in their science notebook, writing cause-and-effect statements. You can provide this sentence frame:

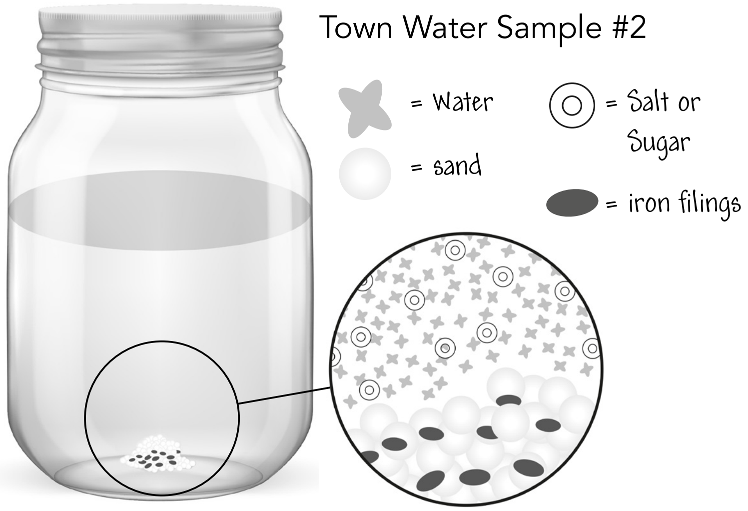
   The liquid in glass _____ turned _____ (effect) when the indicator was added because _____ while the liquid in glass _____ did not change because _____.

> TEACHER NOTE
>
> Cause-and-effect events have causes that generate observable patterns and can be used to explain change. It is important for students to consider this crosscutting concept to help them formulate questions that can be investigated.

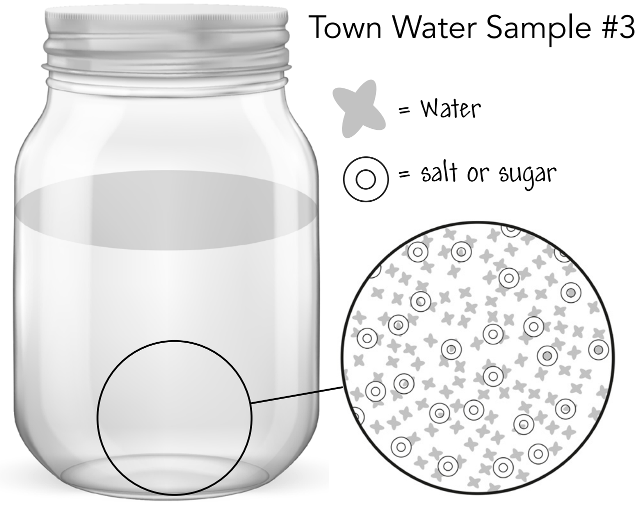
9. Ask students to review their initial model of the two glasses (Step 4) and modify their models to reflect the fact that there is a difference between the matter in the two glasses, which is why the water in the glasses looks different. If necessary, suggest the use of color and/or shapes to represent different types of particles (water particles, sand particles, etc.) in the models.
10. Have students share their revised model in pairs and discuss any new questions they might have. Then facilitate a student-led class discussion about the differences between the two glasses of water and questions the students have that could be investigated to help them identify the matter in the glasses. Write those questions on the Class Question Board. They will be referred to in Lesson 3: Properties of Matter.
11. Ask students what they might do to see if there are any unobservable contaminants in the Town Water Samples. *ESR: We could use an indicator.*
12. Have two students help with a demonstration for the whole class. One student will carefully add 3 drops of phenolphthalein into jars #1 and #2. Ask the class, "What do you notice?" *ESR: The water turned pink, meaning there is something in jar #1 besides the black things and something in jar #2 besides the sand.*
13. Ask the other student to carefully add 3 drops of phenolphthalein into jars #3 and #4. Ask the class, "What do you notice?" *ESR: The water turned pink in jar #3, but not in jar #4. There are contaminants in jar #3, but probably not in jar #4.* Ask the class to identify what the contaminants might be. *ESR: Perhaps sugar or salt. It could be both or only one; we don't know for sure.*
14. Ask students, based on this new information, to revise their models from Lesson 1; Town Water Samples (Step 1 in this lesson) and share with their table group.

    Student models might look like this:





Because of the indicator, I know there are particles in jar #2 that are too small to be seen. They could be salt and/or sugar.



Because of the indicator, I know that either salt or sugar or both are in jar #3.

Part III

Explore 2 (30 minutes)

Obtain information from media about the cause and effect of contaminants in the water.

15. We have just seen how an indicator can tell us if there is invisible matter in water. What kinds of things might be contaminating the water? (If this question is already on the Class Question Board, point to it as a reference.)
16. Play the 'A Tragedy' video from 2:06 to 3:08, which is a news clip on contaminated water. Ask students to think of questions they might ask.

> **TEACHER NOTE**
>
> The video segment from 2:25–2:35 describes possible causes of contamination; segment 2:45–2:51 lists some contaminants; segment 2:51–3:00 describes possible health impacts.
>
> If it's necessary to provide greater student engagement, find a news clip or news article on water contamination for a local area with which students are familiar.

17. At the end of the video clip, ask students to talk with their table groups using these prompts:
    - "What are you thinking about after viewing this video?"
    - "What would a model of this water look like? How is the same or different than the models you have been developing?"
    - "Does watching this clip change your thinking about what's in jar #3 or #4?"

18. Ask a couple of table groups to share their ideas. *ESRs: The model of this water would look like the models we have been developing showing observable and non-observable features. We would use different shapes for each of the particles. Our particles would include water and contaminants. Our models would be labeled. All the jars except #4 could have contaminants.*

19. Next, ask table groups to focus on these two questions:

    - "What experiences have you had related to poor water quality?"
    - "How might water contamination affect California (or your location) on a large scale?"

20. Distribute sticky notes to the groups. Provide the prompt: "As a result of the video and your discussion, what new questions does your group have about the Town Water Samples?" Write one question on each sticky note.

21. Ask groups to select 2–3 questions to share with the class. Facilitate a student-driven class conversation about students' questions. Record new student-generated questions on the Class Question Board or the Design Solutions Question Board in the correct category. Check marks can be used to indicate questions that are repeated.

Part IV

Explore 3 (25 minutes)

Obtain information about the scale, proportion, and quantity of the materials that are in the water.

22. Ask, "How much stuff is in the water? Where do you think we can find answers to this question?" Facilitate a student-driven conversation about ideas on how answers to this question can be found. Chart responses on paper. *ESRs: Conducting investigations in class, sending samples to experts for testing, looking to published materials related to the topic, talking to experts, doing research at a water treatment plant.*

> **TEACHER NOTE**
>
> The idea of using published materials leads to the Explain of this lesson. If this suggestion does not come up, guide the discussion to the idea.

23. Using the student-generated ideas of asking experts or using published materials on possible water contamination to find answers to their questions, provide students with a copy of **5.2.H1: Analyze This.** Read it together as a class. Direct students to underline the evidence in the article that suggests that matter that is too small to be seen can be detected by other means.

TEACHER NOTE

The readability level is 6.2. Students should read or follow along as the article is read aloud.

Differentiation strategy

Struggling readers can be provided more direct instruction on finding evidence as the article is read aloud to them. A discussion of key vocabulary and phrases to look for that suggest "matter is too small to be seen" can occur prior to reading; for example: cannot be seen, no color difference, no taste.

Example evidence:
Paragraph 1: Lead-tainted water has no unusual color, odor, or taste but can damage nerves in the body.

Paragraph 3: While lead in water can't be seen or smelled, there are tests to detect it.

Alternatively, if local water district data and reports are available for your location, substitute local data for **5.2.H1: Analyze This** in order to elicit greater student interest. Another option would be to invite a water district guest speaker to present the data to your students.

Part V

Explain (50 minutes)

Analyze and interpret data to develop a model that indicates the scale, proportion, and quantity of the materials in the water.

24. After reading **5.2.H1: Analyze This** bring the class's attention to the quantity *15 parts per billion* which appears in the third paragraph. Have students discuss with a partner what they think *parts per billion* means and if they can think of a real-world example of one part of something per billion total parts. Use examples from the Teacher Note below to prompt their thinking. Ask students to identify the two materials that are compared in the article (amount of lead is compared to the amount of water).

TEACHER NOTE

Parts per billion (ppb) means there is one unit of a contaminant in one billion total units. Parts per billion indicate the mass of matter in a unit volume of water. Real-world examples of one part per billion (ppb) include:

One grain of sand on the beach

One blade of grass on a football field

One second in nearly 32 years

TEACHER NOTE (continued)

One penny in 10 million dollars

One foot on a trip to the moon

One drop of water in an Olympic-size swimming pool

One sheet in a roll of toilet paper stretching from New York to London.

Differentiation strategy and/or math lesson connection

Write out the number 15

Then underneath it write the number 1,000,000,000 and address place value.

ELA connection

There are several picture books that can be used to help students understand the concept of very large numbers. These include:

- *A Million Dots* by Andrew Clements (2006)
- *Millions, Billions, and Trillions: Understanding Big Numbers* by David A. Adler (2014)
- *How Much Is a Million?* by David M. Schwartz (1985)

25. Connect the reading with the next demonstration of how contaminants can become invisible in the water. Ask students they have ever diluted anything—what was their experience? For example, have they ever made orange juice from a can? What did they do to make the orange juice from the concentrate? *ESR: We had to keep adding water until the concentrate was diluted.* What do they think would happen if they continued to add water? Would it look the same? Would the color get lighter or darker? Would the taste stay the same?

TEACHER NOTE

If students have never made orange juice from a concentrate, play the How to Make Orange Juice from Concentrate video.

26. Connect making the orange juice from concentrate to how students can investigate the dilution of matter (contaminants) in water. Students will start with a visible quantity and use dilutions to illustrate that matter can be present even when it is no longer visible to our eye. Distribute **5.2.H2: How Much is One Part per Billion?** Have students work in groups of 4 to follow the directions and answer the questions.

TEACHER NOTE

Students may not be familiar with using eyedroppers and/or graduated cylinders for measuring volume. Demonstrate the proper use of an eyedropper/pipette. The tip is pointed towards but not in the water container, and the bulb is squeezed and then lowered into the water. Once in the water, the bulb is released, and water is drawn into the eyedropper. Without exerting pressure on the bulb, the eyedropper is lifted out of the water and held tip down into the graduated cylinder. Gentle pressure is used to squeeze the bulb so that a drop forms at the tip and is pulled out by gravity.

For more information on using a pipette, watch the first 40 seconds of Using a dropping pipette. But note that this video only demonstrates how to get fluid into the pipette and not how to use it to make drops. To make drops, you must use controlled, slight pressure on the filled eyedropper/pipette.

The graduated cylinder is used to measure (quantify) liquid volume. If students have not used a graduated cylinder before, demonstrate proper reading of the volume in the graduated cylinder by reading the bottom of the meniscus, or curve, of the water.

27. After the groups have completed their dilutions, have them share their results with two other groups, comparing and contrasting their models.
28. Remind students that they have revised their model from Lesson 1 regarding the 4 jars based on the indicators. They now know about parts per billion. Ask pairs to discuss how this information can be added to their model. Then ask students to revise their model.
29. Then as a class, discuss how their ideas may affect the problem of the Town Water Samples.

Part VI

Elaborate (60 minutes)

Evaluate and communicate information and argue from evidence (data and models) about patterns in the particles in the water.

30. Scientists often have to present data and models to make a case for an engineering design to solve a problem. Have students review the data charts at the end **5.2.H1: Analyze This**. Tell students, “The Portland Public Schools board of education is concerned about contaminated water and what to do about it. You will have an opportunity to present your findings and recommendations to the school board. You will use your models and the data in **5.2.H1: Analyze This**.”
31. ▶ Have students return to **5.2.H1: Analyze This** and review the data for School B only. To assess students on their understanding of scale, proportion, and quantity, ask students to use a whiteboard or a piece of chart paper to draw one particle model of a glass of water coming from the drinking fountain at school B for room 215 and another particle model for the drinking fountain at school B by the door of room 200. Tell students this model does not need to be accurate (they do not need to draw a billion dots), but it should indicate their understanding of the differences by showing room 215 fountain has 2 parts in the same volume that room 200 has in 24 parts (or 1 part for room 215 to 12 parts for room 200).

32. Now have students work with a partner to analyze and interpret all of the school graphs. The following prompts can be provided to guide student analysis of the data:

    a. Is the water clean at these schools? (Is there other matter in the water?) How do you know?

    b. Should students be drinking from the water fountains at school A? B? C?

    c. Which school A, B, or C would you prefer to attend if you wanted water from drinking fountains? Why?

TEACHER NOTE

For more information about Talk Science and the discussion types, visit:
https://inquiryproject.terc.edu/shared/pd/TalkScience_Primer.pdf
https://inquiryproject.terc.edu/shared/pd/cc/DiscussionTypes.pdf

33. ▶ Ask partners to make a poster (or whiteboard) presentation for the Portland Public Schools board of education detailing the availability of safe drinking water at one of 3 specific school sites. Ask students to choose one of these three claims to support; do not include the information in parentheses as this is for your information:

    a. School A has the highest levels of drinking water contamination. (highest level of contamination, the greatest number of fountains exceeding the limit)

    b. School B has the safest drinking water available. (lowest level of contamination (below the limit) for fountains)

    c. School C has the highest number of safe drinking water fountains available. (greatest number of fountains below the limit, but those below the limit are in the range of 5–10 ppb, the one fountain exceeding the limit is the lowest compared to the other school sites)

    Student presentations must state:

    - the claim they are addressing (choice a, b, or c),
    - the evidence from the data that supports their claims,
    - models of their evidence, and
    - possible concerns that students still have regarding the drinking water at that specific school site.

34. After student pairs have completed their posters, do a gallery walk. Provide students with sticky notes to record feedback on the posters. Facilitate the gallery walk and peer feedback.

> **TEACHER NOTE**
>
> Gallery walks and peer feedback suggestions are available in several resources, including: http://www.assessmentforlearning.edu.au/professional_learning/peer_feedback/peer_strategies_enhance.html.
>
> Students should engage in constructive critiques and comments when providing feedback.
>
> If possible, provide students with sample critiques that cite specific evidence which supports a claim and specific "wonderings" for any concerns.

35. After the gallery walk, ask students to discuss with their partners any additional ideas they now have after comparing their work to that of other groups. Give students an opportunity to revise their work.

Part VII

Evaluate (30 minutes)

Communicate information about the particles of matter (energy and matter) and apply it to the engineering design.

36. Ask students to write in their science notebook at least two things they learned about models in this lesson. For example, over time, how did their beginning model change? *ESRs: I learned that models help me "see" what is going on; models can get more refined with new information such as ppb; my models from Lesson 1 of the water samples now shows unseen particles in all jars.*
37. Ask students to write in their science notebook at least two things they learned about what might be in the water. *ESRs: I learned that bad things like lead can be in the water without being visible and that lead can hurt me; I learned that contamination is measured by parts per billion and even if we don't think it is there, it is; I learned to use data and our models to make a presentation.*
38. Ask students to share their ideas from both prompts with their table group. Ask the table group to pick three ideas that they think will help them in their design and two or three questions they now have.

> **TEACHER NOTE**
>
> This is an opportunity for brainstorming and creative thinking by students to reflect on the difficulty of quantifying extremely small values. It also provides an opportunity to formatively assess student understanding of ppb. All answers are acceptable.

39. Have tables share their ideas and questions and add to the Design Solutions Question Board. Conduct a discussion on what students are thinking based on their understanding of parts per billion.

40. Look for a question on the Class Question Board or on the Design Solutions Question Board that is similar to "If there is stuff in the water, what is it?" If that question is not there, prompt students with: "Now that you know a clear glass of water can still be contaminated, how could a scientist investigate the types of matter in the Town Water Sample jars in order to determine all the contents in each jar? Be sure to consider the steps and requirements that scientists need to address in order to make sure the results are reliable."
41. Conduct a brief discussion and chart some of their ideas to use in Lesson 3: Properties of Matter. The lesson will focus on identifying unique and quantifiable properties of matter in order to identify matter.

TEACHER NOTE

This prompt leads to the Lesson 3: Properties of Matter on identifying unique and quantifiable properties of matter in order to identify matter which is the next question to be addressed on the Design Solutions Question Board.

References

Adler, D. A., & Miller, E. (2013). *Millions, Billions & Trillions: Understanding Big Numbers*. New York, NY: Scholastic.

Clements, A., & Reed, M. (2006). *A Million Dots*. New York: Simon & Schuster Books for Young Readers.

Hwang, L. (2019, December 03). Analyze This: Real data on lead levels in school drinking water. Retrieved July 28, 2020, from https://www.sciencenewsforstudents.org/article/analyze-real-data-lead-levels-school-drinking-water

Michaels, S., & O'Conner, C. (2012). *The Inquiry Project's Talk Science Primer*. Retrieved from https://inquiryproject.terc.edu/shared/pd/TalkScience_Primer.pdf

Read, D. (2013, August 22). *Using a Dropping Pipette*. Retrieved from https://www.youtube.com/watch?v=SvXAyuyAw-0

Satterfield, Z. National Environmental Services Center. (2004). *What Does ppm or ppb Mean?* Retrieved from https://www.yumpu.com/en/document/read/31186844/what-does-ppm-or-ppb-mean-national-environmental-services-

Schwartz, D. M., & Kellogg, S. (2012). *How Much is a Million?* Place of publication not identified: Paw Prints.

State of New Jersey Department of Environmental Protection. (n.d.). *Scientific Method "Testable Questions" Worksheet*. Retrieved from https://www.state.nj.us/dep/seeds/airqed/SAMP/questions.pdf

Strategies to Enhance Peer Feedback. (n.d.). Retrieved July 16, 2020, from http://www.assessmentforlearning.edu.au/professional_learning/peer_feedback/peer_strategies_enhance.html

TERC. (n.d.). *Four Discussion Types*. Retrieved from https://inquiryproject.terc.edu/shared/pd/cc/DiscussionTypes.pdf

Texas Commission on Environmental Quality. (n.d.). *What is a Part Per Billion?* Retrieved from http://www.tceq.texas.gov/assets/public/remediation/superfund/jonesroad/ppb_chart.pdf

Toolbox Table of Contents

Analyze This: Real data on lead levels in school drinking water

Monitoring for lead (as in these data) is an important part of identifying risks to health.

by Lillian Steenblik Hwang

Water that appears clear and clean can be unsafe if it contains high amounts of lead, a toxic metal.
Image via iStock.com/Joseph Thomas Photography

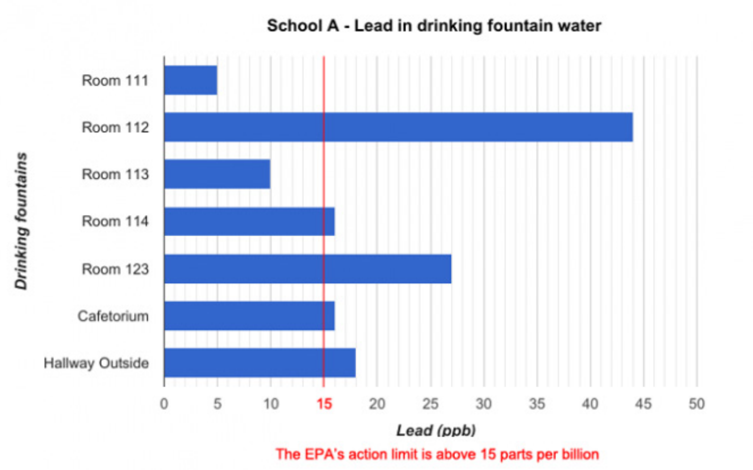
You turn on the faucet to get a glass of water. The liquid comes out clear and odorless. It's safe, right? Maybe not. In some places, such as Flint, Michigan, water coming out of the tap may contain lead, a toxic heavy metal. Finding it can be hard because lead-tainted water has no unusual color, odor or taste. But once inside the body, that lead can damage nerves—including those in your brain!

There are many ways that lead can enter drinking water. The most common way is from the pipes that connect a home or school to a town's main water-supply lines. In many cities, there are still lots of old pipes made of lead. Lead also can be found in the material used to seal connections between pipes. (That sealant has been banned but may still exist in some pipes.) The metal in many faucets, fountains and water outlets also may contain lead.

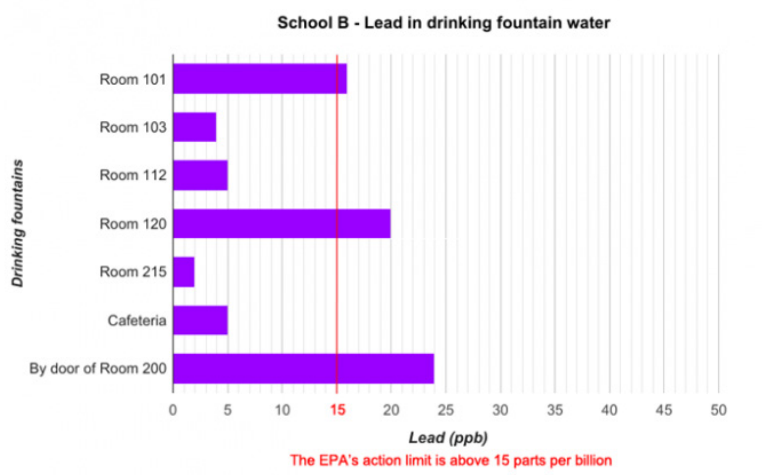
The best way to avoid lead poisoning is to avoid exposure. While lead in water can't be seen or smelled, there are tests to detect it. If those tests reveal that the water has a lead level higher than 15 parts per billion (ppb), the U.S. Environmental Protection Agency (EPA) recommends that people take action to reduce the contaminant. But even low levels are not safe—just safer.

Analyze This: Real data on lead levels in school drinking water (continued)

School districts around the country regularly test their water for lead. Last year, for instance, Portland Public Schools in Oregon had all of their buildings tested. Preliminary data from these tests are now available online. Some of the data from three schools are graphed below. The data graphed include six or seven locations from each of three Portland schools. The school district tested nearly 100 buildings.

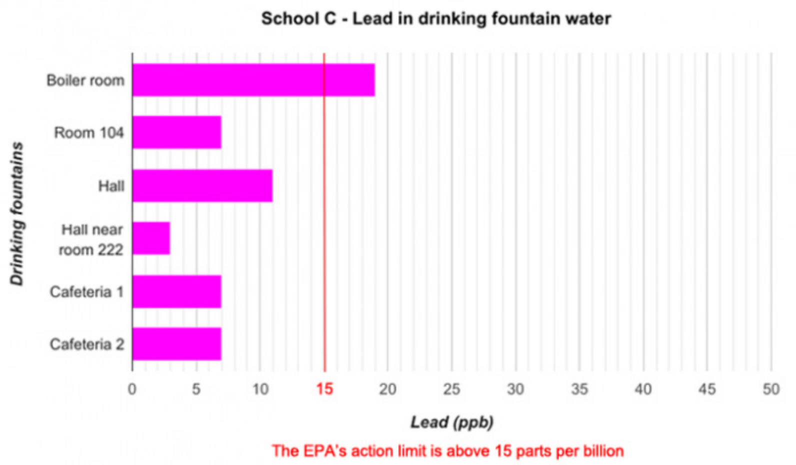


L. Steenblik Hwang



L. Steenblik Hwang

Analyze This: Real data on lead levels in school drinking water (continued)



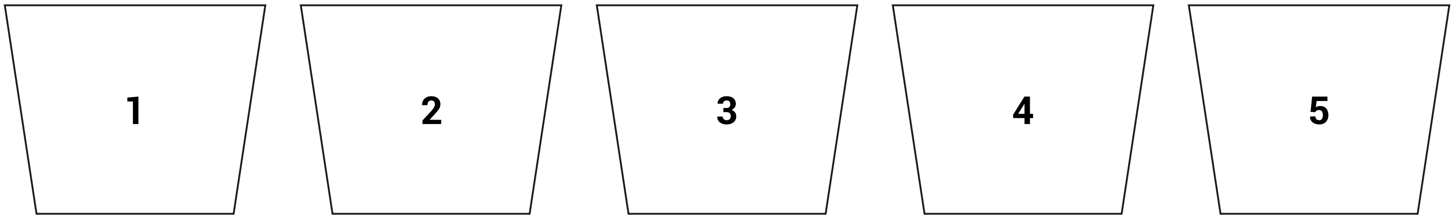
L. Steenblik Hwang

Lillian Steenblick Hwang, Science News for Students, May 3, 2011. Used with permission.

How Much is One Part in a Billion?

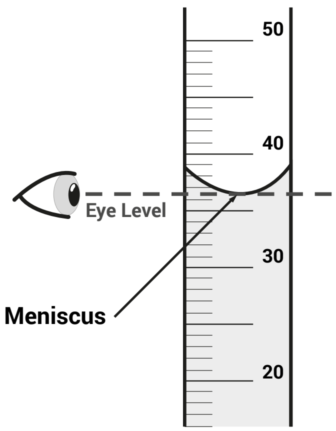
Procedures:

Label the 5 cups with numbers 1, 2, 3, 4, and 5 as shown below.



Working with Cup 1

a. Using the eyedropper, place 99 drops of water in the graduated cylinder. Read the volume of the amount of water and record the volume below. Remember to read volume at the bottom of the meniscus (curve of the water).
(See the image to the right.)

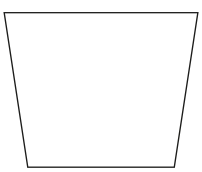


The volume of 99 drops of water is ____ mL.

b. Pour the 99 drops of water into cup 1.

c. Add one drop of food coloring dye to cup 1. Stir.

d. Draw a particle representation of cup 1 below.
This represents one part per hundred or 1/100.



Cup 1

1 drop of dye + ____ drops of water = 1 part in 100 total parts.

How Much is One Part in a Billion? (continued)

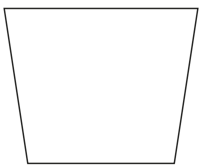
Working with Cup 2

a. Measure another 99 drops of water by pouring it to the same mark on the graduated cylinder as you did for cup 1.

b. Transfer this water into cup 2.

c. Take one drop of water from cup 1 and add it to cup 2. Stir.

d. Draw a particle representation of cup 2 below.
This represents one part in ten thousand (1/10,000 or 1/100 divided by 100).



Cup 2

1 drop from cup 1 + ____ drops of water = 1 part in 10,000 total parts.

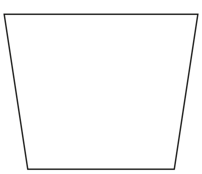
Working with Cup 3

a. Measure another 99 drops of water by pouring it to the same mark on the graduated cylinder.

b. Transfer this water into cup 3.

c. Take one drop of water from cup 2 and add it to cup 3. Stir.

d. Draw a particle representation of cup 3 below.
This represents one part in one million (1/1,000,000 or 1/10,000 divided by 100).



Cup 3

1 drop from cup 2 + ____ drops of water = 1 part in 1,000,000 total parts.

How Much is One Part in a Billion? (continued)

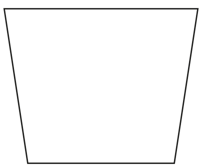
Working with Cup 4

a. Measure another 99 drops of water by pouring it to the same mark on the graduated cylinder.

b. Transfer this water into cup 4.

c. Take one drop of water from cup 3 and add it to cup 4. Stir.

d. Draw a particle representation of cup 4 below.
This represents one part in one-hundred million (1/100,000,000 or 1/1,000,000 divided by 100).



Cup 4

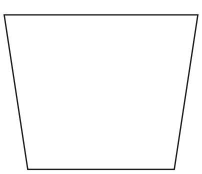
1 drop from cup 3 + ____ drops of water = 1 part in 100,000,000 total parts.

Use Cups 4 and 5 to Make 1 Part Per Billion

a. To make one part per billion, place 9 drops of water in cup 5.

b. Take one drop from cup 4 and add it to cup 5. Stir.

c. Draw a particle representation of cup 5 below.
This represents one part in one billion (1,000,000,000 or 1/100,000,000 divided by 10).



Cup 5

1 drop from cup 4 + ____ drops of water = 1 part in 1,000,000,000 total parts.

Compare and contrast your cup results and model representations with two other groups. Discuss with the other groups and then answer the following questions.

How Much is One Part in a Billion? (continued)

1. Our group results are similar to ______________________________ because ______________________________

____

____

2. Our group results are different from ______________________________ because ______________________________

____

____

3. What are some reasons for similarities and differences in data?

____

____

____

____

Appendix 5.2

Finding Impurities in Water

Next Generation Science Standards (NGSS)

This lesson is building toward:

PERFORMANCE EXPECTATIONS (PE)	
5-PS1-1	Develop a model to describe that matter is made of particles too small to be seen. [Clarification Statement: Examples of evidence supporting a model could include adding air to expand a basketball, compressing air in a syringe, dissolving sugar in water, and evaporating salt water.] *[Assessment Boundary: Assessment does not include the atomic-scale mechanism of evaporation and condensation or defining the unseen particles.]*

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

SCIENCE AND ENGINEERING PRACTICES (SEP)

Planning and Carrying Out Investigations

- Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.
- Make observations and/or measurements to produce data to serve as the basis for evidence an explanation of a phenomenon or test a design solution.

Developing and Using Models

- Identify limitations of models.
- Collaboratively develop and/or revise a model based on evidence that shows the relationships among variables for frequent and regularly occurring events.

Analyzing and Interpreting Data

- Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation.
- Compare and contrast data collected by different groups in order to discuss similarities and differences in their findings.

Engaging in Argument from Evidence

- Compare and refine arguments based on an evaluation of the evidence presented.
- Construct and/or support an argument with evidence, data, and/or a model.
- Respectfully provide and receive critiques from peers about a proposed procedure explanation, or model by citing relevant evidence and posing special questions.
- Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem.

Obtaining, Evaluating, and Communicating Information (Supporting SEP)

- Read and comprehend grade-appropriate complex text and/or other reliable media to summarize and obtain scientific and technical ideas and describe how they are supported by evidence.
- Communicate scientific and/or technical information orally and/or in written formats, including various forms of media as well as tables, diagrams, and charts.

Appendix 5.2

DISCIPLINARY CORE IDEAS (DCI)
PS1.A: Structure and Properties of Matter
• 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.

CROSSCUTTING CONCEPTS (CCC)
Patterns
• Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena and designed products.
Cause and Effect
• Cause and effect relationships are routinely identified, tested, and used to explain change.
Scale, Proportion, and Quantity
• Natural objects and/or observable phenomena exist from the very small ~~to the immensely large or from very short to very long time periods~~.
• Standard units are used to measure and describe physical quantities such as weight, ~~time, temperature,~~ and volume.
Energy and Matter
• Matter is made of particles.

Common Core State Standards (CCSS)

CCSS ELA READING
CCSS.ELA-LITERACY.RI4.7 Interpret information presented visually, orally, or quantitatively (e.g., in charts, graphs) and explain how the information contributes to an understanding of the text in which it appears.
CCSS ELA SPEAKING AND LISTENING
CCSS.ELA-LITERACY.RI5.7 Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently.
CCSS.ELA-LITERACY.SL5.1 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. b. Follow agreed-upon rules for discussions and carry out assigned roles. c. Pose and respond to specific questions by making comments that contribute to the discussion and elaborate on the remarks of others. d. Review the key ideas expressed and draw conclusions in light of information and knowledge gained from the discussions.

Appendix 5.2

MATHEMATICS PRACTICES
MP.2
Reason abstractly and quantitatively.

California English Language Development (ELD) Standards

CA ELD		
Part I.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.		