

**What does Clean Drinking Water have to do with math?**

**VIDEO:** [**https://youtu.be/eCIgeuzFH6I**](https://youtu.be/eCIgeuzFH6I)

**Lesson Plan**

**Teacher Note:** Please preview the entire video and pre-work the questions in order to anticipate students’ needs, misconceptions and other situations that may be unique to your classroom.

You will also need to determine the background knowledge of your students regarding the following topics, and decide the best method for providing that background in order to support the conceptual understanding of the mathematics shown in the video.

* + Scientific notation
  + Decimals
  + Percent

**Common Core Mathematical Content Standards**

* 6.NS.3 Fluently add, subtract, multiply and divide multi digit decimals.
* 7.NS.3 Solve real world and mathematical problems involving the four operations with rational numbers.
* 6.RP Understand ratio concepts and use ratio reasoning to solve problems.
* 7.RP. Analyze proportional relationships and use them to solve real-world and mathematical problems.
* 8.EE Work with radicals and integer exponents
* High School Mathematical Modeling Standard

**Common Core Mathematical Practice Standards**

1. Make sense of problems and persevere in solving them.

2. Reason abstractly and quantitatively

3. Construct viable arguments and critique the reasoning of others.

4. Model with mathematics

6. Attend to precision

**Summary**

Safe drinking water is critical to human survival. How can we be sure the water we are drinking will not make us sick? This video explores how mathematics is used to calculate the number of pathogens in water and determine if a water filter is removing enough of them to meet safe drinking water standards set by the World Health Organization.

**Pre-Activity Discussion:**

* **Vocabulary**
  + Water source – where the water is located
  + Pathogen - a bacterium, virus, or other microorganism that can cause disease
  + Many mathematicians, scientists and engineers use scientific notation to describe very large and very small numbers using powers of 10. A logarithm (log) is a mathematical operation that also uses powers.
  + When working with pathogens, scientists use a specific term when describing the reduction of the amount of organisms. This term is *log reduction*
  + Each log reduction results in a value 10 times smaller
    - 1 log reduction = 90% reduction
    - 2 log reduction = 99% reduction
    - 3 log reduction = 99.9% reduction
    - 4 log reduction = 99.99% reduction
    - 5 log reduction = 99.999% reduction
    - 6 log reduction = 99.9999% reduction

**Differentiation:**

* The questions on the student handout are scaffolded to meet the needs of middle school students who may need extra support.
* Eliminating some of the added questions and/or just posing the question(s) from the video would be a possible differentiation strategy for students who do not need the extra support.
* Students may also benefit by working with others as part of a partner/group investigation of this problem.

**Summary of Information needed and the problems posed in the video:**

* The water source used in this example has an E.coli concentration of 2 x 103 per 100 milliliters or 200,000 bacteria in every 100 ml of water.
* World Health Organization recommends at most 1 bacterium per 100 ml
* Standard water bottle holds 500 ml
* The filter in the video is capable of a 4 log reduction in pathogens. (4 log reduction = 99.99%)

**Part 1: (0:00 – 1:20)**

* Discuss the problem that we are being asked to solve. *How much E.coli needs to be removed so that it is safe to drink?*
* What are the things we need to figure this out? Do we have all the information we need? If not, what else do we need?

**Part 2: (1:25 – 1:50)**

* Question revisited: *How much bacteria needs to be removed to make it safe to drink?*
* Answer: We have 2000 organisms in the 100 ml of water. We need at most 1. We need to remove more than 1999!

**Part 3: (1:55 – 2:28)**

* What if we want to fill a water bottle? It can hold 500ml of water.
* The filter we will use reduces pathogens by 4 logs or 99.99%
* Question: *How many organisms will be removed from the water in our water bottle using this filter?*
* Before showing Part 4, have students share their solution methods (there are multiple ways to arrive at the solution)

**Part 4: (2:33 – 2:40)**

* Question: *How many organisms will be* ***left*** *in the water in our bottle? Is it safe? Does it meet the World Health Organization requirements?*
* After showing the solutions, have students reflect on any errors in their thinking and calculations.

**Part 5: (2:44 – 6:07)**

Video concludes by showing why water filters are needed worldwide and the positive impact the clean water made by these Kohler water filters has on people’s lives in the United States and around the world.

**Extension:**

* The definition of “log reduction” in working with pathogens is “reducing the amount of germs by 10 times for each log reduction”. Investigate the reasoning and history behind the percentages that are used (90%, 99%, 99.9% etc.)
* Is it mathematically possible to have exactly 0 pathogens remaining using the log reduction method? Why or why not?
* Investigate other ways logarithms are used in real world situations.

**Student Handout - *What does Clean Drinking Water have to do with Math?***

**Name(s):**

**Pre-Video Discussion:**  *Notes on important background information.*

**Break 1:**  What are the things we need to figure out? Do we have all the information we need? If not, what else do we need?

**Break 2:** How many bacteria will need to be removed to make 100 ml safe to drink?

**Break 3:** If we clean the water in our water bottle using a filter that has a 4 log reduction (99.99%), how many organisms will be removed?

**Break 4:** How many organisms will be **left** in the water in our bottle? Is it safe?

**ANSWER KEY – What does Clean Drinking Water have to do with math?**

**Part 2**

We have 2000 organisms in the 100 ml of water. We need less than 1. We need to remove more than 1999!

**Part 3**

2 x 103 E.coli = 2000 E.coli

2000 E.coli in 100ml of water

One method –

500ml of the water would contain (5)(2000) or 10000 E.coli bacteria

4 log reduction = 99.99% reduction

(0.9999)(10000) = 9,999 E.coli removed

Second method –

2000 E.coli filtered to a 4 log reduction (99.99%)

(0.9999)(2000) = 1,999.8 E.coli removed from the 100ml of water

500ml water bottle filtered = (5)(1999.8) = 9,999 E.coli removed

**Part 4**

In 500 ml: 10,000 E.coli originally – 9,999 filtered out = 1 left

Or

In 100ml: 2000 E.coli originally – 1999.8 filtered out = 0.2 E.coli left

There is 5 times the amount of water in our water bottle x 0.2 = 1 E.coli left

**Part 5**

Yes!