Water Filtration Competition

Subject: Science (Earth Science, Environmental Science, Aquatic Science)

Grade level: 6-12

Rationale or Purpose: Millions of people in the US rely solely on groundwater for their drinking water, and nearly everyone relies on groundwater to irrigate farmland. Water is filtered as it flows through the ground, but the type of material through which it flows and the length of flow vary considerably. Even municipal water systems have limited ability to filter water, particularly when the type of contaminant is unknown. This lesson/competition allows the students to design a water filtration system. Students should learn the complexity if purifying water, and therefore the importance of preventing pollution in the first place.

Materials:

- 2-liter or 1.5-liter plastic bottles
- scissors
- 250 ml beakers
- "polluted" tap water
- screening
- rubber bands
- heat source for evaporation
- filtration materials – be creative, but these can include soil, clay, sand, gravel, marbles, potting soil, cotton balls, metal scrap, woodchips, sawdust, packing peanuts, charcoal bricks, coffee filters, used overhead transparency sheets, vegetation (such as shredded lettuce)

Lesson Duration: two 50-minute periods.

Objectives:

- Science 112.22 (1A), demonstrate safe practices during field and lab investigations
- Science 112.22 (2B), collect data by observing and measuring
- Science 112.22 (2C), analyze and interpret information to construct reasonable explanations
- Science 112.22 (2D), communicate valid conclusions
- Science 112.22 (4A), collect, analyze, and record information using tools
- Science 112.22 (7B), classify substances by their physical and chemical properties

- Science 112.23 (1A), demonstrate safe practices during field and lab investigations
- Science 113.23 (2B), collect data by observing and measuring
- Science 112.23 (2C), analyze and interpret information to construct reasonable explanations
- Science 112.23 (2D), communicate valid conclusions
- Science 112.23 (4A), collect, analyze, and record information using tools
- Science 112.23 (7C), recognize that compounds are composed of elements
- Science 112.23 (14C), draw conclusions about effects of human activities on the environment

- Science 112.24 (1A), demonstrate safe practices during field and lab investigations
- Science 112.24 (2B), collect data by observing and measuring
- Science 112.24 (2C), analyze and interpret information to construct reasonable explanations

- Science 112.24 (2D), communicate valid conclusions
- Science 112.24 (4A), collect, analyze, and record information using tools
- Science 112.24 (12C), predict the results of modifying the Earth's water cycle
- Science 112.24 (14C), draw conclusions about effects of human activities on the environment

- Science 112.44 (1A), demonstrate safe practices during field and lab investigations
- Science 112.44 (2B), collect data by observing and measuring
- Science 112.44 (2C), analyze and interpret information to construct reasonable explanations
- Science 112.44 (2D), communicate valid conclusions
- Science 112.44 (4C), evaluate the impact of human activity

- Science 112.45 (1A), demonstrate safe practices during field and lab investigations
- Science 112.45 (2B), collect data and make measurements with precision
- Science 112.45 (2D), organize, analyze, evaluate, make inferences, and predict trends from data
- Science 112.45 (2E), communicate valid conclusions
- Science 112.45 (4A), differentiate between physical and chemical properties of matter
- Science 112.45 (4B), analyze examples of solids, liquids, and gases to determine their composition
- Science 112.45 (12C), evaluate the significance of water as a solvent

- Science 112.46 (1A), demonstrate safe practices during field and lab investigations
- Science 112.46 (2B), collect data and make measurements with precision
- Science 112.46 (2D), organize, analyze, evaluate, make inferences, and predict trends from data
- Science 112.46 (2E), communicate valid conclusions
- Science 112.46 (4B), research and identify components of an aquatic ecosystem
- Science 112.46 (4C), collect and analyze quantitative data from aquatic environments
- Science 112.46 (6A), identify the role of various cycles in aquatic environments
- Science 112.46 (8B), analyze the impact of humans on aquatic environments
- Science 112.46 (10C), identify water quantity and quality in a local watershed

Activity:

Step 1: Before the first class, prepare at least one of the bottles that will be used to build the filtration chamber. Cut the bottom off the bottle. Remove the cap and cover the opening with screening to keep the filtration materials inside. Attach the screen tightly with a rubber band.

Step 2: Instruct each team of students (~6 teams per class) to design an idea for a filtration system. Show them the sample filtration chamber you made so they can see how it will work. Each design can use any three of the filtration materials, and use them in any order. Do not tell the students what is in the polluted water. Because results will vary with the materials available and the different possible designs, let the students know that there may not be a single best plan. Also, show them the competition rubric, so students can see that they will be evaluated on both water quality and speed of water through the system.

Step 3: Students should design their filtration systems. Designs should include a simple sketch and a short paragraph describing why they used the materials they did and how they chose the order. Each team hands in the design to the teacher.

Step 4: One at a time the teams discuss in front of the class the details of their design. (The designs should be collected by the teacher to avoid students modifying their plans based on the ideas of others. However, the teams may want to refer to their plans when they present to the class.)

Step 5: Each student should take notes on every presentation. They should then record on the grading rubric sheet which team's filtration system will produce the purest water and which team's system will most quickly transmit 150 ml of water. These predictions should be recorded on the grading rubric sheet and turned in.

Step 6: Before the second class, the teacher should prepare a sample of 250 ml of "polluted" water for each team, plus one extra sample of 150 ml for comparisons.

Step 7: Student teams should build their filtration systems. Instruct students to clean up any spills immediately.

Step 8: Each team will pour a 250 ml of "polluted" water through their filtration systems and collect the water in another beaker. Have teams enter the pollutants on their competition rubric (1, sand; 2, soap; 3, color; 4, salt). Teams should time how long it takes from the time water is first poured into the system until the time 150 ml of water comes out the other end. This time should be recorded.

Step 9: Test 150 ml of water collected through each filtration system against the pollution level in the extra 150 ml sample that was unfiltered.

- Step 9a: Test for sand (and color) by visual examination.
- Step 9b: Test for soap by shaking.
- Step 9c: Test for color again as the water is evaporated.
- Step 9d: Test for salt once water is evaporated using a heat source.

Step 10: Compile results, and add competition points for correctly picking the filtration systems that produced the purest water (if a tie, give points to all teams picking the top systems). Add points for correctly picking the fastest systems. Determine winning team from total number of competition points. If a tie, the team with the shorter time is the winner.

Step 11: Each student should answer question sheet separately and turn in the next day. (Alternatively, these questions could be discussed orally at the end of the competition.)

Modification: Some classes will need more time. This can be made a three-day activity by doing Steps 1-3 on day one; Steps 4, 5, 7 on day two; and Steps 6-11 on day. Step 9 may be done entirely by the teacher, or with the aid of the students. In order to make filtration system assembly easier, you may want to provide metal screens cut to just fit inside the bottles; students could put these between layers.

Student Product: Design for a physical filtration system; competition rubric; questions.

Closure: Students answer question sheet on filtration systems.

Assessment or evaluation: See attached rubric. Students are evaluated on filtration system design, building, and testing; quality of their filtration system; ability to evaluate other designs; ability to answer follow-up questions.

Extension: Students can research what physical filtration methods are used in the municipal water in their area. What chemical filtration methods are used?

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Water Filtration
Competition Procedure

Materials:

- 2-liter or 1.5-liter plastic bottles
- scissors
- 2 250-ml beakers
- "polluted" tap water
- filtration materials
- screening
- rubber bands
- heat source for evaporation

Procedures:

You will design, evaluate, build, and test water filtration systems.

1. Design.
    - These systems will be built within plastic bottles like the one your teacher has as a sample. The bottom will be cut off, and a screen will prevent the small opening from spilling filtration materials. Your system will include 3 of the filtration materials provided to you.
    - You will not know what is in the polluted water until after your system is constructed.
    - Review the competition/grading rubric as you design. Note that you will receive points based both on the purity of the water that passes through your filter, as well as how fast 150 ml will pass through your filter. Water purity is weighted more, and should therefore be the focus of your thoughts. However, if 150 ml does not pass through your filter system in 15 minutes, your team is disqualified and will not earn points for water purity.
    - Your design should consist of a simple sketch and a short paragraph describing shy you used the materials you did, and how the order was chosen. Hand in the design to your teacher.
    - Discuss the details of your design to your class. At this point the teacher will be holding everyone's designs, so there is no worry of someone stealing your ideas.
2. Evaluate.
    - Take notes on the other teams' designs. After hearing all their plans, record which team you predict will score highest on water purity. Record which team you predict will have the filtration system that transmits 150 ml in the fastest time.
3. Build.
    - Cut the bottom off of your plastic bottle.
    - Remove the cap, and cover the opening with screen. Use a rubber band to tightly attach the screen.
    - Create your filtration system just as you designed. Each layer should be about 2 inches thick.

4. Test.
    - Get a 250 ml sample of water from your teacher. Record the pollutants on the competition rubric.
    - Before pouring the polluted sample through your filter, be prepared to 1) start timing to see how long it takes to produce 150 ml, and 2) collect the water flowing through your system.
    - Evaluate your sample based on the teacher's directions.
5. Follow-up.
    - Complete the follow-up sheets.

Name: _____ ***Date:*** _____

Teammates: _____

Water Filtration

Competition

A. Which team's filter will have the purest water?

_____

B. Which team's filter will be fastest?

_____

Water Purity (circle point score)

		abundance			
	pollutant	abundant	some	trace	none
1.	_____	0	1	2	3
2.	_____	0	1	2	3
3.	_____	0	1	2	3
4.	_____	0	1	2	3

Flow Rate

C. How long did it take to collect 150 ml through your filtration system? _____

(circle one point score)

0-60 seconds	4
61-120 seconds	3
121-180 seconds	2
181-240 seconds	1

D. Total team score (sum of purity points plus flow rate points): _____

E. Follow-up Questions (circle score for each question)

Q1.	0	4	8	12	16
Q2.	0	3	6	9	12
Q3.	0	1	2	3	4
Q4.	0	1	2	4	4
Q5.	0	4	8	12	16
Q6.	0	4	8	12	16

Total score for section E: _____

Bonus:

F. How did the team you listed in A do? best (4 pts) 2nd (2 pts) 3rd (1 pt)

G. How did the team you listed in B do? best (2 pts) 2nd best (1 pt)

Total score (sum of D to G): _____

Name: _____ ***Date:*** _____

Water Filtration Competition

Follow-up Questions

1. Which of the filtration material(s) were effective at filtering each of the following:

pollutant 1:

pollutant 2:

pollutant 3:

pollutant 4:

2. If you were to retest with the same polluted water, what changes would you make to your filtration system?

3. Does the order in which you place your filtering materials make any difference? Explain why or why not.

4. What other objects that you were not given access, would improve the physical filtration of the systems built in class? (you may use books, internet)

5. On a separate sheet of paper, design a filtration system using the same materials as in class, that would have an extremely fast flow rate, irregardless of water purity.

6. As in number 5, design a filtration system using the same materials as in class, that would produce a very high water quality, irregardless of flow rate.