Student Worksheet
Water purity and filtration – Getting down to the nanoscale

Water Filtration and Nanoparticles

January 29, 2020

Dear Team:

Thank you for your recommendation to get a filter for the stream on our ranch.

To save money, I would like to have you build a filter that will purify the water in the stream so that people on my ranch can drink the water.

Also, please test the filtered water to make sure that it is safe to drink.

Sincerely,

Manuel Ranchero
Ranch Owner
Rancho Felicidad

Question Will the filter remove disease-causing bacteria?

Make a Prediction _____

_____

_____

_____

_____

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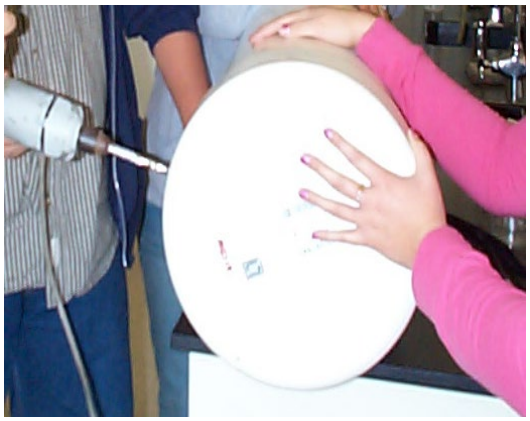
Procedure—Part II: Making the Filter



1. In a well-ventilated area, paint primer around the inside rim of the PVC cap. Be sure to cover the entire inside surface of the cap. (Use the brush that comes with the primer.)
2. Measure the height of the cap. Paint primer on the outside of the PVC pipe to the same depth as the height of the cap.
3. Allow the primer to dry by following the instructions on the can.
4. Apply the PVC cement around the inside rim of the cap.

Safety Alert!

Wear protective gloves while using primer and cement.

Work in a well-ventilated area.

5. Place the PVC cap on one end of the PVC tube and firmly tap it down with a rubber mallet or your hands to secure it in place.
6. Allow the cement to dry by following the instructions on the cement.
7. Drill a 3/8-inch hole in the cap for a 3/8-inch plastic hose. Be sure to wear goggles as you drill to protect your eyes from projectiles.
8. Insert 3/8-inch hose into the hole.
9. Apply silicone aquarium sealer around the outside of the plastic hose so that water will not leak out. Then, ask someone with really long arms to apply the sealant to the inside of the hole.

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10. Use plastic electrical ties to hold up the 3/8 inch hose along the outside of the bio-sand filter.

11. Pour water through the PVC pipe to test whether the system leaks. Water should only exit via the tube.

12. If the system has any leaks, mark the leakage with a permanent marker and allow it to fully dry. Then apply aquarium sealer to the marked areas.

13. Repeat steps 11–12, until the system has no leaks.

14. Add 1/4-inch of pea gravel to the bottom of the bio-sand filter to a depth of 2 inches making sure it covers the plastic hose at the bottom of the filter.

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15. Place the bag of ***clean*** #16 grit sand atop a table. Place the PVC pipe below it, with the capped end touching the floor. Gently scoop the sand into the filter. Continue adding sand until it is 2 inches below to top (for a water reservoir).

16. Take the filter outside. Add a bucket of water to flush the system to ensure that it is working.

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Materials

- knife or nail clipper
- pathoscreen media
- sterile bag with dechlorinating agent
- 2 antiseptic alcohol preparation pads or alcohol swabs/wipes
- permanent marker
- 1 L plastic bottle, with the top removed

Safety Tip

Use care when cleaning and using blades—they are sharp and can cut.

Procedure—Part II: Testing the Filter

1. Wearing protective gloves, remove an alcohol swab from the foil pouch and use it to carefully clean the knife or nail clipper blade.
2. Place the swab atop a flat surface.
3. Use the knife or clipper to open the pathoscreen media and carefully place the media on top of the opened alcohol wipe. Make sure that the contents do not spill out!
4. Use another alcohol wipe to wipe the tube (outside and just on the edge of the inside, if possible) where the water will exit. Lay the tube on top of the wipe to keep the tube clean and free of contamination.
5. Label the sterile bag with your name, date, and time.
6. Open the sterile bag by tearing off the top of the bag along the perforation. Be sure NOT to contaminate the inside of the bag. Leave the small tablet of sodium thiosulfate in the bag—it will remove chlorine from the water.
7. Hold the bag by the wireless white strips at the top and pull. The bag will open.
8. Let the water run for about 30 seconds.
9. Fill the bag to the 100 mL line with the water. If the bag fills above this line, pour out the excess water.
10. Add the pathoscreen media powder to the bag containing your water sample—this nutrient will help any bacteria present to quickly multiply and allow you to detect their presence. Be sure to add **all** of the powder to the bag.
11. Pull the white wire strips taut to close the bag.
12. Firmly hold the wire strips, and carefully but quickly flip the bag 3 times so that the bag folds tightly over the wire to create a tight seal. Fold the wire strips over to seal the bag, as shown in the image at right.
13. Observe the contents of the bag. If the sodium thiosulfate has not fully dissolved, gently shake the bag. Prevent water from leaking out by not squeezing the bag.
14. Place the bag in the 1 L bottle with the top removed for safe transport. Store on a level surface where it will not tip.

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Data

15. Record the color of the bag, the date, and time in the table below.
16. After 24 hours, observe the sample bag and record your observations in the table below. What color is the sample? If it is yellow, does it have black spots?
17. After 48 hours, repeat step 16.

Sample	Description at 24 hr	Description at 48 hr	Is bacteria present?	Conclusion
1				
2				
3				
4				
5				

Materials for disposal

- bucket
- bleach
- water
- straight pin
- spray bottle containing bleach and water in a 1:10 ratio
- paper towels

Disposal

18. Wear a pair of protective waterproof disposable gloves.
19. Remove the sample from the transport bottle and have a lab partner hold the bag upright as you fill the 1 L transport bottle halfway with tap water.
20. Add bleach to the transport bottle until it is ¾ full. Gently shake the bottle to mix the bleach with the water.
21. Place the sample bag in the water bottle and push it down to submerge the bag.
22. Use the straight pin to puncture the bottom corner of the bag. Allow the contents of the bag to empty into the bottle.
23. Flush with tap water the fluid contents of the bottle. Do **NOT** flush the bag.
24. Repeat steps 21–23 to disinfect the inside of the bottle and the bag. You may open the bag and rinse the inside of the bag.

Safety Alert!

The contents of the bag may contain disease-causing bacteria that could cause diarrhea or other illness. Wear gloves and use caution at all times during disposal.

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25. Dispose of the bag, pin, bottle, and gloves in a way that they cannot be recovered, such as placing them in a biohazard bin. Pins should be disposed of in a closed cardboard box before placing them in a biohazard bin. Be sure that pins do not go directly in a plastic bag—they can puncture the bag.

26. Use the spray bottle containing bleach water to disinfect any surfaces that might have come in contact with the sample.

Analysis

27. If the water sample in your bag is black or has black dots in it, then bacteria has been detected. If it is yellow with no trace of black, bacteria has not been detected. Is bacteria present in your samples? For each sample, record your answer in the table on the previous page.

28. Why did you clean the cutting tools and water tube before testing the water for bacteria?

_____

29. Why must the sample be at room temperature for 24 hours before you can expect a color change? _____

30. How might doing this experiment on a very cold day affect the results?_____

_____

_____

31. How might doing this experiment on a very hot day (over 90°F) affect the results?_____

_____

_____

Conclusion

32. In your data table, notice the trend of color throughout the period of time that you tested. What conclusions can you draw about how quickly or slowly the bacteria grew? What can you conclude about how much bacteria were initially present in the sample? Record these conclusions in the data table.

33. Is the filtered water safe for human consumption? _____

_____

34. What recommendations would you make to improve the filter? _____

_____

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35. Suppose your filter system did not work well. What could you recommend to the people who work on that ranch that they do while you test another filter? Explain your answer.

(Hint: review your answer in step 31.) _____

_____

_____

36. Across the Disciplines: Bonus Project: Researchers who develop filtration devices often test for what particles are filtered out. Write a 2-page paper describing one of the following:

- techniques (light, chemicals, etc.) used to identify microscale and nanoscale objects filtered from water
- tools used to see nanoscale objects that are often found in water
- various nanofiltration devices and how they differ from microfilter
- how biolayers assist with filtration

37. Inquiry Extension: Using the information from your project in step 36, brainstorm a procedure on how you could test the size of particles that are filtered from the water.

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