MONDAY MORNING SCIENCE BLAST
Hard Water - Chemical Reactions - Physical Science

“Wisk ends ring around the collar.” “Ajax detergent is stronger than dirt!” These are just two of the numerous commercials that have been used to sell soap and detergent brands through the years. Often it is not the detergent, but the type of water that may spell success or failure. Do you have hard water? If you do, you may use a water softener to help protect your plumbing from scale buildup, prevent soap scum, and lessen the amount of soap and detergent needed for cleaning. You've probably heard that cleaners work better in soft water than in hard water, but does that mean you will feel cleaner if you bathe in soft water? Actually, no. Rinsing in soft water may leave you feeling a little slippery and soapy, even after a thorough rinsing. Why? The answer lies in understanding the chemistry of soft water and soap.

Hard water contains calcium and magnesium ions. Water softeners remove those ions by exchanging them for sodium or potassium ions. Two factors contribute to that slippery-when-wet feeling you get after soaping up with soft water. First, soap lathers better in soft water than in hard water, so it's easy to use too much. The more dissolved soap there is, the more water you need to rinse it away. Second, the ions in softened water lessen its ability to 'stick' to the soap molecules, making it more difficult to rinse the cleanser off your body.

The reaction between the ingredients in soap produce a molecule called glycerol, that bonds with three molecules of sodium stearate (the 'soap' part of soap). This sodium salt will give up the sodium ion to water, while the stearate ion will precipitate out of solution if it comes into contact with an ion that binds it more strongly than sodium (e.g., the magnesium or calcium in hard water). The magnesium stearate or calcium stearate is a waxy solid that you know as soap scum. It can form a ring on your tub, but it rinses off your body. The sodium or potassium in soft water makes it much more unfavorable for the sodium stearate to give up its sodium ion so that it can form an insoluble compound and get rinsed away. Instead, the stearate clings to the slightly charged surface of your skin. Essentially, soap would rather stick to you than get rinsed away in soft water. In this lab, your students will investigate the hardness and softness of water.

To begin, have students hypothesize about the effect that hard and soft water will have on the ability of a detergent to produce suds and predict the relative sudsiness of the three solutions of water in the Data section. Once they have recorded their predictions, instruct your students to label the three bottles as directed. Using the graduated cylinder, students will first measure out 50 mL of distilled water and add this to the bottle labeled “D.” Next they will use the graduated cylinder to measure out another 50 mL of distilled water, adding this to the bottle labeled “H,” then add 1 full teaspoon of Epsom salts to this bottle and shake the bottle until all of the Epsom salts have dissolved.

Next have students use the graduated cylinder to measure out 50 mL of distilled water and add this water to the bottle labeled “S.” After adding 1 full teaspoon of Epsom salts to the bottle, instruct your students to shake the bottle until all the Epsom salts have

dissolved. Next they will add 1 teaspoon of washing soda to this bottle and swirl the bottle to soften the water, recording any observations.

Now have students add 5 drops of detergent to each bottle and vigorously shake each bottle 20 times. Using the metric ruler, they will measure the amount (mm) of suds that forms on top of the water in each bottle, recording this measure in the Data Section. After cleaning each bottle thoroughly to ensure no suds are left, have students dry the bottles by shaking the water out of them. After adding 50 mL of one of the other water samples to one of the clean water bottles, instruct students to add 5 drops of detergent to the water, then shake the bottle vigorously 20 times, measure the amount of suds that form, and record this amount in the Data Section. Finally, students are to repeat Step 9 with the other water samples.

Hard Water

QUESTION: How can hard water be softened?

MATERIALS:

- detergent
- distilled water
- Epsom salts
- graduated cylinder
- medicine dropper
- metric ruler
- plastic water bottles (small) - 3
- teaspoon measure
- washing soda (I use Arm & Hammer Super Washing Soda)
- water samples

PROCEDURE:

1. In this lab you will investigate the effect that hard and soft water will have on the ability of a detergent to produce suds. Hypothesize about the effect hard and soft water will have on the ability of a detergent to produce suds. Predict the relative sudsiness of the three solutions of water in the Data section. Record whether you think the solution will produce a large amount of suds, a moderate amount of suds, or a small amount of suds. Once you have recorded your predictions, then proceed with the activity.
2. Label the three bottles: one “D” for distilled water, another “H” for hard water, and the third “S” for soft water.
3. Use the graduated cylinder to measure out 50 mL of distilled water. Add the 50 mL of distilled water to the bottle labeled “D.”
4. Use the graduated cylinder to measure out another 50 mL of distilled water. Add the 50 mL of distilled water to the bottle labeled “H.” Add 1 full teaspoon of Epsom salts to this bottle. Shake the bottle until all of the Epsom salts have dissolved.
5. Use the graduated cylinder to measure out another 50 mL of distilled water. Add this water to the bottle labeled “S.” Add 1 full teaspoon of Epsom salts to the bottle. Shake the bottle until all of the Epsom salts have dissolved. Now add 1 teaspoon of washing soda to this bottle. Swirl the bottle to soften the water. Record any observations.
7. Add 5 drops of detergent to each bottle. Vigorously shake each bottle 20 times. Use the metric ruler to measure the amount (mm) of suds that forms on top of the water in each bottle. Record this measure in the Data Section.
8. Clean out each of the bottles thoroughly so there are no suds when water is added to the bottle. Dry each bottle by shaking the water out of it.
9. Now add 50 mL of one of the other water samples to one of the clean water bottles. Add 5 drops of detergent to the water. Shake the bottle vigorously 20 times and measure the amount of suds that form. Record this amount in the Data Section.
10. Repeat Step 9 with the other water samples available to you.

DATA:

PRODUCTION OF SUDS			
SAMPLE	**PREDICTION**	**LEVEL OF SUDS (mm)**	**HARDNESS LEVEL (hard, moderate, soft)**
Distilled Water			
Hard Water			
Soft Water			
Sample 1			
Sample 2			
Sample 3			

QUESTIONS:

1. Which sample produced the least suds? Which sample produced the most suds?

2. Why was distilled water used to prepare samples of soft and hard water? Could you have used tap water?

3. Do you think rain water is hard or soft water? Explain.

4. The compound in washing soda is sodium carbonate. How did the sodium carbonate soften the hard water? Write a balanced chemical equation for this reaction.

6. Suppose a family notices that the water pressure in their house is not good enough to flush a toilet on the second floor. Other than a leak, what could be interfering with the flow of water?

7. Explain why drinking hard water might be better for your health than drinking soft water. How could a family have the benefit of hard water for drinking and soft water for washing?