Which Type of Water is The Hardest: Distilled Water, Bottled Mineral Water, or Tap Water?

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Abstract

This experiment measures the hardness of tap water, distilled water, and bottled mineral water. Soap is added to each sample of water to estimate the amount of mineral in each sample, in order to determine the hardness of water in each sample. The result of this experiment reveals that bottled mineral water is the hardest. Further studies are needed to determine what kind of minerals are present in these three samples of water.

Introduction

The purpose of this experiment was to better understand the properties of hard water and soft water, in order to determine which sample of water is more suitable for washing clothes. Usually, water contains a lot of minerals such as iron, calcium, zinc, magnesium, sodium, phosphorous, and manganese [1]. The hardness of water is determined by the amount of dissolved calcium and magnesium in the water [2]. The higher the concentration of calcium and magnesium in the water, the harder the water will be. Conversely, the less calcium and magnesium in the water, the softer the water will be [2]. Hard water can be separated into two categories: temporary hard water and permanent hard water [3]. The hardness of temporary hard water is caused by calcium bicarbonate and magnesium bicarbonate [3]. The hardness of temporary hard water can be removed by heating the water. When temporary hard water was heated, decomposition reaction will occur [3]. The bicarbonate ions will break down into carbon dioxide, carbonate ions and water. [3]. This decomposition reaction is represented by the chemical equation below.

$$CaCO_3(s)+CO_2(aq)+H2O(l)\rightleftharpoons Ca_2+(aq)+2HCO_3^- (aq)\ [3]$$

The carbonate ions decomposed from bicarbonate ions will react with calcium to form calcium carbonate [3]. Furthermore, calcium carbonate is insoluble. This means that calcium carbonate

will not dissolve in water and can be extracted from water. In contrast, permanent hard water cannot be softened by this process. Permanent hard water consists mostly of dissolved calcium sulfate and magnesium sulfate [3]. These substances cannot be precipitated by heating the water [3]. Therefore, the hardness of permanent hard cannot be removed by heating the water. Overall, the hardness of water refers to the amount of dissolved mineral the water contains.

Soft water and hard water both have their benefits and harms. For instance, soft water is more suitable for cleaning and washing clothes [4]. Soft water works more efficiently with soap because it is easier to form bubbles [4], whereas hard water will form fewer bubbles [4]. To continue, the calcium and magnesium in hard water will react with soap to form scum. To test the idea that hard water will produce fewer bubbles, this experiment will add soap to three samples of water: tap water, bottled mineral water, and distilled water. Tap water comes from rivers and reservoirs [5]. Tap water is drinkable after it goes through several processes, such as flocculation and sand filtration [5]. After tap water goes through these processes, chlorine is added to kill the bacteria in tap water [5]. Although most of the particles in tap water are filtered, there are still some amounts of minerals present in tap water [5]. Similarly, bottled mineral water still has a certain amount of minerals, even though it goes through a carbon filtration process [5]. On the other hand, distilled water goes through a boiling process to purify the water. It was hypothesized that bottled mineral water will form fewer bubbles. The expected result of the experiment should show that the higher the concentration of minerals in water, the fewer bubbles it will form.

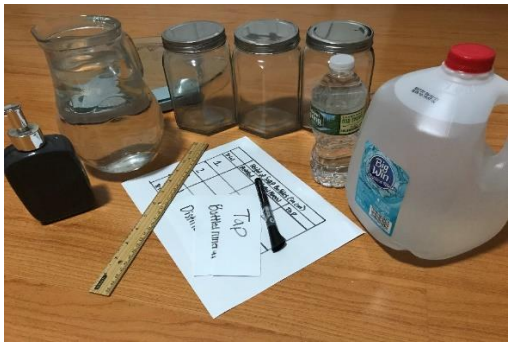
Objective

This experiment will measure the hardness of three samples of water: distilled water, bottled mineral water and tap water. Once measured, the result of this experiment will be analyzed to determine which sample of water is the hardest.

Materials

- Three glass jars (The height of these jars need to be greater than the width of these jars)
- One gallon of Tap water at 70°F
- One gallon of distilled water at 70°F
- One gallon of bottle mineral water at 70°F
- Black marker
- Ruler (Centimeter)
- Stopwatch
- Thermometer
- Measuring cup (300mL)
- Electronic weighing scale
- Liquid soap
- Computer paper and notebook
- Safety Goggle (Spill resistant)
- Paper towels
- Towels

Figure 1: Marteials for this experiment



Procedure

1. Prepare materials and set up workplace.
    I. One covers the workplace with three to four towels to prevent any spills when one is performing the experiment.
    II. One uses a thermometer to measure the three samples of water (tap water, distilled water, and bottle mineral water) to ensure that these three samples of water are at room temperature (70°F).
    III. The three jars are labeled with marker. This action is done to help keep track of which type of water is inside of each jar [6].
    IV. The volume of the three jars are first calculated to determine how much water one should add to each jar. To achieve a better result, one should fill the jar to 1/5 full of water [6]. This means that one should pour 100 milliliters of water if the volume of the jar that one is using is 500 milliliters [6]. (If one has a hard time finding the volume of the jar one is using, one can fill the jar with water using a measuring cup. After that, one can divide how many milliliters one added into the jar by 5.)

2. One uses a measuring cup to measure out the amount of water one had decided, in step IV, add to each appropriate jar [6]. After each jar is filled with water, a black marker is used to mark the height of the water [6] (see figure 2). The mark helps to measure the height of the bubble after shaking the jar.

Figure 2: The three jars after being filled with its sample of water

3. Soap is added to the jar containing distilled water and measured for the height of bubbles formed.

   I. 1 drop of soap per 100 milliliters of water [6] is added to the jar containing distilled water.

   II. The stopwatch is set to 10 seconds. A helper starts the stopwatch, while the jar is shaken.

   III. After 10 seconds, one observes the jar to ensure that the bubbles did not reach the top of the jar (see figure 3). If the bubbles reach the top of the jar, one needs to restart the experiment and change the following factors [6].

      A. Reduce the amount of soap [6].

      B. Reduce the amount of water [6].

      C. Reduce the time of shaking [6].

      D. Use a taller jar.

   IV. A ruler is used to measure the height of the bubbles.

V. The result of distilled water is recorded. (see table 1).

4. Steps (3 I) through (3 V) are repeated for the jar containing bottled mineral water and the jar containing tap water.

Figure 3: The three jar after shaking

5. The three jars are cleaned.

   I. The three jars are opened and the water and bubbles inside the jar are poured down the sink.

   II. The three jars are rinsed with water.

   III. The three jars are wiped with paper towels.

6. Steps (1 II) through (5 III) are repeated for trial 2 and trial 3.

7. **Table 2**: Height of Soap Bubbles (in centimeters)

Trial	Distilled Water	Bottled Mineral Water	Tap Water
1	8.6 cm	4.7 cm	5.6 cm
2	7.5 cm	5.2 cm	5.9 cm
3	7.8 cm	4.9 cm	5.5 cm
Average	7.9 cm	4.9 cm	5.6 cm

[6]

Result

The following height of bubbles were formed from shaking the three jars containing the three samples of water (see table 2 in next page). In the jar containing distilled water, the soap

bubbles reached a height of 8.6 centimeters for trial 1; 7.5 centimeters for trial 2; and 7.8 centimeters for trial 3. The average height of soap bubbles for distilled water is 7.9 centimeters. In the jar containing bottled mineral water, the soap bubbles reached a height of 4.7 centimeters for trial 1; 5.2 centimeters for trial 2; and 4.9 centimeters for trial 3. The average height of soap bubbles for bottled mineral water is 4.9 centimeters. In the jar containing tap water, the soap bubbles reached a height of 5.6 centimeters for trial 1; 5.9 centimeters for trial 2; and 5.5 centimeters for trial 3. The average height of soap bubbles for tap water is 5.6 centimeters.

Analysis

The data of this experiment supports the hypothesis. The result of this experiment shows that bottled mineral water has the highest concentration of minerals. Therefore, bottled mineral water is the hardest water when compared to distilled water and tap water. The minerals in bottled mineral water react with soap to produce scum, which prevents bubbles from forming [7]. Moreover, scum is an insoluble substance that does not dissolve in water [8]. The reaction of the minerals of bottled mineral water and soap is represented by the chemical equation below.

$$CaSO_4(aq) + 2C_{17}H_{35}COONa(aq) \Longrightarrow (C_{17}H_{35}COO)_2Ca(s) + Na_2SO_4(aq)$$ [6]

This chemical equation represents a precipitation reaction. Precipitation reaction is when two soluble solutions react and form a salt that is insoluble [9]. Although this experiment identified that bottled mineral water has the highest concentration of minerals out of the other two samples of water, further studies are needed to determine how high the mineral levels are in these three samples of water.

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