CHEMISTRY

Water Quality Testing

Part One: Quality of Water

Since human settlement, the quality of water in general has degraded overtime, due to increasing waste materials discharged into water bodies. Yet, for the small proportion of fresh water left for consumption by living organisms, monitoring water quality remains of paramount importance.

The consideration of 'good' water quality is dependent upon its use. That is, water for drinking, other domestic uses, agriculture, recreation, and in the environment, have different standards for good water quality. However, a criterion exists for assessing the quality of water:

- Concentration of common ions
- Total dissolved solids
- Hardness
- Turbidity
- Acidity
- Dissolved oxygen and biochemical oxygen demand

The experimental layout below compares water of two different sources based on the properties of: Hardness, Amount of suspended solids, Amount of total dissolved solids, and Presence of carbonates.

Aim: To qualitatively compare tap and creek water on their hardness, amount of suspended solids, amount of total dissolved solids, and presence of carbonates.

Equipment:

- Creek and tap water
- Soap
- Two identical vials
- Plastic container
- Camera
- Clear, tall cup
- White paper and black texta
- 2 coffee filter paper
- Metal bowl

- Small glass cup
- Vinegar
- Medicine cup

Method:

Firstly, collect a large sample of creek water and tap water.

(a) Hardness

1. Fill each vial with an aliquot of different water
2. Add the same amount of soap to each and shape vigorously
3. Take a picture using camera of vials side by side. Compare the amount of lather produced
4. Repeat

Variables:

Dependent: Amount of lather produced

Independent: Water

Control: Amount of water used
Amount of soap used
Equipment and method used

Justification for equipment used:

The vials obtained from a children science kit provided an appropriate container to conduct test.

(b) Suspended solids

1. Using the white paper and black texta, make a disk as shown:

2. Place the clear, tall cup over the disk. Shake sample of tap water vigorously before filling the tube, assess turbidity based on visibility of black lines. Repeat for creek water then compare results.

3. Repeat.

Variables:

Dependent: Visibility of lines

Independent: Water used

Control: Equipment and method used
Light turbidity was recorded in

Justification of equipment used:

A clear, tall cup over a disk with lines was used, as a replacement of turbidity tube, as it used the same concept of vertically looking down and deducing the visibility of a pattern at the bottom.

(c) Total dissolved solids

1. Filter the creek water with the coffee filter paper, collect the filtrate
2. Evaporate the filtrate creek water in a metal bowl with the kitchen stove
3. Repeat above steps for tap water
4. Qualitatively compare the amount of solids left behind
5. Repeat

Variables:

Dependent: Total dissolved solids

Independent: Water

Control: Amount of water used
Equipment and method used

Justification of equipment used:

Due to the unavailability of a Bunsen burner, evaporating basin and pipe clay triangle, a metal bowl and the stove was used instead because the bowl provided a safe container for heating and the stove was the only source of fire inside the domestic household. Also coffee filter paper was used in place of scientific filter paper as it was readily available.

(d) Presence of carbonates

1. Warm water a metal bowl for one minute, then place small glass cup with tap water inside to warm up sample water.

2. Add an aliquot of vinegar using a medicine cup. Observe if any bubbles are formed.

3. Repeat for creek water.

4. Repeat.

Variables:

Dependent: Bubbles

Independent: Water

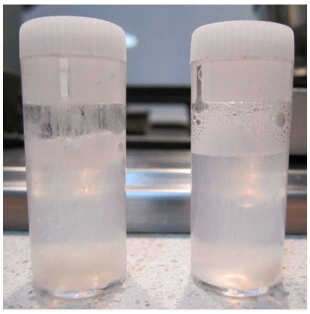
Controls: Equipment and method used
Time for heating the water used to warm the sample water
Amount of water
Amount of vinegar added

Justification of equipment used:

Because an evaporating kit was not accessible, a metal bowl and stove was used to heat up the water and act as a water bath for the sample water. Also, vinegar replaced stronger acids like hydrochloric acid, because concentrated acids cannot be found as household substances. A medicine cup was used to supply an aliquot of liquid.

Results:

(a) Hardness

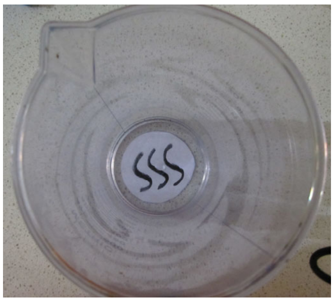


Creek water Tap water

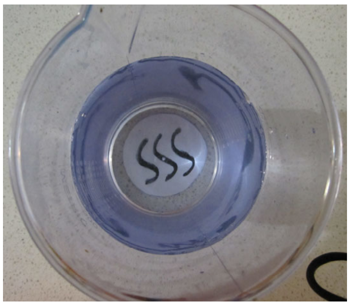
Comparison:

The tap water produced more lather compared to the creek water. Hence, creek water is harder than tap water.

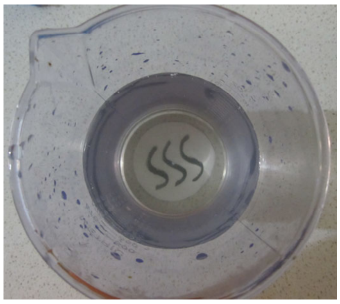
(b) Suspended solids



Without water



Tap water



Creek water

Comparison:

The black lines were less visible when viewed through creek water compared to tap water. Hence, creek water is more turbid than tap water.

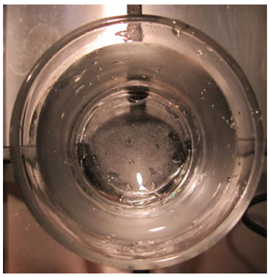
(c) Total dissolved solids

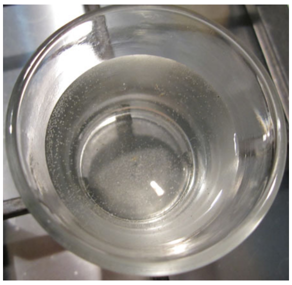
Without water **Tap water** **Creek water**

Comparison:

The creek water left behind more residue compared to tap water. Thus, creek water has a greater amount of dissolved solids.

(d) Presence of carbonates





Tap water **Creek water**

Comparison:

Small bubbles were formed when vinegar was added to creek water, indicating a presence of carbonates. Tap water did not form any bubbles with vinegar, thus there is no carbonate present or concentrations are too low to produce observable reaction.

Discussion (includes justification of methods used):

Water quality is defined by its physical, chemical, biological and aesthetic characteristics, which affects its type of use. This experiment assessed water quality on a physical, chemical and aesthetic basis, whereby analysis of the water composition extends understanding of its commercial, recreational and environmental value.

Water found in natural resources is never pure being affected by its surrounding geology. However, when the fine balance of water is disrupted by community uses such as agriculture, urban and industrial use, and recreation, it becomes essential to monitor the quality of water to ensure no deadly diseases (like chlorea, diarrhoea etc), are spread or the water promotes undesirable outcomes (like algal blooms), which can have adverse effects on its available use and the environment.

Hard water contains considerable concentrations of calcium and magnesium. So for a test measuring hardness, precipitation reactions can only be used (due to presence of other metals) to find the amounts of those certain metals. Soap, when added to water reacts with magnesium and calcium to form insoluble precipitates which appear as gray 'scum' on the surface of water or at the bottom of container. Interpreted from results obtained, creek water consists of a higher concentration of calcium and magnesium ions, as instead of lathering, a greater amount of precipitants was formed with the reaction with soap:

$Mg^{2+}(aq) + CH_{17}H_{37}COO^{-}(aq) \rightarrow Mg(CH_{17}H_{37}COO)_2(s)$
$Ca^{2+}(aq) + CH_{17}H_{37}COO^{-}(aq) \rightarrow Ca(CH_{17}H_{37}COO)_2(s)$

It is commercially more desirable to have water easily lather and form less precipitates, hence why tap water has calcium and magnesium removed before it is supplied for domestic use.

Suspended solids in water are removed before being used for domestic purposes. This is because it gives water an undesirable appearance and taste. Turbidity is a measure of colloidal matter suspended in matter, including both settled solids and particles suspended indefinitely in the water. An analogised turbidity tube was used for this test as it is very simple to use and gives good comparative measure.

There are numerous problems associated with high turbidity as reduced light penetration means aquatic plants perform less photosynthesis, reducing dissolved oxygen and affecting aquatic life. Also, suspended sediments carry nutrients and pesticides into waterways, and small particles absorb solar radiation raising temperatures of water body, resulting in a deteriorated ability of water to support life forms. Moreover, turbid water (greater than three nephelometric turbidity units) is not potable for human drinking as health problems arise if consumed. Thus, tap water appeared much more transparent compared to the creek water which, by observation of water source, does not sustain much aquatic life.

High concentrations of dissolved solids make water uninhabitable for many species, and can cause health issues to humans if not lowered. Further, high levels of sodium in water systems indicate salinity problems. By filtering out the insoluble solids and evaporating the water, dissolved solids which have higher boiling point than water, can be left behind as residue. As results show, creek water contains greater amounts of dissolved solids, as the water would have dissolved surface earthy material (accelerated by human activities such as farming) containing various salts. Otherwise, groundwater aquifers, which are an integral part of creeks and rivers, and storm water, contribute to the increased amount of dissolved solids. Yet, tap water must be consumable for humans (<500 ppm) so has less dissolved solids, as indicated from the results obtained.

When carbonates react with acid, carbon dioxide, water and a salt is formed. The ionic equation is expressed as:

$CO_3{}^{2-}(aq) + H^{+}(aq) \rightarrow CO2(g) + H2O(l)$

Thus, the water was warmed (to increase reaction rate) and had vinegar (an acid) added to it, to see if any bubbles or carbon dioxide was formed. However, an additional test should have been conducted to confirm if gas was carbon dioxide. When limewater reacts with carbon dioxide, it forms a white insoluble precipitant:

$Ca(OH)_{2\,(aq)} + CO_{2\,(g)} \rightarrow CaCO_{3\,(s)} + H_2O_{(l)}$

Carbonates are generally present in water with pH 9 and above. At this pH range water is unsuitable for commercial activities like irrigation (pH of 5.5 - 8.5) and drinking (6-8.5). Additionally, high carbonate levels can cause calcium to precipitate from the soil, reducing the soil's exchangeable calcium content and increasing soil sodicity (hardness). In extreme cases, loss of calcium will affect plant growth. Moreover, precipitation of calcium carbonate in water causes equipment blockages. Thus, tap water did not appear to have carbonates as opposed to creek water, for the reasons of reducing hardness and for preservation of connecting pipes.

Overall, these tests prove tap water as having the superior water quality in terms of domestic use and drinking. Despite being limited to household equipment, which contributed to equipment error, the distinct results provided enough evidence to deem tap water as having the better water quality. However, for more precise comparisons, potential improvements can be achieved using advanced, laboratory equipment and conducting this experiment quantitatively, otherwise, performing additional tests of other properties (dissolved oxygen, acidity etc) to evaluate quality of the water.

Nevertheless, this experiment provided a small insight of the extent water from natural resources fares worse than 'good' quality tap water, and as the NSW office of water states: "While lowered water quality may only be a short–term problem for rivers, water in our groundwater systems has often been stored for thousands of years so any contamination has long-lasting impacts."

Sources:

http://www.waterwatch.org.au/monitoring.html
http://www.sydneywater.com.au/Education/SecondaryStudents/AboutSydneyWater/history.cfm
http://www.gvsu.edu/wri/education/instructor-s-manual-conductivity-11.htm
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Reliability:

The reliability of an experiment's results is dependent upon its consistency and reproducibility. A reliable experiment should be able to provide same/similar results when repeated. This experiment can be considered reliable, as repeats made produced a consistent and distinct qualitative outcome, allowing for appropriate comparisons between the certain property of the tap and creek water.

Validity:

A valid experiment is one which has a method helping to achieve its aim. This experiments aim of comparing the quality of tap and creek water was successfully addressed as the individual methods allowed for fair qualitative comparisons of each water property. Despite the results obtained being qualitative, the method used was still valid as the aim of this experiment was to 'compare,' and for some tests, this eliminated inaccuracy as household equipment would have skewed readings. In conjunction, the controls being kept throughout the repeats ensured no distortions or discrepancies to results were made. Yet, results demonstrated obvious outcomes and answered the aim, therefore the analogised method used is valid.

Conclusion:

We qualitatively compared tap and creek water on their hardness, amount of suspended solids, amount of total dissolved solids, and presence of carbonates. The results obtained showed that tap water had far better water quality than creek water indicated from the creek water's greater hardness, turbidity, dissolved solids, and presence of carbonates.