Hard water challenge

Contents

Acknowledgements

This resource was originally developed by Nottingham Trent University to support outreach work delivered as part of the Chemistry for All Project.

To find out more about the project, and get more resources to widen participation, visit our Outreach resources hub: rsc.li/3CJX7M3.

Guidance notes

The investigation should take approximately four hours to complete in full. It was initially created for 14–16 year-old learners but can be adapted when teaching about hard water to other age groups.

Download the PowerPoint presentation, technician notes and student workbook that accompany this resource at rsc.li/3Pqq6Jz.

Read our health & safety guidance, available from rsc.li/3IAmFA0, and carry out a risk assessment before running any live practical.

Specific safety advice for the chemicals used in this project can be found in the technician notes.

The safety equipment suggested is in line with CLEAPSS requirements. For non-hazardous substances, wearing lab coats can help to protect clothes. The safety rules might be different where you live so it is worth checking local and school guidance.

Learning outcomes

- Explain the construction and use of a look-up chart.
- Follow instructions for carrying out a procedure to test hard water.
- Compare the effectiveness of different water filters.
- Describe the domestic and health issues associated with hard water.

Introduction

In this series of activities, learners will work in pairs or groups of three to investigate the relationship between the concentration of calcium ions and the ‘hardness’ of samples of water.

Use **slides 3–7** of the PowerPoint to introduce what is meant by the hardness of water and how this can be tested in this session.

In **Activity 1**, learners will measure the concentration of calcium ions, in parts per million (ppm), of several solutions. They will then use their results to create a look-up chart. The method is provided in the student workbook.

Slide 9 contains the answers to the questions in the student workbook for **Activity 1**.

In **Activity 2**, the learners will investigate how effectively various water filters remove calcium ions from a sample of calcium chloride with a concentration of 500 ppm. They will do this by determining the calcium ion concentration after the samples have been filtered using their look-up charts. The method is provided in the student workbook.

Slides 10 and 11 of the PowerPoint can be used to introduce the use of water filters and show some career links.

Slide 13 contains the answers to the questions in the student workbook for **Activity 2**.

In **Activity 3**, the learners will confirm their results using commercially available dipsticks which can show the hardness of water samples in a very short time. The instructions for dipsticks tend to vary, so follow the instructions provided on the packaging.

Slide 15 contains the answers to the questions in the student workbook for **Activity 3**.

Career links

Learners should be encouraged to look at the two weblinks provided to learn about scientists who work at Thames Water analysing water supplies and keeping drinking water safe.

Laboratory analyst

Use **slide 6** to introduce learners to Joseph, a laboratory analyst and higher degree apprentice, who works at Thames Water and carries out vital safety tests on drinking water for 15 million people. The video job profile is also available from rsc.li/3Fm1fnC.

Analytical chemists

Use **slide 11**, or go to rsc.li/3ZJNO97, to read about Harsh and Michael's roles. They are analytical chemists who work at Thames Water and have the critical job of analysing samples of water to keep drinking water and sewage systems safe and operational.

Activity 1: measuring calcium concentrations

Answers

(a) Tutors should bear in mind that 4.5% of people are colour blind (most being male, with 8% of men being colour blind). Learners should be able to reflect on the method and relate this to the accuracy of their results.

(b) Learners might reflect on the fact that they could have more confidence in their results if they had calculated an average result after many repetitions. You could calculate class averages to demonstrate this.

(c) The best-fit line should show a linear relationship. Are there any outlying results? Do all the groups have similar charts?

(d) Soft water lathers better with soap, which enables people to clean themselves more effectively and remove germs that may cause health issues such as infections. Soft water also reduces scale build-up in kettles and other appliances.

Activity 2: investigating ion-exchange filters

Answers

(a) Answers will vary but discuss whether the class agreed on which was most effective.

(b) The point of this question is to get learners to think about how they might express relative effectiveness. For example, they could use the difference between the percentage changes in ppm of calcium ions after the water was filtered. The difference between filters can be expressed as a percentage. For example, filter A removes 20% more ions than filter B.

(c) The sketch might show the water filter being positioned so that it allows soft water to be used upstairs in the bathrooms and downstairs by the appliances in the kitchen. Mains water should be allowed to bypass the filter for drinking water so that people can drink hard water rather than soft water.

Activity 3: using dipsticks to measure the hardness of water

Answers

(a) This answer will depend on the brand of dipsticks used, but the quality of the learners' answers can be considered through asking them whether the results from the dipsticks showed the correct relative hardness of the water samples or whether the results from the dipsticks were consistently accurate or inaccurate across the range of solutions tested.

(b) These might be useful to test whether your home water softener is working, or to see whether your local water supply is hard or soft (you could then consider using water-softening products in your appliances).

(c) It is also important to monitor water hardness in aquariums, in hydroponics and in horticulture as mineral and pH levels can affect growth. The ions in hard water can also cause limescale and leave deposits that clog pipes, which makes it important for plumbers to maintain central heating systems.

Further work

The hard water project could lead to further research on water hardness and health or the variation of hardness of water across the country.

Learners could be asked to bring in water samples from their home or they could test samples of bottled water or sea water as follow-on projects.