Escape the Classroom: Contamination busters

The Waterbox

A project funded by the Royal Academy of Engineering

Royal Academy of Engineering | Ingenious

Instruction booklet

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About the Waterbox

Water: it is everywhere. We use it every day – for drinking, washing, flushing, cooking. It is hard to imagine our lives without it, but how much do you know about the science behind it?

This Waterbox was put together by the Cranfield Water Science Institute as part of the Contamination Buster: Escape the Classroom project funded by the Royal Academy of Engineering. It contains 14 chemistry experiments to better understand water science and the basics principles behind water treatment. Designed for KS3 students, the experiments proposed can be performed at home and require only basic household ingredients. As such, the set-up, materials and substances used have been selected so the students can perform the experiments in the safest possible way. All responsibility for the set-up and correct performance of the experiments is borne solely by the person who carries them out. The Cranfield Water Science Institute disclaims any liability with respect to the incorrect use of materials and substances provided in the Waterbox.

The experiments should be carried out only by KS3 students or students from higher key stages. All safety specifications and directions provided in this booklet must be observed. Responsibility for using the substances in a different way to the one described is borne solely by the user.

Box contents

Materials
3 measuring cylinders
3 funnels
250mL beaker
500mL beaker
2 boxes with lids
2 boxes with holes and lids
4 pots with lids
1 rubber tube
Modelling clay
Wooden stirrers
Pipettes
pH indicator strips
Water hardness strips
2 marbles
Rubber bands
Filter paper
Tube connectors
Tube clamp
Aluminium dish
Safety goggles

Reagents
Vinegar
Salt
Sand
Rose water
Granulated activated carbon
Soap
Oil
Clay powder
Food colouring
Calcium acetate
Aluminium sulphate **Warning:** May be corrosive to metals and can causes serious eye damage. Wear eye protection at all time.

How to use the Waterbox

- Read the experiment's instructions carefully before beginning. The time to carry out each experiment is only provided as an indication to the student planning an experiment.
- Wear safety goggles at all times.
- Read the safety warnings, if any.
- Avoid spillage of water to prevent slips, trips and falls
- Work in a tidy area where spillages can be easily contained, cleaned and will not cause any damages to the surface and area where the experiment is carried out.
- Clean up equipment with soap and water after use.
- Do not drink any of the water from the experiments.
- Alert your teacher when supplies begin to run low or run out.
- Complete your experimental writeups as you would for any other experiment
- Ensure all the material is cleaned after use and in the box using the content check list before returning it.

1. Variations in Water Volume

15 minutes

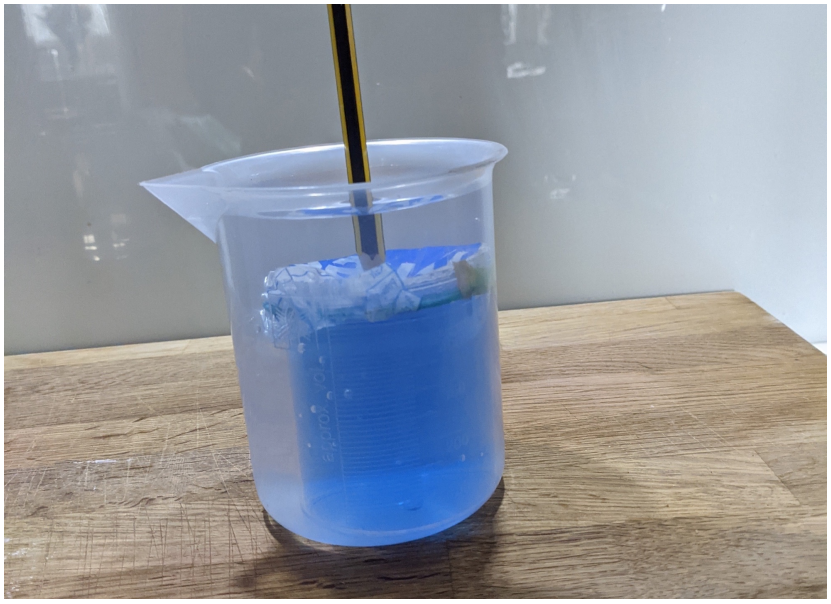
You will need:

- Food colouring
- A stirrer
- A pipette
- A rubber band
- A 500mL beaker
- One pot
- Plastic film (not provided)
- Pencil

Before you start: what do you expect to happen?

Fill the beaker quarters full with cold water. Now, fill the pot up to the brim with hot water. Add a few drops of food colouring and stir. Cover the small pot with some clingfilm and keep in place with a rubber band. Place the small jar in the large beaker. Make sure the pot is completely submerged. Using a sharp pencil, make a hole in the clingfilm.

What happens? Note your observations. Why do you think that happens?



2. Evaporation

10 minutes in the morning
10 minutes at the end of the day

You will need:

- A measuring cylinder
- A pot with a lid
- An aluminium dish
- 2 boxes without holes

Before you start: what do you expect to happen?

Early in the day, use the measuring cylinder to add 40mL of water in a pot with a lid, an aluminium dish, and two boxes. Leave one box, pot and the dish next to each other on a table. Take the other box and place it on a radiator or in direct sunlight. At the end of the day, pour the water back into the measuring cylinder and see how much water remains.

What happens? Note your observations. Why do you think that happens?

3. Condensation

15 minutes

You will need:

- Two pots
- Ice cubes

Before you start: what do you expect to happen?

For the first part, take an ice cube and hold it against a window for 10 seconds. Breathe around the ice cube.
For part two, half fill a pot with ice cubes. Half fill another pot with hot water. Place the pot with the ice cubes on top of the pot containing hot water. Wait 5-10 minutes and check on the ice cubes.

What happens? Note your observations. Why do you think that happens?

4. Precipitation

5 minutes every day for a week

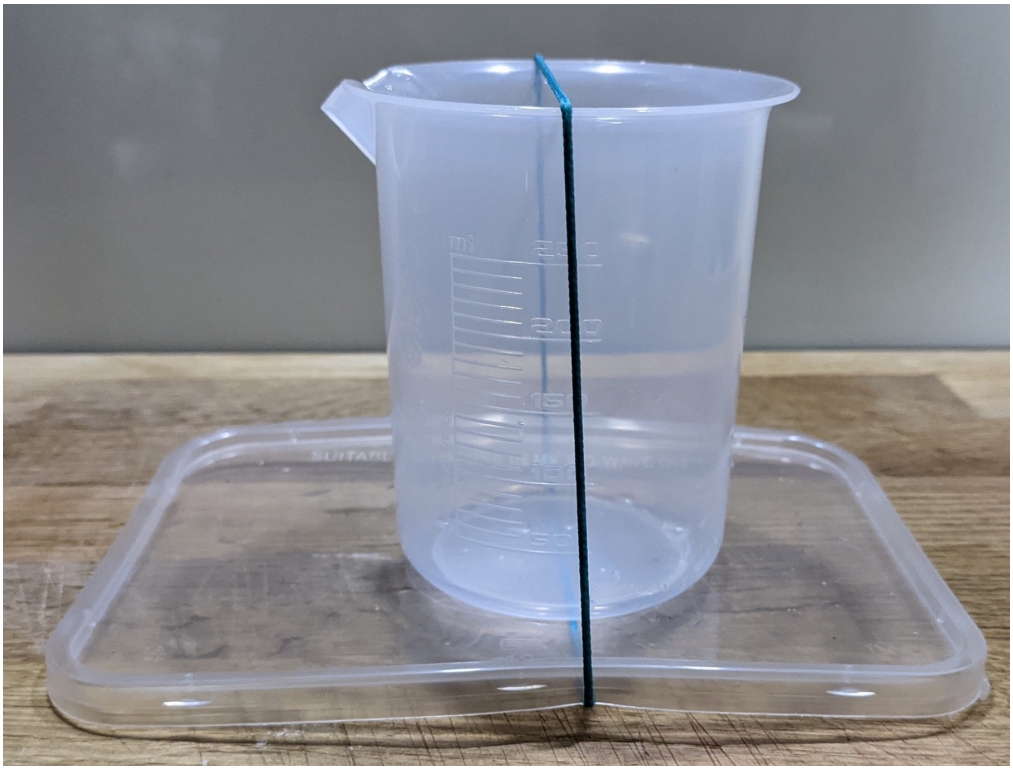
You will need:

- A measuring cylinder
- A box lid
- A beaker
- Two rubber bands

Before you start: what do you expect to happen?

Place the beaker on the box lid, and attach it using the elastic bands. Place this outside, well exposed to rain (not next to a tree or wall) and put several pebbles on the lid to stop it blowing over. Pour the contents into a measuring cylinder every morning for a week and measure the volume collected. Try and note the weather as well.

What happens? Note your observations. Why do you think that happens?



5. Flocculation/Sedimentation

15 minutes

You will need:

- Two pots
- A stirrer
- A pipette
- Clay powder
- Aluminium sulphate **Warning:** May be corrosive to metals and can causes serious eye damage. Wear eye protection at all time.

Before you start: what do you expect to happen?

Pour 100mL of water into each of the two pots. Use a stirrer to add a little clay into each pot. Add 6mL of aluminium sulphate to one of the pots and stir for one minute. Leave the pots to stand for 5 minutes and then compare the contents.

What happens? Note your observations. Why do you think that happens?

6. Filtration

35 minutes

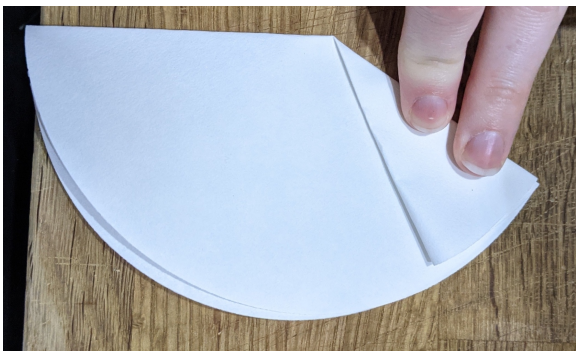
You will need:

- 3 measuring cylinders
- 3 funnels
- A 500mL beaker
- 2 filter papers
- A pipette
- A stirrer
- Sand
- Activated carbon
- Gravel (collect yourself)
- Soil (collect yourself)
- Food colouring

Before you start: what do you expect to happen?

Prepare the filter papers by folding them as shown below. Put a funnel in each measuring cylinder, and add filter paper to two of the funnels.
In one of the filter paper funnels, fill three quarters full of sand and the other three quarters full of activated carbon. In the funnel with no paper, fill three quarters full of gravel. Pour 40mL in each funnel to clean them and pour away the water. Now your filters are ready.
Pour 200mL into a beaker. Add some soil and 1 drop of food colouring and stir. Pour onto the gravel. When no more water is dripping through, pour the filtered mixture onto the sand. When no more water is dripping through again, pour over the activated carbon. Once you are done, you can clean the gravel, sand and activated carbon again and replace them into the reagent bottle.

What happens? Note your observations. Why do you think that happens?



7. Eliminating Smells

35 minutes

You will need:

- A 250mL beaker
- A pot
- A measuring cylinder
- A funnel
- A filter paper
- A pipette
- A stirrer
- Rose water
- Activated carbon

Before you start: what do you expect to happen?

Prepare a filter paper and place in the funnel. Put the funnel in the measuring cylinder. Fill the filter three quarters full with activated carbon. Clean the carbon by pouring 40mL of water through the funnel and pour that water away. You can also use the same activated carbon from the filtration if you clean it.
Put 100mL of water into a beaker. Use a pipette to add 2 drops of rose water and stir. Smell the mixture. Pour it into the activated carbon. Once it is all filtered, pour the water into a pot and smell again. You can clean the activated carbon and use it again.

What happens? Note your observations. Why do you think that happens?

8. Water Hardness

10 minutes

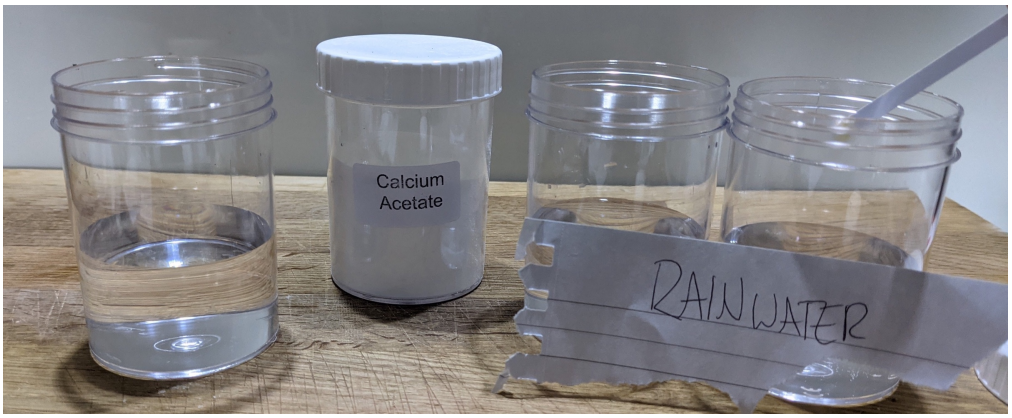
You will need:

- A beaker
- 3 pots
- Aluminium dish
- Two pipettes
- Three water hardness strips
- Rainwater or distilled water
- Tap water
- Calcium acetate
- Liquid soap

Before you start: what do you expect to happen?

Collect some rainwater if you can. Pour 60mL of rainwater into two pots and label them rainwater. Pour 60mL of tap water into the third pot and label it tap water.
Immerse one water hardness strip into one pot of rainwater and place on a dish. Do this for the tap water, making sure the hardness strips are far away from each other. Wait for a minute and then compare the to the universal indicator scale provided.
Add 5mL of soap to each pot from the last part. Place the lids on the pots and shake them.
Take the second rainwater pot and add 1mL of calcium acetate. Place the lid on the pot and shake.

What happens? Note your observations. Why do you think that happens?



9. pH

15 minutes

You will need:

- Two pots
- Aluminium dish
- A stirrer
- A pipette
- A beaker
- Vinegar
- Liquid soap
- 4 pH strips and scale

Before you start: what do you expect to happen?

Add 100mL of water to a pot. Only touching one end of the pH strip, dip the other end into the water for two seconds and compare to the scale. Place the strip on a dish. Next, using a pipette, add 0.5mL of vinegar to the pot and stir. Measure the pH with a new strip and place on the dish, not touching the first strip. Now add 1mL and repeat. Pour 100mL of water and 20mL of liquid soap into a second pot. Dip the final strip and measure the pH and place on the dish, not touching the others. Compare all four strips.

What happens? Note your observations. Why do you think that happens?

10. Water towers

25 minutes

You will need:

- Two boxes with holes
- Two boxes without holes and their lids
- Two tube connectors
- A tube clamp
- Rubber tube
- A clean pot
- A straw (not provided)

Before you start: what do you expect to happen?

Fit the tube clamp onto the tube and place the tube in the boxes with holes. Ensure the clamp is closed. Place the lids on the other boxes and stack them.
Place the two boxes with holes side by side. Fill one three quarters full. Open the clamp. When the water levels have stabilised, place one on top of the stacked boxes. Fill the pot half full of water. Take the straw and place it in the water, inhaling until the liquid nearly reaches your lips. Block the straw with your finger. Leave your finger and shake the straw. Put the straw back over the pot and remove your finger.

What happens? Note your observations. Why do you think that happens?

11. The siphon

10 minutes

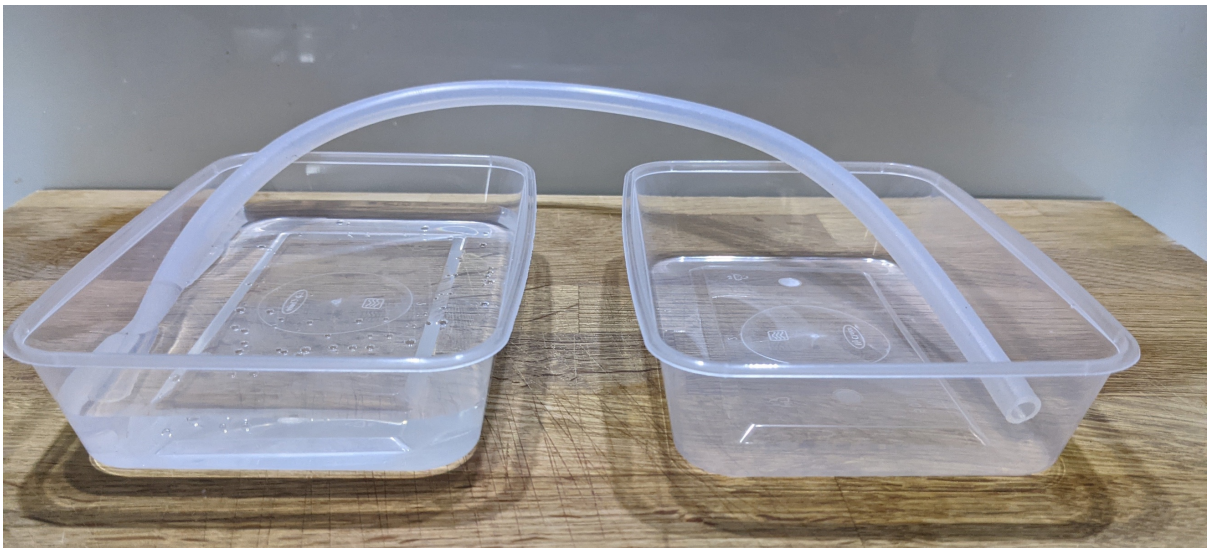
You will need:

- Two boxes without holes
- Rubber tube

Before you start: what do you expect to happen?

Fill one of the two boxes three quarters full with water. Put one end of the tube into the water and the other in the empty box.
Take the tube and immerse it completely in the water to remove all air bubbles. Cover one end with your finger and remove from the water. Leave the other end in the water and place the blocked end into the empty box. Remove your finger.
Pour the water back into the full box. Immerse one end of the tube into water, lower your head to the same level as the boxes, and suck up the water until just before your mouth. Block the end and place in the empty box. Remove your finger.

What happens? Note your observations. Why do you think that happens?



12. Solubility

35 minutes

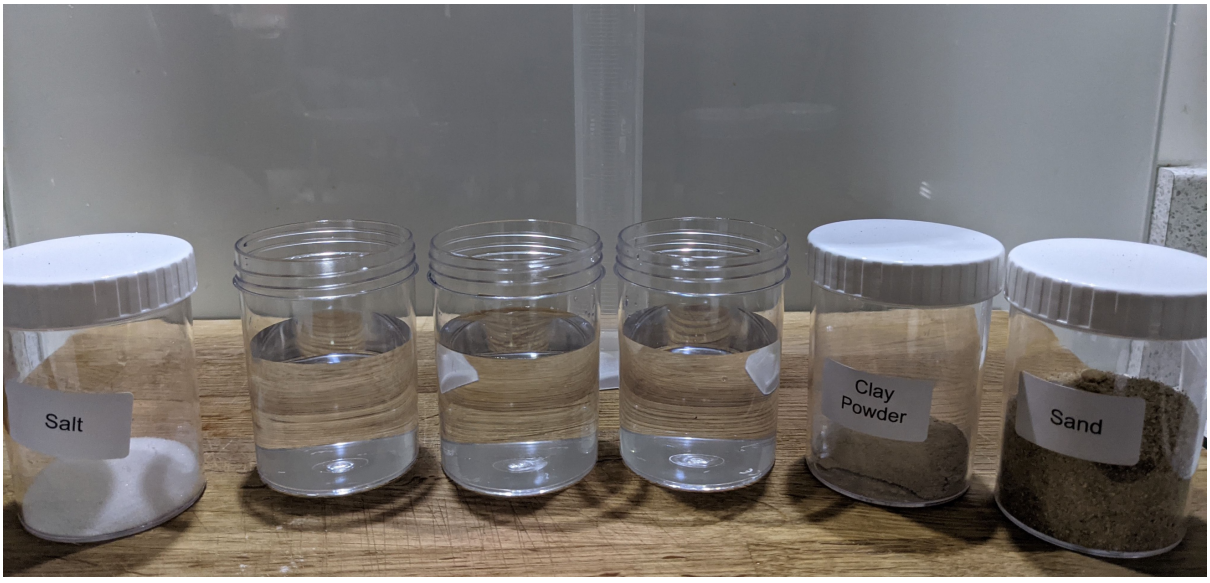
You will need:

- 250mL beaker
- 3 pots
- 3 measuring cylinders
- 3 funnels
- 3 filter papers
- Sand
- Clay powder
- Salt

Before you start: what do you expect to happen?

Pour 100mL into each pot. Put 20mL of salt in one pot, 20mL of clay in the second, and 20mL of sand in the third. Place the lid on the pot, shake well, and let them stand. In the meantime prepare filter papers, place in funnels and place on measuring cylinders.
Filter each of the mixtures.

What happens? Note your observations. Why do you think that happens?



13. Density and Buoyancy

30 minutes

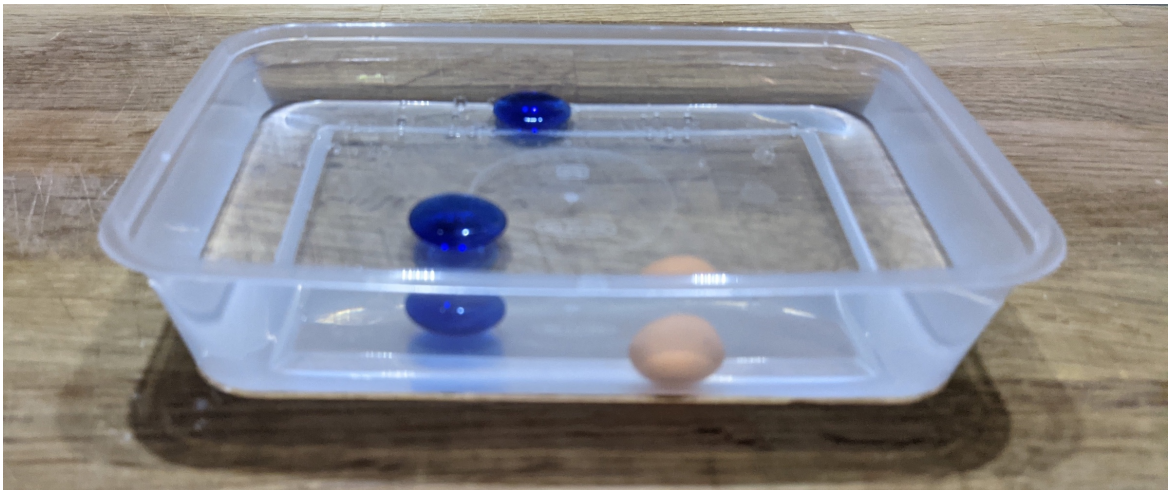
You will need:

- A box without holes
- Modelling clay
- 2 marbles
- A stirrer
- A polystyrene piece (not provided)
- A paper clip (not provided)
- A cork (not provided)
- Any other small items you wish to test that can be dried (not provided)

Before you start: what do you expect to happen?

Fill the box three quarters full with water. Place all the items, one by one, onto the water. Make sure the modelling clay is in a ball shape.
Now mould the modelling clay into the same shape and size as the other items, one by one. When you are done, place it on the water at the exact same time as the matching item.
Mould the modelling clay into a flat bottomed boat – aim for around 2cm long. Place it on the water.
Make a small indent on the clay to show where the water line is at. Now add the marbles one at a time.

What happens? Note your observations. Why do you think that happens?



14. Removing Sand and Oil

30 minutes

You will need:

- Two pots
- Three measuring cylinders
- Sand
- Oil
- A thin straw (not provided)

Before you start: what do you expect to happen?

Measure out 10mL of sand in a measuring cylinder and pour into a pot. Add 90mL of water, place the lid on, and shake. Leave the mixture to stand for a few seconds.
Next, add 10mL of oil into the pot. Replace the lid, shake, and leave to stand for a few minutes.
Repeat the second part but once the pot is shaken, place the thin straw in the pot and blow very gently.

What happens? Note your observations. Why do you think that happens?

Bonus 1: The relationship between the height of water and pressure

This experiment does not use the Waterbox equipment but is also an easy water science experiment. Most of the items will be around your house!

10 minutes

You will need:

- An empty 1L carton
- Sticky tape
- Lead pencil
- Scissors
- 15cm long ruler

Before you start: what do you expect to happen?

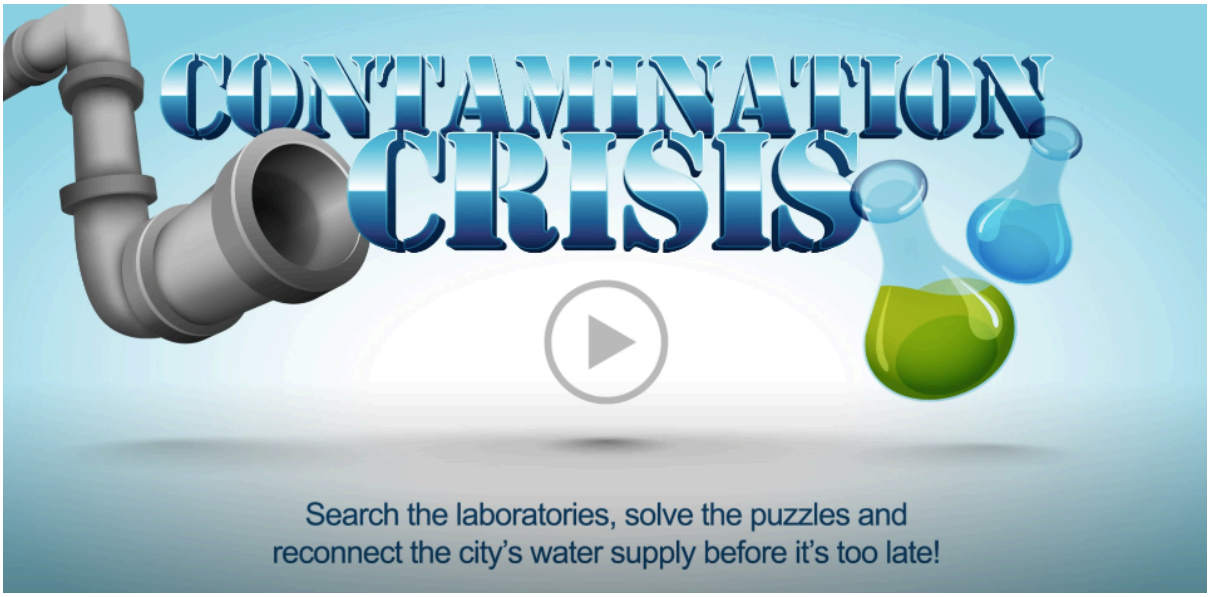
Using a sharp pencil, poke a hole 2cm from the bottom of the carton. Make the hole around 3cm big. Poke 3 holes directly above the first, 4cm apart, so you have a row of holes 4cm apart.
Stick a piece of tape over the 4 holes. Cut a hole in the top of the carton, so you are able to fill the carton up to the brim.
Place the carton in the sink, or in a large, flat bottomed bowl. Grab the bottom of the sticky tape and quickly pull it away in one go.

What happens? Note your observations. Why do you think that happens?

Bonus 2: Escape the classroom

Now that you are a water science expert, you can prolong the experience and test your skills even further with our digital escape room available online at:

https://www.cranfield.ac.uk/EscapeTheClassroom



The water supply has been compromised! Top water scientist, Dr Vasser, retired several years ago, and left specific instructions in her lab on how to fix the problem. However, she has hidden the answers to avoid it falling into the wrong hands. You have 45 minutes to find the answers and fix the water supply to avoid everyone drinking dirty water.

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The Waterbox and its content were put together by the Cranfield Water Science Institute at Cranfield University as part of the Escape the Classroom: Contamination project funded by the Royal Academy of Engineering under the Ingenious Awards scheme.