



THE STORY OF WATER

Education Resource Pack
Key Stage 2 & 3 (Ages 7 -14)



ABOUT THE THAMES FESTIVAL TRUST

The Thames Festival Trust's principle objective is to increase the appreciation of rivers and their importance to us all through creating and promoting river and river-related art, education and heritage programmes.

Our flagship art-based learning project 'Rivers of the World' is delivered in partnership with the British Council. Rivers of the World engages with over 2000 young people each year and inspires them to recognise the potential for art in their lives. It champions creativity, promotes awareness about rivers and provides the framework for an international partnership to flourish.

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PACK CONTENTS

Introduction

Chapter 1: What is water?

Chapter 2: The clean water crisis

Chapter 3: Where does our water come from?

Chapter 4: What do we use water for?

Chapter 5: What happens to all that poo?

Chapter 6: Extreme weather: flood and drought

References

Further Resources

MEET DR PLUMBER PLUGS & THEIR ROBOT HELPERS



I'm **Dr Augustia Plumber**, a great inventor (and self-proclaimed 'Flow-Coach') and I've come from the future to fix your taps and the way you use water.

With the incredible engineering skills of my team, I've created a carbon neutral, bio-mechanically diverse, self-sustaining, no-waste solutions system for the way we all can use water in the future.

Not to mention helping clean up the oceans by creating robot helpers from our old junk and generating free sustainable energy for the people of the planet in the process!

Now I'm visiting you in the 21st Century to investigate how we do things, take you through **The Story of Water** and possibly stem the occasional spring leak or two!

Keep an eye out for my gang of friends who are on hand to help. Speaking of which, let me introduce them...

MEET DR PLUMBER PLUGS & THEIR ROBOT HELPERS

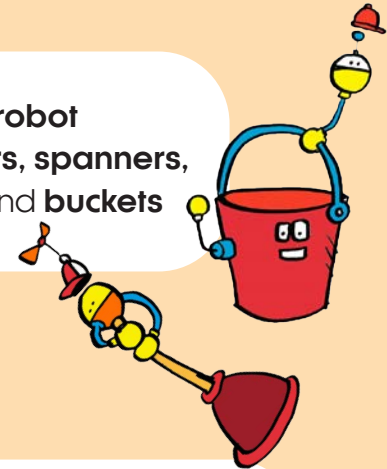


Plugs, the incredible engineer behind the Plugs

Rat Bag Dickens a sewer rat with a special tail



Various **robot plungers, spanners, mops and buckets**



Broll-E, an electronic umbrella-bot with impeccable manners

Mallard, a Rock'n'rollin' duck living the wild life!



And **Bob** who just, well.. bobs..about!



To see more of Dr Plumber and Plug's world visit www.joshknowles.co.uk

Dr Plumber, Plugs and all other characters in Junkutopia are written and created by Josh Knowles (2017)

INTRODUCTION

Water is essential for all life on earth - for plants, animals and humans. We all need safe, clean water and without it a person can only survive for 3-5 days [1]. It is a vital resource that we depend on every day. We drink it, wash and cook with it, we travel on it, play in it and use it to grow crops, run industries and make electricity.

Unfortunately however, a recent report from the World Health Organisation/UNICEF [2] reveals that although billions of people have gained access to clean, safe drinking water since 1990, huge inequalities remain. 1 in 10 people across the world still lack access to safe water: 663 million in total and 1 in 3 people lack access to a toilet – 2.4 billion in total [3].

At the United Nations in September 2015, world leaders adopted a set of 'Sustainable Development Goals' (SDGs) to end extreme poverty, protect the planet and ensure prosperity for all by 2030. Two of these goals have a particular focus on water. SDG 6 aims to 'ensure access to clean water and sanitation for all,' whilst SDG 14 is to 'conserve and sustainably use the oceans, seas and marine resources for sustainable development.'

For these goals to be reached and to preserve our planet for future generations, it is important to help our young people understand more about this vital and precious resource.

This education pack provides factual information and exciting cross-curricular activities for teachers to help their pupils aged 7 – 14 to learn and think critically about water issues. It is designed to expand knowledge and understanding, provide opportunities to develop core skills and encourage pupils to explore and reflect on local and global issues. Each chapter contains information, ideas for discussion and suggestions for cross-curricular activities. The discussions and activities can be used as starting points in individual lessons or as elements of a larger cross-curricular joint project involving collaboration over a number of subjects perhaps with a partner school overseas.

However you use the materials, we hope your pupils enjoy their exploration of the wonderful world of water, as they are the leaders of the future and guardians of our blue planet.



CHAPTER 1

WHAT IS WATER?

Curriculum links: Science, Geography, English

Core skills: Critical thinking and problem solving, communication and collaboration, digital literacy

Learning objectives:

- To stimulate interest in the topic of water, record and expand existing knowledge.
- To encourage pupils to ask scientific questions and carry out investigations related to the three states of water and the water cycle.

Materials you'll need: small bottles of water, post it notes, large pieces of paper, inflatable globe or ball, atlases or iPads, chalk, measuring tapes, balloons, access to water and a freezer, food colouring, bowls, cling film, scissors.

Start your project by dividing your class into groups. Give each group a small bottle of water. Ask them to discuss everything they know about the liquid in the bottle and how it got there. You might ask them to think about:

- ◆ What is water?
- ◆ Where does our water come from and what do we use it for?
- ◆ How is it made clean enough to drink?
- ◆ Why doesn't everyone have access to clean water?
- ◆ How can we help to ensure clean water on our planet for current and future generations?

Encourage them to generate words, ideas and questions and jot these down on sticky notes. These can then be shared and discussed with the rest of the class and displayed on a giant picture of a bottle of water. Have another similar poster to add additional sticky notes showing their 'new learning' as they progress through the project and discover the answers to their questions.

You could follow this up with two brief activities. Firstly pass an inflatable globe or ball around the group. When children catch it, ask them to name and find on the globe, atlas or i-Pad, a major water source such as a sea or river in a particular country or continent. Can they find one for each member of the class or one starting with the same initial as their name? Then organise a true or false water quiz using the following statements. Ask each team to name themselves after one of water sources they found and record any new information on the second bottle poster.



TWELVE FACTS ABOUT WATER... TRUE OR FALSE?

1

Water is a molecule, H₂O: a combination of 2 hydrogen atoms and 1 oxygen atom.

TRUE

2

Water is the only natural substance that exists in all three states, solid (ice), liquid (water) and gas (water vapour) at temperatures normally found on Earth.

TRUE

3

Ocean water is salty.

TRUE

4

60% of the Earth's surface is covered in water.

FALSE - 71% of the Earth's surface is covered in water, which is why the planet looks blue when observed from space[4].

5

Water can be found everywhere you look, in lakes and rivers, and even in people, pets and trees.

TRUE

6

Water evaporates in high temperatures and becomes a gas (water vapour).

TRUE



You can use role play to demonstrate fact 2 by asking groups of pupils to pretend to be molecules in the three states. When water is in its solid state (ice) the molecules are packed closely together to prevent it from changing shape. When it melts and becomes water, the molecules can move around each other and when it is a gas (water vapour) the molecules move quickly and are not bound together. Invite groups of your pupils to demonstrate being ice, water, or vapour molecules when you give this command.

7

Earth is the only planet known to have permanent bodies of water on its surface.

TRUE - but in 2015 NASA confirmed that water flows intermittently on Mars [5].

8

Plants and trees lose water through their roots in a process called transpiration.

FALSE - plants and trees lose water through their leaves in a process called transpiration.

9

The water on Earth is always in movement in a natural water cycle.

TRUE - water vapour rises and condenses to become clouds, which move across skies with the wind. When clouds cool down, they get heavy and precipitation occurs, where water falls from the sky as rain, snow or hail and the cycle begins again [6].

10

5% of the world's water is freshwater.

FALSE - only 2.5% of the Earth's water is freshwater [7].



11

Up to 60% of an adult human body is water [8].

TRUE

12

More people in the world have a mobile phone than a toilet [9].

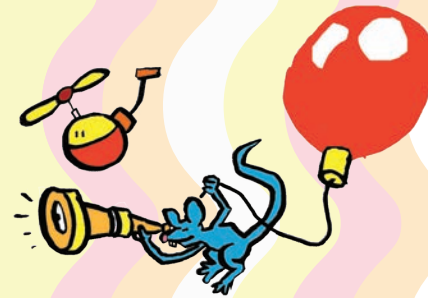
TRUE

ADDITIONAL ACTIVITIES

Try carrying out some activities with your pupils to demonstrate the three states of water and water cycles. You could:

- Make puddles on the playground floor. Draw round them in chalk, measure them and time how long they take to evaporate. Pupils can photograph these at different stages and play them together with time-lapse technology.
- Watch water boil so the water can be seen evaporating in the air. Ensure appropriate health and safety measures are taken for this activity.
- Make and observe ice balloons using these instructions:

- Ask your pupils to partially blow up balloons (one for each group.)
- Add a couple of drops of food colouring, and fill with water from a tap. Squeeze out any excess air and tie a knot in the balloon. Place the balloons in small bowls and put in the freezer for at least 24 hours. Measure the circumference of the balloons before and after they go in.
- Carefully cut and peel away the balloon skin to reveal the ice balls, leaving them in the bowls to catch the water as they melt. It is also a good idea to make sure you have plenty of waterproof coverings.
- Encourage your pupils to observe their ice spheres closely using magnifiers and take photographs, notes and timings as they melt. Ask what happens if they add salt to their ice balloons.
- Prompt pupils to develop their own questions and make notes about the ice ball's appearance and the way it behaves. Discuss their observations and questions.



◆ You might ask:

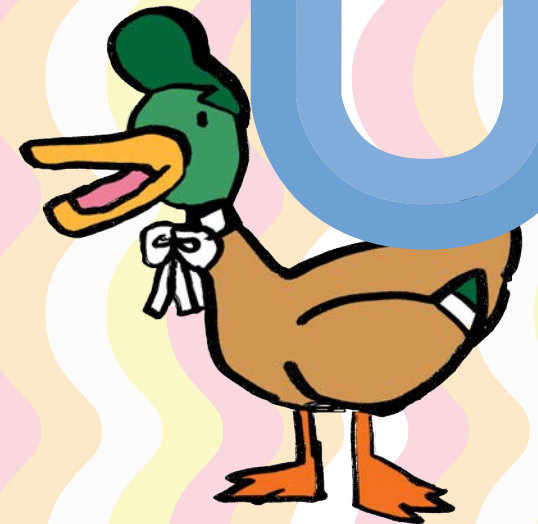
- How would you describe what the ice balloon looks like through a magnifying lens? What does it feel like? Encourage use of creative language and similes.
- What happens as it begins to melt?
- What happens if you add salt to your ice balloon? Salt lowers the freezing point of the water.

◆ To investigate or recap on learning about the water cycle you could encourage groups of pupils to set up a clear transparent plastic bottle, jar or bowl with a small amount of coloured water in it. Cover with cling film, put in a warm place and watch the water evaporate and condense again on the sides and top of the container*.

◆ If you are working with a partner school you could:

- Share some of your pupils' questions and answers about water.
- Create your own water quiz for your partner school.
- Exchange photographs of their ice balloons and water cycle experiments.

*These water experiments and others like them can be found at the UK Met office website at:
<http://www.metoffice.gov.uk/learning/weather-for-kids/experiments/water-cycle>



CHAPTER 2

THE CLEAN WATER CRISIS

Curriculum links: Science, Geography, History, English, Personal, Social and Health Education

Core skills: Critical thinking and problem solving, communication and collaboration, citizenship, creativity and imagination, digital literacy.

Learning objectives:

- To learn about causes of water pollution and raise awareness of the issues associated with water vulnerability.
- To recognise the importance of hand washing and carry out investigations into its effects on health and hygiene.

Materials you'll need: Internet access, atlases, a small ball, glitter, Vaseline or another oil-based substance such as butter.



Our water sources need protection to remain healthy, as they can fall victim to pollution from industrial and human waste and oil spillage. Sediments, pesticides and fertilisers can also pollute our water as they run off fields and riverbanks. As recently as 1959, a member of the House of Lords in the UK Parliament reportedly stated that rivers were 'natural channels for the disposal of waste', and letting them break up organic waste gave them 'something to do', arguing that it was not necessary to purify river water! [10]

Water sources are also polluted by non-human causes, such as a build-up of biodegradable matter that depletes oxygen and can produce harmful toxins such as ammonia. Animals and fish leave waste in water sources and microorganisms including viruses and bacteria often live naturally in water sources.

Can your pupils find news stories about rivers in their country that have been affected by pollution? Discuss the effects that events like these can have on both people and wildlife.

Show your pupils some of the sections on Polluted Rivers from the Rivers of the World Education resources at: <https://thamesfestivaltrust.org/our-work/education-programme/education-resources> to see how some of the major rivers of the world have been affected by pollution.

Discuss in groups actions that could be taken to keep our water sources clean. Contact your local water authority or environment agencies to find out what they do to prevent pollution and make pieces of artwork or posters to show how clean water can benefit the global community.

RIVERS OF THE WORLD: THE KECHENE MAN

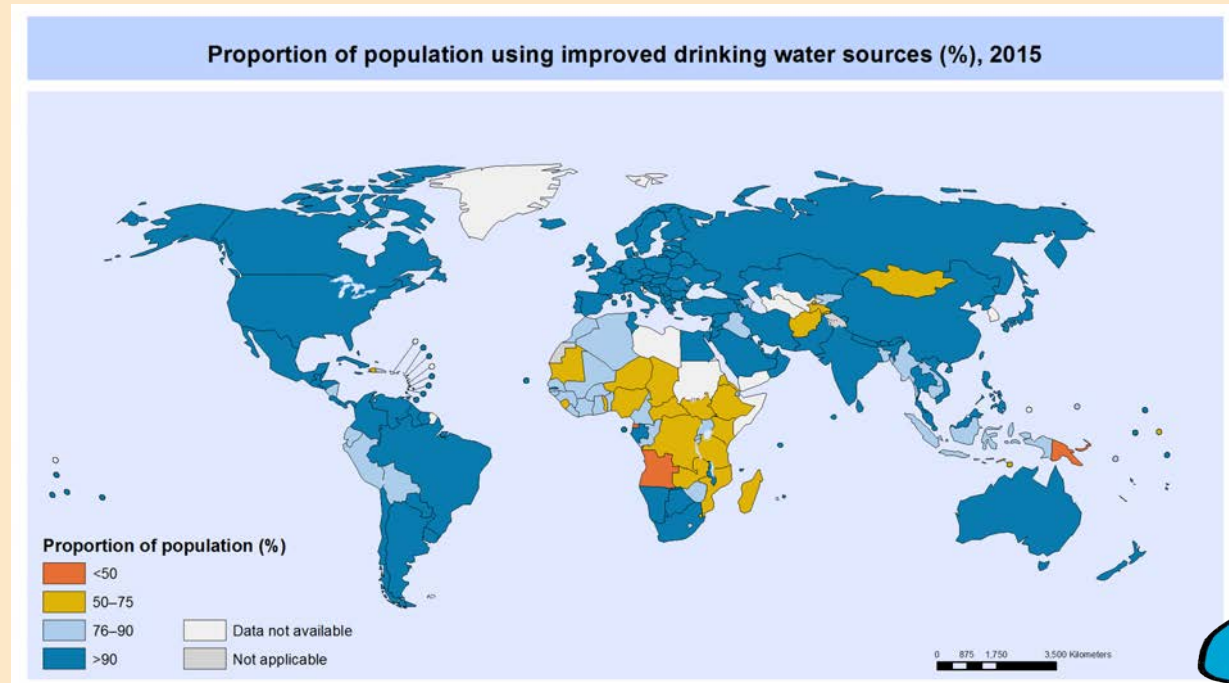
Pupils at Bethlehem School in Ethiopia investigated the Kechene River near their school, as part of their Rivers of the World project. It is polluted by industries but also irrigates crops, which supply the markets of Addis. The students wanted to express the idea that, 'they are what they eat' and inspired by the work of artist Guiseppe Archimboldo they created an image of a sick man from sculptures of vegetables created with leather, metal, paint and waste for their art display.




CLEAN WATER IS STILL AN ISSUE AROUND THE WORLD

Access to clean water remains an issue in many countries, especially those that lack access to abundant freshwater resources or don't have the infrastructure to clean and circulate water. It is estimated that access to clean water could save up to 16,000 lives each week [1]

Share this map with your pupils from the World Health Organisation/UNICEF Joint Monitoring Programme, which shows the percentage of people using a source of water that is protected from contamination.



Divide the class into small groups and ask them to use atlases or the Internet to name three countries in each of the four categories. Can they explain why so many countries in sub-Saharan Africa have greater than 20% of their population using an unimproved water source? What might be done to change this situation? Ask each group to choose a different charity or NGO and find out about some of the work they are doing to support and sustain clean water for all around the world and use this information to prepare a short presentation to share with another class in an assembly.



Lack of access to water also disproportionately affects women. Research from the United Nations suggests that women collectively spend nearly 40 billion hours collecting water each year – this is equivalent to the time the entire labour force of France spends at work every year. [12]

Children also shoulder this burden. In Tanzania, school attendance was 12% higher for girls who live less than 15 minutes from a water source, compared to girls who live an hour or more away. [13] When communities have access to clean water, children can go to school and get an education.

In parts of the world where people cannot turn on a tap to get fresh water, they may have to walk long distances to collect water several times a day. This situation is likely to worsen with climate change, so every drop of water counts.



THE GREAT STINK: A LIQUID HISTORY OF THE THAMES

Like many cities at the time, London was not a pleasant place to live in the 19th Century. The River Thames was very polluted with waste from factories and vast amounts of human waste being dumped into the river. [14] This pollution contributed to the spread of deadly diseases, such as cholera. Between 1831 and 1866, over 40,000 Londoners died in four separate cholera outbreaks. [15]

At the time, cholera was not well understood and there were a number of theories as to how it was spread. Many thought it was a punishment sent from God, some people speculated that rich people were poisoning the poor and most doctors at the time thought it was spread through the air. In response to this Edwin Chadwick, a notorious public health campaigner made a plan to clean up London's air by emptying cesspools and sewage pits into the Thames. [16]



Dr John Snow was the first to recognise the relationship between cholera and contaminated water. He used an outbreak in 1854 to illustrate that most victims were concentrated around one local water pump, into which a contaminated cesspool had leaked. But Snow's theory was unpopular and MP's refused to debate his hypothesis. [17]

However, in 1858 the water pollution combined with a hot summer to make the Thames smell very bad. Even the Houses of Parliament were affected and the curtains were cleaned with a mixture of chloride and lime in a drastic attempt to cover the smell.



I was the first to spot that cholera outbreaks could be traced to contaminated water supplies
- Dr John Snow

In response to 'The Great Stink,' Joseph Bazalgette was commissioned to create a modern sewage system. The sewage system took twenty years to complete. This included the creation of treatment plants that cleaned the water before it went back into the river. [18]

During the Second World War, bombs damaged several treatment plants in London and the River Thames was threatened again. In 1957, the Natural History Museum announced that the Thames was 'biologically dead'. The pollution had diminished oxygen supplies in the water, without which life, including plants, fish and insects, cannot survive. Without these to feed on, larger animals, such as birds, ducks and seals, cannot survive.

It was not until the late 1960s that London's sewers were restored. Since then, the river has benefited from better environmental awareness and greater regulation of what is allowed into the water and how it is managed. It is understood that the Thames is now the cleanest it has been since the Industrial Revolution. Over 100 species of fish have returned, along with many rare species of bird and mammals such as otters, water voles and kingfishers. People have been delighted to see porpoises, dolphins and over 2,000 seals swimming in the river between 2004 and 2014. [19]

I designed a sewage system to stop London smelling so bad!

- Joseph Bazalgette



RESEARCH ACTIVITIES

Ask your pupils to find out what they can about the history of their local river and the lives and work of people including scientists and engineers who have influenced its development. If possible arrange a visit to your nearest river. Do ensure that you take all expected precautions and complete the required risk assessments before you go.

- ◆ Ask your pupils to record what they can see and hear. Is the river fast or slow flowing? What natural and man-made features can they spot? Does the water look clean or polluted?
- ◆ Take measurements of the size of pebbles, temperature of the water and speed of the river by measuring and marking out a distance of ten metres and timing how fast an object such as a toy boat, stick or small orange takes to travel the distance.

- ◆ Collect samples of water and sediment to study back in the classroom and check the levels of acidity using strips of litmus paper.
- ◆ Can they spot any wildlife? Record the weather conditions, temperature and humidity; estimate the width and depth of the river and take notes and photographs.



WATER FOR HEALTH & HYGIENE

Another of the UN's Sustainable Development Goals is to ensure healthy lives and promote wellbeing for all ages. Water can play a vital role in ensuring good hygiene and reducing the spread of disease.

Show your students the short film from the British Council /Royal Society resources Commonwealth Science Class* which demonstrates how a school in Nigeria worked with Professor Oyewale Tomari to investigate the importance of effective hand washing to prevent infection.

Your pupils could then carry out the following activity from these resources to investigate how hand washing can reduce and prevent the spread of illness and disease.

Place a small ball into some Vaseline or other oil based substance (e.g. butter) and then cover it with glitter. Describe that the glitter represents germs. Pass the ball around a circle and explore how germs (glitter) get passed from one person to another. If you do not have glitter available, you could use sand or coloured powder paint.

[*https://schoolsonline.britishcouncil.org/classroom-resources/list/emerging-infectious-diseases-how-do-we-stop-new-diseases-spreading](https://schoolsonline.britishcouncil.org/classroom-resources/list/emerging-infectious-diseases-how-do-we-stop-new-diseases-spreading)

Students should then be split into three groups. Each group will nominate one person to have their hand covered in glitter and Vaseline to represent germs on their hands. Depending on their group, these students then perform one each of the following activities: a. no hand washing, b. wash hands in water and c. wash hands in water and soap. Once finished, each student returns to the group where they shake hands with the person behind them. The second person shakes hand with the third, and so on. Ask students to record what has happened.

Things to discuss:

- What happened when you shook hands with the person behind you?
- What was the most effective washing process? Why do you think that was?
- If you are working with a partner school:
 - Exchange the results of your experiments
 - Design and share posters or short films to highlight the importance of providing access to clean water for all by 2030.



CHAPTER 3

WHERE DOES OUR WATER COME FROM?

Curriculum links: Science, Geography, Personal, Social and Health Education, Citizenship

Core skills: Critical thinking and problem solving, communication and collaboration, citizenship.

Learning objectives:

- To investigate how water is cleaned and transported, how it can be filtered and how issues related to water stress can cause disputes.

Materials you'll need:

Internet access, drawing materials

The water that comes out of the taps at your home and school starts off as rain. This rainwater either flows into rivers and streams or filters through the earth to form 'groundwater'.

Once this water is collected it must be treated to make it safe to use. The water is pumped to water treatment works where it goes through various processes [20]:

- ◆ First it is stored in reservoirs where heavier particles sink to the bottom.
- ◆ Then it is passed through a screen to remove solids in the water, such as leaves and soil.
- ◆ Then particles are removed by filtering and adding chemicals that attract and bind to harmful bacteria in a process called flocculation. This neutralises them, meaning that they are no longer harmful.
- ◆ Now that they are bigger, these particles are removed through more filters, leaving the filtered water clean and colourless. [21]
- ◆ Lastly, in the final treatment chlorine is added to the water as a powerful disinfectant. Although not harmful to people, chlorine ensures that water stays safe to drink as it travels to our taps.

Now the clean water needs to be transported to taps in your homes and schools. It is pumped to you through a network of pipes and pumping stations. [22]

ACTIVITY

Help your pupils to create labelled diagrams or collages, which illustrate the six stages of this process:

1

Collecting rain

2

Storage

3

Screening

4

Removing particles/flocculation

5

Final treatment

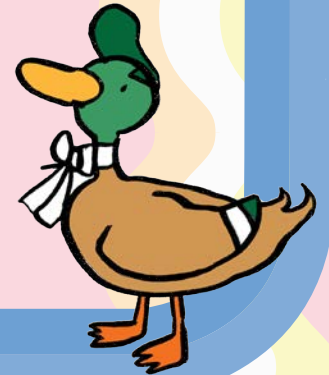
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Getting water to your house

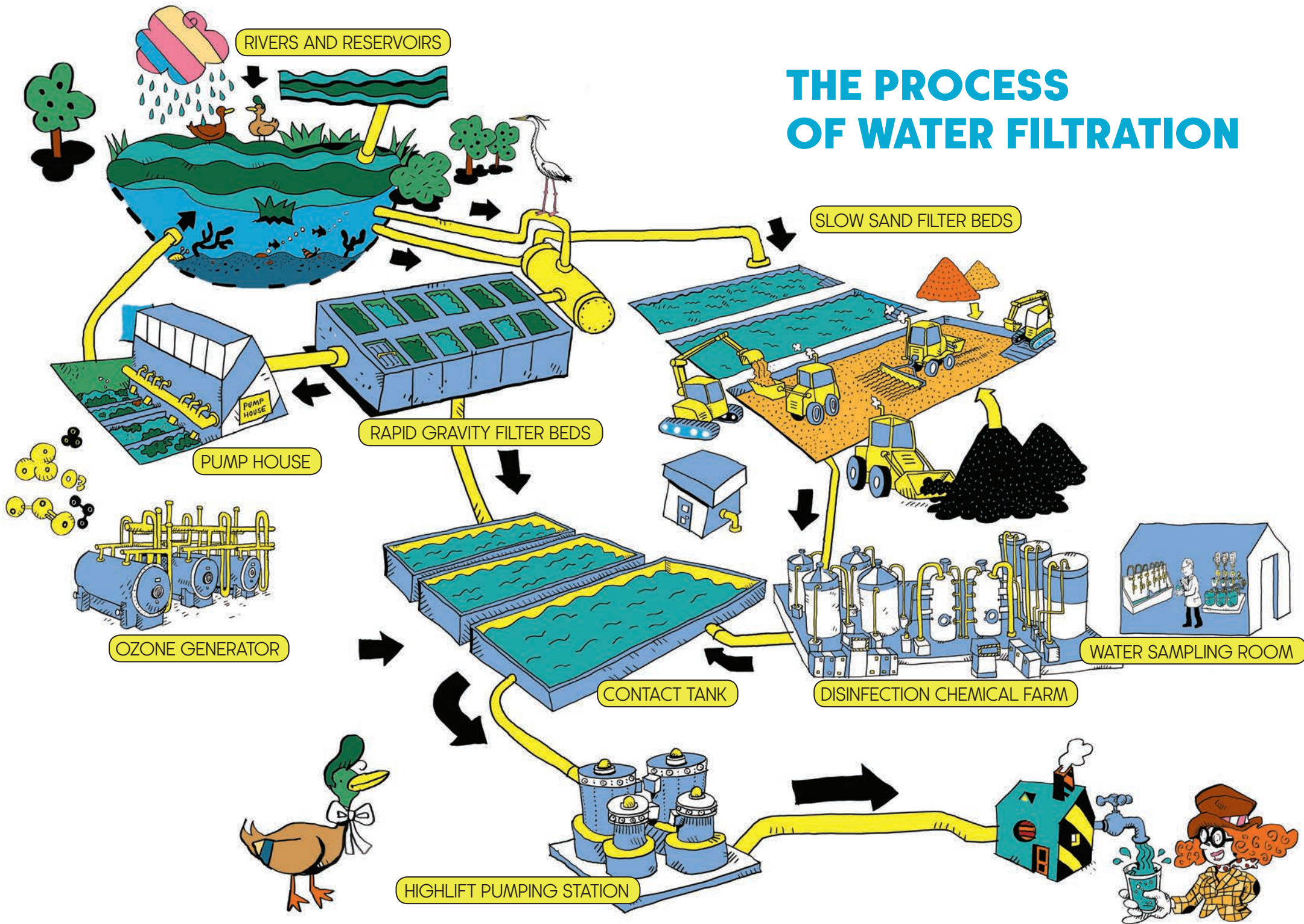
In the UK, freshwater is sourced from lakes, rivers, aquifers and reservoirs. Thames Water supplies water to 76% of London and the Thames Valley, with 9 million people requiring 2.6 billion litres of water each day. [23]

70% of the water supplied to London comes from rivers. Most water is drawn from the River Thames, extracted west of London and stored in large reservoirs. The other 30% of London's water is drawn from underground aquifers, where groundwater has permeated and collected. It is drawn via boreholes – similar to a well.

- Can your pupils find out who provides their clean water, where it originated and how it is made clean enough to drink?



THE PROCESS OF WATER FILTRATION

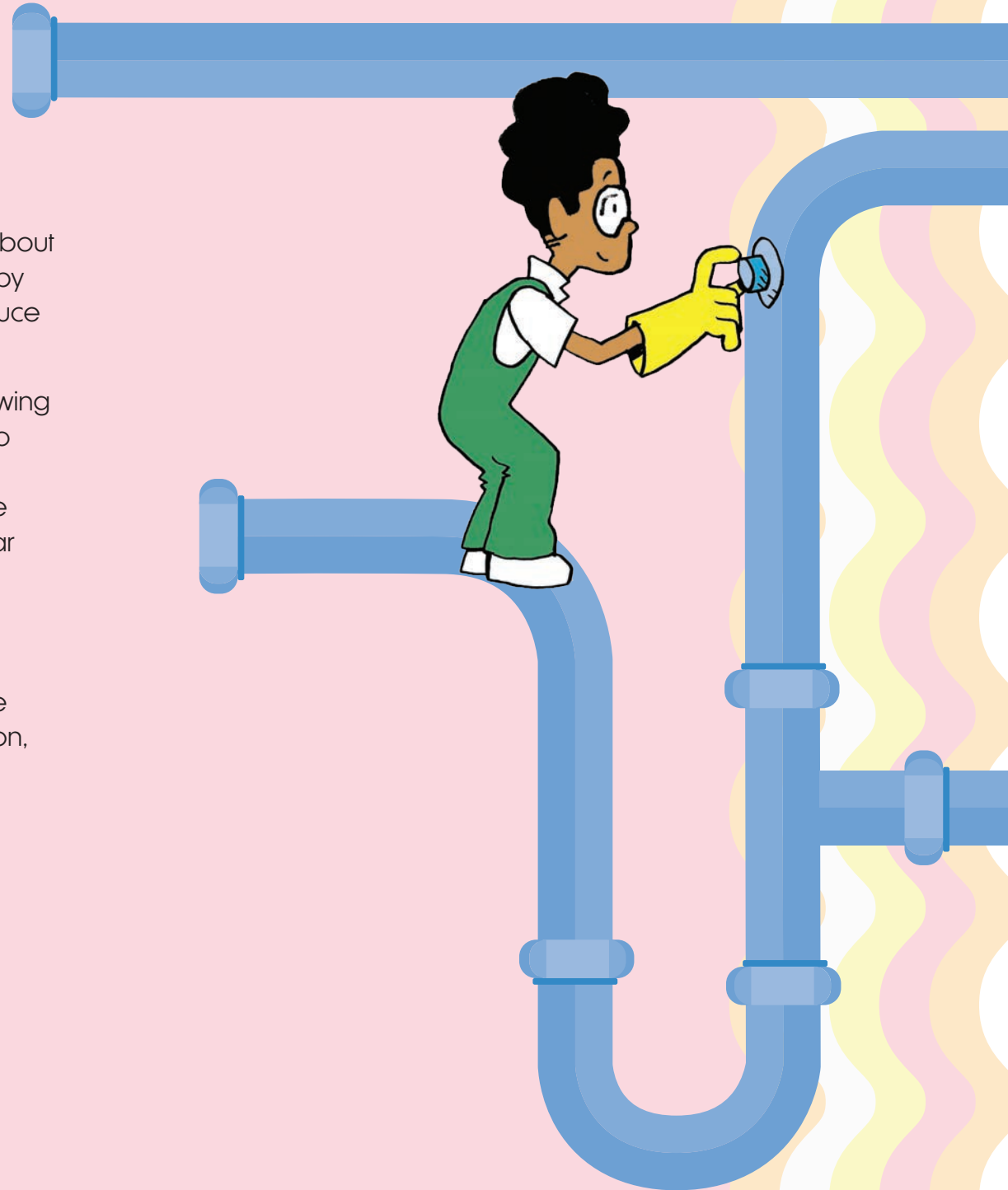


DESALINATION – A TECHNOLOGICAL FIX?

As technology improves, desalination is becoming an increasingly popular way to provide fresh water. There are about 300 desalination plants in the USA and the first was opened by Thames Water in the mainland UK in 2012. This is able to produce up to 150 million litres of drinking water per day. [24]

Desalination plants take saltwater and removes the salt, allowing us to drink and use it as freshwater. After the water is filtered to remove large solids, the water is then served by a high tech process called reverse osmosis to remove the salt and leave pure water. Minerals and chlorine are added to leave regular drinking water. [25]

However, despite the benefits of desalination, there are environmental costs. Desalination creates wastewater that is very salty. When it is emitted back into the sea, it can damage the water and threaten the ecosystems that live in it. In addition, desalination requires a great amount of energy, which can contribute to climate change. [26]



WATER STRESS – THE RIGHT TO USE WATER

Exciting new research from a team at the University of Manchester has led to the creation of a graphene-based sieve capable of removing salt from seawater. [27] The sought-after development has the potential of providing clean drinking water for millions of people who struggle to access adequate clean water sources.

Technological solutions will become increasingly important as water stress grows. This is due to rising populations, the demands of agriculture, industry and hydropower and the effects of climate change. Because of this, water is an increasingly competitive resource. Access to safe and affordable water and sanitation is a human right, recognised by the United Nations. However, because demand is infinite but resources are limited, disputes can arise about access to water resources.

In 1995, scientist and former Vice President of the World Bank Dr. Ismail Serageldin warned, "If the wars of this century were fought over oil, the wars of the next century will be fought over water - unless we change our approach to managing this precious and vital resource." [28]

- ◆ Can your pupils find recent examples of disputes from around the world that have arisen over water usage?
- ◆ What were the causes of these disputes? How were they resolved?
- ◆ Encourage them to discuss Serageldin's controversial point of view. What do they think he means about changing approaches to avoid conflict?



CHAPTER 4:

WHAT DO WE USE WATER FOR?

Curriculum links: Geography, Maths, Personal, Social and Health Education, English, Citizenship

Core skills: Critical thinking and problem solving, communication and collaboration

Learning objectives:

- To compare the amounts of water used by different countries and develop strategies to reduce water usage by your pupils.

Materials you'll need:

Graph paper, large containers

In the UK, each person uses approximately 150 litres of tap water each day. This amount has grown by 1% a year since 1930. [29] This is relatively similar to other European countries with similar climates: Germany uses about 200 litres per person per day, Denmark uses 210 litres. Hotter countries tend to use more: for example, France uses nearly 300 litres; Spain uses just over 300 litres. [30] (Average between 1998-2002)

India uses 140 litres, and China uses approximately 80 litres, although it is estimated that this figure reflects large inequality within these countries (and several others), whereby some people use a lot more, whilst some use a lot less. [31]

The USA uses 575 litres per person per day. [32]

Countries with limited access to natural freshwater sources as well as some of the poorest countries use the smallest amounts. Angola, Cambodia, Ethiopia, Haiti, Rwanda, Uganda, Burkina Faso, Niger, Ghana, Nigeria, Bangladesh, Kenya and Mozambique are all below the water-poverty threshold of 50 litres per person per day. [33]



Share these statistics with your pupils. If possible fill large containers to show the difference between the daily amount used in the UK and Kenya. Ask them to discuss what they think are the main causes of the differences in water use between the countries and if anything surprises them about the statistics? Encourage them to use the figures to create a table and graph comparing the water use of different countries.

ACTIVITY

Try carrying out the following 'Diamond 9' activity taken from the *Water! Water!* pack written by Sheffield Hallam University in collaboration with Practical Action.

This encourages pupils to think about how they might prioritise water usage if they only had less than 50 litres of water a day.

Divide the class into small groups and give each group copies of the Diamond 9 cards on the activity sheet on the next page. Each card has a different everyday use of water.

Encourage each group to discuss, agree and arrange the cards in the diamond 9 shape. Their highest priority card goes at the top followed by the next highest priorities down to the lowest priority at the bottom.

In your group discuss the following questions:

- ◆ Which activities are essential?
- ◆ Why are these activities essential?
- ◆ How could you reduce the amount of water you use for each activity?
- ◆ How could you reuse some water?



DIAMOND 9 CARD SHEET

Showering	Flushing Toilet	Cleaning teeth
Washing dishes	Watering garden	Drinking
Washing clothes	Cleaning house	Cooking

WHAT ARE WE USING WATER FOR IN THE UK?

In the UK, statistics show that we are using our tap water in the following ways: **30%** is used for toilet flushing, **21%** for washing by baths and taps, and **12%** is used for washing by shower. **13%** is used for washing our clothes, **8%** is used for washing dishes. **7%** is used outdoors. Only **4%** of our clean, safe to drink tap water is used for drinking. [34]

WHERE COULD WE SAVE WATER?

A bath uses around 80 litres of water on average, while a shower can use a lot less. A running tap uses over 6 litres of water per minute. If every adult in England and Wales turned off the tap when brushing their teeth, we could save enough water to supply 500,000 homes. [35]

It also takes a lot more water to produce meat than vegetables: 1kg of meat is said to require between 5,000 and 20,000 litres of water, while 1kg of wheat would require between 500 and 4,000 litres. Can your pupils guess which common food requires the most water to produce? The answer is chocolate which requires 17, 196 litres to produce 1kg. [36]

Ask your students to keep a log estimating the amount of water they use each day using the following approximations from *Water Water* written by Sheffield Hallam University in collaboration with Practical Action.

Shower	40 litres	Cooking per pan	1 litre
Bath	80 litres	Washing dishes using bowl	5 litres
Cleaning teeth (tap running)	10 litres	Washing dishes using dishwasher	40 litres
Flushing toilet	10 litres	Cleaning house per bucket	5 litres
Drinking water	0.25 litres per glass	Watering garden	5 litres per 10 minutes



They could go on to create a database of the approximate amounts used by the class in a day, then a week and a year. How much water would this be across the school? Discuss how they could use less water by making small adjustments to their routines- turning the tap off when cleaning their teeth, showering for less time or perhaps eating less chocolate! Make posters with eye-catching slogans and to try to persuade others pupils to use less water and share these across the school.

- ◆ If you are working with a partner school you could compare the water use of both classes and ideas and posters to encourage greater water conservation.



CHAPTER 5:

WHAT HAPPENS TO ALL THAT POO?

Curriculum links: Science, English, History.

Core skills: Critical thinking and problem solving, communication and collaboration.

Learning objectives:

- To learn how human waste is transported and cleaned in sewage works.
- To plan a scientific enquiry to investigate how to filter dirty water.

Materials you'll need:

Internet access, dirty water, sieves or tea strainers, plastic cups, filter paper, scourers and sand.

The word 'sewer' comes from the Latin word 'exaquare', which means 'to carry away water.' The Ancient Romans built public toilets next to the baths with long communal benches with a pit beneath. [37] When the baths were emptied each day, the toilets were flushed out by the bathwater. The Romans didn't have toilet paper but used a sponge on a stick instead! However an even earlier civilisation in the Indus Valley in what is now Pakistan and northwest India developed a public water system and sanitation with toilets which were flushed by emptying a jar of water drawn from the house's central well, through a clay brick pipe and into a shared brick drain.

The modern sewer can be traced back to 1842, in Hamburg, Germany. The city had suffered a devastating fire and whilst rebuilding, laid a series of sewer pipes to cover the city, flushed out by tidewater. [38] This successful model eventually spread throughout the world.

Sewers are still the main way we transport wastewater away from our homes and businesses. Dirty water from sinks, baths, showers, toilets and drains all go to the sewage treatment works. Smaller pipes from our homes connect to hundreds of miles of main sewer pipes that lie beneath our villages, towns and cities. These pipes are placed at a slant so that they use gravity to transport the water. There are also separate surface water sewers that are designed to take rainwater from roofs, roads and pavements.

It is not known how much poo is produced each day. However, estimates suggest that all of the people in the world produce approximately 1,043,000 tonnes of poo each day! [39]

SEWAGE TREATMENT PLANTS

Wastewater is transported through the sewers, through pumping stations and into sewage treatment plants. In London, and the Thames Valley, Thames Water has 2530 pumping stations and 350 sewage works serving the surrounding area. It's Treatment Works in Reading, treats 23,000 litres of wastewater every day – 300-400 litres of water every second. [40]

At the treatment works, the sewage is first passed through a large screening process to remove any large materials such as cotton wool, cotton buds and wet wipes that should not have been flushed down the toilet. These items are generally taken to a landfill.

Following this, water is put into a 'primary settlement tank'. Here the water slows down, allowing solids, called 'sludge', to sink to the bottom of the tank, the sludge is pumped out and into a sludge digester. The cleaner water rises to the top and is pumped through to the next stage of treatment, either percolating filters or aeration lanes. This is the process that the



sewage is biologically treated with the help of naturally occurring bacteria.

After several hours, the water is now pumped into a second settlement tank, where again the larger and heavier particles fall to the bottom becoming sludge, and the clean water rises. The water at this stage has generally reached the quality required for it to be discharged into the local watercourse.

Sometimes the water passes through a third (tertiary) stage just to make sure the water is of a good quality before it goes to the watercourse, it may be passed through filters of sand, reed beds or grass plots ensuring that all particles have been caught. [41] The clean water then flows into a local river or stream. Water may be recycled in and out of rivers many times.



WHAT HAPPENS TO THE SLUDGE?

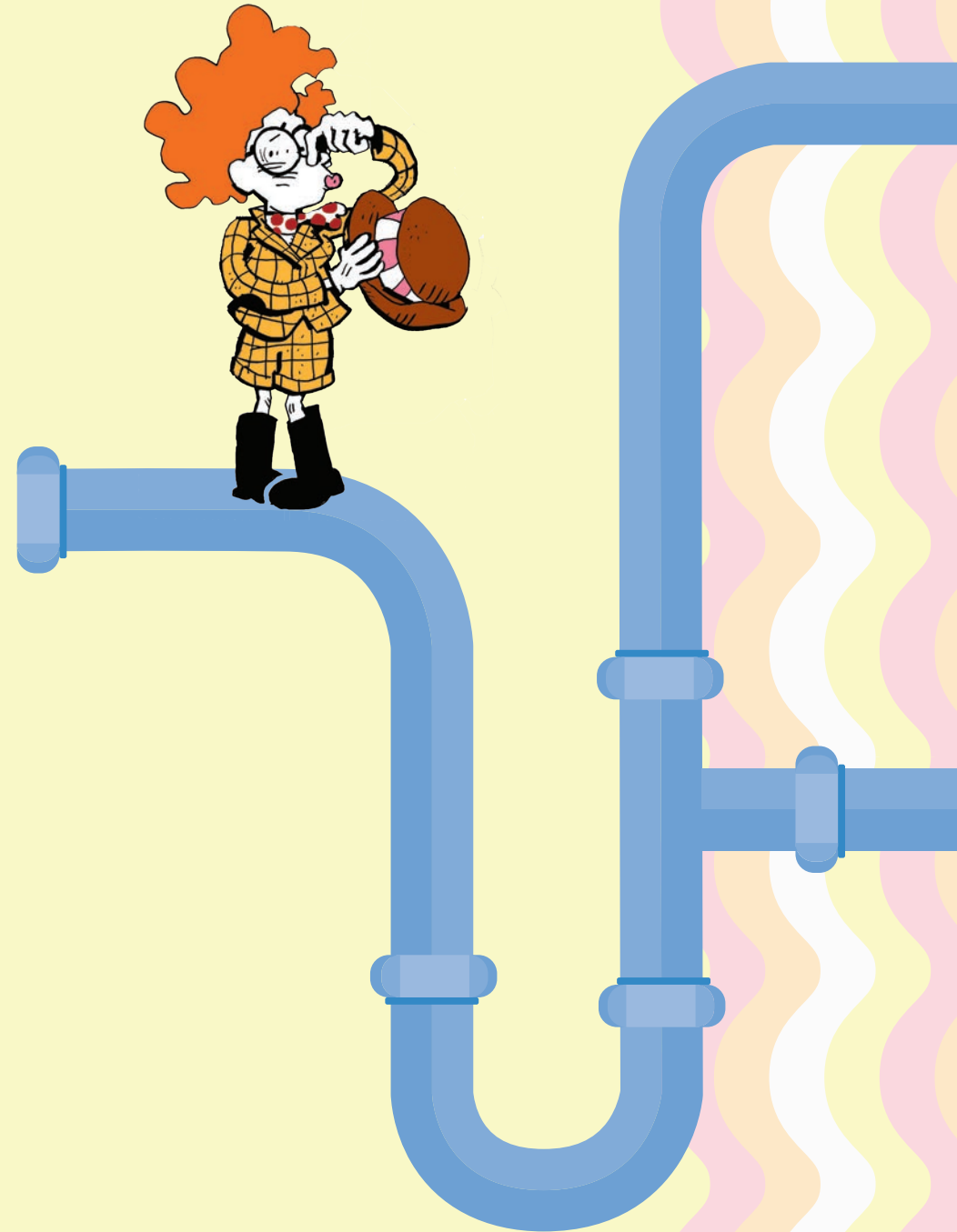
After the sludge has sunk to the bottom of the settlement tanks, it is pumped to sludge digesters, where anaerobic bacteria break down biodegradable material in the absence of oxygen. Heat and power is supplied, encouraging bacteria to consume the sludge, creating biogas, a gas that is combination of methane and carbon dioxide, which can be used to provide power to run the sewage treatment plant or exported to the national grid to create electricity. In the city of Bristol in the UK, some local buses are powered by biogas and South Korea has a water treatment plant that uses human waste to power itself.

After about 20 days the sludge is similar to compost. The sludge is then passed through a gravity belt to thicken it, removing the liquid. The sludge is used by farmers, as fertiliser and spread over agricultural land because it is rich in the nutrients that plants require for growth. [42]

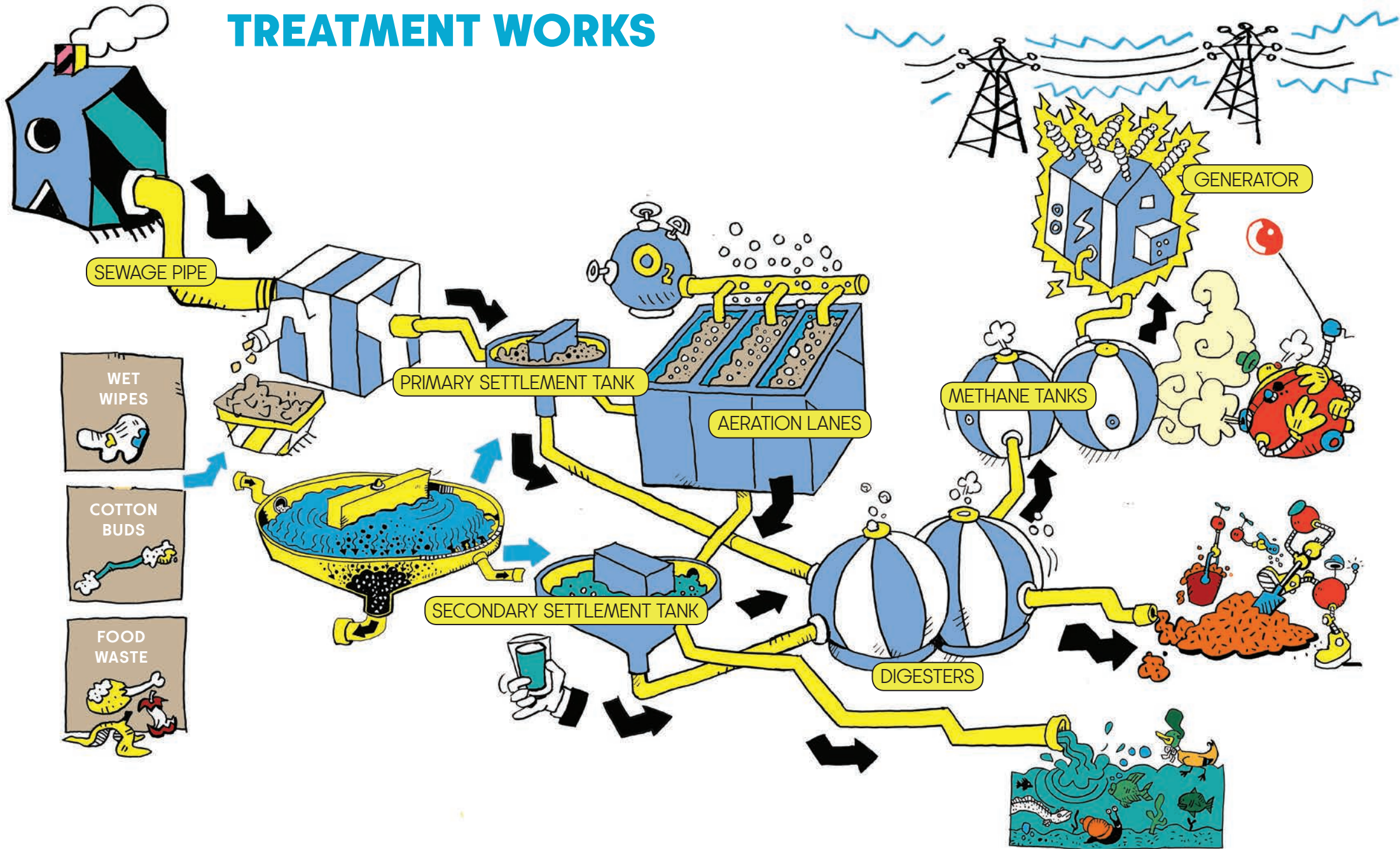
Due to the fact that 2.5 billion people around the world live without access to adequate sanitation alternative toilet solutions have been devised, such as the composting latrine. The composting latrine* not only provides a safe place to go to the loo, it also provides free fertiliser! After people use the toilet they throw some soil and ash into the hole. When one pit is full, they seal it and use the other. Over a few months, the soil and ash help turn the human waste in the sealed pit into completely safe compost. This is then dug out and used on crops. When the second pit is full, the process is repeated.

*Find out what a composting latrine looks like here:

<https://www.wateraid.org/uk/sites/g/files/jkxoof211/files/schools-challenge-ks2-composting-latrine.pdf>



HOW SEWAGE TREATMENT WORKS

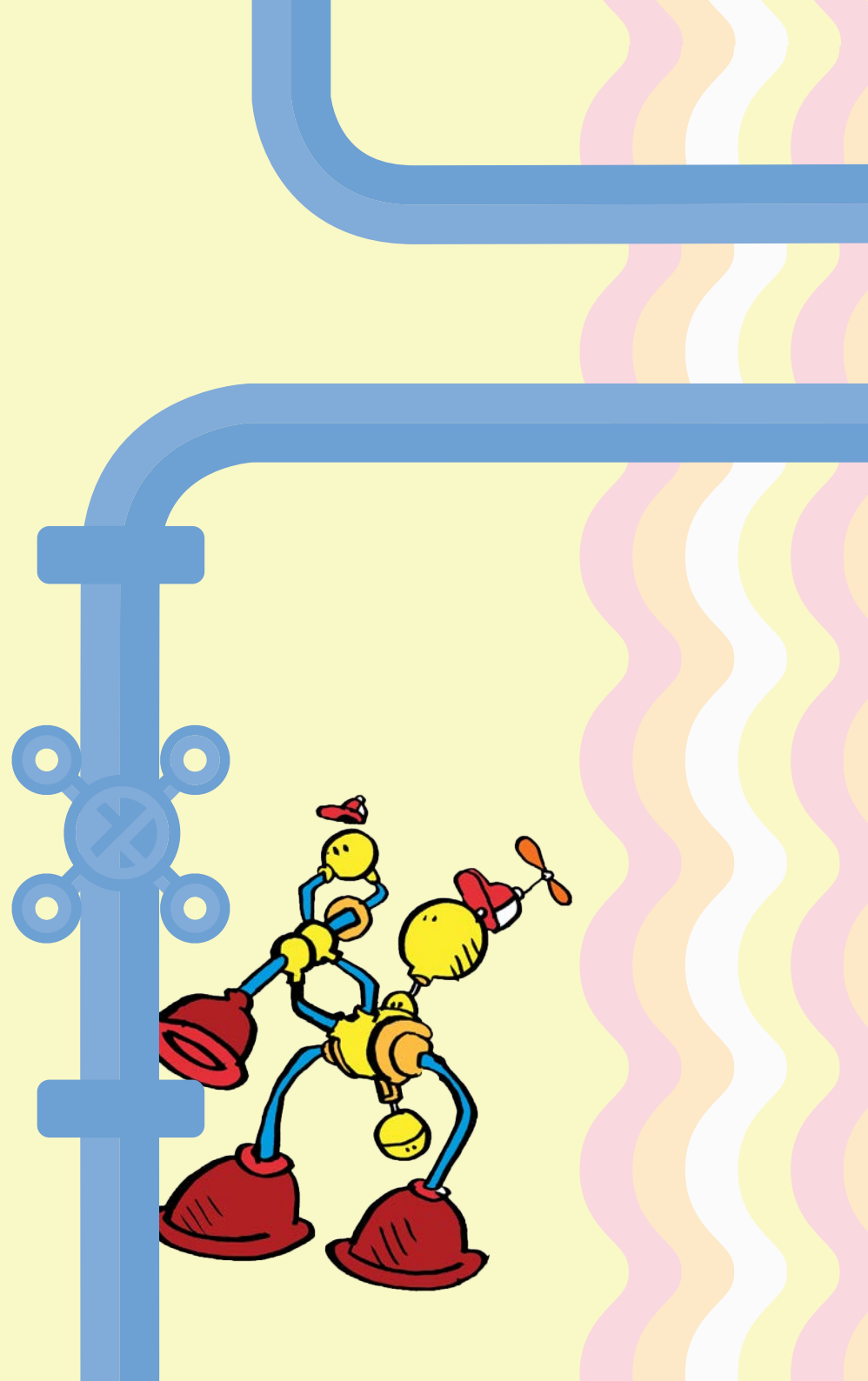


FILTRATION ACTIVITY

Show your pupils the Royal Society film of Professor Brian Cox visiting the Mogden sewage plant to see this filtration process in action at <https://youtu.be/tJHsxvj5YI>

Challenge your pupils to then carry out their own investigations filtering dirty water using sieves or tea strainers, sand on scourers and filter paper. Students can try using the filters in different orders to see what happens but the most effective approach is to use the sieve first, as this has the largest holes and will remove the bigger pieces of rubbish, the sand filter second to remove smaller items and the filter paper or cloth last, as this has the smallest holes. (The water may look cleaner but make sure the pupils do not drink it and wash their hands afterwards!)

This activity is taken from the *Royal Society Brian Cox School Experiments: How can we clean our dirty water?* Short films showing pupils carrying out this experiment and the teacher talking to Professor Cox about the investigation can be found at https://youtu.be/6bY2_a4cqI0



CHAPTER 6:

EXTREME WEATHER, FLOOD & DROUGHT

Curriculum links: Science, Geography, Personal, Social and Health Education, Design Technology, English

Core skills: Critical thinking and problem solving, communication and collaboration, citizenship, student leadership.

Learning objectives:

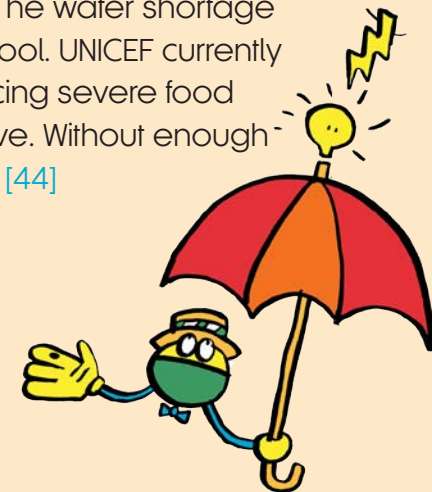
- To learn about the causes and effects of droughts and floods around the world and measures taken to prevent and mitigate the consequences.

Materials you'll need: Construction & modelling equipment, such as: plastic drinks bottles, small food trays, straws, string, card, yoghurt cartons, plant material (e.g. vines) soil, lollipop sticks or similar wooden sticks, scissors, tape and glue.

Drought and flood both occur regularly throughout the world. As the climate changes, weather patterns will change and it is expected that these extreme weather events will occur more regularly.

Drought refers to a prolonged period of unusually dry weather that creates a shortage of water. [43] This can be caused by natural factors such as a lack of rainfall, or human activities including the construction of dams that limit the flow of water downstream. They can also be triggered by a combination of the two, where human actions are causing climate change.

Drought has numerous and various consequences. It endangers lives and has an impact on our environment, damaging biodiversity. In 2016, Ethiopia suffered its worst drought for 50 years when two successive rainy seasons failed. This meant there were no crops to feed either the people or their cattle. The water shortage also caused disease outbreaks, and took children out of school. UNICEF currently estimates that children in Ethiopia, Kenya and Uganda are facing severe food shortages, with more than 3 million children struggling to survive. Without enough clean water and food, children's lives are in extreme danger. [44]



FLOODING ACTIVITY

Floods occur when water, mud and debris spill over riverbanks after prolonged or heavy rain, or when there have been changes to the natural landscape. This can make land fertile but can also cause disasters with loss of life and major problems such as contaminated drinking water, the destruction of homes and habitats and the spread of water borne diseases.

Some countries, such as Bangladesh, have a lot of rain at certain times of the year and this causes flooding. If land used to grow crops gets flooded on a regular basis, then this can contribute to food shortages. In some countries they are trying to solve this problem through the production of floating gardens. These are rafts made of natural resources, normally water hyacinth, soil and cow dung. School children are being taught how to grow crops on the rafts, which then float when flooding occurs: <https://schoolsonline.britishcouncil.org/classroom-resources/list/global-food-security-how-can-we-feed-growing-population>

Encourage your pupils to try constructing their own floating gardens using instructions in the British Council resource:

Design and build a small floating garden. It must float on water in a sink or washing up bowl and be capable of growing seeds on top. Gardens should ideally have a way of being recycled once they are no longer useful. The activity has been inspired by the by *The Floating Garden Challenge* by Practical Action.

You will need to think about the following in your design:

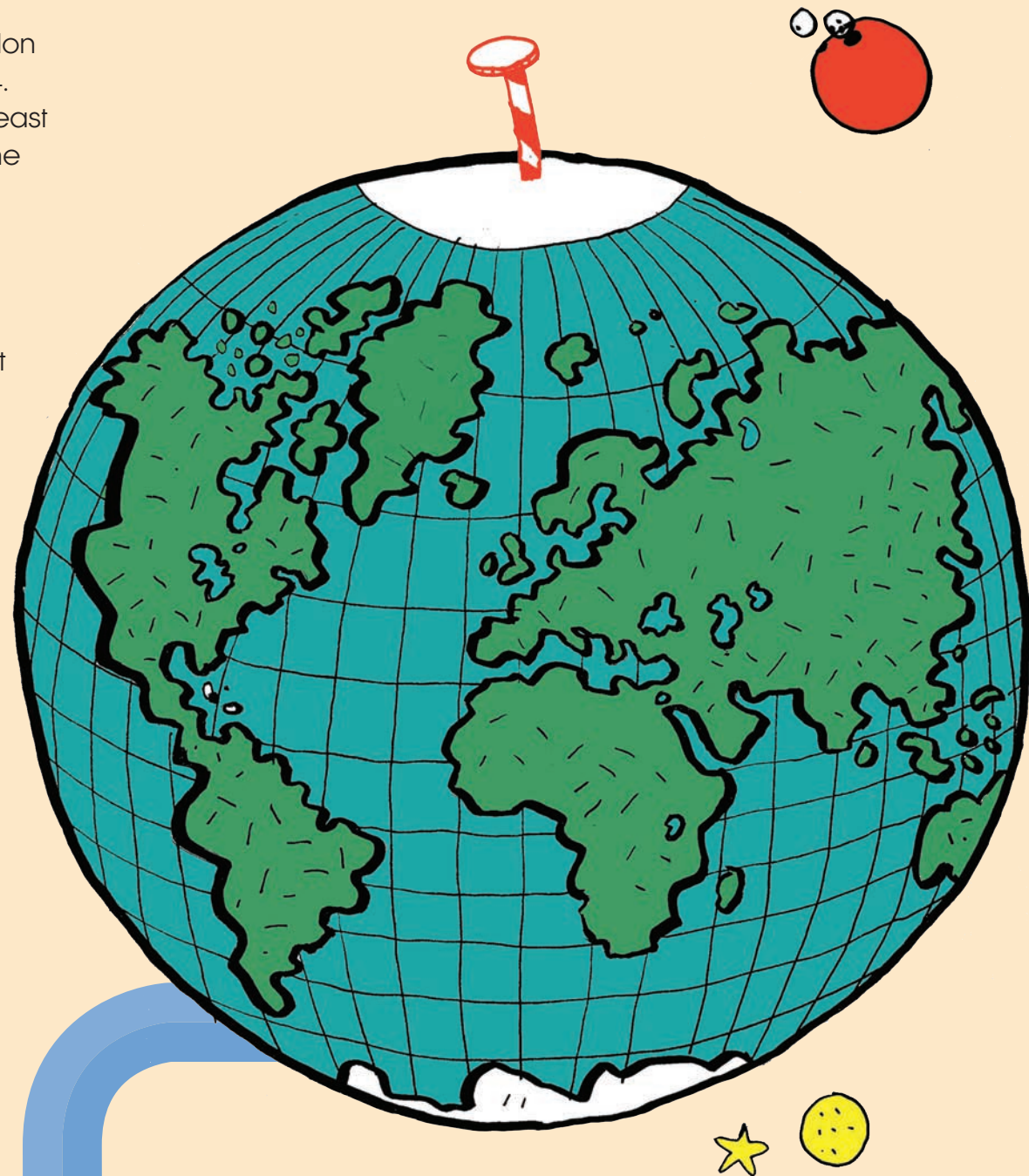
- ◆ Are the materials readily available?
- ◆ How might you dispose of the raft when it can no longer be used? Can it be recycled or used for compost?
- ◆ What size should it be and how well does it float?
- ◆ Extension: Try growing plants on top of your floating garden.



In the UK many towns and cities are at risk of flooding. In London the Thames Barrier was built as part of flood defences in 1984. This is a series of 10 enormous gates crossing the Thames in east London, creating a moveable flood defence. When raised, the central gates are as tall as a 5-storey building.

Other new flood defence schemes including temporary defences, flood modelling using technology and pumps are currently being developed across other key locations in the UK such as Hull and York to provide greater protection against flooding in the future.

- ◆ Discuss with your class why some places are more susceptible to flooding than others. How might human actions make flooding more frequent or severe?
- ◆ Building resilience to flooding can be done through engineering, ecosystem management, or a combination of the two. Can you find out if your local area has built flood defences and has an emergency flood plan?



CLIMATE CHANGE & THE UK

As the effects of climate change are felt, it is likely that the UK will experience much drier, warmer summers and wetter, milder winters. This could cause both increased drought and increased flooding. One of the main issues of climate change is that we do not know exactly what will happen, making it difficult to prepare for.

In response to the growing threat of extreme weather caused by climate change, options include:

- ◆ **Mitigation: attempting to prevent or reduce the changes.**

This would be achieved through combating the causes of climate change, for instance through limiting the emission of greenhouse gas.

- ◆ **Adaptation: adjusting to live alongside the changes.**

Examples of this are numerous, such as investing in more flood defences, storing water and investing in desalination plants.

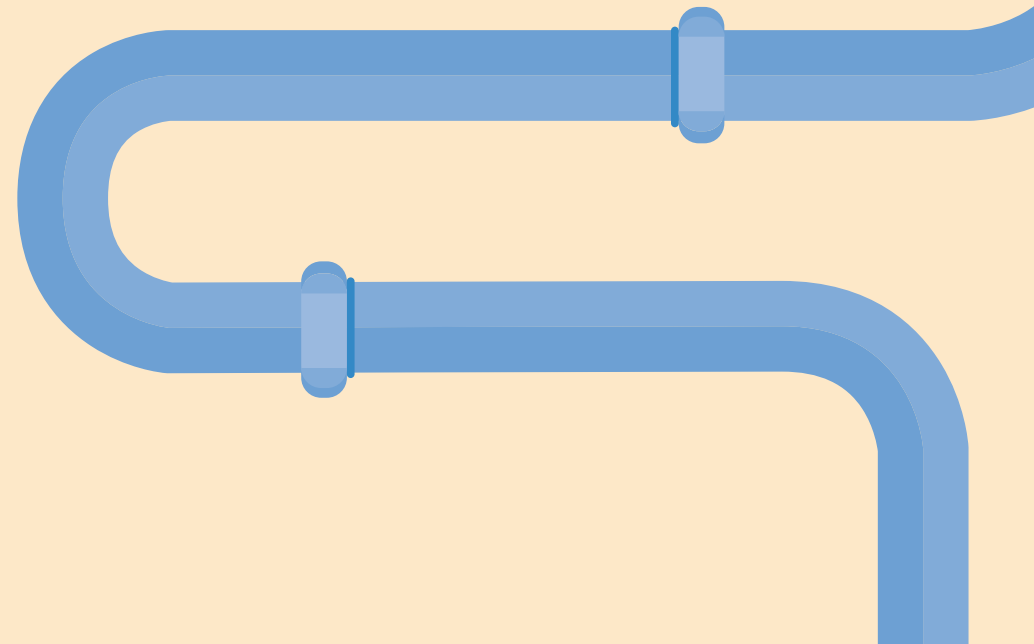
These are both costly, but with investment we can see positive change.

Many actions are a combination of both mitigation and adaptation strategy: for instance, encouraging a cultural shift to using less water.

Making decisions requires an analysis of various economic costs and environmental impacts. This is difficult because often these are not obvious, or require a degree of predicting the future. In California, water has been rerouted to protect parts of the

San Francisco Bay, which were dangerously close to drying up, threatening biodiversity.^[45] However, this has left many farmers struggling to water their crops, and they are understandably angry.

In the Netherlands, a decision was made to sacrifice parts of country, mainly farmland to flooding, to alleviate the risk of flooding in towns and cities. Landowners were financially reimbursed for the land lost. However, if this decision had not been made, the impact could be devastating as 60% of the country lies at sea level or below. ^[46]



ACTIVITY

New developments that affect how water sources are used can be controversial.

Ask your pupils to find out more about these and other recent examples such as the Three Gorges Dam project along the Yangtze River in China, the Belo Monte Dam in Brazil and the Grand Ethiopian Renaissance Dam in Ethiopia.

- ◆ Encourage them to research the arguments both for and against these new developments.
- ◆ Set up a role-play debate where members of your class take on the roles of characters that will be affected by the construction of a development that will affect your local river. Roles could include owners of the new development, environmental activists, members of the media, unemployed local residents, shop owners, the local mayor and other members of the community.
- ◆ Students should consider how their character may be affected if the new development goes ahead, and think of three key points to raise during the debate.
- ◆ Students should vote, in character, at the end of the session for whether the new scheme should go ahead, and evaluate which side produced the most robust arguments.



CELEBRATE YOUR LEARNING – WHAT CAN YOU DO TO MAKE A DIFFERENCE?

At the end of your project on water, why not hold a celebration of learning to share your pupils' progress and raise awareness of some of the issues they have studied with friends and family and other pupils in the school. You could link this with events such as Oxfam Water Week or World Water Day on 22nd March.

Why not show the following Imagine film from Oxfam (<http://www.oxfam.org.uk/education/resources/water-week-for-youth-ambassadors>) and ask pupils to identify actions they might take to help support water-vulnerable communities. They might choose to organise fundraising activities such as a sponsored walk carrying water, or invite their local MP or councillor to talk about their views on local flood defences or international water aid. Pupils could also decide on which pieces of work to show and any water related entertainment, music and refreshments for the event. If you have a partner school, perhaps they could join the celebrations and share your partnership work via Skype or Facetime.



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FURTHER RESOURCES

The Thames Festival Trust has a wide range of resources about rivers <https://thamesfestivaltrust.org/our-work/education-programme>

The Rivers of the World Education Pack containing a wide range of exciting cross curricular activities can be found at: <https://thamesfestivaltrust.org/our-work/education-programme/education-resources>

To find out more about the Sustainable Development Goals watch this animated film written by Sir Ken Robinson and introduced by Malala Yousafza which champions the goals at: <https://vimeo.com/138852758>

The materials in the Commonwealth Science class packs encourage young people around the world to take part in experimental science investigations and consider some of the long term global problems that scientists are working on, but have not yet solved. <https://schoolsonline.britishcouncil.org/about-schools-online/about-programmes/commonwealth-class/get-involved/resources/royal-society>

Water saving tips from National Geographic can be found at: <http://environment.nationalgeographic.com/environment/freshwater/water-conservation-tips/>

This article has information about the report from the World Health Organisation/UNICEF about access to safe drinking water, https://www.theguardian.com/global-development-professionals-network/2017/mar/17/access-to-drinking-water-world-six-infographics?CMP=Share_iOSApp_Other

Good examples of activities and fundraising ideas for schools; <http://www.wateraid.org/>

Popular science, design and technology and STEM teaching resources which focus on a whole range of global issues including energy, climate change, water and disaster risk reduction can be found here: <https://practicalaction.org/schools>

Science Experiments with Water by S Nankivell Aston and D Jackson published by Franklin Watts has examples of investigations with water that can be carried out in the classroom. <https://www.goodreads.com/book/show/6127717-science-experiments-with-water>

Splish Splash Flush from Water Aid is a film showing scientist Adam Hart-Davis on a voyage of discovery down a u- bend and beyond! You can find the film in the lesson plans and resource set (<https://www.wateraid.org/uk/publications/splish-splash-flush-lesson-plans>) on the Water Aid website

The Royal Geographical Society website (<http://www.rgs.org/>) is another good resource.



TELL US WHAT YOU THINK

We'd love to get your feedback so we can monitor and review this resource and future work.

Please send us your comments and feedback to:
www.thamesfestivaltrust.org/about-us/contact

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