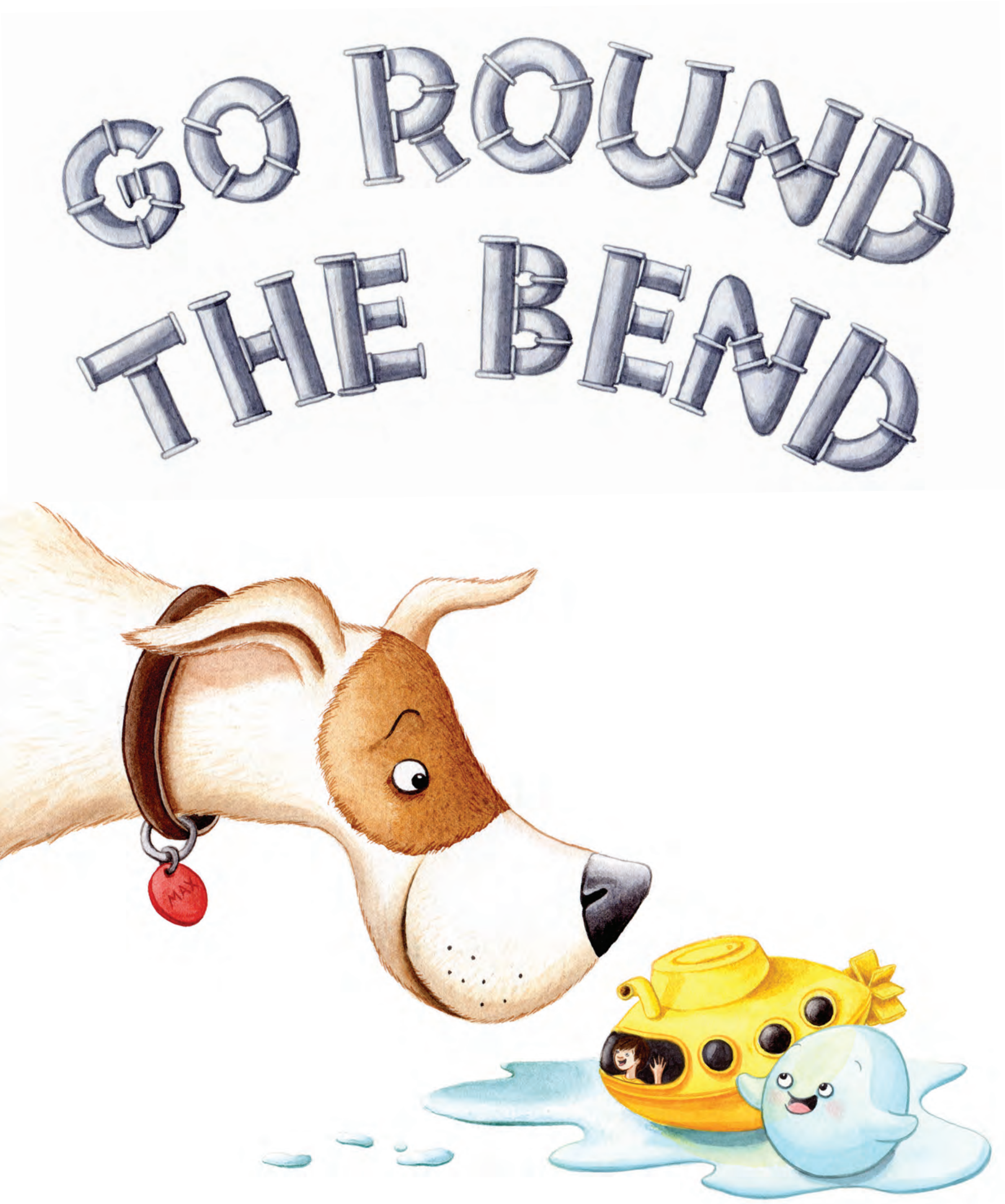
Sam and Flo



By Sally Smith

Illustrated by
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For anybody with a curious mind

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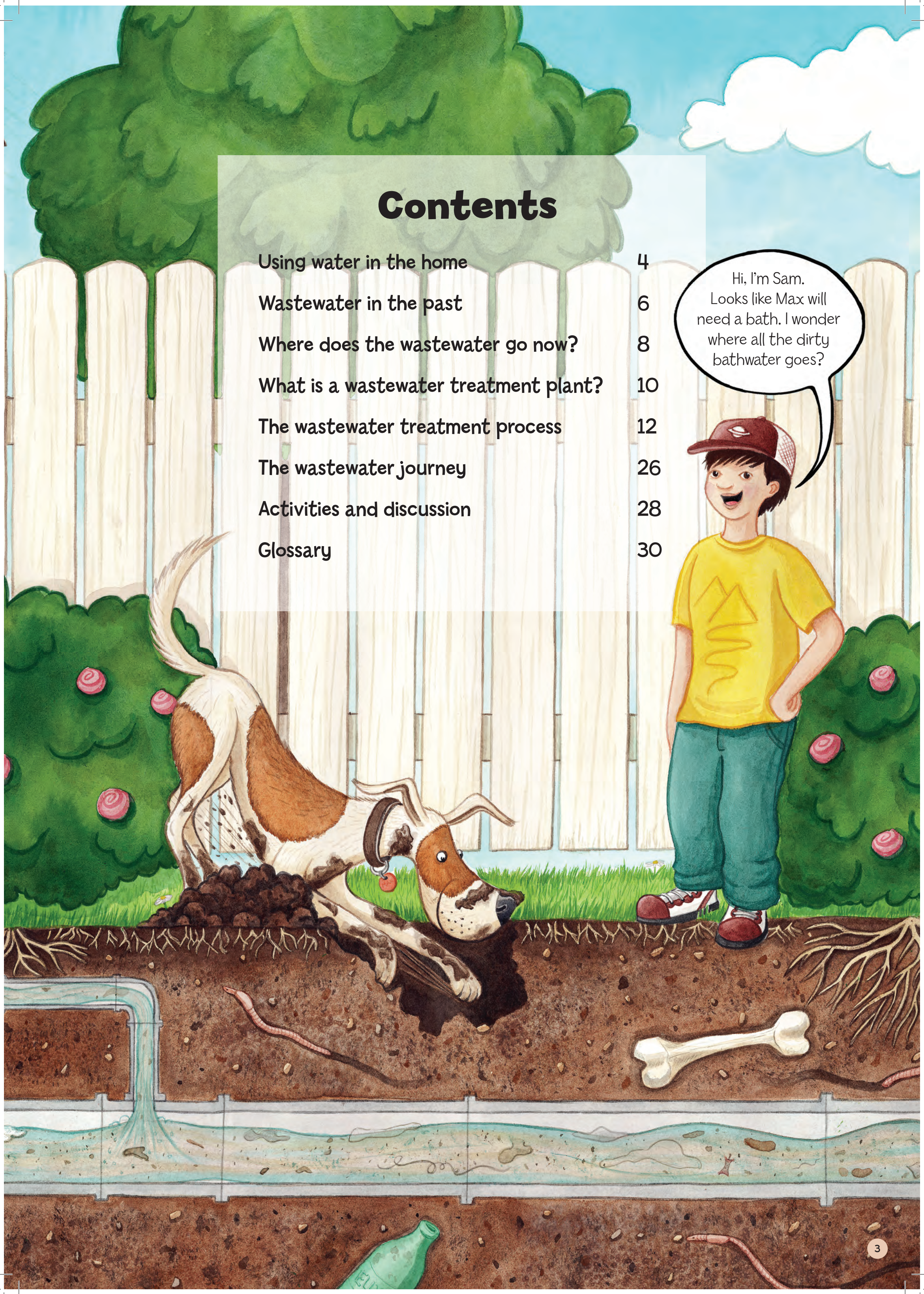


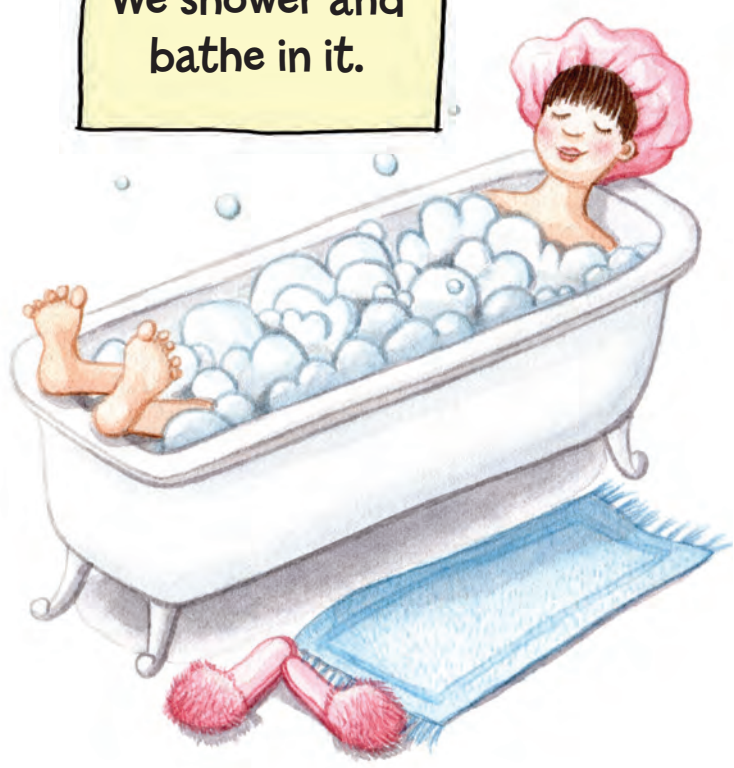
Using water in the home

We use water in our homes in lots of different ways.

We use it to wash our clothes and dishes.

We use it to drink and when we brush our teeth.

We shower and bathe in it.



We flush our toilets with water too.

The used water is called **wastewater**. Most of it is water; the rest includes organic matter such as human waste, food scraps, cooking fats, oil and grease, and **debris** such as sand, grit and plastic.

We even wash our pets in it!

Hello Sam. It looks like Max enjoyed his bath!

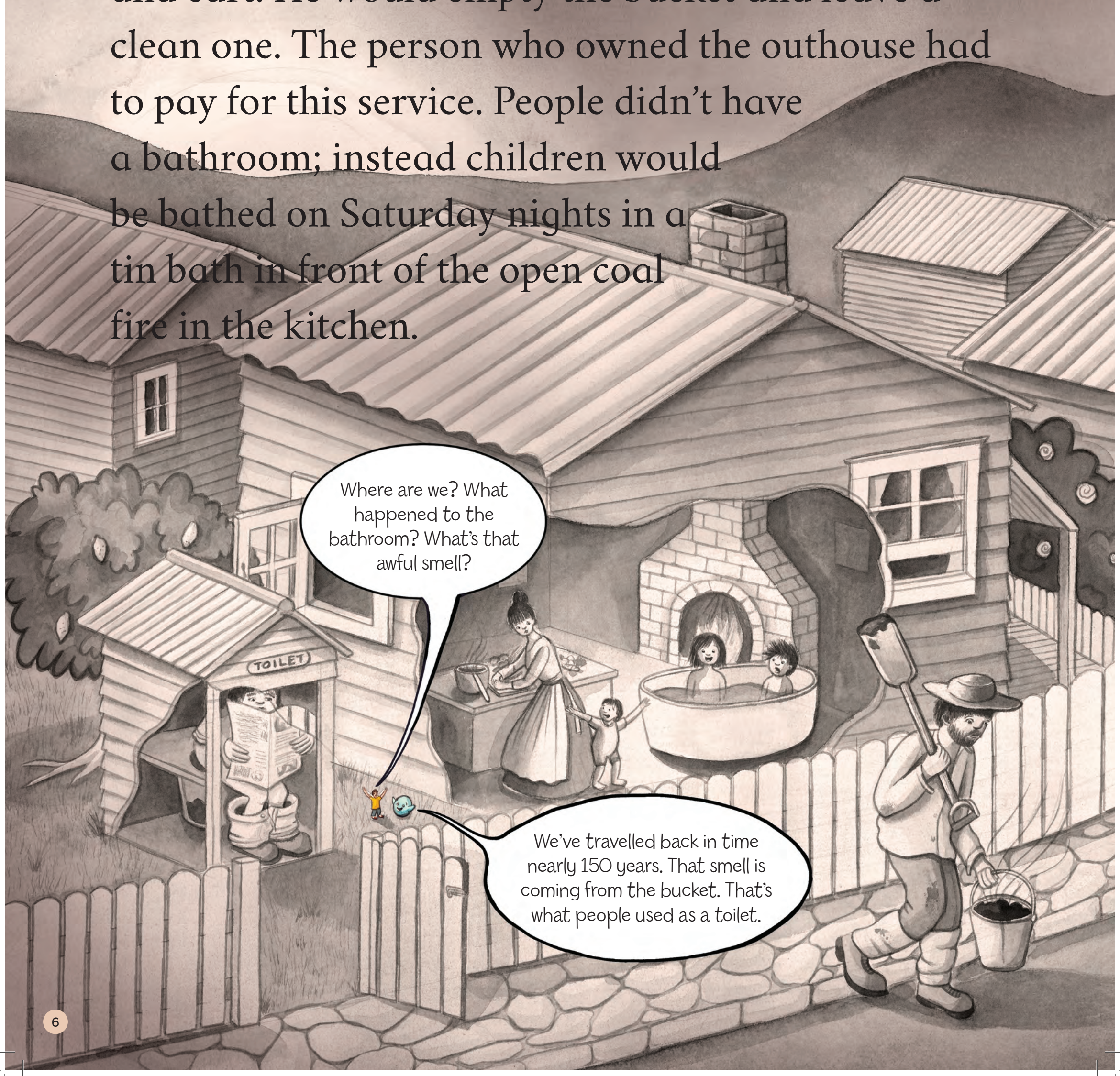
Hi Flo, I haven't seen you for a long time. Uh oh! I can feel myself getting smaller.

Does this mean we are going on another adventure?

Sure does. Hold my hand. I've a new trick to show you.

What used to happen to all the waste?

In the 1800s, before toilets were widely available, people would use a bucket placed in an **outhouse**, which was a small shed in the garden. In the evening a **night soil collector** would come along in a horse and cart. He would empty the bucket and leave a clean one. The person who owned the outhouse had to pay for this service. People didn't have a bathroom; instead children would be bathed on Saturday nights in a tin bath in front of the open coal fire in the kitchen.

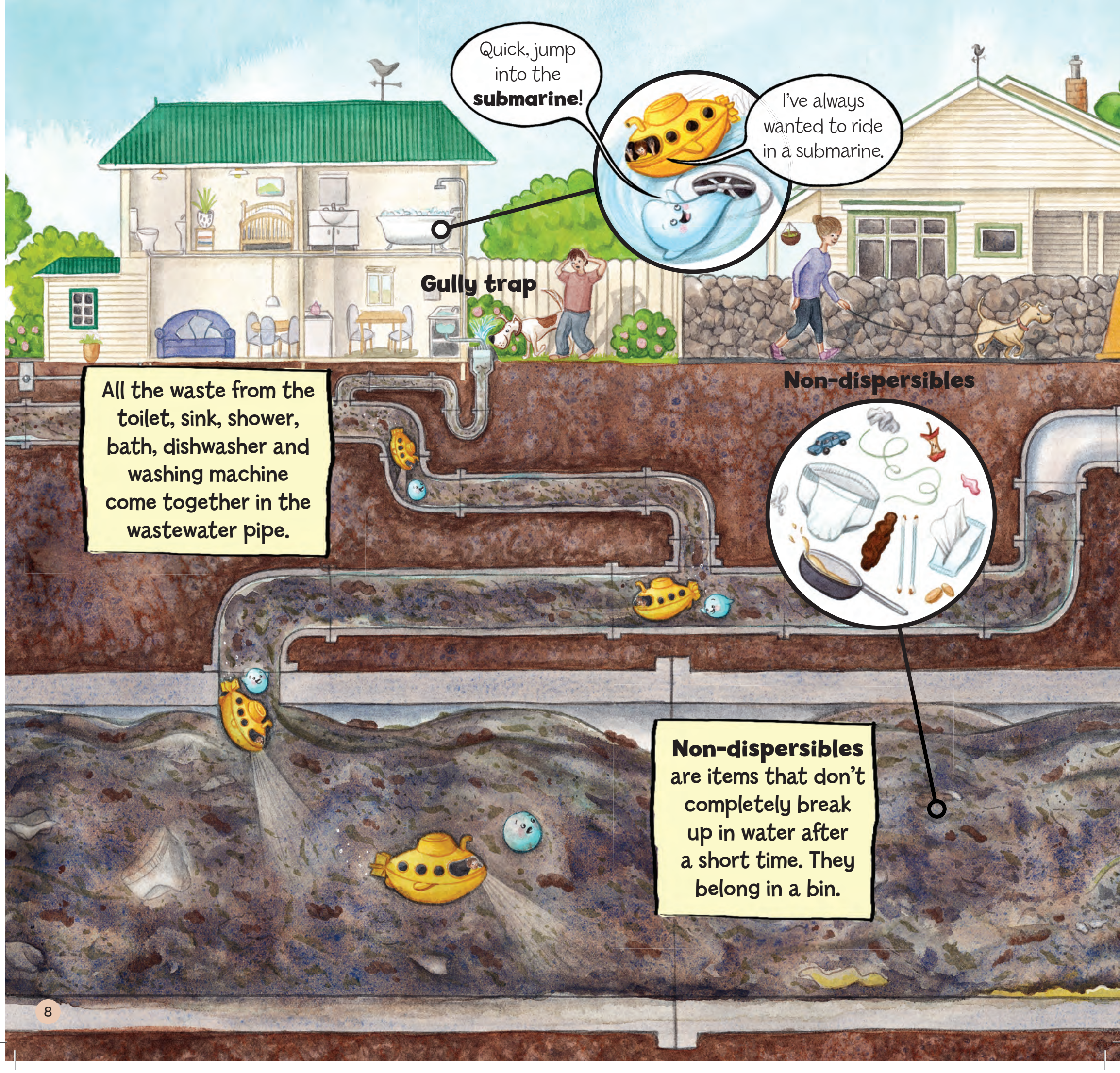


Where did all the waste go in the past?

The night soil collectors worked between 10pm and 5am emptying buckets of human waste into their carts. They took the waste to a **manure depot** on the edge of town. The waste was buried there. Many people ignored this and continued to bury the waste on their own property, which caused the outbreak of diseases such as **cholera** and **typhoid**.

Where does the wastewater go now?

The wastewater goes down the plughole into private wastewater pipes on your property. These connect to the **public wastewater network** which carries your household wastewater to a wastewater treatment plant. The network uses **gravity** and sometimes **pump stations** to move wastewater to larger pipes.



Can you put anything down the toilet?

Only toilet paper, pee and poo should be flushed down the toilet. Everything else – including things like wet-wipes, sanitary products, dental floss, nappies and fat, oil and grease from cooking – should be put in the rubbish bin.

A manhole is a small covered opening in a road or path that a person can go down to work underground.

Manhole

If non-**biodegradable** solid matter such as wet-wipes combine with grease or cooking fat, they can form a **congealed** lump of material called a **fatberg**. Even some wipes with 'flushable' labels can block the pipes in the wastewater system.

Flo, what's all that stuff in the pipe?

That's what happens when people put the wrong things down the sink or toilet. It all builds up and can block the pipe, causing it to overflow.

Fatberg

What is a wastewater treatment plant?

A wastewater treatment plant is the place where wastewater is cleaned so that it is not harmful or dangerous to people or the environment. Unfortunately many countries release wastewater directly into rivers and seas without proper treatment. This affects water quality and can cause people to get sick.

Trunk sewer line

Flo, this pipe is huge!

Interceptor sewer

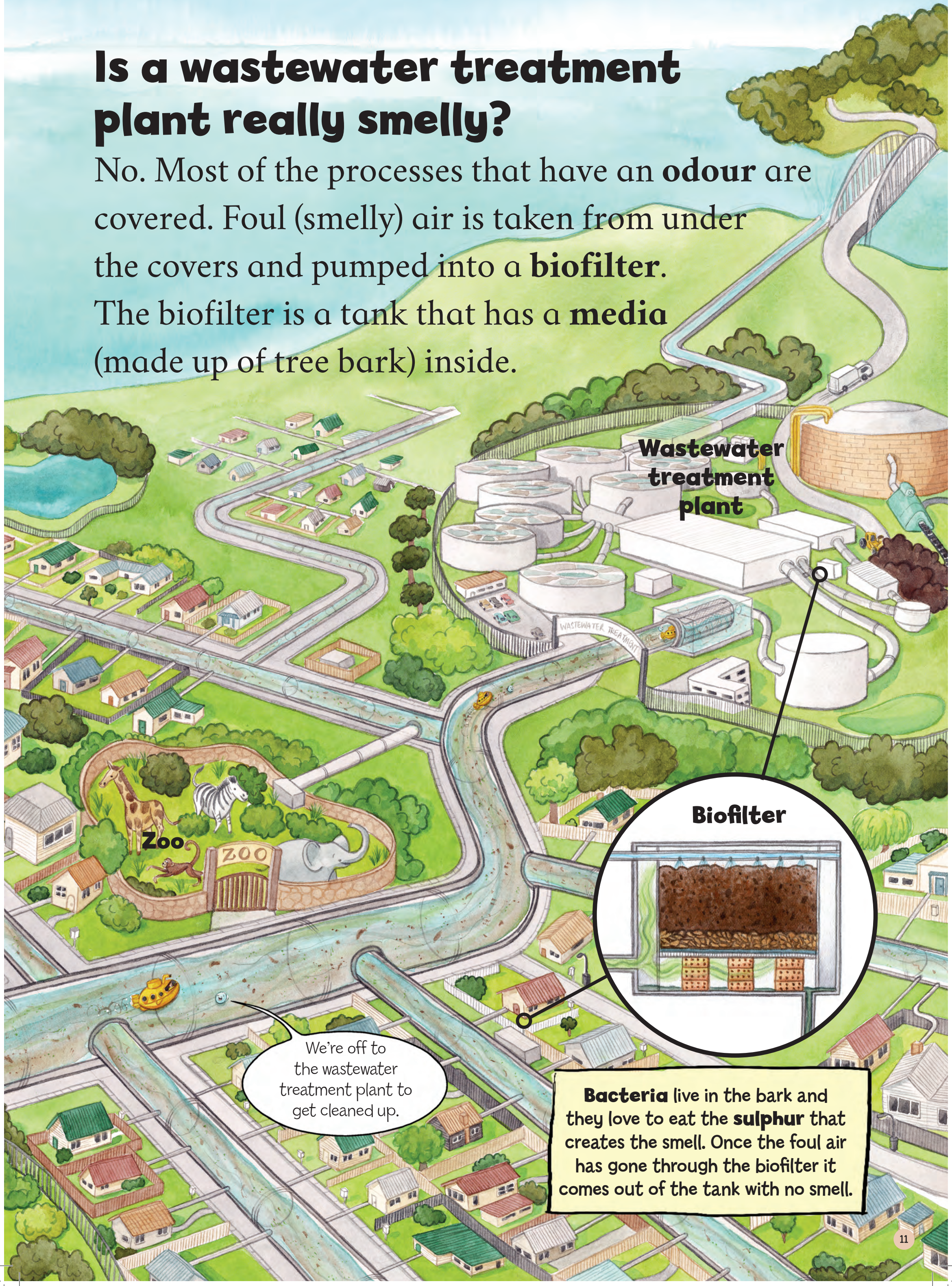
Where are we going to, Flo?

Theme park

An **interceptor sewer** receives the flow from **trunk sewer lines** and directs it to the wastewater treatment plant.

Is a wastewater treatment plant really smelly?

No. Most of the processes that have an **odour** are covered. Foul (smelly) air is taken from under the covers and pumped into a **biofilter**. The biofilter is a tank that has a **media** (made up of tree bark) inside.



Bacteria live in the bark and they love to eat the **sulphur** that creates the smell. Once the foul air has gone through the biofilter it comes out of the tank with no smell.

What happens to the wastewater when it goes through the wastewater treatment plant?

A wastewater treatment plant uses a combination of **physical, mechanical and biological processes** to clean the waste out of the water. The wastewater is separated into **solids** and **liquids**. The liquids are made safe so they can be released into a water body such as a river, **harbour** or the sea and the solids go to **land restoration**.

The objects are collected on **conveyors**, then washed, **dewatered** and taken to a large waste bin. The bin is then taken away by truck and the waste is used for land restoration.

To land restoration by truck

Screenings bin

Screenings out

Rotating fine screen made of 3mm mesh

I don't like this, Flo. Going round and round is making me dizzy.

Raw wastewater in

On entering the treatment plant the **raw wastewater** passes into **rotating** barrel-shaped **screens**. Jets of water blast solid objects – such as nappies, cigarette butts, cotton buds, rags, small toys, wood and fruit – from the mesh screens.

Screened wastewater out

Grit chamber

These bubbles are tickly.

In the grit chamber, air is pumped from a **perforated** pipe inside the tank. This causes a rolling motion so that the heavier sand and grit particles settle at the bottom.

The grit is pumped into **grit classifiers**. This is where it is washed and dewatered before being used for land restoration.

Grit bin

Sludge scrapers

Primary sedimentation tank

Primary wastewater to reactor

Flo, I'm sinking with the other solids! Where are you going?

I'm off to get cleaned up with the rest of the liquids. I'll catch up with you later.

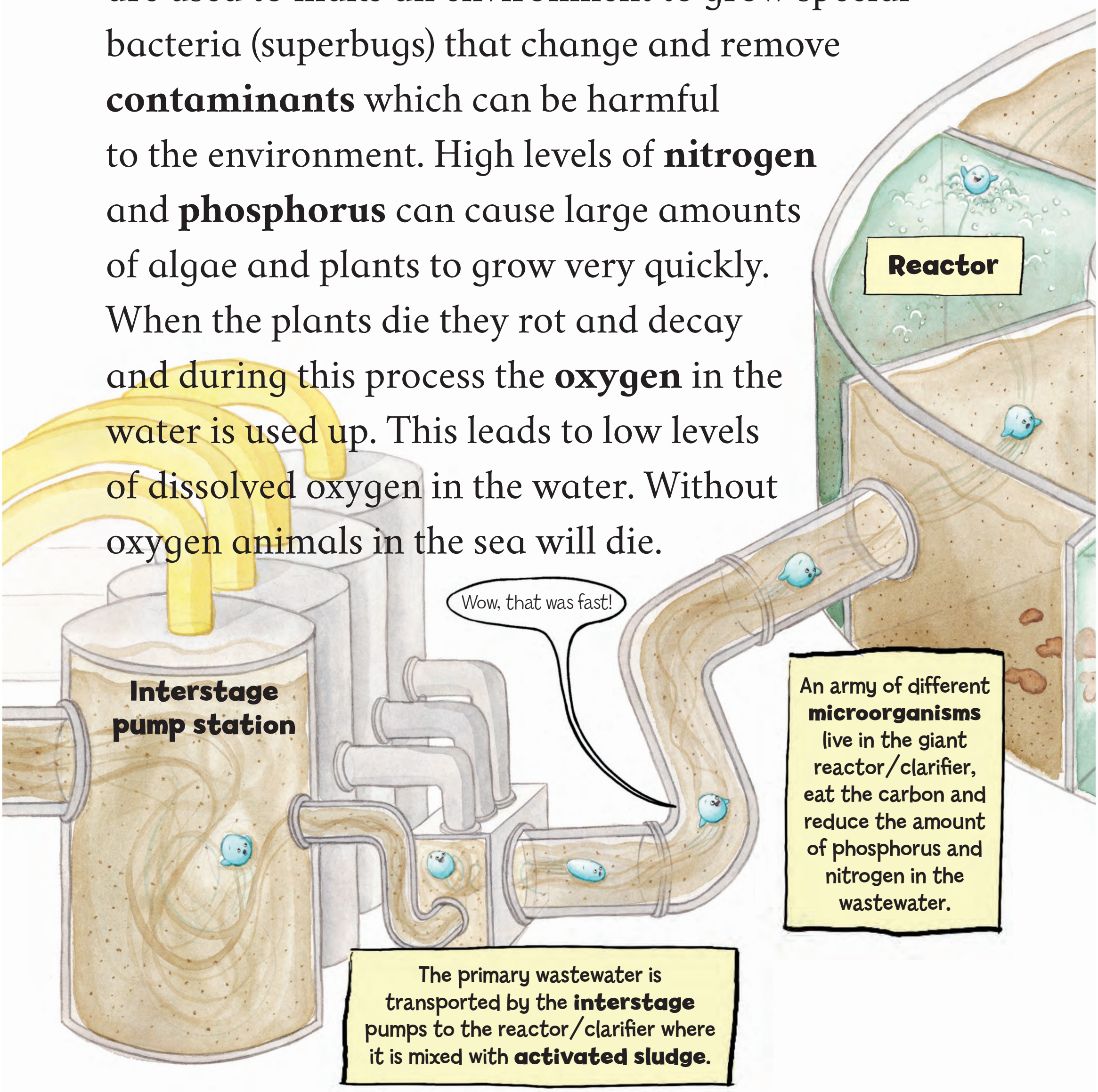
Sludge hopper

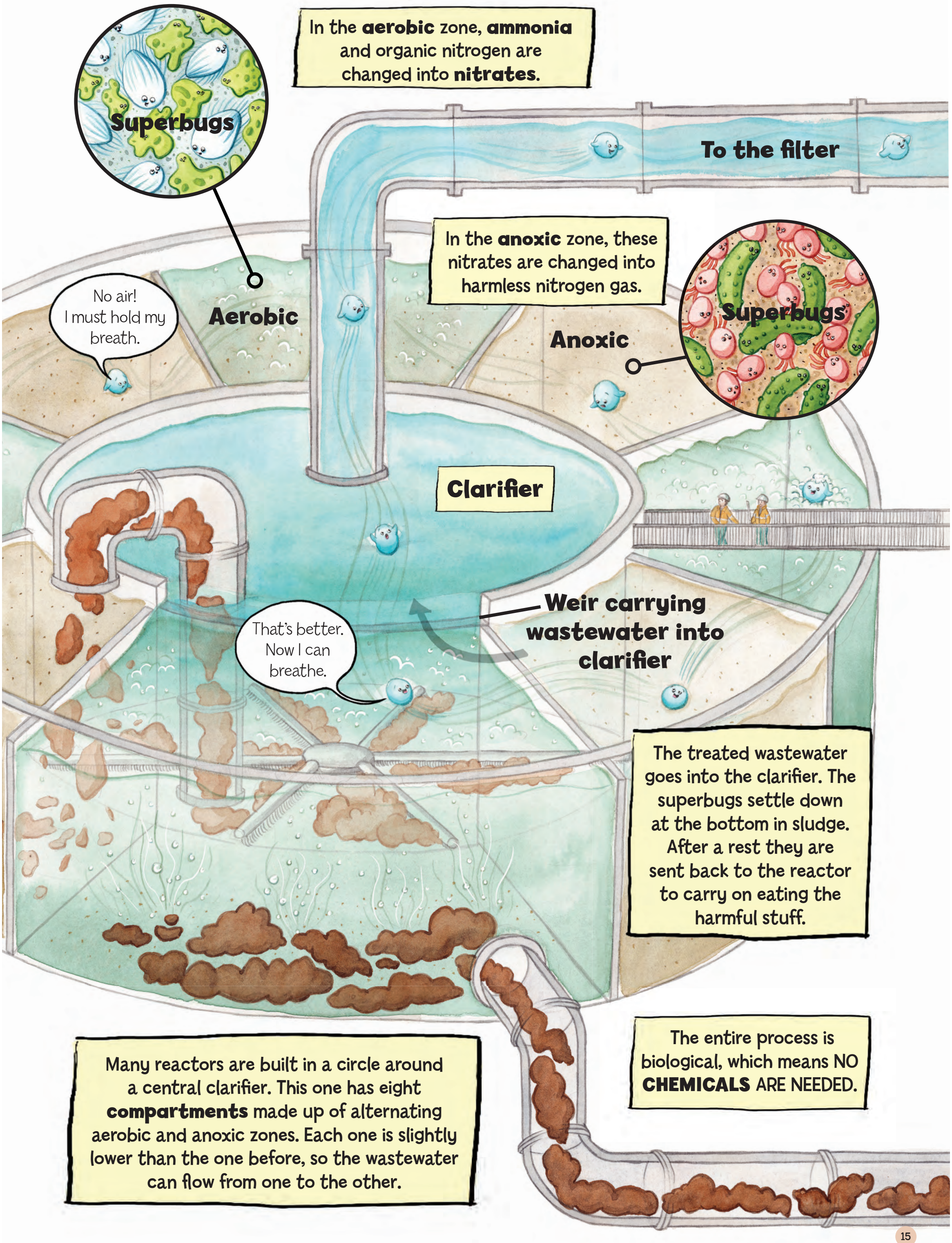
Primary sludge to gravity thickeners

The primary **sedimentation** tanks let the water flow through slowly and smoothly so the **organic matter** can sink to the bottom as **sludge**. This is then scraped into the sludge **hopper** and goes to the gravity thickener. By this stage 70 per cent of the **suspended solids** have been separated from the liquids.

How are the nasty, harmful things taken out of the wastewater?

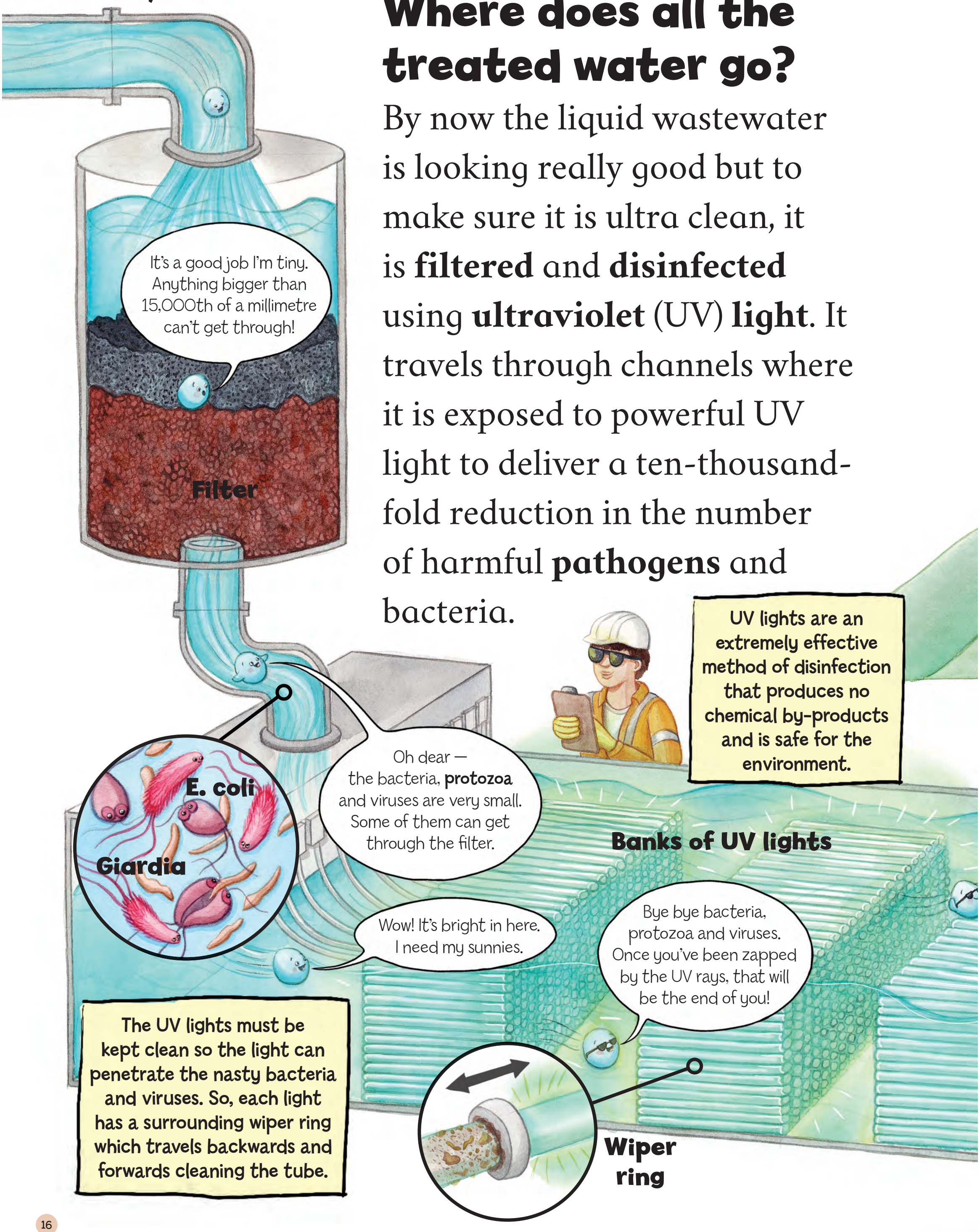
The second part of the process takes place in the reactor/clarifier. This is where **aeration** and pumps are used to make an environment to grow special bacteria (superbugs) that change and remove **contaminants** which can be harmful to the environment. High levels of **nitrogen** and **phosphorus** can cause large amounts of algae and plants to grow very quickly. When the plants die they rot and decay and during this process the **oxygen** in the water is used up. This leads to low levels of dissolved oxygen in the water. Without oxygen animals in the sea will die.



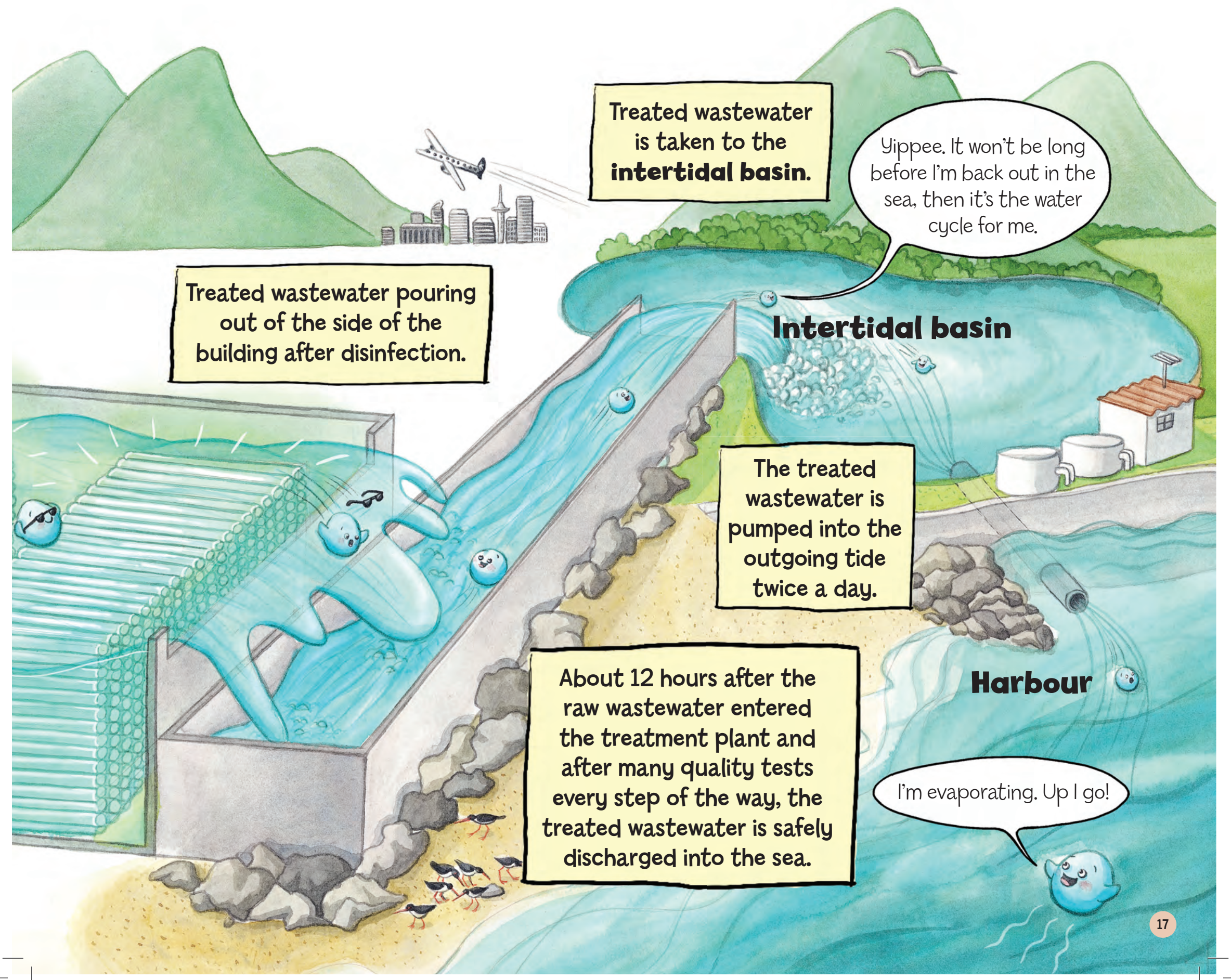

Superbugs
In the **aerobic** zone, **ammonia** and organic nitrogen are changed into **nitrates**.
To the filter
In the **anoxic** zone, these nitrates are changed into harmless nitrogen gas.
No air! I must hold my breath.
Aerobic
Anoxic
Superbugs
Clarifier
That's better. Now I can breathe.
Weir carrying wastewater into clarifier
The treated wastewater goes into the clarifier. The superbugs settle down at the bottom in sludge. After a rest they are sent back to the reactor to carry on eating the harmful stuff.
The entire process is biological, which means NO **CHEMICALS** ARE NEEDED.
Many reactors are built in a circle around a central clarifier. This one has eight **compartments** made up of alternating aerobic and anoxic zones. Each one is slightly lower than the one before, so the wastewater can flow from one to the other.

Where does all the treated water go?

By now the liquid wastewater is looking really good but to make sure it is ultra clean, it is **filtered** and **disinfected** using **ultraviolet** (UV) **light**. It travels through channels where it is exposed to powerful UV light to deliver a ten-thousand-fold reduction in the number of harmful **pathogens** and bacteria.

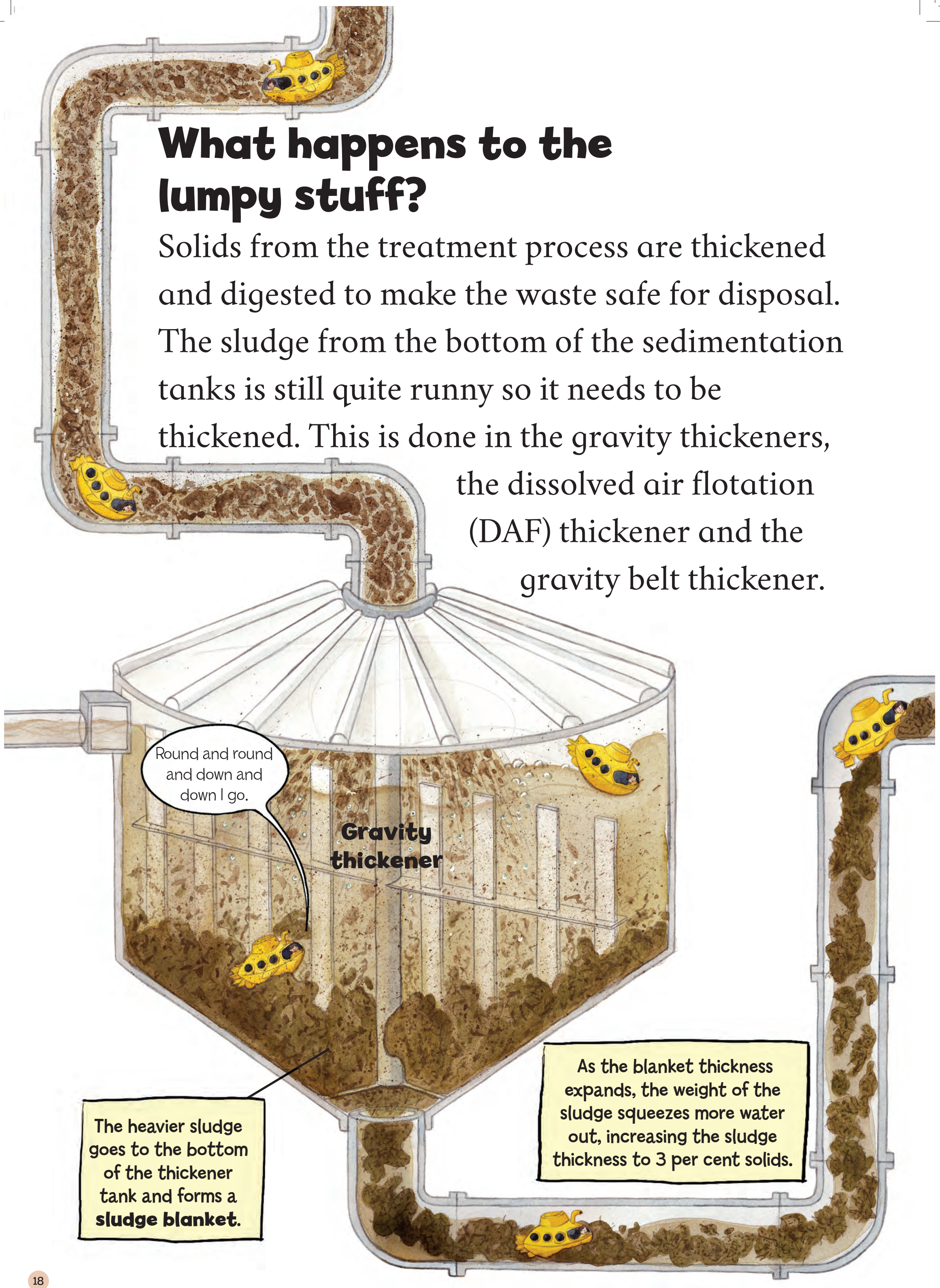


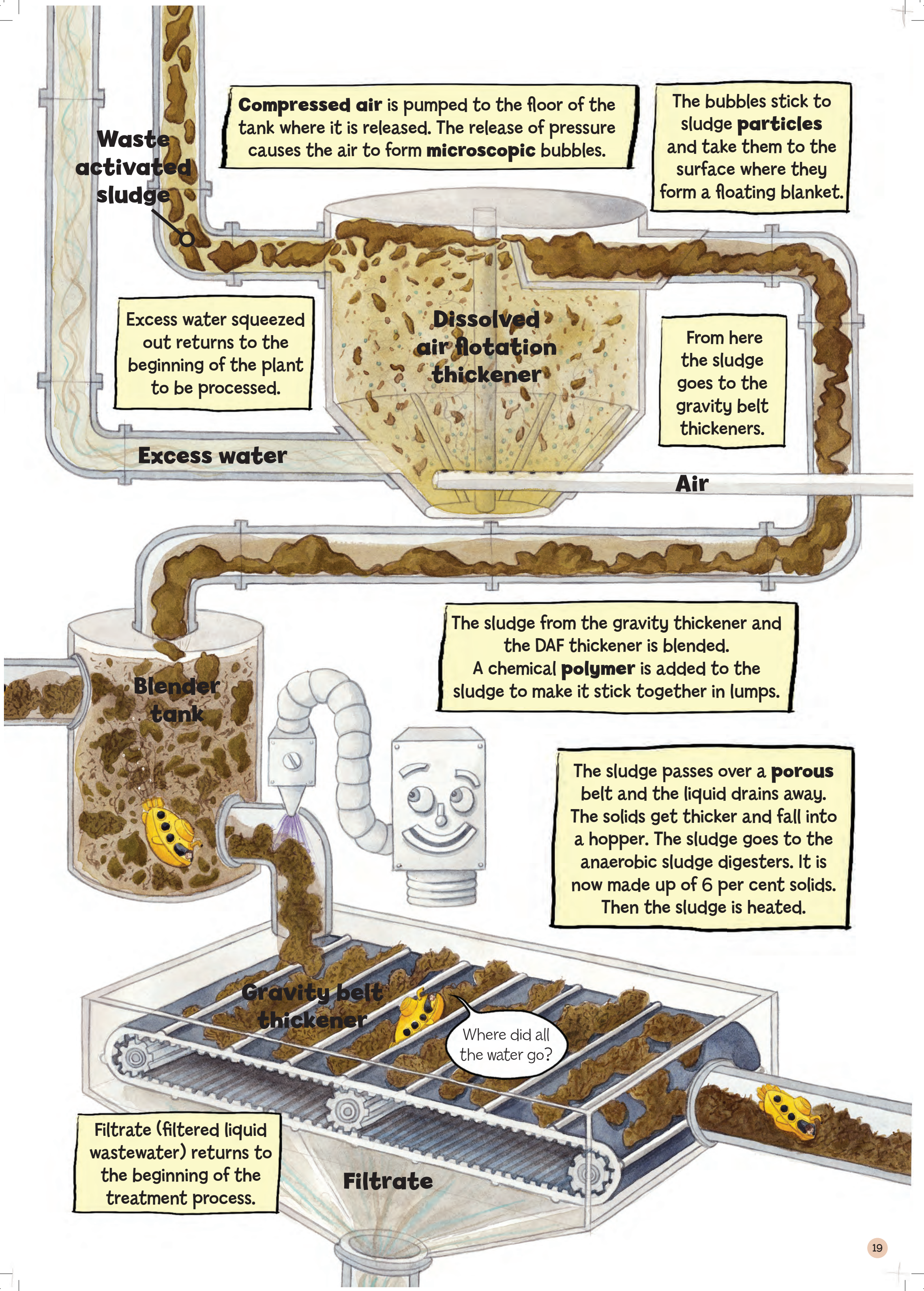
The wastewater treatment plant speeds up the natural **purifying** process of bacteria in the sunlight. The sun emits UV rays that are also capable of killing off pathogens and bacteria. However, as the number of people living in cities and towns increases and industrial activity grows, the natural world can no longer cope with the amount of daily waste being produced.



What happens to the lumpy stuff?

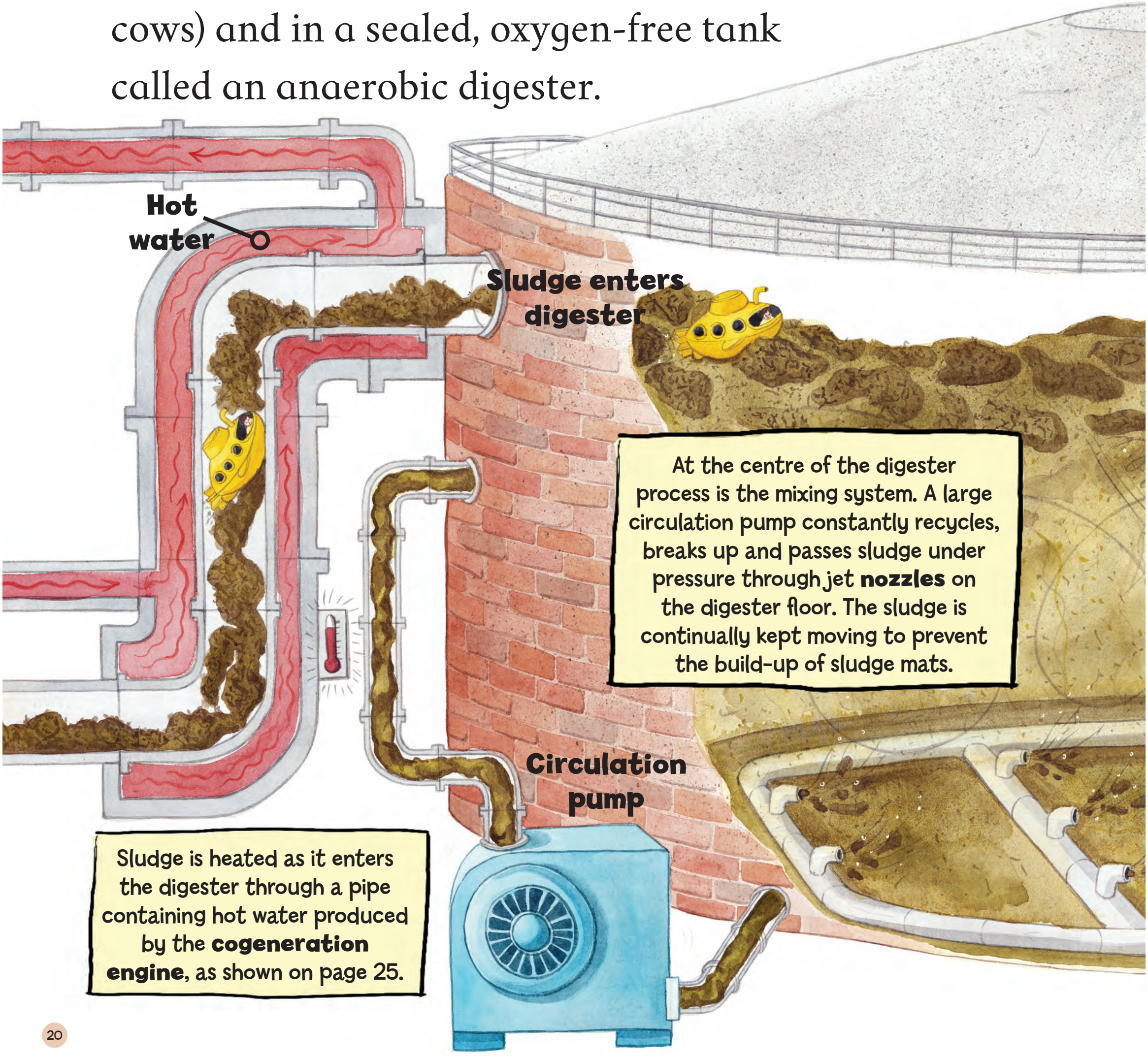
Solids from the treatment process are thickened and digested to make the waste safe for disposal. The sludge from the bottom of the sedimentation tanks is still quite runny so it needs to be thickened. This is done in the gravity thickeners, the dissolved air flotation (DAF) thickener and the gravity belt thickener.




Waste activated sludge
Compressed air is pumped to the floor of the tank where it is released. The release of pressure causes the air to form microscopic bubbles.
The bubbles stick to sludge particles and take them to the surface where they form a floating blanket.
Excess water squeezed out returns to the beginning of the plant to be processed.
Dissolved air flotation thickener
From here the sludge goes to the gravity belt thickeners.
Excess water
Air
Blender tank
The sludge from the gravity thickener and the DAF thickener is blended. A chemical polymer is added to the sludge to make it stick together in lumps.
The sludge passes over a porous belt and the liquid drains away. The solids get thicker and fall into a hopper. The sludge goes to the anaerobic sludge digesters. It is now made up of 6 per cent solids. Then the sludge is heated.
Gravity belt thickener
Where did all the water go?
Filtrate (filtered liquid wastewater) returns to the beginning of the treatment process.
Filtrate

Anaerobic digestion!
What is that all about?

Anaerobic digestion is a collection of processes by which **microorganisms** break down **organic matter** such as animal or food waste. This happens where there is no oxygen – such as in water sediment, water-logged soils, the stomachs of various animals (e.g. cows) and in a sealed, oxygen-free tank called an anaerobic digester.



The sludge stays in the digester for around 20 days. The amount of sludge is reduced by half during this time. The rest of the sludge goes to the **dewatering plant**.

Acid-producing bacteria break down organic materials – e.g. carbohydrates, proteins and fats – into organic acids.

Domed top

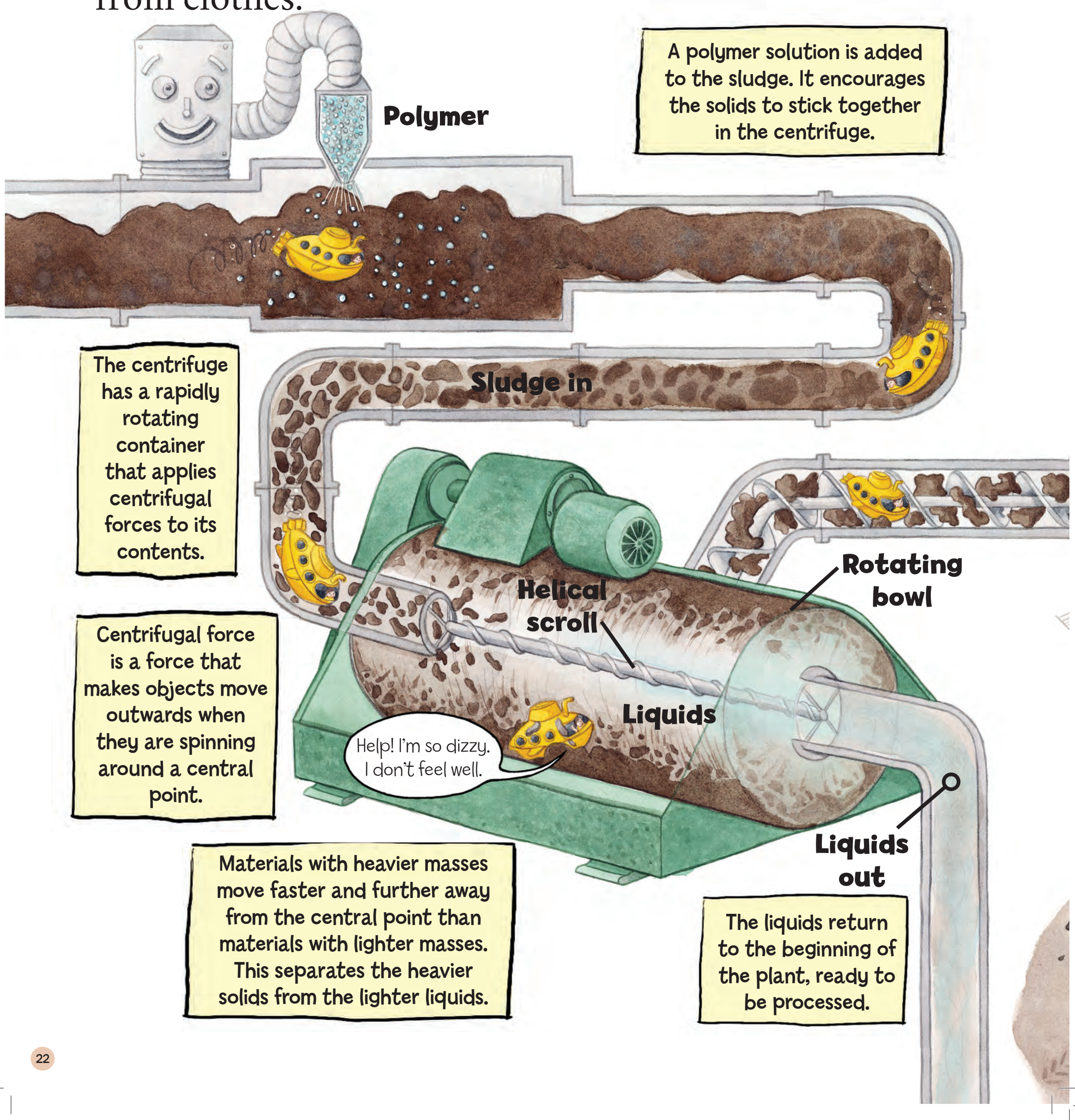
Whoa, It's like being on a ride at the theme park going round and round. I wish Flo were here.

Methane-forming bacteria change the organic acids into methane and **carbon dioxide** gases.

Jet mix pump

What happens to the sludge?

The sludge from the anaerobic digester goes into the dewatering plant. The sludge is spun around in a machine called a **centrifuge**. It removes the water from the sludge just like a spin-dryer removes water from clothes.



Solids out

The solids, now known as biosolids, move along **belt conveyors** and are taken to a biosolids storage building.

Solids

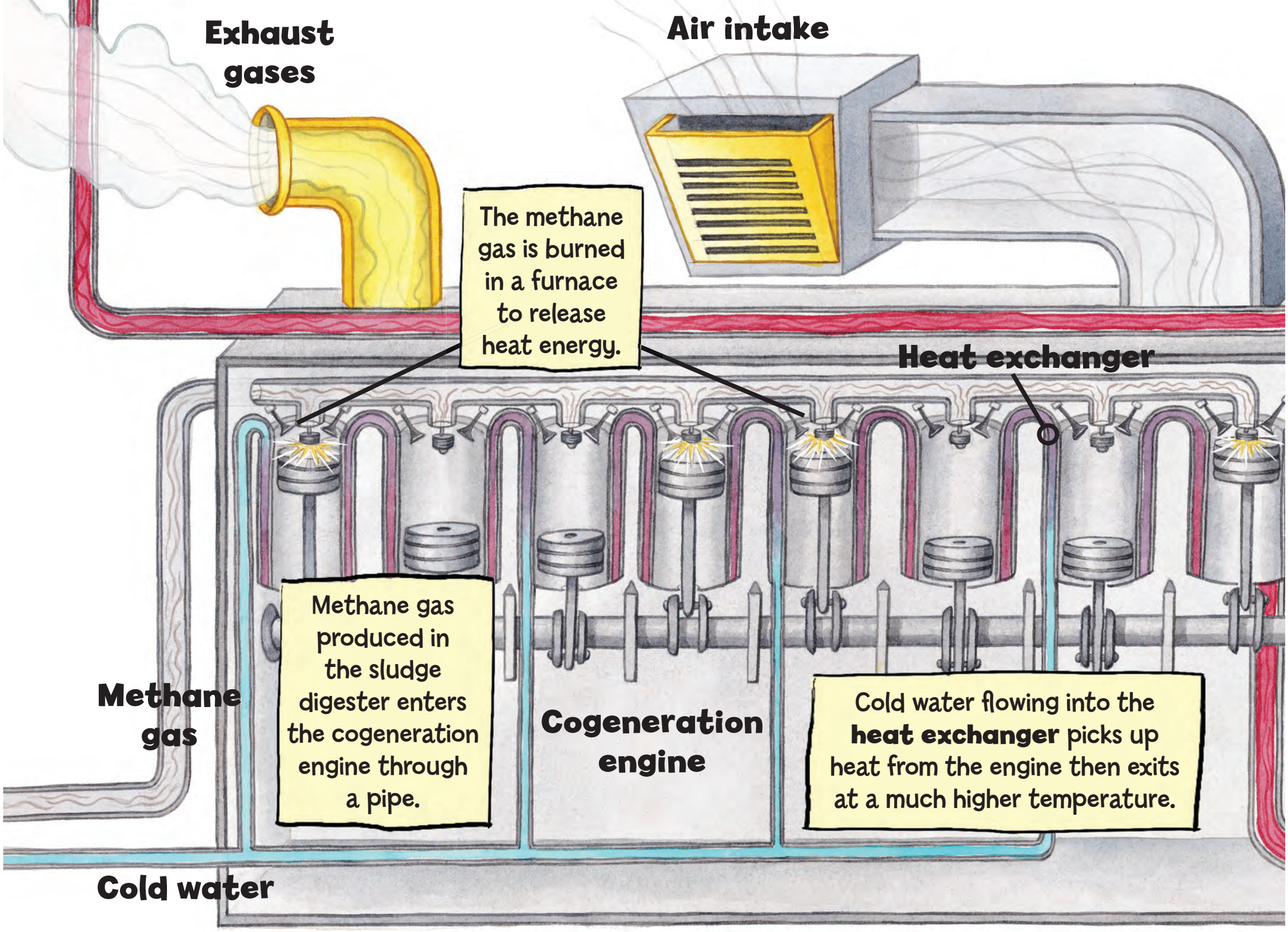
Biosolids may be beneficially used to restore land such as former **quarries**, or are recycled and applied as **fertiliser** to improve and maintain soil quality.

Biosolids storage building

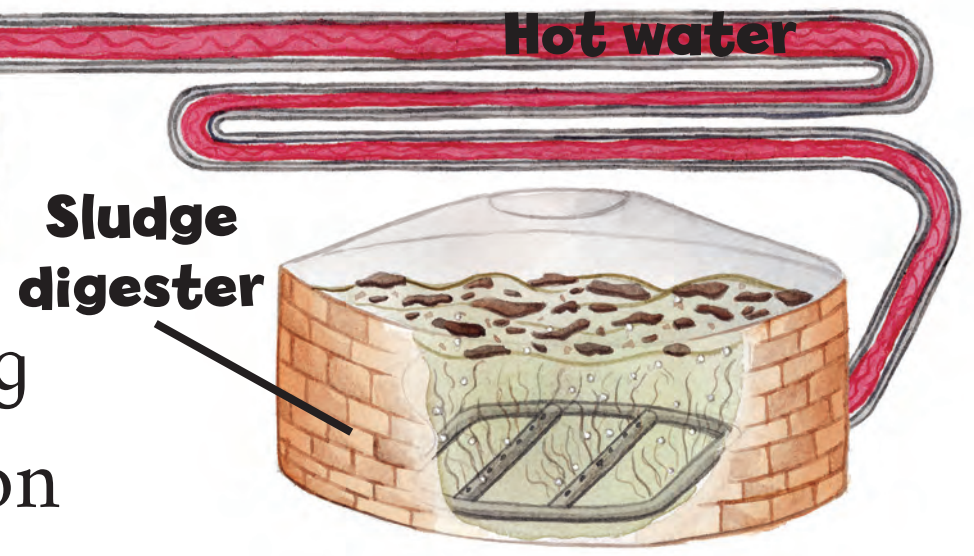
Biosolids are taken away by truck for land restoration.

Can you do anything useful with the material that comes out of the wastewater treatment plant?

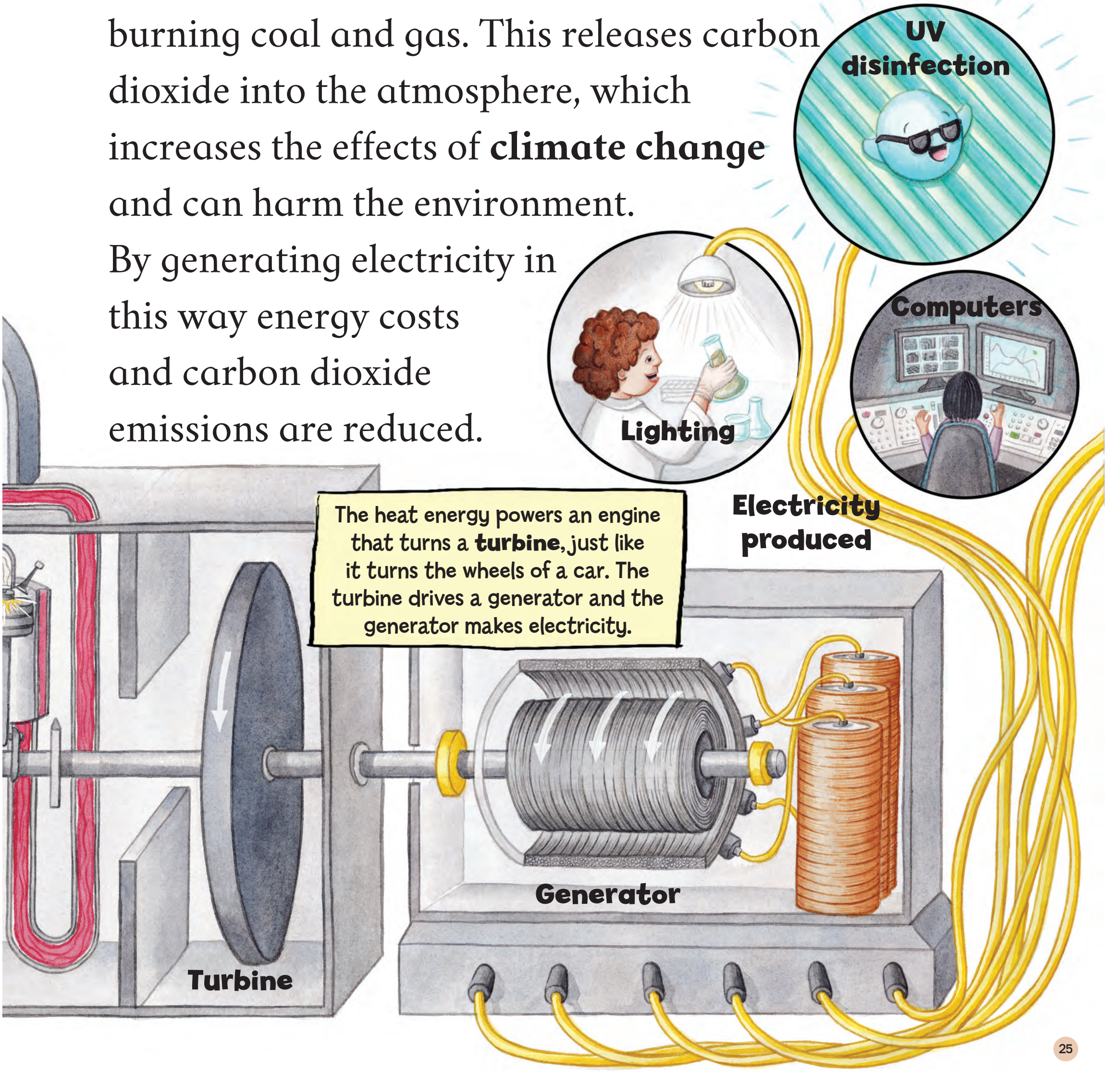
Biosolids are the solid organic materials that are produced during the wastewater treatment process. Because they are **nutrient-rich** and treatment has removed any dangerous microorganisms and odours, they can be used as fertiliser to improve the soil for farming and growing trees. **Methane** gas produced in the sludge digesters can be used to make electricity.



The hot water is used to heat the sludge entering the sludge digester, as shown on page 20.



The electricity made by burning methane gas in the cogeneration engine can be used to treat more wastewater. This means less power is needed from the **national grid**. Some of the national grid electricity is produced by burning coal and gas. This releases carbon dioxide into the atmosphere, which increases the effects of **climate change** and can harm the environment. By generating electricity in this way energy costs and carbon dioxide emissions are reduced.



THE WASTEWATER JOURNEY

Trunk sewer

Interceptor

Raw wastewater

Screening bin

Pump station

Fine screening

Grit removal

Primary sedimentation tanks

Gravity belt thickener

Centrifuge dewatering

Gravity thickener

Biosolids

To land restoration

Reactor
Clarifier
Filter
Ultraviolet disinfection
Intertidal basin
Dissolved air flotation
Cogeneration engine
Anaerobic digestion
Electricity produced
Treated wastewater
Land restoration
Hi Sam. It looks like you made it safely to the end of your wastewater treatment journey.
Yes I did, Flo. Wow! You're evaporating again. Perhaps I'll see you the next time it rains.

Only toilet paper, pee and poo should be flushed down the loo!

What should go where?

Can you sort these items for the toilet and the rubbish bin?

Discussion questions

1. Would you like to be a night soil collector?
2. Why do you think Sam travelled in a submarine through the wastewater treatment system?
3. How can we stop fatbergs building up in our wastewater pipes?
4. What do you think superbugs (also known as *Euplotes*) look like? How could you find out more about them?

Visit www.waterforlife.org.nz for downloadable teacher's resources.

GLOSSARY

Acid - A chemical compound that tastes sour and forms a water solution which turns blue litmus paper red.

Activated sludge - A thick, soft substance used for removing pollutants from wastewater by a biological action involving oxygen.

Aeration - The process in which air is circulated through, mixed with or dissolved in a liquid or substance.

Aerobic - Living, active or occurring only in the presence of oxygen.

Ammonia - A colourless gas that is a compound containing nitrogen and hydrogen. It has a sharp smell and taste and is used to make some cleaning products.

Anoxic - A description of the environment without oxygen.

Bacteria - Very small living organisms made of only one cell that are present everywhere (the air, the soil, on the skin). Many types of bacteria can cause diseases but others can be helpful to humans.

Belt conveyors - Continuously moving porous belts used to move the sludge along.

Biodegradable - Able to break down with the help of bacteria or other living organisms.

Biofilter - A filter bed where microorganisms help break down the particles in wastewater.

Biological processes - Where microorganisms, usually bacteria, are used to break down organic matter in wastewater.

Carbon dioxide - A colourless gas. It is made up of one carbon and two oxygen atoms. People and animals breathe out carbon dioxide.

Centrifuge - A machine that turns a container around very quickly, causing the solids and liquids inside it to separate by centrifugal force.

Chemicals - Any substance consisting of matter, including any solid, liquid or gas. They can be natural or man-made.

Cholera - An infectious and often fatal (can cause death) disease of the small intestine caused by drinking water containing the cholera bacteria. It causes severe vomiting and diarrhoea.

Climate change - When there is a big difference in normal climate patterns over a long amount of time.

Cogeneration engine - An engine that burns fuel to produce heat and electricity.

Compartments - Separate parts or sections.

Compressed air - Air that is under pressure greater than that of the atmosphere.

Congealed - Become semi-solid, especially once cooled down.

Contaminants - A substance that is where it shouldn't be and may be at high enough levels to have a bad effect on our health or on the health of animals or plants.

Conveyors - Pieces of equipment that move materials from one place to another.

Debris - Scattered pieces of rubbish or remains.

Dewatered - Remove water from.

Dewatering plant - A place where water is removed from solid material.

Disinfected/disinfection - The process of cleaning items to destroy disease-causing germs.

E. coli - A bacterium commonly found in the intestines of humans and animals. Some types can cause severe food poisoning.

Exhaust gases - Gases produced by burning fuel such as natural gas, petrol, diesel, fuel oil and coal.

Fatberg - A mixture of fats and items such as wet-wipes, nappies and other waste flushed down toilets that have congealed into a solid lump.

Fertiliser - Something added to soil to help plants grow.

Filter/filtered - Material through which liquids can be passed so the fluids are separated from solid pieces of matter.

Generator - A machine that converts one form of energy into another, especially mechanical energy into electrical energy.

Giardia - A microscopic parasite found worldwide, particularly in areas with poor sanitation and unsafe water.

Gravity - The force of attraction between all masses in the universe, especially the attraction of the earth's mass to bodies near its surface.The further a body is from the earth's surface, the less gravitational force is acting on it.

Grit classifiers - Bins used to separate grit from organic matter and water.

Gully trap - A basin raised off the ground which receives piped wastewater from the kitchen, bathroom and laundry before it is emptied into the sewer.

Harbour - A place on the coast where ships may moor, safely protected from rough seas.

Heat exchanger - A device used to transfer heat between two or more fluids. It can be used to cool and heat.

Helical scroll - A spiral screw that moves solids along the centrifuge.

Hopper - A container that is used for pouring material into a machine or opening.

Interceptor sewer - Part of a sewer network that helps to control the flow of wastewater to the wastewater treatment plant. It receives the wastewater from trunk sewer lines.

Interstage - Between stages.

Intertidal basin - An enclosed water area that holds treated water until the tide comes in.

Land restoration - The process of returning the land to how it used to be after some activity on the land has caused damage, such as quarrying or industrial use.

Liquids - Substances that flow and can be poured. They take the shape of the container in which they are held.

Manure depot - A place for the collection of human waste.

Media - The substance in which an organism lives or is grown.

Methane - A colourless, odourless gas that is lighter than air.

Microbes - Microscopic living things that cause disease.

Microorganisms - Tiny organisms, especially bacteria, protozoa and viruses.

Microscopic - An object so small it cannot be seen without the use of a microscope.

National grid - A system of special wires that takes electricity from power stations, where electricity is made, to all parts of a country.

Night soil collector - A person who used to collect human waste from people's houses, usually at night.

Nitrates - Chemical compounds that contain oxygen and nitrogen which are used in fertiliser.

Nitrogen - A gas with no smell or colour that makes up about 78 per cent of the earth's atmosphere. It is essential for growth and reproduction in both plants and animals.

Non-dispersibles - Things that do not break apart quickly when put in water.

Nozzles - Spouts at the end of pipes, hoses or tubes used to control jets of gas or liquid.

Nutrient-rich - Containing carbohydrates, proteins, fats, vitamins, minerals and fibre.

Odour - A smell.

Organic - Derived from living matter.

Organic matter - Dead plant or animal material. It can also include living microbes and living parts of plants such as roots.

Outhouse - A small shed, separate from the main building, which is built over a bucket toilet or hole in the ground.

Oxygen - A gas with no smell or colour that makes up around 21 per cent of the earth's atmosphere and is needed by animals, humans and plants to live.

Particles - Tiny bits of matter that make up everything in the universe.

Pathogens - Tiny living organisms, such as bacteria or viruses, that make people sick.

Perforated - Pierced with holes.

Phosphorus - A poisonous white or yellow substance that glows in the dark and burns when air touches it.

Physical and mechanical processes - These involve processes such as sedimentation, skimming off floating materials, aeration and filtering.

Polymer - A long or larger molecule consisting of a chain or network of many repeating units. This is formed by chemically bonding together many identical or similar molecules.

Porous - Having small holes that allow air or liquid to pass through.

Protozoa - These are small living things that have one single cell. Most are so tiny that they can only be seen using a microscope.

Public wastewater network - The collection system for carrying liquid waste including sewage through pipes.

Pump stations - Buildings with machinery for pumping liquids from one place to another.

Purifying - To make pure.

Quarries - Places, usually large deep pits, from which stones or other materials have been taken out.

Raw wastewater - Wastewater before it receives any treatment.

Rotating - Turning in a circle around a fixed point.

Screens - Mechanical filters used to remove large objects such as rags, paper, plastics and metals.

Sedimentation - The process in which material from a liquid settles to the bottom of a container.

Sewage - Waste matter, such as pee and poo or other dirty water from homes and factories, which flows away through wastewater pipes.

Sludge - A thick , soft, wet mud.

Sludge blanket - A layer of thicker sludge.

Solids - Substances or objects made up of closely packed molecules that stay the same shape whether in a container or not.

Submarine - A type of ship that can travel both above and below the surface of the sea.

Sulphur - A pale yellow chemical.

Suspended solids - Small solid pieces that float in water.

Trunk sewer line - A sewer line that receives wastewater from many smaller sewer lines.

Turbine - An engine that provides continuous power because a wheel is continually turning due to pressure from fast-moving water, gas or steam.

Typhoid - A disease caused by bacteria. It is passed on through contaminated food and drinking water. It causes a high fever, red spots, vomiting and diarrhoea.

Ultraviolet light - Waves of light that come from the sun.

Waste activated sludge - The part of activated sludge that is removed to keep the biological system in balance.

Wastewater - Any water that has been affected by human use.

Weir - A low, wall-like structure used to direct the flow of water.