

Smoke and steam

*Could smoke from
the mine
harm the people of Lihir?*

*This leaflet
explains all about
smoke and
steam*

There has been some misunderstanding about the effects of the smoke and steam from the mine on the people and gardens of Lihir.

There is not enough smoke of any kind on Lihir to cause harm either to people or the environment.

Read on to find out why. >>

Smoke, steam and humidity

To understand the effects of smoke on Lihir we will look at:

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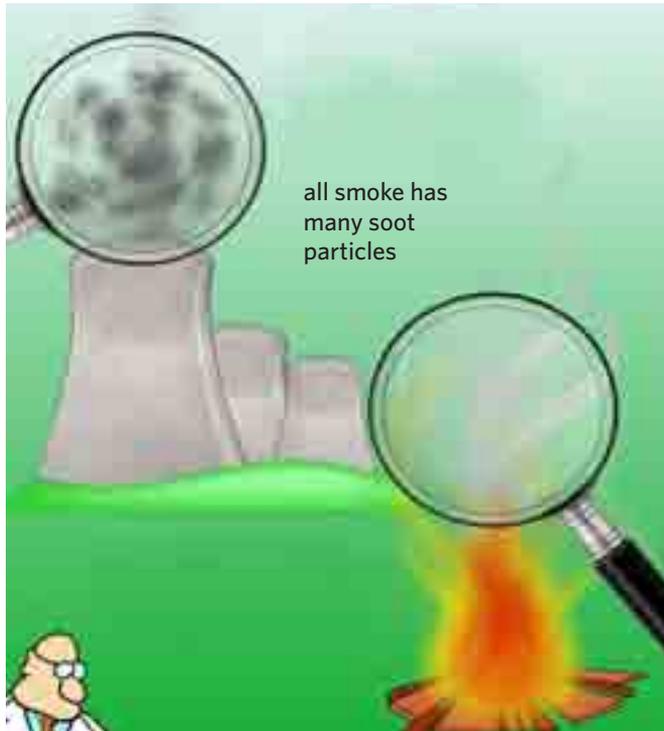


Read the smaller text in the blue bar at the bottom of each page if you want to understand the detailed scientific explanation. >>

1 What is smoke?



Smoke is caused by burning things like wood, petrol or oil. Smoke is made up of **gases**, such as carbon dioxide, which are invisible, and tiny **soot particles** (specks of dirt) which are visible. The more soot particles there are in the smoke, the more visible the smoke is.



Smoke and combustion

Smoke is a mix of **gases** (including carbon dioxide and **water vapour**) and tiny particles (called **soot**) produced by burning wood, leaves, dried plant material, coal, and liquid fuels such as diesel, kerosene or petrol.

The chemical reactions that take place when things burn always require oxygen, and always release energy in the form of heat and light.

Burning is also known as **combustion**.

There are different kinds of gases that are produced by burning these substances, such as carbon dioxide (CO₂), sulfur dioxide (SO₂), and even small amounts of water (H₂O), and these are all invisible.



Four pictures of smoke pollution in China.



Burning wood or coal tends to produce more **soot** (which gives the smoke a white or brown or black colour) than burning petrol. Some of this smoke can be seen in photographs taken by satellites that fly high above the earth. For example, a lot of smoke can usually be seen over China, where there are thousands of factories, as well as many millions of people who burn coal to keep warm. You can see the smoke in the satellite image (below), taken from high above the Earth, which shows the smoke and **smog** (smoke plus fog) hanging over China, Hong Kong and Taiwan.

In many industrial countries coal is burned to produce electrical power. Coal can often have high concentrations of sulfur compounds which result in a lot of sulfur dioxide (SO₂) being present in the smoke when it is burned. This is one reason why acid rain is a big problem in these countries.

Read all about acid rain in Leaflet 1



Explanation of the satellite image of China

This picture of China was taken from a satellite called SeaWiFS (which stands for Sea-viewing Wide Field-of-view Sensor). This satellite orbits the earth at 705km altitude and specialises in detecting plankton and sediments in the ocean. Because it has such a wide field of view, it is also able to take pictures of big areas such as this image which includes most of mainland China. The smoke pollution can be seen clearly in this image as a thin greyish-white layer, which looks quite different from the bright white clouds.

2 Is there any dangerous smoke on Lihir?

There are four kinds of smoke on Lihir:

- 1 smoke from kitchen fires
- 2 smoke from garden fires
- 3 smoke from generators and blasting at the plant site
- 4 smoke from motor vehicles.

There is not enough smoke of any kind on Lihir to cause harm either to people or the environment.

Smoke can make people cough if they breathe it in too deeply.



Smoke from garden fires



Kitchen fire smoke



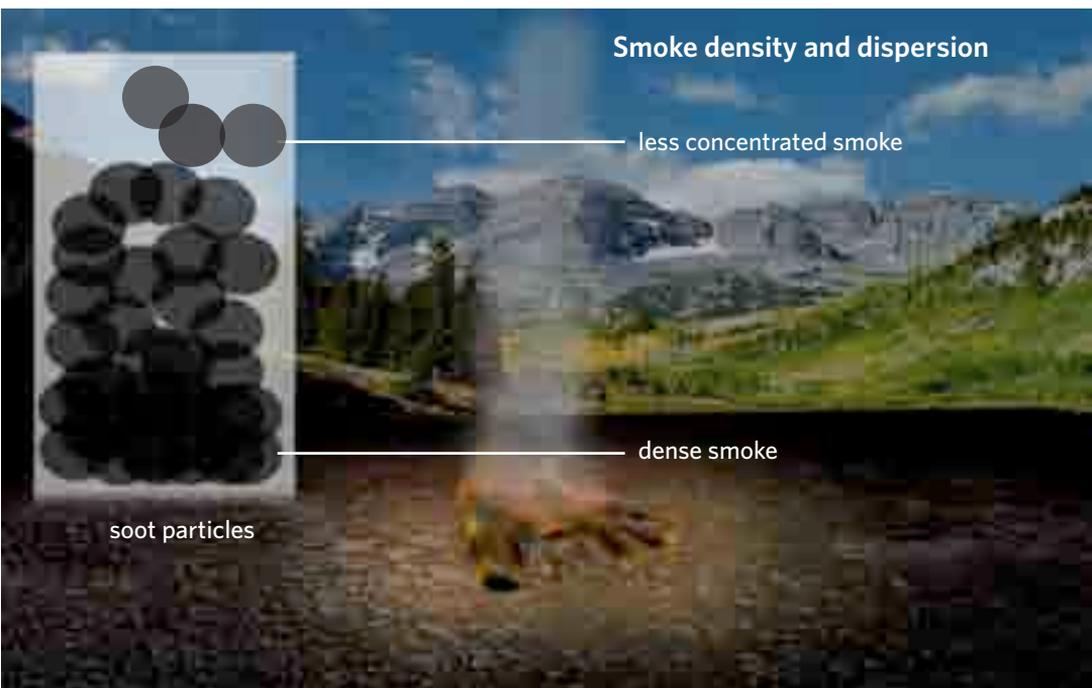
Generator smoke



Smoke from blasting at the mine site

3 What happens to smoke?

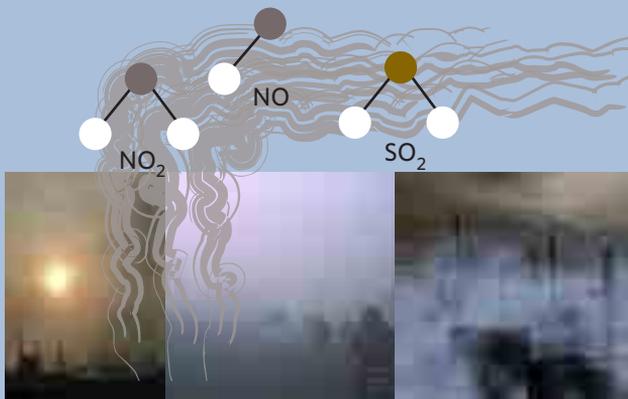
The further smoke moves away from the fire that produces it, the less **concentrated** it becomes because the soot particles spread further apart. Small amounts of smoke, such as the smoke from a kitchen fire, or a cigarette, spread out into the air very quickly as the smoke rises and **disperses** in the wind. This process is called **dilution** — it results in a decrease in the concentration of the smoke.



Smoke pollution

If there is a lot of smoke and not much wind, the smoke can build up in the air surrounding a village or town or city, and cause **pollution** problems, like smog and acid rain.

Read Booklet 1 to learn more about pollution and acid rain.



4 Concentration and dilution

Dilution is the process of becoming **less concentrated**. If we **dissolve** one spoon of sugar in a cup of tea, this is less concentrated than five spoons of sugar in one cup of tea. The same idea can be applied to smoke. Smoke is more concentrated right above a kitchen fire than when it is 500 metres away from the fire, because as it moves away from the fire it spreads out and **disperses**. If we follow the smoke eventually its concentration will be so small we will not be able to tell if it is still there. This is because the smoke has **diluted**.



concentrated smoke

What is meant by concentration?

The **concentration** of any substance is the weight of that substance divided by the volume of another substance in which the first substance is **dissolved** or distributed.

For example, the concentration of sugar in water can be calculated by the weight of the sugar divided by the volume of the water.

Chemicals in smoke and steam on Lihir

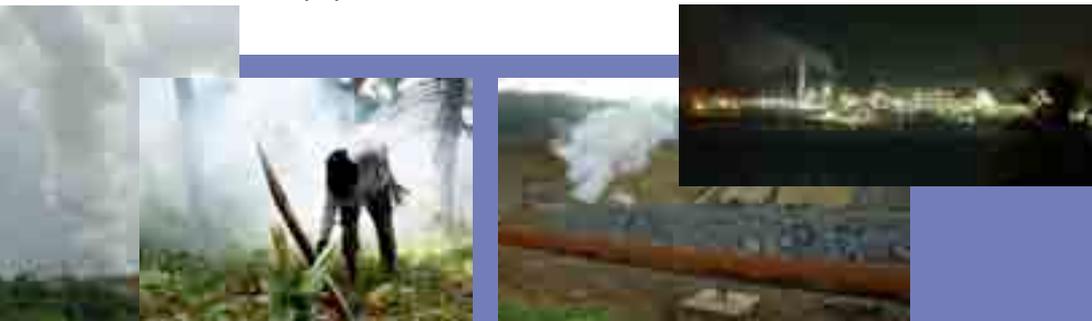
The smoke from the generator contains CO_2

The volcanic steam at Lihir contains significant concentrations of naturally occurring sulphur dioxide SO_2 .

The water which condenses from the geothermal plant contains sulphuric acid which is then neutralised in the cooling tower.

Glossary for smoke and steam

- combustion** another word for burning.
- concentration** the amount of a substance in a particular volume of liquid or gas.
- condensation** when water changes from a gas form to the liquid form, usually as a result of a decrease in temperature.
- de-watering** a safety process to allow naturally occurring volcanic steam to escape from the ground through pipes into the atmosphere.
- dilute/dilution** to make something less concentrated.
- disperse** to spread out; when particles become further apart from each other.
- dissolve** to become absorbed into a liquid so as to form a solution.
- evaporation** the process by which water changes from a liquid to a gas. Evaporation is faster at higher temperatures.
- fossil fuels** fuels such as coal, crude oil, and natural gas, which are formed from ancient plants that have been buried for long periods of time (millions of years), and have been transformed by great pressure. The sediments that these plants were originally embedded in have been turned into rocks by the great weight of additional sediments that have been deposited on top of them over very long periods of time.
- gas** any air-like substance that moves freely to fill any space available.
- gaseous** like a gas.
- pollute** to contaminate or make the environment foul or filthy; to destroy the purity or sanctity of something.
- pollution** something that pollutes.
- smoke** a mix of gases and particles generated by fire.
- smog** a mix of smoke and fog, common in colder industrialised countries.
- soot** tiny solid particles produced by fire, made up mostly of pure carbon.
- steam** the gaseous form of water produced when water is boiled.
- water vapour** the gaseous form of water. When water molecules are floating around freely by themselves in the air.



5 Steam and condensation

Steam is different from **smoke** and clouds. Steam is pure **water vapour**, the **gaseous** form of water, generated by **boiling**, whereas clouds are formed as water **evaporates** at temperatures lower than boiling point (100°C). When steam is very hot it is invisible. It only becomes visible as it cools down or **condenses**, and turns back into water droplets again.



The science behind steam

Steam is generated when water is heated to boiling point, above 100° centigrade. When steam is still very hot it is invisible. If you boil some water you will notice that just above the bubbling water you can see nothing. As the steam rises it cools, **condenses** and becomes visible again like white smoke. The **water vapour** in steam is different to that in clouds because it is hot and not mixed with air.

Steam will **condense** after contact with cooler air or cooler objects. The water molecules, which were separated because of the heat, join together again as the steam condenses to form tiny droplets of water that are visible. If water is boiled with other substances mixed in it, for example alcohol, then the steam may contain some of these other substances.



On Lihir there are many examples of steam rising from the earth. Read on to find out what causes this. >>



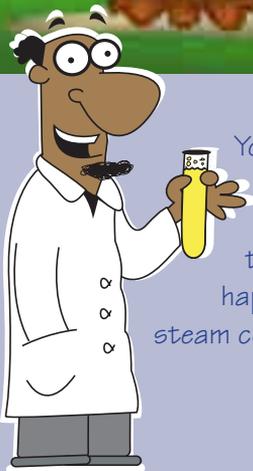
steam

water droplets
condensing



steam

steam
condenses
to water
droplets



You can do a simple experiment to test what happens when steam condenses.

Experiment

Boil some water over a fire. Catch the steam, for example in a large plastic bag, and you will see the steam **condense** and turn back into droplets of water as it hits the cool surface of the bag and cools down.

6 Volcanoes and steam



Steam in Kilauea Iki caldera, Hawaii, generated by rainwater contacting hot rocks 200m below the surface.

The steaming creek at Kapit and the steam on the beach at Niolam is smelly because it is high in sulphur.

In places where there is volcanic activity, the ground can be very hot. This is the case on Lihir Island in PNG, and many other Pacific Islands. The whole area around the Lihir mine and the stockpiles on Niolam is volcanically **semi-active**. Semi-active means the ground is so hot that it turns underground water to steam, but the volcano is not about to erupt.

At Lihir there is also a dome-shaped geological formation called **cap-rock**, which acts like a lid on a steaming pot. The cap-rock traps steam underground, where it builds up a lot of pressure. There have occasionally been explosions at the mine caused by the steam escaping when mine workers penetrated the cap-rock. This is why the mining company pushes pipes deep into the ground, below the cap-rock, to release the steam, see page 11, the **de-watering project**. If there is a lot of sulfur in the hot ground, small amounts of sulfur will also be present in the steam that can be seen emerging at the surface.

Why is the ground so hot inside the pit?

The ground that is being mined for gold inside the pit is very hot because it is part of an old volcano that is still hot.

The volcano is not about to erupt, but because of the way that volcanic activity changed the structure of the earth in the past, a large amount of heat from the earth's

mantle is reaching the surface layers of the crust even now. It seems that gold is often (though not always) found where there has been volcanic activity in the past.

7 The de-watering process at Lihir



Plumes of steam are released all around the rim of the mine pit.

The big plumes of steam around the mine site are part of what is called the **de-watering project**. The purpose of this project is to safely allow the volcanically super-heated water under the ground in the pit to be released as steam, so that the miners can dig up the ore without having to deal with the hot water. They drill deep holes into the earth and put pipes into them, allowing the water, that is very hot (the temperature is higher than the boiling point of water, 100 degrees) to be released as steam away from where the miners are working. These pipes produce the plumes of steam that we can see escaping into the air all around the mine site. The water level under the ground then gets lower, because the water is being gradually removed in the form of steam. The steam on Lihir is quite **acidic** because of significant concentrations of naturally occurring sulphur dioxide which forms sulphuric acid in the steam.



The de-watering pipes release plumes of steam all around the mine site, to make working in the pit safer.



8 The geothermal power project at Lihir

Since 2003 the Lihir Mining Company has been harnessing the natural volcanic steam to generate electricity through the **geothermal power project**. Instead of letting the steam escape up into the atmosphere, the company is now capturing steam through a system of pipes, and piping it to large **steam turbines** in the geothermal power plant. The pressure of the steam going through the turbines forces them to spin, which turns the generator converting the thermal energy in the steam into electricity. The electricity is used to power the gold processing plant.

The steam turbine turns the generator to produce electricity.

Geothermal power is 'clean' power because it does not emit carbon dioxide into our atmosphere like the previous oil-burning generators. Because carbon dioxide causes global warming and climate change, this is a good thing for the rest

of the planet as well as Lihir.

Geothermal power has not yet completely replaced the oil-burning generators at the Lihir mine site, but it has reduced the number of generators from 12 to 3, along with the company's fuel bill, and the total amount of carbon dioxide emitted by the mining operation.



Steam turbines

A **turbine** is a shaft with a series of fans on it, which is enclosed inside a chamber. The jet engines on aircraft are a type of gas turbine, driven by the **combustion** of aviation fuel (kerosene) rather than steam. In steam turbines there are two sets of fans on each end of the shaft (see picture). The piped steam enters the chamber at the centre and

is forced outward, through the fan blades in both directions. Because the steam is under such high pressure, it acts like a powerful wind causing the fans to spin at high speed. The fans spin the shaft, which is connected to an electrical generator that produces the electrical power. The steam is then condensed and cooled in the cooling tower.

9 Time to check how much you've learnt



Answer the questions below to see how well you understand smoke and steam and the concepts of concentration, dilution and condensation.

- 1 Name two things that make smoke different from steam.
- 2 Name four different common sources of smoke on Lihir island.
- 3 What happens to smoke when it becomes diluted?
- 4 What is meant by concentration?
- 5 What happens to steam as it cools ?
What is the difference between steam and water vapour?
- 6 What causes steam to come out of the ground at Lihir?
- 7 What does the de-watering process do?
- 8 How does the geothermal power plant work?

Now, answer the question asked on the front of this booklet:

Could smoke from the mine harm the people of Lihir?

