Burn Brighter this Winter

Air Quality/Wood Smoke Teaching Session For Secondary School

Department of Primary Industries, Parks, Water and Environment
EPA Division

Tasmanian Government

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EPA Division, Department of Primary Industries, Parks, Water and Environment
GPO Box 1751
Hobart 7001
Telephone: (03) 6165 4599
Email: EPAenquiries@environment.tas.gov.au
Web: www.epa.tas.gov.au

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Teaching Session – Secondary

FOR GRADES 7–10

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Background Information for Teachers

Domestic wood smoke is known to cause significant adverse health impacts among some members of the community. The EPA Division of the Department of Primary Industries, Parks, Water and Environment runs a community education program called *Burn Brighter this Winter* which seeks to teach wood heater owners how to operate their wood heater so as to reduce wood smoke in the atmosphere, thereby improving public health outcomes for the Tasmanian community.

This engagement program is part of a broader program called the Domestic Smoke Management Program (DSMP) which was developed to help support the Tasmanian Air Quality Strategy (2006).

How wood smoke affects a person depends on the person's health, age, as well as the amount and time they are exposed to smoke. The Tasmanian Department of Health and Human Services (DHHS) provides information on the potential health impacts of wood smoke exposure. The Department also directs people to the EPA Division real time data on air quality around the State.

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A study led by Dr Fay Johnston of the Menzies Research Institute (Johnson 2013) found that smoke pollution increases both morbidity (sickness) and the death rate in the community. In many towns and cities in Tasmania, levels of wood smoke are higher than nationally agreed levels for many days of the year.

Research indicates that targeted education programs, backed up by appropriate regulations, can be effective in changing the practices of wood heater users, leading to a reduction of excessive emissions of smoke from poorly operated heaters (Ling 2004).

With this in mind, the Tasmanian Government community education program, *Burn Brighter this Winter,* was introduced. It is now in its fifth year in 2016 and target areas have, to date, been East Launceston, West Hobart, Hadspen, Geeveston, Meander, Longford and in 2016, Glenorchy.

Staff from the EPA Division have complemented the *Burn Brighter this Winter* program with school visits in target areas and developed a teaching session for secondary school teachers (below), addressing various aspects of the Australian Curriculum (Science) as at 2016.

How the package addresses areas of the curriculum (Science) is outlined in the table that follows.

Year Level	Aspect of Wood-smoke education session, applicable to years 7-10	Australian Curriculum Code- Science (as at 2016)
Year 7	• Students participate in a practical experiment about inversion layers and interpret that experiment • Students learn about new scientific research relating to the health impacts of wood smoke	ACSSU 117 ACSHE 119
Year 8	• Students learn about the respiratory system and participate in a practical experiment about lung capacity • Students learn about new scientific research relating to the health impacts of wood smoke	ACSSU 150 ACSHE134
Year 9	• Students learn how the respiratory system works and can respond to changes to the environment • Students learn about full and incomplete combustion of wood and its role in energy transfer/home heating • Students learn about new scientific research relating to the health impacts of wood-smoke • Students learn how in some towns and cities, residents have a higher incidence of respiratory and cardiovascular disease, and appreciate why scientists are now there studying the ambient air quality • Students use a digital moisture meter to measure the moisture levels in wood samples	ACSSU175 ACSSU179 ACSHE157 ACSHE228 ACSIS166
Year 10	• Students learn about the chemistry of combustion and the types of products that can result from full and incomplete combustion • Students participate in a practical experiment about inversion layers and interpret that experiment • Students learn about new scientific research relating to the health impacts of wood smoke • Students learn how in some towns and cities, residents have a higher incidence of respiratory and cardiovascular disease, and appreciate why scientists are now there studying the ambient air quality • Students use a digital moisture meter to measure the moisture levels in wood samples	ACSSU187 ACSSU229 ACSHE191 ACSHE230 ACSIS200

Burn Brighter this Winter

Guided lesson adaptable for Grades 7-10

This lesson includes suggested teacher scripts with prompting questions (marked as "Q") and recommended answers *(*marked as *"A" in italics),* and mini science experiments.

You will need: a small glass, a large glass (large enough to fit the small glass inside it), a wine cork, water, a tray, 6 blindfolds, 5 smelly substances and 1 inert material hidden in a box (e.g. smelly vegemite jar or toast, cut onion, half an orange, gum leaves to be crushed, desiccated coconut, smelly sock and one item not smelly e.g a piece of chalk), a bottle of perfume in a spray bottle, 4 glass containers with equal sized necks, blue food dye, yellow food dye, hot and cold water, a piece of thin card, labels, a sink or trough, 1 piece of unseasoned wood, 1 piece of seasoned wood the same size as the unseasoned, a moisture meter or scales to weigh wood, a thick straw and a thin straw, large bowl, a big jar eg. 2 litre, a flexible pipe, water.

Suggested teacher script:
Today we are going to talk about air, how it travels around us, and what happens when air gets polluted with smoke from home wood heaters.
Q. What is air? Can you see it, taste it, smell it?
A. (*Usually not, sometimes*)

Can I have a volunteer to blow up a balloon, and tie a knot at the bottom?

Q. What changes have occurred to the balloon?
A*. (Increase size, walls rigid, misty inside)*

Q. What has caused this?
A. (A*ir from our lungs*)

Q. Describe the air
A. (*It has no colour, it is lightweight)*

Q. Why are the walls misty?
A. (*Water from our breath)*

Air is all around us isn't it? But usually we cannot smell or taste it …but it does take up space. I will show you an experiment with a large glass, a small glass, a cork and some water.

Method:
On the tray, half fill the large glass with water, float the cork on top of the water, invert small glass on top of the water, push down.

Suggested teacher script:
Q. Can anyone see what has occurred?
A. (*The air pushes the water outside the small glass, so the air can push the water out of the way – this is just a reminder that the air takes up space)*

Now we might **add** something to the air, and sense if we can detect some things we add to the air.

Method:
Ask for 6 volunteers from the class. Provide them each with a blindfold. One at a time, blindfold each child then give each of them one item from the box to smell and identify, while blindfolded. Ensure the rest of the class keeps quiet! If you didn't want to bring in a dirty sock, bring a clean one in but just pretend you are going to use it!

Suggested Teacher Script:
Q. Which ones were the easiest to smell?
A. (*Chalk is the least smelly*)

Q. How did the particles of 'smell' get to our noses?
A. (*Through the air*)

Suggested teacher script:
You can see that we can add things to the air. The small, invisible particles that make up the smell move in a process called 'diffusion'. As they reach us, the smells are detected by special cells in our nose. It is like when we smell the sausages cooking when your next door neighbor has a barbeque! The particles are invisible, but moving.

I have another diffusion experiment.

Method:
Ask for 5 more volunteers - stand them in a line, one behind the other, facing away from the class, with person #1 being furthest from the class and person #5 being closest. Tell the volunteers to put their hand up as soon as they smell something new. Do not tell them what they should smell. Then squirt perfume in the volunteers' direction, about 2 metres away from the closest person (#5). Ask the class how the result came about (*normally the closest person to the perfume smells it first, but not always!*)

Suggested teacher script:
Q. Why did the farthest people in the line detect it last?
A. (*The molecules dissipated*)

Q. What if I had a fan going, and directed the perfumed air away, in the opposite direction to our volunteers, would these volunteers still smell it?
A. *(Probably not)*

Sometimes, we can smell things in the air which are natural, but sometimes things in the air are the result of human activity, and can be harmful. They might affect our health and comfort – they are known as POLLUTANTS.

Q. Can anyone think of a pollutant in the air, derived from humans?
A. (*Car fumes, smoke from factories*)

You might say that wood smoke is a natural component of our air, but in the concentrations that it occurs in cities and some towns, it can cause health problems, especially in the very young, the elderly or people with heart and lung disease.

Suggested teacher script:
Sometimes we cannot smell, taste or see pollutants, but sometimes we can. Sometimes their particles are big enough that we can see them floating in the air (like wood smoke particles) and sometimes we cannot see them (like car fumes, or our vegemite toast!) The larger, invisible air particles that scientists test are called PM10 (10 millionths of a metre) and they also test smaller particles, which in some cases can be more damaging and pass from the lungs to the blood system – these are called PM2.5 (2.5 millionths of a metre).

So, wood smoke contains particulate matter (PM10 and PM2.5), toxic volatile organic compounds (VOCs), carbon monoxide, aldehydes, benzene, toluene, nitrogen oxides and more. Some of these chemicals are hazardous in large doses. The health effects of PM10 and PM2.5 include: increased mortality (deaths); increased respiratory diseases such as inflammation of the lungs and increased respiratory illness (e.g. bronchitis, asthma) and symptoms (e.g. cough); adverse effects on the cardiovascular system (circulation); and increased medication use and hospitalisation. The very young, the elderly or people with heart and lung disease are particularly susceptible.

There are many towns and cities in Tasmania, including Launceston, Hadspen, Longford, New Norfolk and Geeveston, which have very high levels of wood particulates. (There is a national standard for particulates, measured over a 24 hour period. Longford, for example, exceeded this standard 45 days in the winter of 2013, and Launceston 14 days). The national standard for the amount of PM10 particles that are in the air is 50 micrograms per cubic metre over a 24 hour period.

Draw this on the board e.g. a representation of a cubic metre with dots in it. If these dots weigh more than 50 micrograms per $m^{3,}$ then the limits are exceeded. There are daily spikes – morning and dinnertime, but scientists take a daily average.

Does anyone in this class, or anyone you know, have asthma? How does it FEEL/what happens to your body/breathing? Do you know what triggers it? Some people's asthma is triggered by things such as dust mites, but aggravated by wood smoke – and sometimes people have to go to hospital because of it. Some people can't go outside on days when there is lots of wood smoke.

Let's take some time to learn how the respiratory system works.

(Watch the first 10 minutes of the Bill Nye the Science Guy youtube https://www.youtube.com/watch?v=4XVzKGC11Ic Alternatively draw the trachea, bronchus, bronchioles, alveoli and talk about pathways of air, the gas exchange

between alveoli and blood vessels, the moisture in lungs, and the role of the diaphragm).

Suggested teacher script:
Sometimes we are lucky enough not to be in the path of pollutants, because the wind disperses them, but often, being in the path of pollutants is unavoidable, due to weather conditions and even the topography of the land in our towns and cities. Does anyone live in a valley and the smoke hangs around all day? Obviously this would make it worse for some people.

Sometimes there is an inversion layer, particularly in valleys, where heavy cold air comes down from the hills in the evening and traps the warmer air in the valley so it cannot escape. Once the sun hits the cold air during the day, it warms up and drifts up, releasing any trapped air particles e.g. smoke from wood heaters.

We can do an experiment on inversion layers.

Method:
See https://www.youtube.com/watch?v=LPvn9qhVFbM and try the inversion layer experiment.

You will need 4 glass containers with equal sized necks, blue food dye, yellow food dye, hot and cold water, a piece of thin card, labels, a sink or trough. Discuss. Ensure that the students realise that the experiment with water simulates what happens with air.

Suggested teacher script:
Scientists have figured out that some of the particles from wood heaters that aren't used properly are worse than those from forest burn-offs. So although the forest burn-offs make a lot of smoke, they are only on a limited number of days per year, and wood smoke from home heaters is a different type of smoke, and can go on all winter – even from May to September.

Q. Does anyone have a wood heater at home?
A. (*Yes/no*)

Q. Did you know that a well operated wood heater can produce a lot less smoke than one used not so well?
A. (*Yes/no*)

(*Show pictures of smoky chimneys on the next page*)

Q. Do you know how to use a wood heater so you get very little smoke?
A. (*See 4 steps to running a wood heater below)*

Suggested teacher script:
There are 4 steps to running a wood heater without generating a lot of smoke.

1) **Use dry wood** (ask for a volunteer to compare a heavy wet wood sample with dry sample of the same size)

Q. What do we extinguish a fire with – for example, when camping?
A. (*Water*)

Q. Does anyone know what happens when we try to burn wet wood?
A**.** (*It is hard to burn, very smoky*)

People should try to buy dry wood (seasoned) – freshly cut wood from a living tree is about <u>half</u> water. Wood should contain less than 20% water if it is to be burnt.

Let's do an experiment.

Method: If you have a moisture meter e.g. from a hardware store, compare the moisture content of the dry/seasoned wood sample vs. the wet/unseasoned wood sample, using the moisture meter, (or you could use scales to weigh the two pieces of wood) – show the students the digital readouts (%water/weights) from both wood samples.

Suggested teacher script:
Q. How do we dry our wood?
A. (*Airy woodshed, gaps between logs, covered on top)*

2) **Build the fire well**

Q. Does anyone know how to build a fire?
A. (*We need AIR and an ignition source, such as a box of matches, a lighter, friction, or something already burning. We need leaves or paper, small sticks, bigger sticks, logs, air between logs, about 2 cm gap)*

Q. Does anyone know what would happen if we had a fire, we put paper on then giant logs.
A. (*It wouldn't work – smoky).*

3) Open the air vent for 20 minutes

After the fire is lit, when we want to put a new log on, have the air vent/little opening on HIGH for 20 minutes, so the wood burns very well before we shut it down ─ this will reduce the smoke by HALF!

Q. Why?
A. (*When we allow enough air into the fire, we have complete combustion. That means that all the wood is burnt and the only by-products are carbon dioxide and water, no unhealthy gases and particles*. *Incomplete combustion is a reaction or process which entails only partial burning of a fuel. This may be due to a lack of oxygen or low temperature, preventing the complete chemical reaction. Carbon monoxide, nitrogen oxides and other compounds such as toxic volatile organic compounds (VOCs), aldehydes, benzene and toluene are produced as by-products from incomplete combustion of carbon.*

4) Have the flue cleaned

Q. What is a flue? What is it for?
A.(*To vent the gases from a fire but it also allows fresh air to enter it, which aids in providing air to a fire*)

Q. Why clean it?
A. (*To clean out sooty creosote, to make the opening wider to let air in and out*).

Sometimes a householder can elongate their flue and that means less smoke for neighbours.

I have another experiment!

Method: Seek a volunteer – to suck air through a thick straw, then a thin straw – Ask the volunteer which straw is easiest to suck air through – *(thick straw)*

Suggested teachers script:
So, the air needed for the fire cannot be drawn in to the heater through a thin pipe as easily as it can through a thick pipe. A heater will work well if the flue is not clogged with an inner layer of creosote.

A wood heater will be smoky when we first light it, or when we put new wood on it, but not for more than 5 to 10 minutes.

If we make a lot of smoke over a long period of time, then our neighbours may be affected.

Q. Imagine if you opened your window for fresh air, and your neighbour had a smoky chimney. How would that feel?
A. *(Bad if it made you sick; it's not fair)*

Q. Do you know how much air we breathe?
A. (See experiment below)

We could do a lung capacity test.

Method: You will need the large bowl, big jar eg. 2 litre filled with water, a flexible pipe about 50cm long, water.

Nearly fill the bowl with water, invert the jar into the bowl of water, trying not to spill much water from the jar. Feed the pipe through the water into upturned jar above the water surface, take a breath, blow into pipe.

Ask the children what they noticed. Conclude that the water displaced, now as air in the jar, is one lungful.

Suggested teachers script:
Q How many breaths do we take per minute/per hour/per day?
A. (*A teenager breathes 12-16 breaths per minute - calculate how many per hour/per day*).

So, if we are breathing polluted air, even though the pollution is tiny, we breathe a lot, so some of that could enter our lungs. Therefore, if we run our wood heaters well, we might breathe less smoke particles.

When you are inside, you might not notice the smoke from your own wood heater…go out and have a look sometime.

If you see a persistently smoky chimney you can tell your parents and they might contact the local council or the EPA Division and they can provide helpful information to the person with the smoky chimney. The person might not need a new heater, they might just need to learn what you have learnt today - or get a taller flue so that neighbours aren't smoked out!

References

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Resources

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134 Macquarie St HOBART 7000
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