Carbon Monoxide in the Context of the Camping Environment

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Camper Hazel Woodhams died from Carbon Monoxide BBQ fumes

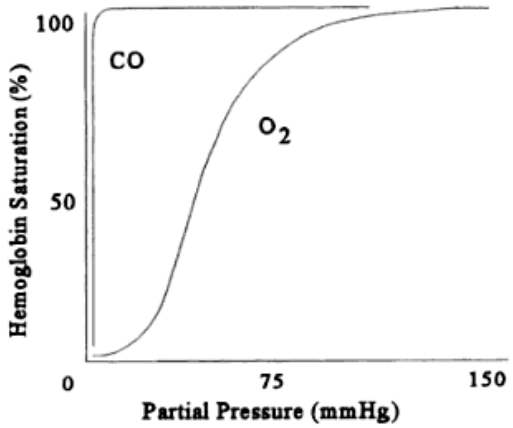
- Hazel Woodhams, 30, was in a tent at Clippesby Hall campsite near Great Yarmouth in July, when she died from carbon monoxide poisoning from a barbecue.
- Her partner, 40-year-old Roland Wessling, suffered severe injuries and spent more than three weeks in Hospital at Gorleston near Great Yarmouth in Norfolk.
- His injuries nearly resulted in him losing an arm due to the poisoning, which also damaged his kidneys.
- An inquest held into Miss Woodhams' death in Norwich heard the charcoal barbecue they had used to cook on filled their tent with toxic carbon monoxide gas overnight after they had brought it inside.
- Mr Wessling woke up disorientated due to carbon monoxide poisoning and called the emergency services.
- Norfolk coroner William Armstrong recorded a verdict of accidental death. He said the tragedy should serve as a warning for people to keep barbecues in the open air

Carbon Monoxide in the Camping Environment

- Carbon Monoxide (CO) is a poisonous gas produced during combustion of fuels containing carbon.
- This can occur when burning any such fuel but this study is focused on charcoal.
- Charcoal BBQs caused death to 17 people in 2012 by carbon monoxide poisoning.
- Many more will have been injured or noticed the symptoms.
- Fatalites ascribed to carbon monoxide result from acute poisoning and those who recover from acute poisoning can suffer long-term effects but chronic poisoning is also possible (the “dizziness of cooks”) following repeated low level exposures.

What Carbon Monoxide does

- Carbon monoxide binds to haemoglobin at the same sites that oxygen does but is held far more strongly forming carboxyhaemoglobin (COHb) (graph taken from Raff – 2003).



- The weak binding of oxygen to haemoglobin is important as otherwise it would not give up oxygen in tissue.
- These effects are complex – it is not simply a matter of CO blocking oxygen from Hb

Symptoms of Acute Poisoning

Carbon monoxide concent	COHb level	Signs and symptoms (derived from Goldstein (2008)
100 ppm		
800 ppm		s within
1,600 p		s, and s than 2
3,200 ppm	50%	Headache, dizziness, and nausea in 5 to 10 min; death within 30 min
6,400 ppm	60%	Headache and dizziness in 1 to 2 min; convulsions, respiratory arrest, and death in less than 20 min
12,800 ppm	>70%	Death in less than 3 min

Aims

The data presented here is part of MSc project from Cranfield University in 2013. The work was performed by the presenter and supervised by the second named author. It focused of the production of CO from charcoal and looks at its effects in tents.

This project had the aim of:

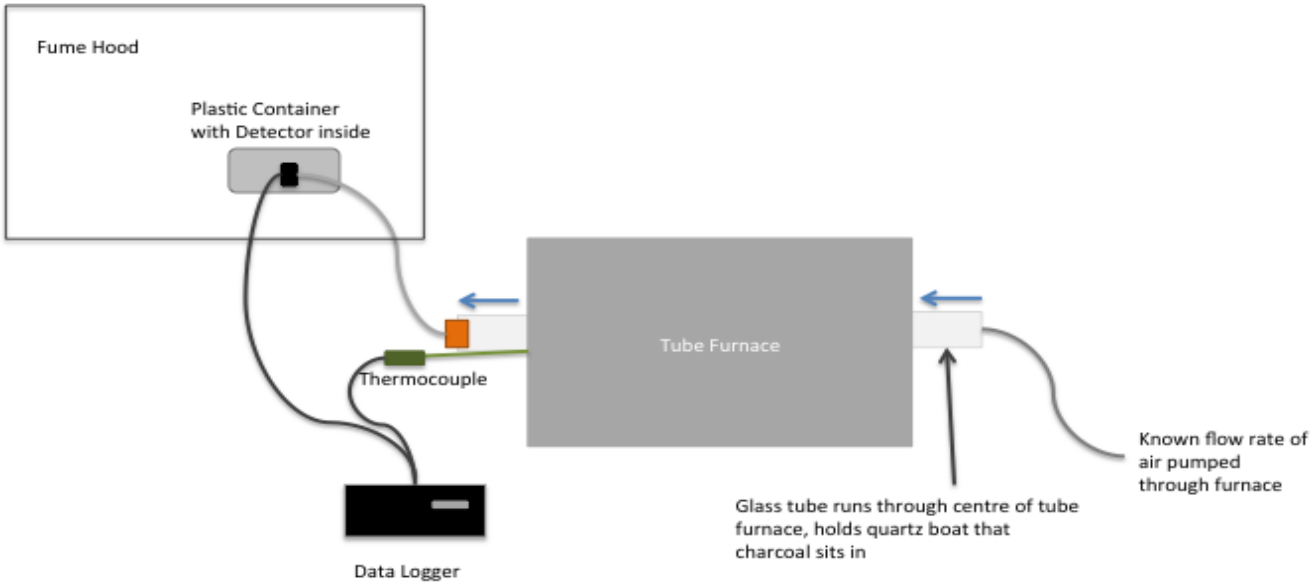
- Raising awareness and obtain a fuller, deeper understanding of the way in which charcoal produces CO
- Producing data that will allow the hazard of carbon monoxide production from hot charcoal to be estimated.

Experimental Work

1. Small scale heating experiments in a tube furnace with no flame.
   The aim was to establish if flame was required for the production of carbon monoxide and to use strictly controlled conditions
2. Larger scale burning experiments in forced air under a bell-jar.
   The aim was to see how flame affected the output
3. Quarter scale BBQ type burning in a quarter scale “tent”.
   Using realistic quantities and volumes

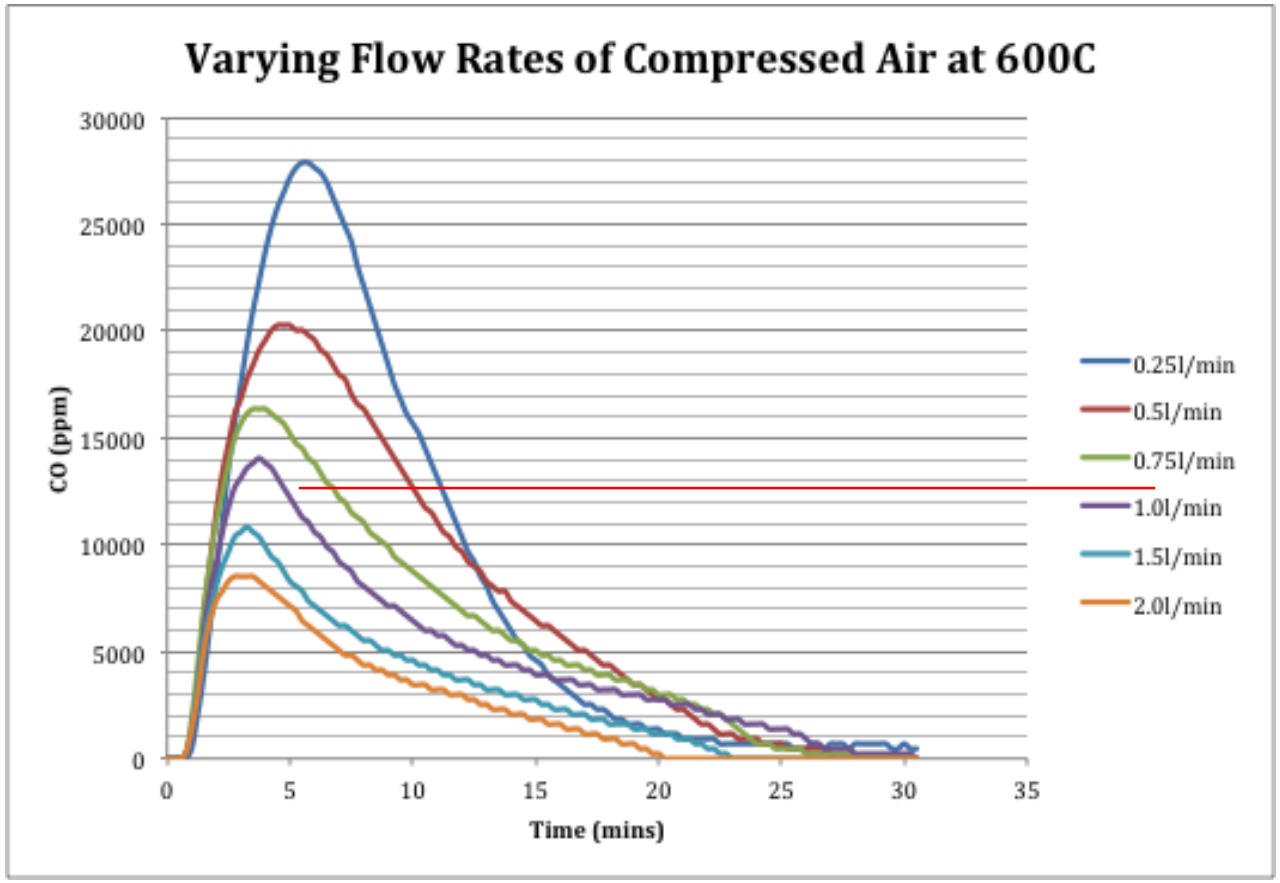
Method 1 – Heating Charcoal

- Small amounts (0.5g) of crushed, untreated (sustainable woodland) charcoal were heated to different temperatures with different superficial flow rates of either compressed or laboratory air over the charcoal to measure the CO produced. All effluent air was passed over an electrochemical CO sensor (City technology).



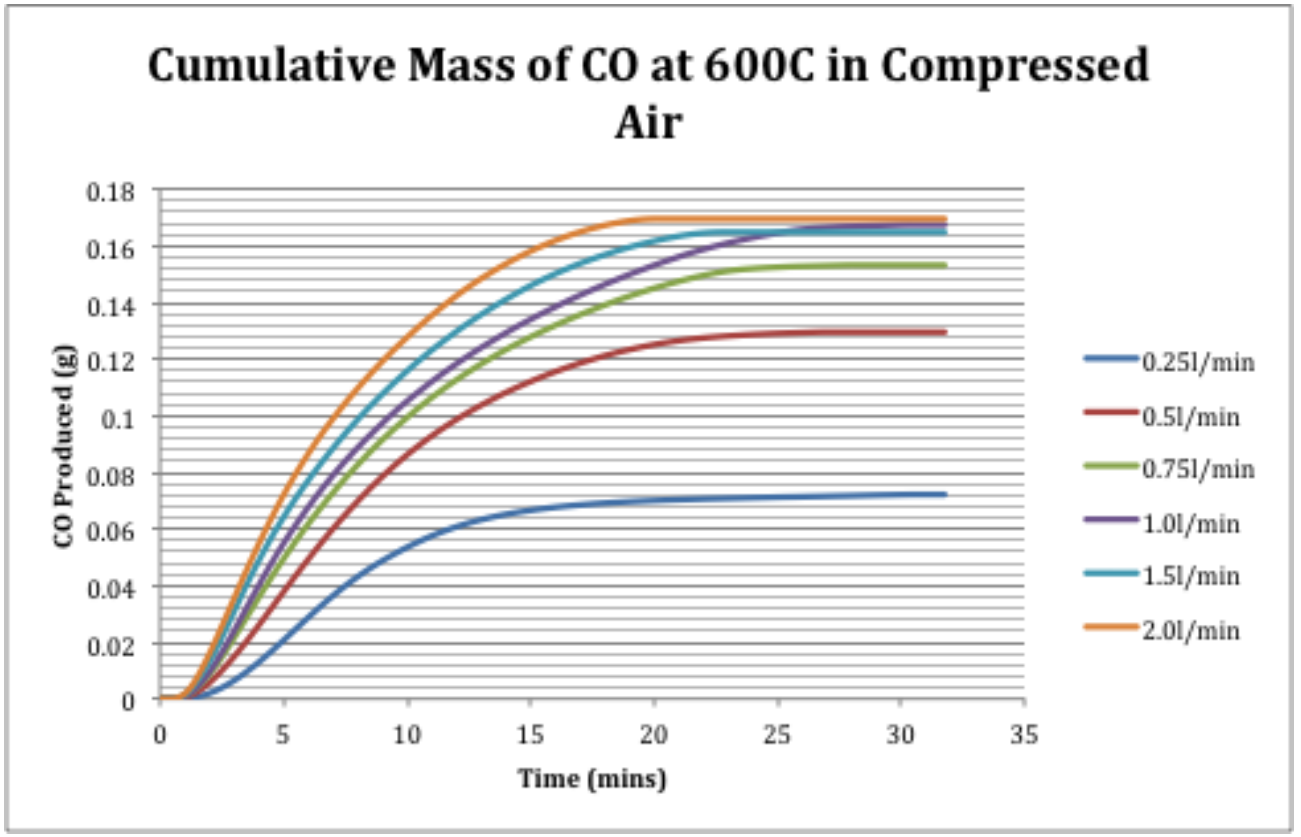
Heating Charcoal

- Varying flow rates of air at a set temperature



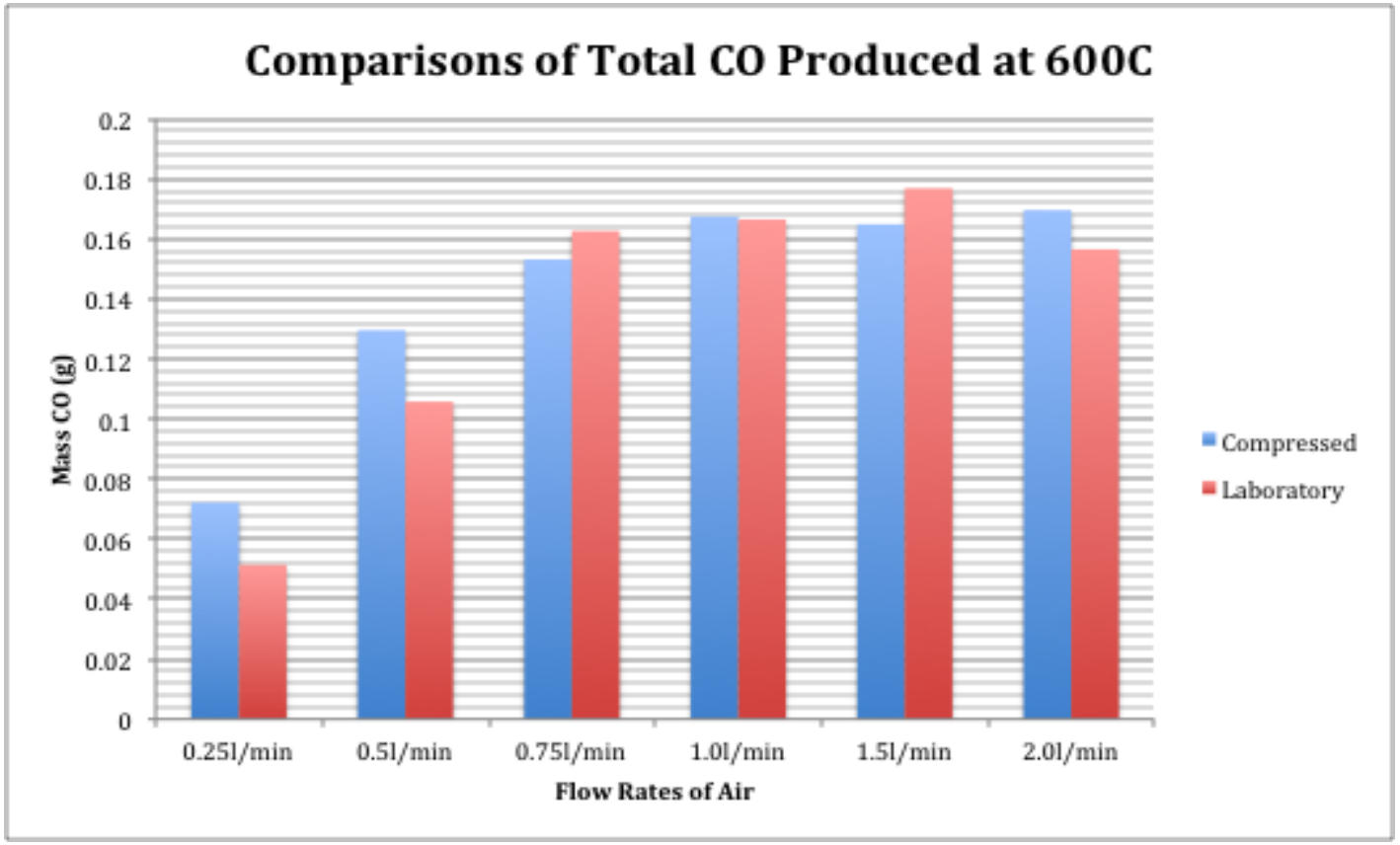
Heating Charcoal

- Varying flow rates of air at a set temperature – Cumulative CO Production.



Heating Charcoal

- Comparing compressed (dry) and lab air (humid).



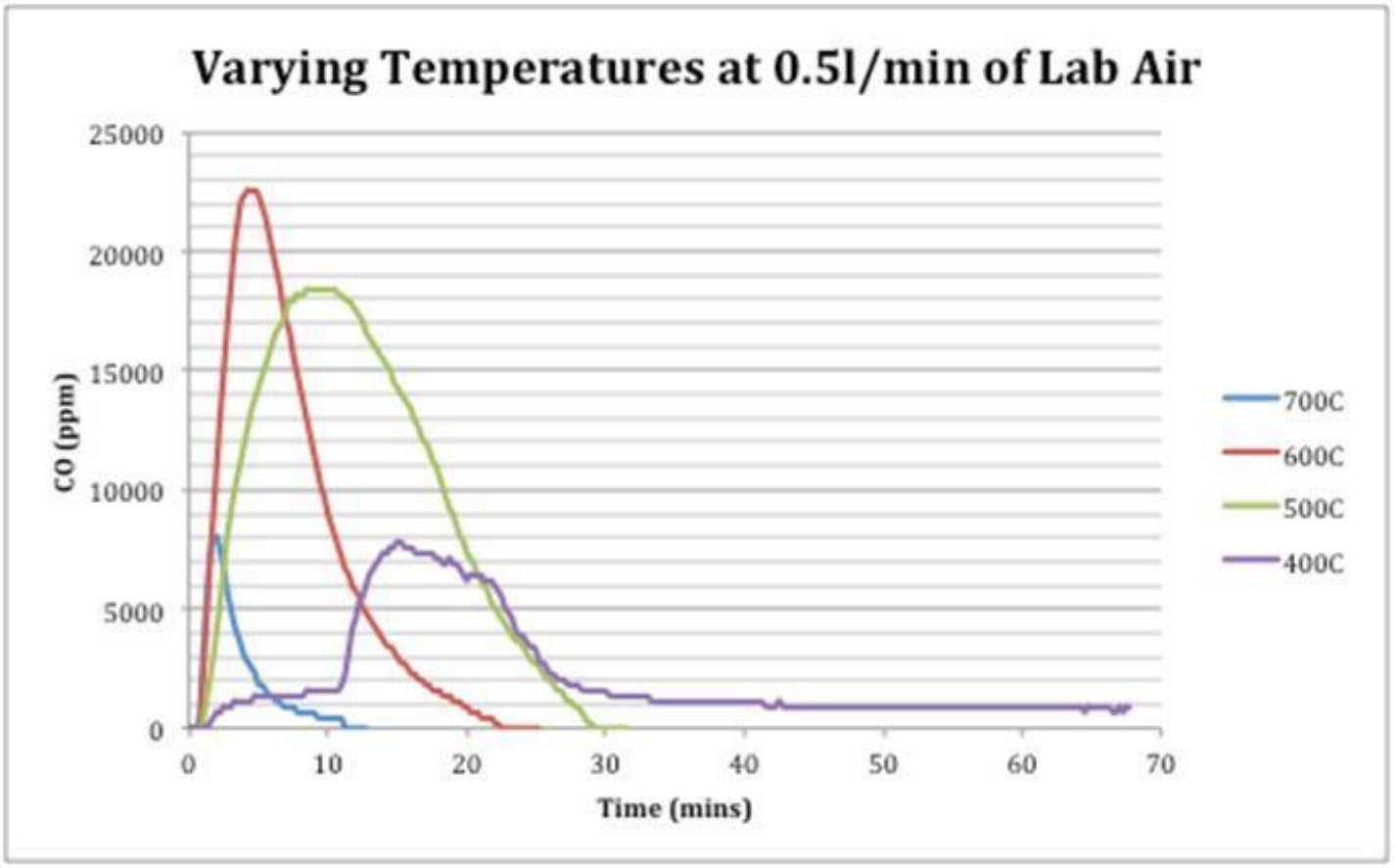
Efficiency of CO Production – varying flow rates, 600°C, Compressed Air

Flow Rate (l/min)	Lost Carbon (g)	Mass of Carbon in CO (g)	% of lost Carbon as CO
0.25	0.474	0.0134	2.83
0.5	0.485	0.0240	4.94
0.75	0.482	0.0285	5.91
1	0.492	0.0313	6.35
1.5	0.483	0.0307	6.35
2	0.485	0.0316	6.51

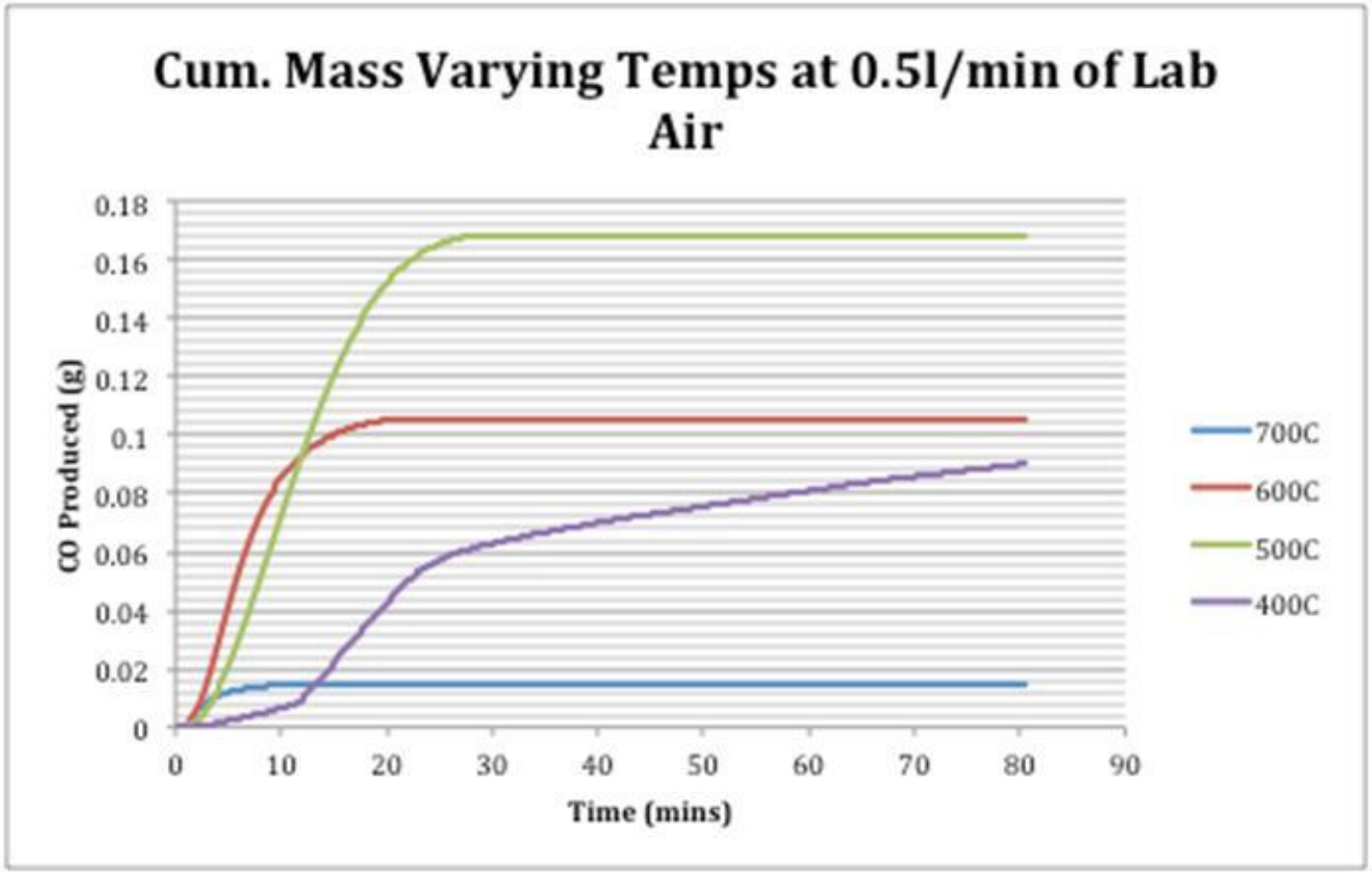
By inference the rest of the lost carbon was carbon dioxide but this was not tested for.

Heating Charcoal

- Varying temperatures at a set flow rate of air



Effect of Temperature



CO Production with temperature?

- All in lab air at 0.5 l/min.

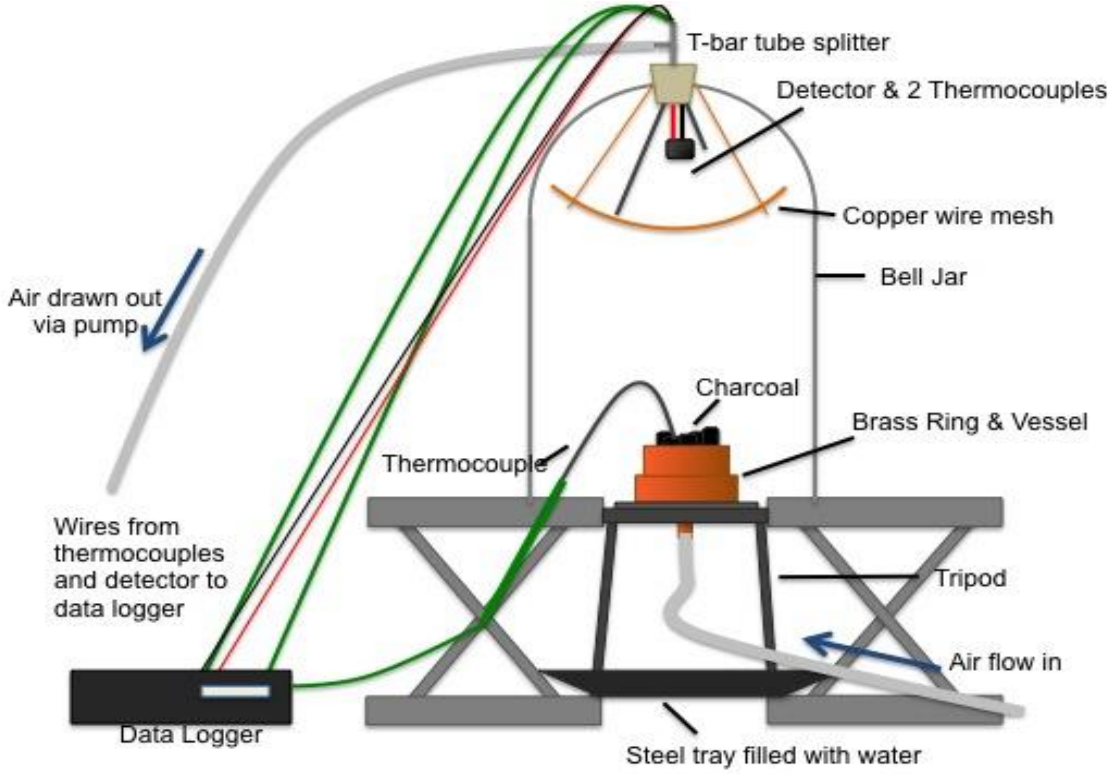
Temperature (deg C)	Lost Carbon (g)	Mass of Carbon in CO (g)	% of lost Carbon as CO
700	0.329	0.007	2.1
600	0.485	0.0240	6
500	0.394	0.072	18
400	0.193	0.0386	20

Conclusions – Flameless Experiments

- Carbon monoxide is evolved by flameless oxidation of charcoal at temperatures as low as 400°C.
- Larger concentrations are produced at lower flows but larger cumulative amounts are produced at higher flows.
- The presence of water vapour in the atmosphere does not seem to change the oxidation rate.
- The flow rate effects, temperature effects and the induction period for evolution at 400°C suggests a complex surface oxidation reaction which is probably controlled by diffusion rates to and from the surface and not by free oxygen concentration where surface oxygen complexes can be evolved as carbon monoxide at low temperatures and (perhaps) carbon dioxide at high temperatures.

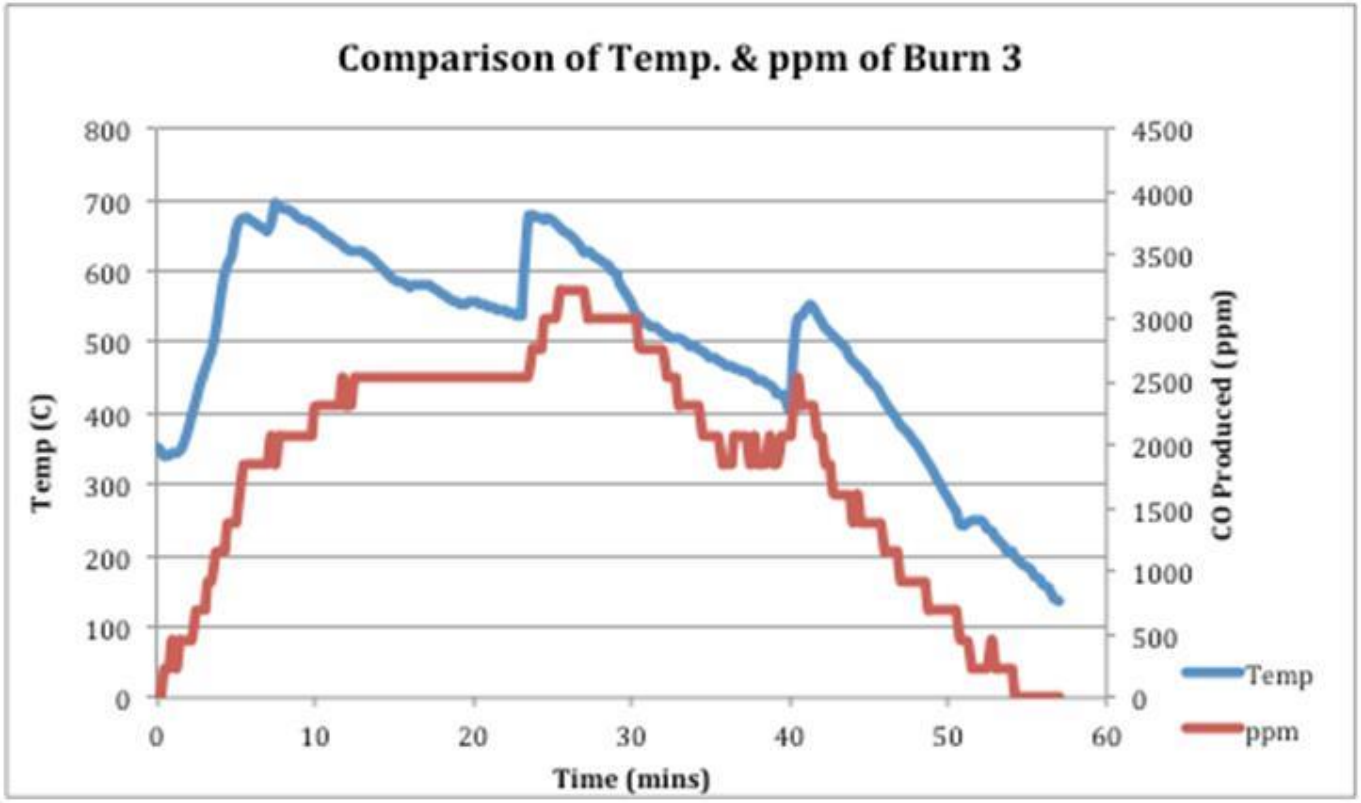
Burning Charcoal

- Burning 10g of charcoal in a brass vessel in the fume hood of the lab



Burning Charcoal

Burning Charcoal in flowing air.



Burning Charcoal in a BBQ

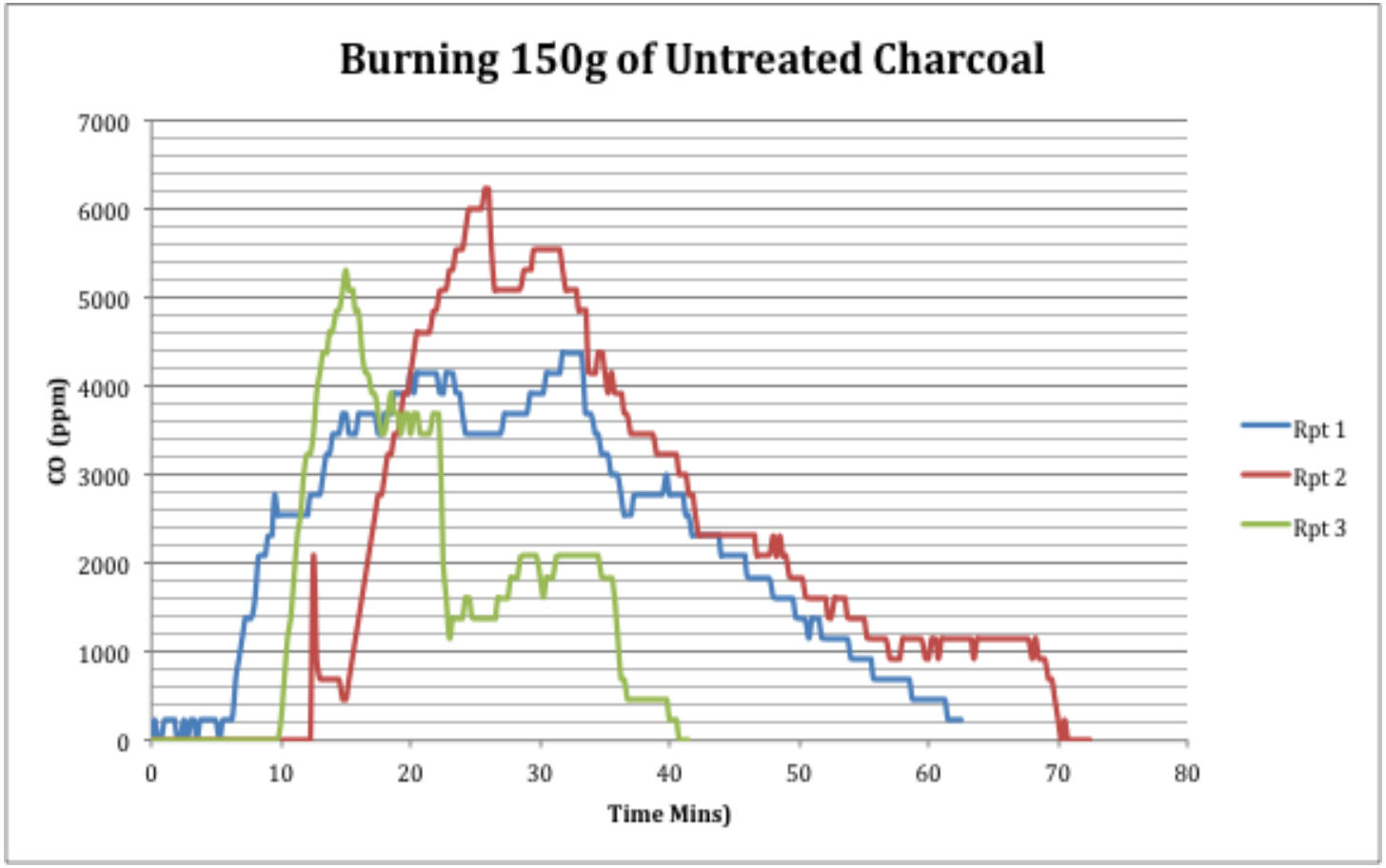
- Scaling up to a small BBQ inside a small ‘tent’

Conditions

- Experiments were conducted to see if the flap should be high or low – low was selected.
- Thermocouples were placed in the burning charcoal but could only be indicative.
- Carbon monoxide dectectors placed in cool part of rising plume.
- No forced ventilation.
- Supermarket charcoal contains hydrocarbon “accelerant”.
- Sustainable charocal was lit with firelighters.
- Readings taken after flames had died down and charcoal was glowing.
- Operators had personal CO detector .

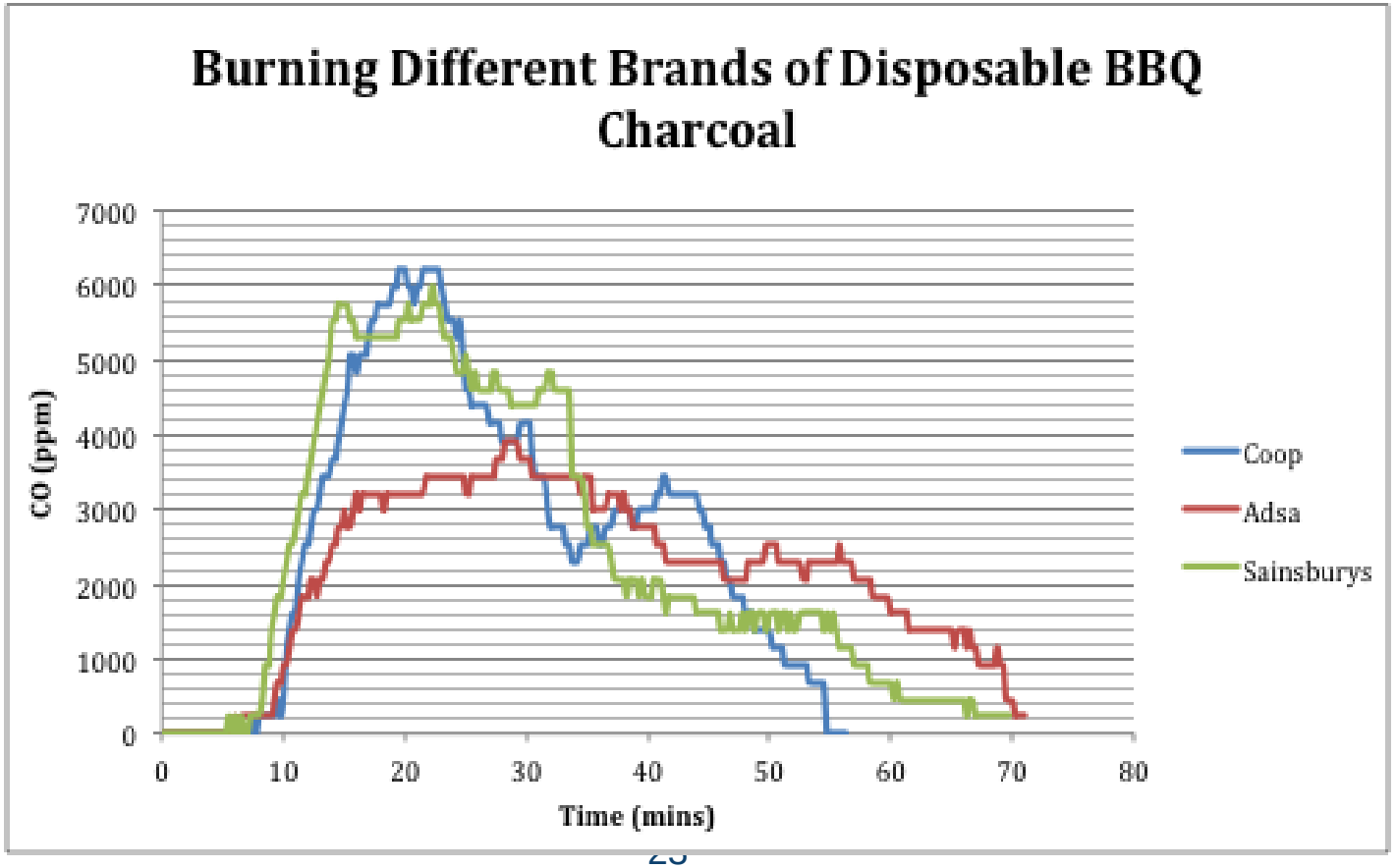
Burning Charcoal in a BBQ

- Burning untreated charcoal



Burning Charcoal in a BBQ

- Burning different brands of pre-treated disposable barbeque charcoal



Conclusion - BBQ.

- Commercial BBQ charcoal was cooler than “sustainable” charcoal (top temperatures in the range 700 to 750°C whereas “sustainable” charcoal was over 800°C)
- The source of the charcoal did not affect the levels of CO produced.
- Sufficient CO was produced to kill in the 20 minute period had the charcoal had been alight inside the tent.

Remember

Carbon monoxide can kill

Never use a fuel-burning appliance inside your tent or awning. Even a warm barbecue can be lethal.

Thank you and Question Time???

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