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Washing SRC Willow

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Supervisors: Jenny Jones, Alan Williams, Bijal Gudka
Thanks to Patrick Mason and Ian Shield
Acknowledgements: Innes Dean, Hannah Birch and Hannah Sherwood

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Are Solid Fuels dated?

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- Increase in the number of solid fuel stoves in operation because of fashion trends
- Conversion of coal power stations to biomass or co-firing
- Developing world requirements for heating and cooking
- One of the oldest technology forms

Willow

Olive

Torrefied Spruce

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The Problems with Biomass?

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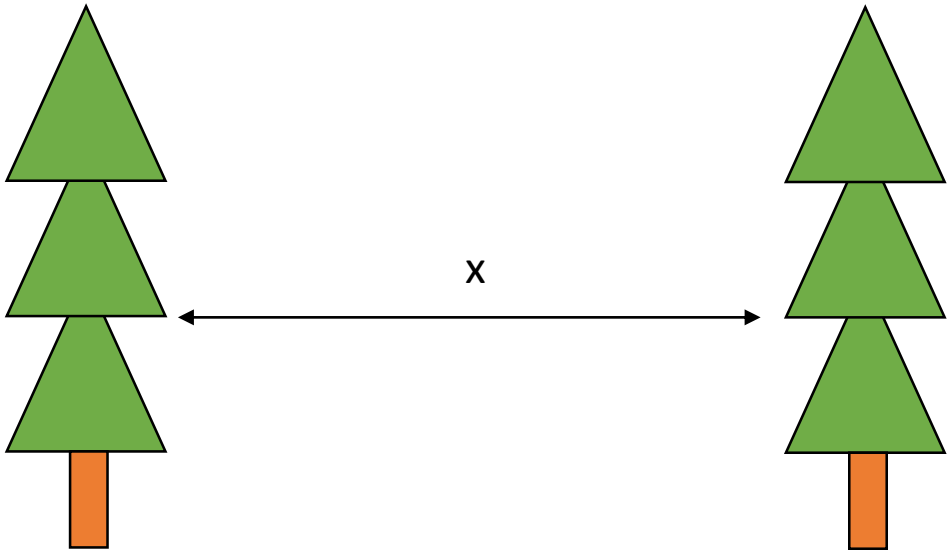
Introducing a Tree Farm with Tree A and Tree B



The Problems with Biomass?

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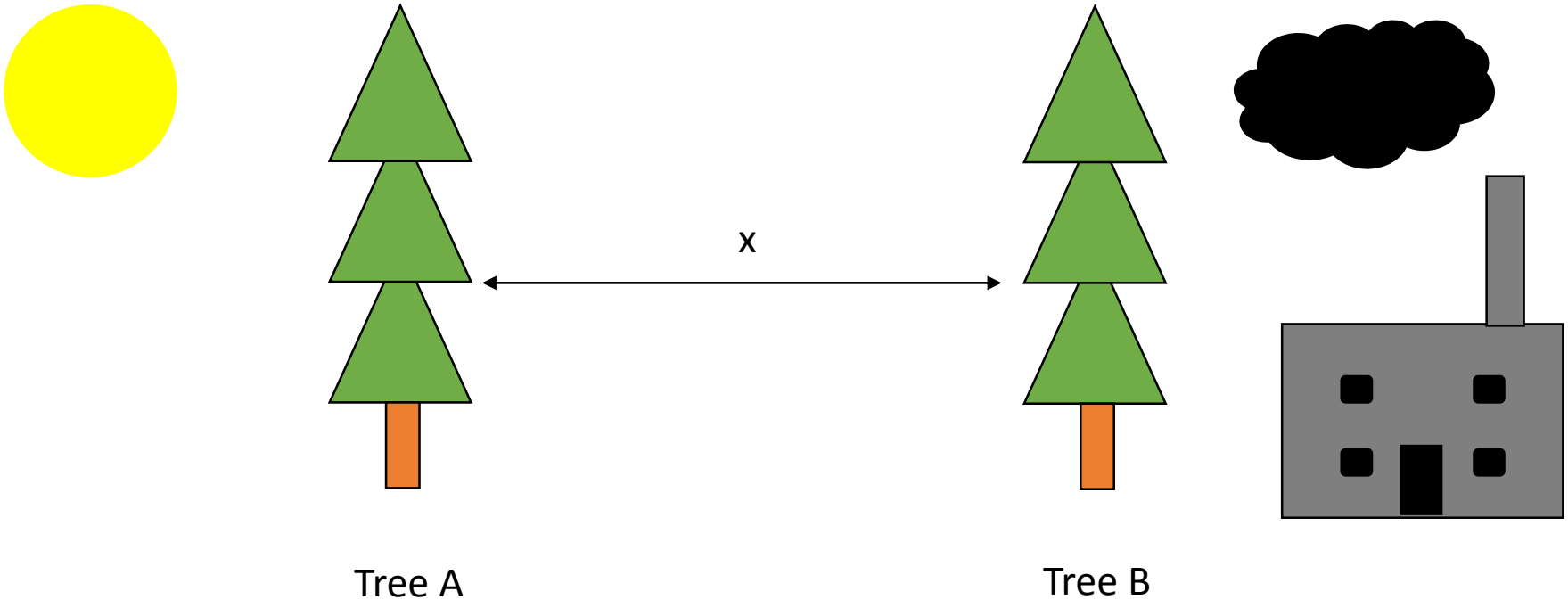
Just because they are on the same farm and will be blended to make one fuel source
Doesn't mean they are the same.



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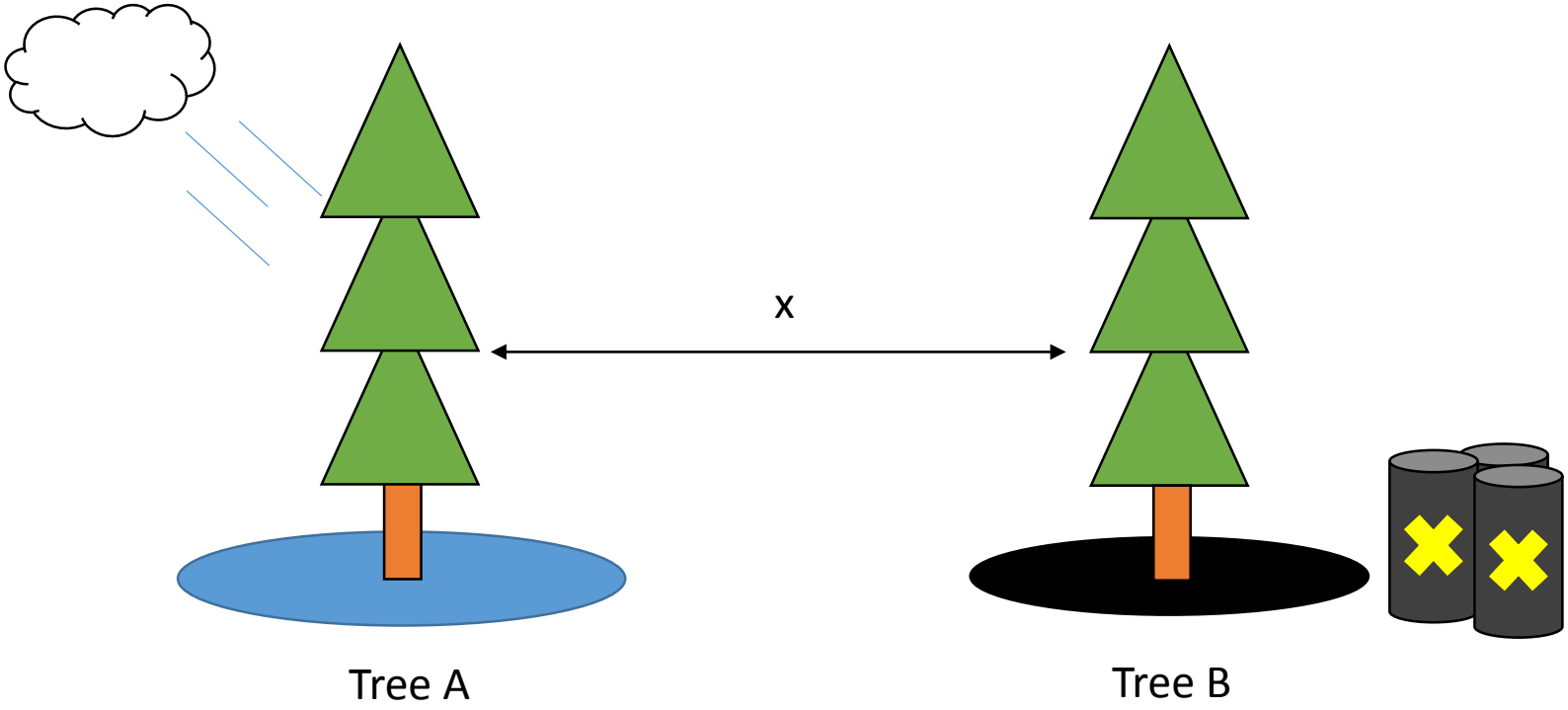

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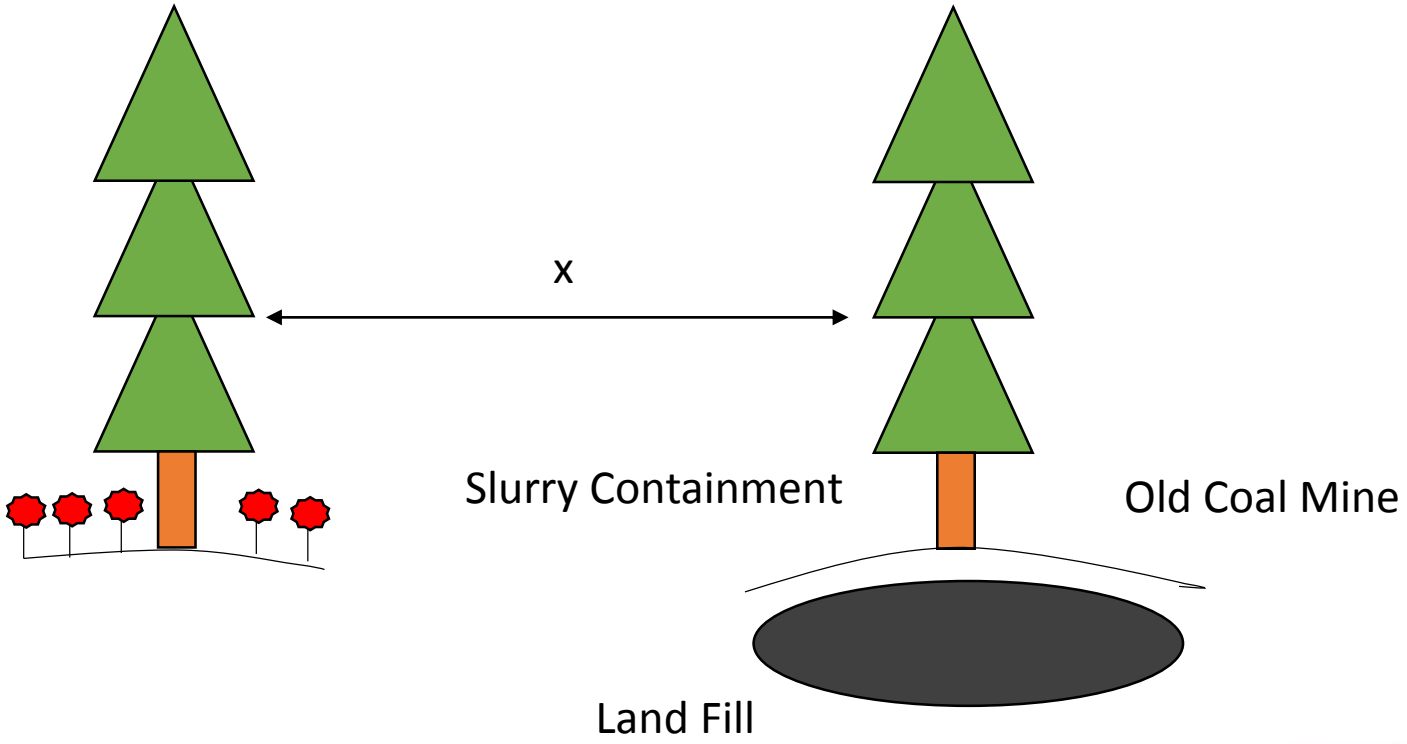

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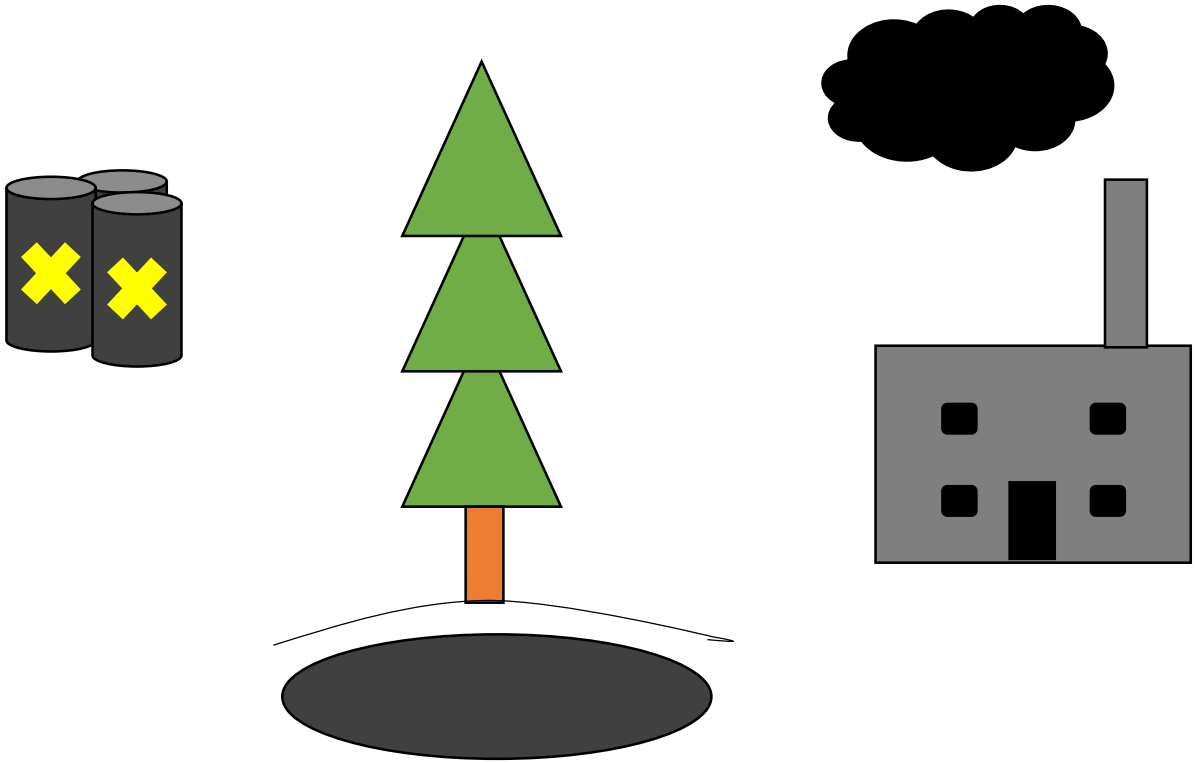
Accumulation of elements within the biomass source

Tree B



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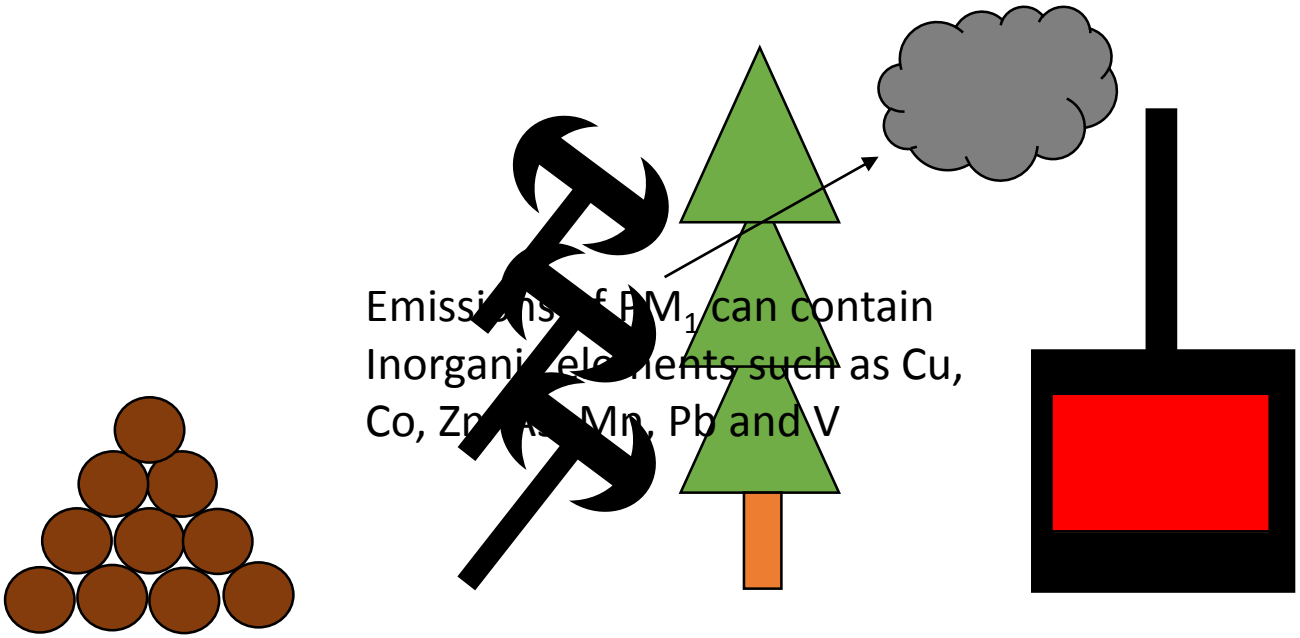
Tree B becomes our solid fuel for our stove



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Washing- A potential Solution

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- Reduce the ash content of a fuel, this means less bottom ash post combustion and therefore prevents ash handling and disposal problems.
- Remove harmful trace metals which can be emitted in PM_1 and become airborne. These trace metals can catalyse lung disease and cause lung cell denaturing.
- Upgrade fuels by removing K and Ca and prevent boiler degradation from clinker and slagging effects.

Washing rig?

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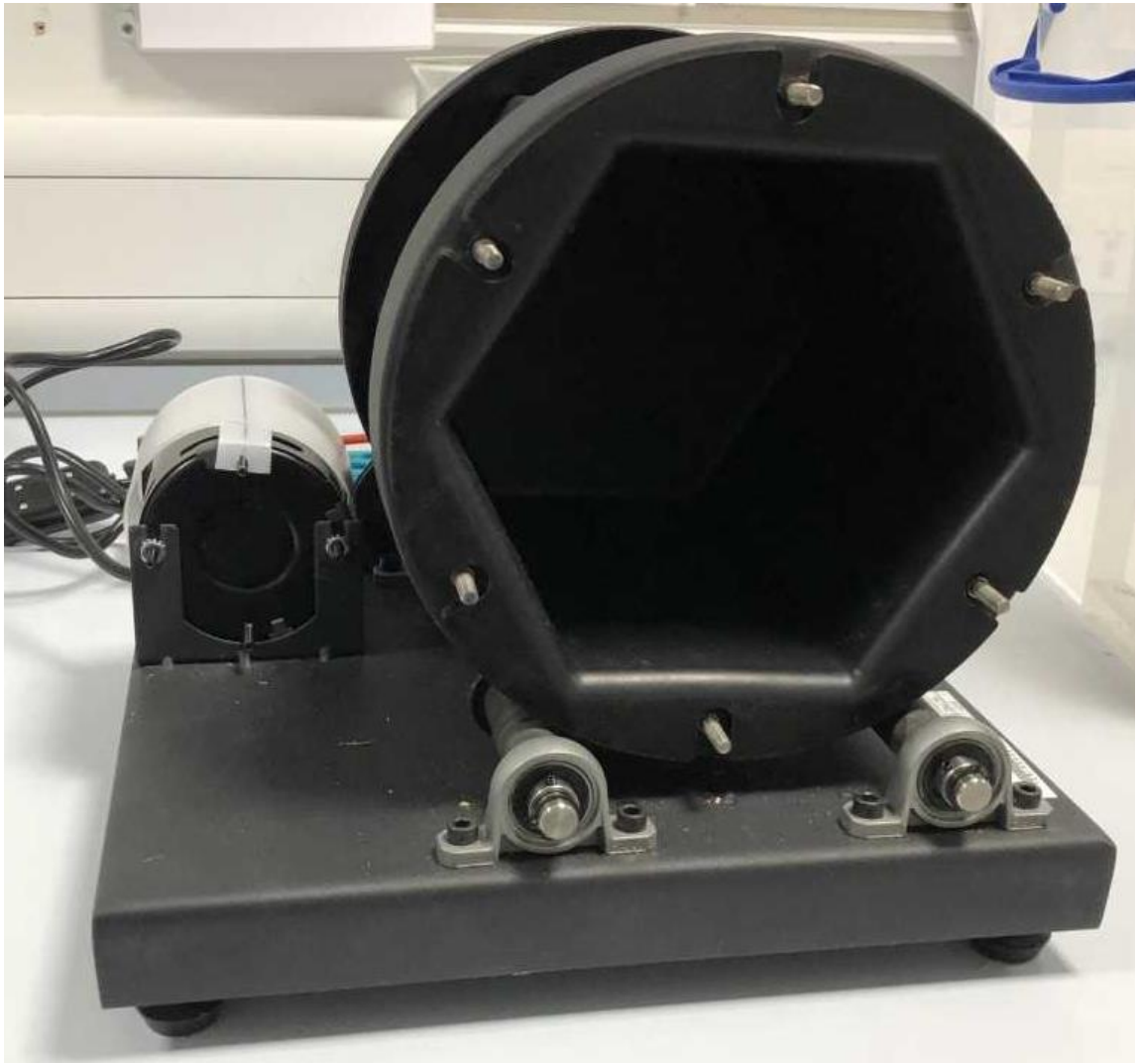

Using a rock tumbler the willow chip was loaded with the water in a ratio of 1:2 by mass.

Removal of the inorganic species is by three mechanisms:

1. Dirt suspension and settling into the water
2. Ionisation of salts
3. Abrasion of particles causing fragments to become suspended or settled in the water

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Separate the phases out

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Biomass

Fines

Leachate

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Mass Balance- Game of Cluedo

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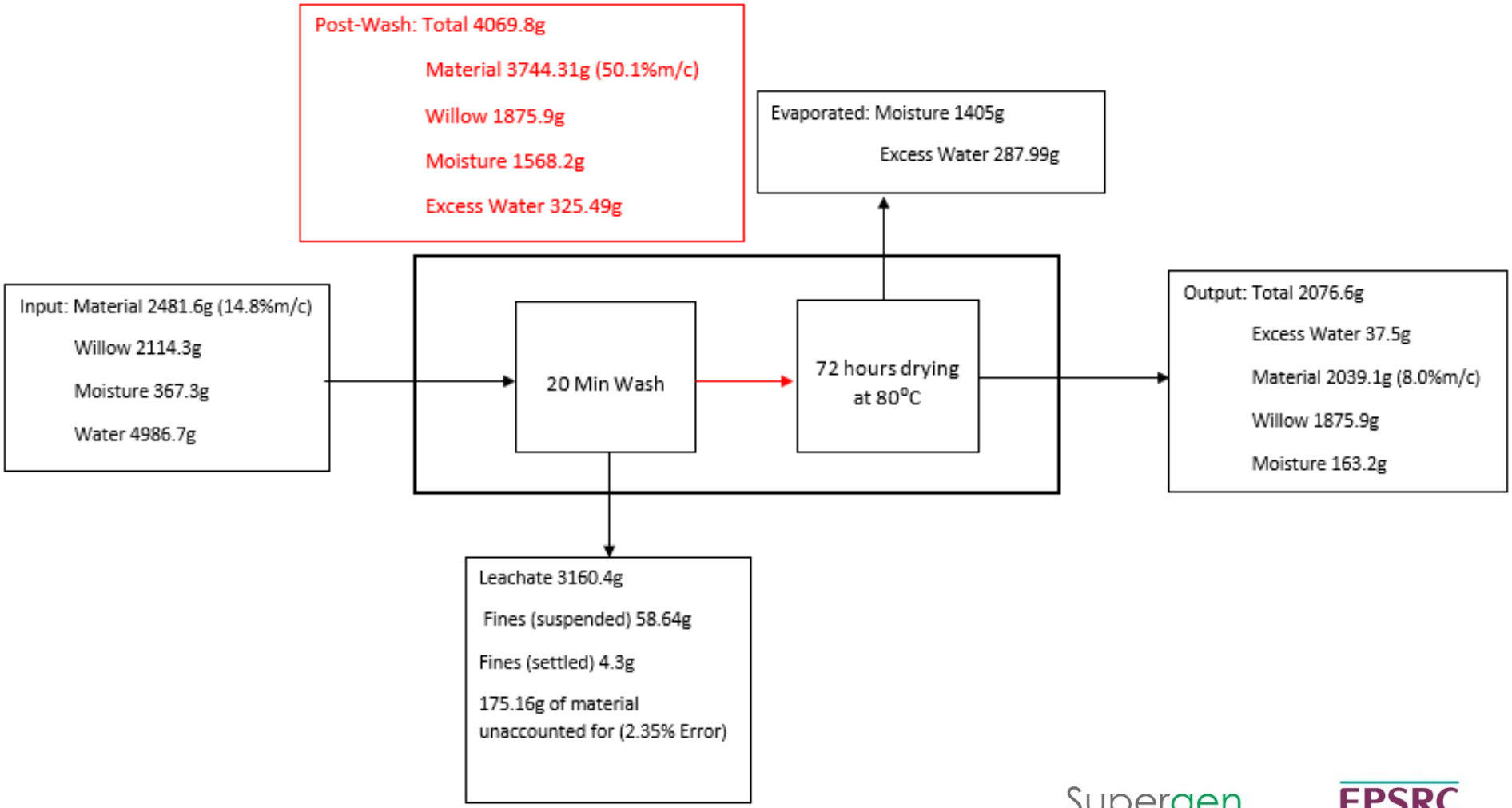

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	Unwashed	20 Minute Wash
Time	0	20
Volatile Matter (%db)	82.48	82.13
Ash	1.65	1.37
Moisture (%AR)	14.80	46.70
C (%daf)	50.19	44.33
H	6.46	5.71
N	0.53	0.59
S	0.11	0.08
O	42.71	49.29

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Biomass

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The table below expresses the amount of each species found in 1kg of fuel

	Unwashed	20 Minute Wash
Ash (%db)	1.65	1.37
Zn	95.1	88.9
Cu	5.9	3.3
Cd	1.2	0.9
Pb	N/A	1.8
Ni	1.3	1.4
Ba	6.7	6.9
Cr	0.8	1.2

	Unwashed	20 Minute Wash
Ca (mg)	3800	3400
K	2270	2000
P	994	807
Mn	195	187
Na	431	356
Fe	411	254
Al	287	201
Si	516	356
Mg	632	607

*All table values are expressed as mg/kg

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Leachate

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	20 Minute Wash
Zn (mg/L)	41.2
Cu	0.49
Cd	0.105
Pb	0.018
Ni	0.007
Ba	0.713
Cr	0.002

	Distilled Water	20 Minute Wash
Ca (mg/L)	3.2	4.18
K	1.5	350
P	0.01	49.1
Na	3.56	5.25
Mg	632	21.3

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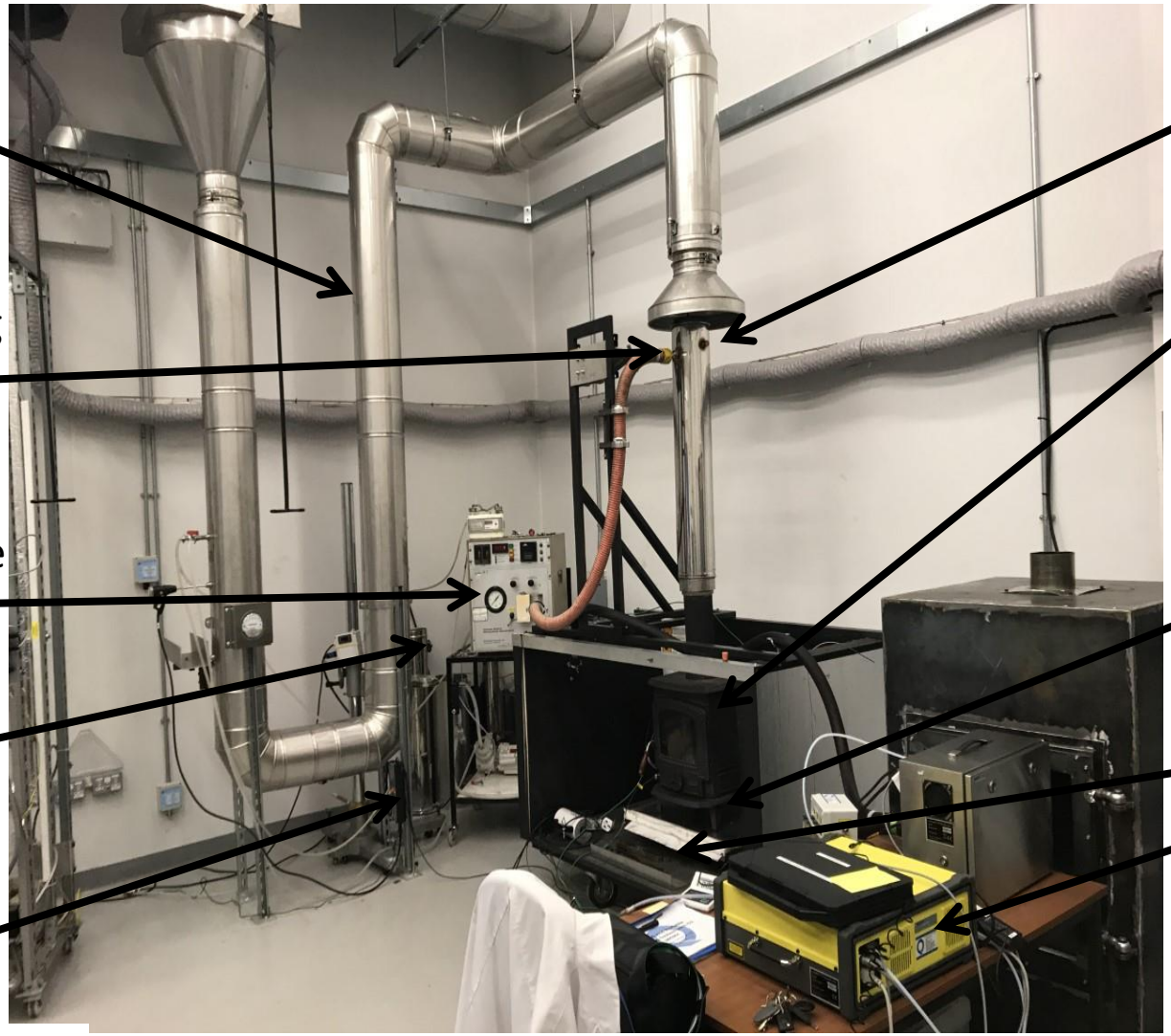

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Burning rate- Washed

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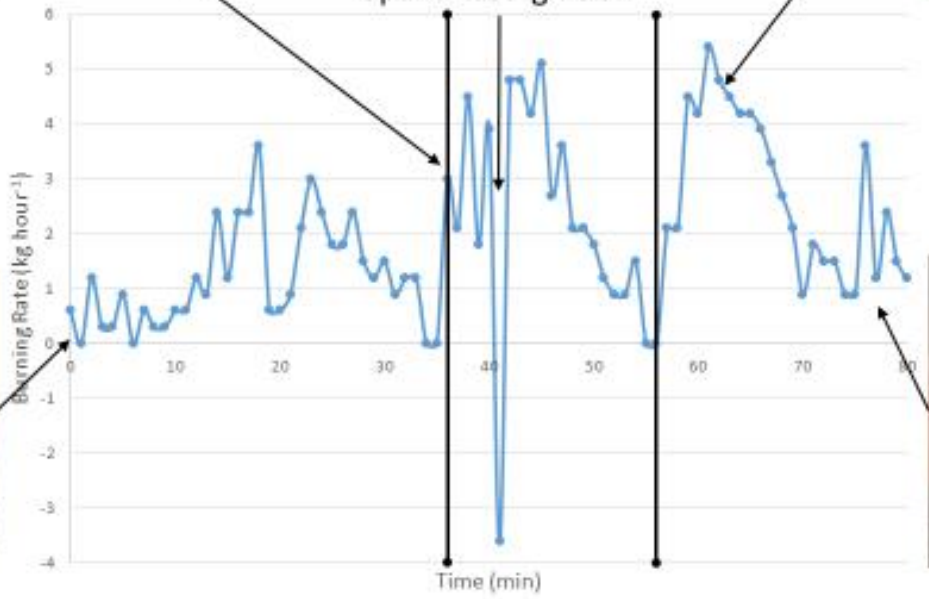
Pre-flaming smoulder

Spark- fast ignition

Flaming Combustion

Fuel Loaded



Post-flaming smoulder

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Particulates

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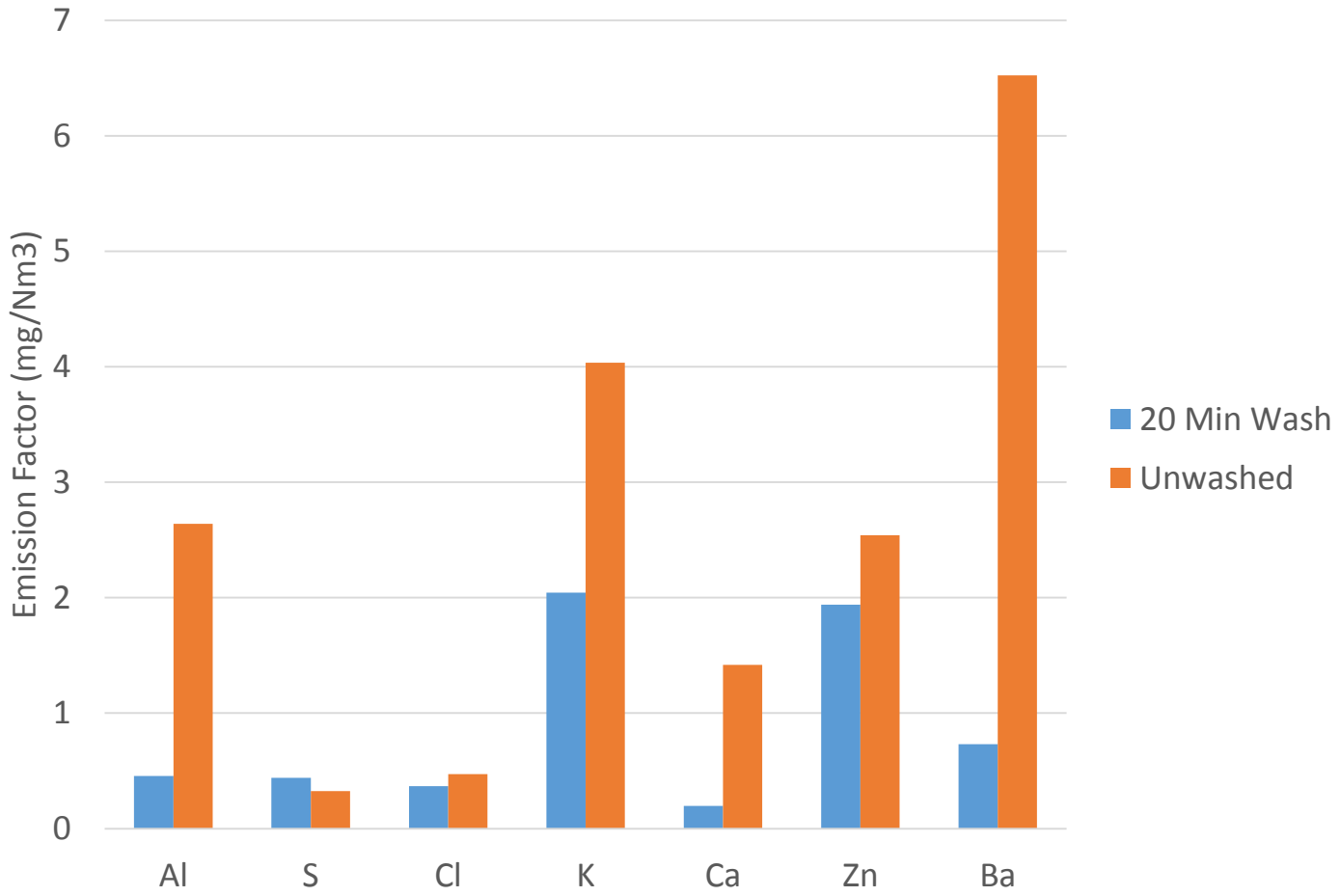
PM emission factor for the unwashed fuel is 240mg/Nm^3
where as the washed fuel is 49mg/Nm^3



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Conclusions

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- Washing will reduce the ash content of SRC willow chip when washed in distilled water
- The washed willow post washing contains less trace metals and inorganics, the trace metals can become suspended in the leachate phase and inorganics are ionised and transfer from the willow chip into the leachate
- The reduced ash content and increased homogeneity of the washed fuel means that during combustion the burning rate is more consistent and flaming combustion is maintained for longer.
- The time period of pre-flaming smouldering is reduced when the fuel is washed. The decreased ash content means the mixture becomes flammable at a lower temperature. This is responsible for the decreased particulate emission factor.
- Trace metal emissions are lower as well as inorganic emissions.

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Acknowledgements

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Thank you
Any question?

David Maxwell (pm12dm@leeds.ac.uk)

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