

Fuel Characterisation at Åbo Akademi University - an update -

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History 1/2

- Research at ÅA on fuels fired in FBC has developed from
 - Coal
 - Peat
 - Biomass
 - Waste derived fuelsto
 - Residues from biofuel production

History 2/2

- Last 5 years presented at IEA-FBC:
 - 2009
 - Fluidised bed technology in waste incineration in Finland (Mikko Hupa)
 - 2008
 - Ash forming matter in peat (Mikko Hupa)
 - 2007
 - Myths and facts of high temperature corrosion
 - Characterisation of sewage sludges (Maria Z)
 - Morphology and composition of bed-material particles from combustion of biomass fuels and wastes in CFB boilers (Vesna Barisic)
 - 2006
 - The Åbo Akademi databases (Maria Z)
 - Heavy metals (EDD+Zn) in waste derived fuels for FBC (Maria Z)
 - 2004
 - Trace metals in "co-firing fuels" (Maria Z)

Aim

- To be able to explain/predict combustion and gasification behaviour in a large scale boiler

With help of characterisation of fuels and their combustion behaviour:

- Standard fuel analyses, ultimate and proximate
- Stepwise leaching
- SEM/EDX studies of lab-ashed fuels
- Lab scale testing of combustion characteristics

ÅA fuel database

- Currently 183 fuel samples analysed
 - Coal, peat, wood derived, agricultural residues, waste derived fuels
- Ultimate analyses
- Ash composition
- Chemical fractionation
- Trace metals (dirty dozen+Zn)

Fuel characterisation work: 2009

- Solid residues from biofuel production

- Biogas
 - Digested sewage sludge (DSS)

- Bioethanol
 - Dried Distillers Grains with Solubles (DDGS)

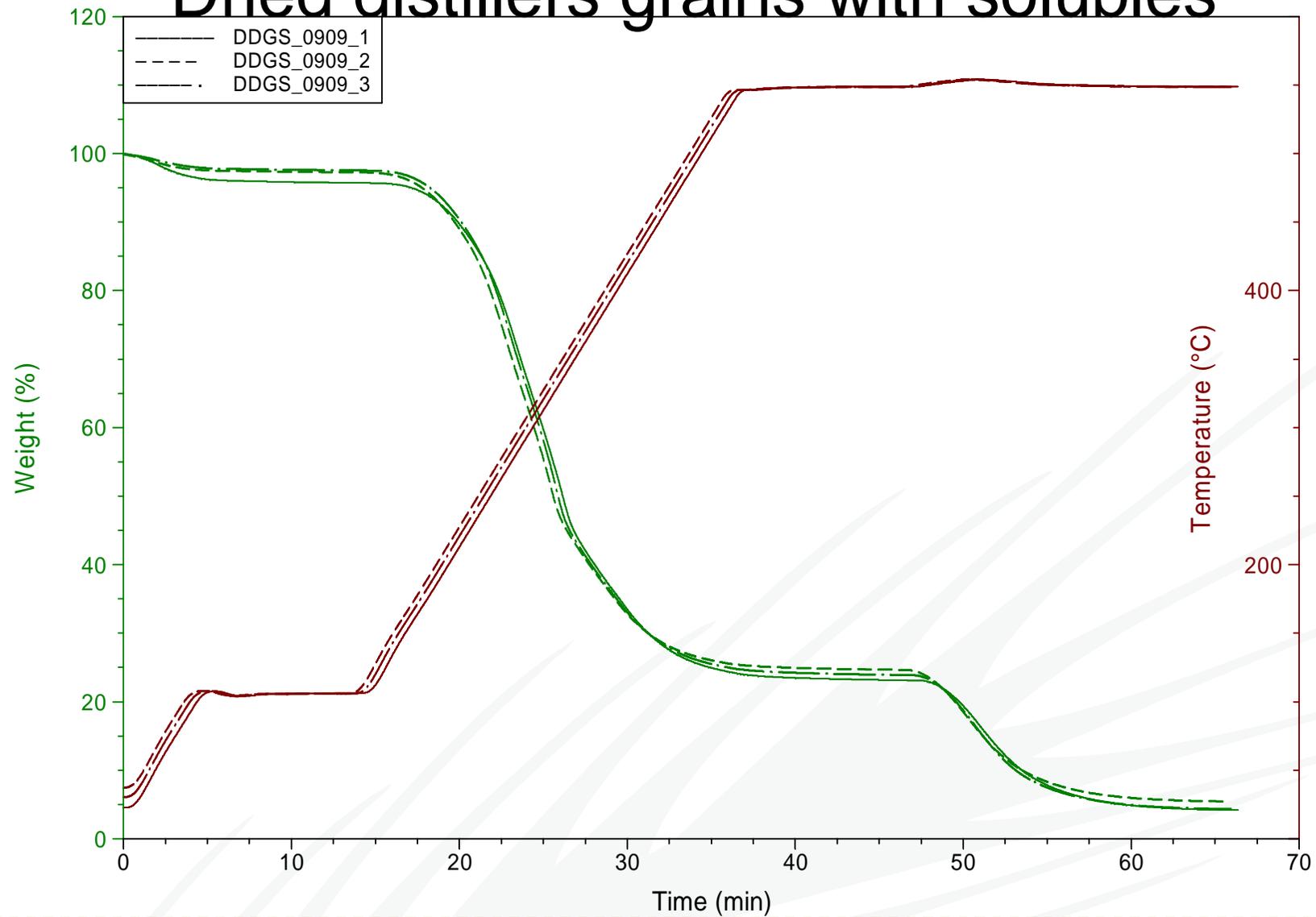
- Biodiesel
 - Rape seed cake (RSC)
 - Palm kernel cake (PKC)

Ultimate and proximate analyses

- Ultimate
 - External laboratory, Swedish standards
- Proximate in TGA:
 - Drying in N₂ heated to 105°C and kept till mass stabilized.
 - 550°C to check the volatile content.
 - Synthetic air (20% O₂ and 80% N₂) to determine the content of fixed carbon
 - The residue is the ash.

Ultimate and proximate analyses

Dried distillers grains with solubles

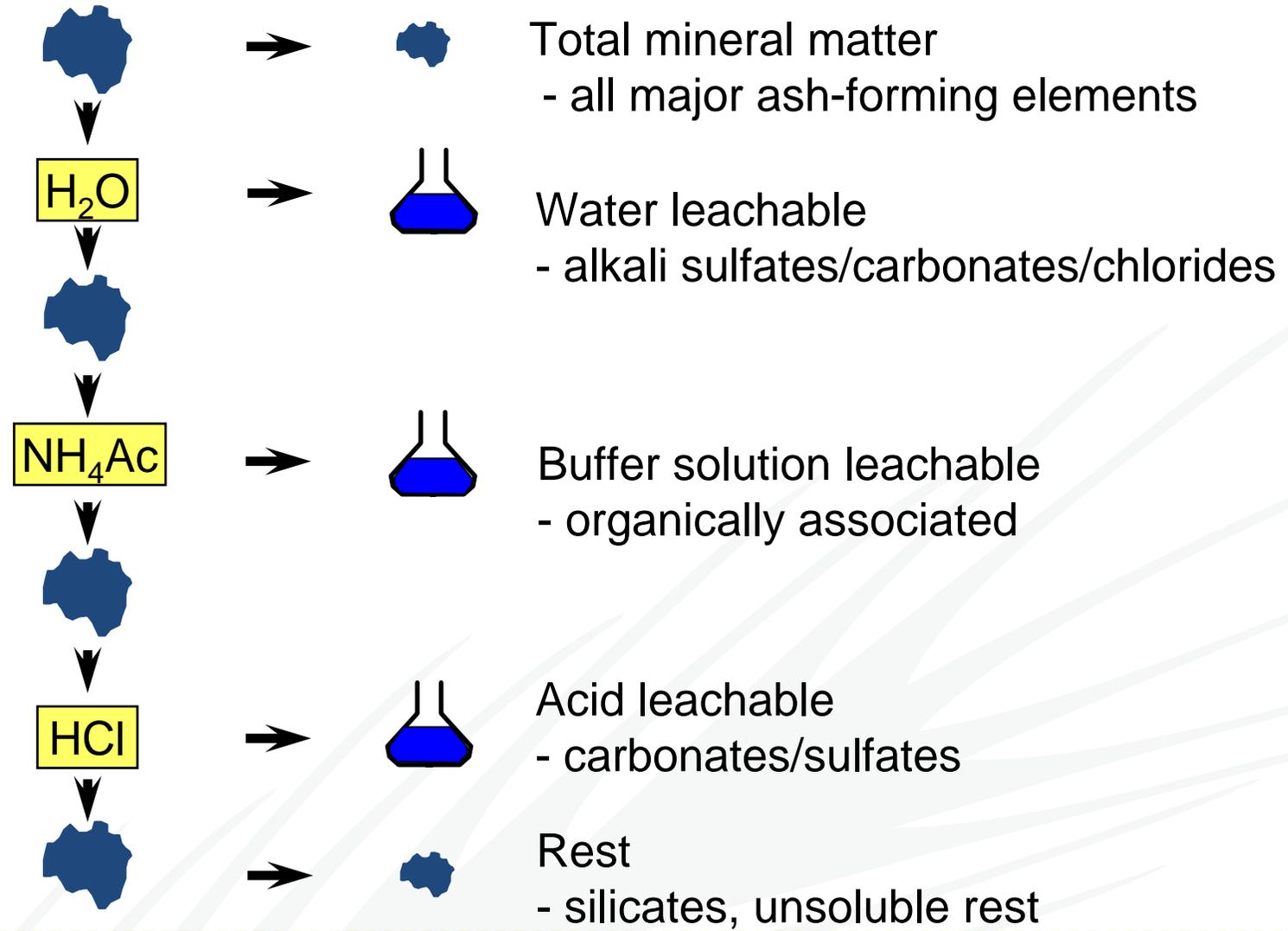


Ultimate and proximate analyses

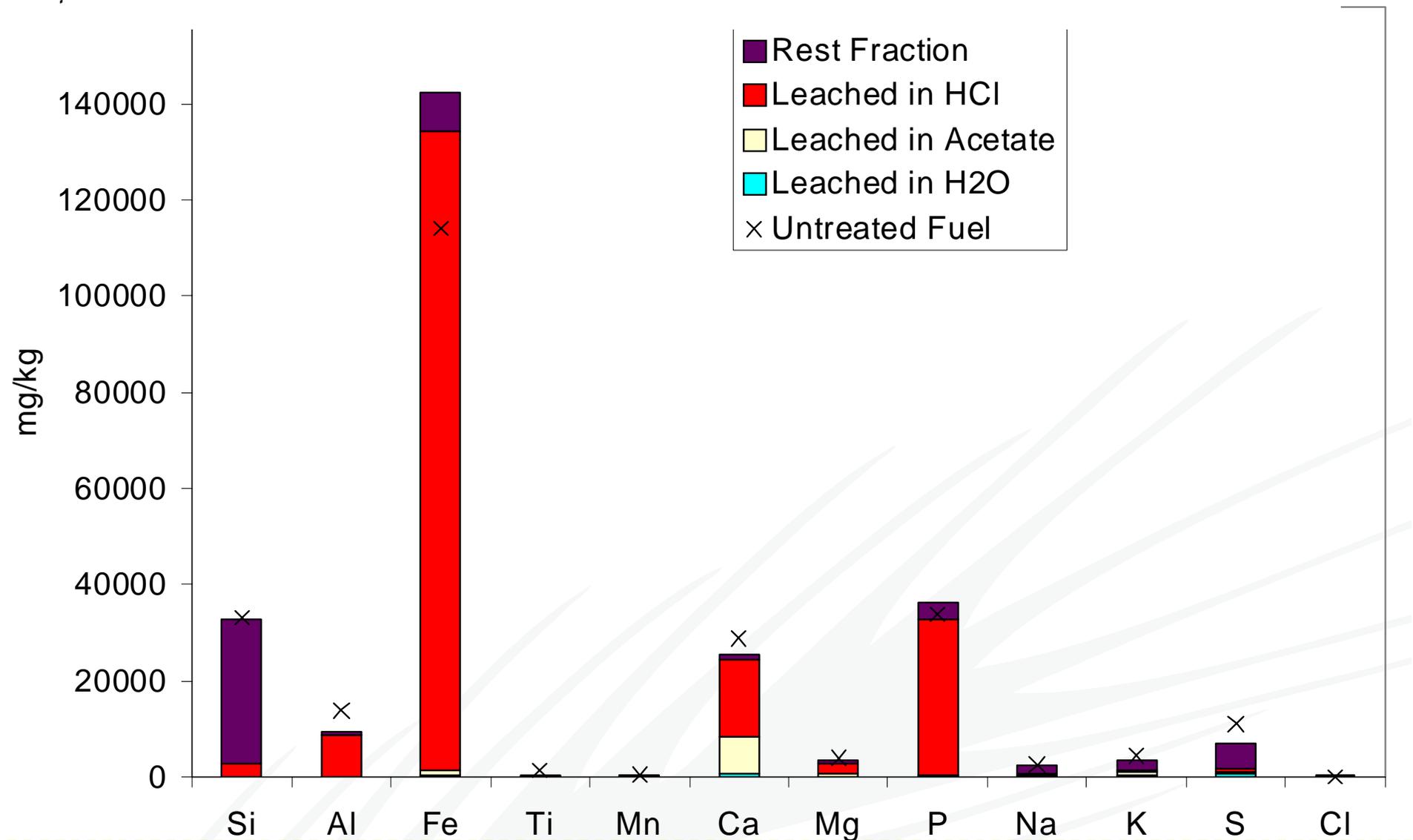
Fuel	Moist. wt-% a.r.	C wt-% d.b.	H wt-% d.b.	N wt-% d.b.	Cl wt-% d.b.	S wt-% d.b.	O wt-% diff.
digested sewage sludge	7.4	26.5	5.9	3.2	0.1	1.2	63.2
rapeseed cake residue	2.1	49.9	6.9	5.1	0.3	0.7	29.9
dried distillers grains with solubles	8.9	46.7	6.7	3.9	0.2	0.3	36.2
palm kernel cake	7.0	47.1	6.5	2.5	0.2	0.2	38.3

Fuel	Volatile wt-% a.r.	Fixed C wt-% d.b.	Ash wt-% d.b.
digested sewage sludge	43.3	10.6	46.1
rapeseed cake residue	74.7	18.8	6.5
dried distillers grains with solubles	75.3	19.9	4.8
palm kernel cake	73.9	21.6	4.5

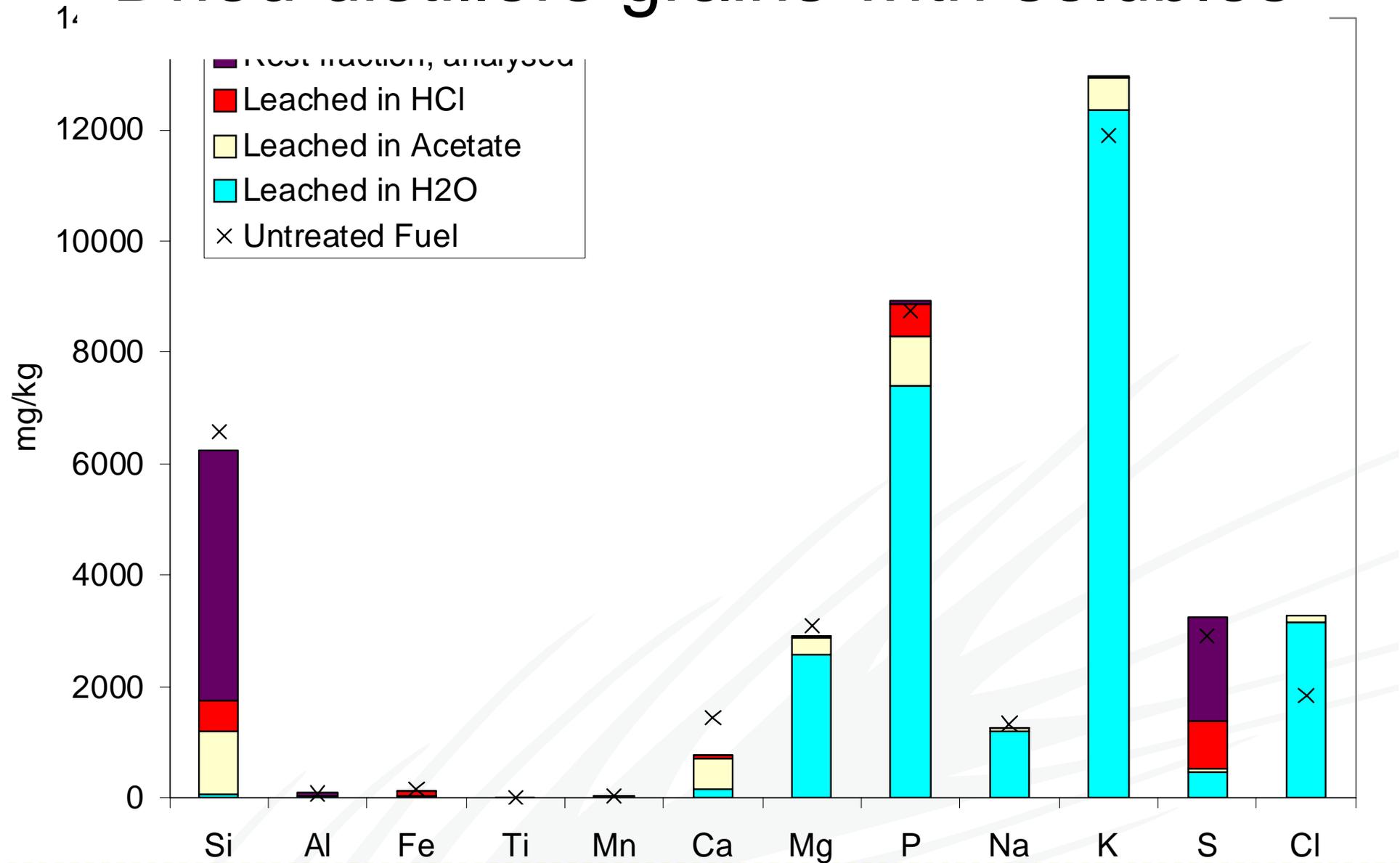
Stepwise leaching



Digested sewage sludge

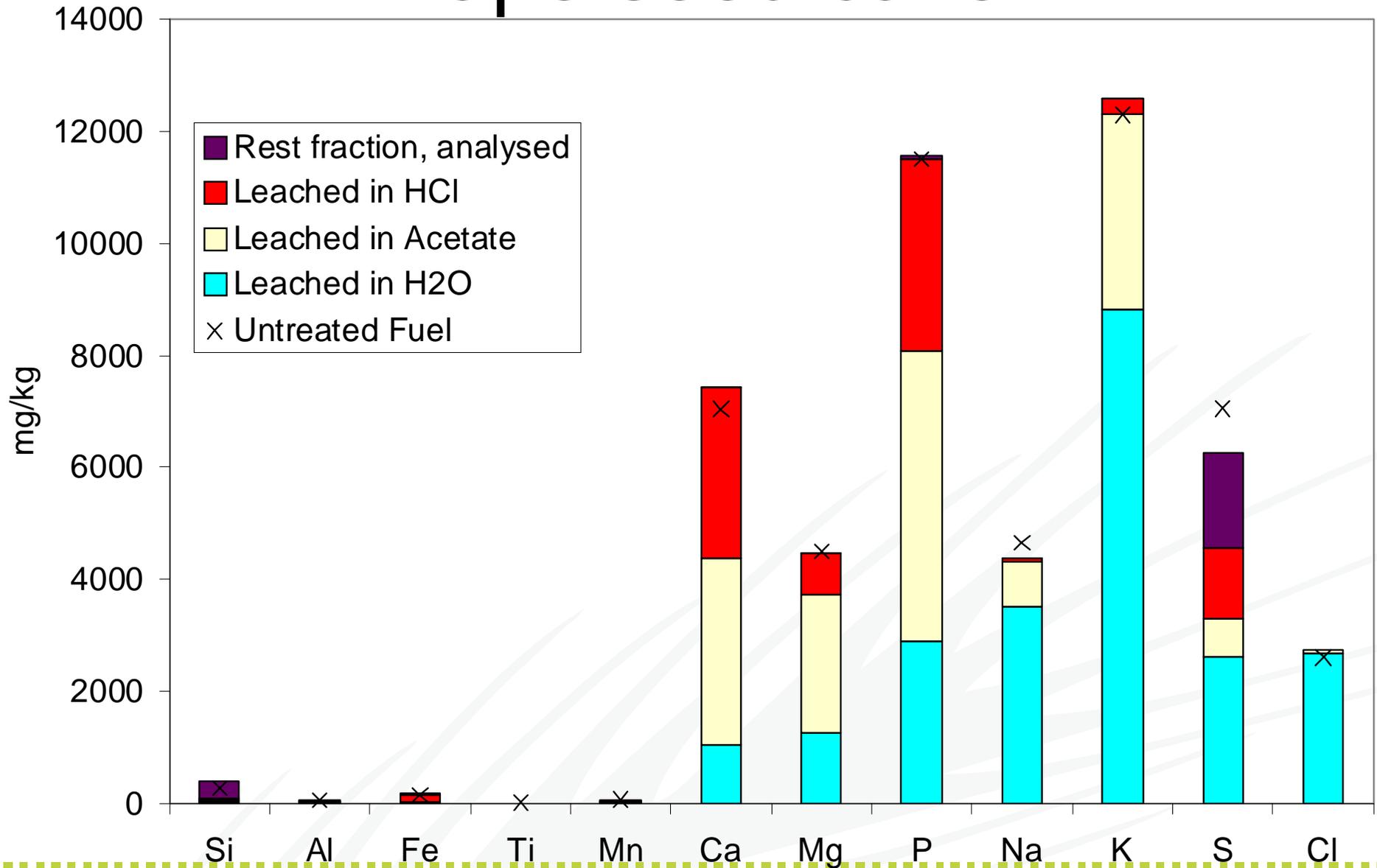


Dried distillers grains with solubles

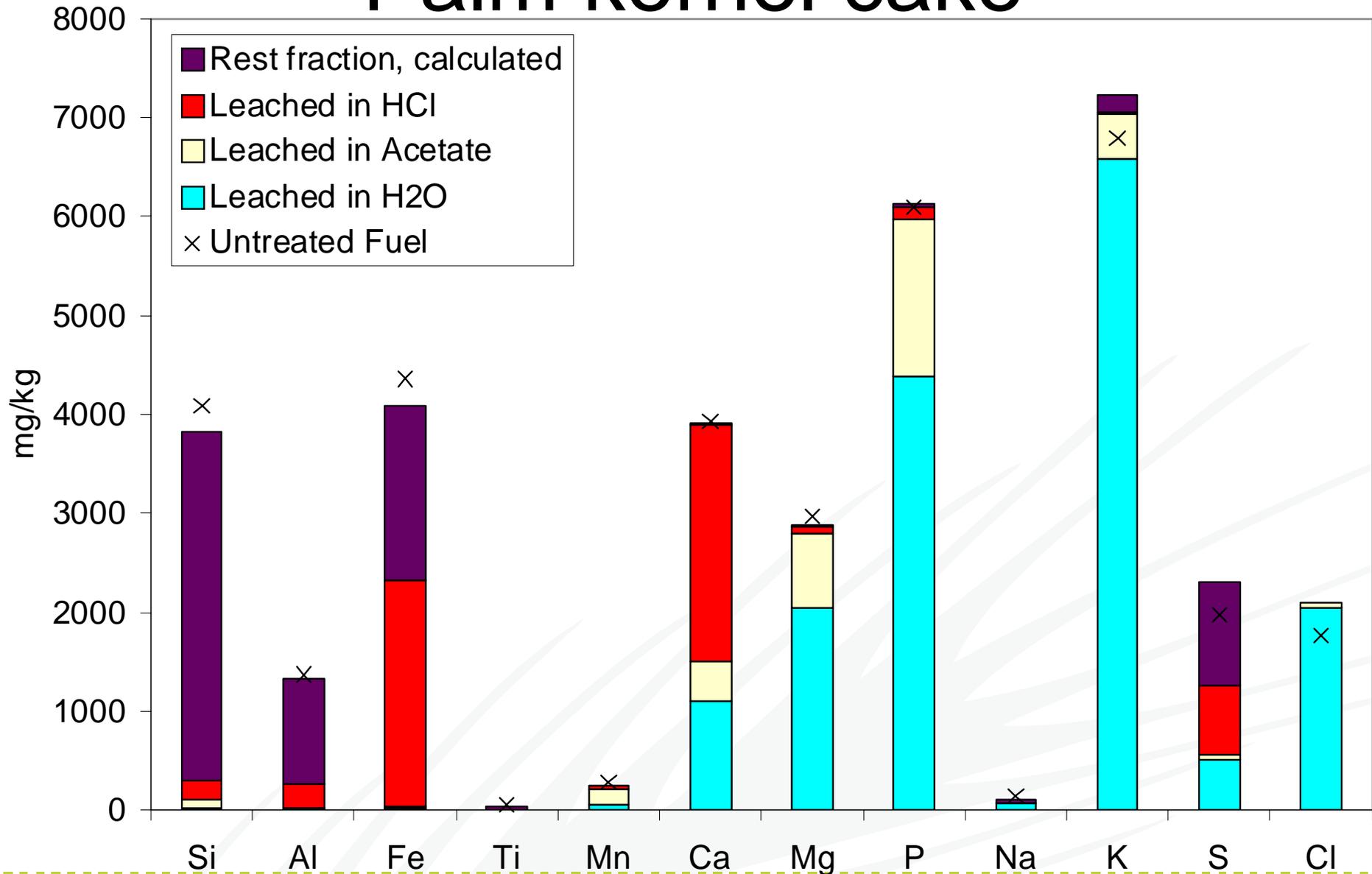


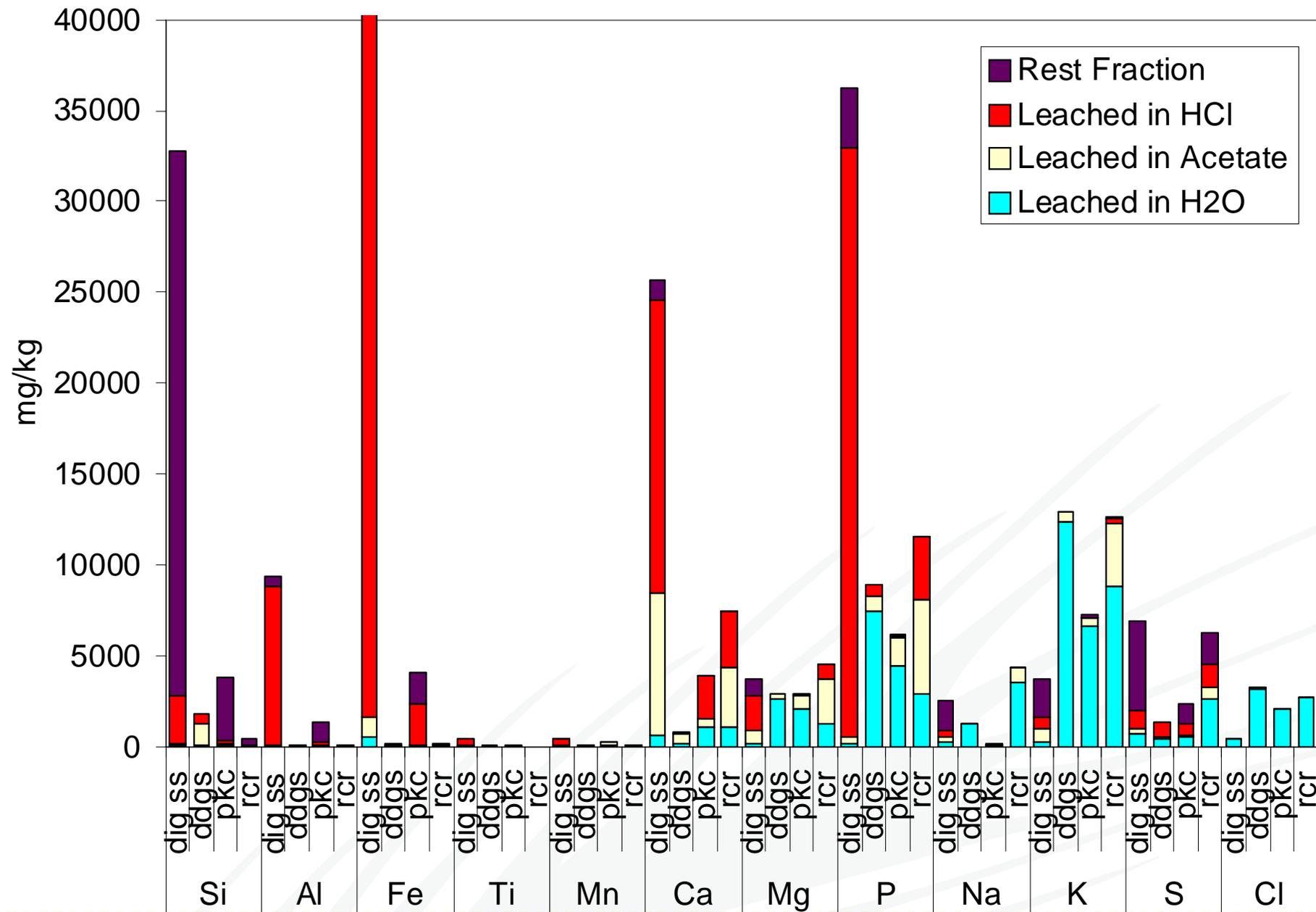
Rape seed cake

rape seed cake



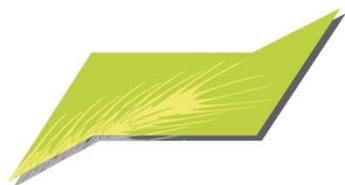
Palm kernel cake





Summary of leaching tests

- Digested sewage sludge:
 - Mainly iron phosphate/sulphate and aluminium silicates
 - Not very soluble ash forming matter compared to the other three fuels
- Dried distilled grains and solubles
 - Low silicates
 - Water soluble magnesium, phosphorous, potassium, chlorine
 - Sulphur also present in covalently bonded form
- Palm kernel cake
 - Silicates and salts of phosphates and chlorides
- Rape seed cake
 - Low silicates
 - Alkali phosphates/sulphates/chlorides
 - Organically associated alkaline earth metals
 - Acid soluble phytic acid (P)
 - Sulphur also present in covalently bonded form

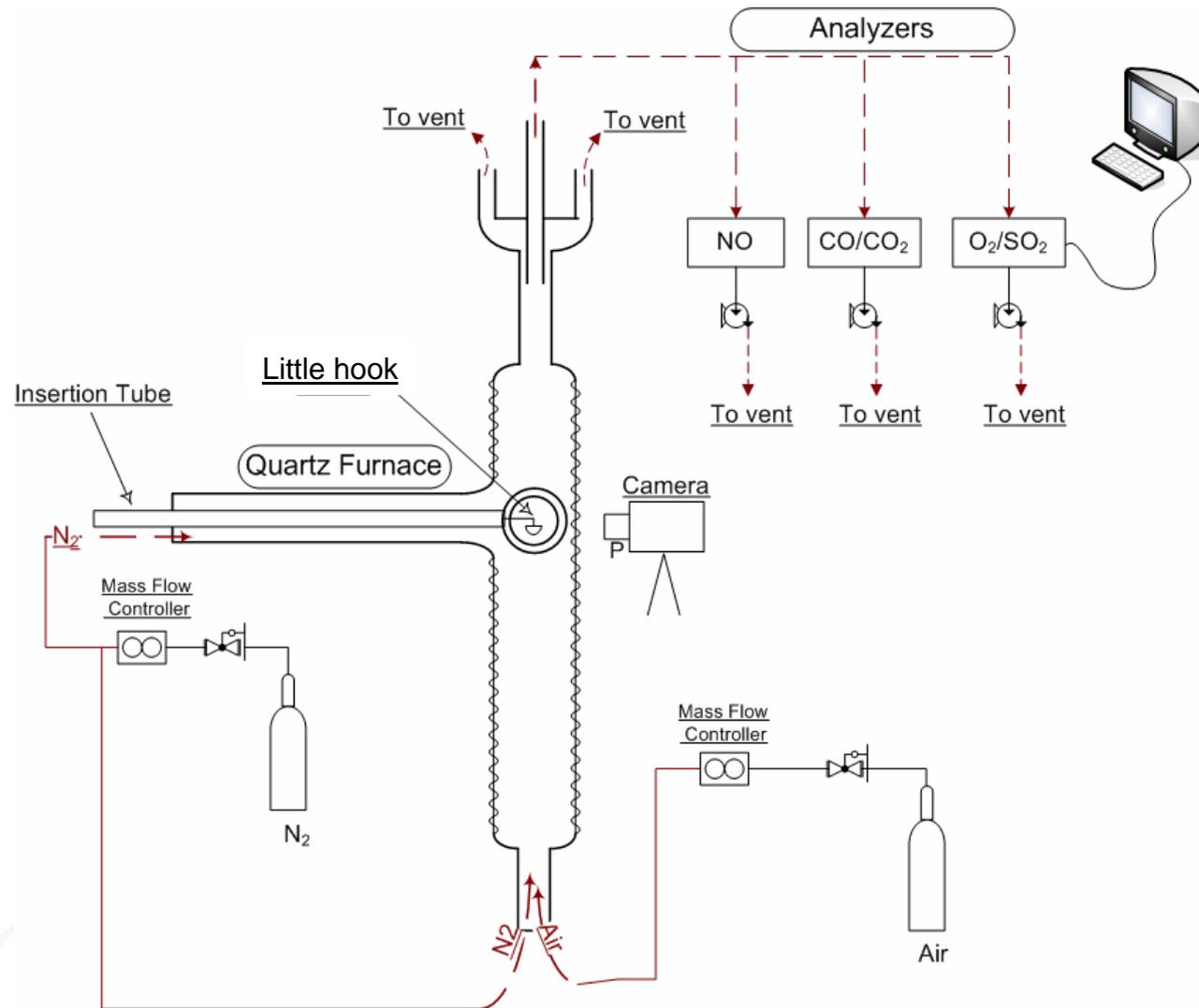


Combustion characteristics

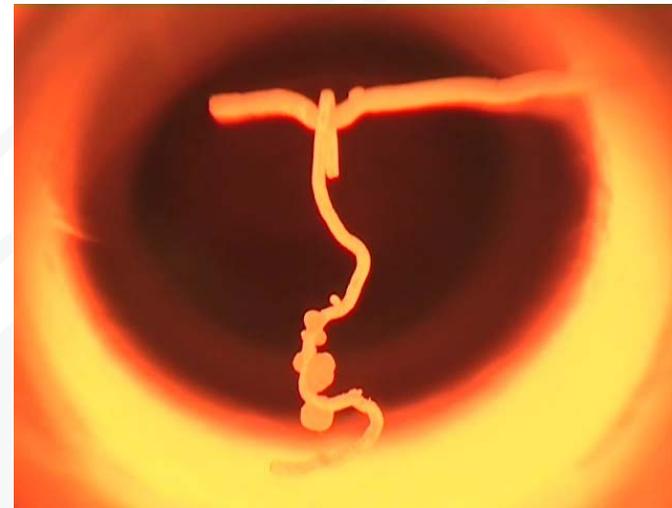
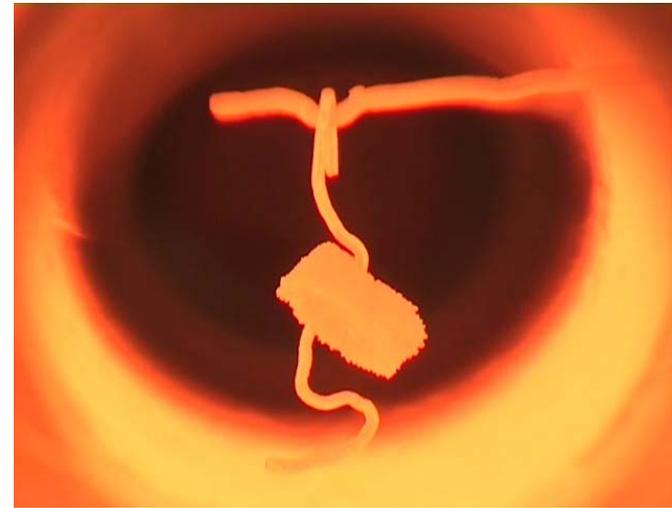
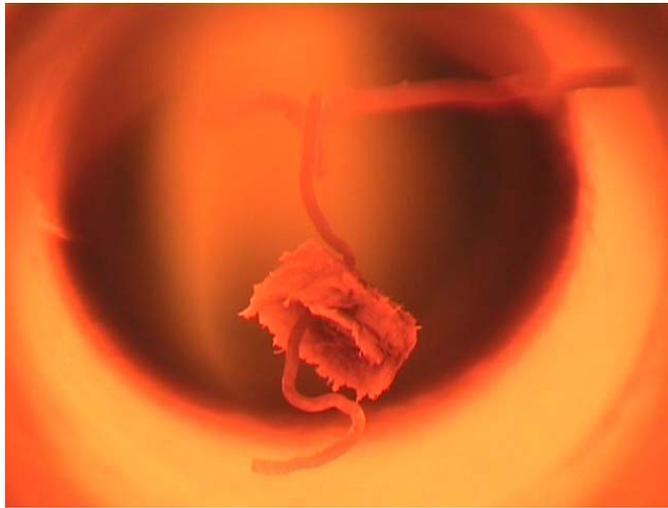
C, N release

Agglomeration characteristics

Experimental Facility



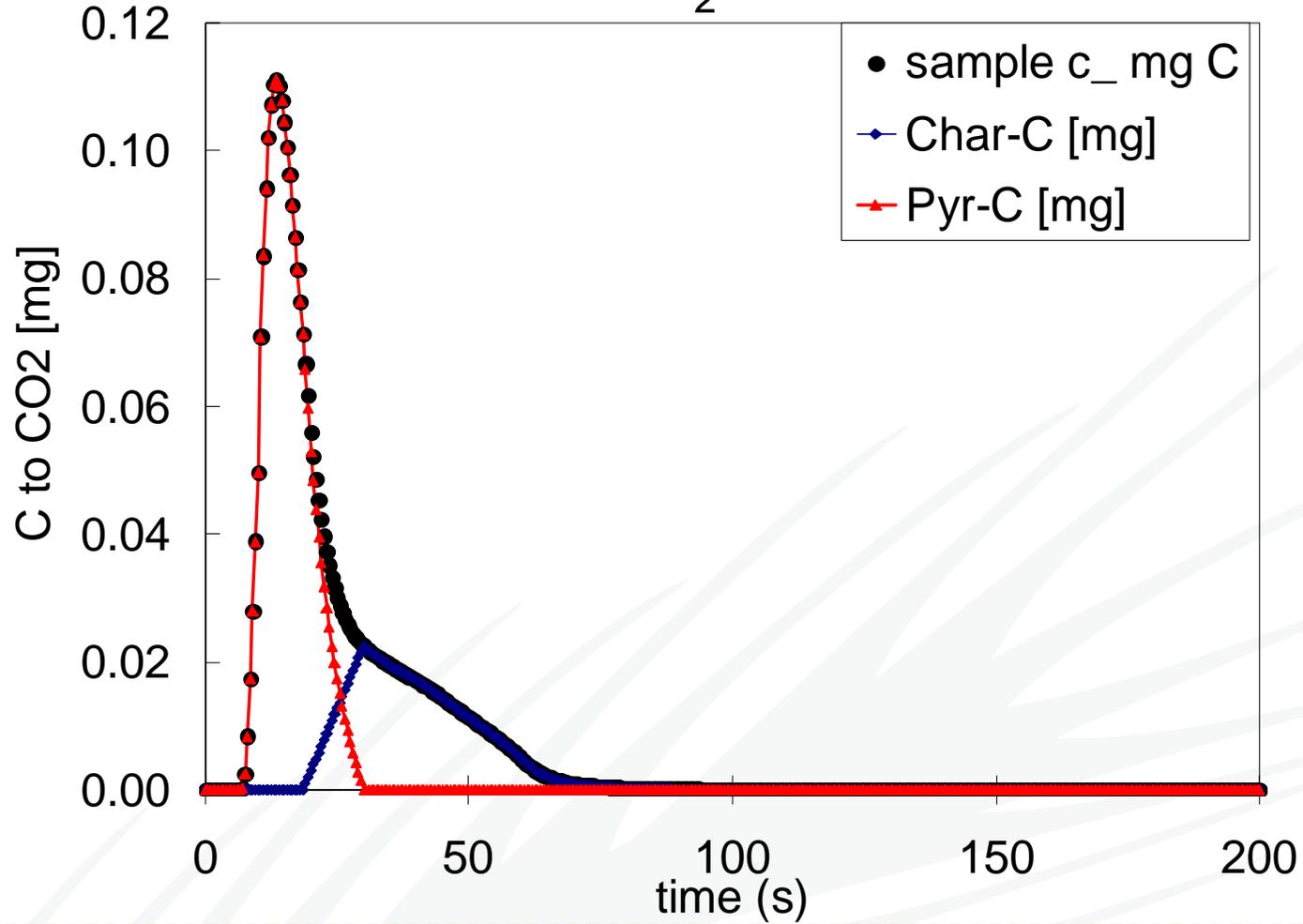
Phase in combustion of straw



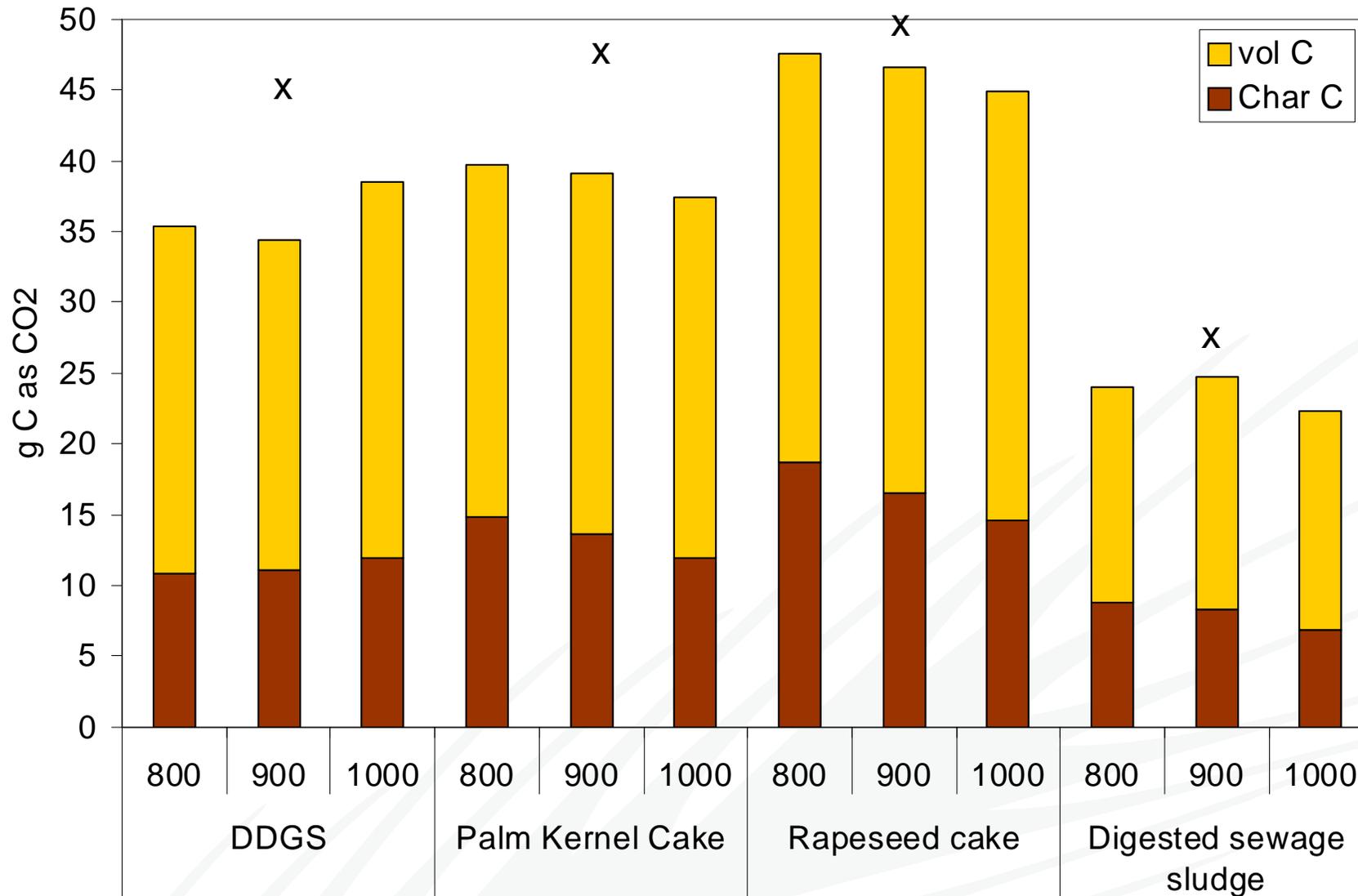
Combustion tests

Distribution between volatiles and char

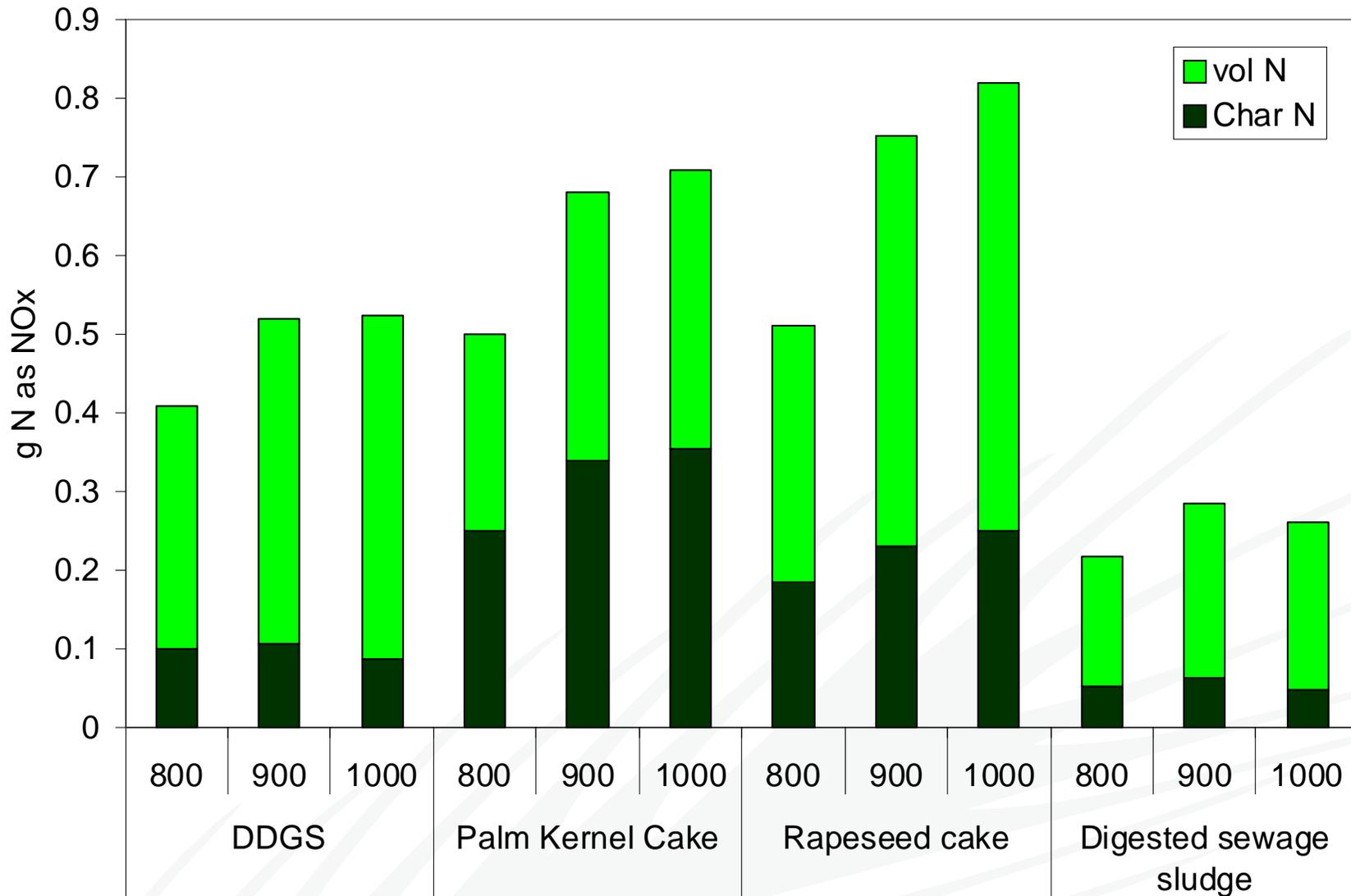
Rapeseed cake 900°C 10%O₂



C emitted as CO₂



g N as NO_x 10% O₂



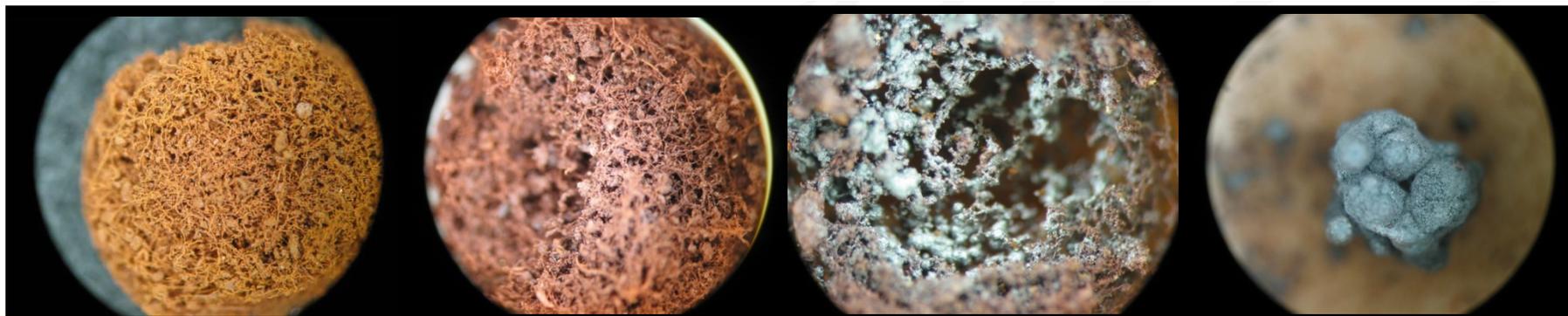
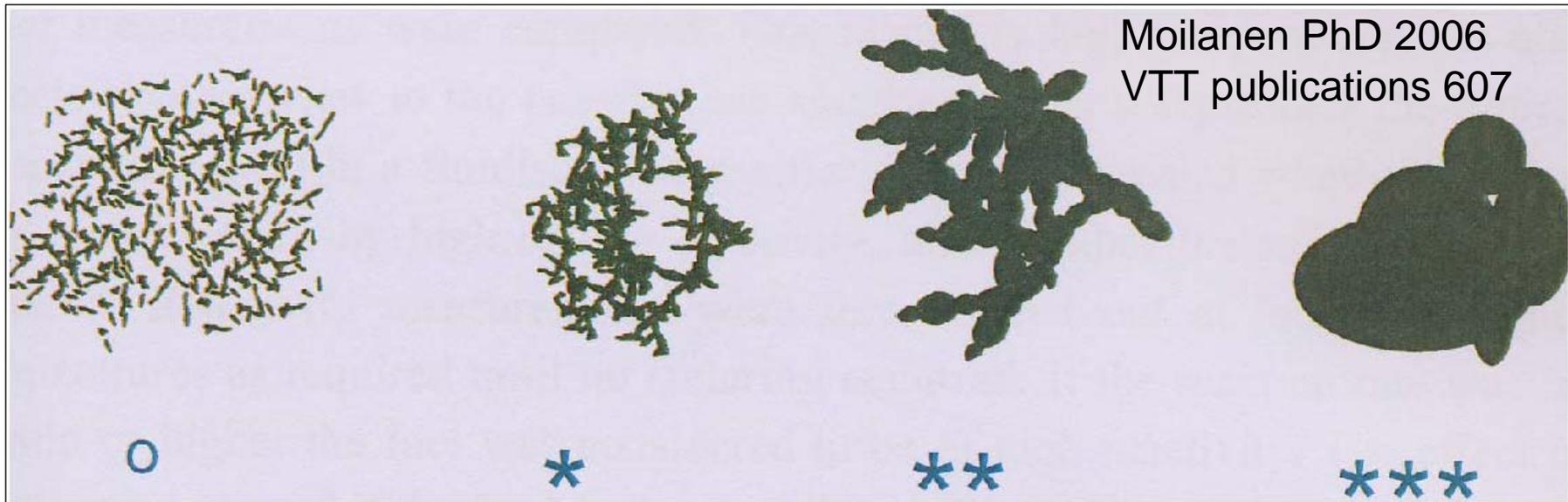
Agglomeration tendencies

- Equipment:
 - TGA-DTA
- Temperatures:
 - 550°C, 650°C, 750°C, 850°C, 950°
- Pressure:
 - 1 bar
- Particle size:
 - < 0.2 mm
- Sample weight:
 - ~16 mg
- Gas:
 - 20% O₂, 80% N₂



Agglomeration tendencies

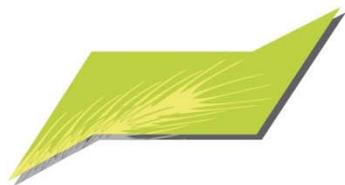
- Fermented sewage sludge



550°C

850°C 59 IEA-FBC/MZ 950°C

1050°C

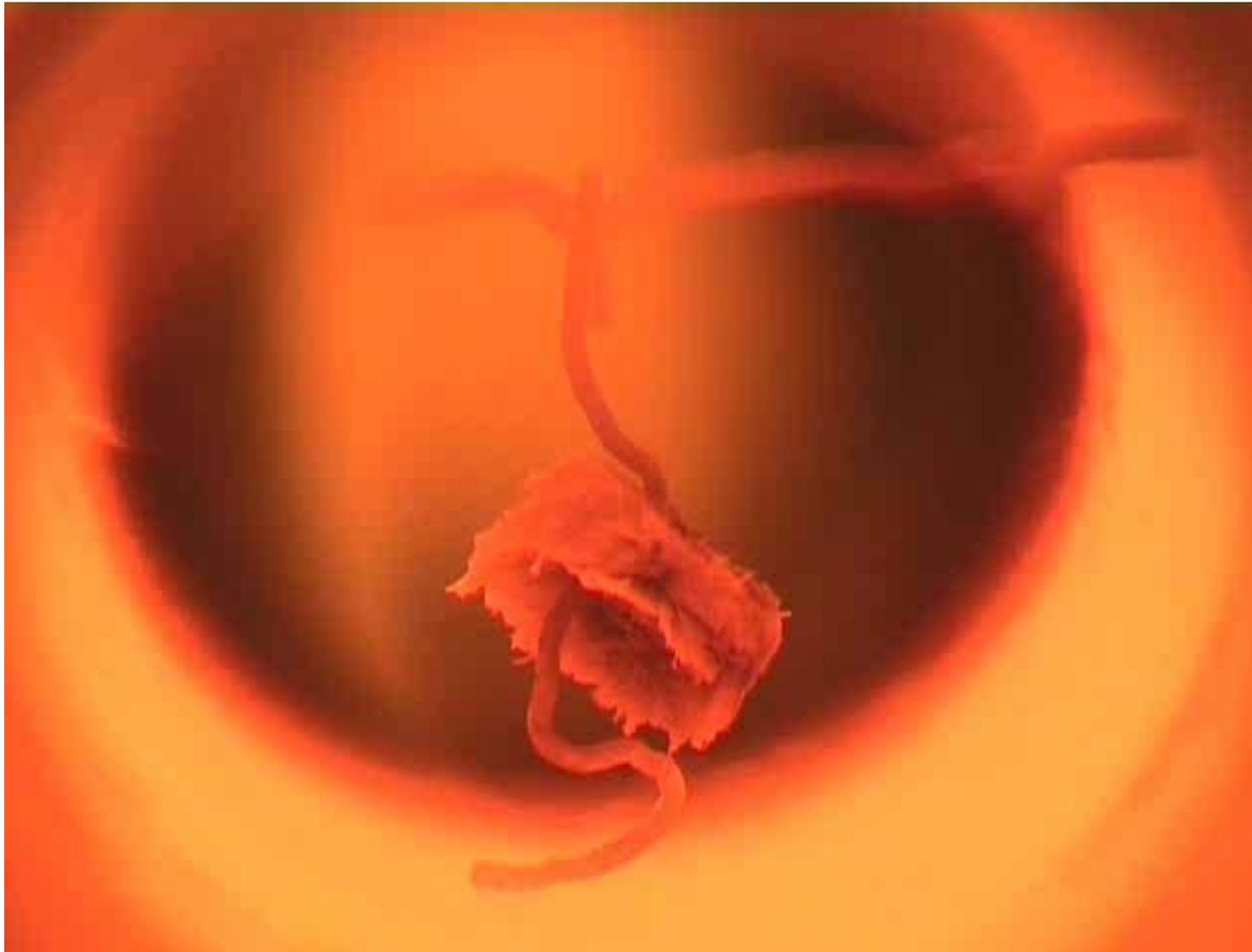


Future work

Future

- Fuel characterisation of challenging fuels
- Sintering tests with ash pellets
(Skrifvars 1994)
- Comparison of agglomeration tendencies with standard methods (ASTM)
- Char reactivity

Combustion of straw



Thank you for your attention