

# **Influence of Fuel Type on Particle and Heavy Metal Emissions during Fixed Bed Combustion of Biomass**

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# Introduction

## Problems with combustion generated particles

- Deposits on heat transfer surface => corrosion, less heat transfer
- Contributes to ambient air pollution => health effect on the general public (submicron particles)

## Particle types during biomass combustion

- Super micron particles => non volatile ash elements entrained in the gas flow
- Submicron particles => vaporisation and condensation of volatile ash elements (K, Na, S, Cl, and Zn)
- Particle concentration (dependent on fuel);  $30 \text{ g/Nm}^3 - 10 \text{ mg/Nm}^3$

## Heavy metals

? Emission levels, formation mechanisms

# Introduction

- **EU's regulation on metal emissions from waste incineration**
- **Dirty dussin (Sb, As, Cd, Co, Cr, Cu, Pb, Mn, Ni, Tl, V, and Hg)**

| <b>Pollutant</b>          | <b>Concentration<br/><math>\mu\text{g}/\text{Nm}^3</math> (6 % <math>\text{O}_2</math>)</b> |
|---------------------------|---|
| Cd+Tl                     | 50  |
| Hg                        | 50  |
| Sb+As+Pb+Cr+Co+Cu+Mn+Ni+V | 500   |

# Goal

Investigate the emissions of particles and heavy metals (EU+Zn) during small scale fixed bed combustion of different biomass fuels

**(i) Emission levels**

(ii) Behaviour of heavy metals

(iii) Validation of thermo chemical models

# Fuels

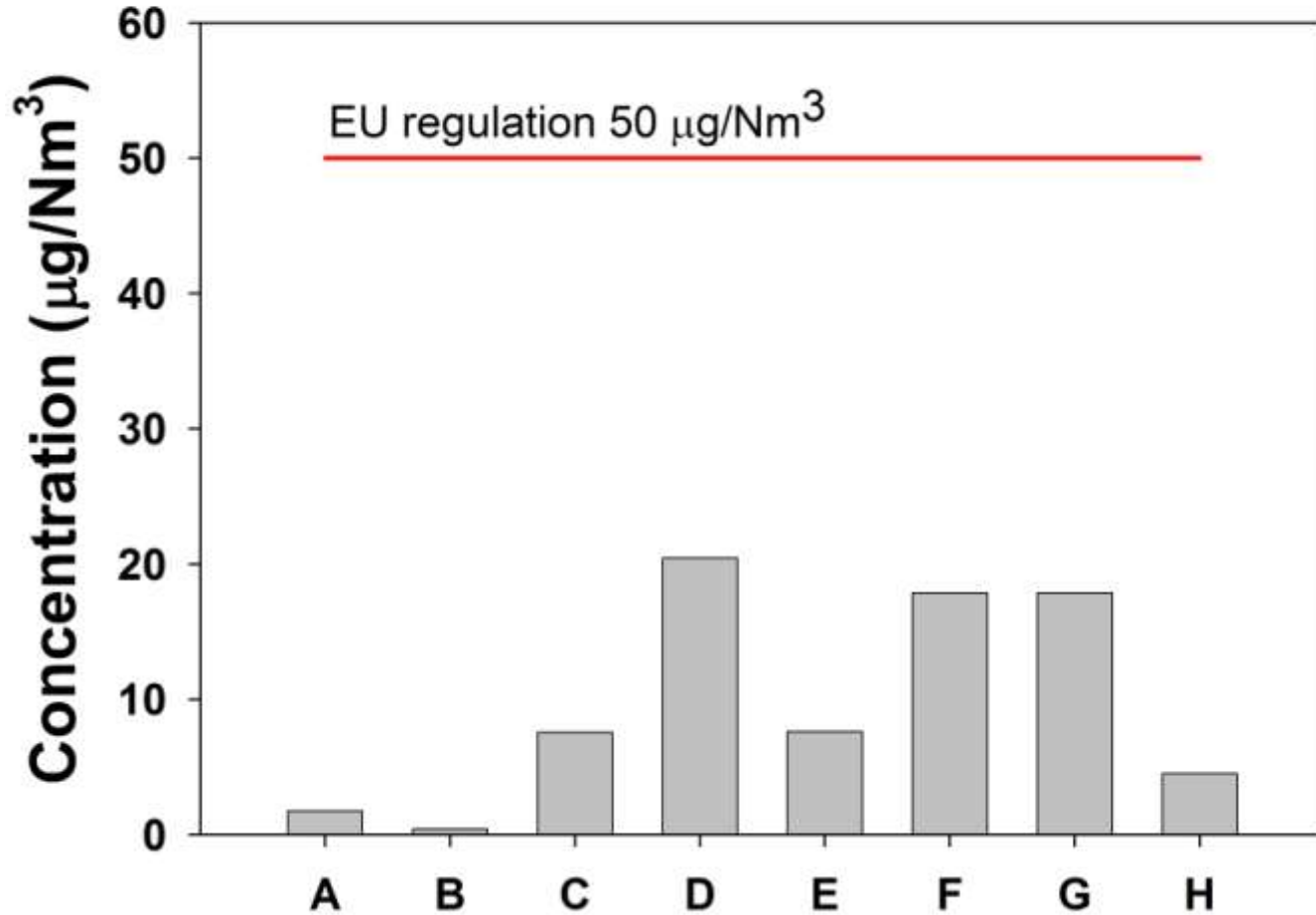
| <b>Fuel</b>           | <b>Form</b> | <b>Code</b> |
|-----------------------|-------------|-------------|
| Stem wood Birch       | Pellet      | A           |
| Stem wood Pine/Spruce | Pellet      | B           |
| Bark Birch            | Pellet      | C           |
| Bark Pine/Spruce      | Pellet      | D           |
| Oats                  | Grain       | E           |
| Salix                 | Pellet      | F           |
| Peat                  | Pellet      | G           |
| Coal                  | Granulate   | H           |

# Fuels

| Fuel                     | A      | B      | C      | D      | E      | F     | G      | H      |
|--------------------------|--------|--------|--------|--------|--------|-------|--------|--------|
| Ash (%)                  | 0.2    | 0.3    | 1.2    | 3.6    | 3.3    | 3.3   | 4.2    | 6.1    |
| Heavy metals (mg/kg dry) |        |        |        |        |        |       |        |        |
| Mn                       | 53.4   | 82.9   | 300    | 489    | 55.8   | 78.2  | 102    | 167    |
| As                       | <0.5   | <0.4   | <0.9   | <0.5   | <0.3   | 0.395 | 1.42   | <0.4   |
| Cd                       | <0.006 | <0.006 | 0.147  | 0.387  | <0.006 | 1.83  | <0.006 | 0.0283 |
| Co                       | 0.108  | 0.0506 | 0.342  | 0.359  | 0.0193 | 0.22  | 0.845  | 2.05   |
| Cr                       | 0.581  | 0.061  | 0.412  | 3.19   | 0.786  | 5.04  | 3.97   | 3.44   |
| Cu                       | 0.949  | 0.627  | 2.84   | 3.37   | 4.17   | 4.87  | 3      | 2.38   |
| Hg                       | <0.01  | <0.01  | <0.01  | 0.0307 | <0.01  | <0.01 | 0.0218 | <0.05  |
| Ni                       | 0.843  | <0.05  | 0.371  | 1.23   | 1.1    | 1.11  | 2.08   | 5.11   |
| Pb                       | 0.165  | 0.0577 | 0.202  | 1.38   | <0.05  | 0.673 | 0.76   | 4.15   |
| V                        | 0.0093 | 0.0085 | 0.0468 | 0.707  | <0.08  | 0.783 | 3.88   | 5.53   |
| Zn                       | 19.6   | 12.9   | 183    | 116    | 36.1   | 103   | 5.59   | 6.36   |

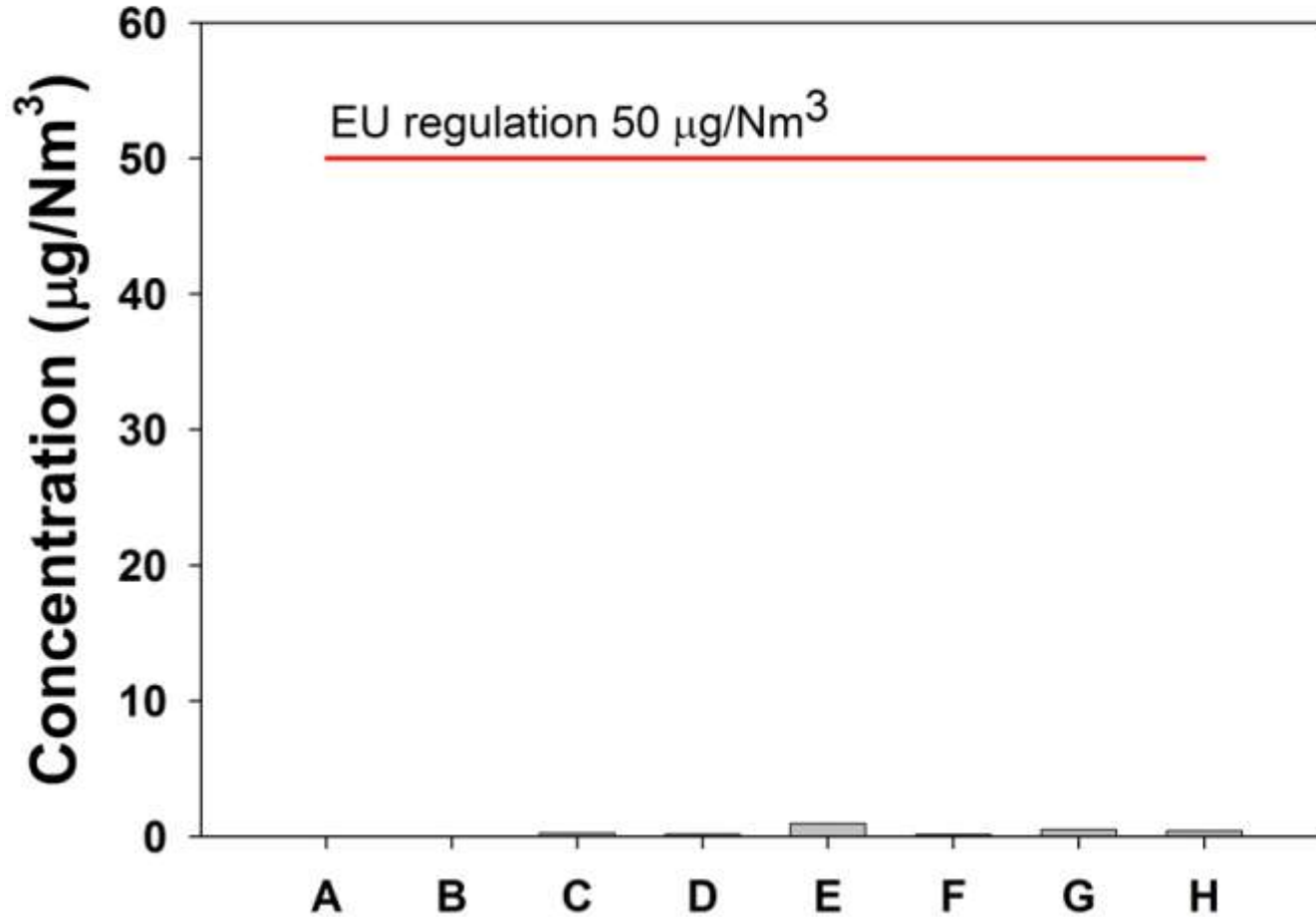
# Results

## Cd+Tl



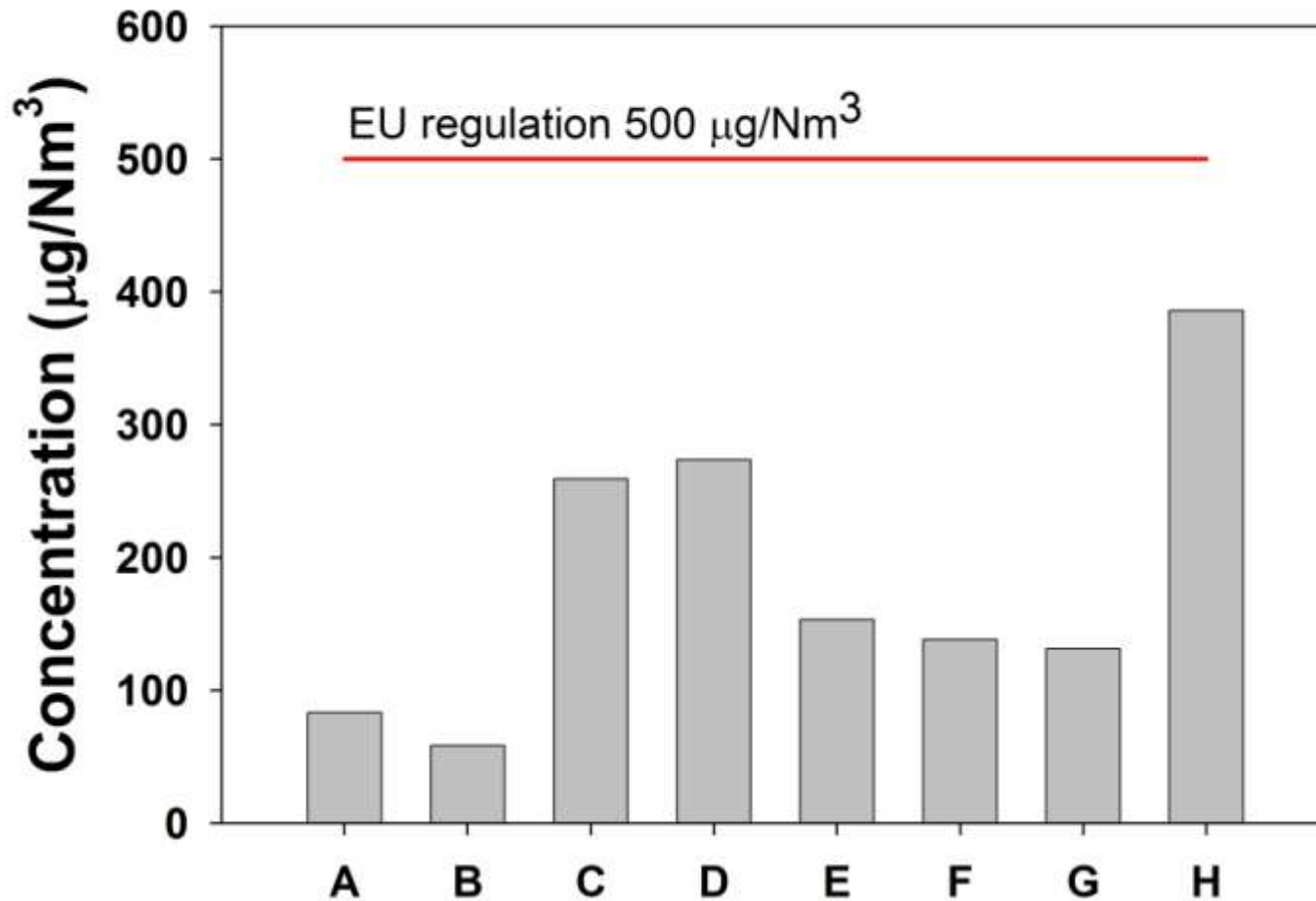
# Results

## Hg



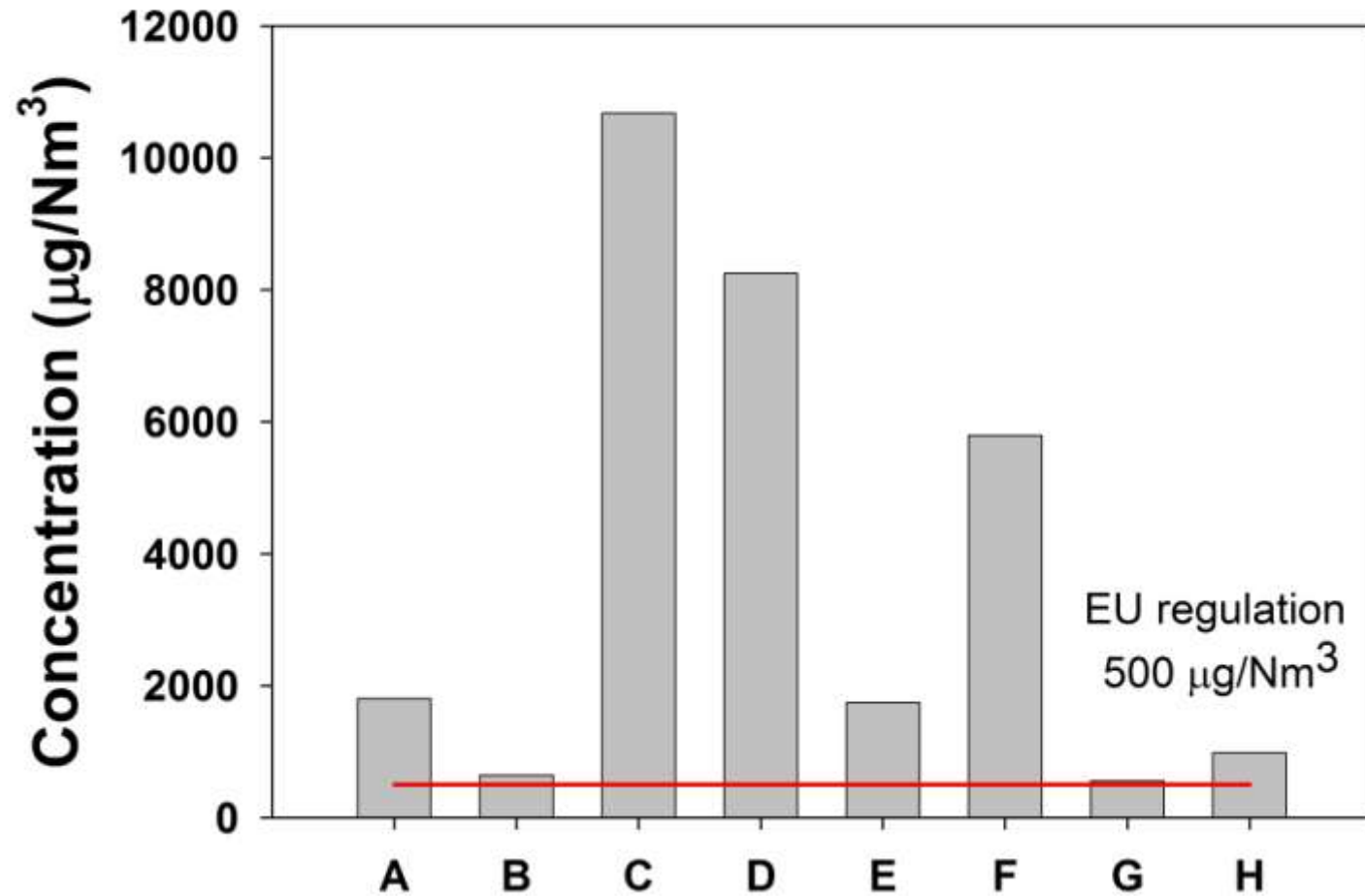
# Results

**Sb+As+Pb+Cr+Co+Cu+Mn+Ni+V**



# Results

## Zn



# Further work

- Formation mechanisms
- Chemical equilibrium modelling of the behaviour of heavy metals during combustion
- Toxicological studies (in-vitro) on particle emissions from biomass combustion