# POLLUTANTS FROM WASTE AND COAL CO-COMBUSTION IN THE CFB & BFB


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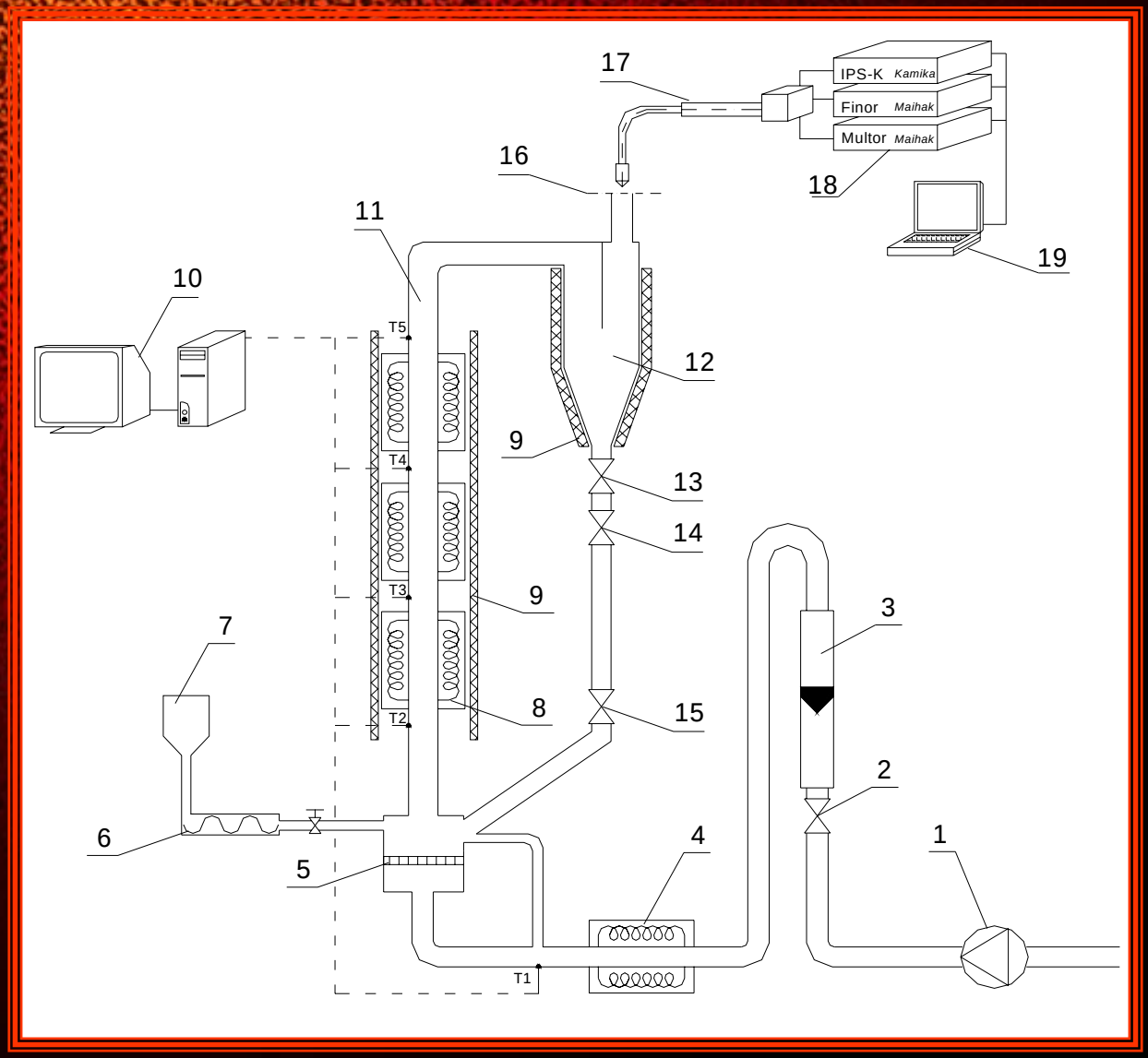
**IEA – FBC Workshop**
**'Future Challenges for Waste Combustion and Co-combustion in FBC'**
**May, 24, 2004, Vienna, Austria**

- Waste combustion and co-combustion gives an opportunity to split waste utilization with the production of energy. For this purpose fluidized bed technology is one of the most efficient process. However, combustion of waste could be also a significant source of pollutants.
- Issue: microparticle emissions (PM 2.5 , PM 10), other pollutants ( $SO_2$, $NO_x$, CO, heavy metals content in the fly ash).

# Laboratory stand with CFB and BFB

- Column ∅5cm in diameter,
- Gas velocity: $u_B$=3,2 m/s (BFB) and $u_F$=4,8 m/s (CFB),
- Samples of fuel: 1g and 2g,
- Temperature controlled automatically; t=850$^o$C ±10$^o$C,
- Equipped with *Maihak* and *Kamika* analyzers,
- Bed material: silica sand of $dp_{50}$=80 μm and $d_{min}$>63μm

# Laboratory stand scheme




1. Air compressor
2. Ball valve
3. Flow meter
4. Preheater
5. Grid
6. Fuel feeder
7. Fuel
8. Heaters
9. Thermal insulation
10. Heaters control system
11. Combustion chamber
12. Cyclone
13. Feed valve
14. Drain valve
15. Flow regulating valve
16. Exhaust gas
17. Probe
18. Analyzers
19. Data storage

T1-T5 Thermocouples

# Microparticles analyzer (IPS-K)

- Infrared Particle Sizer System,
- Range: 0,35 ÷300 µm,
- Fulfilling ISO 9096 and PN-Z-04030-7 requirements.

# RESEARCH

## Stage 1: pollutant emissions from 6 waste fuel combustion in the CFB

Fuel 1: granulated waste coal

Fuel 2: hard coal sludge

Fuel 3: refused coal 0-10mm

Fuel 4: refused hard coal 0-10mm


Fuel 5: granulated coal with addiction of sewage sludge (H-34)


Fuel 6: refused hard coal 0-40mm

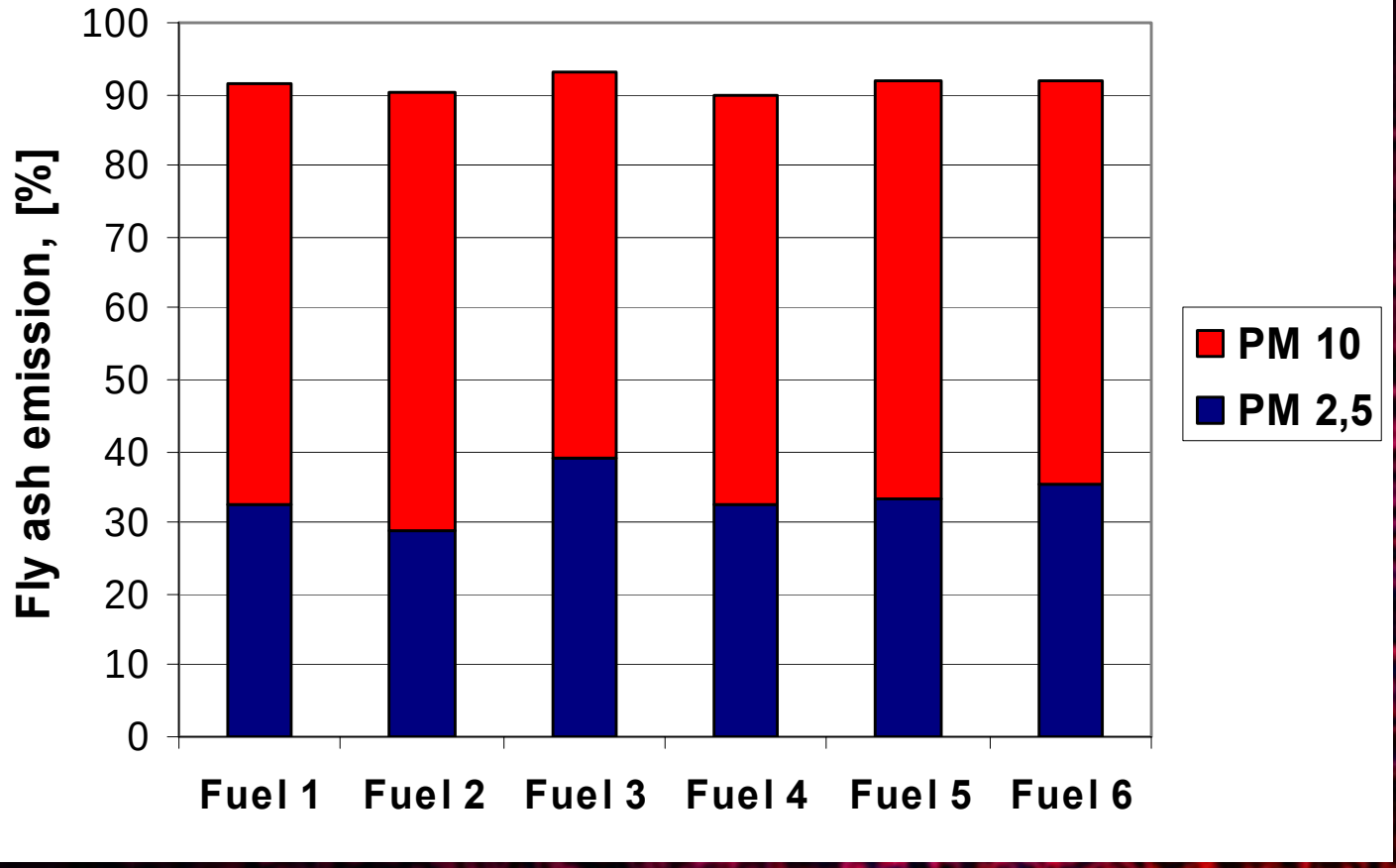
# Results of proximate analysis

| Parameter | | Fuel 1 | Fuel 2 | Fuel 3 | Fuel 4 | Fuel 5 | Fuel 6 |
|---|---|---|---|---|---|---|---|
| Moisture (total) | % | 22,4 | 23,5 | 6,2 | 8,4 | 7,9 | 5,1 |
| Moisture (air dried) | % | 1,5 | 1,1 | 0,6 | 0,9 | 3,5 | 0,5 |
| S | % | 0,67 | 0,69 | 0,50 | 0,64 | 0,80 | 0,29 |
| C | % | 29,1 | 36,4 | 13,9 | 16,4 | 25,7 | 19,9 |
| Ash | % | 40,6 | 30,6 | 72,6 | 67,2 | 54,2 | 65,5 |
| Fixed carbon | % | 6,9 | 12,1 | 4,3 | 5,0 | 9,4 | 11,7 |
| Volatiles | % | 17,3 | 21,3 | 12,3 | 13,5 | 25,4 | 14,0 |
| HHV | kJ/kg | 11650 | 15060 | 5000 | 5750 | 9960 | 7710 |
| LHV | kJ/kg | 10410 | 13720 | 4550 | 5190 | 8860 | 7190 |

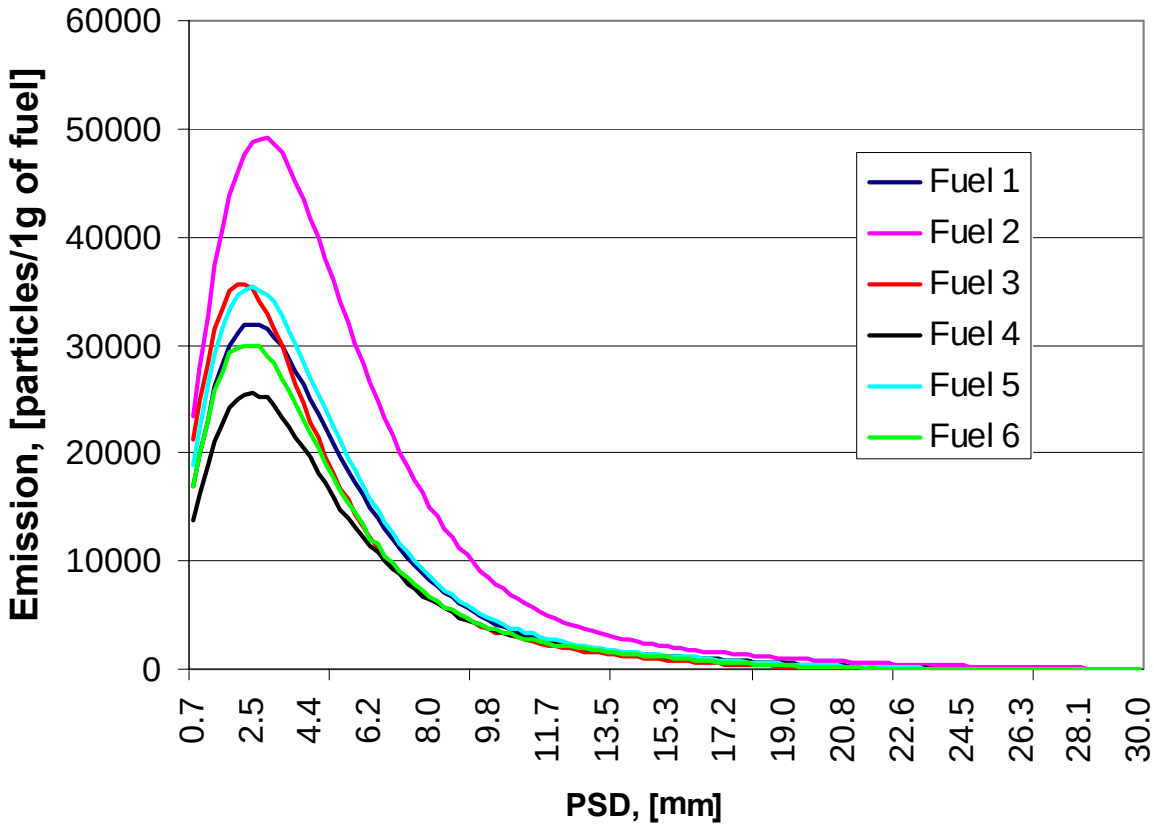
# Heavy metals content in the fly ashes (ppm)

| Element | Fuel 1 | Fuel 2 | Fuel 3 | Fuel 4 | Fuel 5 | Fuel 6 |
|---|---|---|---|---|---|---|
| Pb | 2100 | 1910 | 2270 | 2200 | 2120 | 2300 |
| As | 62 | 44 | 46 | 25 | 27 | 33 |
| Zn | 333 | 167 | 339 | 293 | 1090 | 48 |
| Ni | 93 | 112 | 97 | 130 | 76 | 131 |
| Co | 34 | 36 | 36 | 34 | 33 | 35 |
| Mn | 437 | 377 | 537 | 536 | 399 | 449 |
| Cr | 121 | 187 | 163 | 181 | 167 | 258 |
| Cd | 74 | 55 | 58 | 13 | 51 | 60 |

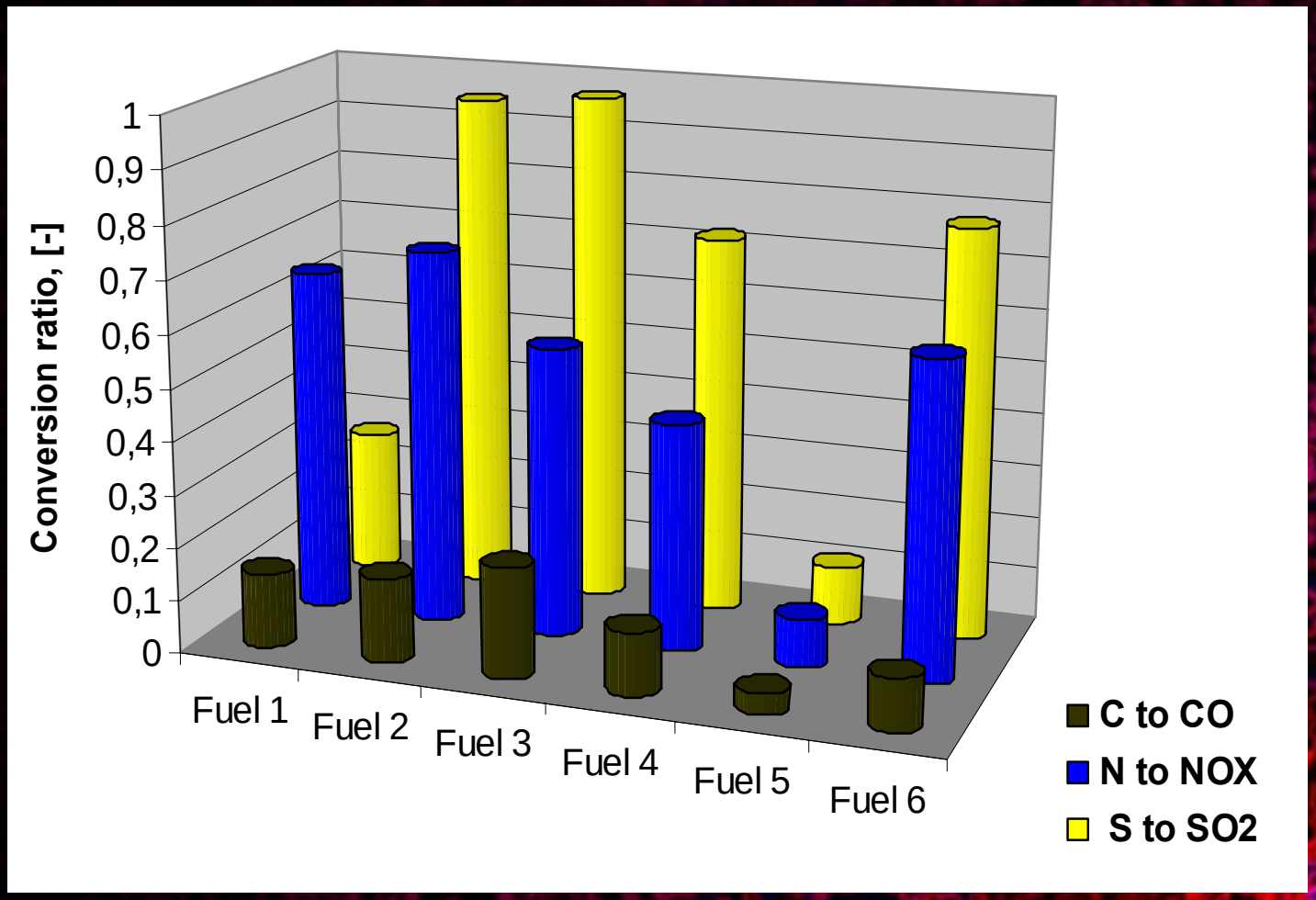
# Microparticle emissions



# Volatile ash emissions



# Conversion of gaseous pollutants



# CONCLUSIONS (STAGE 1)

- Waste fuels could be co-combusted with coal,
- Coal sludge (fuel 2) combustion resulted in relatively high volatile ash and microparticles emission,
- Fuel 6 needs grinding before utilization in the CFB boiler,
- Poor conversion of C was observed,
- High content of Pb in the fly ashes.

# Stage 2: emissions from co-combustion of waste with hard coal in the BFB

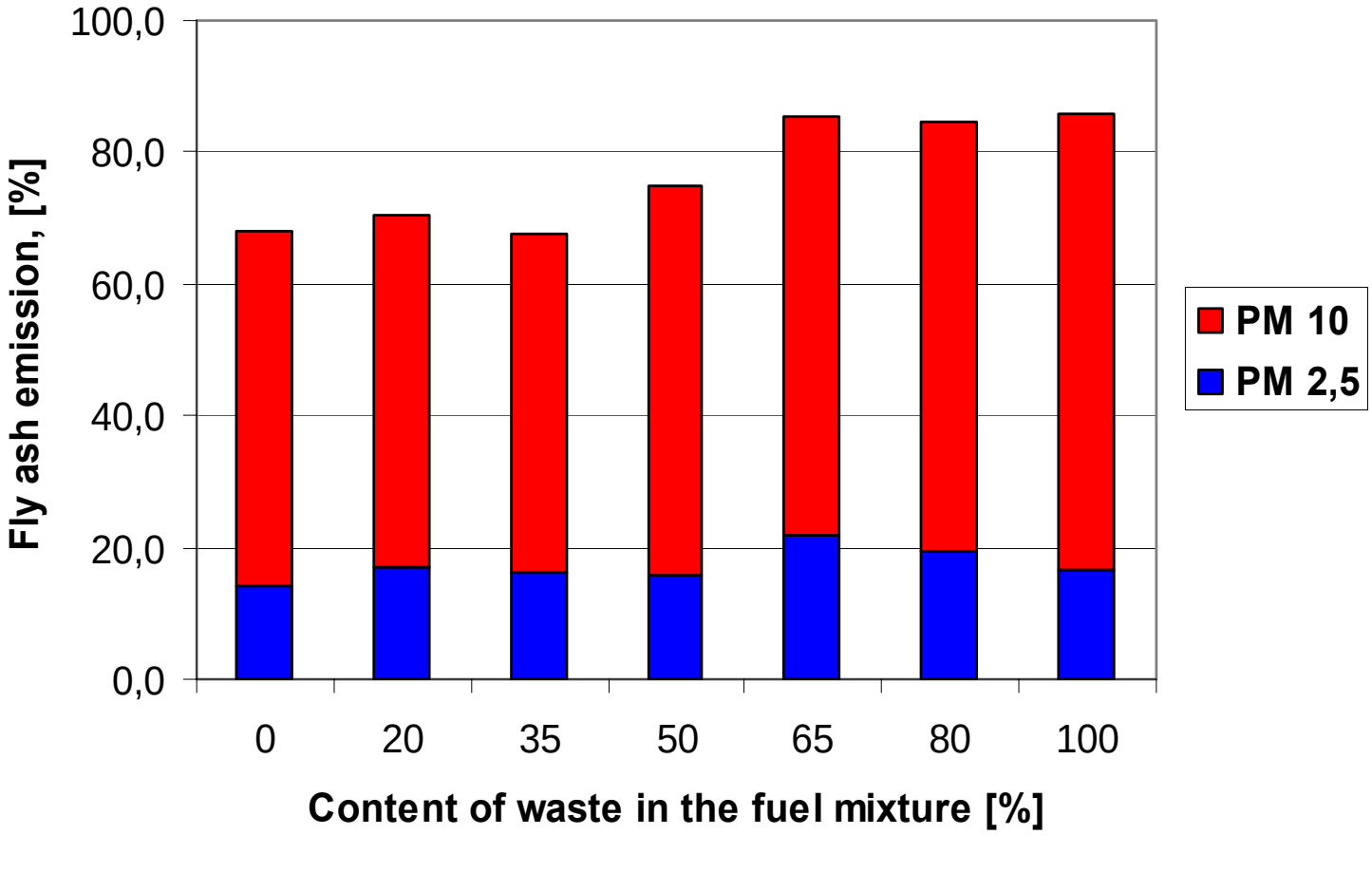
Waste from paper mill facility
(dried sludge from waste-paper discolourization)

| Fuel | Moisture (total) [%] | Moisture (air dried) [%] | C [%] | S [%] | Ash [%] | Volatiles [%] | HHV [kJ/kg] | LHV [kJ/kg] |
|---|---|---|---|---|---|---|---|---|
| Waste | 50,0 | 0,5 | 5,8 | 0,07 | 12,1 | 8,1 | 3650 | 1360 |
| Coal | 8,4 | 0,9 | 47,9 | 1,6 | 19,6 | 22,9 | 22460 | 19730 |

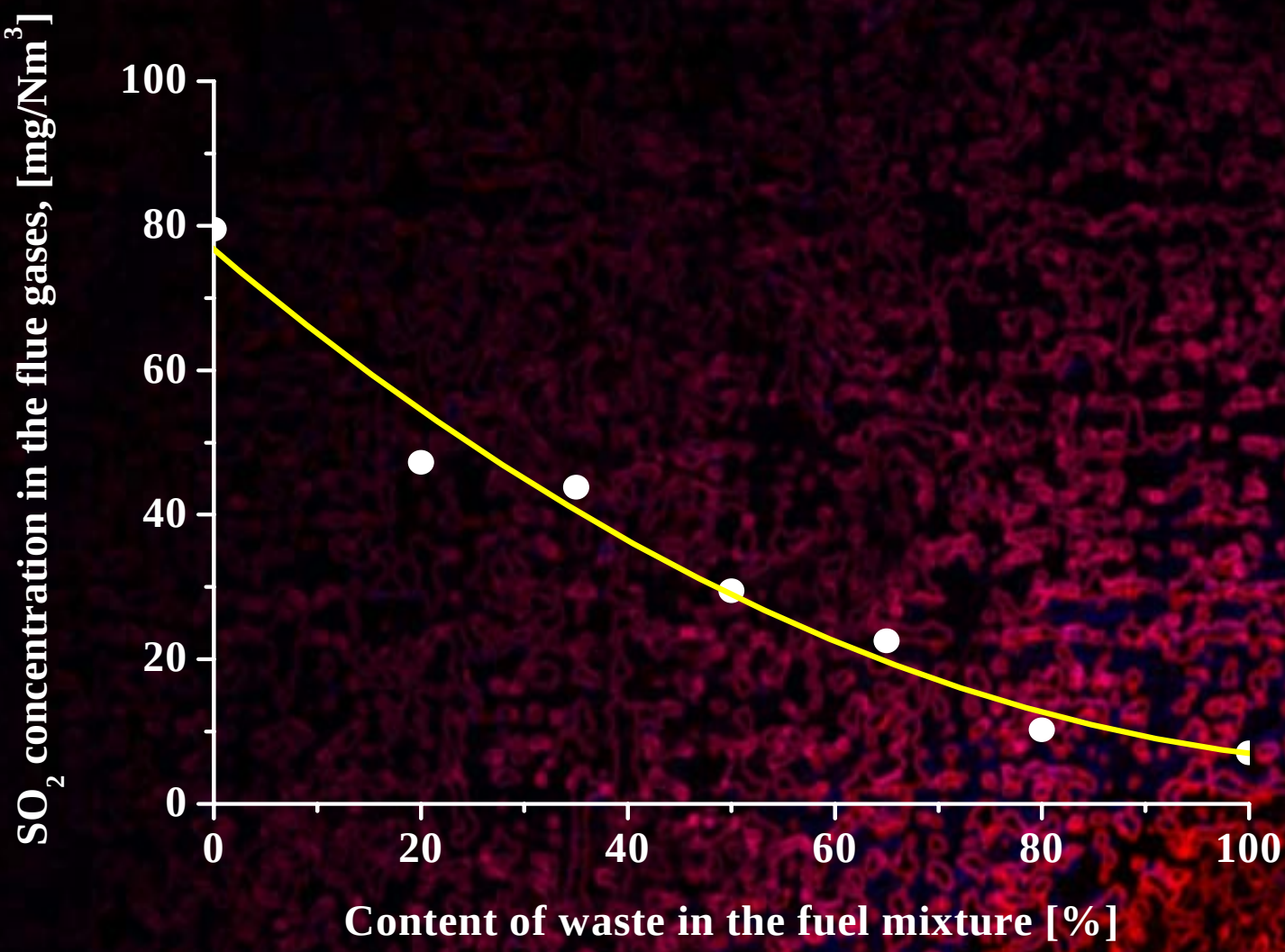
# Content of selected elements in waste, coal and their ashes

| Element | Unit | Coal | | Waste | |
|---|---|---|---|---|---|
| | | Fuel | Ash | Fuel | Ash |
| Pb | [mg/kg] | - | - | - | - |
| As | [mg/kg] | - | 54,4 | - | 0,94 |
| Zn | [mg/kg] | 1418 | 372 | 71,1 | 28,3 |
| Ni | [mg/kg] | 25,3 | 142 | 24,9 | 25,9 |
| Co | [mg/kg] | 21,4 | 40,8 | 18,4 | 19,8 |
| Fe | [%] | - | 4,71 | - | - |
| Mn | [%] | 0,012 | 0,05 | 0,011 | 0,017 |
| Cr | [mg/kg] | 75,8 | 193 | - | - |
| Ti | [%] | 0,252 | 0,71 | 0,247 | 0,31 |
| Ba | [%] | - | 0,21 | - | - |
| Ca | [%] | - | 3,45 | 19,6 | 29,9 |
| K | [%] | - | 2,68 | 0,005 | 0,48 |
| Cd | [mg/kg] | - | 14,3 | 4,95 | 5,60 |
| S | [%] | 0,319 | 1,37 | - | 0,32 |
| P | [%] | - | 0,20 | - | 0,03 |
| Si | [%] | 1,33 | 14,8 | 7,74 | 13,3 |
| Al | [%] | 0,04 | 11,0 | 8,57 | 10,4 |
| Mg | [%] | 0,76 | 2,18 | 1,81 | 0,27 |

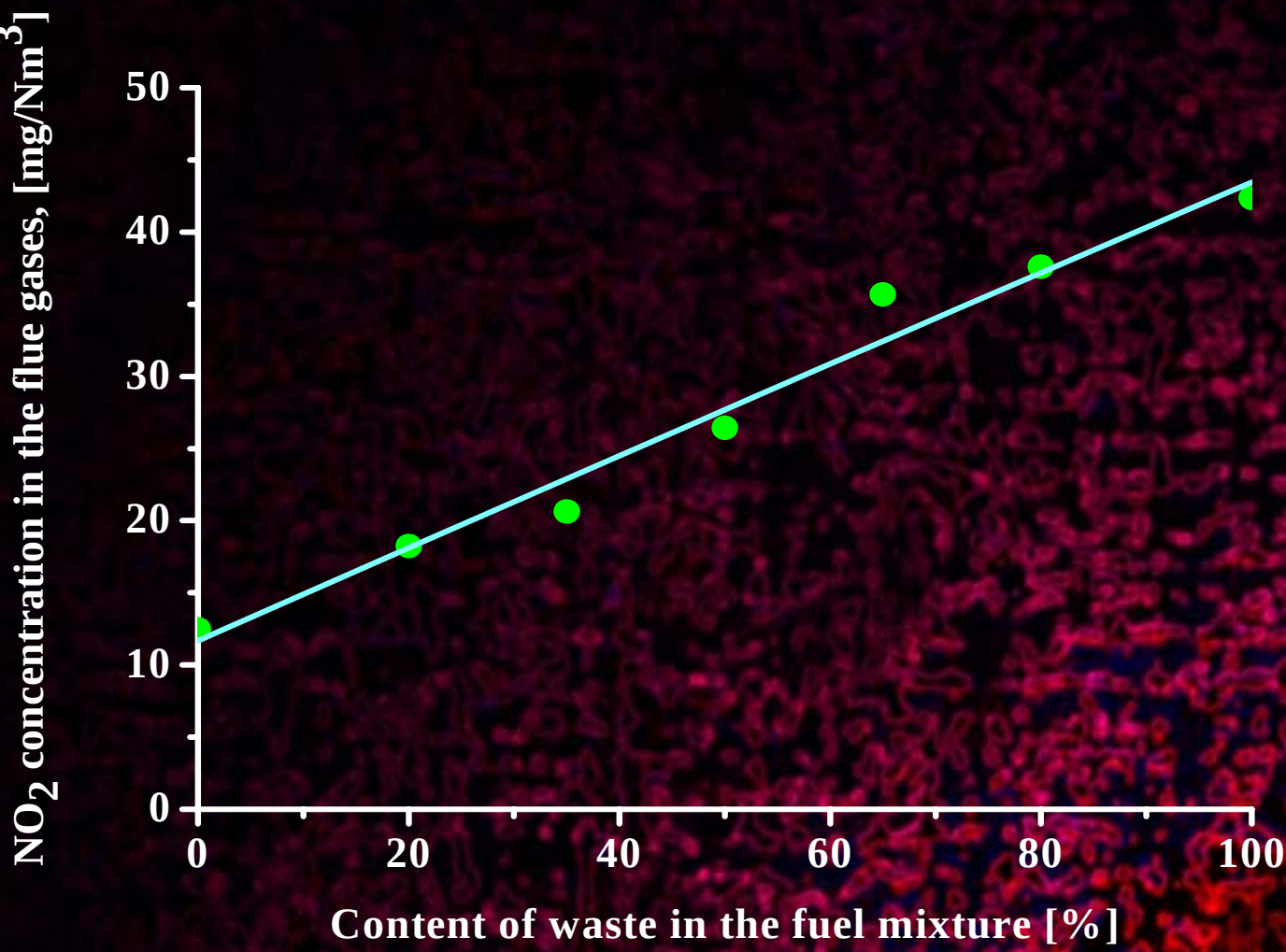
# Microparticle emissions



# $SO_2$ EMISSIONS



# $NO_x$ EMISSIONS



# CONCLUSIONS (STAGE 2)

- The waste could be an addiction for the coal,
- Higher emissions of $NO_X$,
- Reduction of $SO_2$ emissions,
- Higher concentrations of PM 2,5 and PM 10 in the exhaust gases,
- The waste could be co-combusted without significant pollution enhancement, when it's not exceeding the 35-50% of fuel composition.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THANK YOU
for your attention