# CHEMICAL AND ECOTOXICOLOGICAL PROPERTIES OF ASHES PRODUCED IN THE CO-COMBUSTION OF COAL AND SEWAGE SLUDGE

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The main aim of this work is to study the effeet of the partial and complete substitution of coal by SS in the quality of the by-products produced in a fluidized bed combustor (FBC). To achieve this aim, a comparative study on the chemical composition and the ecotoxic level of these by-products was performed. In order to evaluate the chemical and ecotoxicological properties of the ashes, the following combustion assays were performed: Assay A - Combustion of a Colombian coal; Assay B - Co-combustion of coal and a stabilized SS; Assays C and D - Combustion assays with different ratios of SS/sand (bed material). In each combustion test, samples were collected from the bed of the reactor (bottom ashes) and from two cyclones (1st and 2nd cyclone ashes). The characterization of the ashes was focused on two aspects: (1) the bulk content of a set of metals and (2) the characterization of eluates produced according to the European Standard leaching test EN 12457-2. The eluates were submitted to a chemical and to an ecotoxicological characterization and classified according to an adaptation performed to the French regulation "Criterion and Evaluation Methods for Waste Ecotoxicity" (CEMWE).

In Table 1 it is shown the chemical characterization of the eluates produced by the materials. Considering the ecotoxicity assays, the eluates of bottom and fly ashes have shown low ecotoxie levels. The D. magna was, generally, more sensitive than the V. fischeri. The ashes of the 1st cyclone showed the highest ecotoxicity levels for V. fischeri and D. magna. The ashes produced during the combustion of SS have shown higher ecotoxicity levels than those produced during the combustion of coal and co-combustion of coal and SS.

Table 1 – Ecotoxicological charaeterization of the eluates (a EC50 30min (% v/v); b EC50 48h (% v/v))

| Bio-indicator | Fuel | | | Assay A | | | Assay B | | | Assay C | | | Assay D | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sand | Coal | SS | BA | 1st Cy | 2nd Cy | BA | 1st Cy | 2nd Cy | BA | 1st Cy | 2nd Cy | BA | 1st Cy | 2nd Cy |
| V. fischeri a | >99 | 47.8 | 88.1 | 47.3 | >99 | >99 | >99 | >99 | >99 | >99 | 24 | >99 | >99 | 23 | >99 |
| D. magna b | >95 | 16.2 | 15.9 | >95 | 43 | >95 | 45 | 58 | 67 | 39 | 10 | >95 | 21 | 15 | >95 |

In Tahle 2 it is shown the chemical characterization of the eluates produced by the materials. The Biogran® has shown the highest concentrations of TDS, COD, phenol index and free cyanides and relatively high concentrations of Cr, Cr (VI), Cu, Ni, Zn and Fe. The bottom and the 1st cyclone ashes were characterized by the high pH values of the eluates. The leaching test has shown low mobility of metals from the by-products produced during the combustion tests. Cr and Cr (VI) were detected in the eluates of the 1st cyclone ashes

produced in combustion tests A and B and in the 2nd cyclone ashes produced in the co-combustion test and iu the combustion tests C and D, while Ni and Zn were more released from the ashes of the 2nd cyclone produced during the combustion of coal. The combustion of SS has promoted, generally, the production of bottom ashes with higher leaching rates of Zn, Fe and Al.

Table 2 – Chemical characterization of thc eluatcs (Units: mg/kg db, except Moisture: wt% db, pH: Sorensen scale, Conductivity: µS/cm)

| Element | Bed Material/Fuel | | | Assay A | | | Assay B | | | Assay C | | | Assay D | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sand | Coal | SS | BA | 1st Cy | 2nd Cy | BA | 1st Cy | 2nd Cy | BA | 1st Cy | 2nd Cy | BA | 1st Cy | 2nd Cy |
| pH | 8.9 | 3.6 | 7.5 | 11.0 | 7.6 | 6.8 | 10.0 | 8.3 | 7.3 | 10.1 | 11.2 | 8.4 | 10.1 | 11.3 | 8.0 |
| Conduct. | 3.8 | 878 | 1,288 | 177 | 1,660 | 1,472 | 375 | 1,310 | 1,348 | 501 | 890 | 1,015 | 720 | 972 | 1,382 |
| TDS | 11,542 | 8,985 | 50,746 | 1,781 | 20,619 | 23,511 | 3,765 | 17,298 | 16,623 | 5,335 | 7,555 | 9,938 | 8,110 | 9,652 | 15,750 |
| COD | <97 | 321 | 56,514 | 99 | 97 | 97 | 165 | 102 | 102 | 284 | 111 | 162 | 110 | 111 | 168 |
| Phenol Index | 0.70 | <0.54 | 12 | <0.50 | <0.52 | <0.53 | <0.50 | 1.4 | <0.52 | <0.50 | <0.50 | 1.4 | <0.50 | <0.50 | <0.50 |
| Free cyanides | <0.10 | <0.14 | 1.2 | <0.13 | <0.14 | <0.14 | <0.13 | <0.13 | <0.13 | <0.10 | 0.17 | <0.10 | <0.10 | 0.14 | <0.10 |
| As | 0.44 | <0.04 | <0.04 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | 0.17 | <0.03 | <0.03 | <0.03 | <0.03 | 0.52 |
| Cd | <0.32 | <0.35 | <0.35 | <0.32 | <0.34 | <0.34 | <0.32 | <0.33 | <0.32 | <0.32 | <0.32 | <0.32 | <0.32 | <0.32 | <0.32 |
| Cr | <0.50 | <0.54 | 1.5 | <0.50 | 1.7 | <0.53 | 1.3 | 15 | 20 | <0.50 | 1.6 | 5.3 | <0.50 | <0.50 | 0.91 |
| Cr(VI) | <0.50 | <0.54 | 1.0 | <0.50 | 1.3 | <0.53 | 0.83 | 11 | 12 | <0.50 | 1.1 | 4.2 | <0.50 | <0.51 | 0.75 |
| Cu | <0.41 | <0.44 | 4.1 | <0.41 | 0.89 | <0.43 | <0.41 | <0.42 | <0.42 | <0.41 | <0.41 | <0.41 | <0.41 | <0.41 | <0.41 |
| Hg | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Ni | <0.63 | 2.3 | 2.9 | <0.63 | <0.66 | 5.3 | <0.63 | <0.64 | 2.7 | <0.63 | <0.63 | <0.64 | <0.63 | <0.64 | <0.64 |
| Pb | <1.0 | <1.1 | <1.1 | <1.0 | <1.0 | <1.1 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| Zn | <0.13 | 8.9 | 2.4 | <0.13 | 0.73 | 7.8 | <0.13 | <0.13 | 0.38 | <0.13 | 0.16 | <0.13 | 1.4 | <0.13 | <0.13 |
| Fe | <0.60 | 6.1 | 3.9 | <0.60 | <0.63 | <0.63 | 3.3 | <0.60 | <0.60 | 0.82 | <0.60 | <0.61 | 12.4 | <0.61 | <0.61 |
| Al | <3.4 | <3.7 | <3.7 | 11 | <3.6 | <3.6 | 14 | 10 | <3.5 | 26 | 18 | 7.1 | 57 | 29 | <3.4 |

According with CEMWE criterion, the bottom ashes produced in the combustion of coal and co-combustion of coal and SS has presented no evidence of ecotoxicity, while the fly ashes collected in both cyclones were classified as ecotoxic. According to the CEMWE, the ashes trapped in the 1st and 2nd cyclones of the combustion assay C and the ashes trapped in the 2nd cyclone during the combustion assays D must be classified as ecotoxic materials. The bottom ashes collected in combustion assays C and D and the ashes collected in the 1st cyclone of the combustion assay D ashes showed no evidence of ecotoxicity.