

Characterization of Coal Fly Ashes Using Leaching and Ecotoxicity Tests

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SUMMARY: The chemical and ecotoxicological properties of eluates of six coal fly ash samples collected from different coal incineration plants were examined in the present work. The batch leaching tests EN 12457-2 and EN 12457-3 and the percolation test NEN 7343 for classification of waste as suggested by the European Council decision 2003/33/EC, were applied in conjunction with a battery of bioassays. The test organisms that were used for the toxicity evaluation of fly ash eluates included the photobacterium *Vibrio fischeri*, the algae *Pseudokirchneriella subcapitata* and the crustacean *Daphnia magna*. Results indicated that the concentration of Ba, Cr, Mo, sulphates and TDS exceeded the limit values for inert or for non-hazardous waste. The toxicity of undiluted eluates obtained from batch leaching tests towards algae *P. subcapitata* and crustacean *D. magna* was generally high, reaching up to 100 % effect, while low toxic response was observed for photobacterium *V. fischeri*. The ecotoxicological index of three fly ash samples was in agreement with physicochemical index, as samples yielding high ecotoxicological index had elevated number of constituents exceeding the limit values for inert or non-hazardous waste (high physicochemical index). However, for the other three fly ash samples, the ecotoxicological index was high, while the physicochemical index was specifically low, indicating that physicochemical analyses may underestimate the environmental hazard of these samples.

Keywords: fly ash; toxicity; leaching tests; waste characterization; bioassays

EXPERIMENTAL

Fly ash samples

Six fly ash samples were collected from coal power plants in Europe: - United Kingdom (FA1 and FA3), Austria (FA5), Italy (FA2 and FA4) and Greece (FA6). The numbering of samples was based on the pH values of solid samples, from sample exhibiting the lowest pH= 9.3 (FA1) to sample exhibiting the highest pH= 12.8 (FA6).

Leaching test

- EN 12457-3, two-stage batch leaching test for L/S= 2 L/kg and a cumulative L/S= 10 L/kg
- EN 12457-2, one stage batch leaching test for L/S= 10 L/kg
- NEN 7343, Percolation test, first eluate fraction, for L/S= 0.1 L/kg

Bioassays

- Photobacteria *Vibrio fischeri* (Microtox test)
- Algae *Pseudokirchneriella subcapitata* (72 h growth inhibition test)
- Crustaceans *Daphnia magna* (24 h immobilization test)

Evaluation of physicochemical index

$$PCI = \frac{n_1 + 2 \cdot n_2 + 3 \cdot n_3}{N}$$

n_1 , n_2 and n_3 , the number of constituents exceeding the leaching limit values of the decision 2003/33/EC for inert, non-hazardous and hazardous waste, respectively.

N : the number of different leaching tests or leaching stage applied for the characterization of waste.

Evaluation of ecotoxicological index

$$ETI = \sum_{i=1}^N \log \left[1 + n \cdot \left(\frac{\sum_{i=1}^{N_i} T_i}{N_T} \right) \right]$$

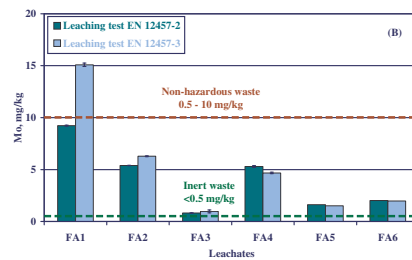
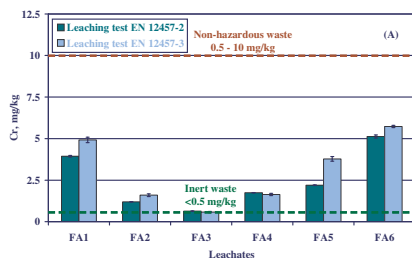
n : the number of bioassays exhibiting a toxic response higher than 10 %.

N_T : the total number of bioassays carried out for the toxicity assessment of a sample eluate.

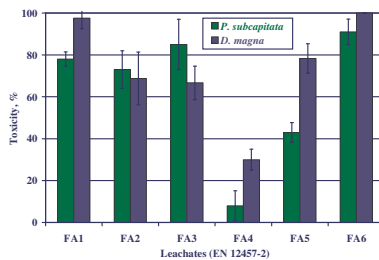
T_i : the toxicity of individual sample eluate, %.

N : the total number of leaching tests/stages used for sample characterization.

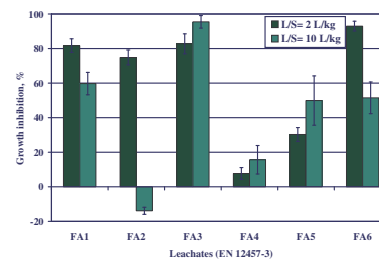
RESULTS



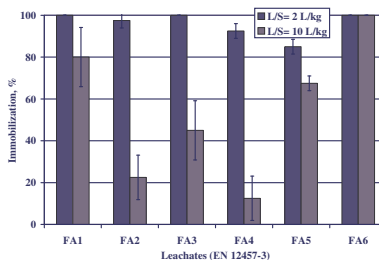
Comparison between the amount of Cr (A) and Mo (B) leached out from fly ashes by the application of leaching test EN 12457-2 and EN 12457-3 for a cumulative L/S= 10 L/kg



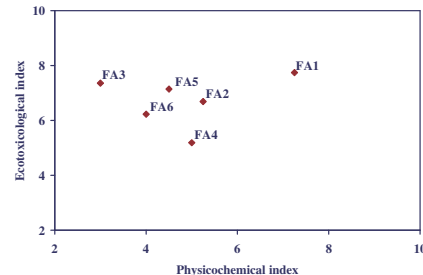
Toxic effect of EN 12457-2 eluates on *D. magna* and *P. subcapitata*



Toxic effect of EN 12457-3 eluates on *P. subcapitata*



Toxic effect of EN 12457-3 eluates on *D. magna*



Relationship between Ecotoxicological and Physicochemical indexes of fly ash samples

CONCLUSIONS

- ✓ Fly ash samples examined could not be classified as inert waste. The concentration of Ba, Cr, Mo, sulphates and TDS exceeded the limit values for inert or for non-hazardous waste.
- ✓ The application of EN 12457-2 leaching for the examination of the leaching limit values for L/S= 10 L/kg, may result to underestimation of the classification of waste.
- ✓ The sensitivity of both algae *P. subcapitata* and crustacean *D. magna* on the toxic action of the fly ash eluates was specifically high, while low toxic response was observed for photobacterium *V. fischeri*.
- ✓ The ecotoxicological index of three fly ash samples was in agreement with physicochemical index, as samples yielding high ecotoxicological index had elevated number of constituents exceeding the limit values for inert or non-hazardous waste.
- ✓ For the other three fly ash samples, the ecotoxicological index was high, while the physicochemical index was specifically low, indicating that physicochemical analyses may underestimate the environmental hazard of these samples.