

## Characterization of the ash samples used for thermal recovery of phosphorus

Georgeta Predeanu<sup>1</sup>, Valerica Slăvescu<sup>1</sup>, Bogdan Ștefan Vasile<sup>1</sup>,  
Bruno Valentim<sup>2</sup>, Alexandra Guedes<sup>2</sup>, Ana Claudia Santos<sup>2</sup>, Guozhu Ye<sup>3</sup>,  
Elsayed Mousa<sup>3</sup>, Hayati Olgun<sup>4</sup>, Özben Kutlu<sup>4</sup>

<sup>1</sup> National University of Science and Technology POLITEHNICA Bucharest, Research Center for Environmental Protection and Ecofriendly Technologies, 1-7 Gheorghe Polizu Str., 011061 Bucharest, Romania

<sup>2</sup> Department of Geosciences, Environment and Spatial Plannings, Faculty of Sciences, Earth Science Institute-Porto Pole, University of Porto, Rua do Campo Alegre s/n, 4169-007 Porto, Portugal

<sup>3</sup> Swerim AB, Aronstorpsvägen 1, 974 37, Luleå, Sweden

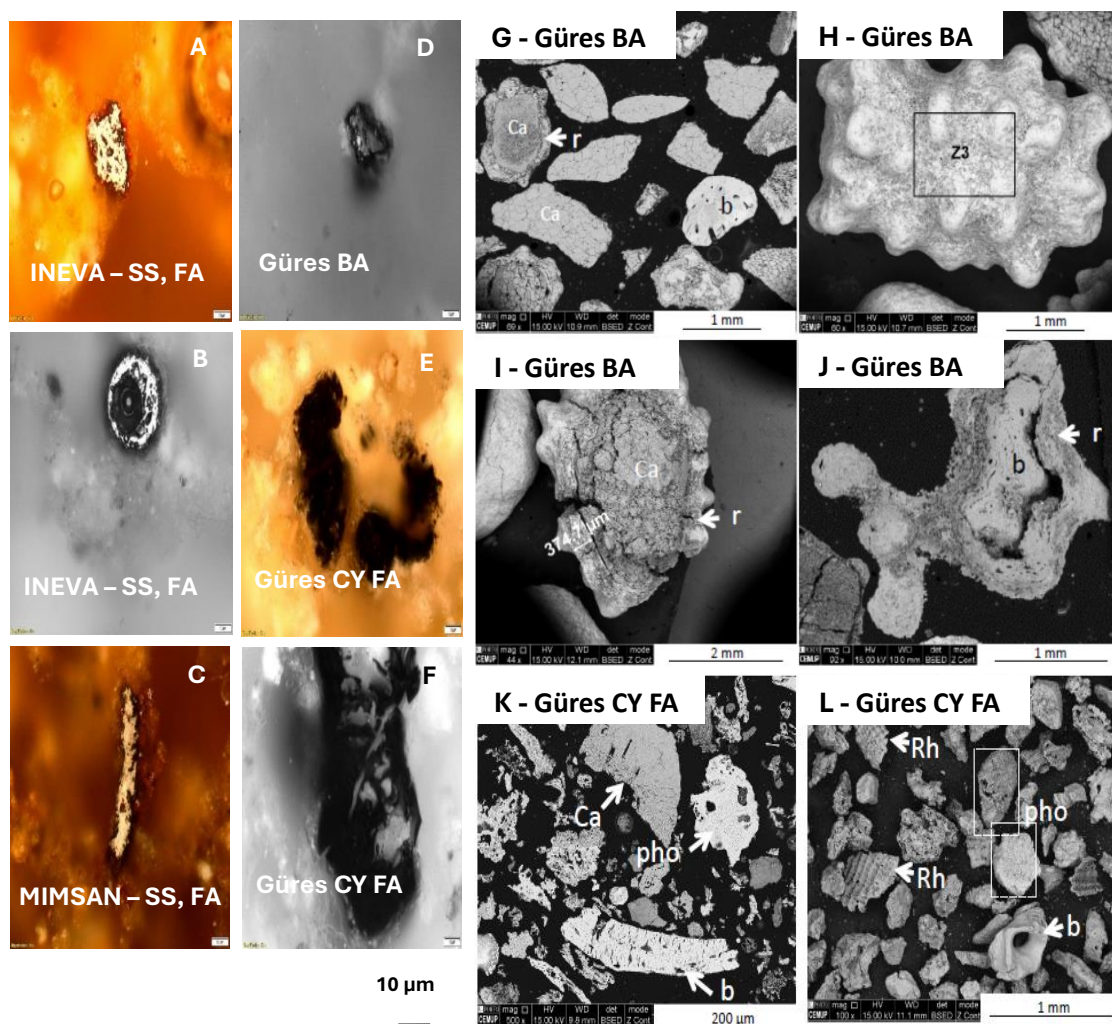
<sup>4</sup> Ege University, Solar Energy Institute, 35100 Bornova, Izmir, Turkey

The P-rich ash samples produced at different temperatures (750 and 950 °C) were collected from some fluidized bed combustion Power Plants from Turkey, respectively Güres and Beypi burning aviary manure, and INEVA and MIMSAN burning sewage sludge. Extensive analysis of ash included, besides chemical analysis, various techniques such as XRF, optical microscopy, and SEM-EDS, for characterization purposes. Proximate and elemental results reveal moisture variation between 0.08 wt.% and 0.48 wt.%, while the ash content (on a dry basis; db) ranged from 71.68 wt.% to 99.71 wt.%. The volatile matter (db) ranged between 0.29% and 4.40%, and the fixed carbon (db) reached up to 25.96%. Additionally, total sulfur content (db) spanned from 0.65 % to 34.37%. XRF investigations show that the concentration of P<sub>2</sub>O<sub>5</sub> in the P-rich ashes ranged from 6 wt.% to 34 wt.%. The ashes from laying hens and poultry litter manure incineration contained 4.4-8.5 wt.% of P, the highest content being found in Güres cyclone ash.

The morphological aspect of the ash particles resulting from the combustion of sewage sludge (SS) from the INEVA and MIMSAN samples are shown in Figure 1A-1C. These particles' morphology is spherical, and many have very high reflectance, evidencing the presence of metal oxides.

In the aviary manure ashes, the type of fluidizing sand bed used has a major influence on the composition of the bottom ash (BA) and fly ash (FA). BA consisting of calcium carbonate sand exhibited Ca-K-S-P-rich rims, while silicate sand bed led to Si-K-Ca-S-P-rich rims. FA primarily consisted of calcium carbonate sand and rim fragments, discrete particles of chicken and poultry litter manure, and sewage sludge that underwent thermal transformation without reacting with the fluidized bed sand. FA also contained fragments of cereal husk and small-sized silica sand. Figures 1D-1F show residual isotropic and slightly porous biomass carbon, from the aviary bed. Güres BA has a substantial content of CaCO<sub>3</sub> sand (Fig. 1G and 1H), in many cases enveloped by a thick layer of sulphates and chlorides (r) (Fig. 1G). The core of these particles is composed of a partially decomposed CaCO<sub>3</sub> sand bed particle or a bone fragment (Fig. 1I and 1J, respectively).

Güres cyclone ash (CY) is composed of particles with sizes ranging between 25 and 200  $\mu\text{m}$ , corroborating the sieving analysis. Compared with the BA, the morphotypes composition is quite heterogeneous, including fragments of  $\text{CaCO}_3$  sand (Ca) (pristine or decomposed), rims of S, K, and P retention, bone fragments (b), rice husk relics (Rh), partially baked excreta, and phosphospheres (pho) (Fig. 1K-L).



**Figure 1:** A-F, (Incident light microscopy) bright morphotypes (A-C; INEVA and MIMSAN ash); residual char (D-F; Güres ash INEVA (D, E); G-L, (SEM BSE mode) Güres ashes (G, I and K polished block).

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