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Chemical and Mineralogical Study of Fly Ash from Swiss Municipal Solid Waste Incineration Plants and Recovery Potential of Heavy Metals

The 29 Swiss municipal solid waste incineration (MSWI) plants combust annually ~4 Mio tonnes of waste producing 75'000 tonnes of fly ash. These are enriched in heavy metals and cannot be disposed without further treatment. The current state-of-the-art treatment is the FLUWA process which separates heavy metals from fly ash by acidic leaching and transfers them to a hydroxide sludge (HS). At present, it is the only process that meets the demands of the new Swiss Waste Ordinance (VVEA) which prescribes the recovery of heavy metals from fly ash prior disposal from 2021 onwards. FLUWA treatment requires low pH (~3) and oxidising conditions to prevent a reductive cementation of Pb and Cu in the presence of metallic aluminium (Al0). Thus, the addition of acid and H2O2 is necessary as fly ash has a high acidic neutralizing capacity (ANC) and variable Al0 content. The recovery of Zn after the FLUWA treatment can be performed by an electrolytic process (FLUREC), currently performed only at one MSWI plant.

This is the first study combining chemical and structural information of all fly ash produced in the same period. A sampling campaign was launched in winter 2017 to obtain representative fly ash from every MSWI plant in Switzerland. The samples were analysed by XRD and XRF to determine their chemical and mineralogical composition. The ANC was analysed by titration and a suitable Al0 analysis method was evaluated and applied.

The results show that:

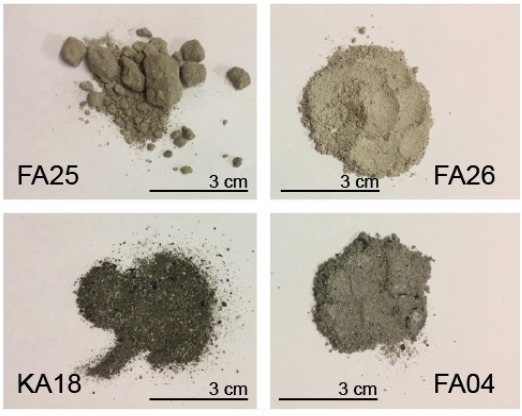
The averaged chemical composition of fly ash is dominated by CaO, Cl-, SO3, Na2O, SiO2, K2O. Zinc (3.6 wt. %) is the most common of all heavy metals, in total 7.5 wt. %. Thus, the annual estimated recovery potential is around 2'200 t Zn, 530 t Pb, 66 t Cu and 22 t Cd. A quantity, which would otherwise be disposed on a landfill.

The crystalline phases in fly ash are mainly NaCl, KCl, CaCO3, CaSO4, Ca2Al2SiO7, SiO2 and a large number (>10) of minor phases. The amorphous part accounts for about 40 wt.%. The reactivity of fly ash during the FLUWA process is controlled by solid phases, e.g. CaO/CaCO3 which contributes significantly to the ANC. Therefore, the knowledge of the solid phase composition is essential to describe dissolution reactions.

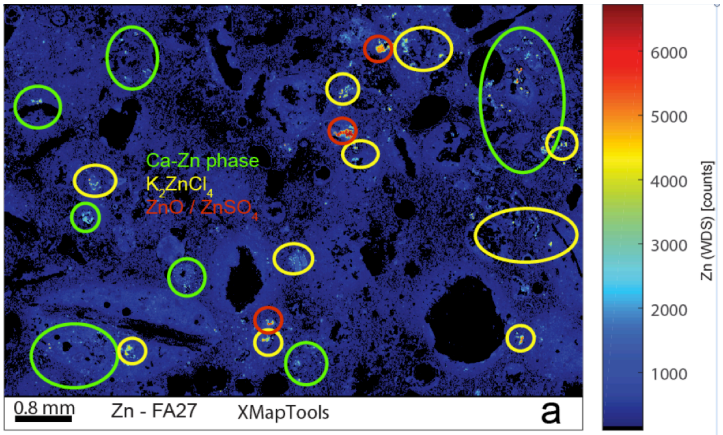
All Swiss MSWI plants produce fly ash composed of the same constituents. However, the elemental content varies around 30 % and the content of the solid phases ~40 % due to different waste input material and process conditions. Thus, divers ANC and Al0 content result in fly ash types which are highly suitable for the FLUWA process (low ANC and Al0 content) and some with a low suitability (high ANC and Al0 content).

This dataset can also be used for feasibility studies. One example presented, is the grouping of all fly ash in four classes by cluster analysis of the parameters Zn and Al0 concentration, ANC and the amount of fly ash produced by each MSWI plant. The resulting classes correspond to the suitability for the FLUWA process and provide information that can be used for future planning, e.g. by mixing fly ash of different classes prior to FLUWA treatment. The latter will be important as only 12 MSWI plants are equipped with a FLUWA facility but all fly ash has to be treated in the future.

The study also demonstrates the amount of heavy metals remaining in the depleted fly ash after the FLUWA treatment (e.g. Sb and Sn). Future studies should focus on these metals and evaluate their environmental impact in a mid- to long-term perspective.



Different texture of fly (FA25, FA26, FA04) and boiler ash (KA18).



Zn map of FA27, showing the distribution of Zn in the fly ash. The colour represents the counts and thus the relative concentration

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