Incinerator Bottom Ash (IBA) - Characterisation of material components, mineralogy and elemental composition

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Characterisation of a large composite IBA sample from the WtE plant Amager Bakke, Denmark, revealed new insights about the untapped resource potential. The work is published online in GEUS Bulletin Vol 43 2019.

Methodology

Four IBA samples were collected in duplicate each day for 30 consecutive days in November 2017 from the Amager Bakke WtE plant, Denmark (Fig. 1A). Each sample weighed c. 15 kg, and the total sampled material weighed c. 1800 kg. Samples were retrieved with a shovel from a conveyor belt (Fig. 1C), and fragment sizes ≤ 63 mm were considered representatively sampled. Material components was characterised on a 28 kg composite sample. Prior to characterisation, the sample was cleaned with acid (Fig. 1D) then sieved into seven fractions (Fig. 1E). IBA sizing from 2-63 mm was hand sorted into the following categories: ferromagnetic metal (using a magnet, Fig. 1. F), diamagnetic metal (using a metal detector), glass, ceramics and mineral construction materials (visual sorting). The remaining material fraction was assigned as slag. The resulting fractions and material classes were weighed (results shown in Fig 2. and 3). Further analysis was carried out, which is not shown in this poster: Analysis with X-ray fluorescence (XRF) on all metal fragments to categorise them according to alloying elements, analysis with Scanning Electron Microscope (SEM) on cross sections of 10 pieces of slag to investigate their mineralogy, and analysis of elemental composition with Inductively Coupled Plasma Spectroscopy (ICP-MS and ICP-OES) on one series of IBA samples (30 samples in total) after removing magnetic metal.

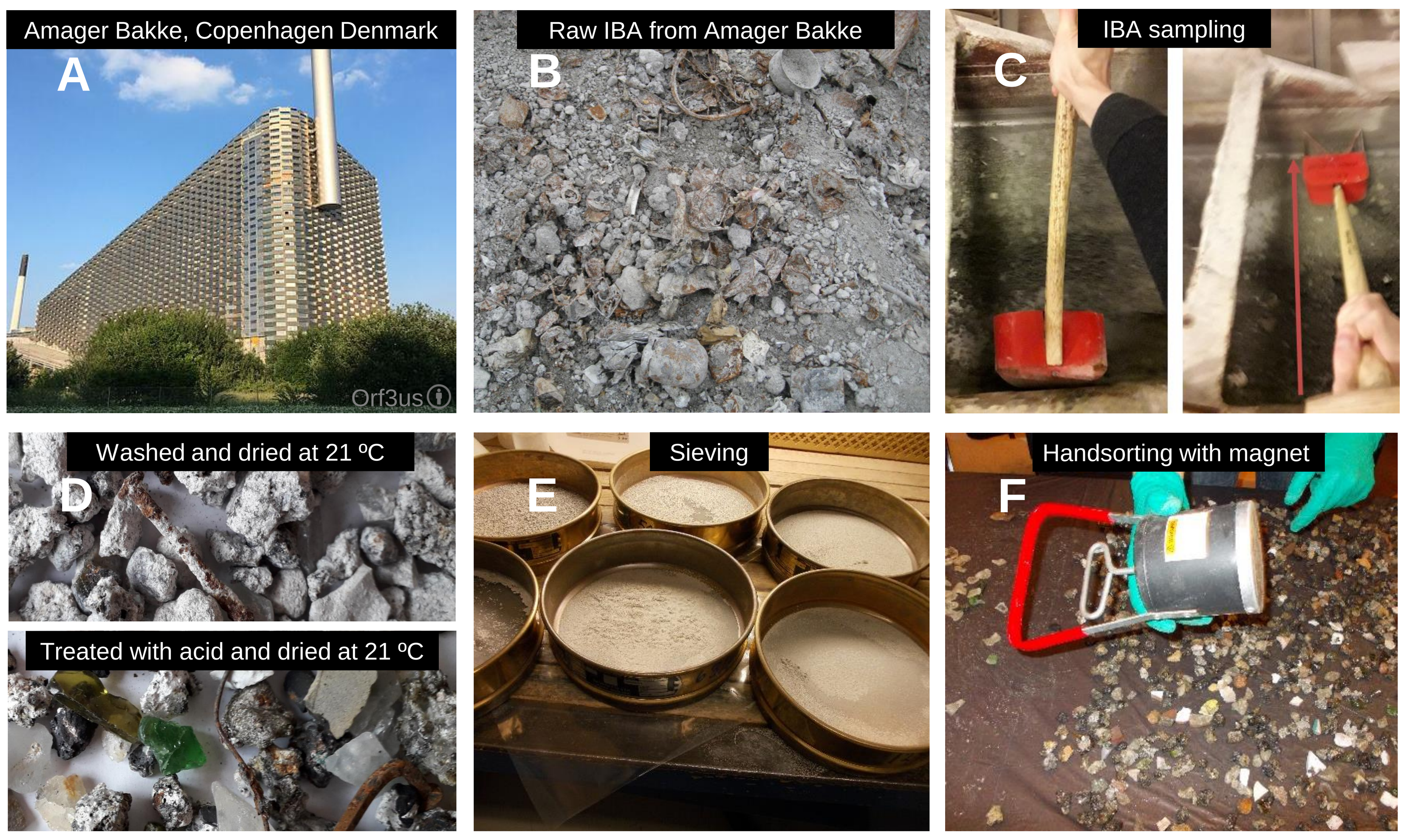

Fig. 1: A. Amager Bakke (WtE plant), B. IBA, C. IBA sampling, D. IBA treated/non-treated, E. Sieving. F. Characterisation.

Untapped resources!

The composite IBA sample consisted of 86 wt% coarse (2-63 mm) material and 14 wt% fine (< 2 mm) material. Hand sorting the coarse fraction resulted in five distinct classes: ferromagnetic metal (29 wt%), diamagnetic metal (6 wt%), glass (14 wt%), ceramics and mineral construction materials (14 wt%) and slag (37 wt%; Fig. 3). Today ferromagnetic and diamagnetic metals undergo recycling, but their value/use-potential depends on their purity-level. Thermal degradation introduces a lot of impurities (Fig. 3) but also the size-degradation decrease the purity-level (i.e. higher surface-area to mass ratio). Regarding size we see that the component composition varies with grainsize (Fig. 2): ceramics, building materials and ferromagnetic metal dominates at larger grain sizes, whereas glass and melt mostly occur at 2-16 mm, and 2-63 mm respectively. Most of the glass in IBA is probably not pure enough for conventional glass recycling (the majority being either small or melted), but there are other options e.g. in glass wool insulation or as aggregate in concrete. A handheld XRF instrument was used for further subgrouping of metals alloys. This revealed that melted aluminium was pure - showing one benefit of the thermal process. Some stainless-steel types were ferromagnetic, and their alloying elements, especially chromium, would therefore be downcycled in the IBA-recycling. Chemical analysis indicate that gold, lead, silver, cadmium, antimony and zinc are potential resources in the 0-2 mm fraction. More research is needed to clarify this potential.

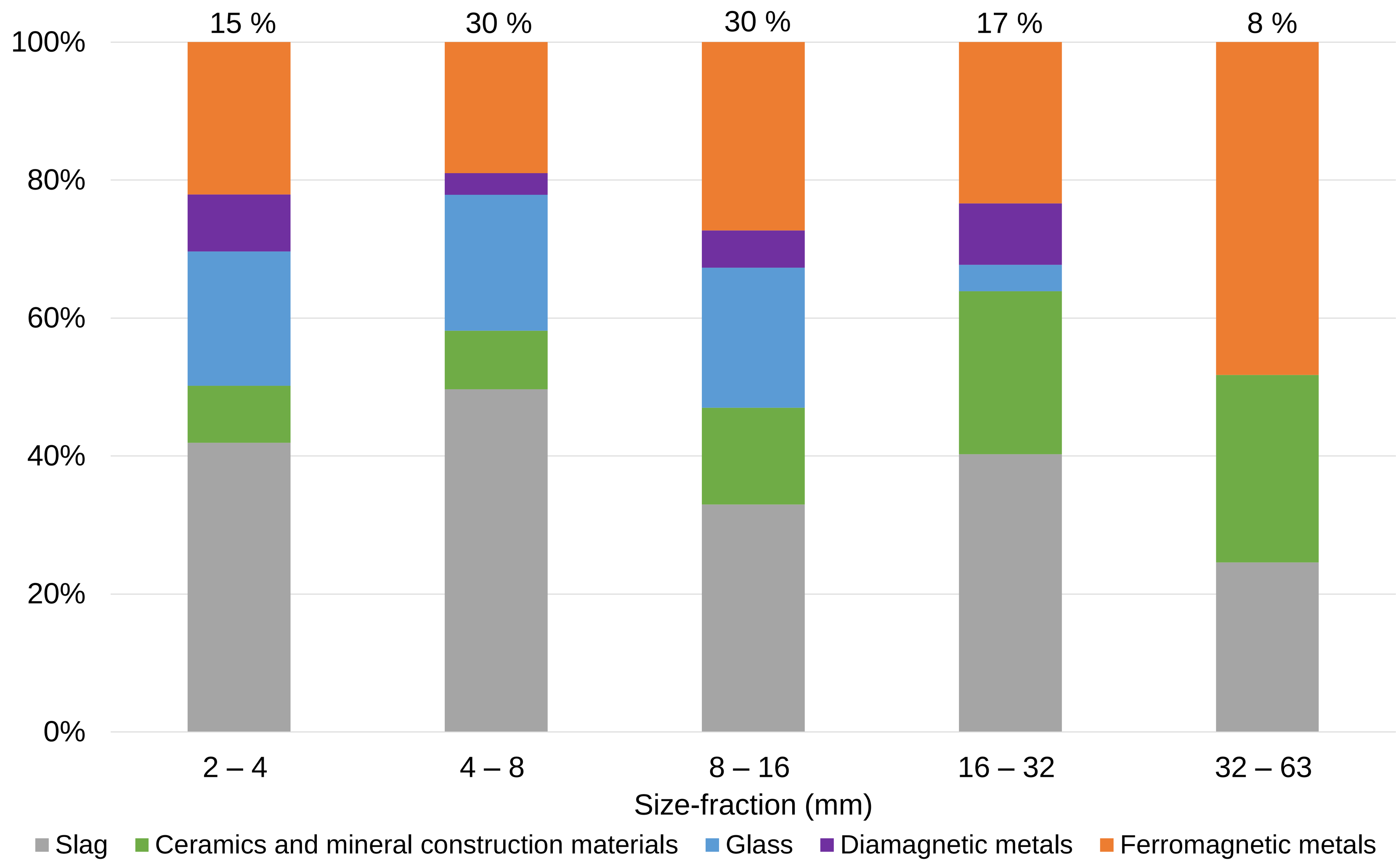

Fig. 2: The distribution of main components according to fragment size. Percentages at the top of the chart refer to the distribution of size-fractions and sums to 100 %. Modified from Clausen et al. 2019.

High level of degradation

Sub-group-characterisation was done according to level of degradation, and we found that 77 wt% was thermally degraded: either melted or deformed by heating, see Fig. 3. At Amager Bakke the combustion temperature is 950-1100 °C, with a lower temperature expected on the moving grate. However, some materials were melted despite their high melting points: e.g. glass (1400-1600 °C), steel (1150-1500 °C) copper (1084 °C) and brass (900-1000 °C). This indicates that the high level of degradation is caused by pockets of waste material acting as flux agent. The degradation of ferromagnetic metal and glass has substantially reduced their purity – thereby decreasing their intrinsic value, see Fig. 3. In addition, two coins were found; one was corroded (ferromagnetic) the other melt damaged (diamagnetic). The slag (melt with inclusions) is a dominating fraction. Chemical analysis show that no particular metals concentrate in the slag and that the slag composition is very similar to the average of 0-63 mm IBA. In conclusion, the material degradation in the incinerator leads to a substantial decrease of the quality and recyclability of IBA. Future studies should therefore examine what causes the degradation and how it can be mitigated at the powerplant.

Fig. 3: Diagram with the asorted material catagories displaying example photos. Diagram is not showing diamagnetic metal, ceramics and mineral construction material. Percentages refer to composition of 2-63 mm IBA fraction.

Conclusion

IBA flows at the Amager Bakke plant carry a non-utilised secondary raw material resource, such as:

- pure glass (not recycled at present)
- impure glass, slag, ceramics and building material (potential as higher-value aggregates)
- ferro- and diamagnetic metals in the form of slags, melts and oxides
- metals in the 0–2 mm fraction such as gold, lead, silver, cadmium, antimony and zinc

Feel free to contact Rune Clausen regarding possibilities for collaboration at rjc@geus.dk.

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