Description and interpretation of organic matter in soils and waste by means of thermal analysis

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Organic matter plays a crucial role in many environmental processes. The description of organic matter needs methods that can reflect the complexity of the material. Thermal analysis is an effective analytical technique for this purpose. The presentation gives two examples, where thermogravimetry (TG) and differential scanning calorimetry (DSC) were used for the interpretation of environmental processes.

In a field trial compost was applied on soils. Organic matter increase in soils can be a method to store carbon which contributes to climate protection. It is necessary to describe the increase of organic matter in a differentiated way to clearly distinguish the impact and the stability of different organic materials. The long term behaviour is of big relevance. TG and DSC are able to describe this long term behaviour in a more proper way than any other combustion method that is usually carried out to quantify organic matter in soils (loss on ignition, TOC). The beginning and the end of organic matter decomposition can be recognized more precisely and the DSC profile also displays the two peaks that can be assigned to the decomposition process. The first one has a maximum between 300 and 350 °C, the second one at about 500 °C. Up to about 150 °C interlayer water in clay minerals volatilizes. The mass losses of the two peaks were quantified. Whereas the first peak showed higher variation of the results, the second one varied significantly less. We assume that this second peak can be interpreted as stable humic fractions, whereas the first one covers a heterogeneous mixture of different, less recalcitrant organic compounds. With this procedure we are able to assess changes in soil organic matter in a more accurate way. The decay of carbonates is highly affected by the presence of organic matter. It starts at about 650 °C whereas the decay of pure $CaCO_3$ takes place > 700 °C.

The second example deals with organic matter of municipal solid waste (MSW). This material has a high potential of gaseous emissions especially methane that is a relevant greenhouse gas. Therefore in some countries MSW has to be pre-treated before landfilling. This pre-treatment can either be incineration (MSWI) or biological treatment (MBT). In MSWI the organic compounds are efficiently deteriorated (residual TOC of about 2 % referring to dry matter), whereas in MBT a remarkable carbon content remains (residual TOC of about 17 % DM) with a low gas generation potential. Besides this residual carbon content two further effects have to be taken into consideration, when balancing the strategies – water evaporation and carbon decay. Fresh MSW has water content between 25 and 45 % of fresh matter. The drying of the material leads to an endothermic reaction that can be displayed by means of DSC. The drying energy reduces the potential energy gain (also waste heat could be used for energy production instead of pre-drying, which is commonly implemented). The carbon decay in MSWI leads to further energy demand as this effect is endothermic. DSC is a useful tool to demonstrate this process.

Both examples stress the high value of thermal analysis in the description and interpretation of the fate of organic matter in biological processes. Taking the total sample without any pre-treatment is an advantageous feature of the technique.