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EXPLORING THE AMOUNT OF PLASTICS IN THE FEED OF AUSTRIA'S WASTE TO ENERGY PLANTS

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Introduction

Consumption of plastics and thus also the generation of waste plastics have increased tremendously during the last decades. Whereas at the beginning of the 1980s global consumption of plastics amounted to about 65 million tons (PlasticsEurope, 2013), in 2013 worldwide production has increased to almost 300 million tons (PlasticsEurope, 2015). A significant share of plastics (more than one third) is used in very short-life products, such as packaging, and are thus almost directly contributing to present waste generation (unlike plastics used e.g. in the building and construction sector) (PlasticsEurope, 2015).

In many affluent countries separate collection of specific plastic wastes (with special focus on packaging plastics) has been introduced during the last decades. The aim is to reduce the quantity of mixed household wastes, and to generate post-consumer waste streams that contain polymer types which can undergo high quality recycling.

The amount of plastic waste separately collected is usually recorded quite accurately, simply due to its economic value, but also due to its positive image for the plastics industry (e.g. contribution to circular economy). The vast majority of waste plastic generated however is not separately collected, but together with other materials (e.g. municipal solid waste (MSW), commercial waste (CW), waste electrical and electronic equipment (WEEE)), thereby resulting in "mixed wastes". Data about the plastic content in these mixed wastes is derived from literature or is based on sorting analyses. Due to the fact that waste composition may show significant variations even over time periods of some days (Morf and Brunner, 1998), a few single sorting campaigns are not sufficient to calculate a reliable annual average plastic content in mixed wastes. Furthermore, the plastic content of wastes determined via sorting analyses may be of limited significance even for the respective waste sample analysed: 1) due to the lack of visual recognisability of different materials and 2) due to the fact that sorting analyses usually aim at determining the content of different waste fractions (such as biowaste, hygienic products, composite materials,…) that do not necessarily contain only plastics or are free of plastics.

All these limitations demonstrate that figures about plastics in mixed wastes and thus also total quantities of plastic wastes generated are associated with significant uncertainties. Hence, also

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data about the recycling or thermal recovery quota of plastic waste, as published for different European countries (e.g. BIO Intelligence Service, 2013; Bogucka et al., 2008; PlasticsEurope, 2013), are rather uncertain.

The aim of the current study was to determine the total amount of plastics present in mixed wastes (collected as MSW or CW) by applying a novel approach, the so called Balance Method (Fellner et al., 2007). The investigations have been conducted for Austria for the year 2014.

Method

The Balance Method, utilized to determine the plastic content in mixed wastes, was originally developed to evaluate the ratio of energy from biogenic sources in the feed of waste to energy plants, but it also allows calculating the content of plastics in the waste feed.

The Balance Method combines data on the elemental composition of biogenic and fossil organic matter with routinely measured operating data of the Waste to Energy (WtE) plant. In principle the method utilizes one energy balance and five mass balance equations, whereby each balance describes a certain waste characteristic (e.g. content of organic carbon, lower calorific value). Each balance equation encompasses a theoretically derived term (left side of equations) that has to be attuned to measured data of the incineration plant (right side of equations). A simplified structure of the set of equations is illustrated in Figure 1, whereas the detailed mathematical description of each equation is given in Fellner et al. (2007). Besides the elemental composition of biogenic and fossil organic matter present in waste, the Balance Method requires the following operating data of the WtE plant: quantity of fuels incinerated (waste mass and auxiliary fuels), the amount of solid residues and steam produced, as well as data about the volume and composition of the dry flue gas (O_2 and CO_2 content).

Because the system of equations (set of constraints) used within the Balance Method is over-determined (6 equations for 4 unknowns), data reconciliation has to be performed to eliminate data contradiction and to improve the accuracy of the results. The reconciled values are subsequently used to compute the unknown quantities (mass fraction of biogenic matter m_B, of fossil organic matter m_F, of inert matter m_I and water m_W) including their uncertainties.

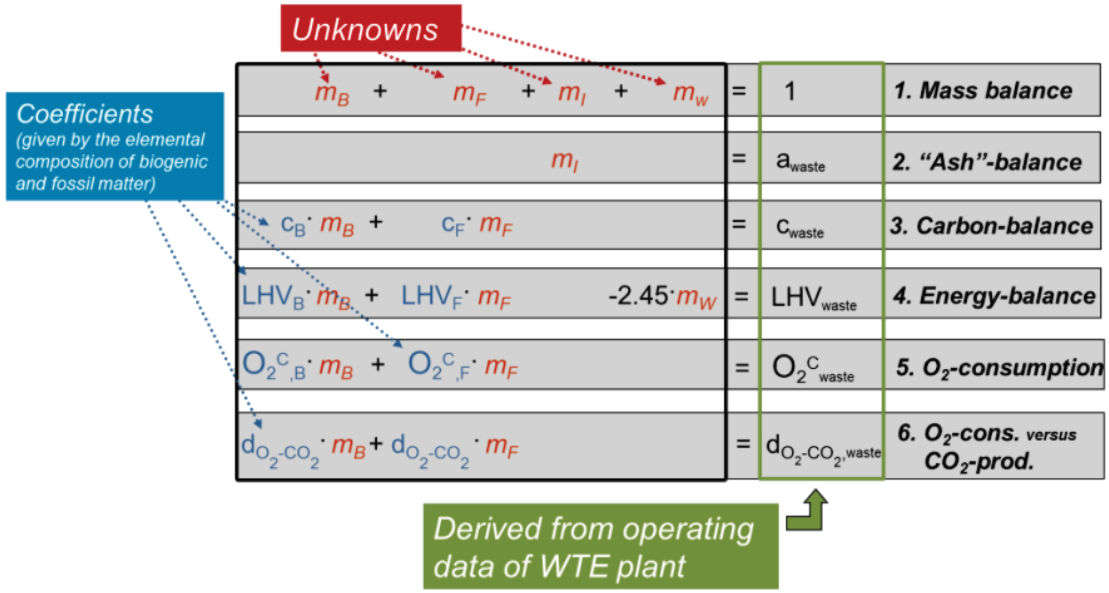

Figure 1 **Simplified set of equations used by the Balance Method**

The mass fraction m_F represents the content of synthetic polymers in the waste feed of the plant. By considering typical values for the ash content of plastics a_p (representing the content of inorganic additives and fillers), the fraction of plastics c_P in the waste feed can be easily determined according to the following equation:

$$c_P = \frac{m_F}{(1 - a_p)}$$

Based on national material flow studies focusing on Austrian plastics production and consumption (Bogucka and Brunner, 2007; Fehringer and Brunner, 1997) the average content of inorganic additives and fillers a_p is estimated to 90 ± 40 g/kg plastic, which is used in the present study.

Materials

The Balance Method has been applied to all Austrian WtE plants, with the exception of three facilities (two are combusting only hazardous waste and one facility was under reconstruction during the year 2014). Thus altogether the waste feeds from 10 waste incineration plants have been characterized with respect to their plastic content. Based on the calculated composition of the waste feed of each plant (using the Balance Method) and its respective annual waste throughput the total amount of waste plastics thermally recovered has been determined.

Table 1 gives an overview of the 10 WtE plants that have been investigated. The annual capacity of these facilities amounts to about 2.1 million tons of waste. The plants utilize different types of combustion technologies (grate incineration or fluidized bed combustion) and mainly incinerate municipal solid waste, commercial waste, sewage sludge and refuse derived fuels (see Table 1), whereby the share of the different wastes may vary significantly throughout a year.

Table 1: Overview of Waste-to-Energy plants in Austria

WtE plant	Combustion technology	Waste incinerated (qualitative information)
A	Grate incinerator (GI)	MSW
B	Grate incinerator (GI)	MSW and CW
C	Stationary fluidized bed combustion (FBC)	RDF and SS
D	Stationary fluidized bed combustion (FBC)	RDF and SS
E	Circulating fluidized bed combustion (FBC)	RDF and SS
F	Grate incinerator (GI)	CW
G	Stationary fluidized bed combustion (FBC)	RDF
H	Grate incinerator (GI)	MSW and CW and minor amounts of SS
I	Grate incinerator (GI)	MSW
J	Grate incinerator (GI)	MSW and CW and minor amounts of SS

MSW… Municipal solid waste, CW … commercial waste, SS… sewage sludge, RDF… refuse derived fuels

Results and Discussion

Prior to the application of the balance method, the input data, in particular the operating data of the plants have been checked regarding their plausibility. Thereto, existing correlations between the volume & composition of the flue gas and the steam production have been used. In total almost 97 % of the overall waste feed (thus more than 2 million tons out of 2.1 million tons waste throughput) has been analysed in the study, a sample size that can hardly be achieved by any other analysis method.

Figure 2 shows the plastic contents in the feed of selected WtE facilities given as monthly averages (incl. uncertainties). The results demonstrate large temporal variations in the waste composition and also significant differences between the plants. For instance the plastic content in the feed of WtE plant E varies between 18 % and 26 % (weight percentage). The lowest plastic contents were observed for WtE plant C (annual mean of 11 %), whereas the feed of WtE plant F is characterized by the highest content of plastics (annual mean of 21 %). In general the results of the analyses indicate that the content of plastics in the feed of waste incinerators is by trend higher for plants with a higher proportion of commercial waste.

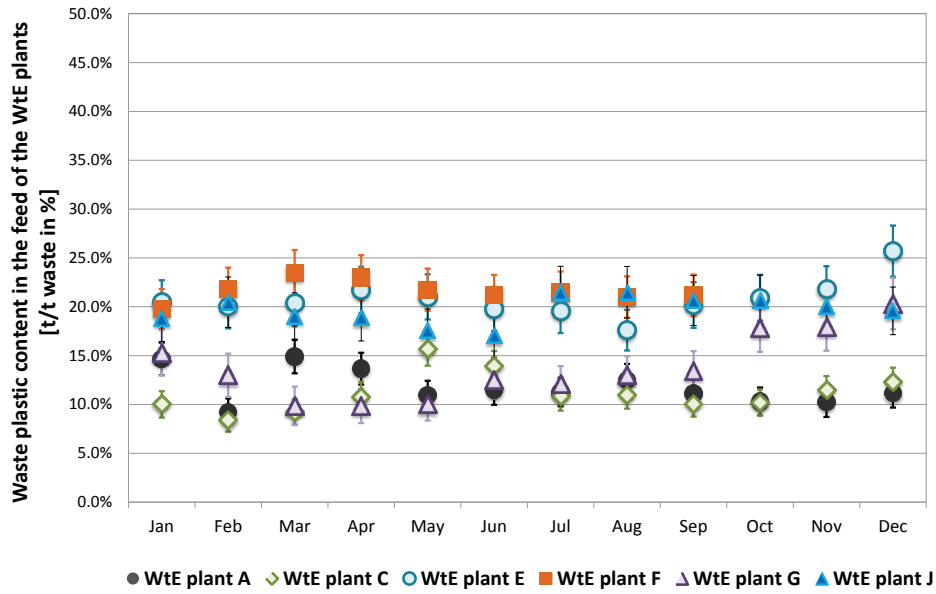

Figure 2: Plastic contents (incl. their uncertainties) in the waste feed of selected WtE plants – given as monthly averages (including statistically derived uncertainties)

In Figure 3 the annual flows of waste plastics through all 10 WtE plants are summarized. In total about 347 ± 16 kt of plastics have been thermally utilized in Austria´s waste incineration plants in 2014, which corresponds to an average plastic content of 17 % ± 1 % in the waste feed. Assuming an average lower calorific value of waste plastic of 33.5 MJ/kg this equals an energy input of 11,600 ± 500 TJ/a via plastic waste.

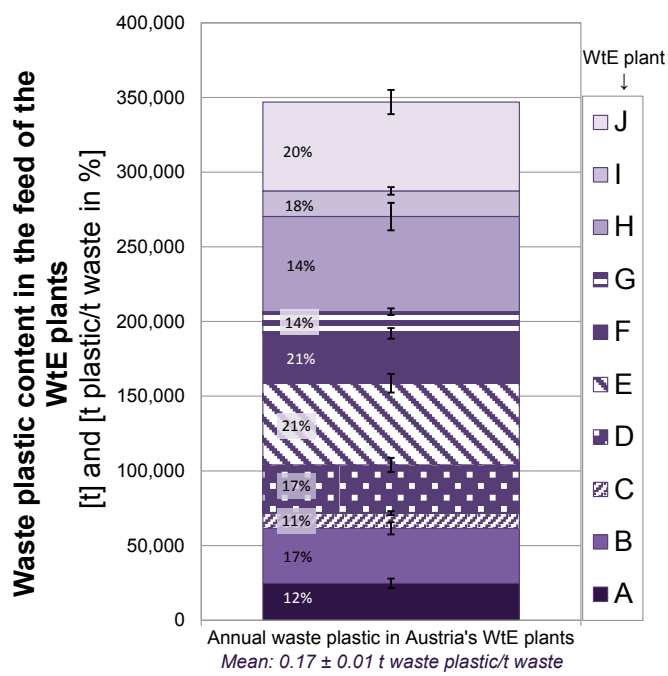

Figure 3: Total amount of waste plastics in Austria´s WtE facilities in tons (incl. their uncertainties) and average plastic contents related to the total waste feed (given in %) for the year 2014

Looking at the total plastics waste stream produced in Austria, this utilization of waste plastics in WtE plants (347 kt) represents by far the largest share of all processes, compared with mechanical (160 kt in 2010) and chemical recycling (65 kt). Noteworthy is the fact that a significant amount of mechanically and chemically recycled plastics originates from production or imported waste. The dominance of WtE plants in the overall waste plastics processing means that there is still potential for further increasing the material and chemical recycling rates by diverting waste plastics away from the municipal solid waste, by means of enhanced collection schemes or effective separation technologies. However, what kind of separation processes can be utilized, how effective these technologies are (also with respect to generate “clean” plastic wastes without hazardous additives), and to which extent these processes are feasible from an economic but also from a technical point of view, needs to be further investigated. In the meantime Austria´s WtE plants contribute to an environmental friendly and energy-efficient utilization of post-consumer waste plastics.

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References

BIO Intelligence Service, 2013. Study on an increased mechanical recycling target for plastics, Final report prepared for Plastics Recyclers Europe.

Bogucka, R., Brunner, P.H., 2007. Plastic flows and their management in Austria and Poland: Challenges and opportunities. Institute for Water Quality, Resources and Waste Management, Vienna University of Technology, Vienna.

Fehringer, R., Brunner, P.H., 1997. Kunststofflüsse und die Möglichkeiten der Kunststoffverwertung in Österreich (in German: Analysis of national plastic flows in Austria). Institute for Water Quality, Resources and Waste Management, Vienna University of Technology, Vienna.

Fellner, J., Cencic, O., Rechberger, H., 2007. A New Method to Determine the Ratio of Electricity Production from Fossil and Biogenic Sources in Waste-to-Energy Plants. Environmental Science & Technology 41, 2579-2586.

Morf, L.S., Brunner, P.H., 1998. The MSW Incinerator as a Monitoring Tool for Waste Management. Environmental Science & Technology 32, 1825-1831.

PlasticsEurope, 2013. Plastics – the Facts 2013 An analysis of European latest plastics production, demand and waste data. PlasticsEurope, Brussels, p. 40.

PlasticsEurope, 2015. Plastics – the Facts 2014/2015 An analysis of European latest plastics production, demand and waste data. PlasticsEurope, Brussels, p. 34