# Composition of Mixed Commercial Waste with Focus on Recyclable Fractions

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**Abstract:**
The European Union aims at transforming its economy into a circular economy. One approach to increase recycling is the separation of valuables from mixed waste streams, such as mixed commercial waste (MCW). For this purpose, the MCW has to be characterized in terms of its composition and selected fuel-relevant parameters. The present article provides this data for Austrian MCW.
The investigated MCW was collected from a number of different companies in Styria and Vienna. The methodology for all sorting activities was based on the Austrian Standard ÖNORM S 2127. In addition, four material fractions have been sorted into a recyclable and a non-recyclable part. Laboratory analysis of water content, heating value, chlorine and ash content was carried out according to the required standards.
The compositions of the MCW samples show a broad variety regarding certain material fractions. The share of those materials, which are potentially suitable for recycling, varies between 40% and 50%. The main reason for the differences is most probably the origin of commercial waste.
The recyclable part of three out of the four investigated material fractions is higher than the non-recyclable part. In total, however, the non-recyclable quantity amounts up to nearly a third of the four fractions. That means that the mass potential of valuables in Austrian MCW varies around 30%.
The values of the parameters water content, heating value, chlorine and ash content confirm that the MCW constitutes a suitable input for the production of solid recovered fuel.

**Keywords:** commercial waste, composition, recycling, sorting analysis.

## 1 Introduction

### 1.1 Motivation

The European Union aims at transforming its economy into a circular economy and at establishing a recycling society. For this purpose, the European Commission has adopted a Circular Economy Package with a strong impetus to foster recycling and close material loops. Among the measures of this policy initiative, are the introduction and/or increase of recycling rates for different waste streams, such as municipal waste in the Waste Framework Directive [1] and packaging waste in the Packaging Waste Directive [2]. A well-established approach to increase recycling is the separate collection of recyclable waste fractions by means of source separation. But still, there is a lot of recyclable material left in mixed waste streams. The mixed waste stream, which gained the most attention in the previous decades, was municipal waste. In order to increase recycling, other mixed waste streams have to be taken into consideration, among which is mixed commercial waste (MCW).
A country, which has long experiences with regulating mixed commercial waste (MCW), is Germany. The German Commercial Waste Ordinance [3] was already introduced in 2002 and in 2017 a major

revision took place. In this amendment, operators of waste pre-treatment facilities were required to reach a recycling rate of 30% for mixed commercial waste (Art. 6 (5)).
The basis for the management of commercial waste streams with regard to its recyclability is the detailed knowledge of its composition in terms of material fractions. Usually, the whole fraction of a material, which is regarded as valuables (e.g. paper, cardboard, glass, plastics, metals, wood) is considered as recyclable, but in practice, it is not. Exemplary reasons for this deficiency are:

- technical problems (e.g. disassembling of composites is not possible),
- low quantities of specific material types, which make recycling not cost-effective or
- contamination with dust or chemical pollutants.

When mandatory recycling targets have to be reached, these obstacles need to be considered.
MCW is often used as input material for the production of solid recovered fuel (SRF). In these cases, data about fuel qualities of MCW are of high interest. Main parameters in this respect are water content, heating value as well as chlorine and ash content.

## 1.2 Characterisation of Mixed Commercial Waste (MCW)

### 1.2.1 Germany

In Germany, mixed commercial waste (MCW) is on the political agenda for nearly two decades and therefore a number of sorting analysis have been carried out in order to analyse its composition. In a study, commissioned by the German Federal Environment Agency [4], data on the composition of commercial waste in Germany have been collected from literature and additionally sorting analyses have been carried out. The results were aggregated to an average composition, which is presented in table 1.

Table 1: Average composition of MCW in Germany for the year 2013 [4]

| Material fraction | Weight per cent 2013 [4] |
|---|---|
| Paper / Cardboard | 26.0 |
| Plastics | 22.6 |
| Wood | 8.0 |
| Metals | 4.5 |
| Glass | 1.5 |
| Textiles | 8.4 |
| Biowaste | 9.6 |
| Composites | 5.2 |
| Inert | 3.2 |
| Others | 3.5 |
| Fine fraction (< 40 mm) | 7.5 |
| Total | 100.0 |

Comparing the different results of the MCW sorting activities, it can be observed, that the composition varies remarkably between the different investigated waste samples. One main reason for the differences is the origin of the MCW. In order to identify the influence of the source of the MCW, Helftewes [5] has sorted waste samples of five different commercial branches, i.e. catering (restaurants, hotels, cinemas, etc.), healthcare (nursing homes, hospital, etc.), food (bakeries, butchers, etc.), craft (construction, various trades), and institutional sources (universities, banks, insurances, etc.). In Figure 1 the resulting compositions of MCW from these sectors are compared with the average composition of table 1 (black bar on the left). [4, 5]

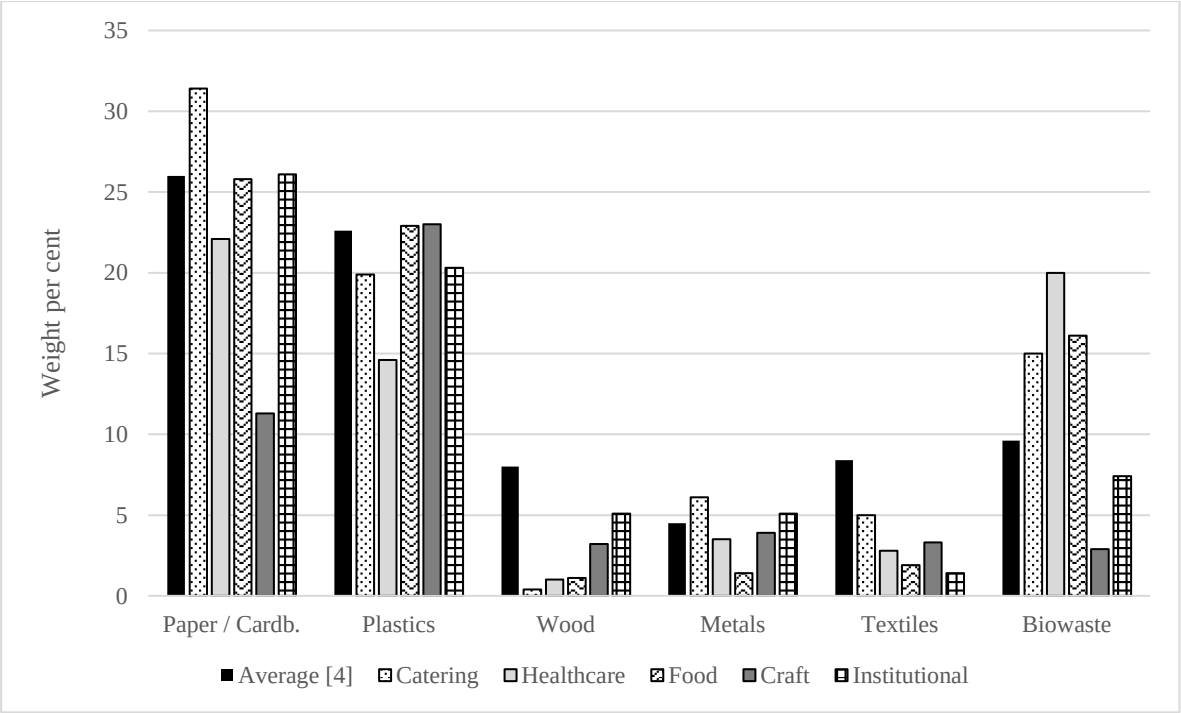

Figure 1: Share of main components of different MCWs [4, 5]

Figure 1 shows a very heterogeneous picture with differing compositions. In general, it can be stated, that for most samples the paper/cardboard fraction is the largest one, followed by the plastic and the biowaste fraction. Exceptions are the commercial sectors of crafts and of healthcare with a slightly differing order. The share of the recyclable fractions paper/cardboard, plastics, wood and metals varies between about 40% and 60%.
In contrast to information about the composition of MCW, no data about the fuel relevant parameters heating value as well as chlorine and ash content in German commercial waste could be found.

### 1.2.2 Austria

In comparison to Germany, the situation in Austria is more difficult to analyse. No specific legislation has been adopted for commercial waste as a separate waste stream and definitions for mixed commercial and mixed municipal waste are overlapping. Thus, data regarding commercial waste in Austria is less available. Regarding the composition of MCW, only a study by Wellacher&Pomberger [6] investigated the share of selected recyclable materials (see figure 2). Data about heating value, chlorine content and ash content could not be detected in Austria, too.

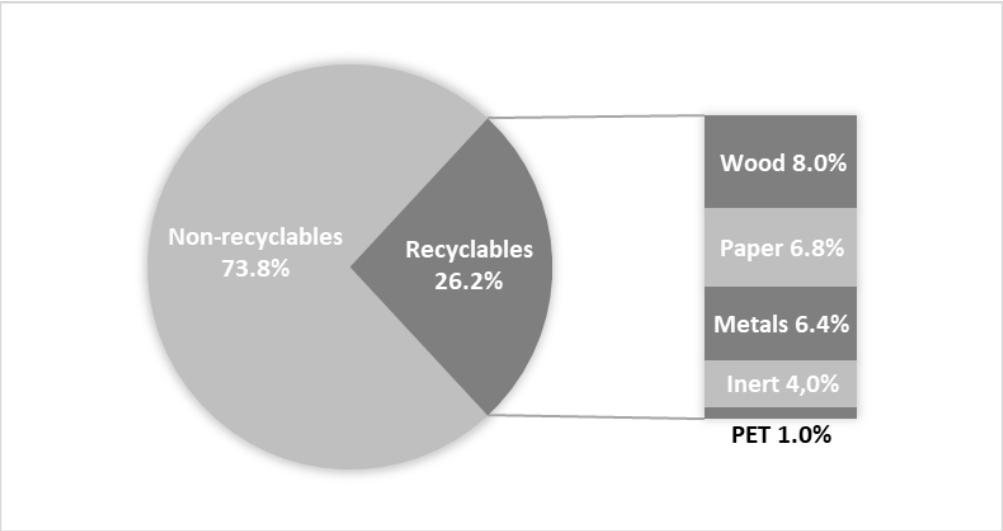

Figure 2: Content of selected recyclables in MCW in Austria for 2017 [6]

### 1.3 Project framework and objective

The present research work is part of the K-project Recycling and Recovery of Waste 4.0 (ReWaste4.0), which is managed under the Austrian COMET programme. The ReWaste4.0-project consists of two scientific-technical areas with seven specific sub-projects. The main objective of the project is the development of a smart waste factory of the future, based on Industry 4.0 approaches. In addition to mixed municipal waste, the project has a strong focus on MCW. During a number of experiments regarding the waste characterisation and some technical processes, the material composition of MCW has been investigated. One of the experiments included also laboratory analysis, covering – among others – water content, heating value as well as chlorine and ash content of the sorted MCW fractions. Additional sorting analyses of MCW, including selected laboratory analyses, are planned for summer 2019.

Aim of this contribution is the presentation of the data about the composition of Austrian MCW as well as the average data about its parameters water content, heating value as well as chlorine and ash content.

## 2 Materials and methods

### 2.1 Analysed mixed commercial waste (MCW)

The MCW, which was used for the sorting analyses and subsequent laboratory analyses, was collected from companies in Styria and Vienna and transported to waste treatment sites (site 1 in Styria, site 2 in Vienna). Detailed data about the individual companies, which had produced the waste, and their related commercial sector are not available. Subsequently, the MCW was subject to diverse project related experiments, among which also sorting analyses were carried out in the years 2018 and 2019. At site 1, two experiments took place, in which in total about 3,200 kg of waste was sorted. The sorting analysis at site 2 comprised also two experiments with about 19,800 kg MCW in total.

### 2.2 Sorting methodology

The basis for the sorting methodology of all mentioned sorting analyses was the Austrian Standard ÖNORM S 2127 “Basic characterisation of waste heaps or from solid waste from containers and transport vehicles”. In this standard, the minimum increment mass $m_{inc}$ [kg] is calculated according to Equation (1), at least, however, 0.2 kg ($d_{95}$ is the 95$^{th}$ percentile particle size in mm).

$$M_{inc}\,[kg] = 0.06 * d_{95}\,[mm] \quad (1)$$

A representative sample consists of at least ten increments. The number of representative samples which have to be taken depends on the statistical population of the waste material.
The results of the four experiments are difficult to compare because they have different sorting objectives which lead to different frame conditions.
Objectives:

- Material-specific aspects of waste comminution
- Recycling potential in MCW
- Retrieving samples of recycling materials for sensor analyses
- Determination of statistical accuracy of sampling procedures

Frame conditions of sorting:

- Sorting equipment: either sorting table or sorting station with conveyor belt
- Number of sorting fractions: between 9 and 28 material fractions
- Pre-treatment methods of selected waste samples:
  - Comminution of waste samples
  - Sieving of waste samples into grain classes
  - Removal of a fine fraction prior to sorting.

In order to balance the mentioned differences and make the four sorting analyses comparable, the data had to be harmonised and aggregated. This data processing has to be taken into consideration when evaluating the resulting data and drawing conclusions.

### 2.3 Share of recyclable vs. non-recyclable fractions

In the light of the German Commercial Waste Ordinance [3], it is of specific interest, which share of a material fraction can be recycled and which not. Therefore, a sorting analysis has been carried out at a German pre-treatment facility for MCW in the year 2018. In total, nine samples of commercial waste have been sorted, coming from different commercial sources. In the sorting analysis, four recycling fractions, i.e. glass, paper/cardboard, plastic and wood, have been further divided into a recyclable and a non-recyclable part. In addition, the plastic material has been sorted into a 2D- and a 3D-fraction. The sorting instruction was based on the material characteristics of the waste and not on their pollution with dust or dirt and also not on the market conditions for valuables.
Criteria for distinguishing between recyclable and non-recyclable materials included:

- Legislation: For the definition of the recyclability of waste wood, legislation has been adopted by Germany [7] and Austria [8].
- Standards: For example, EN 643 (European List of Standard Grades of Paper and Board for Recycling) determines tolerance levels for impurities.
- In addition to regulations in official documents, recycling companies issue criteria for the acceptance of recycling materials as input into their plants.

It has to be taken into consideration that some of the above-mentioned criteria are not immediately applicable during a practical sorting activity. For example, the limit values for heavy metals or organic group parameters cannot be measured onsite. Therefore, alternative more practicable sorting criteria have to be applied.

### 2.4 Methodology of laboratory analyses

For one of the experiments, a quantity of about 2.4 tonnes MCW was not only sorted, but the sorting fractions were also subject to laboratory analysis. For the analysis of the parameters, the following standards were applied:

- Water content: DIN EN 14346 (procedure A), Characterization of waste — Calculation of dry matter by determination of dry residue or water content.

- Calorific value: DIN 51900-1, Testing of solid and liquid fuels – Determination of gross calorific value by the bomb calorimeter and calculation of net calorific value – Part 1: Principles, apparatus, methods. In the following, the results are stated as net calorific value and therefore had to be calculated from the measured gross calorific value.
- Chlorine content: DIN EN ISO 10304-1, Water quality— Determination of dissolved anions by liquid chromatography of ions — Part 1: Determination of bromide, chloride, fluoride, nitrate, nitrite, phosphate and sulphate (Sample preparation by calorimetric digestion: ÖNORM EN 14582).
- Ash content (815°C): DIN 51719, Testing of solid fuels – Solid mineral fuels – Determination of ash content.

## 3 Results

### 3.1 Mixed Commercial Waste Composition in Austria

Table 2 shows the results of the four sorting analyses of Austrian MCW in an aggregated way. Due to the different number of sorting fractions, only four fractions of valuables (paper/cardboard, plastics, wood, and metals) are directly comparable.

Table 2: Aggregated results of MCW sorting analyses in Austria in 2018 and 2019

| **Material fraction** | **Weight per cent [%]** | |
|---|---|---|
| | **Site 1 (2 experiments)** | **Site 2 (2 experiments)** |
| Paper/cardboard | 16.8 | 12.0 |
| Plastics | 19.1 | 16.2 |
| Wood | 7.1 | 9.9 |
| Metals | 4.3 | 4.0 |
| Inert | 4.3 | 58.0 |
| Textiles | 3.6 | |
| Others | 44.7 | |
| Total | 99.9 | 100.0 |

In general, it can be stated that also in Austria the compositions of different MCW-samples show remarkable differences. While the share of metals is very similar, the share of paper/cardboard differs by the factor 1.4. In contrast to the German MCW-composition (see chapter 1.2.1), the paper/cardboard fraction is clearly lower than the plastic fraction. The percentage of the four recycling fractions paper/cardboard, plastics, wood and metals varies between 40% and 50%.

### 3.2 Share of recyclable vs. non-recyclable fractions

The sorting activity regarding the share of recyclable vs. non-recyclable fractions comprised nine samples from different commercial sources. The results are presented in boxplots in order to show the variety (size of the box) between the samples (see Figure 3). The relevant value for comparing the quantity of the fractions is the median.

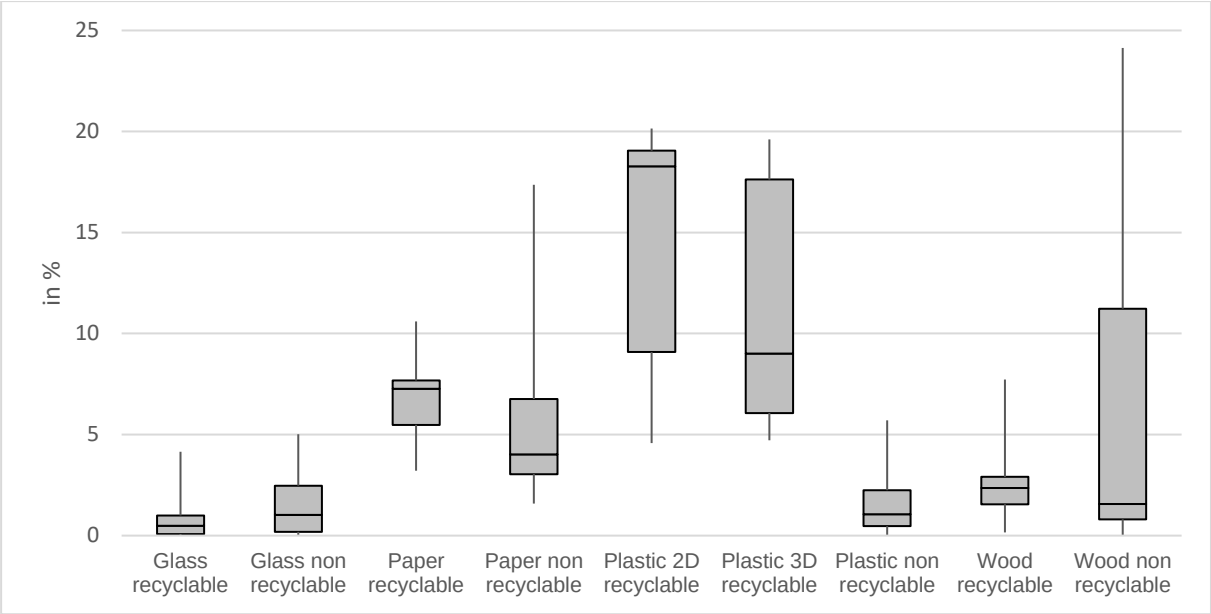


Figure 3: Boxplot of the share of selected fractions of nine German commercial waste samples in 2018.

For three of the four materials the recyclable share is higher than the non-recyclable share, in the case of plastics much higher; the exception is the glass fraction. Nevertheless, the non-recyclable material constitutes almost a third of the four investigated fractions.
Regarding the variety of the fraction quantities between the samples, the fractions differ remarkably. Especially the two plastic fractions and the non-recyclable wood fraction show a very broad variety.

### 3.3 Laboratory parameters of MCW in Austria

One MCW-sample was analysed regarding the parameters water content, heating value, chlorine content and ash content. These parameters give information about the quality of the material as a fuel. The results of the analysis are presented in table 3.

Table 3: Results of laboratory analyses of an MCW-sample in Austria

| Parameter | Results |
|---|---|
| Water content | 16.3 % |
| Lower heating value | 15,9 MJ/kg DM* |
| Chlorine content | 0.9 % DM* |
| Ash content | 36.1 % DM* |

* DM: Dry matter

The measured values of the MCW, especially the lower heating value and the chlorine content, are in a range which allows for the utilisation of this material as input for the production of solid recovered fuel (SRF).

## 4 Conclusions

In the course of the ReWaste4.0-project, four experiments were carried out, in which the composition of Austrian mixed commercial waste (MCW) was analysed. Due to the necessary data processing (harmonisation, aggregation), the comparability of the compositions is limited. Nevertheless, it can be stated that the composition of the samples shows a broad variety for certain material fractions. Especially those fractions are concerned, which constitute the main share of the sample (i.e. paper/cardboard and

plastics). Regarding the content of the materials, which are potentially suitable for recycling, the values vary between 40% and 50%. When comparing the results with compositions analysed in Germany, the variety of compositions becomes even broader and the potentially recyclable content varies between 40% and 60%. The main reason for these differences is most probably the origin of commercial waste.
In a sorting activity of nine MCW-samples in Germany, the potentially recyclable material fractions glass, paper/board, plastics, wood were further divided into a recyclable and a non-recyclable part. With the exception of glass, the recyclable part was higher than the non-recyclable part, especially higher for the plastic fraction. In total, however, the non-recyclable quantity amounts up to nearly a third of the four fractions. Depending on the origin, certain fractions differ heavily. Especially the two recyclable plastic waste fractions and the non-recyclable wood fraction show a very high variety of data results. Considering the content of non-recyclables materials, the mass potential of valuables in Austrian MCW varies around 30%.
One of the Austrian sorting analyses was used to determine the parameters water content, heating value, chlorine content and ash content. The measured values are in a range which allows for the utilisation of this material as input for the production of solid recovered fuel (SRF).

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**References**
[1] European Union: Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives, amended by Directive (EU) 2018/851 of the European Parliament and of the Council of 30 May 2018.
[2] European Union: European Parliament and Council Directive 94/62/EC of 20 December 1994 on packaging and packaging waste, amended by Directive (EU) 2018/852 of the European Parliament and of the Council of 30 May 2018.
[3] Commercial Waste Ordinance: Verordnung über die Bewirtschaftung von gewerblichen Siedlungsabfällen und von bestimmten Bau- und Abbruchabfällen (Gewerbeabfallverordnung – GewAbfV) BGBl. I S.1938/2002, Deutschland, as amended BGBl. I S. 2234, 2260 as of 18.04.2017.
[4] Dehne, I.; Oetjen-Dehne, R.; Siegmund, N.: Stoffstromorientierte Lösungsansätze für eine hochwertige Verwertung von gemischten gewerblichen Siedlungsabfällen. Umweltbundesamt Texte 18/2015, Dessau-Roßlau, March 2015.
[5] Helftewes, M.: Modellierung und Simulation der Gewerbeabfallaufbereitung vor dem Hintergrund der Outputqualität, der Kosteneffizienz und der Klimabilanz. Dissertation, Rostock, 2012.
[6] Wellacher, M.; Pomberger, R.: Recyclingpotenzial von gemischtem Gewerbeabfall. Österreichische Wasser- und Abfallwirtschaft, Volume 69, Issue 11-12, pp 437-445, December 2017.
[7] Waste Wood Ordinance: Verordnung über Anforderungen an die Verwertung und Beseitigung von Altholz (Altholzverordnung - AltholzV) BGBl. I S. 3302/2002, Deutschland, as amended BGBl. I S. 626, 638 of 29.03.2017
[8] Recycling Wood Ordinance: Verordnung des Bundesministers für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft über das Recycling von Altholz in der Holzwerkstoffindustrie (RecyclingholzV) BGBl. II Nr. 160/2012, Österrreich, as amended BGBl. II Nr. 178/2018.