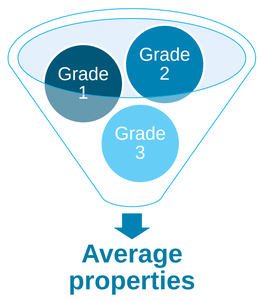
Analysis of different polypropylene waste bales – evaluation of the source material for PP Recycling

Jutta Geier[1], Márton Bredács[1], Andreas Witschnigg[2], Daniel Vollprecht[3], Gernot Oreski[1]

[1] Polymer Competence Center Leoben GmbH (PCCL), Leoben, Austria – jutta.geier@pccl.at
[2] PreZero Polymers Austria GmbH, Haimburg, Austria
[3] University of Augsburg, Chair of Resource and Chemical Engineering, Augsburg, Germany

MOTIVATION

- Polypropylene (PP) is the **second most widely used plastic** in Europe, making its recycling essential due to the **high amount of waste** produced every year [1].
- The use of PP recyclates in more demanding applications is still restricted by their **quality**. The occurrence of **different polymeric and foreign impurities** deteriorates the properties of the recyclates compared to virgin materials.
- PP recyclates are a mixture of **different PP grades** with consequently only **average properties** of the contained grades (e.g. melt flow behaviour) [2].
- Some processing methods or applications require materials with **specific processing and mechanical properties** that are **not met** by recyclates from **mixed grades**.



OBJECTIVES

- Obtain an **overview** about the **source material for PP recycling** by analysing different PP containing waste bales.
- Determine the **amount of PP** and **impurities** (polymeric impurities and foreign materials).
- Evaluate the **proportion** between PP products **processed** with **different methods** and thus the proportion of grades with different **melt flow rates** (= decisive processing parameter).
- Investigate possible **seasonal fluctuations** of the waste bale content.

EXPERIMENTAL

- For a recycler, PP waste is available in form of **different types** and **qualities** of pre-sorted **waste bales** (pure, mixed with other polymers).
- In this work two pure PP (PP1, PP2), two mixed polyolefin (MPO1, MPO2) bales and a mixed PP-polystyrene (PP/PS) bale were investigated.
- The investigation was conducted as follows (see Fig.1):
  1) **Random sampling** of 5 to 10 kg from each bale.
  2) Manually **sorting according to material** (polymer type, foreign materials).
  3) Further **sorting** of the **PP fraction** according to **processing method**: extrusion blow moulding (EBM), injection moulding (IM), thermoforming (THF) and films/flexibles (FLEX). Examples for each processing method can be found in Tab. 1.
- To account for **seasonal fluctuations**, this procedure was carried out **4 times a year**.

Processing method	Examples
IM	Food container, buckets
EBM	Detergent bottles, ketchup bottles
THF	Trays, yoghurt cups
FLEX	Pasta packaging, sweets wrapping

Tab. 1: Examples of PP articles of each processing method.

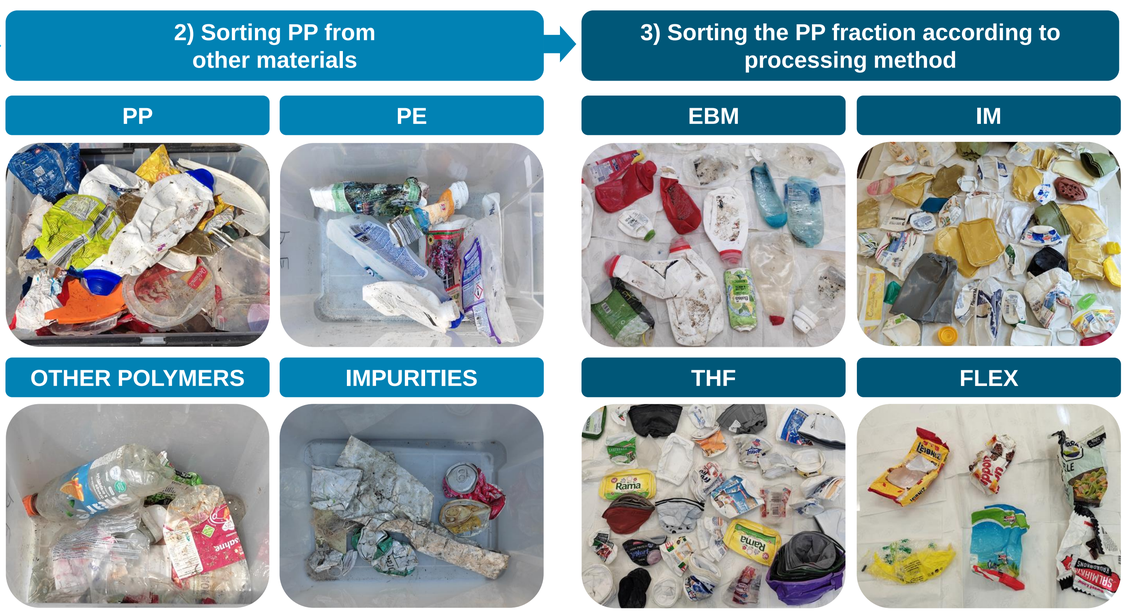


Fig. 1: Schematic of the bale analysis performed.

RESULTS

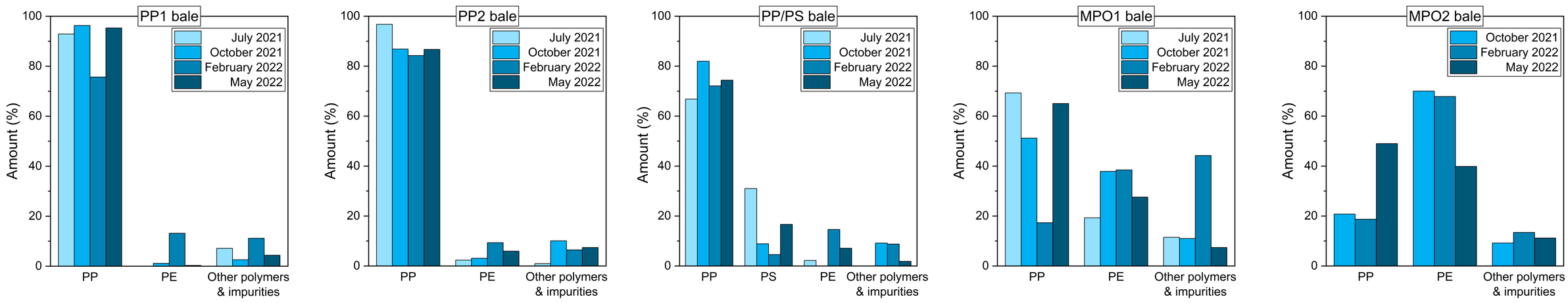


Fig. 2: Material composition of different PP containing waste bales.

- The results of the **sorting according to materials** are shown in Fig.2.
- The **pure PP** bales showed **PE contents** of up to **13 %**. As expected, the **MPO bales** have a **higher PE content**.
- In the **PP/PS bale** the **PP amount** was always **higher** than the PS content.
- The content of impurities differs depending on the bale type. The **MPO** bales showed the **highest amount** of polymeric and foreign **impurities**.
- The separation into the **different processing methods** (see Fig. 3 for the examples of the PP1 and MPO1 bales) showed that **IM** is the **predominant processing method**, followed by EBM and THF. The Flex amount was found to be the smallest.
- The proportion of the processing classes was found to **vary with sampling time**. The recyclates would have shown **different processability** at each sampling time due to the different melt flow behaviour of the processing fractions (e.g. higher EBM amount → lower melt flow rate).

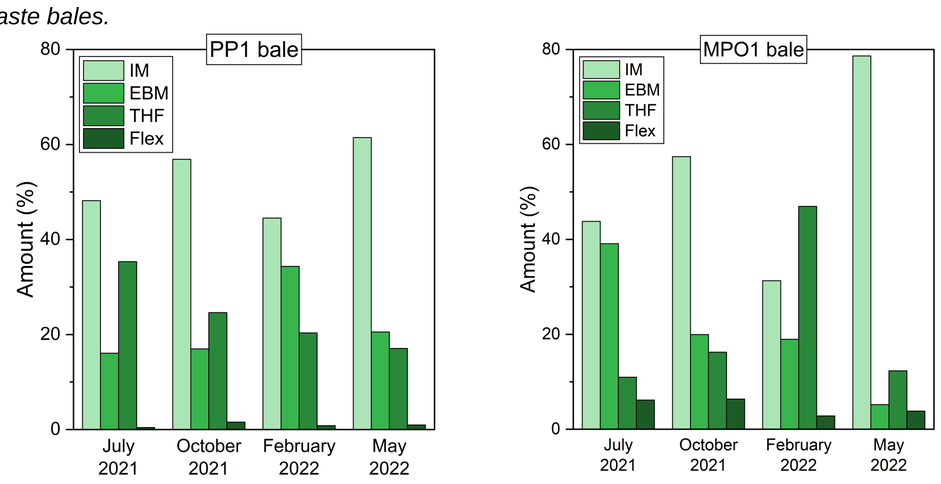


Fig. 3: Results of the sorting according to processing method shown on the example of the PP1 and MPO1 bales.

CONCLUSION

- **Pure PP** bales still contain a fairly **high amount of PE** in some cases.
- Some bales were found to have **high levels of impurities**, which would severely affect the quality of a recyclate without further treatment.
- The proportion of the **differently processed PP** fractions **varies with sampling time,** which would have resulted in **different processabilities** (i.e. melt flow behaviour) and properties of the produced recyclates.
- A **higher** and more **consistent recyclate quality** could be achieved by **enhanced sorting techniques** capable of sorting by processing methods.

OUTLOOK

- The **bale analysis** will be **continued** for another year to determine whether the obtained seasonal variations of the proportions of the impurities and the differently processed products are random or reproducible.
- This work serves as a starting point for an upcoming **quality evaluation** where **different recyclates** (from mixed PP vs. from PP sorted by processing method) will be assessed based on their thermal and mechanical performance.

ORCID ID

For a study on PP recyclate, see also the following poster:
J. Hinczica - "Mechanical short-term and long-term properties of PP recyclate blends"

REFERENCES
[1] Plastics Europe. (2021). Plastics - the Facts 2021
[2] Alvarado Chacon, F., Brouwer, M. T., Thoden van Velzen, E. U., & Smeding, I. W. (2020). A first assessment of the Impact of impurities in PP and PE recycled plastics. Wageningen Food & Biobased Research, Wageningen

This research work was performed at the Polymer Competence Center Leoben GmbH (PCCL, Austria) within the framework of the COMET-program of the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology and the Federal Ministry for Digital and Economic Affairs with contributions by Montanuniversität Leoben and PreZero Polymers Austria GmbH. The PCCL is funded by the Austrian Government and the State Governments of Styria, Lower Austria and Upper Austria.