LEmPlaR

Losses & Emissions in Plastic Recycling

Public Summary

2024

Background

LEmPlaR focused on product losses and emissions in PP and PET recycling to increase the recycling rate of these plastics and reduce their environmental impact. Measurement techniques to assesss losses, emissions, and contaminants, as well as the development of mitigation actions, were in scope. Product losses decrease yield and impact the environment. Some emissions concern water treatment and air quality. In the recycling process, examples of emissions and losses include incorrectly sorted plastics, microplastics, organic residue, inks, and adhesives. At the project's start, there was a lack of quantitative data on these emissions and losses.

Objectives

LEmPlaR's goals were to:

- Detect, quantify, and qualify the different losses and emissions in various parts of the sorting and washing cycle.
- Identify possible causes of plastic loss and unwanted emissions in recycling processes.
- Define a mitigation strategy for different causes.
- Enable recyclers to recycle plastics more efficiently by increasing the yield without impacting the environment.

This project contributed to MMIP6 "Closure of Industrial Chains," specifically to the circular plastics part. With this project, we enabled an increase in the recycling rate and a reduction in emissions to the environment.

Results

For this project, we mimicked the industrial recycling process of rigid PP packaging and PET trays using the reprocessing facilities at NTCP. We checked the layout against high-quality industrial installations in the Netherlands to ensure it closely resembled a real-size process. Using these setups, we performed trials on PP and PET with a large number of sampling points for different intermediate and output streams. This includes product, residue, and water samples. This is not yet common in the industry, where often only output streams are sampled.

We developed practical analytical tools to quantify losses, contaminants, and emissions using existing laboratory techniques. We distinguished air, water, and solid samples for this quantification. We used the following techniques:

- **Air**: We used online particle sizing (PM1, PM10, TSP) and offline analysis of particles collected on filters by TGA, TED GCMA for polymer determination, and SEM for visualization.
- **Water**: We used standard methods for total solids and total suspended solids. TGA was used to determine the ratio of organics and volatiles, plastics, and inorganics. DSC and TGA TED GCMS were used for polymer determination. We measured conductivity, turbidity, COD, and DOC to assess the general cleanliness of the washing water. We determined total nitrogen with the Hach cuvette test and elemental analysis using ICP-OES. Water samples were analyzed for micropollutants, including multiple PFAS substances. Nile Red staining was used to visualize the presence of microplastics.
- **Solids**: We determined the moisture content and surface contamination in solid samples. The flake size distribution was determined using a vibratory sieve shaker. ATR-NIR was used to analyze the composition of flake streams.

The major results of the trials are the mass balances over the whole process for each plastic. Below you will find several mass balances for typical reprocessing layouts. The focus of LEmPlaR was on PP and PET. However, the developed methods have also been applied to other plastics such as LDPE, LLDPE, and HDPE in different projects. This public report shows mass balances for PP and PET in Figure 1 and 2.

The input of the process is always set to 100% of the target material, meaning that the input itself can still contain moisture, surface contamination, and other plastics.

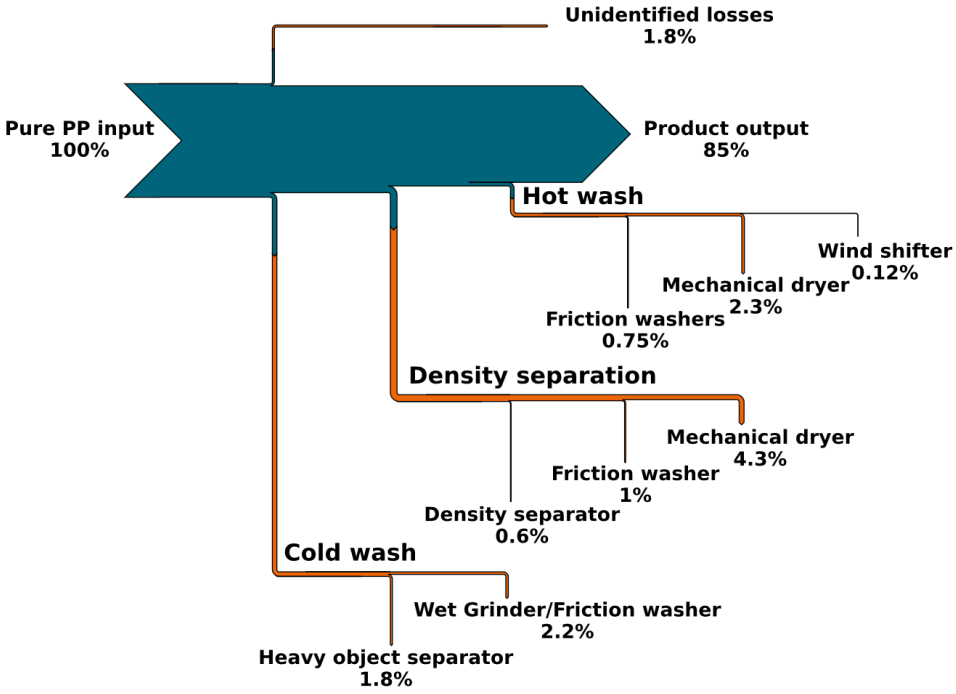

Figure 1 - Mass balance over the whole process for pure PP input set to 100%.

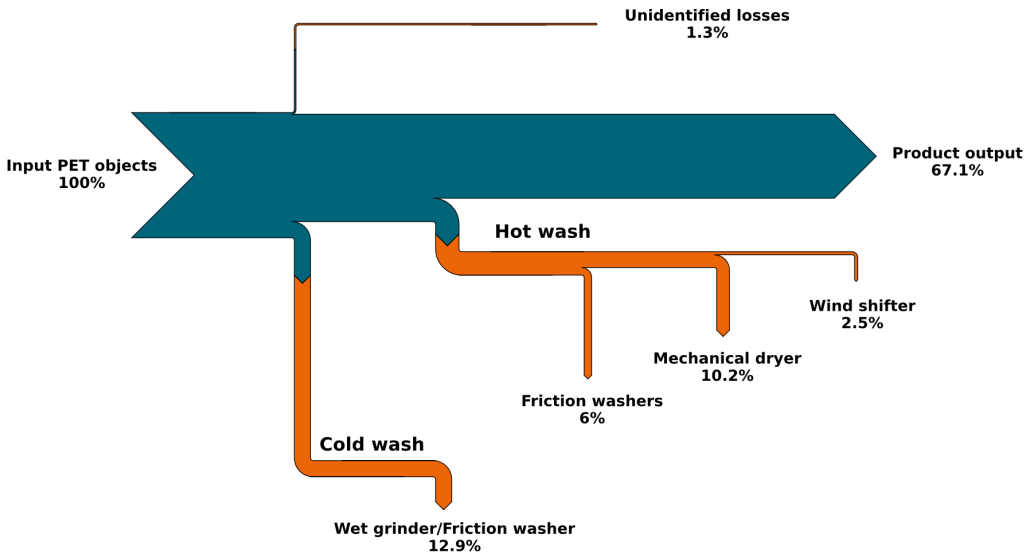

Figure 2 -Mass balance over the whole process for input PET objects set to 100%.

In general, losses can be mitigated by choosing a sufficiently large screen in the wet granulator that is still small enough to enable efficient washing. This reduces the formation of microplastics below 2 mm that would be lost during the process. Additionally, we conclude that mechanical drying is a major cause of microplastic formation in mechanical recycling. This can be mitigated by reducing the centrifugal speed while monitoring the moisture content of the flakes.

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