FACULTY OF BIOSCIENCE ENGINEERING

LCPE Laboratory for Circular Process Engineering

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TO SORT OR NOT? THE IMPACT OF COLLECTION SCHEMES ON PLASTIC WASTE FEEDSTOCK QUALITY AND ITS SUITABILITY FOR RECYCLING

Introduction

While plastic production is at an all-time high with a reported 400.3 Mt global production in 2022, recycling rates are still lacking behind with an average global recycling rate at approx. 9% (Plastic Europe, 2023). In order to meet circular economy (CE) and sustainability targets such as defined by the European Green Deal, recycling rates have to increase. Since recycling rates targets might not be reachable with current waste management practices alone, post-sorting of residual waste might be one option to increase recycling rates. However, collecting and sorting for more quantity usually comes at the price of lower quality of sorted bales (Picuno et al., 2021), which in literature is known as the "quantity-quality trade-off assumption" (Brouwer et al., 2019). This includes that more heterogeneous feedstock is more difficult to sort into high purity output at material recovery facilities (MRF) which in turn will have an impact on recycling facilities and quality of recyclates derived from mechanical and chemical recycling processes (Brouwer et al., 2018; Kusenberg et al., 2022). Even if waste items are sorted correctly at MRFs, design choices such as multi-layer packaging, will result in significant contamination on polymer and elemental level (Roosen et al., 2020). These quality constraints may have a significant effect on recyclability of plastic waste and might result in the necessity of extensive pre- or post-treatment (Lase et al., 2022; Roosen et al., 2020). Extensive pre- and/or post-treatment might in turn have a direct impact on economic performance of recycled plastic (Civancik-Uslu et al., 2021; Larrain et al., 2021). This study aims to compare the influence of the collection scheme on the quality and suitability for recycling processes of sorted bales from PMD and post-sorted (PoS) waste streams processed at the same MRF.

Material and Methods

- Quantification of mass and residue fraction of samples prior and after washing
- Shredding, ball milling and pulverisation of samples incl. sieving using a 425 µm sieve

Sample collection

- Sampling of four bales: LDPE, HDPE, PP Rigid, DKR350 from PMD and post-sorting
- Grab samples and target items (n=5, 10 replicates) of each bale
- Special items from post-sorting, e.g. textiles, HH plastic items, toys

Sample preparation

Washing

- 65°C
- Water only

VOC analysis

Waste characterisation

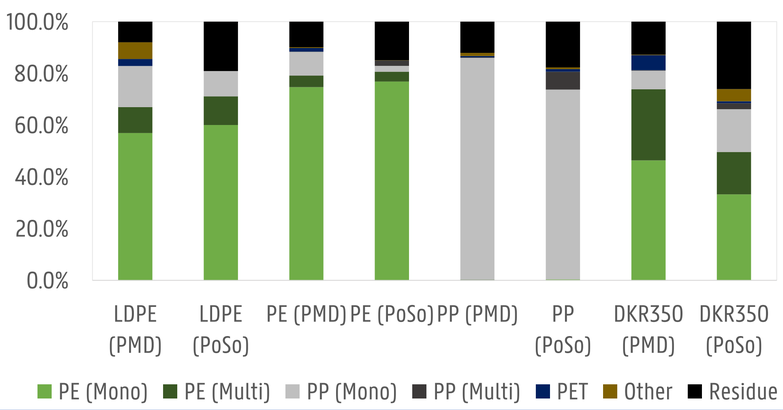
Quantification of

- Polymer composition based on ATR-FTIR and IR microtome
- Elemental composition using a PerkinElmer 2400 Series II CHNSO Elemental Analyzer
- Metal and halogen concentration using an ICP-OES Thermo iCap 7200 and an IC Eco Metrohm, respectively

- Quantification of VOCs (unwashed samples)
- Pyro-GC-MS

Results and Discussion

Polymer composition of sorted bales (LDPE, HDPE, PP rigid and DKR350) from PMD and post-sorting MRF



Residue level:
- Post-sorting > PMD
- DKR350 highest level

Bale quality:
- Does not differ significantly
- Post-sorting slightly better than PMD

Results & Discussion (cont.)

Sorted PMD bales

LDPE, HDPE, PP rigid, DKR350

Post-sorted bales

Elemental composition (wt%) exemplified for DKR350 (PMD)		
N	0.02 ± 0.01 (200 ppm)	0.34 ± 0.04 (3400 ppm)
C	73.30 ± 1.09	74.70 ± 5.30
H	12.60 ± 0.41	11.62 ± 1.47
S	0 ± 0	0 ± 0

Max. allowance Pyrolysis:
- 700 ppmw

Impact for Hydro Treatment: (HT)
- More severe operating conditions in HT
- Salt formation

Possible reasons:
- Synthetic fibers (e.g., PA)
- Biomass

Fate
- Will likely evaporate / form small compounds containing N
- Can be removed during hydrogenation

Pre-treatment
- Washing improves THC
- Possibly by removing food/residue derived halogens

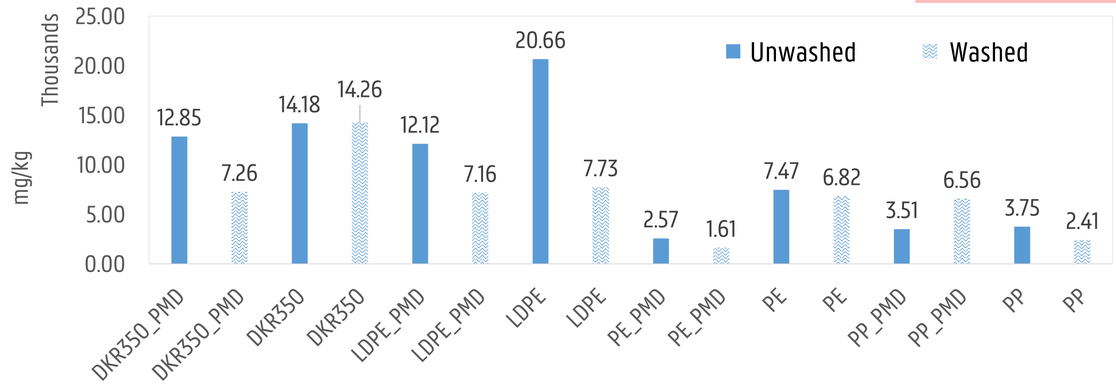
Post-Sorted bales
- Detected THC lower than PMD bales
- Possibly due to handling at MRF

In general, THC is low compared to previous studies

Total Halogen Content (mg/kg)

	PMD		Post-sorting	
Bale	unwashed	washed	unwashed	washed
LDPE	1.8	2.6	3.0	1.8
PE	2.4	1.1	0.9	0.8
PP	0.9	1.2	0.8	2.0
DKR350	4.9	1.75	1.8	1.4

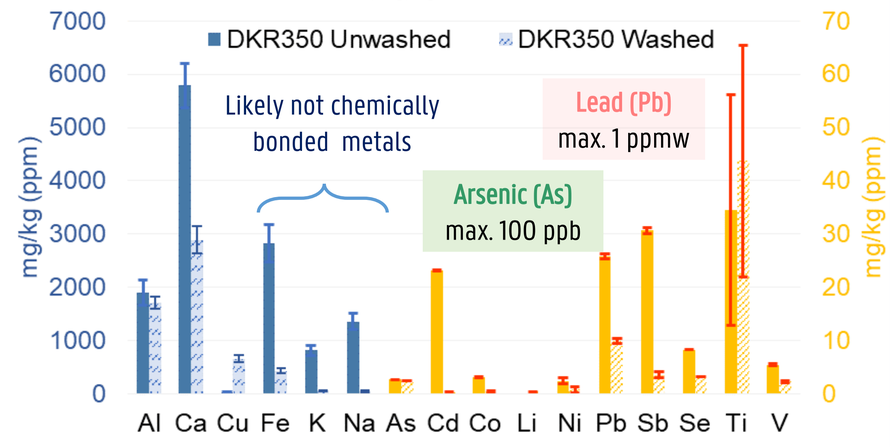
Total Metal Content (TMC) (mg/kg) for sorted bales with different pre-treatment



PMD bales
- On average, PMD bales have a lower TMC than Post-sorted bales

Restricted Metals (Cd, Ni, Pb)
- Detected in samples of both collection schemes
- Highest concentration in LDPE and DKR350

Metal concentration (mg/kg) of 16 metals for DKR350 (PMD)



- Pb exceeds pyrolysis limit for DKR350 samples (PMD and post-sorted)

Pre-Treatment
- Washing decreases TMC by more than 50% for some samples

Unwashed: 1.28 wt%
↓
Washed: 0.59 wt%

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