

Grønt Punkt Norge (Green Dot Norway)

ENHANCING PLASTIC RECYCLING

The Role of Collection and Sorting Methods

REPORT





Grønt Punkt Norge

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1 ● SUMMARY ✓

This report examines whether the quality of post-consumer plastic packaging is dependent on the collection method — comparing mechanically sorted plastics at a material recovery facility (MRF), with plastics sorted at source (SAS) by households.

Flexible LDPE and rigid PP from two sources were tested (the MRF ROAF and SAS Kedenburg), before mechanical recycling at Vogt-Plastic. Some batches were further treated by deodorization. The analyses focused on material properties, contamination levels, odour, and overall quality of the recyclates.

Plastics originating from the MRF required more chemicals and water during washing. They also displayed higher levels of contaminants, reducing the quality of the resulting recyclate. Differences between the MRF and SAS were most pronounced for flexible LDPE, which absorbed more odour-causing substances, and oils. Deodorization reduced volatile compounds and odours, albeit it did not eliminate the contamination gap between the material from the MRF and the SAS. Rigid PP generally contained fewer impurities than LDPE, but PP from the MRF still had lower quality indicators than PP from SAS.

From a quality perspective source separation produces cleaner plastic recyclates that can be used in higher-value applications. According to the results, MRF-based collection leads to lower-quality material indicators. However, it is to be acknowledged that advanced washing or decontamination techniques can help reduce contamination in plastics from MRFs. Identifying specific chemical and odour sources may lead to targeted solutions, bridging the gap in performance between plastics derived from MRFs and SASs.

2. COLLABORATORS & PARTNERS

This project was initiated by Plastretur AS and Handelens Miljøfond (Norwegian Retailers' Environment Fund).

An overview of all collaboration partners can be found in Table 1.

// TABLE 1: COLLABORATORS AND PARTNERS.

COMPANY	CONTACT PERSON	ROLE
Grønt Punkt Norge AS	Sina Maria Lystvet, Ingunn Schrøder	Project leader
Handelens Miljøfond	Sjur Kvifte Nesheim	Project owner
Plastretur AS	Petter Aaby Vebenstad	Steering committee
Plastics Recyclers Europe	Mathilde Taveau, Andromeda Scoppio	Steering committee
Romerike avfallsforedling IKS, ROAF	Terje Skovly	MRF sorting
Umweltdienste Kedenburg GmbH	Anne Duehlmann, Stephan Glattkowski	Fine sorting of source separated material
Vogt-Plastic GmbH	Fabian Lüth, Andreas Vogt	Recycler
Norner AS	Ole Jan Myhre	Analysis

3. BACKGROUND

The European Union has set specific recycling targets that require at least 50% of all plastic packaging to be recycled in every member state by 2025. As part of the European Economic Area (EEA), Norway follows these targets.

Currently, Norway is far from achieving 50%: in 2023, Plastretur AS reported that only 34% of plastic packaging was recycled. The main reason for this shortfall is that, in 2023, 56% of plastic waste from households was not source-separated by consumers and therefore ended up in residual waste.

Only 44% of plastic packaging is separated at source (SAS), resulting in plastic packaging also being collected and sorted from residual waste. This collection method requires specialised infrastructure called material recovery facilities (MRF). In such facilities, residual waste is treated, and valuable fractions such as plastics, metals and others are sorted out for recycling. The remaining waste is incinerated with energy recovery. According to Handelens Miljøfond, Mepex and Norner, more MRFs are needed for Norway to be able to reach the 2025 recycling targets. Several municipalities in Norway have already decided to invest in such infrastructure and will build facilities across the country, in Midt-Norge (Sesam), Østfold (ØAS) and Rogaland (IVAR).

In addition to the MRFs, Plastretur AS and Tomra are building a plastics recovery facility (PRF). The facility will use input materials from SASs and MRFs, and sort different types of plastics into separate polymer fractions, e.g. HDPE, LDPE, PP, and PET. Each fraction will subsequently be recycled.

It is widely believed that MRF-derived material is more contaminated, meaning it is of lower quality and is more challenging to recycle into high-value applications, compared to SAS-derived material. Several factors support this view. Consumers who sort at source are instructed to empty and rinse packaging before disposal, yielding a cleaner fraction. Plastics from residual waste often retain more product residue, as well as being mixed with other waste, e.g. organic material, hygiene products, and diapers. Understanding the material quality differences between SAS and MRF is therefore critical.

In this project, SAS material¹ underwent advanced sorting at Kedenburg, and MRF material was collected and advanced sorted at ROAF. All the material originated from Norwegian household waste. The material was shipped to Vogt-Plastic for washing, deodorisation and pelletizing. Detailed descriptions of the Kedenburg, ROAF and Vogt-Plastic facilities are included in the following sections:

3.1 KEDENBURG – DESCRIPTION OF THE SORTING FACILITY

The Kedenburg sorting facility receives only SAS material. Near-infrared (NIR) sensors are used to separate flexible films and rigid plastics. After the bales are opened, the material passes a ferrous metal separation unit and a wind shifting unit. Then the material passes the double deck ballistic separation unit (upper and lower deck) for separation of flexible and rigid plastics, as well as fines. Large sized, flexible film from the upper ballistic separation deck and flexible film from the wind shifting unit are combined.

Rigid plastics continue through another ferrous metal remover and a second wind shifter. Flexible films separated here mix with smaller films from the lower ballistic deck.

Finally, rigid plastics pass through eight NIR sensors, which sort them by polymer type. Each polymer group is baled and sold for recycling.

3.2 ROAF – DESCRIPTION OF THE SORTING FACILITY (MRF)

At ROAF, input material is mixed residual waste. Green bags of food waste are first separated. The remaining bags are opened, and the contents pass through 16 NIR sensors that identify types of waste and sort them into the following fractions:

- Food waste
- PET
- Rigid PP
- Flexible LDPE
- HDPE
- Mixed plastics
- Paper
- Metals
- Residual waste that goes to incineration and energy recovery

3.3 VOGT-PLASTIC – DESCRIPTION OF RECYCLING FACILITY

At Vogt-Plastic, the first step is removing wires. The plastic is then shredded and ground while being washed in cold water without caustic chemicals. A centrifugal separator with water removes contaminants, before the plastic is extruded with degassing and melt filtration. An optional extra decontamination step further degasses the resin.

4. AIM OF THIS STUDY

This study compares quality and contamination levels of plastics from MRF and SAS plastics, focusing on:

- Rigid PP
- Flexible LDPE

These plastics were chosen because flexible LDPE more readily absorbs oil, grease, and odours, whereas rigid PP is less prone to absorption.

This study also examines whether thorough cleaning can reduce differences in odour, and whether this type of cleaning affects technical properties. Material properties are analysed, including migration and screening analyses for substances that potentially migrate into food simulants. Odour can be a limiting factor for the usage of recycled plastics, so odour from each batch is compared.

5. EXPERIMENTAL

Testing was carried out on rigid PP and flexible LDPE collected in May and June 2023 from two sources - MRF (ROAF) and SAS (Kedenburg).

5.1 RECYCLING AT VOGT-PLASTIC

Vogt-Plastic received four separate fractions for recycling, see Table 2 for details. Material was analysed prior to any testing, then washed, deodorised and pelletized. Washing was performed at 55 °C, which is typically considered as in-between “cold” and “hot” washing .

// TABLE 2: INPUT MATERIAL AT VOGT-PLASTIC.

ID	MATERIAL	AMOUNT [TONS]	ORIGIN	DATE OF RECYCLING
V1.1	LDPE film	17,4	ROAF	12.03.23
V2.1	PP	8,35	ROAF	19.07.23
V3.1	LDPE film	11	Kedenburg	02.08.23
V4.1	PP	11,3	Kedenburg	09.08.23

// TABLE 3 SHOWS DETAILS OF THE WASHING PROCESS FOR EACH FRACTION.

	LDPE MRF	LDPE SAS	PP MRF	PP SAS
Overall water consumption [cbm]	77	24	65	31
Water throughput [cbm/t]	9,7	3,2	10,7	3,8
Defoaming agent used [l]	49	19	40	23
CSB sewage water [mg/l]	17875	4275	9275	2666
CSB sewage water [kg]	1376,4	102,6	602,9	82,6
CSB sewage water [kg/t]	173,0	13,7	99,0	10,0
Time [h]	11,5	8	9,5	8,2
Speed [kg/h]	691,7	938,6	641,2	1006,1

5.2 NORNER

Norner carried out laboratory testing and analysed samples received from Vogt-Plastic of recycled rigid PP and flexible LDPE. Testing of technical quality was performed according to the parameters in RecyClass. Samples tested by Norner are described in Table 4.

Odour testing was performed according to VDA 270, suitable for controlling the odour perception of a component or materials. Testing was performed by Norner's internal panel for organoleptic testing.

Properties specified by RecyClass are MFI, content of ash, gas, moisture and volatiles. It also includes visual inspection for impurities and appearance, as well as quantified analysis of PP in PE and PE in PP.

SAMPLE NAME	WASTE SOURCE	MATERIAL TYPE	SAMPLE DESCRIPTION
V1.1	MRF	PE	LDPE
V1.2	MRF	PE	LDPE - deodorised
V2.1	MRF	PP	PP
V2.2	MRF	PP	PP - deodorised
V3.1	SAS	PE	LDPE
V3.2	SAS	PE	LDPE - deodorised
V4.1	SAS	PP	PP
V4.2	SAS	PP	PP - deodorised

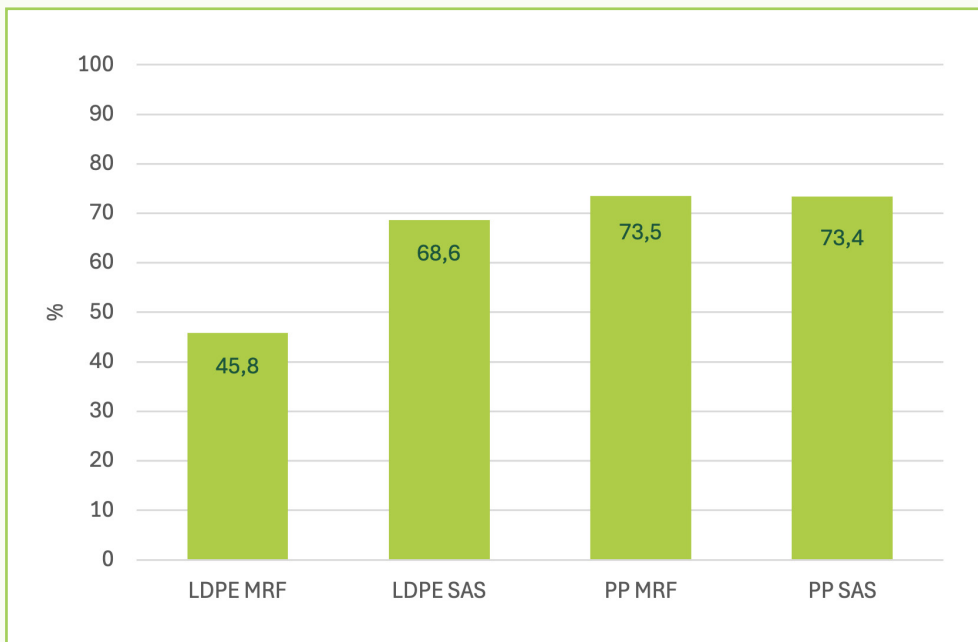
Migration testing was performed, followed by NIAS screening and semi-quantitative analysis. Results were compared to migration limits in the food contact directive (EU) No. 10/2011. Norner also organised target analyses of PAH, PAA and MOSH/MOAH carried out by Eurofins.

6. RESULTS & DISCUSSION

6.1 RESULTS FROM RECYCLING AT VOGT-PLASTIC

Vogt-Plastic recycled both MRF and SAS material, both with and without deodorisation.

Recycling yield is shown in Figure 1. For detailed results, see Table 6 in Appendix.



// FIGURE 1: RECYCLING YIELD FOR EACH FRACTION.

As seen in Figure 1, the LDPE from MRF has lower recycling yield, compared to SAS. There was an increased amount of sewage sludge, water consumption and water pollution in the LDPE and PP from the MRF compared to the SAS material.

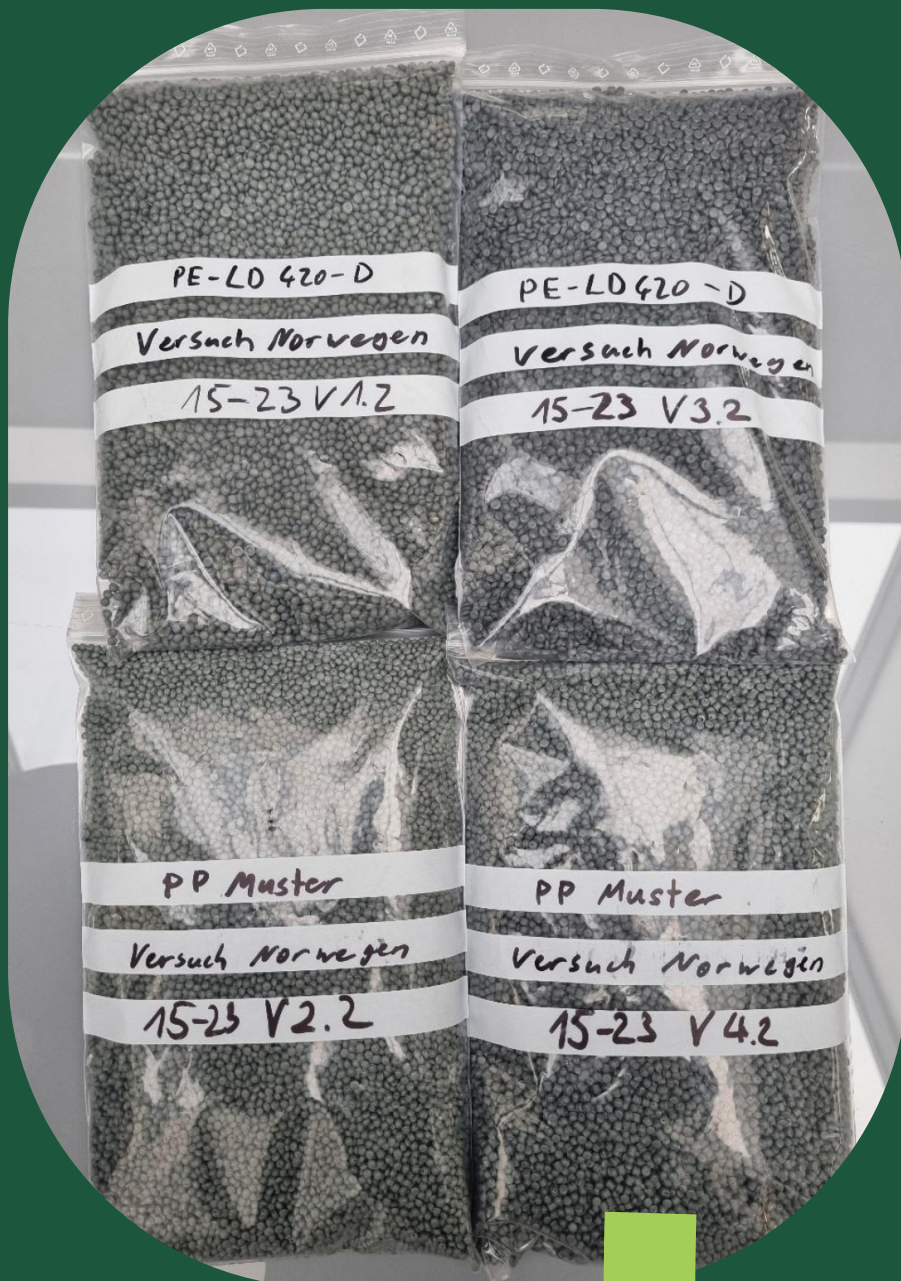
A large quantity of PE-film was found in the sinking fraction due to atypical density in both LDPE fractions. A possible reason for this is the presence of mineral fillers, which is used, for example, as an antislip agent in film production. RecyClass considers the addition of fillers in LDPE film, that increase its density, noncompatible with recycling.

The results from the initial resin testing performed at Vogt-Plastic can be found in Table 5. There was a higher polymer purity in the MRF material, compared to the SAS material. This could be due to differences in set-up of the NIR-scanners and processes at ROAF compared to. Kedenburg. Material from the MRF was more yellow, compared to the SAS material. This is shown in Figure 2.

// TABLE 5: INITIAL RESIN TESTING FROM VOGT-PLASTIC.

	LDPE MRF	LDPE SAS	PP MRF	PP SAS
PP content [%]	4,7	6,9	89	77
MFR (190/2.16)	1.3 g/10 min	0.9 g/10 min		
MFR (230/2.16)			24 g/10 min	14 g/10 min
Yield stress [Mpa]	11	17	26	24
E-Modul [Mpa]	250	270	1170	1110
KSZ (23°C) [kJ/m²]	63 (P*)	72 (P*)	5,9 (C*)	7,2
SZ (23°C) [kJ/m²]	N/A	N/A	66 (C*)	87
KSZ (- 20°C) [kJ/m²]	12 (P*)	6 (C*)	2,2 (C*)	2,6

// FIGURE 2: RECYCLED MATERIAL FROM THE MRF (LEFT) AND THE SAS (RIGHT).



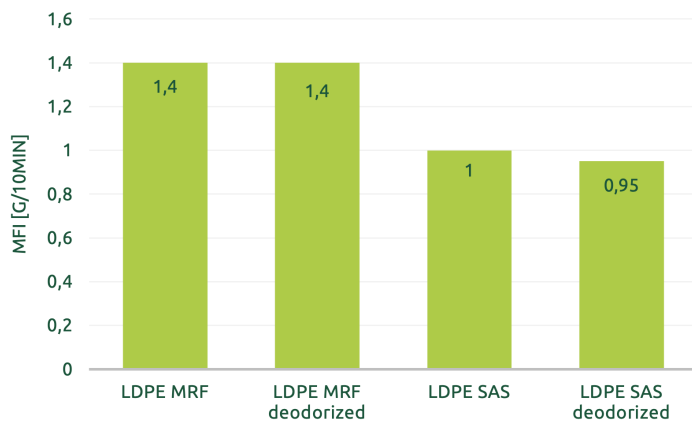
6.2 RESULTS FROM TESTING AND ANALYSES AT NORNER

This section describes results from the testing performed by Norner on eight samples from Vogt-Plastic. Testing was performed according to RecyClass.

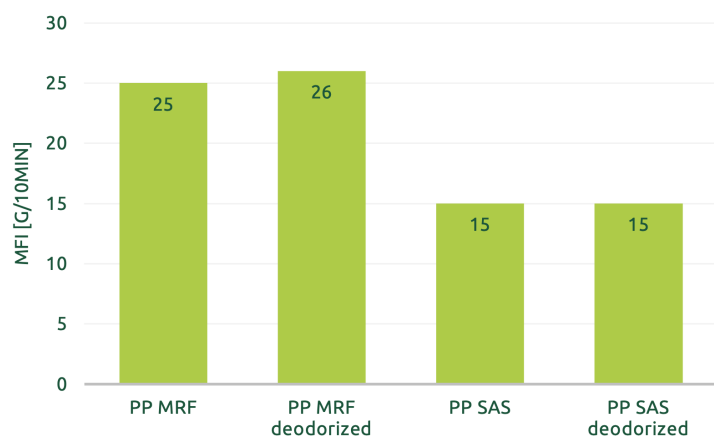
6.2.1 MATERIAL PROPERTIES

Material properties for all eight pellet samples from Vogt-Plastic were tested at Norner. The material properties tested were MFI, water content (WC), ash, gas content, volatile content (VOC) and impurities. Results are summarized in Figures 3 - 6. Detailed results can be found in Table 7 in the Appendix.

MFI values of LDPE and PP are higher in the MRF samples than the SAS samples. See Figures 3 and 4.

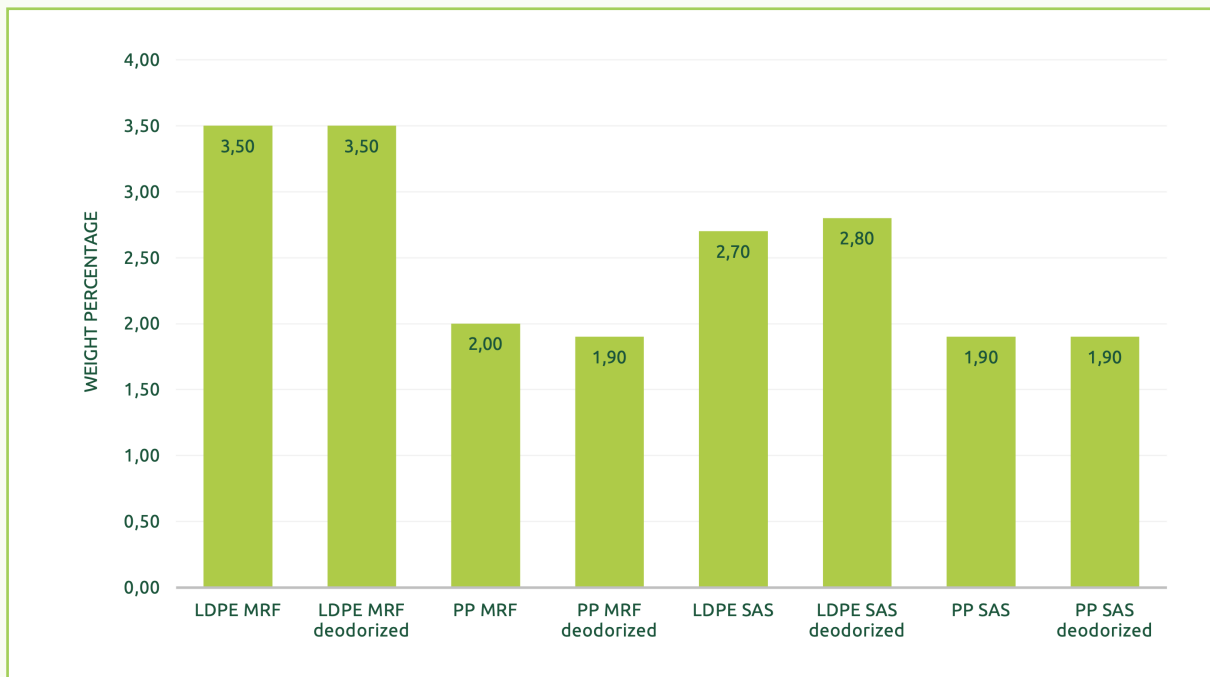


// FIGURE 3: MFI FOR LDPE.



// FIGURE 4: MFI FOR PP.

Ash content in all samples is presented in Figure 5. The ash content was higher in LDPE from the MRF, compared to LDPE from SAS. For PP, the ash content was at the same level for both sorting methods, but it was lower compared to LDPE.



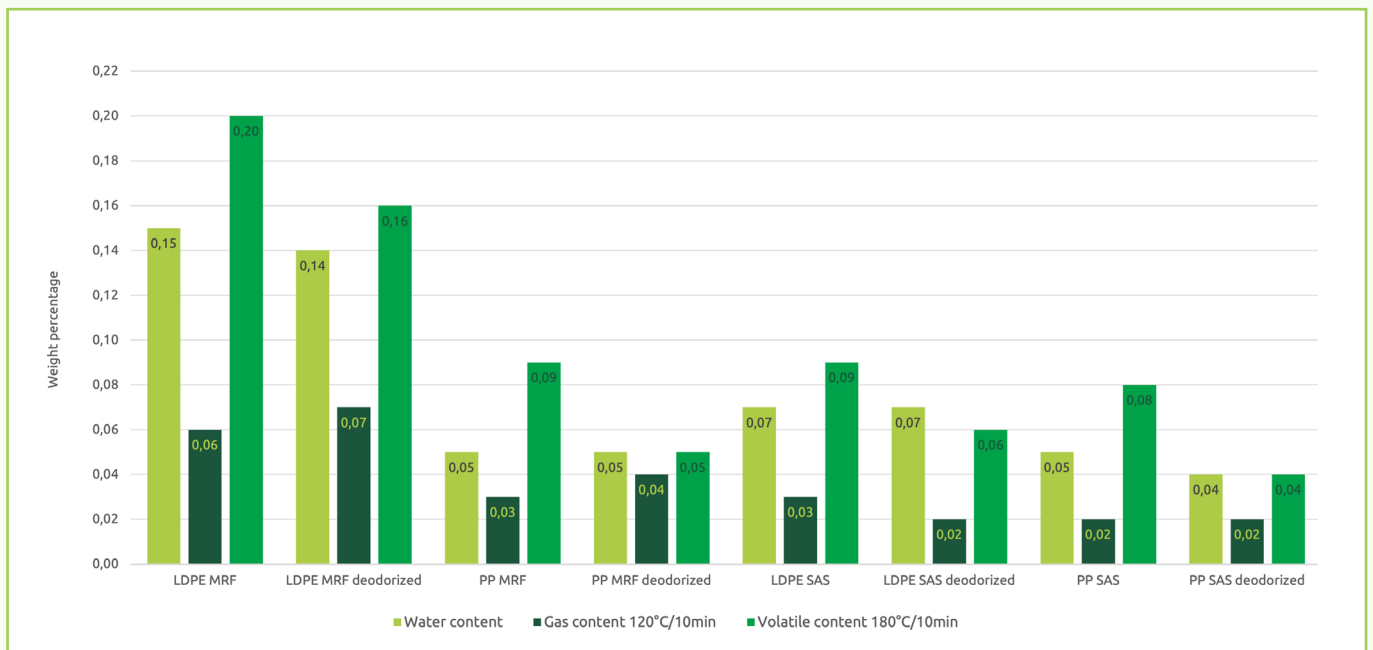
// FIGURE 5: ASH CONTENT IN ALL TESTED SAMPLES, ALL VALUES ARE GIVEN IN PERCENTAGE WEIGHT [WT%].

Results of water, gas and total volatile content are shown in Figure 6. The water content was higher in the LDPE from the MRF, compared to the LDPE from SAS. The water content for the LDPE from MRF samples was 0,15 % and 0,14 %, respectively, above the RecyClass limit of 0,1 %. Water content in all other samples was below 0,1 %. The water content was on the same level for both sorting methods for PP, and generally lower compared to the LDPE.

The gas content was systematically higher in samples from MRF, compared to SAS. For LDPE, the difference in gas content between the MRF and SAS was significantly higher, compared to the PP samples. The gas content in PP was overall lower than in the LDPE.

The total volatile content (VOC) was systematically higher in samples from the MRF, compared to SAS. For LDPE, the difference in VOC between the MRF and SAS was significant. For PP samples, the difference in VOC between the MRF and the SAS material was smaller compared to that of LDPE. The VOC content in PP was overall lower, compared to in LDPE.

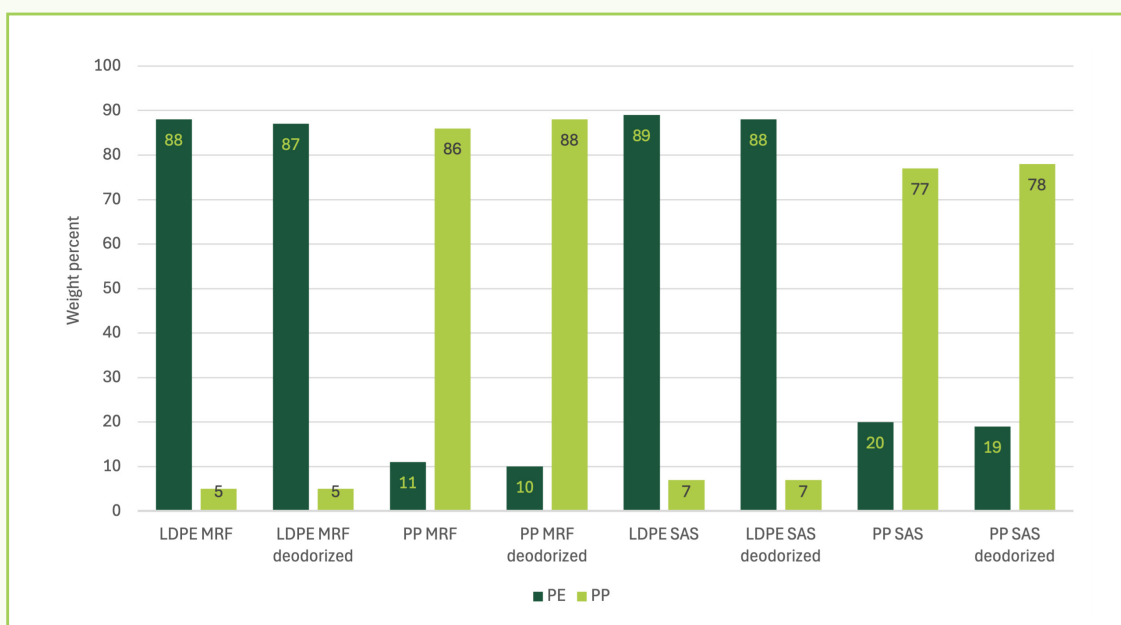
The VOC was systematically lower for deodorised samples, but this was not the case for water and gas content. The effect of deodorisation on VOC was expected, as it is a thermal treatment, thus reducing VOC in the process.



// FIGURE 6: WATER, GAS AND VOLATILE CONTENT IN TESTED SAMPLES, ALL VALUES DISPLAYED IN PERCENTAGE WEIGHT (WT%).

Based on these results it can be concluded that the contamination level of ash, gas and volatile contents are significantly higher for LDPE from the MRF, compared to SAS. The difference in contamination for PP is slightly higher for the MRF, compared to SAS. In total, MRF has a higher level of contamination than SAS.

Figure 7 shows the results from determination of foreign polymers in each fraction. All samples were analyzed using FTIR.



// FIGURE 7: CONTENT OF FOREIGN POLYMERS IN THE SAMPLES, BASED ON FTIR.

The SAS samples contain higher levels of foreign PE in PP, and foreign PP in LDPE. Especially, the amount of PE in PP is significant. It is important to note that the PE content is measured by the amount of ethylene. PE content is measured as ethylene. PP often contains some ethylene naturally (as a copolymer with propylene), but this typically explains less than 5% (often under 3%) of ethylene found in mixed waste. Therefore, it is most probably a higher content of PE (typically HDPE) in the PP rigid fractions, and

highest in the SAS fraction. It is assumed that a higher sorting performance for the MRF could be a contributing reason for higher levels of foreign PE in PP or PP in LDPE at least in this case.

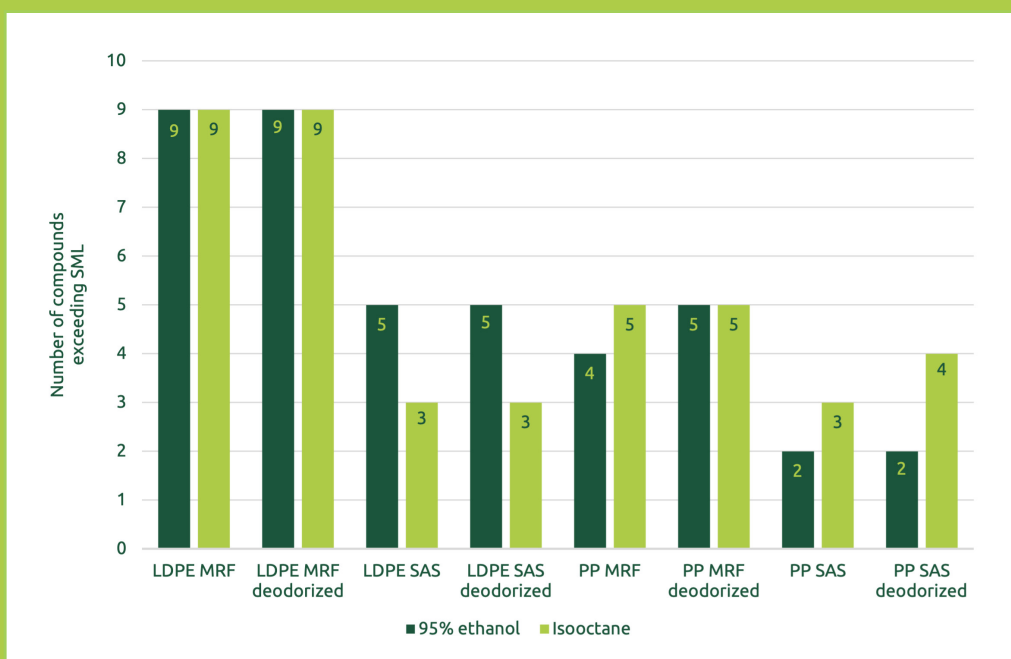
The reported differences in MFI as seen in Figures 3 and 4, could be caused by the specific differences in the resin selection of the packages collected. For PP it is probably influenced by the higher amount of PE present in the SAS sample, which typically has a lower MFI.

6.2.2 MIGRATION OF SUBSTANCES

Migration testing was performed with food contact simulants at two different conditions:

- 95 % ethanol, 40 °C, 10 days
- Isooctane, 20 °C, 2 days

In total, 53 compounds were quantified in the migration analysis. Ten different chemical compounds were detected in higher amounts than the specific migration limit (SML) in both simulants. Results are presented in Figure 8. Details of what compounds were found, as well as quantity, are found in Tables 8 and 9 in the Appendix. SML is defined by either regulation EU 10/2011 or estimated by TTL Cramer Classification.



// FIGURE 8: NUMBER OF COMPOUNDS EXCEEDING THE SML IN BOTH SIMULANTS.

Specific migration limit (SML) specifies the maximum quantity of substances allowed to migrate to food. This ensures the safety of plastic materials. Similar trends and compounds were found in both food contact simulants, 95 % ethanol and isooctane.

In total, 53 different compounds were quantified in all the pellet samples. Out of these 53 compounds, 10 compounds were detected in higher amounts than the SML in both simulants. As can be seen in Figure 8, most compounds that exceeded the SML were found in MRF material and LDPE contained more migrating substances than PP.

Most compounds that were found to exceed the SML values are known to be used in either plastic production or are likely related to the packaged substrate. E.g. were two compounds with unknown structure found in both simulants. These are common to find in glycerol mono stearate (GMS), which is a common additive in plastic packaging used as an antifogging or antistatic agent. GMS is fully food approved and can be sourced from animal fat, tallow or plant-based fat.

Four compounds that were found to exceed the SML were ethyl hexadecanoate, 9-octadecenoic acid (commonly found in animal and vegetable fats), ethyl octadecenoate and benzoic acid, dodecyl ester. Common uses for these compounds are in cosmetics and candles, scent additive in perfume industry, food flavoring and food preservatives. This indicates that the origin of these compounds is probably from the packaged substrate.

The same is true for octocrylene, which is common in UV-filters in cosmetics. This compound is considered a substance of high concern. Its presence can be related to cross contamination

of the recycling streams. Although exceeding SML of 0,05 mg/kg, the amount detected was reasonably small (0,12 mg/kg).

One unknown compound was also found to exceed the SML of 0,01 mg/kg.

Detected polysaturated hydrocarbons (POSH) were significantly above regulated SML (60 mg/kg) for LDPE MRF samples in 95 % ethanol. In isooctane, the SML values for LDPE MRF were 2-3 higher compared to LDPE SAS. Total amount of migration for all samples was over the SML limit of 60 mg/kg, mainly influenced by POSH migration. Samples with lowest migration in total were PP samples from SAS collection.

From above results it can be concluded that:

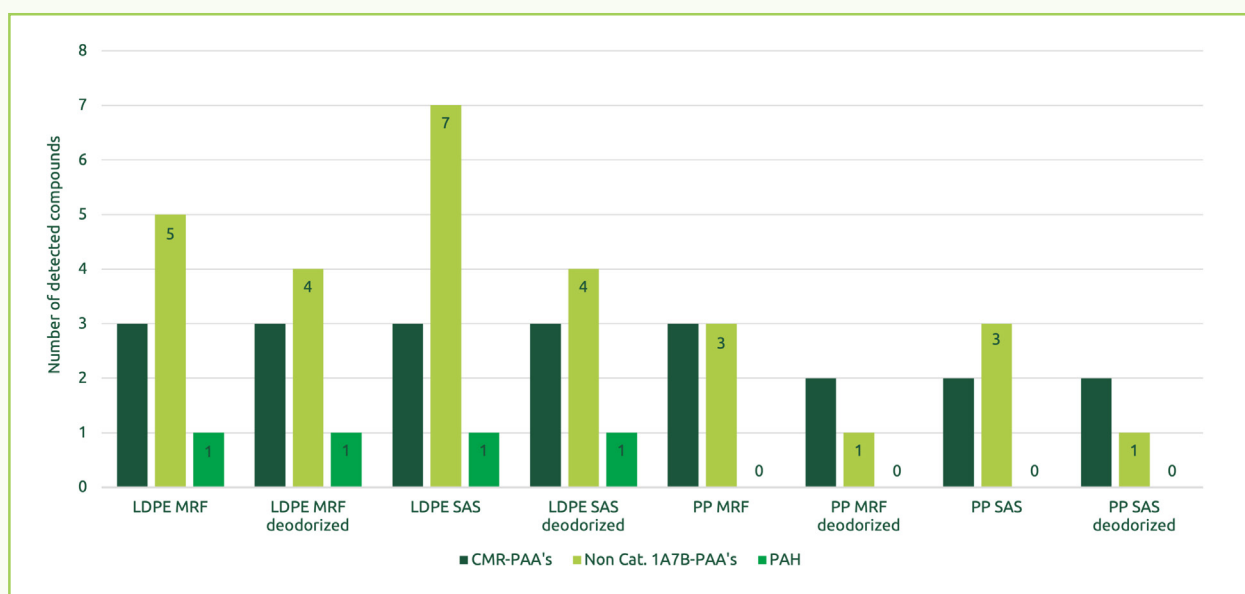
- The LDPE samples contain much more migrating substances and contaminations than PP.
- The MRF samples contain a higher amount of the migrating substances than the SAS in both LDPE and PP.
- In general, very few unknown substances were detected
- The above listed substances are mostly related to common plastic additives or skin care/cosmetic products, and though common, they are not necessarily food approved.

6.2.3 TARGET ANALYSES OF SUBSTANCES

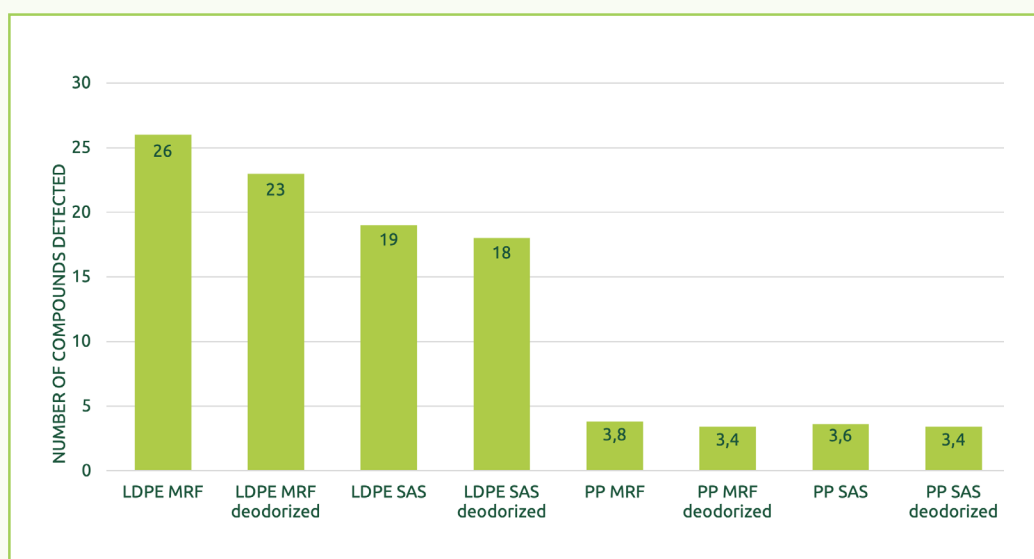
Migration testing of PAH, PAA and MOSH/MOAH was carried out by Eurofins under these conditions:

- PAAs were tested using 3 % acetic acid, 60 °C, 10 days
- PAHs were tested using isooctane, 30 °C, 2 days
- MOAH was tested using 95 % ethanol, 60 °C, 10 days

Results of PAAs and PAH are shown in Figure 9, and results for MOAH are shown in Figure 10. Detailed results can be seen in Table 10 in Appendix.



// FIGURE 9: NUMBER OF DETECTED PAA'S AND PAH IN RECYCLED MATERIAL.



// FIGURE 10: NUMBER OF DETECTED MOAH C11-C35 IN RECYCLED MATERIAL.

The results of the target analysis showed that both the LDPE and PP samples contained CMR-PAAAs. LDPE had three different substances, while PP had two (the same substances as LDPE). These are present in both the MRF and the SAS samples. Both the LDPE and PP samples contained several non-CMR PAAAs. LDPE had 4 - 7 different substances while PP 1 - 3 of the same. These are present in both MRF and SAS samples. LDPE had one PAH substance while

PP did not have any PAH. Both the LDPE and PP samples contained MOAH components.

The results show that the LDPE contains significantly higher levels of these PAH, PAA and MOAH substances. The residual PAA, PAH and MOAH is reduced, or significantly reduced with the deodorisation during recycling at Vögt-Plastic.

6.2.4 ORGANOLEPTIC TESTING

Odour characteristics for all eight samples were evaluated and compared. The average score of each tested sample is shown in Figure 11. For detailed scoring, see Table 11 in Appendix. The evaluation is given as grades according to the definitions listed in the method description. VDA 270 categorises the odour on a scale from 1 to 6, where 1 is defined as “perceptible, not disturbing” and 6 is defined as “disturbing or not acceptable”.



// FIGURE 11: RESULTS OF ORGANOLEPTIC TESTING FOR EACH RECYCLED SAMPLE.

The results show that LDPE has higher odour intensity and LDPE from MRF without deodorisation is especially oily and stinging. PP samples before deodorisation had a perfume-like smell, and less odour after deodorisation. In conclusion, the odour intensity is significantly reduced by the deodorisation.

7. CONCLUSION

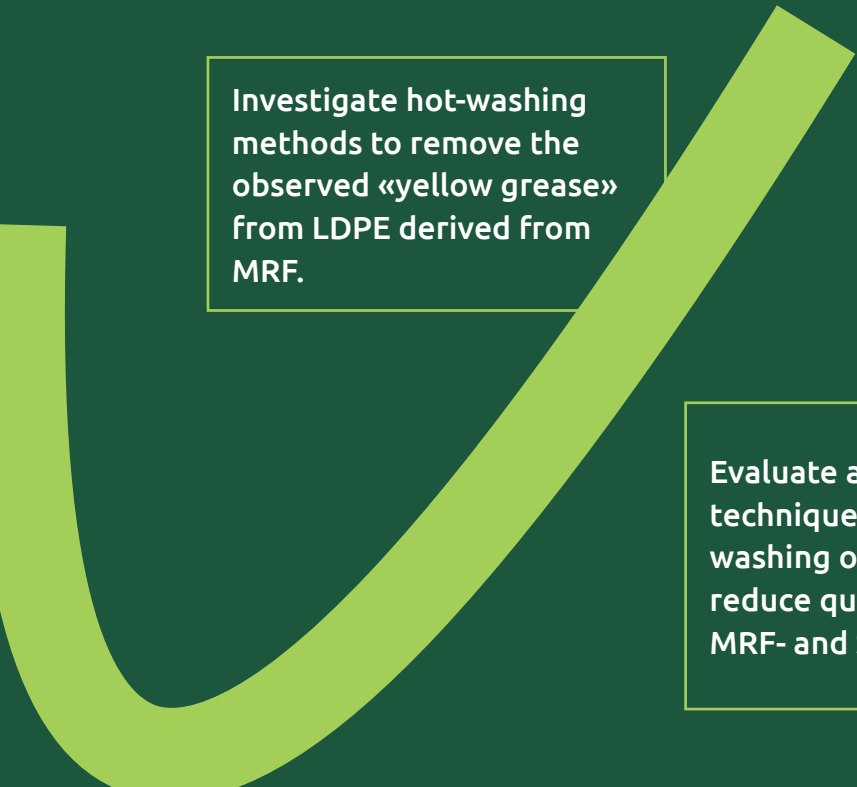
Materials sorted at the MRF showed a higher precision in polymer content compared to those from SAS, likely due to differences in NIR sensor configurations at the sorting facilities. However, recycling plastics from the MRF involves higher consumption of water and defoamer, and generates more sludge compared to SAS materials. Despite these additional efforts in cleaning, the MRF-derived plastic still shows significantly lower quality.

Analyses revealed higher contamination levels—such as migration of substances, ash content, water, gas, and volatile organic compounds (VOC)—for both LDPE and PP from MRF, with LDPE consistently being more affected than PP. These results confirm the initial hypothesis that flexible LDPE absorbs contaminants more readily and thus exhibits greater quality differences between MRF and SAS than rigid PP.

Results showed that LDPE and PP from SAS is less contaminated and more suitable for high value applications, compared to material from MRF. The effect of deodorization is also significant in reducing contaminants. Based on the washing method in this report, transitioning from SAS to MRF will affect the quality negatively.

8.

RECOMMENDATIONS



Investigate hot-washing methods to remove the observed «yellow grease» from LDPE derived from MRF.

Test various washing approaches (temperature variations, detergents) to improve plastic quality

Evaluate alternative decontamination techniques (such as specialised washing or thermal treatments) to reduce quality differences between MRF- and SAS-derived plastics.

Examine the reasons behind the elevated POSH levels found particularly in LDPE from MRF.

Clarify whether the similarities in volatile substances and migrating chemicals are due to cross-contamination during recycling processes or result from a common geographical source (Norway). Consider comparative analyses using samples from other regions or recycling facilities.

APPENDIX

// TABLE 6: ANALYSIS OF THE ORIGINAL SUBSTANCE AS RECEIVED AT VOGT-PLASTIC.

	LDPE MRF		LDPE SAS		PP MRF		PP SAS	
	original substance		original substance		original substance		original substance	
	[kg]	[%]	[kg]	[%]	[kg]	[%]	[kg]	[%]
Input, brut	17410	100,2	10980,0	100,3	8330,0	100,5	11300,0	100,5
Wires (from bales)	34	0,2	37,0	0,3	43,0	0,5	56,0	0,5
Input	17376	100,0	10943,0	100,0	8287,0	100,0	11244,0	100,0
Resin	7955	45,8	7509,0	68,6	6091,0	73,5	8250,0	73,4
Sinking fraction	6482	37,3	2677,0	24,5	1077,0	13,0	2178,0	19,4
Sewage sludge	641	3,7	144,0	1,3	593,0	7,2	226,0	2,0
Melt filter residue	311	1,8	133,0	1,2	246,0	3,0	225,0	2,0
Condensate from degassing	22	0,1	7,0	0,1	7,0	0,1	6,0	0,1
Difference in inventory	1965	11,3	473,0	4,3	273,0	3,3	359,0	3,2
Estimated humidity in input material		22,0		10,0		11,0		9,0

// TABLE 7: RESULTS FROM PELLET TESTING.

Sample name	Sample description	MFI g/10min]	WC [wt%]	Ash [wt%]	Gas content 120°C/10min [wt%]	Volatile content 180°C/10min [wt%]	Impurities	Visual spection
V1.1	LDPE MRF	1,4	0,15	3,5	0,06	0,2	None	Various sized pellets
V1.2	LDPE MRF deodorised	1,4	0,14	3,5	0,07	0,16	None	Various sized pellets
V2.1	PP MRF	25	0,05	2	0,03	0,09	None	A lot of agglomerates
V2.2	PP MRF deodorised	26	0,05	1,9	0,04	0,05	None	Few agglomerates
V3.1	LDPE SAS	1	0,07	2,7	0,03	0,09	None	OK
V3.2	LDPE SAS deodorised	0,95	0,07	2,8	0,02	0,06	None	OK
V4.1	PP SAS	15	0,05	1,9	0,02	0,08	None	Few agglomerates
V4.2	PP SAS deodorised	15	0,04	1,9	0,02	0,04	None	OK

// TABLE 8: QUANTIFIED CHEMICAL COMPOUNDS EXCEEDING THE SML IN 95 % ETHANOL. ALL VALUES ARE GIVEN IN MG/KG. VALUES EXCEEDING SML ARE GIVEN IN BOLD.

Chemical compound	SML (mg/ kg)	V1.1 LDPE MRF	V1.2 LDPE MRF	V3.1 LDPE SAS	V3.2 LDPE SAS	V2.1 PP MRF	V2.2 PP MRF	V4.1 PP SAS	V4.2 PP SAS
Ethyl hexadecanoate (-palmitate)	1,8	8,170	7,350	0,202	0,232	0,136	0,166	0,050	0,058
9-Octadecenoic acid (oleic acid)	1,8	32,011	27,413	5,936	5,008	2,148	3,836	0,097	0,126
Ethyl octadecenoate (-stearate)	1,8	2,731	2,616	0,090	0,107	0,068	0,098	0,036	0,054
Benzoic acid, dodecyl ester	1,8	2,020	1,983	0,055	0,046	0,033	0,054	0,029	0,039
GMS-90 contamination (not deriv)	0,01	0,005	0,005	0,016	0,013	0,045	0,037	0,035	0,043
Octocrylene	0,05	0,103	0,083	0,117	0,110	0,013	0,021	0,019	0,026
GMS-90 contamination (not deriv)	0,01	0,016	0,011	0,010	0,009	0,028	0,033	0,045	0,057
Unknown	0,01	0,108	0,103	0,036	0,031	0,014	0,023	0,007	0,009
Cholesterol		0,117	0,106	0,021	0,022	0,011	0,013	0,004	0,005
POSH*	60	287,2	274,6	102,3	122,1	52,7	63,7	31,5	36,0
Total amount	60	407,9	387,6	122,0	142,8	57,7	72,1	34,4	40,0

// TABLE 9: QUANTIFIED CHEMICAL COMPOUNDS EXCEEDING THE SML IN ISOOCTANE. ALL VALUES ARE GIVEN IN MG/KG. VALUES EXCEEDING SML ARE GIVEN IN BOLD.

Chemical compound	SML (mg/ kg)	V1.1 LDPE MRF	V1.2 LDPE MRF	V3.1 LDPE SAS	V3.2 LDPE SAS	V2.1 PP MRF	V2.2 PP MRF	V4.1 PP SAS	V4.2 PP SAS
Ethyl hexadecanoate (-palmitate)	1,8	7,496	7,217	0,116	0,160	0,157	0,147	0,042	0,052
9-Octadecenoic acid (oleic acid)	1,8	30,638	29,046	0,281	0,326	5,854	3,119	0,123	0,132
Ethyl octadecenoate (-stearate)	1,8	2,787	2,797	0,030	0,048	0,053	0,049	0,016	0,022
Benzoic acid, dodecyl ester	1,8	1,876	1,879	0,041	0,042	0,053	0,050	0,043	0,049
GMS-90 contamination (not deriv)	0,01	nd	nd	0,004	0,004	0,043	0,028	0,043	0,049
Octocrylene	0,05	0,074	0,075	0,063	0,062	0,033	0,025	0,038	0,041
GMS-90 contamination (not deriv)	0,01	0,010	0,006	0,006	0,006	0,046	0,034	0,057	0,054
Unknown	0,01	0,099	0,107	0,022	0,020	0,021	0,019	0,008	0,010
Cholesterol		0,121	0,128	0,018	0,018	0,030	0,025	0,011	0,012
POSH	60	260,6	256,4	80,2	99,9	122,6	84,2	72,9	66,8
Total amount	60	355,7	349,8	92,8	114,5	138,2	95,5	84,6	79,1

// TABLE 10: RESULTS OF TARGET ANALYSIS OF LDPE AND PP PERFORMED BY EUROFINs.

			LDPE SAMPLES				PP SAMPLES			
			MRF	MRF	SAS	SAS	MRF	MRF	SAS	SAS
				Refresh		Refresh		Refresh		Refresh
			3 % acetic acid				3 % acetic acid			
Specific migration of CMR-PAA's	CAS	LOD (mg/kg)	Result (mg/kg)				Result (mg/kg)			
2-Aminotoluen	95-53-4	0,002	0,034	0,002	0,071	0,013	0,017	0,003	0,014	0,005
2-Metoxyanilin	90-04-0	0,002	0,055	0,004	0,37	0,024	0,002			
Dianilinmethane	101-77-9	0,002	0,016	0,005	0,4	0,052	0,018	0,002	0,02	0,009
Specific migration of non Cat. 1A7B-PAA's			3 % acetic acid				3 % acetic acid			
2-Ethoxyanilin					0,032		0,02		0,014	
2-Dimethylanilin	95-68-1	0,01	0,21	0,019	0,058	0,091	0,016		0,017	
3-Amino-4-methoxybenzanilid	120-35-4	0,01			0,015					
4-Aminotoluol	106-49-0	0,01	0,031		0,037	0,01				
4-Chloro-2,5-dimeoxyanilin	6358-64-1	0,01			0,013					
Anilin	62-53-3	0,01	0,08	0,024	0,16	0,069	0,026	0,012	0,029	0,015
p-Toluidine-2-sulfonic acid	88-44-8	0,01	0,028	0,016	0,011	0,014				
Sum CLT/ACT-Acid	88-53-9/88-51-7	0,01	0,072	0,037						
Specific migration of PAH			Isooctane				Isooctane			
Phenatrene	85-01-8	< 0,005	0,016	0,013	0,023	0,013				
Specific migration of MOAH			95 % EtOH				95 % EtOH			
MOAH (aromatic hydrocarbons) C15-C35 SUM			26	23	19	18	3,8	3,4	3,6	3,4

// TABLE 11: RESULTS FROM ODOUR TEST OF PELLETS EXPOSED 24H/40°C IN WATER.

SAMPLE	DESCRIPTION	JUDGE 1	JUDGE 2	JUDGE 3	AVERAGE SCORE	ST. DEV.
V1.1	LDPE MRF	4	3.5	4	3.83	0.29
V1.2	LDPE MRF deodorised	4	2	3	3.00	1.00
V2.1	PP MRF	3	1.5	2	2.17	0.76
V2.2	PP MRF deodorised	2.5	1	1	1.50	0.87
V3.1	LDPE SAS	3.5	4.5	3	3.67	0.76
V3.2	LDPE SAS deodorised	3	1.5	4	2.83	1.26
V4.1	PP SAS	3.5	1.5	3	2.67	1.04
V4.2	PP SAS deodorised	2.5	1	1	1.50	0.87

NOTES

