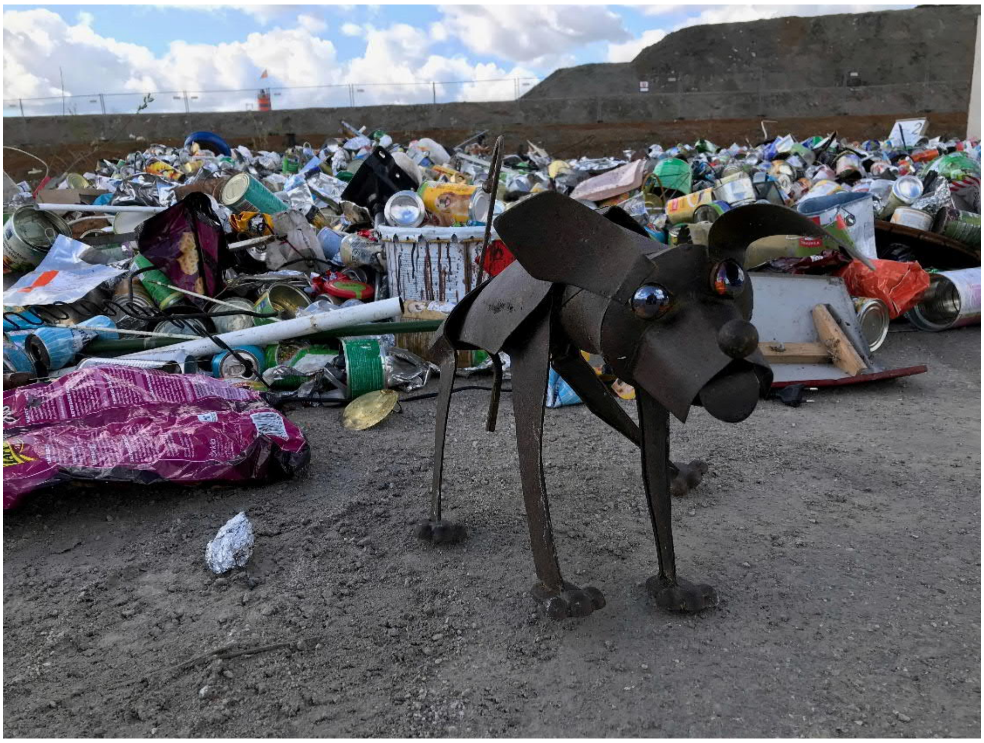
CUSTOMER REPORT VTT-CR-00500-19



Metal distribution in consumer collection systems - Mepak-study 2019

This report replaces version sent on 14th of November 2019. Data in Table 26 is corrected. Previous version must be invalidated.

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Confidentiality: Public

Report's title

Metal distribution in consumer collection systems - Mepak-study 2019

Customer, contact person, address	**Order reference**
Mepak-Kierrätys Oy, Satu Estakari Mikonkatu 15 B 00100 Helsinki	Mepak-tutkimus 2019
Project name	**Project number**
Mepak-study 2019	123243

Summary

The main objective of the study was to find out the distribution of packaging metal, small metal items and waste reject fraction (incorrectly source separated material) in separately collected metal waste from consumers and possible differences between different housing types and geographical areas in the seven research areas specified by the customer in the invitation to tender. The research areas covered whole Finland with the exception of Aland.

For each research area, both property-specific (door-to-door) collection and regional collection (Rinki eco take-back points) metal waste loads were sampled, with a total of 16 sampled loads. For one research area, the variation of the contents of the loads was studied by sorting the samples from two separate loads, and the repeatability of the sampling method and sorting with three parallel samples from the same load. During the study, a total of 20 samples were sorted. A further study was conducted to determine the share of other than metal materials in non-depositable metal packaging waste from consumer collection.

The study's time span was from April to July 2019. The study resulted in a breakdown of consumer-collected metal packaging, small metal items and waste reject fraction, both by research area and nationwide. No significant regional differences were found in the composition of the consumer collected metal waste. The approach chosen for the study was found to be reasonably replicable, feasible and applicable in the future for similar research.

The study was ordered by MEPAK-kierrätys Oy, and executed in co-operation with Suomen palautuspakkaus Oy (Palpa), Suomen Kiertovoima Ry (KIVO), Finnish Packaging Recycling RINKI Ltd and Pirkanmaa Centre for Economic Development, Transport and the Environment (PIR-ELY). Satu Estakari (Mepak) acted as the chairman of the working group and Pasi Nurminen (Palpa), Timo Hämäläinen (KIVO), Pertti Tammivuori and Jaana Lindman (Rinki) and Tuomo Aunola (PIR-ELY) as members of the group.

The study was conducted by VTT Technical Research Centre of Finland. Experts involved were Suvi Jokinen (project manager), Tommi Kaartinen, Tuomo Mäkelä and John Bachér.

Espoo, 14.11.2019

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Distribution

Orderer, members of the working group, VTT

Contents

1. Description and aims of the study

The goal of this study was to determine the composition of metal waste collected separately from consumers in Finland. The study consisted of the determination of distribution between metal packaging, small metal items and deposit beverage cans, as well as incorrectly source separated waste, later referred to as reject waste fraction, in consumer collection systems. Metal packaging waste and other small metal item waste from households are collected in the same collection bins. Different stakeholders are responsible for the collection, recycling and costs of various metal categories: Mepak-Kierrätys Oy is responsible for metal packages, municipalities for the small metal items and Suomen Palautuspakkaus Oy for the deposit beverage cans.

The study also investigated possible differences in the composition of metal waste between different forms of housing (urban, sparsely populated). This was done by examining the differences between different collection methods (property-specific, later referred to as door-to-door and regional collection, later referred to as eco take-back points), as the collection method can be used to roughly estimate the difference in composition between urban and sparsely populated housing metal waste. Separate door-to-door collection describes denser urban housing, while eco take-back point collection represents suburban and / or sparsely populated housing. In Finland, the municipalities are responsible for arranging separate door-to-door collection, and the eco take-back points are mainly managed by Rinki. There are also additional regional collection points organized by municipalities, but these points were not part of the present study.

The study was carried out in seven research areas specified in the invitation to tender. The research areas covered whole Finland (except Aland). This way it was possible to make rough estimates of the possible variation in the composition of the collected metal waste in Finland between different geographical areas. For each research area, the study was performed for both door-to-door and and eco take-back point collected metal waste. A further study was performed to determine the share of other than metal materials in non-depositable packaging metal waste from consumer collection.

Main result of the present study is the distribution of metal waste into categories that are on the responsibility of different stakeholders. Additional results of the study are the distribution inside Finland between different geographical areas as well as different collection methods and forms of housing. The information obtained from the study is used as a basis for statistics on the amount of packaging metal and small metal items, also including the proportion of possible waste reject fractions. The results can be also used to improve waste sorting guidance where appropriate.

2. Implementation of the study

2.1 Design

The planning and operational implementation of the study was carried out in cooperation with the customer. The customer was responsible for arranging the collection of the study loads in each research area and for the organization of the collected loads at the terminals where sampling took place. These terminals are shown in Table 1. Metal waste from the terminals ends up being forwarded to the metal recycling industry.

VTT was responsible for the design and practical implementation of sampling and sorting studies.

2.1.1 Research areas and schedule

The purpose of the study was to obtain information on the composition of consumer-collected metal waste across Finland. In order to carry out the study, Finland was further divided into research areas based on RINKI's logistic contract areas. A map (text in Finnish) of these contract areas is shown in Figure 1. There are a total of 11 Rinki contract areas. Seven research areas were created of these 11 areas by combining Rinki areas that according to the customer represent each other as much as possible with regards to consumer-collected metal waste. A more detailed description of the research areas formed is given in Table 1.

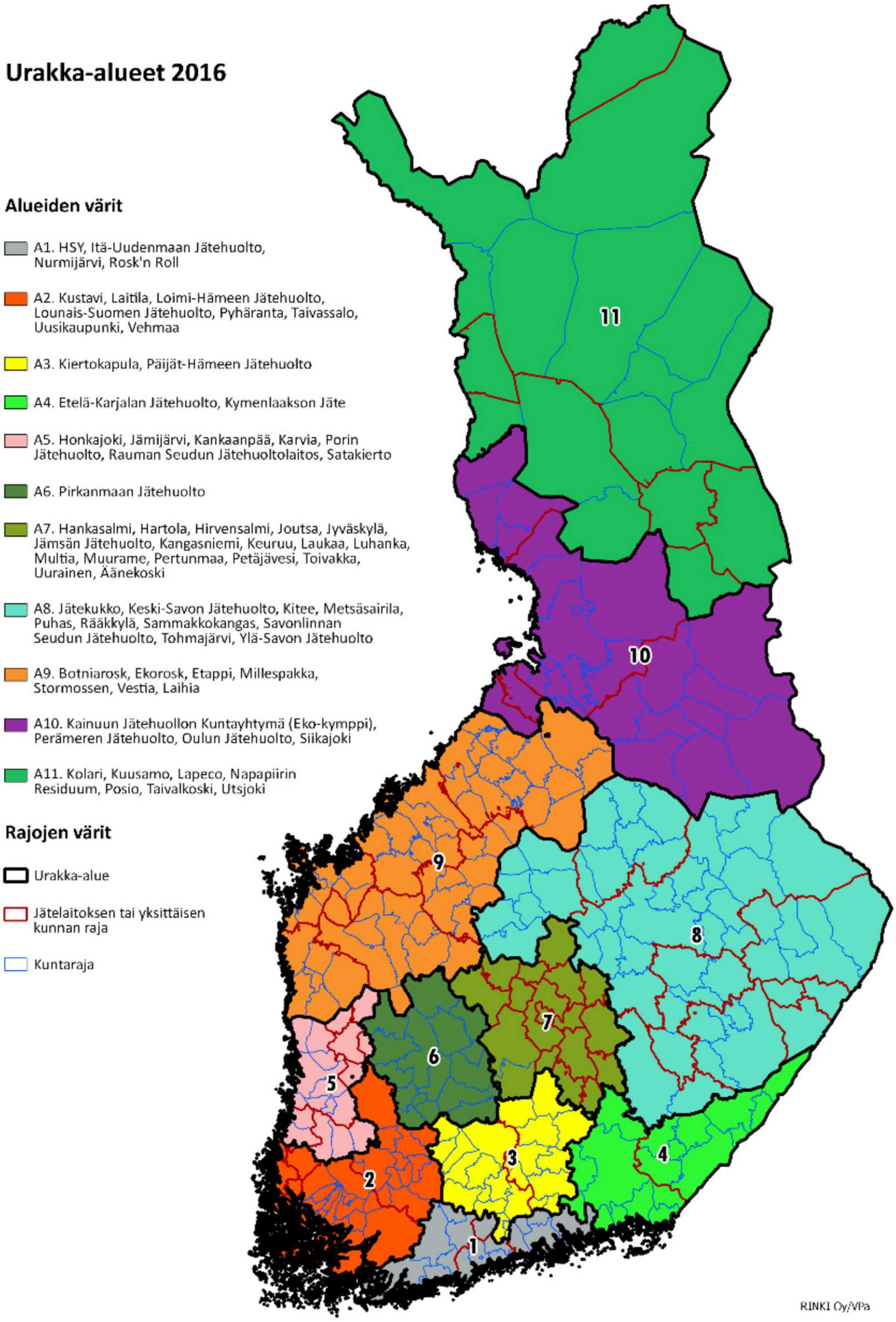

Figure 1. RINKI contract areas in 2016 (Koivunen, J. 2016)

From the customer's wish, the implementation of the work took place from April to July 2019, within which the collection of research loads and the practical work with sampling and manual sorting was carried out. The actual sample collection and sampling dates are shown in Table 1.

Table 1. A summary of the research area data, terminals, sampling and sampling schedules.

Research Area	Rinki contract area No.	Loads collected (weeks n:o)	Terminal	Sampling time
1	**1** (HSY, Itä-Uudenmaan Jätehuolto, Nurmijärvi, Rosk'n Roll)	19-21	HSY Helsingin seudun ympä-ristöpalvelut - kuntayhtymä, Espoo	24.5.2019 (week 21)
2	**3** (Kiertokapula, Päijät-Hämeen Jätehuolto)	21-25	Kuusakoski Oy, Lahti	18.6.2019 (week 25)
3	**2** (Kustavi, Laitila, Loimi-Hämeen Jätehuolto, Lounais-Suomen Jätehuolto, Pyhäranta, Taivassalo, Uusikaupunki, Vehmaa)	17-19	Lounais-Suomen Jätehuolto Oy, Salo	7.-8.5.2019 (week 19)
	5 (Honkajoki, Jämijärvi, Kankaanpää, Karvia, Porin Jätehuolto, Rauman Seudun Jätehuoltolaitos, Satakierto)			
4	**6** (Pirkanmaan Jätehuolto)	20-23	Stena Recycling Oy, Jyväskylä	3.-4.6.2019 (week 23)
	7 (Hankasalmi, Hartola, Hirvensalmi, Joutsa, Jyväskylä, Jämsän Jätehuolto, Kangasniemi, Keuruu, Laukaa, Luhanka, Multia, Muurame, Pertunmaa, Petäjävesi, Toivakka, Uurainen, Äänekoski)			
5	**4** (Etelä-Karjalan Jätehuolto, Kymenlaakson Jäte)	21-26	Kuusakoski Oy, Joensuu	26.6.2019 (week 26)
	8 (Jätekukko, Keski-Savon Jätehuolto, Kitee, Metsäsairila, Puhas, Rääkkylä, Sammakkokangas, Savonlinnan Seudun Jätehuolto, Tohmajärvi, Ylä-Savon Jätehuolto)			
6	**9** (Botniarosk, Ekorosk, Etappi, Millespakka, Stormossen, Vestia, Laihia)	19-21	Lassila & Tikanoja Oyj, Mustasaari	20.-21.5.2019 (week 21)
7	**10** (Kainuun Jätehuollon Kuntayhtymä (Eko-Kymppi), Perämeren Jätehuolto, Oulun Jätehuolto, Siikajoki)	18-24	Napapiirin Residuum Oy, Rovaniemi	11.6.2019 (week 24)
	11 (Kolari, Kuusamo, Lapeco, Napapiirin Residuum, Posio, Taivalkoski, Utsjoki)			

2.1.2 Variations in the contents of loads, representativeness of loads, repeatability of sampling

The representativeness of the loads was estimated to form of 1) big enough size of the load and 2) the number of collection bins from which the load was created; the more collection bins in the load the more representative load and thus the sample. As far as possible, the study sought to achieve a minimum size of the load to be 1000 kg.

In the context of the agreed schedule and the available resources, the study could only be carried out for a limited number of samples per research area. For one research area, more extensive studies were carried out to investigate the variation in the contents of the loads and to assess the representativeness of the proposed sampling method. It was decided to carry out this broader study in the first research area (Research area 3). This way it would have been possible to change the approach in the remaining research areas, if problems were identified in the broader study.

The variations in the contents of the collected loads was to be investigated by taking and sorting separate samples collected from three separate loads from the same research area and the same waste collection method. The repeatability of the sampling method was evaluated from one load per collection type. The sampling plan for the broader study has been illustrated in Figure 2. Variation in loads contents and repeatability studies were conducted for both door-to-door and eco take-back point collected metal waste.

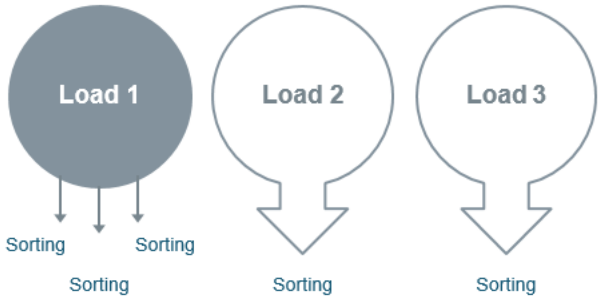

Figure 2. Visualisation of the sampling plan to investigate the variations in the content of the loads and to assess the repeatability of the sampling method.

2.2 Sampling

The aim of sampling was to obtain as representative a sample as possible from the consumer-collected metal waste from both door-to-door and take-back point collection. The sampling plan was prepared based on European guidelines and standards (Wahlström et al. 2009, CEN 2007). The sufficient size of the sample to be taken for the manual sorting was evaluated to be 100 kg.

From each of the seven areas one load of both door-to-door and take-back point collected metal waste was collected and submitted to a pre-agreed terminal for sampling. A total of two loads per research area were collected, with the exception of research area 3, where more loads were collected to investigate the variations in the contents of the loads.

Before sampling, the load was stirred mechanically and spread to form a flat layer. If necessary, the largest loads were pre-splitted mechanically before the load was spread in order to reduce the amount of manual work needed in the later stages of the sampling (figures 3 and 4). Subsequently, large, vague or particularly heavy pieces which would have not fitted in the sampling specimen or which would have distorted the sorting results, were removed from the load (figures 5-7). The pieces removed from the load before sampling were weighed in their own categories (e.g. packaging metals, small metal items, waste electric and electronical equipment (WEEE) and other waste reject fractions) and their quantities were taken into account in the overall mass balance.

The actual sample for manual sorting was taken as a point random sampling from the leveled load (Figure 8). In random sampling, all particles have an equal theoretical opportunity to end up in the sample. The sample was composed of several incremental samples taken at different points, which were merged into one aggregate sample. For each of the research areas, these aggregate samples were delivered to the VTT premises where the manual sorting was carried out.

Figure 3. Mechanical pre-treatment of the loads.

Figure 4. Spreading of loads for sampling.

Figure 5. Larger metal pieces removed from the loads before sampling. Left: packaging metal, right: small metal items.

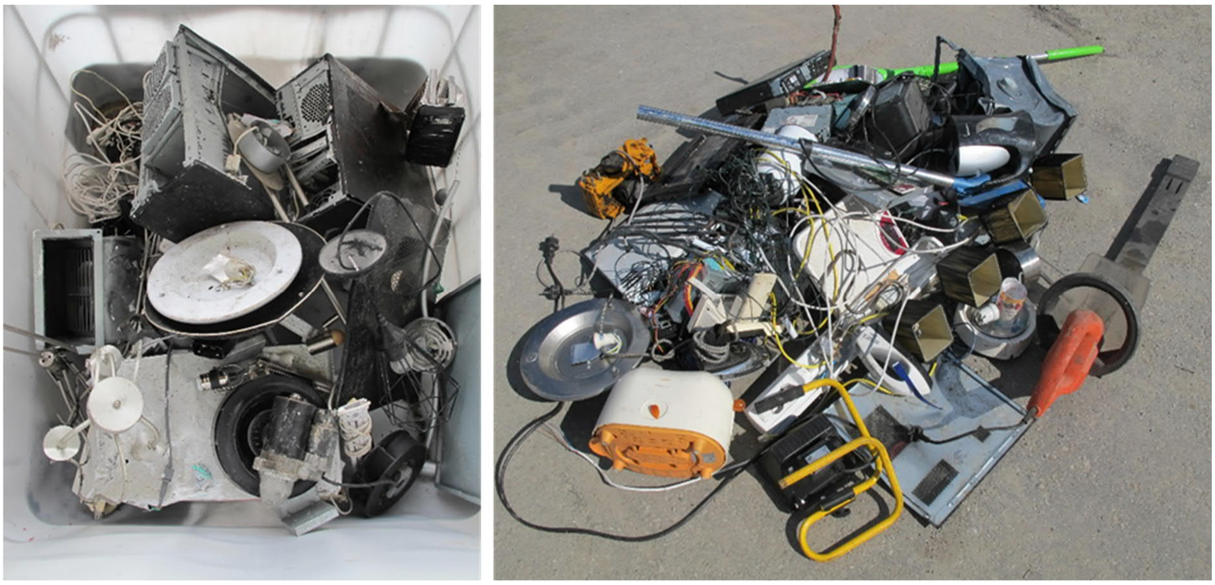

Figure 6. Large waste electrical and electronic equipment (WEEE) removed from the loads before sampling.

Figure 7. Large waste reject material removed from the loads before sampling.

Figure 8. Point sampling from a spread load.

2.2.1 Research area 1

Research area 1 composed of ***Rinki contract area 1 (HSY, Itä-Uudenmaan Jätehuolto, Nurmijärvi, Rosk'n Roll)***. Metal waste in the area was collected during weeks 19-22. Detailed load information is given in table 2.

The loads collected from the research area (Figure 9) were submitted by local partners to HSY terminal in Espoo, where sampling was carried out by VTT on 24.5.2019.

In the terminal, the loads were stored next to each other in piles and separated by a concrete wall. The area reserved for sampling was covered, clean and paved. For the handling of loads, a bucket loader with a balance was used. The loads were mixed with the bucket loader at their storage location and were spread with the bucket loader, one bucket at a time into a separate sampling area. After the sampling from the first load was completed, the remainder of the load was scraped aside by the bucket loader, and the second load was spread to the same place. The amount of material in the study was weighed by the bucket loader.

Table 2. Load data, research area 1

Collection method	Route Information	Load mass (proportion taken into study)	Load pre-splitted (yes/no)	Compacted waste (yes/no)	Dry load (yes/no)	Other remarks
Door-to-door	118 properties on the route, collection bins 121 pc • 240 l (110 pc) • 300 l (6 pc) • 660 l (5 pc)	1400 kg	no	no	yes	-
Eco take-back point	20 eco take-back points on the route, collection bins 22 pc • 2,5 m^3 (7 pc) • 3 m^3 (11 pc) • 4 m^3 (2 pc) • 5 m^3 (1 pc) • 7 m^3 (1 pc)	1590 kg	yes	no	yes	-

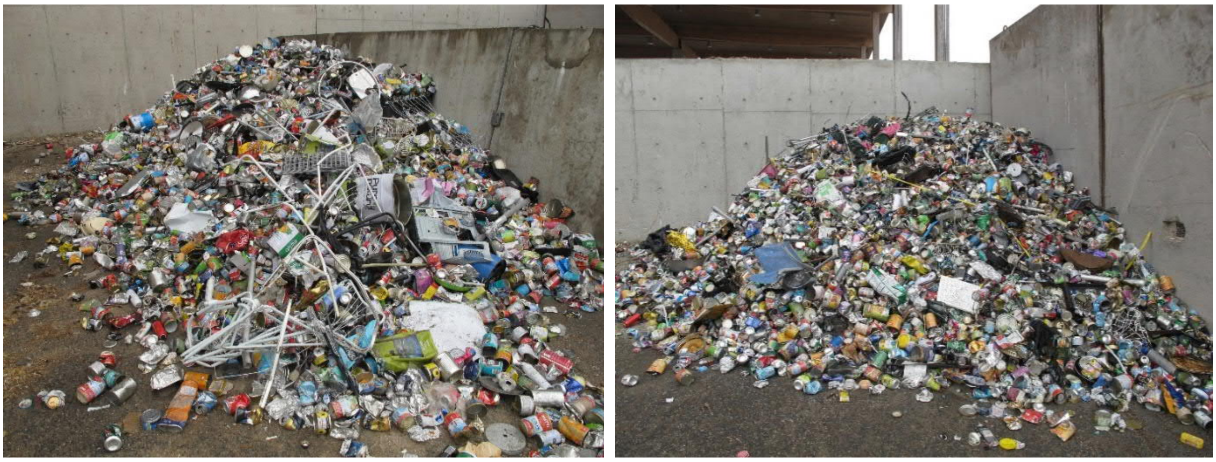

Figure 9. Loads received from research area 1. Left: door-to-door collected load, right: load from eco take-back points.

2.2.2 Research area 2

Research area 2 composed of ***Rinki contract area 3 (Kiertokapula, Päijät-Hämeen Jätehuolto)***. Metal waste in the area was collected during weeks 21-25. Detailed load information is given in table 3.

The loads collected from the research area (Figure 10) were submitted by local partners to Kuusakoski Oy's terminal in Lahti, where sampling was carried out by VTT on 18.6.2019.

In the terminal, the loads were stored in skips, the door-to-door collected load in an open skip and the eco take-back point load on a covered skip. The area reserved for sampling was uncovered, paved but sandy. A bucket loader was used for handling of loads. The loads were poured from the skips with the help of the bucket loader to the area reserved for sampling, after which they were stirred by bucket loader. After the sampling from the first load was completed, the remainder of the load was scraped aside by the bucket loader, and the second load was spread to the same place. Eco take-back point load was pre-splitted before sampling, and the amount of mass taken into study was found out by weighing the amount of waste left out of the sampled material and reducing this amount from the total mass of the load.

Table 3. Load data, research area 2.

Collection method	**Route Information**	**Load mass (proportion taken into study)**	**Load pre-splitted (yes/no)**	**Compacted waste (yes/no)**	**Dry load (yes/no)**	**Other remarks**
Door-to-door	123 properties on the route, collection bins 123 pc • 140 l (3 pc) • 240 l (105 pc) • 300 l (1 pc) • 660 l (14 pc)	1480 kg	no	yes	yes	-
Eco take-back point	10 collection bins on the route • 3 m^3 (2 pc) • 4 m^3 (1 pc) • 7 m^3 (7 pc)	1240 kg	yes	no	yes	-

Figure 10. Loads received from research area 2. Left: door-to-door collected load, right: load from eco take-back points.

2.2.3 Research area 3

Research area 3 composed of ***Rinki contract areas 2 (Kustavi, Laitila, Loimi-Hämeen Jätehuolto, Lounais-Suomen Jätehuolto, Pyhäranta, Taivassalo, Uusikaupunki, Vehmaa) and 5 (Honkajoki, Jämijärvi, Kankaanpää, Karvia, Porin Jätehuolto, Rauman Seudun Jätehuoltolaitos, Satakierto)***. Metal waste in the area was collected during weeks 17-19. Detailed load information is given in table 4.

The loads collected from the research area (Figures 11 and 12) were submitted by local partners to Lounais-Suomen Jätehuolto Oy's terminal in Salo, where sampling was carried out by VTT on 7.-8.5.2019.

A total of six loads were expected to arrive at the terminal, three from door-to-door collection and three from eco take-back point collection. Three loads were ready at the terminal and fourth load arrived on the first sampling day. Two planned loads, one from each collection type did not arrive. The loads were stored next to each other in a large field where the sampling also took place. The area in question was uncovered, paved, and partly sandy. For the mixing of loads, an excavator with a grab was used, and all loads were examined whole without pre-splitting. The large and heavy pieces removed from the loads were collected either in large waste containers, in which they were weighed with a fork-trolley scale, or in skips that were weighed by a vehicle scale.

Table 4. Load data, research area 3.

Collection method	Route Information	Load mass (proportion taken into study)	Load pre-splitted (yes/no)	Compacted waste (yes/no)	Dry load (yes/no)	Other remarks
Door-to-door, load 1	121 properties on the route, collection bins 122 pc • 120 l (2 pc) • 140 l (22 pc) • 240 l (55 pc) • 330 l (7 pc) • 340 l (1 pc) • 370 l (2 pc) • 380 l (23 pc) • 660 l (10 pc)	1780 kg	no	yes	no	three samples taken from the load
Door-to-door, load 2	30 properties on the route, collection bins 30 pc • 240 l (30 pc)	600 kg	no	no	no	-
Eco take-back point, load 1	10 eco take back points on the route, collection bins 10 pc • 8 m^3 (10 pc)	5480 kg	no	no	no	three samples taken from the load
Eco take-back point, load 2	3 eco take back points on the route, collection bins 6 pc • 7 m^3 (6 kpl)	2860 kg	no	no	no	-

Figure 11. Loads from Door-to-door collection received from research area 3. Left: load 1, right: load 2.

Figure 12. Loads from eco take-back point collection received from research area 3. Left: load 1, right: load 2

2.2.4 Research area 4

Research area 4 composed of ***Rinki contract areas 6 (Pirkanmaan Jätehuolto) and 7 (Hankasalmi, Hartola, Hirvensalmi, Joutsa, Jyväskylä, Jämsän Jätehuolto, Kangasniemi, Keuruu, Laukaa, Luhanka, Multia, Muurame, Pertunmaa, Petäjävesi, Toivakka, Uurainen, Äänekoski)***. Metal waste in the area was collected during weeks 20-23. Detailed load information is given in table 5.

The loads collected from the research area (Figure 13) were submitted by local partners to Stena Recycling Oy's terminal in Jyväskylä, where sampling was carried out by VTT on 3.-4.6.2019.

In the terminal the loads were stored next to each other in piles and separated by a concrete wall. The area reserved for sampling was uncovered, clean and paved. There was an excavator with a grab for handling of loads. Loads were stirred by the excavator at their storage site and spread to the same place for sampling. Water was drained from the loads when mixing them. Both loads were pre-splitted before sampling. The amount of mass taken into study was found out by weighing the amount of waste left out of the sampled material by a vehicle scale and reducing this amount from the total mass of the load.

Table 5. Load data, research area 4.

Collection method	Route Information	Load mass (proportion taken into study)	Load pre-splitted (yes/no)	Compacted waste (yes/no)	Dry load (yes/no)	Other remarks
Door-to-door	162 properties on the route, collection bins 162 pc • 140 l (9 pc) • 240 l (138 pc) • 300 l (1 pc) • 660 l (14 pc)	1620 kg	yes	no	no	-
Eco take-back point	10 collection bins on the route • 5 m^3 (2 pc) • 7 m^3 (8 pc)	1420 kg	yes	no	no	-

Figure 13. Loads received from research area 4. Left: door-to-door collected load, right: eco take-back point load.

2.2.5 Research area 5

Research area 5 composed of ***Rinki contract areas 4 (Etelä-Karjalan Jätehuolto, Kymenlaakson Jäte) and 8 (Jätekukko, Keski-Savon Jätehuolto, Kitee, Metsäsairila, Puhas, Rääkkylä, Sammakkokangas, Savonlinnan Seudun Jätehuolto, Tohmajärvi, Ylä-Savon Jätehuolto)***. Metal waste in the area was collected during weeks 21-26. Detailed load information is given in table 6.

The loads collected from the research area (Figure 14) were submitted by local partners to Kuusakoski Oy's terminal in Joensuu, where sampling was carried out by VTT on 26.6.2019.

In the terminal the loads were stored in uncovered skips. Area reserved for sampling was uncovered and paved. A bucket loader was used for handling of loads. The loads were poured from the skips with the help of the bucket loader to the area reserved for sampling, after which they were stirred by the bucket loader. After the sampling from the first load was completed, the remainder of the load was scraped aside by the bucket loader, and the second load was spread to the same place. Load collected from Eco take-back points was pre-splitted before sampling, and the amount of mass taken into study was found out by weighing the amount of waste left out of the sampled material and adding into this mass the mass of the sampled material plus the masses of larger pieces that were removed from the load before sampling.

Table 6. Load data, research area 5.

Collection method	Route Information	Load mass (proportion taken into study)	Load pre-splitted (yes/no)	Compacted waste (yes/no)	Dry load (yes/no)	Other remarks
Door-to-door	79 properties on the route, collection bins 81 pc + 0,5 m^3 waste from outside the bins. • 140 l (4 pc) • 240 l (68 pc) • 300 l (1 pc) • 660 l (8 pc)	1320 kg	no	yes	no	-
Eco take-back point	11 collection bins on the route • 7 m^3 (11 pc)	1630 kg	yes	no	no	-

Figure 14. Loads received from research area 5. Left: door-to-door collected load, right: eco take-back point load.

2.2.6 Research area 6

Research area 6 composed of ***Rinki contract area 9 (Botniarosk, Ekorosk, Etappi, Millespakka, Stormossen, Vestia, Laihia)*** Metal waste in the area was collected during weeks 19-21. Detailed load information is given in table 7.

The loads collected from the research area (Figure 15) were submitted by local partners to Lassila & Tikanoja Oyj's terminal in Mustasaari, where sampling was carried out by VTT on 20.-21.5.2019.

In the terminal, the loads were stored next to each other in piles and separated by a concrete wall. Area reserved for sampling was uncovered and paved, with traces of paper waste on the pavement. A bucket loader with a bucket scale was available for sample handling. Loads were mixed with the bucket loader at their storage location and spread to the same place for sampling. Both loads were pre-splitted before sampling. The masses of material contained in the study were found out by weighing the mass of material removed from the loads and reducing it from the total masses of the loads.[1]

Table 7. Load data, research area 6.

Collection method	Route Information	Load mass (proportion taken into study)	Load pre-splitted (yes/no)	Compacted waste (yes/no)	Dry load (yes/no)	Other remarks
Door-to-door	183 properties on the route, collection bins 187 pc • 140 l (27 pc) • 240 l (92 pc) • 300 l (27 pc) • 660 l (37 pc)	2358 kg	yes	no	no	-
Eco take-back point	14 eco take back points and 14 collection bins on the route • 770 l (1 pc) • 3 m^3 (1 pc) • 5 m^3 (4 pc) • 7 m^3 (8 pc)	1860 kg	yes	no	no	-

Figure 15. Loads received from research area 6. Left: door-to-door collected load, right: eco take-back point load.

[1] *When calculating the results, it was found that the weighing results of the units removed from the loads were not aligned with the total masses of the loads arrived at the terminal, and on the other hand did not correlate with the visual assessment of the removed share. Most likely, the mass of the bucket (500 kg) had remained not subtracted from mass of material removed from the load and thus included in the weighing results obtained. The mass of the bucket was reduced afterwards. There is no full certainty as to the correctness of the calculations, since the exact number of the removed bucketfuls of material was not recorded at the time of sampling. In calculating the results, the bucket mass has been deducted from the weighing result three times, based on the estimate of the amount of the removed bucketfuls.*

2.2.7 Research area 7

Research area 7 composed of ***Rinki contract areas 10 (Botniarosk, Ekorosk, Etappi, Millespakka, Stormossen, Vestia, Laihia) and 11 ((Kolari, Kuusamo, Lapeco, Napapiirin Residuum, Posio, Taivalkoski, Utsjoki).*** Metal waste in the area was collected during weeks 18-24. Detailed load information is given in table 8.

The loads collected from the research area (Figure 16) were submitted by local partners to Napapiiri Residuumi Oy's terminal in Rovaniemi, where sampling was carried out by VTT on 11.6.2019.

In the terminal, the loads were stored next to each other in piles and separated by a concrete wall. The area reserved for sampling was uncovered and paved with some gravel in the area. A bucket loader with a bucket scale was available for sample handling. Loads were mixed with the bucket loader at their storage location and spread to the same place for sampling. Load collected from eco take-back points was pre-splitted before sampling. The masses of material contained in the study were found out by weighing the mass of material removed from the loads and reducing it from the total masses of the loads.

Table 8. Load data, research area 7.

Collection method	Route Information	Load mass (proportion taken into study)	Load pre-splitted (yes/no)	Compacted waste (yes/no)	Dry load (yes/no)	Other remarks
Door-to-door	22 properties on the route, collection bins 22 pc • 240 l (22 pc)	1060 kg	no	no	no	-
Eco take-back point	24 eco take back points and 24 collection bins on the route • 0,8 m^3 (1 pc) • 3 m^3 (20 pc) • 4 m^3 (1 pc) • 7 m^3 (2 pc)	2220 kg	yes	no	no	-

Figure 16. Loads received from research area 7. Left: door-to-door collected load, right: eco take-back point load.

2.3 Sorting studies

2.3.1 Manual sorting

The sorting study was conducted by manual sorting. In the method, each object in the sample is visually evaluated and the wastes are sorted to pre-determined categories. The samples (á 100 kg) were sieved to separate the fine material (< 20 mm), as manual sorting is generally applicable for larger particles. Due to the mass and volume of the samples to be sorted, the sieving was performed for each sample at the stage when the largest objects were first sorted. Manual sorting of samples occurred at VTT's premises.

The individual objects contained in the samples were sorted to categories based on general waste recycling and sorting guidelines. Total of 12 categories were used: Packaging metal, small metal items, plastic packaging, waste electrical and electronic equipment (WEEE), mixed municipal solid waste, hazardous waste, glass, wood, bio-waste, cardboard, paper and fines (< 20 mm). Examples of these categories are shown in figures 17-28. Possible unclarities with respect to distinction between packaging metal and small metal items were solved by the definition of packaging and packaging waste according to waste legislation (VNa 518/2014, § 3).

Number of metal, plastic and glass beverage containers were also documented in each category. In addition, packaging metal was divided into a clean and dirty fraction for studies conducted in a further part of the study (section 2.3.2). Table 9 contains all the categories used in the sorting, as well as examples of the most characteristic objects found in these categories.

The following principles were followed in sorting the samples:

- All objects were sorted as they were. If a given object consisted of two or more parts made of different materials, the parts were removed from each other only if they were removable by hand without tools, and if the consumer would have had a chance to remove parts from each other before putting into the collection bin. Otherwise, an object containing two or more materials was sorted into a category where most of the material mass of the object belonged.
- If an item was of a non-metal material but was clearly an integral part of a metallic object belonging to metal collection, it was sorted to the category where the original object of the metal belonged (e.g. loose plastic handle from a frying pan to small metal items).
- Similarly, if an item was clearly identifiable as an integral part of an object belonging to other than metal collection, the item was sorted according to an entire object (e.g. the plastic shell of the coffee machine to WEEE).
- The number of beverage containers was calculated according to loose items, i.e. each piece of beverage package found in the sample was counted separately as its own container. All beverage containers found in the samples were not whole. Instead, only a small piece could be found in the sample, and it was not possible to determine the compatibility of different pieces.
- In some cases, depending on its purpose of use, an item could have been sorted as either packaging metal or small metal item. However, the original purpose of use of an item was impossible to identify on the basis of visual inspection. In the case of such items, a decision was taken to sort all such items consistently in the same way (e.g. all aluminium foil dishes to packaging metal).

Table 9. Categories used in manual sorting and typical objects in these categories.

Metal		
Category	**Sub-category**	**Typical objects in the category**
Metal packaging	• Clean packaging metal • Dirty packaging metal → OPTION • Deposit bewerage can • Non-depositable bewerage can	Canned food, beverage cans, empty pressure containers and paint cans, edible oil and beverage canisters, metal tube packages, lids of cans and bottles, aluminium foil and dishes, full metal medicine blister packages
Small metal objects		Frying pans, dishes, kitchen utensils, cutlery, heat candle and outdoor fire shells, tomb candle covers, tools, storage boxes, lanterns, ball grills, sports equipment
Waste reject fraction		
Category	**Sub-category**	**Typical objects in the category**
Plastic packaging	• Other than bewerage package • Deposit bewerage package • Non-depositable bewerage package	Potato chip bags, coffee packages, pet food bags and other similar plastic packaging with metal-coloured inner lining, thin metal film containing plastic medicine blister packs
Waste electrical and electronic equipment (WEEE)		Small household appliances and parts thereof, lamps, LED and energy saving lamps, wires, chargers, headphones, flashlights, shavers, power tools
Mixed municipal solid waste		Ceramics, porcelain, articles of plastics and toys, clothing, rubber, filament lamps, wrappings of spread (butter) packages, glass other than separate-collection glass (matte glass, window glass, glassware, heat-resistant glass, mirror glass), halogen lamps, objects consisting of metal and non-metallic material, where the proportion of non-metallic material exceeds the proportion of the mass of the metal
Hazardous waste		Non-empty pressure packages, paint cans with paint inside, batteries, small batteries, hazardous chemicals, oil filters, New Year's tin, syringes/needles, medicines
Glass	• Other than bewerage package • Deposit bewerage package • Non-depositable bewerage package	Coloured and colourless clear glass bottles and glass jars
Wood		Wood pieces, wooden objects, plywood
Biowaste		Food scraps, household and toilet papers, small parts of plants
Cardboard		Cardboard and cardboard packaging with a metallic inner lining, metal-based potato chip tubes
Paper		Newspapers, magazines, advertisements, copy papers, letters and cards
Fines (<20 mm)		Screws, nails, sand, paper silt, wood sticks, glass crumbs, small wrinkled aluminium foil pieces, bread bag closures, can lids, jewellery, coins, knob needles

Figure 17. Metal Packages, left the dirty fraction and on the right clean fraction.

Figure 18. Small metal objects.

Figure 19. Plastic packages.

Figure 20. WEEE.

Figure 21. Mixed municipal solid waste.

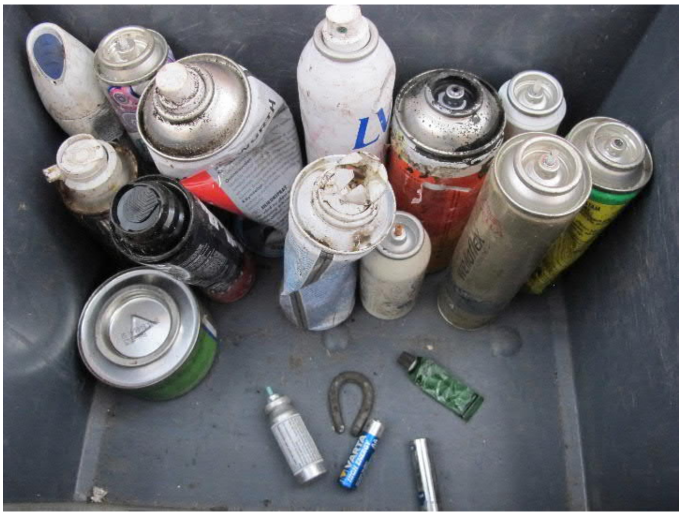

Figure 22. Hazardous waste.

Figure 23. Glass.

Figure 24. Wood.

Figure 25. Biowaste.

Figure 26. Cardboard.

Figure 27. Paper.

Figure 28. Fines <20 mm.

2.3.2 Share of other materials in packaging metal waste

As a further study the share of other than metal materials in non-depositable packaging metal waste from consumer collection, such as paper, plastics and biowaste, was determined. Studies related to this further study were performed in connection with manual sorting from material classified as packaging metal.

For the studies, metal packages were sorted to two separate fractions, pure and dirty, in connection with the manual sorting. Pure packaging metal fraction contained clean (flushed) packaging consisting only of metal, i.e. not having a separate label, lid, etc. In case an object contained also other material than metal, such as paper, plastic or biowaste, the object was sorted into the dirty fraction. The dirty fraction also included empty paint cans, which had a thin layer of dried paint. Paint cans with larger paint quantities were sorted into hazardous waste.

For each sample, a 10 to 15 kg portion of the dirty metal package fraction from manual sorting was further for the contents of different materials. Non-metallic material was removed from the dirty metal packages using appropriate manual and non-power methods. As much as possible of the non-metallic material contained in the packages was removed in dry conditions. Fine-grained material (< 1 mm), which has loosened from the cans, was sorted as biowaste if it could be identified with certainty. Otherwise, fine-grained material was sorted into fine material fraction, which included, for example, sand, rust, and very small grained unrecognisable material. Some materials, such as paint residues and glued labels, required removal using a suitable solvent. All the removed materials were divided into fractions and and weighed.

Only materials contained in metal packages that were firmly attached to metal containers, and which are not intended to be removed from the packaging before sorting (unlike, for example, loose caps), and with exception of biowaste, were classified as other than metallic materials in the metal packages.

3. Results

3.1 Manual sorting

The masses of the categories obtained by manual sorting were weighed and their percentage in the samples (100 kg) were calculated. Also taking into account the masses of the large objects removed prior to sampling, it was possible to calculate the composition of the whole of the load examined.

3.1.1 Research area 1

Rinki contract area 1 (HSY, Itä-Uudenmaan Jätehuolto, Nurmijärvi, Rosk'n Roll)

The distribution of consumer-collected metal waste from door-to-door and eco take-back point collection between packaging metal, small metal items and waste reject fraction in research area 1 is shown in Figure 29.

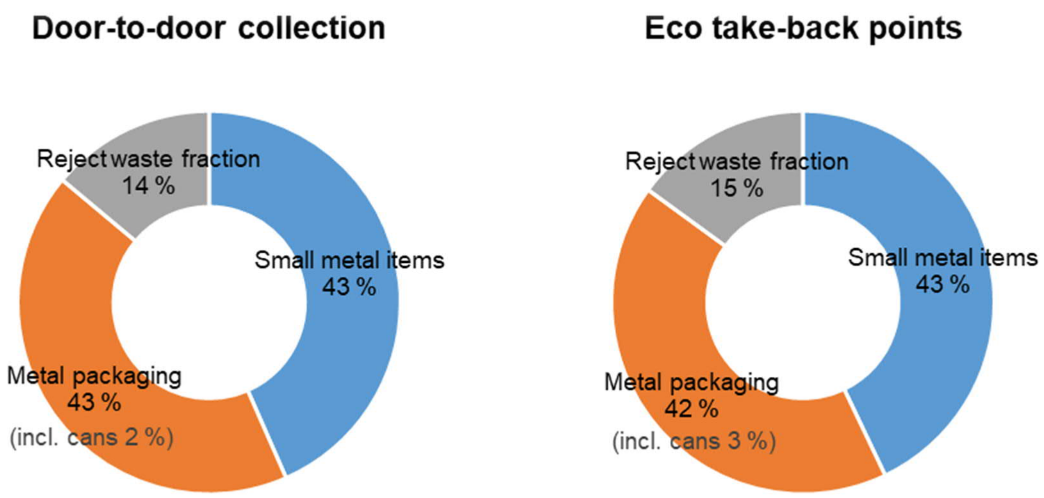

Figure 29. Distribution between packaging metal, small metal items and reject in research area 1.

Number of beverage cans and the composition of the waste reject fraction in manually sorted samples are presented in tables 10 and 11, respectively.

Table 10. Number of beverage cans in manually sorted sample (100 kg) in research area 1.

Fraction	Door-to-door collection	Eco take-back point collection
Deposit beverage can	16 pc	28 pc
Non-depositable beverage can	145 pc	294 pc

Table 11. Composition of the waste reject fraction in research area 1 (number of beverage containers expressed in pc per 100 kg sample)

Fraction	Door-to-door collection	Eco take-back point collection
Plastic packages	0,7 % Deposit plastic bottle, 1 pc	0,7 % Deposit plastic bottle, 1 pc
WEEE	6,4 %	4,1 %
Mixed municipal solid waste	1,8 %	1,3 %
Hazardous waste	2,1 %	0,8 %
Glass	1,3 %	1,0 % Non-depositable glass bottle, 1 pc
Wood	0,2 %	0,5 %
Biowaste	0,0 %	1,3 %
Cardboard	0,1 %	0,3 %
Paper	0,0 %	0,0 %
Fines (<20 mm)	1,3 %	4,9 %

3.1.2 Research area 2

Rinki contract area 3 (Kiertokapula, Päijät-Hämeen Jätehuolto)

The distribution of consumer-collected metal waste from door-to-door and eco take-back point collection between packaging metal, small metal items and waste reject fraction in research area 2 is shown in Figure 30.

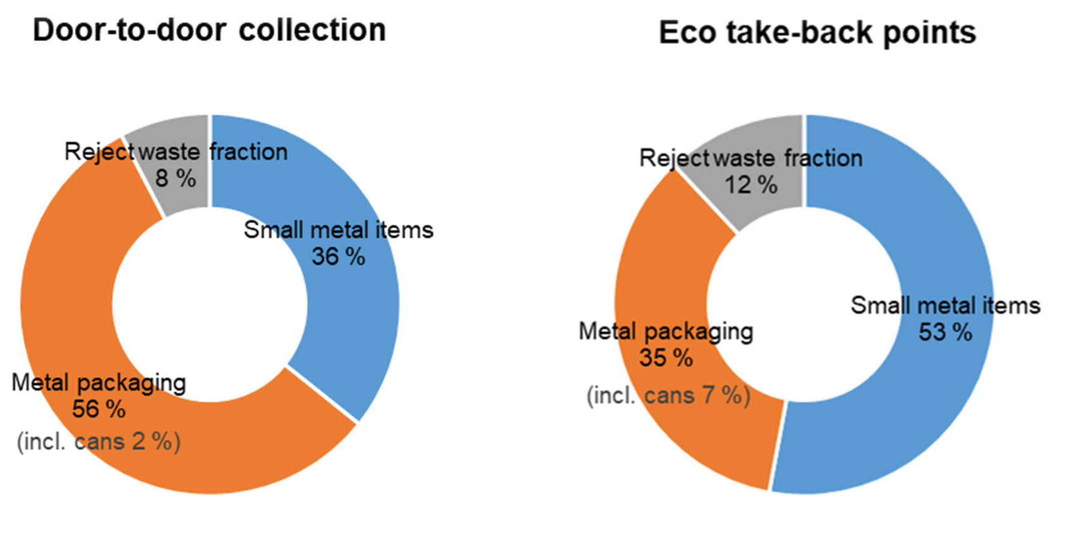

Figure 30. Distribution between packaging metal, small metal items and waste reject fraction in research area 2.

Number of beverage cans and the composition of the waste reject fraction in manually sorted samples are presented in tables 12 and 13, respectively.

(sis. tölkit 7 %)

Table 12. Number of beverage cans in manually sorted sample (100 kg) in research area 2.

Fraction	Door-to-door collection	Eco take-back point collection
Deposit beverage can	20 pc	51 pc
Non-depositable beverage can	175 pc	697 pc

Table 13. Composition of the waste reject fraction in research area 2 (number of beverage containers expressed in pc per 100 kg sample)

Fraction	Door-to-door collection	Eco take-back point collection
Plastic packages	0,8 % Deposit plastic bottle, 2 pc	0,6 % Deposit plastic bottle, 2 pc
WEEE	1,2 %	4,0 %
Mixed municipal solid waste	0,9 %	0,9 %
Hazardous waste	0,9 %	1,4 %
Glass	0,2 %	2,0 % Deposit glass bottle, 1 pc
Wood	0,4 %	0,3 %
Biowaste	0,2 %	0,0 %
Cardboard	0,1 %	0,2 %
Paper	0,0 %	1,1 %
Fines (<20 mm)	2,9 %	1,7 %

3.1.3 Research area 3

Rinki contract areas 2 and 5 (Kustavi, Laitila, Loimi-Hämeen Jätehuolto, Lounais-Suomen Jätehuolto, Pyhäranta, Taivassalo, Uusikaupunki, Vehmaa, Honkajoki, Jämijärvi, Kankaanpää, Karvia, Porin Jätehuolto, Rauman Seudun Jätehuoltolaitos, Satakierto)

As a result of the broader study in area 3, the results shown below have been obtained as an average of two loads. The results of load 1 have also been obtained as an average of three parallel samples.

The distribution of consumer-collected metal waste from door-to-door and eco take-back point collection between packaging metal, small metal items and waste reject fraction in research area 3 is shown in Figure 31.

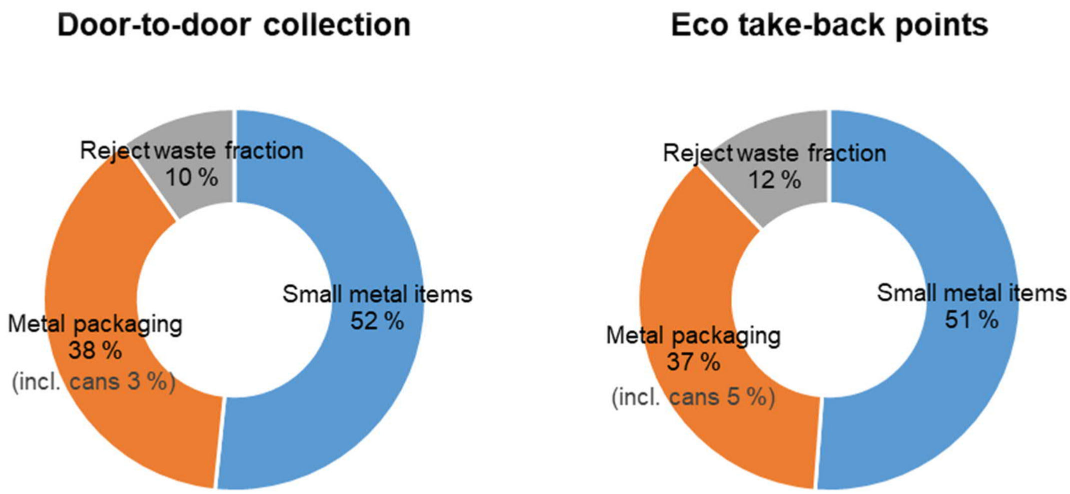

Figure 31. Distribution between packaging metal, small metal items and waste reject fraction in research area 3.

Number of beverage cans and the composition of the waste reject fraction in manually sorted samples are presented in tables 14 and 15, respectively.

Table 14. Number of beverage cans in manually sorted sample (100 kg) in research area 3.

Fraction	Door-to-door collection		Eco take-back point collection	
	Load 1, avg. (n=3)	Load 2	Load 1, avg. (n=3)	Load 2
Deposit beverage can	10 pc	26 pc	15 pc	13 pc
Non-depositable beverage can	360 pc	195 pc	476 pc	478 pc

Table 15. Composition of the waste reject fraction in research area 3 (number of beverage containers expressed in pc per 100 kg sample)

Fraction	Door-to-door collection	Eco take-back point collection
Plastic packages	0,8 % Deposit plastic bottle, 1 pc (load 1, n=3)	0,7 % Non-depositable plastic bottle, 1 pc (load 1, n=3) Deposit plastic bottle, 1 pc (load 2)
WEEE	4,3 %	4,1 %
Mixed municipal solid waste	1,6 %	2,5 %
Hazardous waste	0,6 %	1,1 %
Glass	0,7 % Non-depositable glass bottle, 2 pc (load 1, n=3) Deposit glass bottle, 1 pc (load 1, n=3)	0,4 % Deposit glass bottle, 3 pc (load 1, n=3) Non-depositable glass bottle, 3 pc (load 1, n=3)
Wood	0,2 %	0,2 %
Biowaste	0,0 %	0,0 %
Cardboard	0,1 %	0,2 %
Paper	0,3 %	0,1 %
Fines (<20 mm)	1,2 %	2,8 %

3.1.4 Research area 4

Rinki contract areas 6 and 7 (Pirkanmaan Jätehuolto, Hankasalmi, Hartola, Hirvensalmi, Joutsa, Jyväskylä, Jämsän Jätehuolto, Kangasniemi, Keuruu, Laukaa, Luhanka, Multia, Muurame, Pertunmaa, Petäjävesi, Toivakka, Uurainen, Äänekoski)

The distribution of consumer-collected metal waste from door-to-door and eco take-back point collection between packaging metal, small metal items and waste reject fraction in research area 4 is shown in Figure 32.

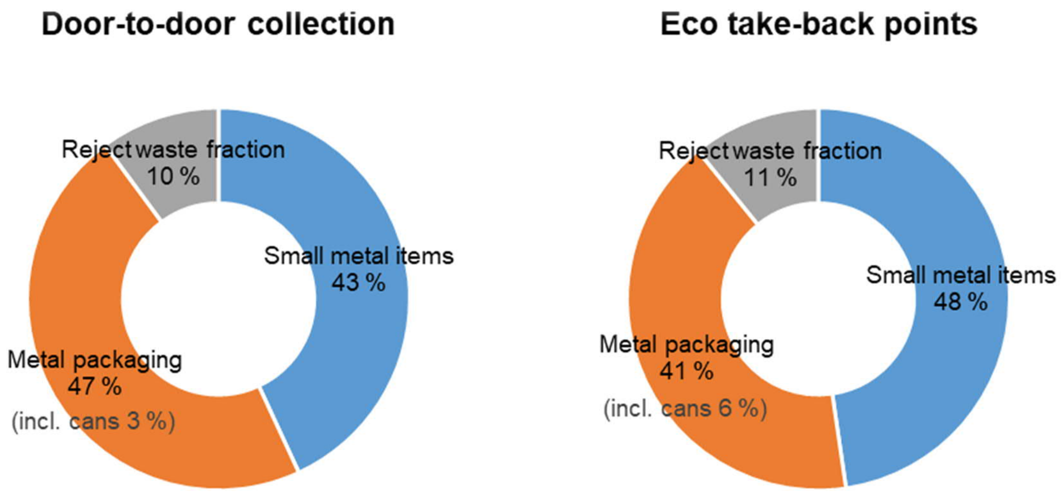

Figure 32. Distribution between packaging metal, small metal items and waste reject fraction in research area 4.

Number of beverage cans and the composition of the waste reject fraction in manually sorted samples are presented in tables 16 and 17, respectively.

Table 16. Number of beverage cans in manually sorted sample (100 kg) in research area 4.

Fraction	Door-to-door collection	Eco take-back point collection
Deposit beverage can	25 pc	51 pc
Non-depositable beverage can	276 pc	455 pc

Table 17. Composition of the waste reject fraction in research area 4 (number of beverage containers expressed in pc per 100 kg sample)

Fraction	Door-to-door collection	Eco take-back point collection
Plastic packages	0,4 % Deposit plastic bottle, 1 pc	0,8 % Deposit plastic bottle, 3 pc Non-depositable plastic bottle, 1 pc
WEEE	3,8 %	2,8 %
Mixed municipal solid waste	2,2 %	1,9 %
Hazardous waste	1,0 %	1,3 %
Glass	1,1 % Non-depositable glass bottle, 2 pc	0,8 % Non-depositable glass bottle, 1 pc
Wood	0,3 %	0,1 %
Biowaste	0,0 %	0,0 %
Cardboard	0,1 %	0,1 %
Paper	0,0 %	0,4 %
Fines (<20 mm)	1,1 %	2,8 %

3.1.5 Research area 5

Rinki contract areas 4 and 8 (Etelä-Karjalan Jätehuolto, Kymenlaakson Jäte, Jätekukko, Keski-Savon Jätehuolto, Kitee, Metsäsairila, Puhas, Rääkkylä, Sammakkokangas, Savonlinnan Seudun Jätehuolto, Tohmajärvi, Ylä-Savon Jätehuolto)

The distribution of consumer-collected metal waste from door-to-door and eco take-back point collection between packaging metal, small metal items and waste reject fraction in research area 5 is shown in Figure 33.

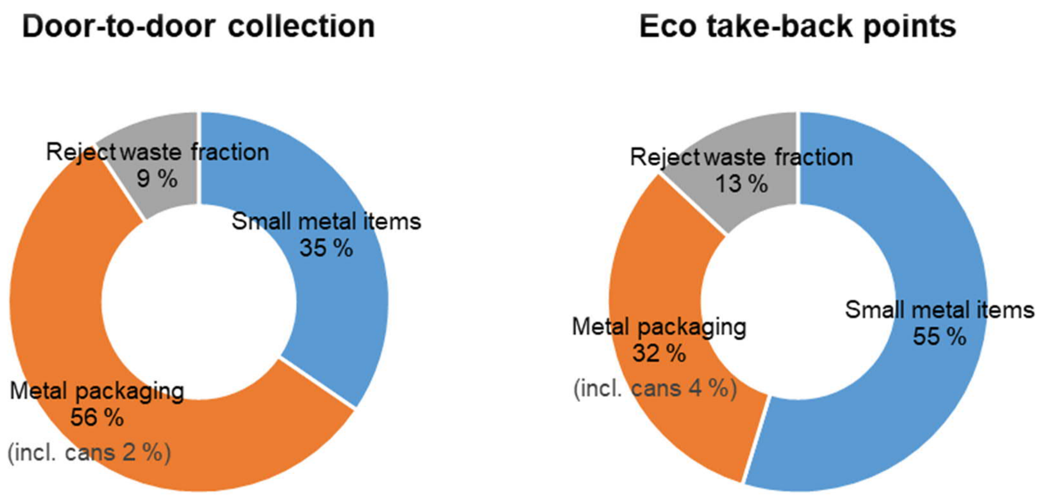

Figure 33. Distribution between packaging metal, small metal items and waste reject fraction in research area 5.

Number of beverage cans and the composition of the waste reject fraction in manually sorted samples are presented in tables 18 and 19, respectively.

Table 18. Number of beverage cans in manually sorted sample (100 kg) in research area 5.

Fraction	Door-to-door collection	Eco take-back point collection
Deposit beverage can	14 pc	65 pc
Non-depositable beverage can	165 pc	332 pc

Table 19. Composition of the waste reject fraction in research area 5 (number of beverage containers expressed in pc per 100 kg sample)

Fraction	Door-to-door collection	Eco take-back point collection
Plastic packages	1,0 %	0,9 %
WEEE	3,2 %	5,4 %
Mixed municipal solid waste	2,4 %	2,2 %
Hazardous waste	0,4 %	1,3 %
Glass	0,2 %	0,9 % Deposit glass bottle, 4 pc
Wood	0,0 %	0,2 %
Biowaste	0,0 %	0,0 %
Cardboard	0,2 %	0,1 %
Paper	0,0 %	0,0 %
Fines (<20 mm)	1,9 %	2,1 %

3.1.6 Research area 6

Rinki contract area 9 (Botniarosk, Ekorosk, Etappi, Millespakka, Stormossen, Vestia, Laihia)

The distribution of consumer-collected metal waste from door-to-door and eco take-back point collection between packaging metal, small metal items and waste reject fraction in research area 6 is shown in Figure 34.

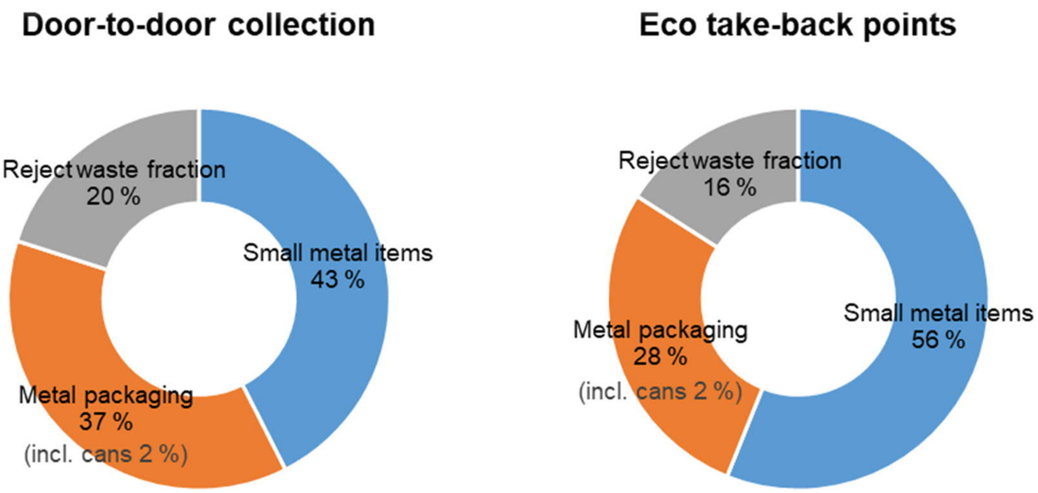

Figure 34. Distribution between packaging metal, small metal items and waste reject fraction in research area 6.

Number of beverage cans and the composition of the waste reject fraction in manually sorted samples are presented in tables 20 and 21, respectively.

Table 20. Number of beverage cans in manually sorted sample (100 kg) in research area 6.

Fraction	Door-to-door collection	Eco take-back point collection
Deposit beverage can	11 pc	54 pc
Non-depositable beverage can	158 pc	235 pc

Table 21. Composition of the waste reject fraction in research area 6 (number of beverage containers expressed in pc per 100 kg sample).

Fraction	Door-to-door collection	Eco take-back point collection
Plastic packages	1,4 % Deposit plastic bottle, 1 pc Non-depositable plastic bottle, 18 pc	0,5 % Non-depositable plastic bottle, 1 pc
WEEE	11,7 %	8,8 %
Mixed municipal solid waste	2,7 %	2,0 %
Hazardous waste	1,4 %	1,5 %
Glass	1,0 %	0,7 %
Wood	0,1 %	0,3 %
Biowaste	0,6 %	0,0 %
Cardboard	0,1 %	0,3 %
Paper	0,0 %	0,0 %
Fines (<20 mm)	1,0 %	1,8 %

3.1.7 Research area 7

Rinki contract areas 10 and 11 (Kainuun Jätehuollon Kuntayhtymä (Eko-Kymppi), Perämeren Jätehuolto, Oulun Jätehuolto, Siikajoki, Kolari, Kuusamo, Lapeco, Napapiirin Residuum, Posio, Taivalkoski, Utsjoki)

The distribution of consumer-collected metal waste from door-to-door and eco take-back point collection between packaging metal, small metal items and waste reject fraction in research area 6 is shown in Figure 35.

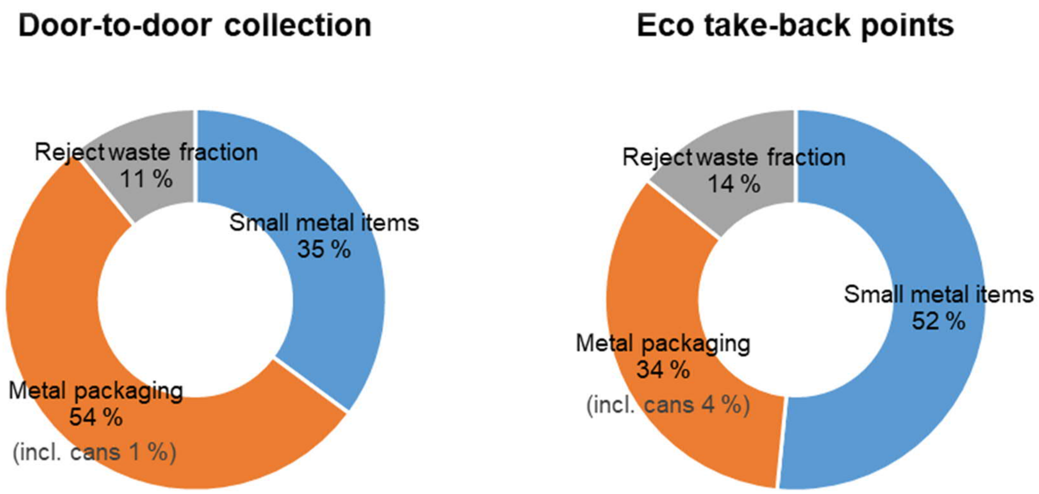

Figure 35. Distribution between packaging metal, small metal items and waste reject fraction in research area 7.

Number of beverage cans and the composition of the waste reject fraction in manually sorted samples are presented in tables 22 and 23, respectively.

Table 22. Number of beverage cans in manually sorted sample (100 kg) in research area 7.

Fraction	Door-to-door collection	Eco take-back point collection
Deposit beverage can	22 pc	129 pc
Non-depositable beverage can	53 pc	285 pc

Table 23. Composition of the waste reject fraction in research area 7 (number of beverage containers expressed in pc per 100 kg sample).

Fraction	Door-to-door collection	Eco take-back point collection
Plastic packages	0,8 % Deposit plastic bottle, 1 pc	1,0 % Deposit plastic bottle, 4 pc Non-depositable plastic bottle, 1 pc
WEEE	2,0 %	7,1 %
Mixed municipal solid waste	2,3 %	1,8 %
Hazardous waste	2,1 %	1,9 %
Glass	1,9 %	1,0 % Deposit glass bottle, 2 pc
Wood	0,0 %	0,0 %
Biowaste	0,2 %	0,5 %
Cardboard	0,4 %	0,2 %
Paper	0,0 %	0,0 %
Fines (<20 mm)	1,2 %	0,7 %

3.1.8 Summary and nationwide distribution

Summary of the distribution of metal packages, small metals items and waste reject fraction in door-to-door and eco take-back point collection systems in research areas 1-7 is shown in figures 36 and 38. The composition of the waste reject fraction in each research area is presented in the case of door-to-door collection in Figure 37 and in the case of eco take-back point collection in Figure 39.

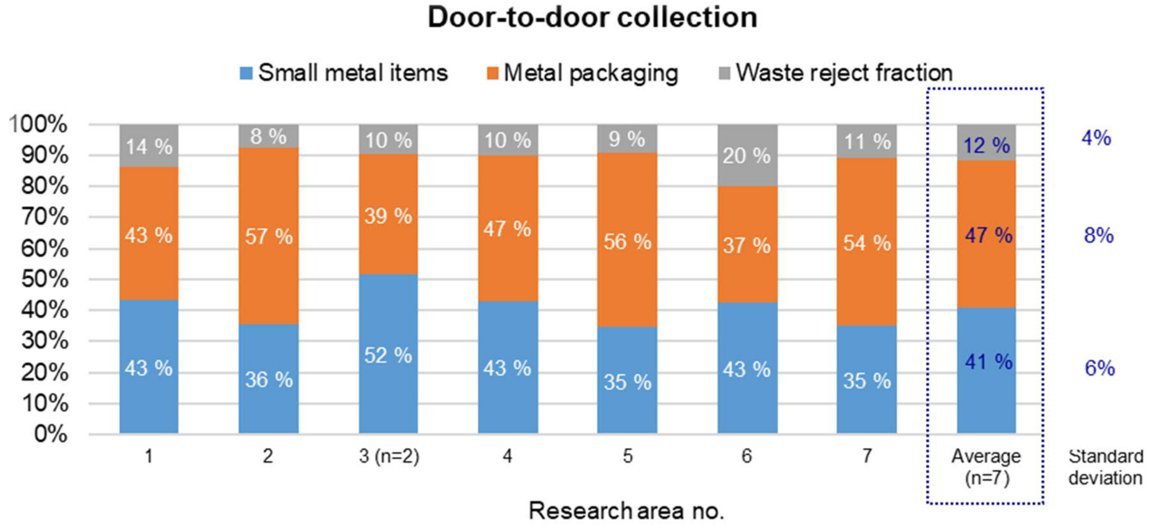

Figure 36. Distribution of metal packages, small metals items and waste reject fraction in door-to-door collection in research areas 1-7.

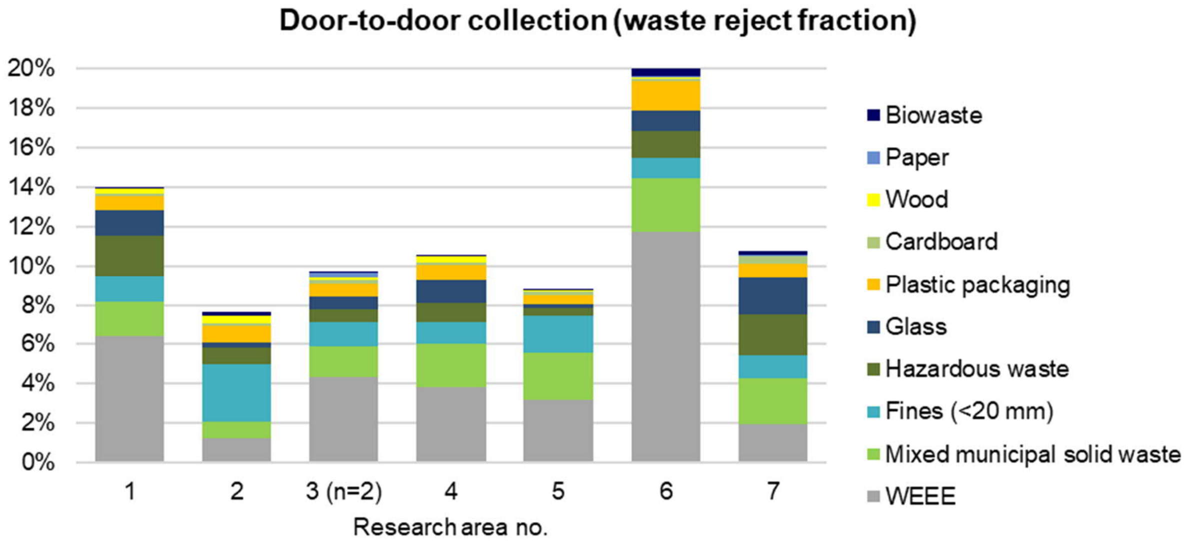

Figure 37. Composition of the waste reject fraction in door-to-door collection in research areas 1-7.

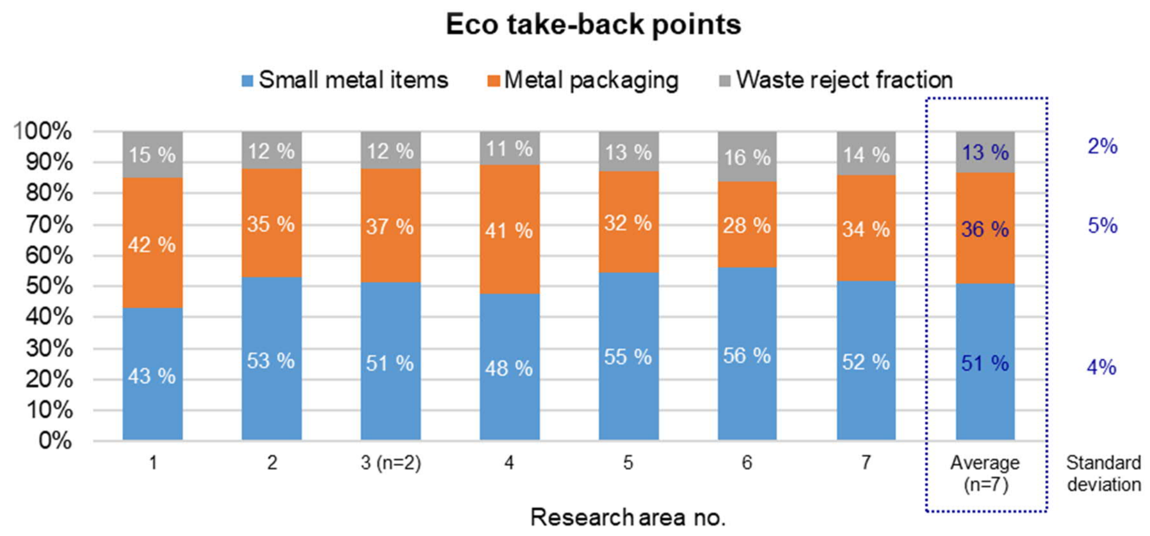

Figure 38. Distribution of metal packages, small metals items and waste reject fraction in eco take-back point collection in research areas 1-7.

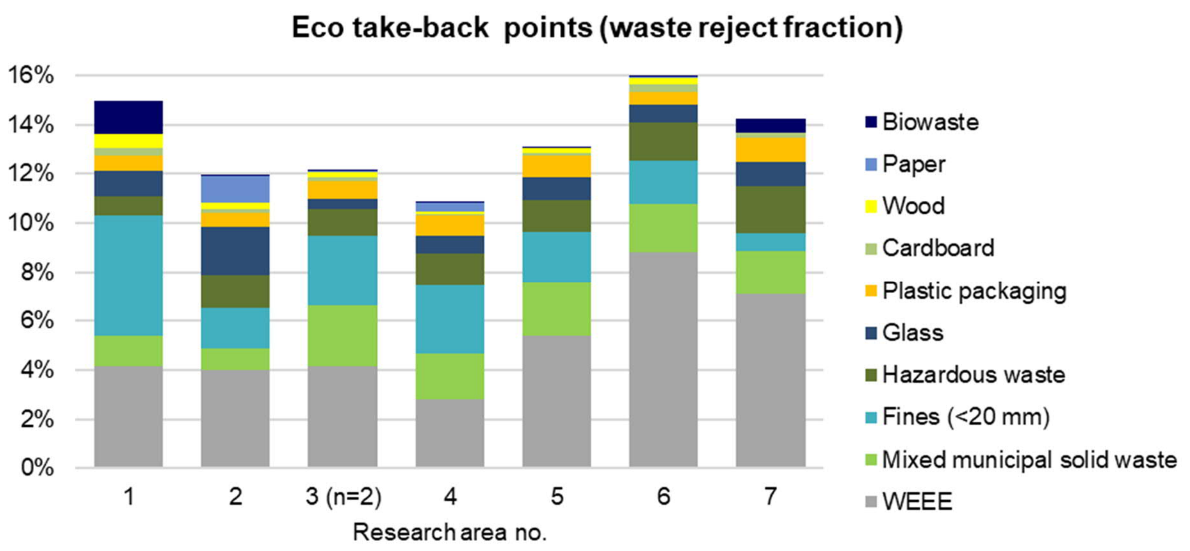

Figure 39. Composition of the waste reject fraction in eco take-back point collection in research areas 1-7.

The nationwide distribution of separately collected metal waste from consumers (excl. Aland) between small metal items, metal packages and waste reject fraction was calculated using an assumption, that the consumer collection systems end up with 2 kg of metal waste per capita in Finland Per year (Salmenperä et al. 2019). The total population of the research areas was obtained by reducing the population of Aland from the population of Finland (Statistics Finland 2019). As a result, the total amount of consumer-collected metal waste was 11000 tons per year. The estimate for total amount of door-to-door collected metal waste was derived by reducing the amount of metal waste collected by Rinki in eco take back points in 2018 (6100 t, amount delivered by the client). Thus the estimated amount of metal waste generated from door-to-door collection was 4900 t.

On the basis of the composition of the samples, distributions were calculated for small metal items, metal packages and waste reject fraction in both collection methods as an average for all research areas. These distributions were multiplied with metal amounts arising from door-to-door and eco take-back point collection, and as a result a nationwide distribution of separately collected consumer metal waste was obtained (figure 40).

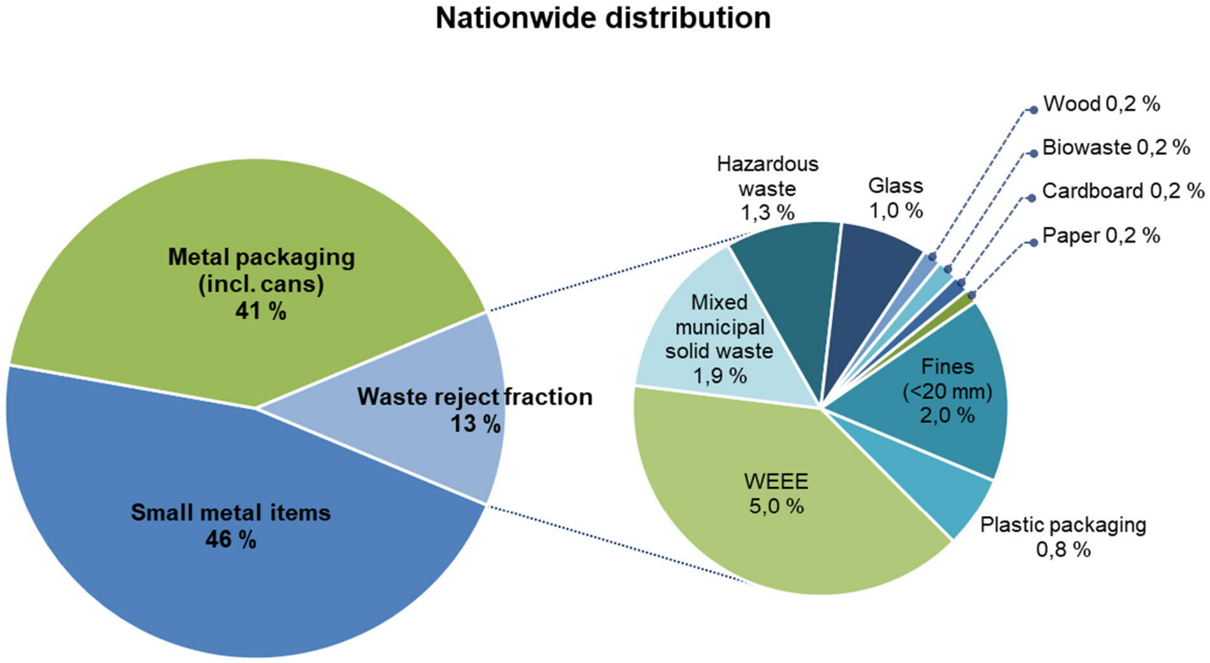

Figure 40. The nationwide distribution of metal packages, small metal items and waste reject fraction in consumer-collected metal waste.

In the calculation of the national distribution, also another approach, which used weighing of the research area specific results by the population in each research are, was used. The total amount of metal waste collected from the research areas (= Finland, excl. Aland) in tonnes (estimated at 11 000 t) was allocated to the coarse population of the research areas for each of the seven research areas, assuming that the metal accumulation per capita does not vary across Finland. The quantities of metal waste in each research area were further divided by the shares of different collection methods (door-to-door and eco take-back point collection) reported by the client. These amounts were multiplied by the distributions in the samples of the research areas and resulted in tonnes of each category (metal packages, small metal items and waste reject fraction) per research area and aggregated nationally.

In practice, the results of the population-weighted approach were fully consistent with the distribution described above. The above non-weighted average calculation can be considered a priority taking into account the number of samples studied. This way, for example, an individual sample representing one highly populated area does not cause increased uncertainty in the results.

3.2 Material distribution of packaging metal

Based on the masses of materials removed from the dirty packaging metal waste, the percentages of metal and other material fractions in the packaging metal were calculated. The proportions of the materials were expanded to match the size of the packaging metal of the manually sorted sample (100 kg). Packaging metal waste also included paper, plastic, biowaste, paint, and fines (< 1 mm), which consisted of sand, rust and unidentified material. Sorting loss is assumed to be attributed mainly to the drying of the samples during sorting. Table 24 shows the results of this study separately for door-to-door and eco take-back point collected packaging metal. Figure 41 shows the material distribution of packaging metal as an average for both door-to-door and eco take-back point collection.

Table 24. Results of the study for door-to-door and eco take-back point collected packaging metal.

Fraction	Door-to-door collectio		Eco take-back point collection	
	Average (n=7)	Standard deviation	Average (n=7)	Standard deviation
Metal	97,4 %	0,5 %	96,8 %	1,2 %
Paper	1,7 %	0,2 %	2,0 %	0,3 %
Plastic	0,1 %	0,1 %	0,1 %	0,1 %
Biowaste	0,3 %	0,2 %	0,6 %	0,9 %
Paint	0,2 %	0,3 %	0,1 %	0,1 %
Fines	0,2 %	0,1 %	0,2 %	0,2 %
Sorting loss	0,1 %	0,1 %	0,1 %	0,1 %

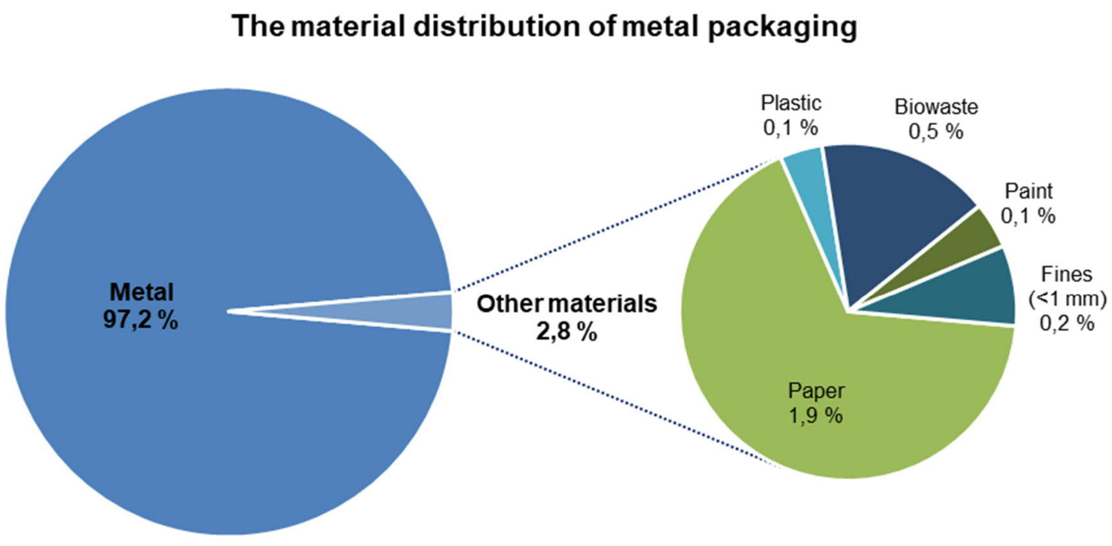

Figure 41. Distribution of metal and other materials in consumer-collected packaging metals as an average for door-to-door and eco take-back point collection.

3.3 Assessment of reliability of the study method and sources of error

According to VTT's experience, the results of the waste sorting surveys vary considerably from the performer, as sorting occurs mainly on the basis of visual evaluation and the sorting result is influenced by the performer's interpretation of the sorted material. In this work, the manual sorting was performed by the same experienced persons for each sample, thereby minimizing the impact of the performer on the sorting result.

In addition to sorting, the potential effect of the performer was also taken into account in sampling. Sampling was carried out by the same persons in each research area in order to ensure the representativeness of the sampling and as uniform as possible approach in each sampling. In addition, same sampling tools were always used, except for mechanic assistance from terminals.

Broader studies of the first research area (research area 3) showed only slight variations in the contents between different loads (table 25). Because of misunderstandings, one load of both collection methods did not arrive in the terminal, and thus the study assessed only two different loads per collection method. In the context of the study timetable, it was not possible to acquire substitute loads to replace the missed ones.

Table 25. Variation of content between two loads collected from the same research area

Category	Door-to-door collection				Eco take-back point collection			
	Load 1	Load 2	Average (n=2)	Standard deviation	Load 1	Load 2	Average (n=2)	Standard deviation
Packaging metal	36,5 %	40,6 %	38,5 %	2,9 %	39,1 %	34,2 %	36,7 %	3,4 %
Small metal items	54,9 %	48,4 %	51,6 %	4,6 %	47,3 %	55,1 %	51,2 %	5,5 %
Plastic packages	0,5 %	1,1 %	0,8 %	0,5 %	0,8 %	0,6 %	0,7 %	0,1 %
WEEE	2,6 %	6,1 %	4,3 %	2,5 %	3,5 %	4,8 %	4,1 %	1,0 %
Mixed municipal solid waste	2,4 %	0,8 %	1,6 %	1,1 %	3,0 %	2,0 %	2,5 %	0,7 %
Hazardous waste	0,4 %	0,8 %	0,6 %	0,3 %	1,0 %	1,2 %	1,1 %	0,2 %
Glass	0,6 %	0,8 %	0,7 %	0,1 %	0,6 %	0,2 %	0,4 %	0,3 %
Wood	0,2 %	0,2 %	0,2 %	0,0 %	0,3 %	0,0 %	0,2 %	0,2 %
Biowaste	0,0 %	0,0 %	0,0 %	0,0 %	0,0 %	0,0 %	0,0 %	0,0 %
Cardboard	0,1 %	0,2 %	0,1 %	0,1 %	0,3 %	0,1 %	0,2 %	0,1 %
Paper	0,2 %	0,4 %	0,3 %	0,1 %	0,0 %	0,1 %	0,1 %	0,1 %
Fines (<20 mm)	1,7 %	0,7 %	1,2 %	0,7 %	4,1 %	1,6 %	2,8 %	1,8 %

A broader study to assess the internal variation within a load also showed that the chosen sampling method was well repeatable (table 26), and thus the study can be carried out in the future in each research area by taking and sorting one sample of the loads of both methods of collection.

Table 26. Variation of content between the three samples taken from the same load (á 100 kg).

Category	Door-to-door collection, load 1					Eco take-back point collection, load 1				
	Sample 1	Sample 2	Sample 3	avg. (n=3)	Standard deviation	Sample 1	Sample 2	Sample 3	avg. (n=3)	Standard deviation
Packaging metal	39 %	35 %	35 %	37 %	2,4 %	41 %	38 %	38 %	39 %	1,8 %
Small metal items	51 %	58 %	55 %	55 %	3,2 %	46 %	48 %	48 %	47 %	1,1 %
Plastic packages	0,54 %	0,45 %	0,41 %	0,47 %	0,07 %	1,0 %	0,65 %	0,77 %	0,80 %	0,17 %
WEEE	3,0 %	1,7 %	3,1 %	2,6 %	0,78 %	3,7 %	3,2 %	3,4 %	3,5 %	0,26 %
Mixed municipal solid waste	1,7 %	3,2 %	2,2 %	2,4 %	0,79 %	2,9 %	2,8 %	3,2 %	3,0 %	0,22 %
Hazardous waste	0,58 %	0,16 %	0,51 %	0,41 %	0,23 %	0,85 %	1,2 %	0,93 %	0,99 %	0,17 %
Glass	0,86 %	0,61 %	0,29 %	0,59 %	0,29 %	0,55 %	0,42 %	0,85 %	0,61 %	0,22 %
Wood	0,40 %	0,01 %	0,05 %	0,15 %	0,21 %	0,55 %	0,20 %	0,29 %	0,35 %	0,18 %
Biowaste	0,03 %	0,06 %	0,02 %	0,04 %	0,02 %	0,02 %	0,02 %	0,01 %	0,02 %	0,00 %
Cardboard	0,13 %	0,11 %	0,06 %	0,10 %	0,04 %	0,17 %	0,28 %	0,36 %	0,27 %	0,10 %
Paper	0,45 %	0,02 %	0,00 %	0,16 %	0,25 %	0,08 %	0,05 %	0,02 %	0,05 %	0,03 %
Fines (<20 mm)	1,7 %	0,88 %	2,6 %	1,7 %	0,87 %	3,0 %	5,4 %	3,9 %	4,1 %	1,2 %

The loads collected for the study filled the minimum requirements for the mass of a load (1000 kg) set out in the beginning of the study, with the exception of one load from the door-to-door collection in research area 3 (load 2, size 600 kg). However, the material in the door-to-door collection is collected from a considerable amount of collection points, which in turn can be estimated to increase the representativeness of the sample. Door-to-door loads were smaller than eco take-back point loads with one exception (research area 6). This is due to the slower accumulation in the amount of door-to-door collected metal waste, the accumulation rate of which was also observed to vary between geographical areas.

Composition of metal waste in the supplementary municipal regional collection remained outside the scope of this study, but it can be assumed that the contents of the Rinki eco take-back point and municipal regional collection points are not substantially different in composition. Municipal regional collection points are usually located in more remote regions, but about 75-80% of the regional collection points are Rinki eco take-back points, and there are no municipal supplementary points in all regions.

Due to the time span of the study, it was not possible to assess the seasonal variation in the composition of the consumer-collected metal waste. Also, it was not possible to determine the moisture content of the consumer-collected metal waste in a reliable manner due to the fact that the loads were stored outside before sampling. After collection, loads got wet and dried several times even before sampling. Samples taken in a tight timetable were not sorted immediately after sampling. The samples were also stored outdoor, partly exposed to weather conditions.

Any variables that might affect the results could not be influenced during the study. These variables included, for example, equipment available for weighing and handling of samples at the terminals. The weighing accuracy of scales may vary, depending on the type, calibration and size of the scales. In addition, the mixing and spreading of loads may have had an impact on the distribution of packaging metal and small metal items to be examined. The packaging metal is typically smaller in size and lighter, while large items are more likely to be “small metal”. When pre-splitting the sample, for example by using an excavator grab, more large metal might have been left out of the sample. The large items are more easily accessible to the surface and grasp more easily to the grab than small ones. In the bucket loader, when mixing loads, this effect may not be apparent to the same extent.

4. Conclusions and recommendations

VTT has studied the distribution of metal waste in consumer collection systems according to a collaborative research plan designed with the client. The aim was to establish as comprehensive an estimate of the metals distribution as possible based on experimental research, taking into account the timetable for the work.

The main objective of the study was to assess the distribution of packaging metal and small metal items from consumers in separately collected metal waste, as well as any differences between different housing and geographical areas. The seven areas of research defined by the client covered the entire Finland except the Aland. In each research area, a study was carried out on both the door-to-door and the eco take-back point collected metal waste by sampling from one load per each collection method. In addition, variation in the contents of the loads was studied at one research area by sorting the samples taken from separate loads. The repeatability of the sampling method was assessed by taking parallel samples from single loads. The study also assessed the shares of impurities, i.e. other than metal materials in non-depositable metal packaging waste.

Figures 36 and 38 show distributions of the main categories of the study in each of the seven research areas. The door-to-door collected metal load typically consisted of about 100-200 collection points and the eco take-back point collected load of around 10-20 collection points. The variations of the packaging metal and small metal items shares between the different areas of research can be regarded as relatively small in both collection types, taking into account the heterogeneous nature of the material. The proportion of small metal items was, as expected, somewhat higher in the eco take-back point collection systems, as the collection bins used in them are larger than in the door-to-door collection systems, so that the containers can accommodate more and larger small metal items. A slightly greater variation was observed in the share of the waste reject fraction, particularly in the case of door-to-door collected material, although the variation was mainly derived from the abundant share of waste reject fraction in a single research area (area 6). In the case of other research areas, the variation was relatively low for waste reject fraction in both collection types.

Clearly, most of the waste reject fraction contained in the consumer-collected metal waste consisted of waste electrical and electronic equipment (WEEE), which was found mainly in large waste reject fraction, but also in smaller items in manual sorting. The share of fines (< 20 mm) is explained by its high metal content, as it consisted roughly of about 80% of small and packaging metal. However, in spite of its metallic content, the fines fraction is classified as waste reject fraction, as it remains, due to its small size, mainly outside the recycling process and also outside the manual sorting in this study. The large number of undischarged pressure packages increased the proportion of hazardous waste in the waste reject fraction. These packages belong to metal waste only when emptied properly. It is recommended to study the possibility of clarify the waste sorting instructions, particularly in the case of WEEE.

As results of an additional study, the metal packaging from the consumer collection systems contained 3 % other material than metal. Most of the non-metallic material consisted of paper originating from packaging labels. Other found materials included bio-waste, plastic, paint and fine material consisting of sand, rust and unidentified material (< 1 mm).

The development needs identified during the study were the clarification of communication and guidance among the co-operation bodies and the minimisation of possible variables, e.g. in the storage of samples and in relation to mechanical handling. The timing challenges in terms of material accumulation must also be taken into account as early as possible in the design of work. In the future, it is also recommended that, in addition to the minimum size requirement, the recommended minimum number of collection points is also set for the loads to be collected. This applies in particular to loads from the eco take-back point collection where the individual collection points to be emptied are generally large in size but low in number. However, the second load of the parallel loads assessed in research area 3 consisted only of material collected from a few points, but the loads were not found to differ remarkably in contents.

One of the most significant error sources of a study described above arises from the persons performing the study. In this study this error was minimised by using the same experienced experts throughout the study. The size of the loads and samples collected for the study was found to be appropriate for representativeness and technical implementation. The results are expected to be well replicable. In conclusion, the approach chosen for research will also be applicable in the future to conduct a similar study.

The conclusions set out above are based on an assessment of the composition of the consumer-collected metal waste. The study was designed to be as comprehensive as possible within the boundary conditions of schedule and resources. In the future, a reassessment of the distribution of metallic waste may be necessary, e.g. in the case of changes in legislation which may have a direct or indirect effect on the content of metallic waste, or when otherwise suspecting changes in waste quality.

5. Literature

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