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THE QUALITY AND QUANTITY OF WASTE COLLECTED IN A PIPELINE-BASED WASTE COLLECTION SYSTEM

Case Jätkäsaari and Case Kalasatama

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ABSTRACT

The European Union guides Finland and other member states towards a more resource-efficient Europe where recycling is optimized. A lot of the community waste has been mixed waste that has ended up in landfills.

The EU Waste legislation, which has been implemented into the Finnish waste legislation in 2012, subjects all activities that produce waste to the following waste management hierarchy: The first priority is to avoid generating any waste and, if waste is generated, it must be prepared for re-use or recycling. If re-use is impossible, waste is to be recycled as material or made into energy. Only when it is not technically or economically feasible to utilize the waste, it can be placed in landfills.

There is a lot of room for improvements in the recycling efforts, and in the development of waste collection systems. An alternative to the traditional truck-based waste collection is a pipeline-based waste collection system.

The aim of this research was to collect accurate information about the quality and quantity of the waste that is collected through the pipeline-based waste collection system in the Jätkäsaari and Kalasatama areas in Helsinki, and to compare the pipeline-based waste collection system to the traditional waste collection. The sorting effectiveness of the inhabitants in these case areas was also examined, as well as their experiences with the system.

This research studied primarily the community waste generated by households. The waste components that are collected in the pipeline-based waste collection system are mixed waste, biowaste, paper and cardboard. Other waste components such as glass, metal, large mixed waste and large cardboard are collected in recycling rooms.

This research was commissioned by Procofin Ltd for the designing process of an automated pipeline-based waste collection system, for planning efficient waste management, for making material recycling more efficient, and for planning waste consulting. The collected information in this research helps to improve environmental efficiency in the case areas of Jätkäsaari and Kalasatama, and also in future areas where pipeline-based waste collection systems are implemented.

Keywords: waste, pipeline-based waste collection system, Jätkäsaari, Kalasatama, City of Helsinki

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TIIVISTELMÄ

Euroopan unioni ohjaa Suomea ja muita jäsenvaltioitaan kohti resurssitehokasta Eurooppaa, jossa kierrätys on optimoitu. Suuri osa yhdyskuntajätteestä on ollut tähän saakka sekajätettä, joka on päätynyt kaatopaikoille.

EU:n jätelainsäädäntö, joka saatettiin osaksi Suomen jätelainsäädäntöä vuonna 2012, alistaa kaikki toimet, joista syntyy jätettä jätehuollon hierarkiaan: ensisijaisesti tulee välttää jätteen synty ja jos jätettä syntyy, se on valmistettava uudelleenkäyttöä varten. Mikäli uudelleenkäyttö ei ole mahdollista, jäte tulee kierrättää materiaalina tai hyödyntää muuten, esim. energiana. Vasta siinä vaiheessa kun jätteen hyödyntäminen ei ole teknisesti tai taloudellisesti toteutettavissa, se voidaan sijoittaa kaatopaikalle.

Kierrätyksessä ja jätteenkeräyksen kehityksessä on tilaa parannuksille. Varteenotettavana vaihtoehtona perinteiselle jätteenkeräykselle on jätteiden putkikeräysjärjestelmä.

Tämän tutkimuksen tavoitteena oli kerätä tietoa jätteen laadusta ja määrästä Helsingin Jätkäsaaren ja Kalasataman alueilla, joissa jäte pääsääntöisesti kerätään jätteen putkikeräysjärjestelmällä, ja verrata jätteen putkikeräysjärjestelmää perinteiseen jätteenkeruuseen. Lisäksi tässä työssä kartoitetaan alueiden asukkaiden lajittelutehokkuutta ja heidän kokemuksiaan järjestelmästä.

Tässä tutkimuksessa tarkastellaan pääasiassa yhdyskuntajätettä, jota syntyy kotitalouksista. Jätteen putkikeräysjärjestelmällä kerätään sekajätettä, biojätettä, paperia ja kartonkia. Lisäksi muita jätejakeita, kuten lasia, metallia, suurta sekajätettä ja suurta pahvia, kerätään kierrätyshuoneissa.

Tämän tutkimuksen on tilannut Procofin Oy jätteen putkikeräyksen ja tehokkaan jätehuollon suunnittelun tueksi, sekä materiaalitehokkuuden ja jätekonsultoinnin kehittämiseksi. Tässä tutkimuksessa kerätyt tiedot auttavat parantamaan ekotehokkuutta Jätkäsaaressa ja Kalasatamassa sekä tulevilla alueilla, joihin suunnitellaan jätteen putkikeräysjärjestelmiä.

Asiasanat: jäte, jätteen putkikeräysjärjestelmä, Jätkäsaari, Kalasatama, Helsingin kaupunki

CONTENTS

1 INTRODUCTION

The European Union has an aim to guide Finland and its other member states towards a more resource-efficient Europe where recycling is optimized (European commission, 2015). At the moment, a lot of the community waste, as in waste generated in people's homes, has been mixed waste. This waste usually ends up in landfills. (Statistics Finland, 2013.) This means that the sorting-out process of waste needs to be improved.

According to Finland's new waste legislation, which was announced in May 2012, mixed household waste unsuitable for recycling should end up in a Waste-to-Energy plant instead of a landfill starting from the year 2014.

The Government Decree on landfills (331/2013 section 27 and 28) also states that placing organic waste at landfills will be forbidden from the beginning of 2016 (section 53). This aims to improve the recovery of waste and the development of waste treatment methods. Mixed waste is the largest waste component which the organic matter landfill ban will affect. (Wahlström, Laine-Ylijoki & Jermakka 2012, 19, 23.) It means that large amount of the community waste that used to go to landfills, now must be recycled or biologically processed.

It seems that there is a lot of room for improvement in the recycling efforts and also in the development and design of waste collection systems. A noteworthy alternative to the more traditional truck-based waste collection is the pipeline-based waste collection system, where waste travels from specific inlet points through an underground pipeline network to a waste collection station, from where it is taken for further processing depending on the waste component.

This research deals with the community waste that is generated in households in Jätkäsaari and Kalasatama, where waste collection is primarily carried out by a pipeline-based waste collection system. The collected waste components are mixed waste, biowaste, paper and cardboard. Other waste components, such as glass, metal, large mixed waste and large cardboard are collected in separate recycling rooms.

All waste components collected through the pipeline-based waste collection system in Jätkäsaari were examined and, for comparison, the mixed waste from Kalasatama. The pipeline-based waste collection system is almost identical in both areas, so it was not considered necessary to examine other waste components at this point.

The main objectives of this research were to collect accurate information about the composition and quantity of the waste that is collected through the pipeline-based waste collection system in Jätkäsaari and Kalasatama areas, and to compare the pipeline-based waste collection system to the traditional waste collection (garbage trucks and bins). Also the residents' experiences with the system, both in Jätkäsaari and Kalasatama, were collected.

The research questions that were prepared at the beginning of this research, helped to design the actual waste research, the questionnaire directed to the residents, and to specify the desired direction of the research.

The research questions were:

1) Does a pipeline-based waste collection system affect the quality of the waste?
2) How do the residents experience the system?
3) Is a pipeline-based waste collection system better (or worse) than the traditional waste management system?

The results of this research are used for

- the designing process of an automated pipeline-based waste collection system
- planning efficient waste management
- making material recycling more efficient
- planning waste consulting

2 BACKGROUND AND OBJECTIVES OF THE RESEARCH

This research was commissioned by Procofin Ltd. There was a need to collect accurate information for the designing process of an automated pipeline-based waste collection system. With that information, environmental efficiency in the case areas of Jätkäsaari and Kalasatama, and also in future areas where pipeline-based waste collection systems are implemented, could be improved.

There was also a need to get experiences from the residents about the functionality of the pipeline-based waste collection system, in order to indicate the possible problems, and to improve the service level and the overall satisfaction.

2.1 Waste acts, decrees and regulations in Finland

The Finnish waste legislation was renewed in 2012, when the new Waste Act (646/2011) and Decree (179/2012) came into force. The new waste legislation complies with the EU Waste Framework Directive (2008/98 / EC). According to the EU Waste legislation, all activities that produce waste are subjected to the following waste management hierarchy (Figure 1):

1) The first priority is to avoid generating any waste (*prevention*)
2) If waste is generated, it must be prepared for re-use or recycling (*preparing for re-use and recycling*)
3) If recycling is not possible, waste is primarily recycled as material or made into energy (*other recovery, e.g. energy recovery*)
4) Waste can be placed in landfills only if its use is not technically or economically feasible (*disposal*)
   (EU Waste Framework Directive 2008/98 / EC, article 4)

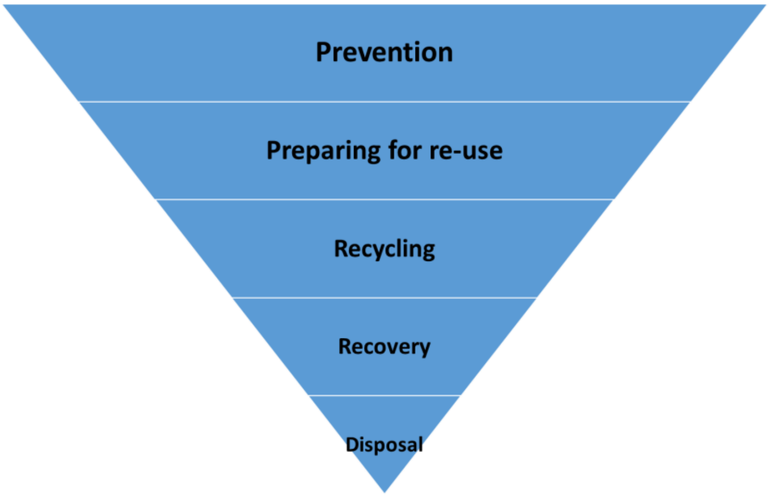

Figure 1. Waste hierarchy

The Metropolitan area and Kirkkonummi general waste management regulations are given on grounds of the Waste Act (646/2011 § 91) and their implementation is monitored by the Helsinki Region Environmental Services (HSY). The general waste management regulations apply to all residents of Helsinki, Espoo, Kauniainen, Vantaa and Kirkkonummi, as well as operators that are subjected to the waste management organized by HSY. The waste management regulations apply to traders only as far as it is necessary to prevent hazard and harm due to waste and waste disposal. (HSY, 2012, 3, 7.)

The regulations specify that recyclable material from municipal waste has to be separated and placed to separate bins according to the following conditions:

1) biowaste, if the residential property has at least ten (10) apartments, or if on a non-residential property at least fifty (50) kilograms is produced per week

2) cardboard, if the residential property has at least ten (10) apartments, or if on a non-residential property at least fifty (50) kilograms is produced per week

3) glass, if the residential property has at least twenty (20) apartments, or if on a non-residential property at least fifty (50) kilograms is produced per week

4) metal, if the residential property has at least twenty (20) apartments, or if on a non-residential property at least fifty (50) kilograms is produced per week

5) large cardboard, if on a non-residential property at least fifty (50) kilograms is produced per week (HSY, 2012.)

The responsibility to organize the collection of paper waste is on the producers as mentioned in section 48 of the Waste Act.

2.2 Waste management in Helsinki

The municipality of Helsinki has arranged its waste management alongside with the municipalities of Espoo, Kauniainen and Vantaa by establishing the Helsinki Region Environmental Services (HSY). One of its primary tasks is the reception and treatment of waste, invoicing of waste charges and waste guidance (the Waste Act 646/2011, section 43).

HSY commissioned a sorting survey from TNS Gallup in autumn 2014. The survey was directed to the residents of the Helsinki metropolitan area and Kirkkonummi. Over 1000 inhabitants responded to the survey and the results indicated that residents sort out their waste more enthusiastically than before. In particular, women proved to be diligent sorters. (HSY, 2015a.)

According to the survey, sorting glass and metal has increased the most. Glass was sorted always or often by 71 % of the respondents and metal by 59 % of the respondents. In the previous year, glass was sorted by 64 % and metal by 51 % of the respondents. (HSY, 2015a.)

In addition, the sorting of hazardous waste, scrap metal and biowaste has increased. Sorting cardboard has declined slightly from the previous year. (HSY, 2015a.)

According to the survey, residents perceive the use of mixed waste for energy as a good thing. Of all the respondents, 92 % welcomed the fact that mixed waste is used for energy in the Vantaa Energy's Waste-to-Energy power plant. The majority of respondents (67%) felt that using mixed household waste for energy is a very good thing, and a quarter of the respondents (25%) felt it was a good thing. Less than one percent of the respondents had a negative opinion. (HSY, 2015b.)

The change in the treatment of mixed waste was seen positive by highly educated people, people in high positions, as well as by seniors. The most critical attitude towards burning mixed waste was in the 25-34 age group, people that had a lower level of education, as well as the unemployed. (HSY, 2015b.)

2.3 Pipeline-based waste collection systems

The use of underground waste management systems in urban areas has increased within the last two decades (ISWA, 2013, 8). One of the first underground pipeline-based waste collection systems was installed in Disney World, Florida in the early 1970`s (ISWA, 2013, 23). After that, other areas around the world from Wembley city (Great Britain) to Abu Dhabi (UAE) and Barcelona (Spain) have either replaced traditional waste management with an underground pipeline-based waste collection system, or installed the system in a new urban area (ISWA, 2013, 24-27).

The first pipeline-based waste collection system in an urban housing area in Finland was installed in Suurpelto, Espoo in 2009. Other pipeline-based waste collection systems in Finland can be found in Jätkäsaari (Helsinki), Kalasatama (Helsinki) and Vuores (Tampere), and similar systems are built in Kivistö (Vantaa) and in Kruunuvuorenranta (Helsinki).

There are many advantages for using a pipeline-based waste collection system, such as benefits for the environment, satisfaction of the residents and users of the system, and benefits even for the economy.

As Table 1 shows, a pipeline-based waste collection system allows a more efficient, cleaner and safer waste management. This is beneficial to the city`s environmental conditions and for the overall image.

Table 1. Advantages and disadvantages of the pipeline-based waste collection system (ISWA, 2013, 14)

Advantages	Disadvantages
Minimized operation cost and long term savings	Heavy construction operations needed requiring high investment costs
Ability to collect apparently all waste streams	Cannot collect large items, bulky wastes, WEEE and has difficulties with glass wastes
Flexible system with the ability to easily adopts to changes	After installation the flexibility of the system is reduced
Minimized usage of garbage collection trucks in urban areas	Truck transportation is not eliminated
Minimized noise, aesthetic pollution and odor problems	Risk of problems related to pipe blockages
Release of surface space for community needs or development	Public willingness and training to proper disposal required
Enhanced safety for collection workers (hygiene, accidents, etc.)	Experienced workforce is required

The pipeline-based waste collection system causes less noise and reduces carbon dioxide emissions due to reduced waste-truck traffic. Because the waste travels through an underground pipe network to a spesific point, a waste collection station, there is less need for the transport of waste. The need for stops, as well as loading and unloading of waste containers, are also significally reduced. (Envac, 2008.)

Hygiene is also improved. The residential areas and working places are cleaner, and because there is no lifting, pulling or risk of infection or cuts, the waste collectors` working environment is improved since physical contact with the waste has been eliminated. (Envac, 2008.)

The investment costs for a pipeline-based waste collection system are higher, but this is offset by the considerably lower operating and maintenance costs, and also the substantial space savings when the collection of waste in separate waste rooms in each building are decreased. (Envac, 2008.) When comparing to traditional waste management, after a bit higher investment costs, the operating costs of a pipeline-based waste collection system will be much lower. The pipeline-based waste collection system is a viable option expecially for urban, densely populated areas.

2.4 Pipeline-based waste collection system in Jätkäsaari and Kalasatama

The City of Helsinki put to tender different waste management systems and the decision to install Envacs` automated underground pipeline-based waste collection system was made in 2011. The waste collection system was commissioned by Jätkäsaaren jätteen putkikeräys Oy and Kalasataman jätteen putkikeräys Oy, which are non-profit sub companies of the City of Helsinki.

The installation of the pipeline-based waste collection system in Jätkäsaari and Kalasatama began in May 2011 in Jätkäsaari and Kalasatama. The system will be completed in full in Jätkäsaari in 2025. At that point, there will be approximately 165 inlet points, 10 kilometres of pipeline and approximately 19 tons of waste will be collected per day.

The pipeline-based waste collection system will be fully completed in Kalasatama in 2030. At that point, there will be approximately 180 inlet points, 13 kilometres of pipeline and approximately 21 tons of waste will be collected per day.

In both areas, each property has their own determined waste collection points. The waste collection points (inlet points) are usually located in connection to the exits in each block. The resident or an employee sorts out the waste to mixed waste, biowaste, paper and cardboard, and take them to the appropriate inlet point.

The inlet points used by the residents are circular and have a diameter of 300 mm. The paper inlets have also a volume control to prevent simultaneous input of excessive amounts of waste.

The inlet point hatches open with a personal smart key (RFID-key, Figure 2). The electric locks in the inlet points prevent outsiders from using or vandalizing the system. The smart keys are encoded for each apartment and business premises.

Figure 2. RFID-key in Jätkäsaari

The pipeline-based waste collection system works on automation. The emptying of the inlet points are done automatically using underpressure. Each inlet point is emptied two times a day, or when the sensors in the inlet points identify that the temporal storage container is full.

The emptying is done in the order of waste purity. Biowaste is emptied first. After biowaste, mixed waste is emptied and it cleans the pipe network from biowaste residue. After mixed waste, waste that is suitable for material recycling is emptied. First paper, and finally cardboard.

Using an underground pipe network, the waste travels from the inlet points to the waste collection station and to their designated waste containers. In Jätkäsaari there is a waste collection station beneath the Hyväntoivonpuisto park and in Kalasatama beneath Kalastama Centre REDI.

Waste collection vehicles pick up the full containers from the stations and transport the waste for further processing. The waste is utilized as recycled material (paper and cardboard), incinerated for energy (mixed waste) or turned into compost soil (biowaste).

Mixed waste is transported to Vantaa Energy`s Waste-to-Energy plant in Långmossebergen in Eastern Vantaa where it is incinerated to produce heat and electricity. Biowaste is transported to the Ämmässuo Waste Treatment Center in Espoo, where it is composted into soil. Cardboard is recycled into paper roll cores, paper sacks, paper bags and book binding cardboard. Paper is recycled into newspaper, toilet paper and kitchen paper. (Jätkäsaaren jätteen putkikeräys Oy, 2014.)

The pipeline-based waste collection system works as shown below and in Figure 3.

1) Each waste component has its own inlet point.
2) Waste is stored in a temporal storage container operated by a valve for a short period. When the computer-controlled emptying process starts, the valve opens and one waste fraction is collected at a time.

3) Each waste fraction is transported through the same underground pipe network at a speed of 70 km/h.
4) Fans in the waste collection station create underpressure that sucks the waste to the collection station.
5) Waste is directed to the right container.
6) Before releasing the transport air, the air is cleaned through special filters.
7) Mixed waste, paper and cardboard are compressed, biowaste is not.

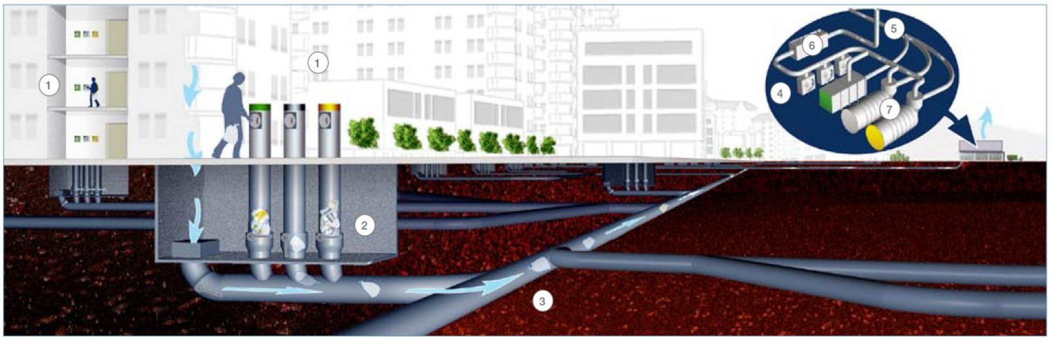

Figure 3. Pipeline-based waste collection system, stationary system (Envac, 2008)

2.5 Recycling rooms in Jätkäsaari and Kalasatama

Waste components that are not collected in the pipeline-based waste collection system but are obligated to be collected (according to the Metropolitan area and Kirkkonummi general waste management regulations), are collected in recycling rooms.

The recycling rooms are either regional (in Jätkäsaari) or located in each block (in Kalasatama). The waste components that are collected in the recycling rooms are glass, metal, large cardboard and large mixed waste.

Large mixed waste consists of waste items that are too big for the pipeline-based waste collection system, e.g. old carpets or broken hockey sticks. Large mixed waste, however does not consist of furniture, mattresses or household appliances. Large cardboard consists of e.g. whole pizza boxes and cardboard boxes that are too big for the pipeline-based waste collection system.

2.6 Jätkäsaari

Jätkäsaari is a new residential area built on the southwest tip of Helsinki in the West Harbour district (Figure 4).

Figure 4. Jätkäsaari (City of Helsinki map services, 2015)

The construction of Jätkäsaari started in 2009 and will be finished in 2025. At this time there will be approximately 17 000 residents and 6 000 jobs in Jätkäsaari. (City of Helsinki, Jätkäsaari.)

The pipeline-based waste collection in Jätkäsaari is divided into two areas: area 1 and area 2. Area 1 contains at the moment Saukonpaasi (Figure 5). There are residential houses and offices in the area. During this research, there were 800 residents in area 1.

Area 2 contains at the moment the north side and the west side of Hyväntoivonpuisto (Figure 5). There are residential houses, offices, a restaurant, coffee shops and retailers in the area. During the research, there were 2 375 residents in area 2.

Figure 5. Area 1 and 2 at the moment (City of Helsinki map services, 2015)

There are both rented flats and owner-occupied houses in Jätkäsaari. The age distribution ranges from elderly people to students and families with small children.

In Jätkäsaari there are regional recycling rooms. The recycling rooms are designed to be located in such a way that they are at a reasonable distance from each property. Waste transportation can be done mainly on foot. All residents in Jätkäsaari can use the recycling rooms. Currently one recycling room is completed in Jätkäsaari, and there are also two temporary recycling containers (Figure 6). As Jätkäsaari area is built, new recycling rooms will be completed.

Figure 6. Recycling room and containers in Jätkäsaari (City of Helsinki map services, 2015)

2.7 Kalasatama

Kalasatama is a new residential area built on the eastern inner city of Helsinki (Figure 7).

Figure 7. Kalasatama (City of Helsinki map services, 2015)

The construction of Kalasatama started in 2009, and construction will proceed one area at a time. The first area that will be completed is Sörnäistenniemi.
The whole area will be finished in 2030. At this time there will be approximately 20 000 residents and 8 000 jobs in Kalasatama. (City of Helsinki, Kalasatama.)

At the moment, there are residential houses, a restaurant and a retailer in Kalasatama. The residential houses range from rented flats to owner-occupied houses. The age distribution in the area is wide, including homes for elderly people, student apartments and homes for families with small children. During the research there were 1 820 residents in Kalasatama.

In Kalasatama, each block has their own recycling room. Currently five (5) recycling rooms are completed in Kalasatama (Figure 8) and as the area is built, new recycling rooms will be completed.

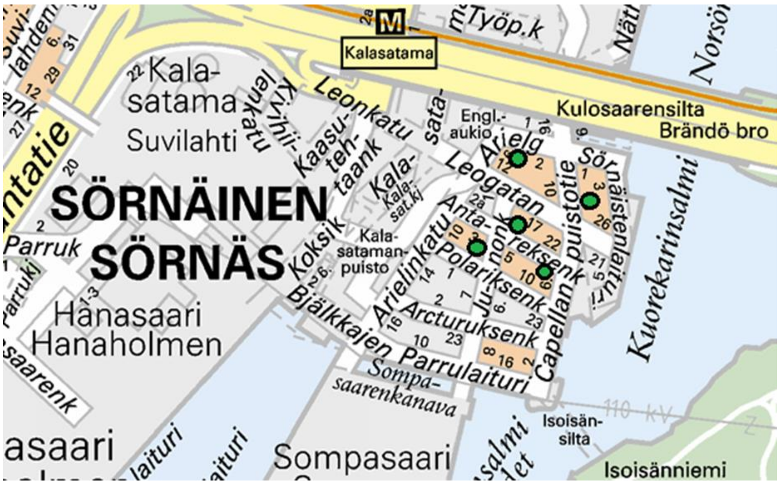

Figure 8. Recycling rooms in Kalasatama (City of Helsinki map services, 2015)

3 RESEARCH METHODS

3.1 Planning

The waste research started by familiarizing with previous researches made in Finland about the quantity and quality of waste in the Helsinki metropolitan area. The same researches serve as reference material for this research. The best research method for this research was defined and research weeks were set in September and October 2014.

A separate work description was done to each of the waste researches. An example of a work description can be found in Appendix 1.

The result collection form was made for each waste fraction and it was fulfilled during each research day. An example of a result collection form can be found in Appendix 2.

3.2 Mixed waste and biowaste

The research on mixed waste and biowaste was conducted in a way that the results would be comparable to the research made in 2011 about the properties of biowaste in the Helsinki metropolitan area and the research made in 2012 about the properties of mixed waste in the Helsinki metropolitan area, both done by the Helsinki Region Environmental Services Authority (HSY).

The research on mixed waste and biowaste was held in September 2014 (week 37, 9.-11.9.2014). The waste collection week (week 36) was chosen in such a way that the week would represent the seasonal characteristic of the amount and quality of waste as good as possible and that the results would be comparable to the results of the previous researches.

The weather during the collection week was partly cloudy and the temperature was 12-18°C.

Fifteen (15) waste components were selected for the research of mixed waste. The waste components were biowaste, garden waste, packaging plastic, other plastic, paper, soft paper, packaging cardboard and other cardboard, packaging metal and other metal, packaging glass and other glass, hazardous waste, other combustible waste and other incombustible waste. The description of each waste component can be found in Appendix 3.

Six (6) waste components were selected for the research of biowaste. The waste components were biowaste, biodegradable bags, mixed waste, fiber (paper, cardboard etc.), metal and glass.

The waste loads were sorted in Ämmässuo Waste Treatment Centre in an outer hall. HSY's staff provided the needed equipment, did the necessary arrangements and assisted in the transfer of large amounts of waste. Waste sorting was carried out by employees from Procofin Ltd. The sorting of waste was carried out by 2-4 persons during each morning of the research.

3.3 Paper and cardboard

The research on paper and cardboard was held in October 2014 (week 42, 20.-21.10.2014). The waste collection week (week 41) was chosen in such a way that the week would represent the seasonal characteristic of the amount and quality of that waste as good as possible.

The weather during the collection week was cloudy and the temperature was 10-17°C.

Five (5) waste components were selected for the research of paper. The waste components were paper, plastic, biowaste, cardboard and other waste (e.g. metal, glass).

Plastic was separated from the rest of the waste because it causes the most problems in paper machines and ruins the recycled paper. Plastic is shown as black holes and patches in the finished product and the product usually have to be discarded (Suomen keräystuote Oy).

Four (4) waste components were selected for the research of cardboard. The waste components were cardboard, paper, biowaste and mixed waste.

The waste loads were sorted in Paperinkeräys Ltd's premises in Vantaa in an outer hall. Paperinkeräys Ltd's staff did the necessary arrangements and assisted in the transfer of large amounts of waste. Procofin Ltd provided the needed equipment and the sorting of waste was carried out by 2 employees from Procofin Ltd during each morning of the research.

3.4 Sampling and sorting by hand

Procofin Ltd provided the needed personal protection items, such as protective coveralls, cut resistant gloves, eye protection and respirators.

The sorting of mixed waste took place in a sorting table over a sieve (50 mm). The phases of the sieving process can be seen in Table 2.

Table 2. Sieving phases

Phase	Task
1	The waste was transferred from the buckets to the sieve.
2	The sieve (50 mm) was shaken in such a way that the underflow went through the sieve. Material remaining in the sieve was sorted by hand to the buckets around the sorting table.
3	The underflow (particle size less than 50 mm) were transferred by hands to the relevant buckets.
4	The buckets were weighed and the weights were checked. The combined weight had to be equal to the total weight of the samples at the beginning.

The waste was transferred from the buckets to the sieve. The sieve was shaken in such a way that the underflow went through the sieve. Material remaining in the sieve was sorted by hand to the buckets around the sorting table according to the sorting guidelines (Appendix 3). The underflow of the sieve formed the fine particles. Those waste components that clearly were recognizable, such as metal and glass, were transferred to the appropriate waste bucket. The rest of the underflow were classified as biodegradable fine particles.

The sorting of biowaste also took place on the sorting table. No sieve was used due to the fact that the sample was so small. The biowaste was sorted by hand to the buckets around the sorting table.

The sorting of paper and cardboard was carried out in the ground of the hall. The chosen waste components from the composite sample were sorted by hand to the buckets around the sorters.

The identification of the sorted waste components were done visually. The different waste components were separated from each other. If the waste was clearly of one waste component by the most part, the waste was sorted according to the heavier waste component, e.g. a packaging that contained a large quantity of food was placed to the biowaste. The aim of this was to get the actual weight of the samples. The weight of the bucket or bin is not included to the weight of the waste.

If the waste was not identifiable, the waste was sorted to either other combustible waste or other incombustible waste.

3.5 Recycling rooms

During this research, the accumulation of waste in the recycling rooms was monitored. The filling of the waste bins were assessed visually for a month. The selected monitoring period was from week 32 to week 36.

Large cardboard was emptied twice a week and large mixed waste once a week in Jätkäsaari. In Kalasatama both large cardboard and large mixed waste were emptied once a week. Glass and metal were emptied once a month. The monitoring period was chosen in such a way that it was a month before the waste research. The monitoring process of each waste component was initiated after emptying of the bins and was discontinued after one month.

3.5.1 Calculating the waste

In this research, the used density for glass and metal are estimates given by the HSY (Pyykkö, L. 2013, 3):

- Glass 270 kg/m³
- Metal 120 kg/m³

The density of large mixed waste is 100 kg/m³. This is an estimate that has been calculated from the mixed waste data received from HSY.

The density of large cardboard is 50 kg/m³. This is an estimate that has been modified from the data received from HSY.

Glass and metal are collected to 240-liter waste bins, large mixed waste is collected to 800-liter waste bins and cardboard is collected to trollies (0.85 m³). In the two recycling containers in Jätkäsaari, metal is collected to 660-liter waste bins.

The filling degree in waste bins was evaluated visually. The degree of filling was multiplied with the full weight of the waste bin to receive the weight of the waste.

Below is an example of the calculation formula:

Glass collection bin (240 liter), the degree of filling is 90%

$$\frac{270\ \text{kg} / \text{m}^3}{1000} = 0{,}27\text{kg / liter}$$

0.27 kg/liter x 240 liter= 64.8 kg

64.8 kg x 0.9 = 58.32 kg

A glass waste bin that is 90% full, weighed approximately 58 kilograms.

4 CASE JÄTKÄSAARI

During the sampling period in September, there were 3 175 residents in Jätkäsaari.

Research area 1 (mixed waste) has approximately 800 residents and research area 2 (biowaste, paper and cardboard) has approximately 2 375 residents.

In Jätkäsaari there are three (3) regional recycling rooms. The waste accumulation may be affected because of that, and it may affect the quantity and quality of waste in the containers of the pipeline-based waste collection system. This has been taken into account.

4.1 Mixed waste

The mixed waste container was brought from the Jätkäsaari waste collection station to the Ämmässuo Waste Treatment Centre on Tuesday 9 September 2014. The container was weighed and the driver informed the samplers the weight of the container.

The sieve was assembled outside the outer hall and the plastic buckets were marked to represent each selected waste component. There were fifteen (15) selected waste components. The waste components were biowaste (biowaste and garden waste), plastic (packaging plastic and other plastic), paper (paper and soft paper), cardboard (packaging cardboard and other cardboard), metal (packaging metal and other metal), glass (packaging glass and other glass), hazardous waste, other combustible waste and other incombustible waste.

The content of the container was emptied to the concrete floor of the outer hall in the Waste Treatment Centre. Visual observation of the waste was done: how many intact garbage bags there were (%), how much loose waste (%), what was the quality of the waste (in other words, if it represented the waste component).

Representative samples of the waste were taken into three (3) big bins. The samples were examined and sorted through a sieve (50 mm) by hands (Figure 9). Particle size bigger than 50 mm was overflow and particle size smaller than 50 mm was underflow.

Figure 9. Sorting table and sieving (Photo: Inna Harju)

The waste was sorted according to the sorting instructions (Appendix 3). In situations where the waste was a combination of two wastes (e.g. yoghurt carton that contained yogurt), the waste was sorted according to the waste which was heavier. If the waste was not identifiable, the waste was sorted to either other combustible waste or other incombustible waste.

The underflow of the sieve (less than 50 mm) were gathered together and weighed after recognizable waste components (such as metal and glass) were taken out of the underflow and put to their designated buckets.

The buckets and the bins were weighed before and after the sorting, and the weights were recorded. The used scale was an electronical scale with a precision of 0.2 kilograms and measuring range of 0-50 kilograms.

Photographs were taken through the whole process. The buckets and the bins were cleaned after use.

4.1.1 Results

The share of intact bags of the total waste volume was approximately 20% and the volume of loose waste was approximately 80% (visual estimate). This shows that a big part of the waste bags put in the inlet point shatter on the way to the container or in the container.

The weight of the mixed waste in the container was 8 780 kilograms. The container had collected mixed waste for a month. Each resident in Jätkäsaari produces 132 kilograms approx. of mixed waste per year. This was obtained by dividing the weight of the container with the number of residents and multiplying it by 12 (number of months in one year):

$$\frac{8\ 780\ \text{kg}}{800\ \text{residents}} \times 12 = 132\ \text{kg/resident/year}$$

The composition of mixed waste is shown in Table 3 and Figure 10. The description of each waste component can be found in Appendix 3.

Table 3. Composition of waste in mixed waste sample, Jätkäsaari

	Weight (kg)	**Weight - %**
Container	8780,00	
Composite sample	30,72	0,35
Waste component:		
biowaste	0,84	2,82
garden waste	0,06	0,20
packaging plastic	5,50	18,49
other plastic	3,00	10,09
paper	2,48	8,34
soft paper	1,08	3,63
packaging cardboard	2,68	9,01
other cardboard	0,72	2,42
packaging metal	1,14	3,83
other metal	0,38	1,28
packaging glass	0,06	0,20
other glass	0,02	0,07
hazardous waste	0,00	0,00
other combustible waste	6,08	20,44
other incombustible waste	0,06	0,20
corrugated cardboard	1,08	3,63
fine particles	4,56	15,33
IN ALL	29,74	
loss	0,98	

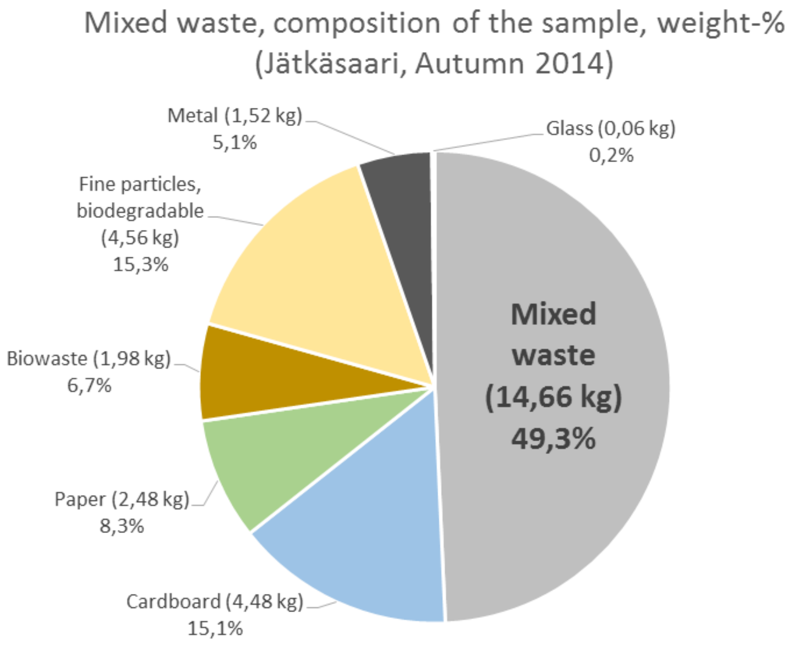

Figure 10. Composition of waste in mixed waste sample, Jätkäsaari

Almost half of the total waste was mixed waste (about 49 weight-%). The weight-% of mixed waste was obtained by summing up plastics (packaging plastic and other plastic) and other waste (combustible and incombustible waste).

Of recyclable fiber material (paper and cardboard) nearly 7 kilograms was found. This is about 24 weight-% of the total sample. The fiber material was a little bit damp, so this might have had an effect on the weight.

Of recyclable metal 1.52 kilograms was found. This is about 5 weight-% of the total sample. Of recyclable glass 0.06 kilograms was found. This is about 0.2 weight-% of the total sample. Biowaste and biodegradable fine particles weighed about 6.5 kilograms. This is 22 weight-% of the total sample.

One striking observation was that there was a lot of paper in the mixed waste. One possible reasons for this might be that the volume control in the paper inlet point caused the residents to throw their paper waste into the mixed waste inlet points.

The weight difference between the composite sample and the combined samples (single samples) was 0.98 kilogram. The reasons for this could be that some of the waste fell to the ground during the sieving process or when the waste was transferred from the buckets to the sieve. Evaporation or that small waste residues were left on the sieve or in the buckets may also have affected the weight. The difference between the weights was expected, and it was 3% of the composite sample.

4.2 Biowaste

The biowaste container was brought from the Jätkäsaari waste collection station to the Ämmässuo Waste Treatment Centre on Thursday 11 September 2014. The container was weighed and the driver informed the samplers the weight of the container.

The plastic buckets were marked to represent each waste component. There were six (6) selected waste components. The waste components were biowaste, biodegradable bags, mixed waste, fibre (paper, cardboard etc.), metal and glass.

The content of the container was emptied to an empty lot in the Waste Treatment Centre (near the biowaste treatment hall). Visual observation of the waste was done: how many intact biowaste bags there were (%), how much loose waste (%) and what was the quality of the waste (in other words, did it represent the waste component).

A representative sample of the waste was taken to a big bin (Figure 11).

Figure 11. Taking the biowaste sample (Photo: Inna Harju)

The sample was examined and sorted in a sorting table. The remaining fine particles were put to the biowaste bucket.

The buckets and the bins were weighed before and after the sorting, and the weights were recorded. The used scale was an electronical scale with a precision of 0.2 kilograms and measuring range of 0-50 kilograms.

The buckets and the bins were cleaned after use. Photographs were taken through the whole process.

4.2.1 Results

Biowaste from the container mostly consisted of fine particles. A few biodegradable bags were found, some of which were broken (either in the inlet point or in the container). Biowaste may have started to compose spontaneously in the container, which would explain the large amount of fine particles.

There was also a lot of paper in the biowaste. One possible reasons for this might be that the volume control in the paper inlet point is causing residents to throw their paper waste to biowaste inlet points or use bags made of paper as biowaste bags. Paper is biodegradable but it is preferred as a recyclable material.

The weight of the biowaste in the container was 680 kilograms. The container had collected biowaste for a week. Each resident in Jätkäsaari produces 15 kilograms approx. of biowaste per year. This was obtained by dividing the weight of the container with the number of residents and multiplying it by 52 (number of months in one year):

$$\frac{680\ \text{kg}}{2\ 375\ \text{residents}} \times 52 = 15\ \text{kg/resident/year}$$

Composition of biowaste is shown in Table 4 and Figure 12.

Table 4. Composition of waste in biowaste sample, Jätkäsaari

	Weight (kg)	Weight - %
Container	680,00	
Composite sample	19,02	2,80
Waste component:		
biowaste	12,90	68,40
biodegradable bags	0,84	4,45
mixed waste	1,48	7,85
fiber	3,62	19,19
metal	0,02	0,11
glass	0,00	0,00
IN ALL	18,86	
loss	0,16	

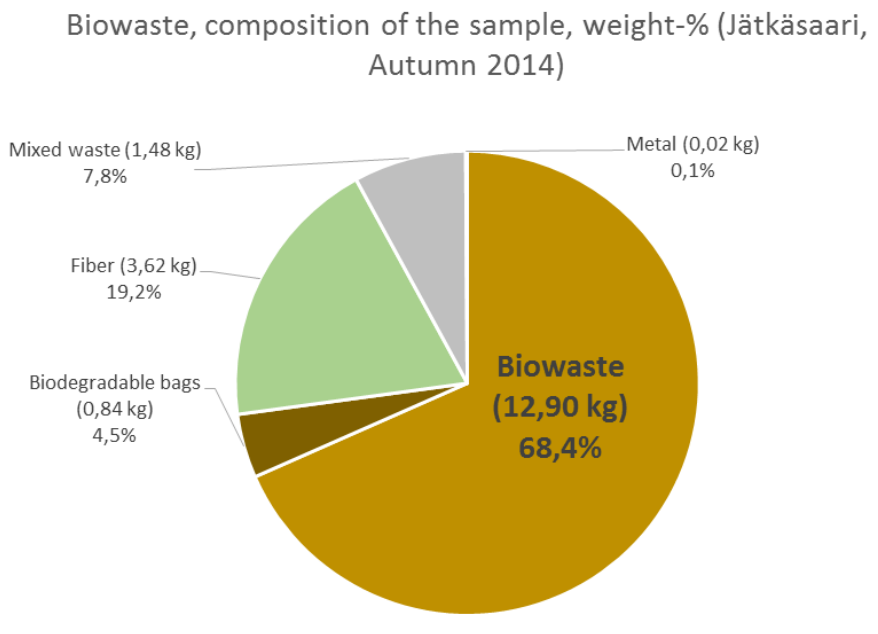

Figure 12. Composition of waste in biowaste sample, Jätkäsaari

Over 70 % of the total sample weight was biowaste (biowaste and biodegradable bags). About 19% was fiber (paper and cardboard), which is biodegradable, and about 8% was non- biodegradable (mixed waste and metal). Mixed waste consisted mainly of pieces of a pot made of clay. No glass was found in the sample.

The weight difference between the composite sample and the combined samples (single samples) were 0.4 kilogram. The reasons for this could be that some of the waste fell to the ground during the sorting process or e.g. when the waste was transferred from the buckets to the sorting table. Evaporation or that small waste residues were left on the sorting table or in the buckets may also have affected the weight. The difference between the weighs was expected, and it was only 1.4 % of the composite sample.

4.3 Paper

The paper container was brought from the Jätkäsaari waste collection station to the Paperinkeräys Ltd's premises in Vantaa on Monday 20 October 2014. The container was weighed and the weight was informed to the samplers at the end of the day.

The content of the container was emptied to the concrete floor of the hall (Figure 13).

Figure 13. The content of paper container from Jätkäsaari (Photo: Inna Harju)

The pile of waste was mixed by a wheel loader to achieve a more representative sample. Visual observation of the waste was made: how much of the waste was paper and if there was any other waste.

The container consisted mostly of paper, so differing from the earlier researches, a representative sample of the other waste found in the container was taken to a big bin. The sample was examined and sorted.

Plastic buckets were marked to represent selected waste components. There were four (4) selected waste components: plastic, biowaste, cardboard and other waste.

The buckets and the bins were weighed before and after the sorting, and the weights were recorded. The precision of the used scale was 0.5 kilogram. This affected the sample weights.

Photographs were taken through the whole process, and at the end of the day, the buckets and the bins were cleaned after use.

4.3.1 Results

The estimation of paper in the whole container was 95% approx. of the whole container (visual estimate). The quality of the paper was not the best, it was slightly damp (the reason might be because there was other waste in the container that may have caused dampness), but the load was accepted by Paperinkeräys Ltd.

The weight of the paper in the container was 1 680 kilograms. The container had collected paper for a week. Each resident in Jätkäsaari produces 37 kilograms approx. of paper per year. This was obtained by dividing the weight of the container with the number of residents and multiplying it by 52 (number of months in one year):

$$\frac{1\ 680\ \text{kg}}{2\ 375\ \text{residents}} \times 52 = 37\ \text{kg/resident/year}$$

The sample, that was taken, was from the other waste found in the container. The sample of the other waste components weighed 8 kilograms and it was 0.05% of the total weight of the container.

Composition of other waste in the paper sample is shown in Table 5 and Figure 14.

Table 5. Composition of other waste in paper waste sample, Jätkäsaari

	Weight (kg)	**Weight - %**
Container	1680,00	
Composite sample	8,00	0,48
Waste component:		
cardboard	0,75	10,00
other waste (e.g. mixed waste)	1,25	16,67
biowaste	2,50	33,33
plastic	3,00	40,00
IN ALL	7,5	
loss	0,50	

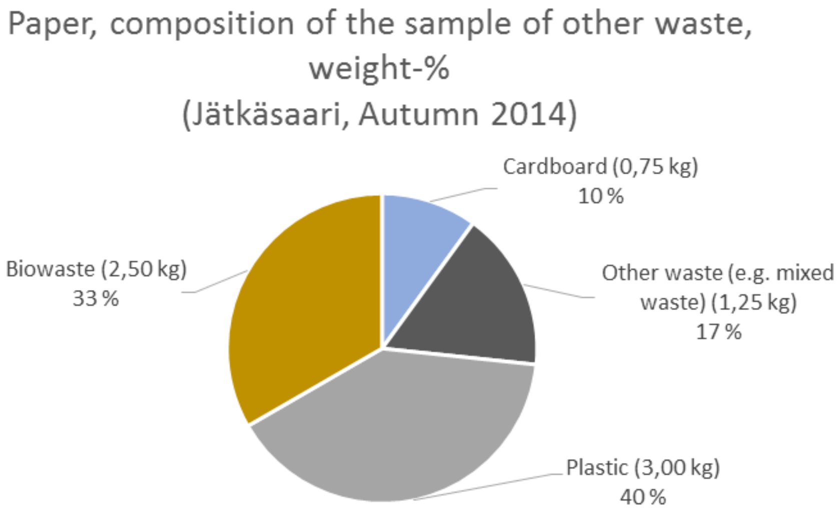

Figure 14. Composition of other waste in paper waste sample, Jätkäsaari

The amount of plastic in the taken sample was 3 kilograms. It is 40% of the whole sample weight. Of the whole container weight it is only 0.002%.

The amount of biowaste in the sample was 33 weight-% (2.5 kg) and cardboard 10 weight-% (0.75 kg).

Other waste (17 weight-%) contained mixed waste, electrical and electronic equipment (mobile phone) and metal (e.g. BBQ- pliers, hair spray bottle, toilet brush). It weighed 1.25 kilograms.

The weight difference between the composite sample and the combined samples (single samples) were 0.50 kilogram. The reasons for this could be evaporation or the sensitivity of the used scale. The difference between the weights was expected, and 6 % of the composite sample.

4.4 Cardboard

The cardboard container was brought from the Jätkäsaari waste collection station to the Paperinkeräys Ltd's premises in Vantaa on Tuesday 20 October 2014. The container was weighed and the weight was informed to the samplers at the end of the day.

The content of the container was emptied to the concrete floor of the hall. The pile of waste was mixed by a wheel loader to achieve a more representative sample. Visual observation of the waste was made: how much of the waste was paper and was there any other waste.

A representative samples of the waste was taken to two (2) big bins (80 litre). Plastic buckets were marked to represent selected waste components. There were four (4) selected waste components: cardboard, paper, biowaste and mixed waste.

The buckets and the bins were weighed before and after the sorting (Figure 15), and the weights were recorded. The precision of the used scale was 0.5 kilogram. This affected the sample weights.

Figure 15. Weighing of the waste (Photo: Inna Harju)

Photographs were taken through the whole process, and at the end of the day, the buckets and the bins were cleaned after use.

4.4.1 Results

The estimation on cardboard in the whole container was less than 50% (visual estimate). The rest was other waste that had for some reason ended up in the cardboard container. Possible reasons for this might be that the volume control in the paper inlet point is causing residents to throw their paper waste to other inlet points, poor sorting, waste was left in the pipe of the pipeline-based waste collection system and when the cardboard was sucked to its own container, the waste left in the pipes was sucked along.

The cardboard load was not accepted and it was sent to the Vantaa Waste-to-Energy plant for incineration.

Composition of cardboard sample is shown in Table 6 and Figure 16.

Table 6. Composition of waste in cardboard waste sample, Jätkäsaari

	Weight (kg)	**Weight - %**
Container	680,00	
Composite sample	14,50	2,13
Waste component:		
cardboard	5,00	35,09
corrugated cardboard	1,00	7,02
paper	3,00	21,05
mixed waste	2,50	17,54
biowaste	2,75	19,30
IN ALL	14,25	
loss	0,25	

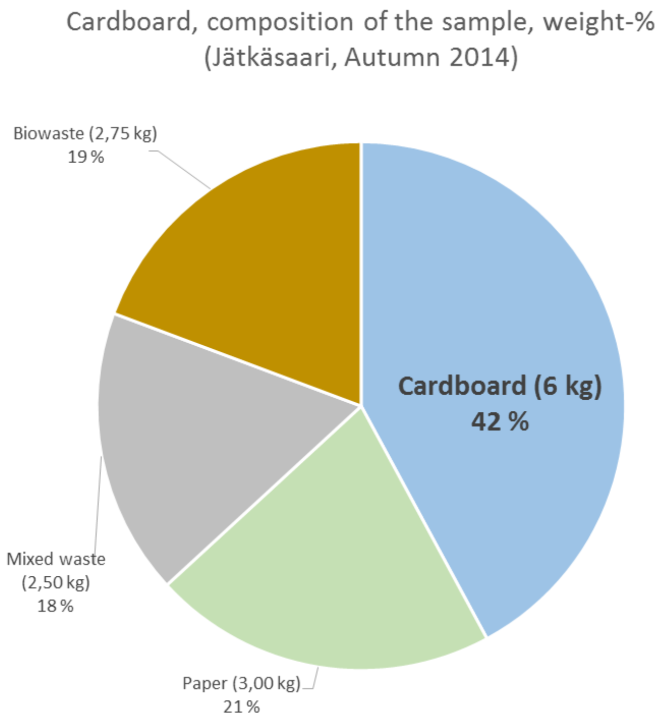

Figure 16. Composition of waste in cardboard waste sample, Jätkäsaari

Only 42 % of the total sample weight was cardboard. A small amount of paper is acceptable in cardboard, but fifth of the total weight is too much. There were 21% (3 kg) of paper in the sample.

About 19 weight-% (2.7 kg) was biowaste and 18 weight-% (2.5 kg) was mixed waste. No metal or glass was found in the sample.

The weight difference between the composite sample and the combined samples (single samples) were 0.25 kilograms. The reasons for this could be evaporation or the sensitivity of the used scale. The difference between the weights was expected, and 1.7 % of the composite sample.

4.5 Recycling rooms

There are three (3) recycling rooms in Jätkäsaari. The filling of the waste bins in the recycling rooms were assessed visually for a month. The selected monitoring period was from week 32 to week 36.

The filling of the recycling room waste bins were checked (on the afternoon) a day before the emptying (in the morning). Because of the time period between the checking and the emptying, the bins may have been fuller on the emptying day.

The amount of recycling room waste in Jätkäsaari is shown in Table 7. The calculation formula for the waste amount can be found in section 3.5.1

Table 7. The amount of recycling room waste in Jätkäsaari

	kg/month	kg/week	kg/resident/year
LARGE MIXED WASTE	2080	520	7,9
LARGE CARBOARD	1855	464	7,0
METALL	242	60	0,9
GLASS	586	147	2,2

In the large mixed waste bins there were mixed waste which should have been put to the pipeline-based waste collection system instead, such as small waste bags. In addition, there were also some waste that did not belong in the large mixed waste bins. These were mattresses and furniture that have been instructed to be taken by the residents to the HSY Sortti- station or to order a Nouto-Sortti for them (a chargeable pick-up service for large waste items).

5 CASE KALASATAMA

During the sampling period in September, there were 1 820 residents in Kalasatama.

In Kalasatama there are five (5) recycling rooms that are located in each block. The waste accumulation may be affected because of that, and it may affect the quantity and quality of waste in the containers of the pipeline-based waste collection system. This has been taken into account.

5.1 Mixed waste

The mixed waste container was brought from the Kalasatama waste collection station to the Ämmässuo Waste Treatment Centre on Wednesday 10 September 2014. The container was weighed and the driver informed the samplers the weight of the container.

The plastic buckets that were marked the day before (Jätkäsaari mixed waste research) were used. There were fifteen (15) selected waste components. The waste components were biowaste (biowaste and garden waste), plastic (packaging plastic and other plastic), paper (paper and tissue paper), cardboard (packaging cardboard and other cardboard), metal (packaging metal and other metal), glass (packaging glass and other glass), hazardous waste, other combustible waste and other incombustible waste.

The content of the container was emptied to the concrete floor of the outer hall in the Waste Treatment Centre. The pile of waste was mixed by a wheel loader to achieve a more representative sample. Visual observation of the waste was done: how many intact garbage bags there were (%), how much loose waste (%) and what was the quality of the waste (in other words, did it represent the waste component).

Representative samples of the waste were taken into three (3) big bins. The samples were examined and sorted through a sieve (50 mm) by hand (Figure 17). Particle size bigger than 50 mm was overflow and particle size smaller than 50 mm was underflow.

Figure 17. Sorting in Ämmässuo Waste Treatment Center (Photo: Inna Harju)

The waste was sorted according to the sorting instructions (Appendix 3). In situations where the waste was a combination of two wastes (e.g. yoghurt carton that contained yogurt), the waste was sorted according to the waste which was heavier. If the waste was not identifiable the waste was sorted to either to other combustible waste or other incombustible waste.

The underflow of the sieve (less than 50 mm) were gathered together and weighed after recognizable waste components (such as metal and glass) were taken out of the underflow and put to their designated buckets.

The buckets and the bins were weighed before and after the sorting, and the weights were recorded. The used scale was an electronical scale with a precision of 0.2 kilograms and measuring range of 0-50 kilograms.

Photographs were taken through the whole process. The buckets and the bins were cleaned after use.

5.1.1 Results

The share of intact bags of the total waste volume was about 10% and the volume of loose waste was 90% (visual estimate). This shows that a big part of the waste bags put in the inlet point shatter on the way to the container or in the container.

The weight of the mixed waste in the container was 3 180 kilograms. The container had collected mixed waste for a week. Each resident in Kalasatama produces 91 kilograms approx. of mixed waste per year. This was obtained by dividing the weight of the container with the number of residents and multiplying it by 52 (number of weeks in one year).

$$\frac{3\ 180\ \text{kg}}{1\ 820\ \text{residents}} \times 52 = 91\ \text{kg/resident/year}$$

Composition of mixed waste is shown in Table 8 and Figure 18. The description of each waste component can be found in Appendix 1.

Table 8. Composition of waste in mixed waste sample, Kalasatama

	Weight (kg)	**Weight - %**
Container	3180,00	
Composite sample	29,24	0,92
Waste component:		
biowaste	2,44	8,46
garden	0,01	0,03
packaging plastic	4,60	15,95
other plastic	2,82	9,78
paper	2,32	8,04
soft paper	1,72	5,96
packaging cardboard	2,62	9,08
other cardboard	0,14	0,49
packaging metal	0,76	2,64
other metal	0,04	0,14
packaging glass	0,10	0,35
other glass	0,00	0,00
hazardous waste	0,08	0,28
other combustible waste	4,79	16,61
other incombustible waste	0,00	0,00
corrugated cardboard	0,00	0,00
fine particles	6,40	22,19
IN ALL	28,84	
loss	0,40	

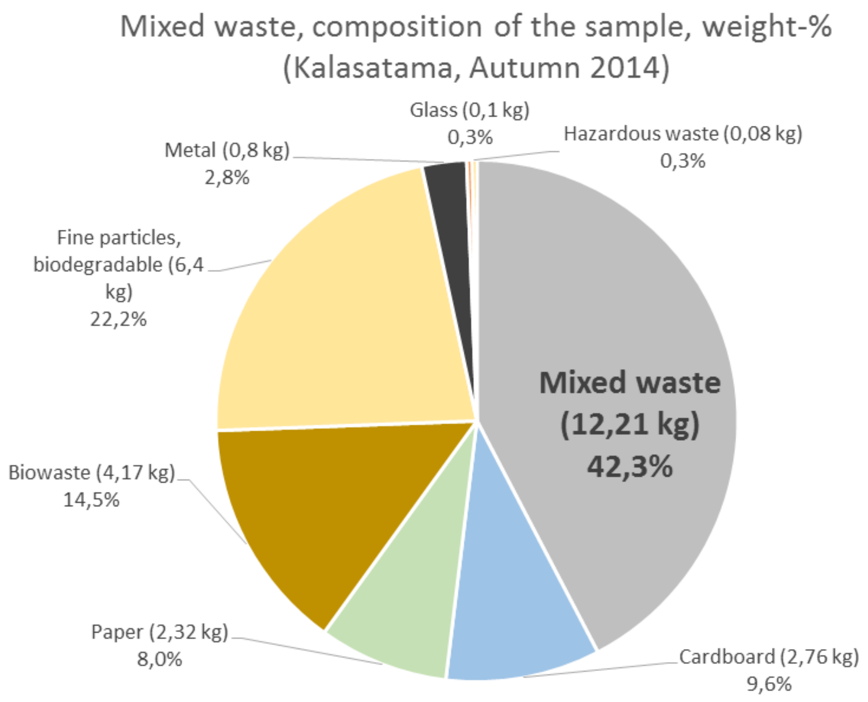

Figure 18. Composition of waste in mixed waste sample, Kalasatama

A little less than half of the total waste was mixed waste (about 42 weight-%). The weight-% of mixed waste was obtained by summing up plastics (packaging plastic and other plastic) and other waste (combustible and incombustible waste).

Of recyclable fiber material (paper and cardboard) nearly 5 kilograms was found. This is almost 18 weight-% of the total sample. The fiber material was a little bit damp, so this might have an effect on the weight.

Of recyclable metal 0.8 kilogram was found. This is about 2.8 weight-% of the total sample. Of recyclable glass 0.1 kilogram was found. This is about 0.3 weight-% of the total sample. Biowaste and biodegradable fine particles weighed about 10.6 kilograms. This is almost 37 weight-% of the total sample. One battery was found in the sample. This constitutes as hazardous waste.

The weight difference between the composite sample and the combined samples (single samples) were 0.4 kilograms. The reasons for this could be that some of the waste fell to the ground during the sieving process or when the waste was transferred from the buckets to the sieve. Evaporation or that small waste residues were left on the sieve or in the buckets may also affect the weight. The difference between the weights was expected, and it was only 1.4 % of the composite sample.

The mixed waste in Kalasatama was moister than the mixed waste in Jätkäsaari. The reason for this may be that the mixed waste pile from Kalasatama was mixed by a wheel loader before taking a sample, unlike the mixed waste pile from Jätkäsaari.

There was also larger amount of paper in the waste compared to the mixed waste in Jätkäsaari. This might be due to the fact that during the waste collection week there was a clog in the pipeline that had to be opened using compressed air. When there is a clog in the pipeline, compressed air drives the clog to the mixed waste container. This way the clog does not spoil pure waste components, such as paper and cardboard that are reusable material.

5.2 Recycling rooms

There are five (5) recycling rooms in Kalasatama. The filling of the waste bins in the recycling rooms were assessed visually for a month. The selected monitoring period was from week 32 to week 36.

The filling of the recycling room waste bins were checked (on the afternoon) a day before the emptying (in the morning). Because of the time period between the checking and the emptying, the bins may have been fuller on the emptying day.

The amount of recycling room waste in Kalasatama is shown in Table 9. The calculation formula for the waste amount can be found in section 3.5.1

Table 9. The amount of recycling room waste in Kalasatama

	kg/month	kg/week	kg/resident/year
LARGE MIXED WASTE	2880	720	18,9
LARGE CARBOARD	1764	441	11,6
METALL	183	46	1,2
GLASS	399	100	2,6

In the large mixed waste bins there was mixed waste which should have been put to the pipeline-based waste collection system instead, such as small waste bags and old shoes. In addition, there were also some waste that did not belong in the large mixed waste bins, such as mattresses. These kind of wastes are instructed to be taken by the residents to the HSY Sortti- station or to order a Nouto-Sortti for them (a chargeable pick-up service for large waste items).

6 COMPARING THE RESEARCH RESULTS TO TRADITIONAL WASTE MANAGEMENT

The results of the quality and quantity of mixed waste and biowaste were compared to earlier researches made by the Helsinki Region Environmental Services Authority (HSY). The results were obtained by similar methods and the received results were comparable. The only difference was the sample weights. In HSY`s research 26 280 kilograms of mixed waste (Pulkkinen, S. & Sinisalo, S. 2012, 16) and 4 480 kilograms of biowaste (Toukola, V. et al. 2011, 22) were examined.

The composition of the paper sample was not compared to any other researches. The paper sample was mostly paper, and other waste components were only marginal. This is very common when collecting recyclable paper from households.

The cardboard sample was not representative and therefore not comparable to any other researches.

The recycling room waste was compared to the initial data collected when the recycling rooms were designed. The quantity of large mixed waste collected in the recycling rooms was taken into account when calculating the quantity of mixed waste.

6.1 Mixed waste

Helsinki Region Environmental Services Authority (HSY) has made a similar research on mixed waste in 2012. The research was about the composition and quantity of mixed waste produced in households in the Helsinki metropolitan area. Four different types of residential properties were studied: 2-4 apartment, 5-9 apartment, 10- 20 apartment and over 20 apartment residential buildings. The research was conducted in Autumn 2011 and the research week was week 37. (Pulkkinen, S. & Sinisalo, S. 2012, 5, 13.)

In this research the results were compared to the results obtained by HSY about 10-20 apartment and over 20 apartment residential buildings, because the research area in Jätkäsaari and Kalasatama consist mainly of these type of buildings. The collected data from the HSY research is presented in Figure 19.

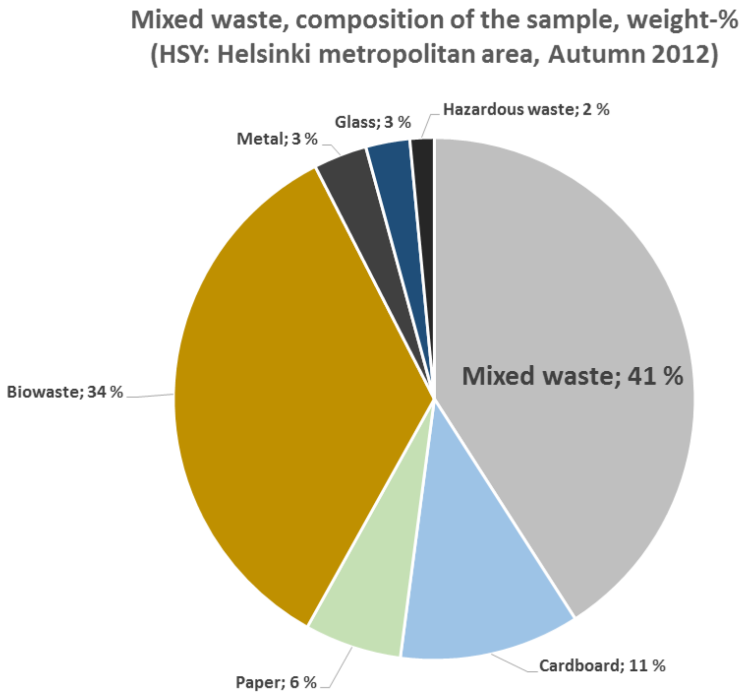

Figure 19. Composition of waste in mixed waste sample in HSY research

In the similar research done by HSY, they found 41% of mixed waste. The percentage is almost similar to the sample taken in Jätkäsaari (49%) and Kalasatama (42%).

Recyclable fiber material was found 17% in HSY`s research. The corresponding figure in Jätkäsaari was about 23% and in Kalasatama almost 18%. The large amount of cardboard in Jätkäsaari sample increased the proportion of the fiber material.

The amount of biodegradable waste in HSY`s research was 34%. In Jätkäsaari it was 22% and in Kalasatama almost 37%.

The amount of metal found in HSY`s research was 3%. Almost the same amount (2.8%) was found in the Kalasatama sample. In Jätkäsaari sample there were 5% of metal. Non-deposit aluminum cans found in the sample affected the proportion of metal in Jätkäsaari.

There were significantly lesser glass in Jätkäsaari and Kalasatama samples than in the HSY research (3%). Glass found in Jätkäsaari was 0.2% and 0.3% in Kalasatama.

HSY found 2% of hazardous waste in their research. There were no hazardous waste found in Jätkäsaari sample, and in Kalasatama only 0.3%.

The results obtained from the waste collected through the pipeline-based waste collection system seems to indicate that each resident in Jätkäsaari produces 132 kilograms and each resident in Kalasatama produces 91 kilograms of mixed waste per year. The comparable figure in the research of HSY was 163 kilograms of mixed waste per year (Pulkkinen, S. & Sinisalo, S. 2012, 5).

Some mixed waste, which should have been put to the inlet points of the pipeline-based waste collection system, ended up in the large mixed waste bins in the recycling rooms. If the large mixed waste results are added to the mixed waste volume collected in the pipeline-based waste collection system, each resident in Jätkäsaari produces 140 kilograms and each resident in Kalasatama produces 110 kilograms of mixed waste per year.

6.2 Biowaste

Helsinki Region Environmental Services Authority (HSY) has made a similar research on biowaste in 2011. The research was about the quality and quantity of biowaste produced in different kinds of properties in the Helsinki metropolitan area. The properties are apartment buildings, row and semi-detached houses, schools, hospitals, restaurants and retail stores. The research was conducted in spring 2010 and the research weeks were week 19 and 20 (Toukola, V. Sinisalo, S. Sormunen K. & Pulkkinen, S. 2011, 14, 17).

In this research the results were compared to the results obtained by HSY about apartment buildings, because the research area in Jätkäsaari and Kalasatama consist mainly of these type of buildings. The collected data from the HSY research is presented in Figure 20.

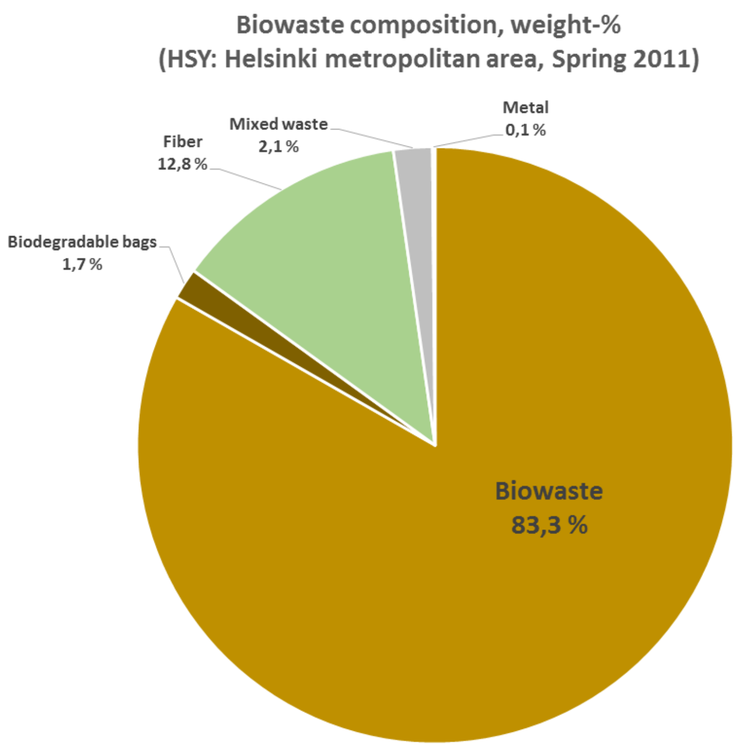

Figure 20. Composition of waste in biowaste sample in HSY research

In the research done by HSY the amount of biowaste was 83 weight-% (biowaste and garden waste). The weight percentage of biowaste in Jätkäsaari was 68%. There was over two times more biodegradable bags in Jätkäsaari sample (4.5%) than in HSY sample (1.7%).

Recyclable fibre material was found almost 13% in HSY research. The corresponding figure in Jätkäsaari was over 19%.

Over 2% of the sample weight in HSY`s research did not belong to biowaste (mixed waste and metal). The corresponding figure in Jätkäsaari was almost 8%. Mixed waste in Jätkäsaari sample consisted mainly of pieces of a pot made of clay and this raised the weight percentage.

No glass was found either in HSY research or in Jätkäsaari.

Each resident in Jätkäsaari produces 15 kilograms approx. of biowaste per year. The comparable figure in the research of HSY was 29 kilograms of biowaste per year (Toukola, V. Sinisalo, S. Sormunen, K. & Pulkkinen, S. 2011, 29).

6.3 Paper

According to the received results, each resident in Jätkäsaari produces 37 kilograms of paper per year. The estimate given by Paperinkeräys Ltd is about 70 kilograms per resident per year in the Helsinki metropolitan area in apartment buildings.

The low amount of paper can be explained by the quality results received from other waste researches in Jätkäsaari. A lot of paper was found in mixed waste, biowaste and cardboard, and this could explain the missing paper.

6.4 Recycling room waste

HSYs estimates that each resident annually produces 3 kilograms of glass and 1.2 kilograms of metal. The results from Kalasatama`s recycling rooms support this, as shown in Table 9. In Jätkäsaari the amount of glass per resident (2.2 kg) is a bit less than the average. The amount of metal on the other hand was quite small, about 1 kilogram per resident per year. Some of the metal that should have been collected in the recycling room might have ended up in the pipeline-based waste collection system, which explains the large amount of metal in the Jätkäsaari mixed waste results (Figure 10).

It was estimated that each resident produces 2.5 kilograms of large cardboard per year. This was a professional assessment used in the designing of the recycling rooms. (Pyykkö, L. 2013.) Both of the case areas (Jätkäsaari and Kalasatama) are new residential areas. This means that a lot of moving in takes place. This might explain the large quantities of large cardboard found in the recycling rooms. The amount of large cardboard in Jätkäsaari was about 8 kilograms and in Kalasatama almost 12 kilograms per resident per year.

6.5 Residents` experiences

The questionnaire directed to the residents about the pipeline-based waste collection system (Appendix 4) was held in October 2014 in a residents gathering and in March 2015 via an answering box left in Jätkäsaari info center

"Huutokonttori" and in the residents’ space in Kalasatama. A total of 40 responses were received (from Jätkäsaari 20 and from Kalasatama 20).

The majority of the respondents were women (in Jätkäsaari 11 and in Kalasatama 14) and middle-aged or older (Figure 21).

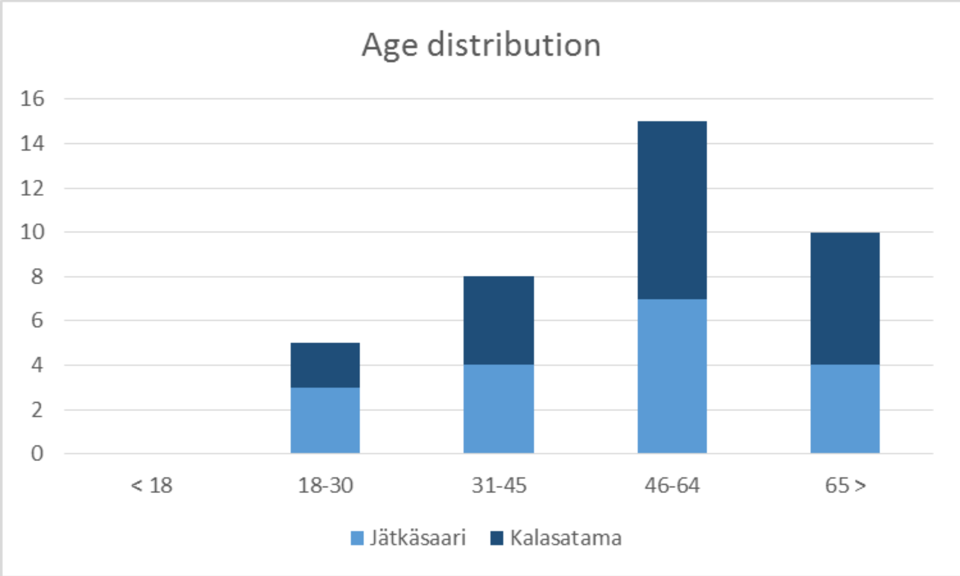

Figure 21. Questionnaire question: Age distribution

In Jätkäsaari half of the respondents (10) were employed and in Kalasatama the majority of the respondents either worked (8) or were retired (8). Of all the respondents, there were only 3 students. (Figure 22.)

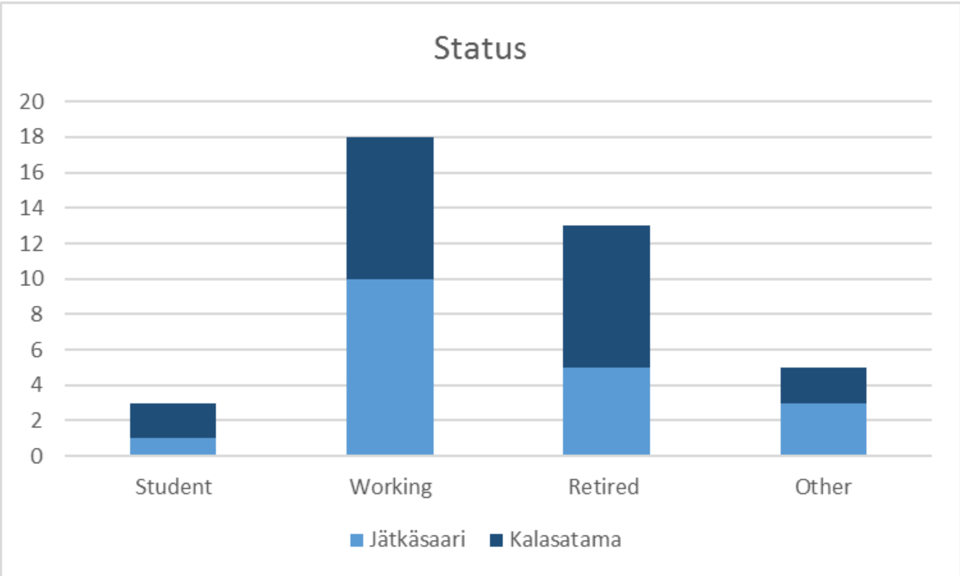

Figure 22. Questionnaire question: Status

Most of the respondents had not experienced any difficulties with the pipeline-based waste collection system (Figure 23). Those that had had difficulties with the system, told that the inlet point doors were too small or that the recycling room was messy.

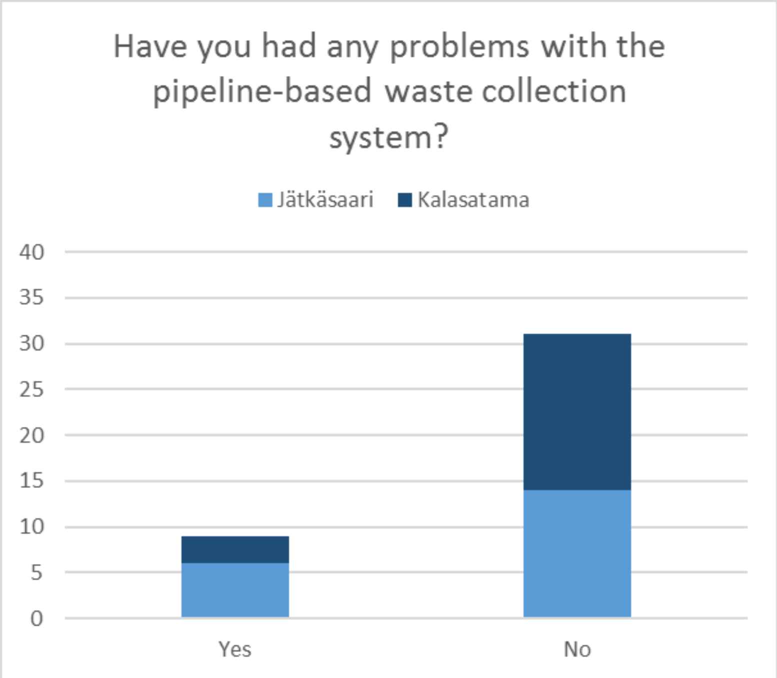

Figure 23. Questionnaire question: Problems with the system?

More than half (12) of the respondents in Jätkäsaari were familiar with the web pages made for the pipeline-based waste collection system, but in Kalasatama only 8 out of 20 were familiar with the web pages.

The majority of respondents, both in Jätkäsaari (14) and Kalasatama (16), used the recycling rooms.

The majority of respondents felt that the pipeline-based waste collection system is better than the traditional waste collection (Figure 24). Major reasons for this were cleanliness, silence and the disappearance of garbage trucks from the yard.

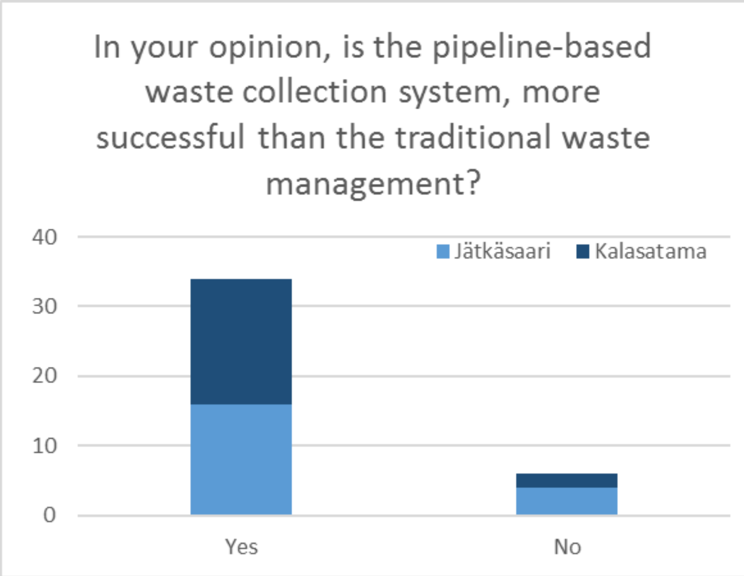

Figure 24. Questionnaire question: Better or worse?

6.6 Reliability of the research and possible sources of error

The quality and quantity research of the pipeline-based waste collection system was a random sample research. The composite samples were taken randomly from different parts of the waste pile.

The samples, that were taken, were less than 1% of the total weight of the waste container. Even though the target was to take as representative sample as possible, the results can only be indicative, because the whole container was not examined.

The mixed waste container from Jätkäsaari was supposed to be from area 2, but when the container was fetched the wrong container was taken (area 1 container). This was not noticed until later. The container from area one had collected mixed waste for a month. This had to be taken into account when calculating the amount of waste per resident.

The precision of the used scales in the conducted waste researches might have an effect on the quantities of waste.

Other properties in Jätkäsaari and Kalasatama affect the waste research results (quantity and quality). In Jätkäsaari, in addition to apartment buildings, there are offices, retailers and a restaurant. Also one property collects waste with the traditional way (of their own will) parallel to the pipeline-based waste collection system. In Kalasatama there is a restaurant and a grocery store.

The recycling rooms also have an effect on the amount of waste, e.g. some of the mixed waste and cardboard, which should have been put to the inlet points of the pipeline-based waste collection system, ended up in the large mixed waste bins and the large cardboard trollies in the recycling rooms.

Only a small part of all the residents in Jätkäsaari and Kalasatama responded to the questionnaire. The assumption is that those residents, who had a clear opinion on the matter, also responded to the questionnaire. The resident experiences presented in this research can only be indicative.

7 CONCLUSIONS

The quality and quantity of the waste in this research seems to be almost equivalent to the quality and quantity of waste collected in the traditional waste management, with a few exceptions. There was a lot of paper found in the mixed waste, biowaste and cardboard samples. One possible reason for this might be that the volume control in the paper inlet point caused the residents to throw their paper waste to other inlet points.

The amount of waste per resident per year was slightly lower than in the research made by HSY. Based on the results, it seems that mixed waste, biowaste and paper is produced less when using the pipeline-based waste collection system compared to the traditional waste management. Before the data is fully secured, it is recommended to repeat the research after a certain period of time to confirm the results.

A pipeline-based waste collection system divides the opinions of the residents. Some people find it easy to approach and modern, while others appreciate more the traditional waste management and its familiarity. All in all, the majority of the respondents had a positive image of the pipeline-based waste collection system. The pipeline-based waste collection system had taken time to get used to, and that might be the reason why some of the waste, which should belong to the pipeline-based waste collection system, had ended up in the recycling rooms. It is recommendable that residents' guidance is to be increased.

The recycling rooms in Kalasatama, where they are located in each block, seem to be more successful and more appreciated than the regional recycling rooms in Jätkäsaari. This particularly applies to the collection of glass and metal.

It should be taken into account that the present research on the quality and quantity was carried out in the implementation phase of the pipeline-based waste collection system. It is also important to remember to compare the extent of the investigation. In this research, only a fraction of all collected waste was examined, and, therefore the results are only indicative.

The cardboard sample was not a representative in this research. Later observations have shown that the composition of the cardboard container differ considerably and that the container used in this research had an atypical composition. Cardboard is recommended to be renewed.

The results of this research should not be applied elsewhere than the metropolitan area because waste management regulations can differ in different parts of the country. Many different factors affect the waste composition and quantity, such as the age distribution and the income levels of the inhabitants, the type of housing (e.g. owner occupation, rental housing, part-ownership housing) and separate waste management.

For future research on the composition and the quality of waste collected by a pipeline-based waste collection system, a few follow-up research proposals that should be taken into account, can be given:

- When emptying the waste container, it is recommended to mix the pile of waste, for example with a wheel loader, to achieve a more representative sample.

- If laboratory analyses are needed, a sample of the fine aggregate should be taken from the waste pile during the emptying of the container to determine the moisture. It is also beneficial if the sample can be crushed on-site prior to sending it to the laboratory.

It seems that waste collection using a pipeline-based collection system does not affect the quality or quantity of the waste significantly. When making decisions concerning waste management, other factors, such as hygiene, image and cost-effectiveness, should be emphasized more. The pipeline-based waste collection system is a viable option for urban densely populated areas.

The purpose of this research was to be a preliminary research of the quality and quantity of the waste collected in the pipeline-based waste collection system. Further researches are recommended and comparative research should be done from time to time, for example every two (2) years.

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APPENDICES

APPENDIX 1. WORK DESCRIPTION

Waste research, pipeline-based waste collection system: mixed waste and biowaste

Place: Ämmässuo Waste Treatment Centre, HSY
Address: Ämmässuontie 8, 02820 Espoo

Person in charge

Person	Email	Phone number
Inna Harju/Procofin	inna.harju@procofin.fi	040 833 1236
Jukka Kivivasara/Procofin	jukka.kivivasara@procofin.fi	040 833 1231
Hannu Juntunen/HSY	hannu.juntunen@hsy.fi	040 717 7099

Basic info

Description

The purpose of this research is to determine the sorting effectiveness of the inhabitants that live in the new housing areas of Jätkäsaari and Kalasatama, where waste collection is done primarily by the pipeline-based waste collection system.

In this research the content of the mixed waste and biowaste containers are examined.

- The mixed waste container coming from Jätkäsaari represents the amount of waste that has accumulated in one (1) week.
- The mixed waste container coming from Kalasatama represents the amount of waste that has accumulated in one (1) week.
- The biowaste container coming from Jätkäsaari represents the amount of waste that has accumulated in one (1) week.

The containers are brought from the waste collection stations (in Jätkäsaari and Kalasatama) to the Ämmässuo Waste Treatment Centre. The containers are emptied and a representative sample of the waste is taken.

The research methods used are visual observation and sorting through a sieve (50 mm).

Name of sampler

Inna Harju, 040 833 1236
Jukka Kivivasara, 040 833 1231
Linda Tikkanen, 040 833 1235
Mervi Koskinen, 050 460 2027

Work description

Mixed waste (9.-10.9.2014)

1) The container is brought from the waste collection station (Jätkäsaari/Kalasatama) to the Ämmässuo Waste Treatment Centre. The container is weighed and the drivers informs the samplers the weight of the container.
   a) Jätkäsaari tuesday 9.9.2014
   b) Kalasatama wednesday 10.9.2014

2) The content of the container is emptied to an empty lot in the waste treatment centre (near the landfill).

3) Photographing

4) Visual observation of the waste
   a) how many intact garbage bags (%)
   b) how much loose waste (%)
   c) the quality of the waste (does it represent the waste component)

5) Representative sample of the waste is taken to the bins (done by the samplers)
   a) intact garbage bags, sufficient sample (about 10-20 pcs.)
   b) other waste to the bins, sufficient sample (about 10-20 litre)

6) The samples are taken to a hall for further examination (hall)

7) The remaining content of the container is taken to the Vantaa Energy's waste-to-energy plant for further treatment (incineration)

8) The examination of the samples and sorting through a sieve (50 mm)
   a) weighing of the sample (bins)
   b) the garbage bags are opened and the sample is sorted through a sieve:
      i) particle size bigger than 50 mm (%)
      ii) particle size smaller than 50 mm (%)
   c) classification to selected waste components (buckets)
   d) weighing of the waste components

9) the selected waste components:
   a) biowaste
      i) biowaste

    - ii) garden waste
  - b) plastic
    - i) packaging plastic
    - ii) other plastic
  - c) paper
    - i) paper
    - ii) tissue paper
  - d) cardboard
    - i) packaging cardboard
    - ii) other cardboard
  - e) metal
    - i) packaging metal
    - ii) other metal
  - f) glass
    - i) packaging glass
    - ii) other glass
  - g) hazardous waste
  - h) other combustible waste
  - i) other incombustible waste

10) Cleaning of the buckets and the bins

Biowaste (11.9.2014)

1) The container is brought from the waste collection station (Jätkäsaari) to the Ämmässuo Waste Treatment Centre. The container is weighed and the drivers informs the samplers the weight of the container.

2) The content of the container is emptied to an empty lot in the Waste Treatment Centre (near the biowaste treatment hall).

3) Visual observation of the waste
    - a. how many intact garbage bags (%)
    - b. how much loose waste (%)
    - c. the quality of the waste (does it represent the waste component)

4) Representative sample of the waste is taken (done by the samplers)

5) The sample is taken to a hall for further examination

6) The remaining content of the container is taken to the biowaste treatment hall for further treatment (composting)

7) The examination of the sample
    - a. weighing of the sample
    - b. sorting to selected waste components (buckets)
        - i. biowaste
        - ii. biodegradable bags

        iii. other waste
            1. mixed waste
            2. fiber (paper, cardboard etc.)
            3. metal
            4. glass
    c. weighing of the waste components

8) Checking that the single samples weight as much as the composite sample

9) Cleaning of the buckets and the bins

APPENDIX 2. RESULT COLLECTION FORM

QUALITY AND QUANTITY OF WASTE COLLECTED IN THE PIPELINE-BASED WASTE COLLECTION SYSTEM
MIXED WASTE

SAMPLING	
Sample (e.g. where is it coming from):	
Specify date and time(s) of sampling:	
Name of sampler(s):	
Specify detailed sampling location:	
Specify persons to be present (other than the sampler):	
SAMPLE PROCESSING/HANDLING	
Sample processing (how is the sample treated, e.g. sieving):	
Specify date and time(s) of sample processing/handling:	
Name of sample handler(s):	
Overflow (%):	Underflow (%):
Loss:	Weight - % of loss:
More information:	

	Weight (kg)	Weight - %
Container		
Composite sample		
Waste component:		
biowaste		
garden waste		
packaging plastic		
other plastic		
paper		
soft paper		
packaging cardboard		
other cardboard		
packaging metal		
other metal		
packaging glass		
other glass		
hazardous waste		
other combustible waste		
other incombustible waste		
corrugated cardboard		
fine particles		
loss		
IN ALL		

APPENDIX 3. SORTING GUIDE

SORTING GUIDE

BIOWASTE
- leftover food
- fruit and vegetable skins or peels
- tea leaves and tea bags
- coffee grounds (and filters)
- egg shells, fishbones
- dried up or spoiled food
- food packaging, where the majority of the weight is biowaste
- wood-based bedding of pets e.g. pellets

GARDEN WASTE
- leaves from trees and shrubs
- branches from trees and shrubs
- lawn trimmings
- parts of plants
- withered flowers

PAPER
- newspapers and magazines
- advertising mail
- envelopes with windows also
- copypaper
- colored copypaper

SOFT PAPER
- paper handkerchiefs, paper towels, toilet paper

PACKAGING CARDBOARD
- cardboard (also with aluminium lined) milk, juice, cream, sour milk, yogurt, wine and detergent cans
- dry products paper or cardboard packaging, e.g.
    - cereal, biscuit and confectionery packages
    - pizza boxes
    - egg and fruit carton
    - potato chip bags and bread bags made of paper
- paper bags and sacks
- disposable plates made of cardboard
- wax paper: wrapping paper, gift wrapping paper

OTHER CARDBOARD
- book covers
- posters
- photographs
- postcards
- wallpaper

PACKAGING PLASTIC

- plastic bags and sacks
- plastic wrap
- packaging plastics (e.g. frozen vegetable and cereal bags)
- plastic bottles, containers, canisters, buckets, e.g. empty oil and detergent bottles
- plastic lids and caps
- disposable plastic tableware
- food packaging plastics e.g. yoghurt cups, butter and margarine containers
- styrox

OTHER PLASTIC

- small plastic items e.g. dish wash brush, plastic shells
- plastic furniture
- plastic flower pots
- deodorant (plastic)
- floppy disks, video tapes
- toothbrush, empty toothpaste
- pipes and hoses
- brown packing tape
- binder, plastic pocket, contact plastic
- raincoats
- inflatable toys
- vinyls
- plastic sheeting (loan cover), plastic grid
- plastic floor coverings
- shower curtains
- empty blister pack
- blood and fluid bags used in hospitals
- construction materials e.g. gutters

PACKAGING GLASS

- glass jars
- glass bottles
- glass containers
- drinking glass

OTHER GLASS

- car window glass
- crystal
- heat-resistant glass (ovenware, the oven door glass, e.g. Pyrex)
- window glass
- thermal glass
- mirror

PACKAGING METAL

- beverage cans
- foil
- yoghurt lid
- aluminum trays
- food tins
- empty paint cans

- aerosol cans

OTHER METAL
- bicycles
- metal machinery and equipment (no electrical and electronic waste)
- metal furniture, metal parts of furniture
- electric wire
- keys
- tools, bolts, nails
- bicycle lock
- paper clips
- pot, pan

OTHER COMBUSTIBLE WASTE
- wood
- textiles e.g. fabrics, curtains, rugs, tablecloths
- clothes
- shoes
- bags
- diapers, menstrual products
- absorbent cotton
- rubber, rubber bands
- plush toys
- vacuum cleaner bags
- cigarette butts
- doggy doo
- tennis balls

OTHER INCOMBUSTIBLE WASTE
- glass objects with metal parts
- ceramics, porcelain
- bricks, pottery
- stones
- ash

HAZARDOUS WASTE
- batteries
- medicines
- oils
- nail polish, nail polish remover
- solvents, paints
- fluorescent lamps
- thermometers
- adhesives, acids, photographic chemicals
- dusty asbestos-containing materials (e.g. old pipe insulation)
- fireworks, flares

APPENDIX 4. QUESTIONNARE FORM

RÖÖRI
JÄTKÄSAARI

KYSELYLOMAKE JÄTKÄSAAREN ASUKKAILLE JÄTTEEN PUTKIKERÄYSJÄRJESTELMÄSTÄ

TAUSTATIETOJA

Sukupuoli
◯ Nainen
◯ Mies

Ikä
◯ alle 18
◯ 18 - 30
◯ 31 - 45
◯ 46 - 64
◯ 65 tai vanhempi

Työ
◯ Opiskelija
◯ Työssä
◯ Eläkkeellä
◯ Muu

JÄTTEEN PUTKIKERÄYSJÄRJESTELMÄ

Onko teillä ollut ongelmia jätteen putkikeräyksen kanssa?
◯ Kyllä
◯ Ei

Jos vastasitte *Kyllä*, millaisia?

Kierrätyshuoneet

Käytättekö alueellisia kierrätyshuoneita?
◯ Kyllä
◯ Ei

Jos vastasitte *Ei*, miksi ette käytä?

Tiedotus

Oletteko tutustuneet RÖÖRI:n nettisivuihin (www.jatkasaarenroori.fi)?
◯ Kyllä
◯ Ei

Lopuksi:

Onko jätteen putkikeräys mielestänne toimivampi ratkaisu kuin perinteinen jätehuolto?
◯ Kyllä
◯ Ei

Miksi?

Vapaa sana:

KIITÄMME TÄRKEÄSTÄ PALAUTTEESTANNE!

IMU
KALASATAMA

KYSELYLOMAKE KALASATAMAN ASUKKAILLE JÄTTEEN PUTKIKERÄYSJÄRJESTELMÄSTÄ

TAUSTATIETOJA

Sukupuoli
◯ Nainen
◯ Mies

Työ
◯ Opiskelija
◯ Työssä
◯ Eläkkeellä
◯ Muu

Ikä
◯ alle 18
◯ 18 - 30
◯ 31 - 45
◯ 46 - 64
◯ 65 tai vanhempi

JÄTTEEN PUTKIKERÄYSJÄRJESTELMÄ

Onko teillä ollut ongelmia jätteen putkikeräyksen kanssa?
◯ Kyllä
◯ Ei

Jos vastasitte *Kyllä*, millaisia?

Kierrätyshuoneet

Käytättekö korttelikohtaista kierrätyshuonettanne?
◯ Kyllä
◯ Ei

Jos vastasitte *Ei*, miksi ette käytä?

Tiedotus

Oletteko tutustuneet IMU:n nettisivuihin (www.kalasatamanimu.fi)?
◯ Kyllä
◯ Ei

Lopuksi:

Onko jätteen putkikeräys mielestänne toimivampi ratkaisu kuin perinteinen jätehuolto?
◯ Kyllä
◯ Ei

Miksi?

Vapaa sana:

KIITÄMME TÄRKEÄSTÄ PALAUTTEESTANNE!