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ANALYSIS OF PLASTIC WASTE FROM THE BIOWASTE PRE-TREATMENT PROCESS. CASE OF HELSINKI REGIONAL ENVIRONMENTAL SERVICE

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ABSTRACT

Bio-waste is the waste generated following food consumption and is essential in households, public places, offices, and companies. Plastic is a material widely utilized in everyday life, from product packaging to food packaging to office supplies.

However, according to HSY data, bio-waste also contains a considerable amount of plastic that is difficult to handle. That amount of plastic trash will become rejected garbage throughout the processing process. This project was planned and completed at HSY to analyze the data of waste rejected from biowaste pre-treatment. Before this project, the question was how much of the plastic contained in the wreckage was removed from the pre-treatment system. What percentage of those plastics are, and how can the impurities be separated from the rejected waste mix?

The figures are mainly taken from the company's annual report and analyzed the data by quantitative method. The process of gathering and interpreting numerical data is known as quantitative research. It may be used to discover patterns and trends, make predictions, investigate causal linkages, and generalize results to larger groups.

After analysing the results, I found that the amount of plastic in the rejected waste composition accounts for 80%, and the main types of plastic are PVC, PET, PP, and LDPE. Most of the plastic in the rejected waste is plastic from the food industry like food wraps - they make up 70%, and the rest is from plastic bags.

Keywords: Compost, rejected waste, biowaste, plastics

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1. INTRODUCTION

1.1 Background

According to HSY, biowaste is food and kitchen waste that decomposes and composts. Fibrous materials that degrade quickly can also be classified as garbage (Biowaste - HSY). And according to EC/Europa.eu, Natural rubbish involves biodegradable nursery and park trash, food and kitchen squander from families, coffee, caterers, and retail ventures, and compostable waste from food handling plants. Ranger service and horticultural extras, fertilizer, sewage ooze, and other biodegradable squanders are moreover restricted, as are regular materials, paper, and handled wood. (M&K Inno. 2014) Biowaste is a biodegradable type that composes and composts food, kitchen waste, garden, and park waste. A plastic bundle is a holder, covering, sack, or container made of plastic that is utilized to bundle an item available to be purchased (Plastic – HSY). With the explanation on Toppr.com, plastics are a class of semi-synthetic or synthetic compounds based on polymers. Versatility in the assembling system grants polymers to be shaped, expelled, or squeezed into strong objects of different structures.. It will enable the material to conform and is justifiable for applications. (Synthetic Fibers and Plastics | Plastics – Toppr.com)

Most modern plastics come from petrochemicals derived from fossil fuels such as natural gas or oil. On the other hand, newer plastic production processes use alternatives made from renewable ingredients such as corn or cotton derivatives. This versatility and many beneficial attributes such as lightweight, durability, flexibility, and inexpensive production processes have contributed to its widespread acceptance in modern culture.

Rejected waste is the majority of it being plastic due to the domestic rubbish collection procedure. It is up to 74% of mixed garbage is biological waste, according to the HSY report. As a result, there would be a lot of plastic in the bio-waste collected every day. All plastic in the trash will be screened and sent through the sieve line during the pre-treatment process. In this thesis, we refer to it as the rejected component of the biowaste pretreatment process.

This recycling and reuse idea is a significant way to help solve the problem of storing and using this rejected waste. Previously, this rejected waste would have been deposited at the landfill and taken to the Vantaa energy company to generate electricity; however, if a way to utilize and recycle it can be worked out, HSY will have a large amount of raw material in plastic to make recycled products in the future. My project mainly focuses on plastics rejected from the biowaste pre-treatment process. The research question in the thesis - first is “how much plastics after the treatment process?”; the second question is “what types of plastics in the rejected?”; and “Find out why the amount of plastic waste is so much in bio-waste?” Furthermore, simple explanation for recycling plastic waste into energy at domestic power plants.

To complete this thesis, I gained major help from the staff at HSY. During my internship and work to achieve this thesis, I observed the biological waste pretreatment system, followed by sampling analysis for the necessary values for later.

1.2 Limitation of the study

The main focal point of this study is how to analyze and make the most clearly the amount of plastic in the rejected waste. Using the quantitative research method, the date from the sample collected from the treatment process and all the data obtained from monthly reports and annual reports make it possible to analyze how to recycle or utilize materials. The primary and most abundant ingredient in the above-rejected waste is plastic. The prominent and most recognizable plastics are PP, PVC, HDPE, LDPE, and PET.

In addition to plastic, there are also pieces of wood of various sizes and some types of metal in a rejected waste container, such as spoons, knit and es, and forks, and they will not be the subject of discussion in this article.

2. LITERATURE REVIEW

2.1 Plastics review

Plastics are broad synthetic or semi-synthetic materials made chiefly of polymers. (Plastic – HSY) Plastics may be moulded, extruded, or pressed into solid objects

of their fluidity. Theirs widespread use is due to its versatility and other characteristics, such as being lightweight, robust, flexible, and economical to create. Human industrial systems are usually used to manufacture plastics. Most modern plastics are produced from fossil fuel-based compounds such as natural gas or petroleum; however, current commercial technologies use renewable feedstock like maize or cotton derivatives. (Charles M. 2022)

Around a third of plastic is used in packaging in industrialised economies, and about the same amount is used in structures for piping, plumbing, and vinyl siding. Automobiles (up to 20% plastic) (Andrady AL, Neal MA. 2009), furniture, and toys are among the other applications. Plastic applications vary in developing countries; packaging accounts for 42% of India's usage. (Andrady AL, Neal MA. 2009) Polymer implants and other medical devices are generated at least in part from plastic in the medical profession. Every ten years, the amount of plastic generated per person doubles.

There are four types of plastic commonly used in food and beverage packaging: PET, HDPE, LDPE and PP. In addition, occasionally, some other types of plastic can be found in the biological waste bins, such as PVC used to make plastic wrapping paper or PS plastic or PS plastic in the form of foam.

The ARVI research program focused on material value chains with a systemic perspective - relevant to the problem, finished the research and estimated that enterprises and consumers create 140,000 tons of plastic packaging trash. The number of families is expected to increase by 0.7% every year on average (S. Minna, S-A. Henna. 2021) (CLIC Inno. Ltd. 2017). Furthermore, according to the HSY annual report, the total amount of waste rejected from biowaste screening is between 3000 and 4500 tons per year, and plastic accounts for up to 15% of mixed garbage. The majority of today's plastic packaging trash is burnt to generate heat. Only approximately a quarter of the waste gets recycled. The percentage of recycled and bioplastics in plastic packaging is still relatively small – around 2%. (HSY annual report - 2021)

2.2 Biowaste review

Nursery and park trash, food and kitchen squander from houses, cafés, catering and retail outlets, and similar to food handling plants are biodegradable, and that implies they are separated into normal parts, carbon dioxide, and water fume by animals like microscopic organisms and growth. Degradable fibrous materials can also be classified as biological waste, and it is shown in table 1. (HSY.fi - Biowaste website)

Table 1. Biowaste sorting guide

Bio-waste		
Kitchen waste	Food waste	- Leftovers - Dried and contaminated foods
	Other food waste	- Fruits, vegetables, root vegetable shells, eggs shells - Gut waste from berries, fruits, and vegetables - Fish percussion waste, bones - Coffee and tea reindeer with filter papers
Garden waste	Twigs and branches	- Twigs, branches, wrists (under the thickness of the wrists) - Shrubs, pikeperch, cones, …
	Apple	Apple from yards
	Other garden waste	- Leaves of trees and shrubs - Lawn moving residues - Withered flowers, flower soil
Another biowaste		- Bites of pets - Dead animals

2.3 Biowaste in mixed waste of the residents of the Helsinki Metropolitan Area

According to the study, the mixed waste of the residents of the Helsinki Metropolitan Area contains an average of 51.1 kg of biowaste per inhabitant per year, which is 39.4% of the total amount of mixed waste. Of the research groups,

the highest number of biowaste in mixed waste is in those living in one-apartment properties. They accumulate an average of 87.2 kg/person of biowaste in mixed waste per year, which is 45.3% of the total amount of mixed waste generated by the research group. The inhabitants of this research group put the most kitchen bio waste into mixed waste 64.3 kg/person, which is 74% of the total amount of biowaste.

Garden waste accounted for 22% of all biowaste among the mixed waste in this research group. The rest of the biowaste is another biowaste, including pet chews (HSY annual report- 2021). That is why there is a large amount of plastic in bio-waste and plastic from garbage bags and other plastic products such as plastic bottles, food wraps, etc. and brought to the treatment area. After the first treatment phase, impurities like plastic are removed from the biowaste treatment process. (HSY annual report - 2021)

Table 2. Amount of Biowaste in the Helsinki Metropolitan Area in 2007, 2012, 2015, 2018 and 2021

		kg/per/year				
		2007	2012	2015	2018	2021
Biowaste		68,7	61,3	58,4	52,7	51,1
	Kitchen waste	42,1	44,5	41,4	45,7	43,1
	Another biowaste	26,6	16,8	17	7	8

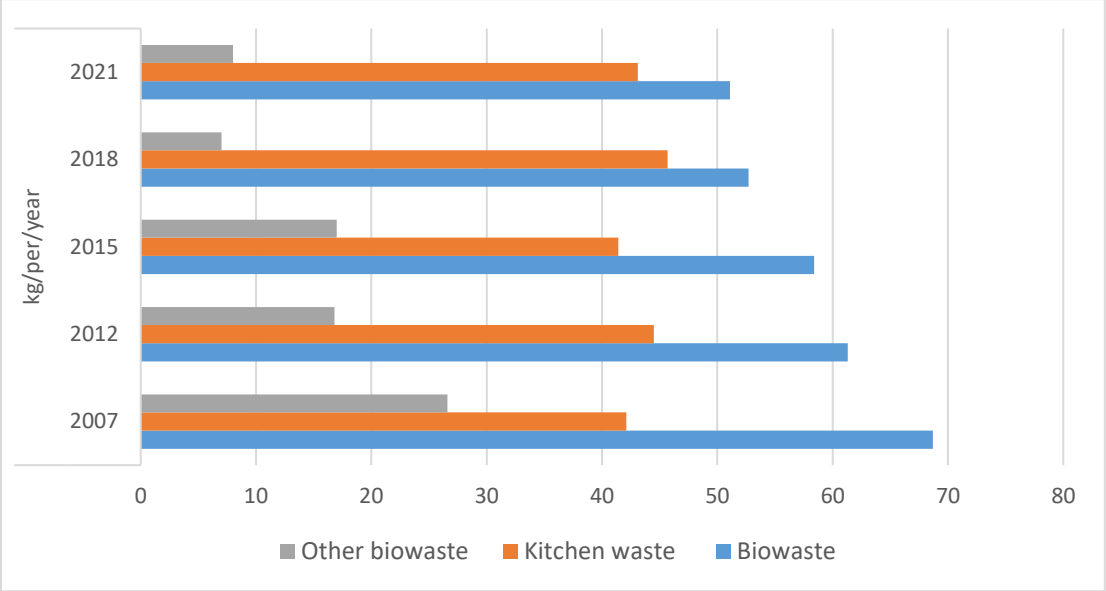

Figure 1. Amount of Biowaste in the Helsinki Metropolitan Area in different years

As shown in table 2 and figure 1, the amount of biowaste in the Helsinki area in different five years by kilograms per person per year.

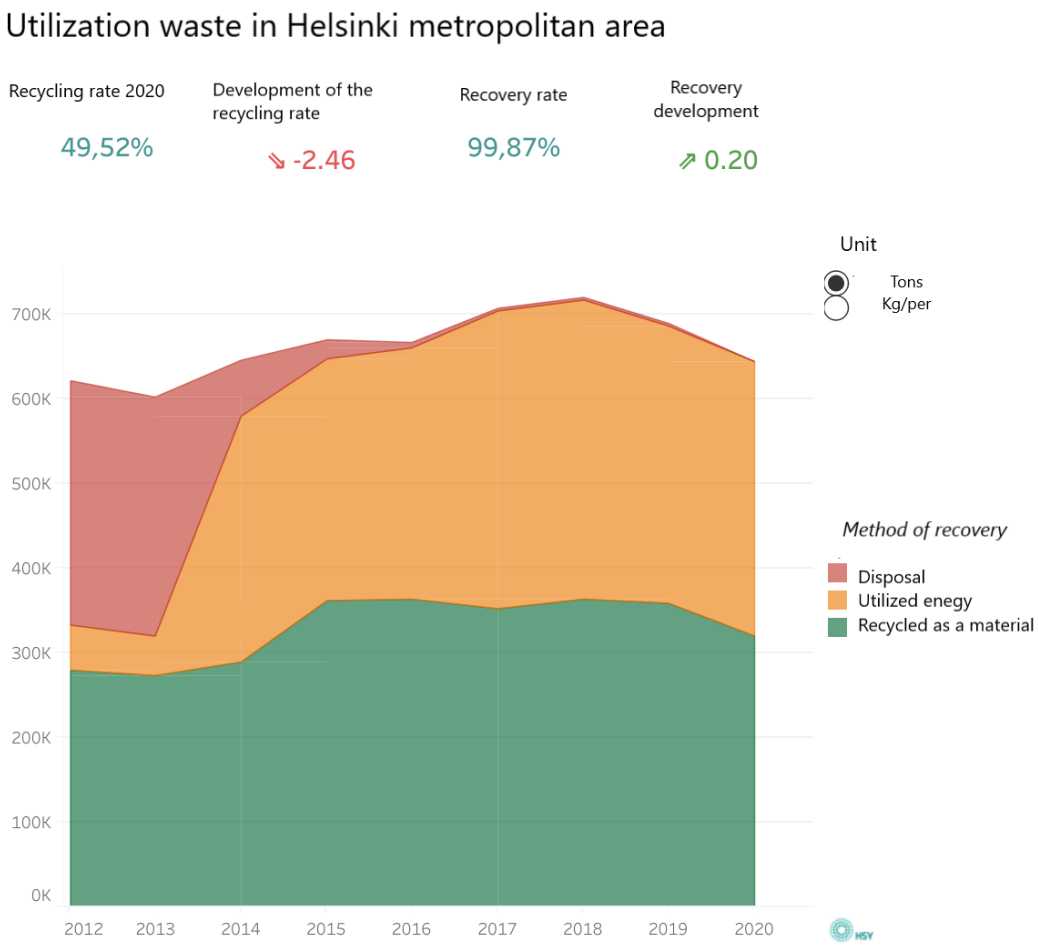

Figure 2. Utilization of waste in the Helsinki metropolitan area in 8 years

Figure 2 shows the percentage of waste reuse and recycling in the capital area over eight years - from 2012 to 2020

2.4 Research question

The following study question was developed in response to the findings reported above “how much of the total rejected waste from the bio-waste pretreatment process is plastic, and what percentage was another waste?”. In addition, the auxiliary research question was what types of plastic do they include in that amount of plastic? Those questions are the premise for the development of this project. Moreover, having too much plastic waste left in landfills will also affect the quality of other products because, at HSY, they also process biological waste and produce land for planting trees.

2.5 The convenience of plastic and the rejected components

Firstly, we knew that plastic products are convenient and compact for product packaging, with minor damage during transportation. However, it also has a negative side that happens over an exceedingly extended period. Plastic products are challenging to clean entirely so that they can be reused. Due to the space between the microplastics, plastic containers and containers can easily catch odours and keep odours for quite a long time. So, plastic products will be returned to the waste treatment plant for processing, crushing, and sorting after being used.

However, plastic waste has increased over the years, leading to an excess of processing. At HSY, the amount of trash discarded every year is up to 3500 tons, of which most are plastic products.

2.5.1 Problems caused by rejected components

Rejected ingredients are usually stored in large containers and sent to landfills for long-term storage. However, because they cannot generate heat on their own, these piles will freeze and be challenging to move or manage during the winter.

In addition, storing in landfills for too long leads to increased bacteria. With that said, the number of components removed is not entirely plastic. They also contain wood chips, pieces of metal, and sometimes even pieces of food that come out on conveyor belts. However, wood chips can be reused as raw materials for the process of mixing with natural waste for drying.

2.5.2 Meaning of problem-solving

The sorting process makes it easier to deal with rejected waste; the amount of garbage declined can also be reduced year by year, minimizing the storage method on the site and ensuring guaranteed not to affect other products.

In addition, solving this rejected waste will help maximize the rotation in the treatment area, increase the number of plastic materials generated, and earn a significant profit for the sale of plastic products and clean recycled materials for other manufacturing companies.

3. HSY AND ÄMMÄSSUO ECO-INDUSTRIAL CENTER

HSY is a consortium of four major cities, Vantaa, Helsinki, Espoo, and Kauniainen, providing municipal water and waste management services and information on the urban area and environment. HSY also offers environmental and regional data on air quality, climate change, and housing. It is the largest Finnish company in water and the environment.

3.1 Ämmässuo eco-industrial centre

The Ämmässuo eco-industrial centre began operations as a landfill in 1987. At the same time, as waste streams began to be utilized and recycled more efficiently than before, the amount of waste brought to the landfill also decreased. When the Vantaa waste to energy plant was opened in 2014, the export of mixed waste to Ämmässuo ceased utterly. (HSY.fi main page)

Figure 3. Ämmässuo eco-industrial centre

Today, Ämmässuo has moved from traditional landfill operations to the reuse and further processing of various waste material streams. The eco-industrial centre Ekomo (Figure 3) has developed in the area where circular economy companies cooperate and HSY.

3.2 Biological treatment

Eco-industrial centre Ämmässuo treats bio-waste, where biogas and compost are produced. Activities produce odours during biogas treatment and composting plants and field composting. (HSY annual report – 2019/2020.)

The biological waste treatment produces odours from almost every process. However, the amount of odour gradually decreased as this process progressed. The treatment process includes pre-treatment bodily waste, digestion, pre-incubation, sanitation, and post-incubation (Figure 2). (HSY annual report – 2019/2020.)

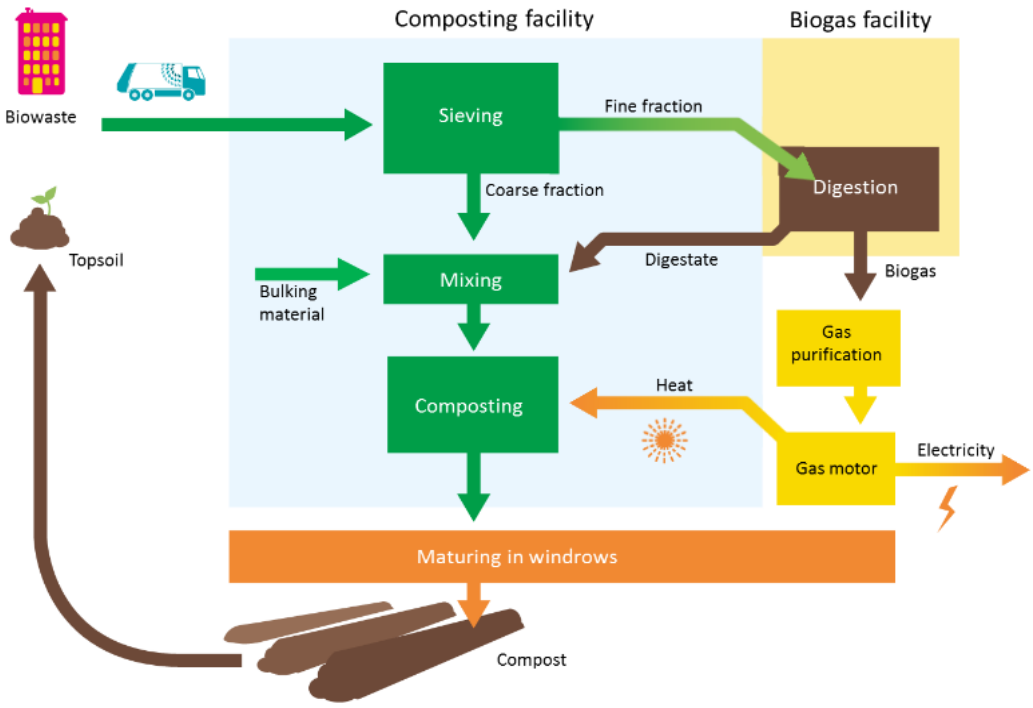

Figure 4. Ämmässuo's biowaste treatment processes

Waste pretreatment means sifting through the discarded and non-biodegradable components of the composting process: plastics.

4. REJECTIONS FROM THE TREATMENT PROCESS STEPS

4.1 Process steps

Biowaste is carried to the Ämmässuo biowaste treatment plant from all across the area. First, the biological waste will be transported to the pretreatment area's lobby. It is broken into little pieces, which opens the garbage bags and allows the

operations to proceed more simply. Biological waste will be blended with other substances such as wood chips in a controlled atmosphere and temperature. After the natural waste has been mixed, it will be transferred to a pre-treatment process, crushing, and screening. It is also filtered, which means that unwanted elements like metal and plastic are separated. This crushing and screening method effectively separates plastics and metals from the composting process. The digesting process excludes coarser materials, such as wood and yard waste, and materials with larger particle sizes (more than 80mm). Analytically, around 30% of the garbage is sent directly to the composting process, with the remaining being delivered to the biogas facility.

The crushing and screening system takes place in a closed system consisting of four parts (See Appendix 1 for an illustration)

- Part A with machines (20,21,21) have a capacity is 65 kW
- Part B with machines (22,24,27) has an ability is 65KW
- Part C is a hurricane (28) has a capacity is 29,7 kW
- Part D is a drum-wind sifter that has a capacity is 48,9 kW.

The sieving line consists of the following items depicted in Figure 5 below. The numbers in brackets refer to the corresponding numbers in the figure:

(20) Crushing-Mixing unit: fed by a wheel loader, breaking up material blocks and dosing the sieving material to the sieve line.

(21) Rising conveyor: transport the sieving material to the sieve line.

(22) Feeding conveyor sieve 50 mm: supplying the sieving material to the star-screen 50mm

(24–25–26) Star-sieve 50 mm, Feeding conveyor, Star-sieve 12 mm

(24) The upper sieve-deck 50 mm: consists of 4 sieving segments.

(25) The conveyor: transports the sieve underflow < 50 mm to the fine screen deck.

(26) The lower sieve-deck 12 mm: consists of 6 sieving segments.

(27) Conveyor overflow 12–50 mm: transports the sieve overflow 12–50 mm to the outside Hurricane wind sifter.

(28) Wind-sifter / De-stoner (existing/relocated): The 12–50 mm material is fed directly from the (27) conveyor to the wind sifter.

(29) Conveyor > 50 mm: transport the light fraction to the (30) conveyor > 50 mm.

(30) Conveyor > 50 mm: transport the light fraction to the (31) container-filling system.

(31) Container-Filling system: is fed from the (30) conveyor > 50 mm. The container-filling system fills the container which is placed below.

The most crucial step in the pre-treatment system is step 20, removing garbage bags before they are put into the system by forklifts to make the treatment process faster and more optimized. Since the garbage bag has been removed before being put into the system, it is easier to divide the size of the waste.

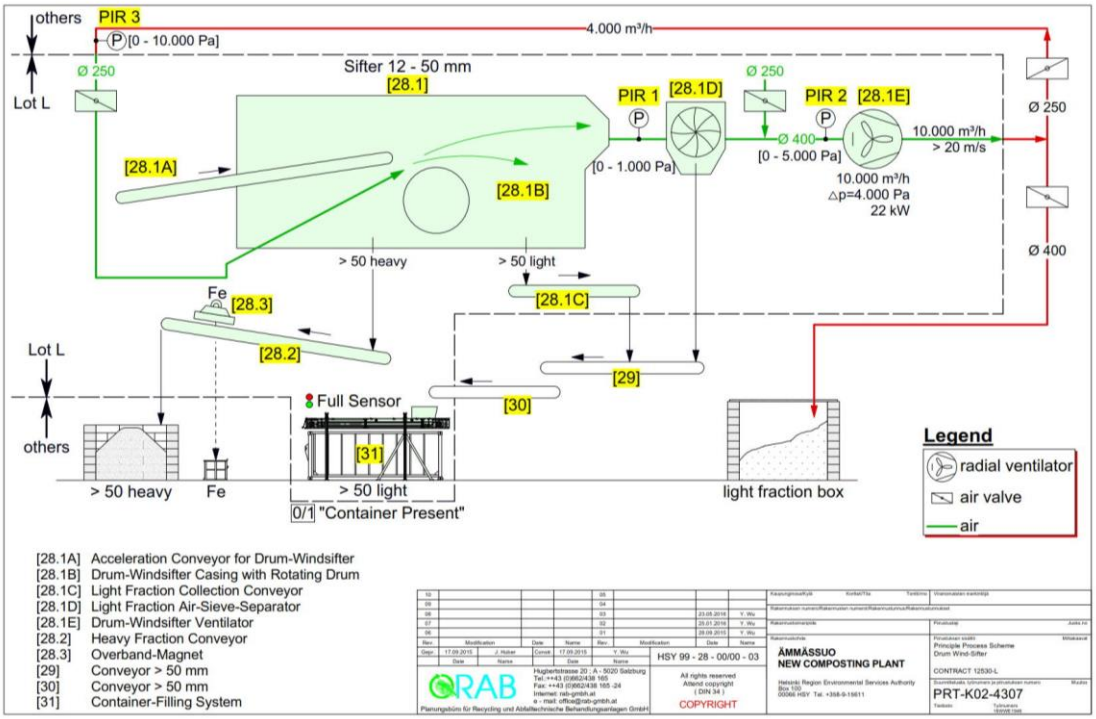

Figure 5. Drum-Wind sifter Scheme

In part D of the Sieving Line 4 (Figure 5), after materials sized 12–50 mm pass through the conveyor belt (28.1A), while materials more prominent than 50 mm in length and heavy - mainly wood during the process of being pushed out - will fall onto the conveyor belt. (28.2). From this conveyor, a large magnet (28.3) will be used to attract the metallic materials contained in this material. Items more oversized than 50 mm but light, such as crushed pieces of plastic or plastic bags, are blown through the conveyor belt (28.1C) through the windscreen wipers. In Figure 6, the pressure system sucks the plastic out of the line. Next, they will pass through the conveyor belt (28.1C) to the conveyor belt (29) and (30) will then enter the container. Most of the waste is screened and stored in containers called disposal. More significant than 50 mm in size but light are plastic bags of cloth mixed in with small pieces of wood used to process and compost biowaste.

Figure 6. Light fraction air-sieve-separator

4.2 Amount and composition of the rejects

The overall quantity of overflow of biowaste each year is enormous. The amount of surge in 2021 would be 3592 tons. It was delivered to Vantaan Energia Oy's waste-to-energy plant for energy recovery. By 2022, the total waste overflow

collected can be estimated at 40-60 tons each week. Of that, 80% are plastics such as bioplastics and everyday plastics used on the family side, and the remaining 20% are small glass, small metal, fabric, and wood. For material recovery, around 30 tons of mixer burner, metal separated from the process, and obsolete parts of compost lathes were provided *(according to HSY year report).* The plastic will be removed from the wind-sifter and stored in plastic storage. Those plastics will be removed and placed in a container to await treatment. However, because there are no treatment measures in place, the amount of plastic gathered over time has become excessive. It is also difficult to process it simultaneously since the resins obtained are not of the same kind and have distinct physical and chemical properties, needing the employment of a classification system if they are to be treated.

Figure 7. Sample of waste overflow

Common plastics make up the bulk of the waste bins (Figure 7). It is demanding to recycle because the plastics are not the same, and it is difficult to dissolve them in

the same solvent. PP, PVC and LDPE plastics account for about 70–75 % of the total number of plastics sorted. They are mostly food bags, food wraps, and plastic bottles containing spices such as mustard or honey. In addition, the amount of PET plastic is minimal because it is mainly bottle caps or boxes of small yoghurts that have been crushed or added during screening.

Figure 8. Waste overflow storage in the field

4.3 Possibilities of utilization and necessary treatment

In this study, the focus is on being able to sort plastics out to make the recycling process more accessible. Manual sorting might be done, but it is not good practice to be able to sort tons of rejections. My idea for this classification is to use a large ability water tank. All rejected waste will be dumped into the tank. The mixing blades will be activated, and the heavy debris or heavy material will sink to the bottom, leaving plastic waste at the top, and the edge will push them into a mesh hopper and make them dry. Landfilling and decomposing cannot be used to treat plastics; the way to deal with these discarded components is to use natural solvents such as Limonene.

5. EXPERIMENTAL PROCESS

5.1 Material and equipment

The place where I took the sample is under the conveyor belt of the final line in the pre-treatment process. To be able to collect samples in a refuse collection area, the following protective gear and respirator masks are necessary:

- Protection coverall
- Back hang air-purifying (Figure 9)
- Face shield connects with the air purifying by the tube (Figure 9)
- Work safe gloves
- Safety shoes

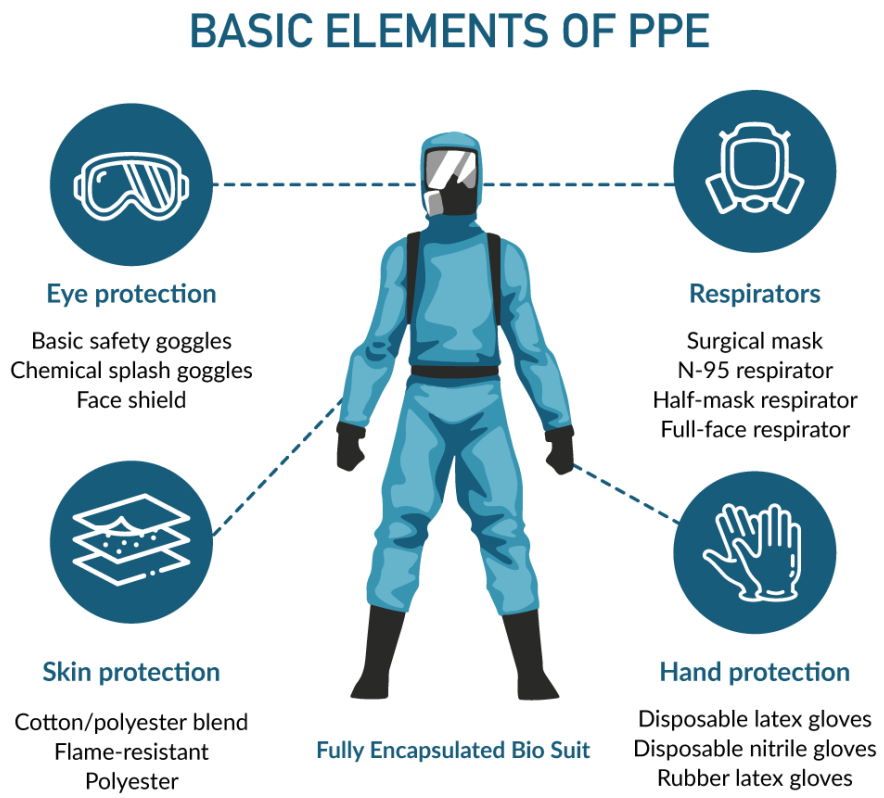

Figure 9. Protective gear when taking samples in Ämmässuo with a surgical mask (CSCU company)

Figure 10. Air purifier and face shield used at Ämmässuo

This backpack air purifier filters the air and fine dust present in the processing areas. In the treatment areas, the air contains a lot of gas due to the decomposition

of biological waste, so it is necessary to wear this air purifier every time it is required to enter the treatment area for sampling. In addition to gas, the processing area also has a lot of fine dust. They come from the process of drying or mixing garbage with wood chips. This air purifier has a protective effect on the respiratory tract and is not affected by gas or dust.

Based on the biogas effect level, the sample collected from the biowaste pre-treatment was categorized as biohazard level 2 (LouAnn C. Burnett et al., 2009, p.9), which means all the equipment mentioned is required and avoids eye contact. If eye contact happens, immediately rising your eye with the specialized solution is necessary.

Figure 11. Specialized eyewash solution

Always carry a gas warning device to receive a timely warning when the gas exceeds the allowable threshold. Need to leave the area immediately when the alarm sounds.

Figure 12. Gas alert device

Figure 13. Walkie-talkie (Radio phone)

I notified the monitoring room and the forklift operators by using a walkie-talkie to announce that I would be down the system in 5-10 minutes to take a sample.

5.2 Sample collection and the sample analyzed

I implemented the collection of samples six times at random dates over four months, and the total quantity of waste picked as a test sample was 200 kg. 200kg of crushing and screening rejected trash within three weeks was collected. For six container swaps, the total number of samplings is six. Each collection was sorted, and notes were taken on the amount of plastic and other debris gathered. Sampling takes place as guide follows; after a week of operation, the container was complete, and the hatch of the container is closed to replace it with a new container. As the forklifts moved the container, an individual container of approximately 30 kg was placed under the conveyor belt. Garbage that went through the conveyor belt felt into the small container.

After collecting a certain amount of waste, the trash was sorted manually. This classification allowed me to see what percentage of plastic and other junk was collected.

6. ANALYTICAL METHODS AND DATA COLLECTION

All figures of the same value are obtained from the monthly and annual reports of HSY. In addition, the data was collected by sampling the storage area of the rejected waste. Values derived through sampling and analysis indicate variance in quantity and composition and change in the amount of garbage collected by week and year.

The quantitative strategy was employed to gather and analyze numerical data, with laboratory tests and data from the company's report. After classifying and analyzing the data from the collected samples, the total mass of each test sample should be recorded. The calculated amount of resin has a negligible difference (Table 3).

Table 3. The amount of samples rejected and percentage of plastic rejected

Sample date	**20/1/2022**	**1/2/2022**	**15/2/2022**	**3/3/2022**	**15/3/2022**	**2/4/2022**
Weight of sample	30 – 40 kg	50 kg	30 kg	20 kg	10 kg	30 kg

Plastic in percent	75%	81%	88%	80%	90%	78%
Other waste	15%	19%	12%	20%	10%	22%

The data collected, together with the analysis of the year's assessment, will be the most accurate data on the composition of rejected bio-waste.

Table 4. Tonnes of biowaste treatment in 2021 (HSY annual report)

Waste types	***Received***	***Composting plant treatment***	***Digestion treatment***	***Field treatment***	***Rejected***
Biowaste	50 973	28 859	22 025	89	3592

In 2021, the quantity of waste components derived from bio-waste was in Table 4. In Table 5, the amount of biological waste and its components denied in 2021. The amount of waste and rejected elements increases significantly during the summer months and months with public holidays such as October, the fall holiday, and December has Christmas Day. An interview with my managers was made to get the best result from the analysis. In the interview, I asked them to give me some comments on why the amount of plastic was raised, and their statement was mentioned in the Result chapter.

Table 5. The amount of biowaste and rejected waste in 2021

Year	Month	Biowaste	Rejected
2021	1	3 580,06	186,54
2021	2	3 317,92	118,40
2021	3	4 022,52	386,64
2021	4	3 920,78	406,80
2021	5	3 832,26	397,90
2021	6	3 646,96	388,76
2021	7	3 069,14	337,00

2021	8	3 692,42	345,22
2021	9	4 074,96	153,22
2021	10	3 745,98	321,40
2021	11	4 032,28	250,82
2021	12	3 864,12	325,48
Total:		**44 799,40**	**3 618,18**

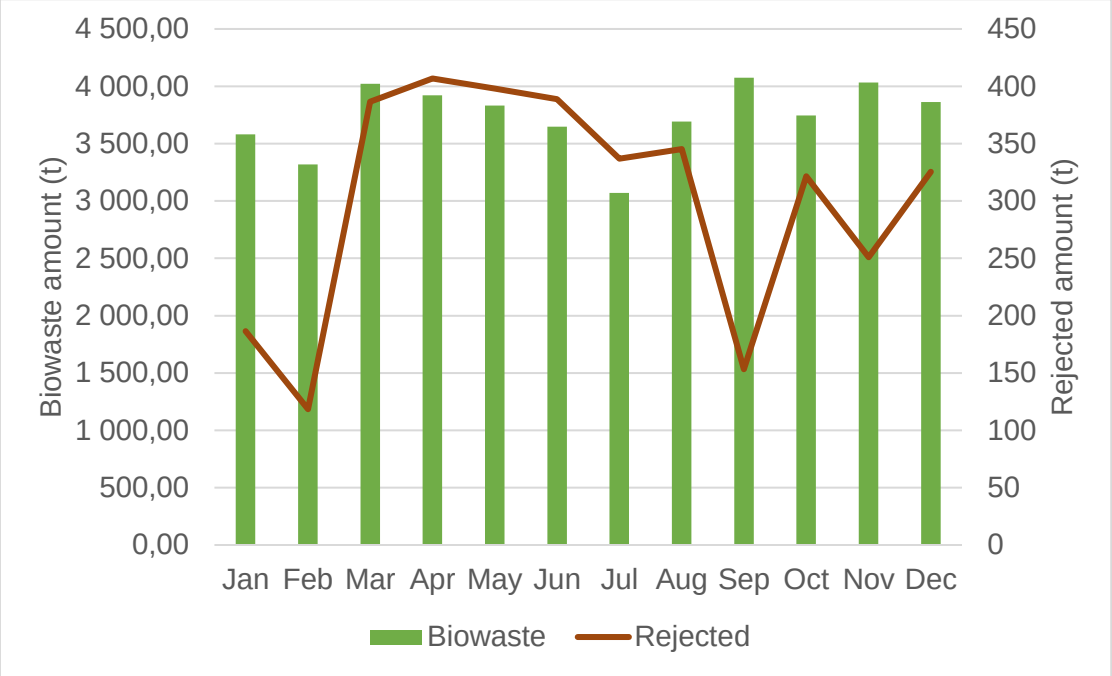

Figure 14. Different biowaste and rejected waste in 2021

Looking at chart 14, the columns and lines clearly show the difference in the amount of garbage between the months in 2021.

7. RESULT AND DISCUSSION

7.1 Result

To get the results for this sampling process, based on my own working and sampling experience, the samples were obtained have a specific difference or influence due to system operation. In addition, it also depends on the amount of waste that the system collects. For example, in one ton of biological waste, 200 kg of rejected plastic waste can be collected, and the quality of the test sample will be higher. However, with the number of test samples that I have obtained, the

data is evaluated and analyzed in the most objective way to obtain the most accurate value.

From the analysis results obtained through the sorting process of the collected samples, the total amount of plastic in the rejected waste collected is approximately 80%. The data are shown in Table 6 and Figure 15, depicting the exact amount and change and difference in the amount of waste collected in the first four months of 2022.

Table 6. The amount of biowaste, rejected and plastic in the first four months of 2022 (HSY private system report)

Year		Biowaste	Rejected	Plastic
2022	January	3 776,40	212,08	159,06
2022	February	1 869,28	236,24	199,62
2022	March	3895,04	501,48	426,26
2022	April	3735,06	243,88	190,23

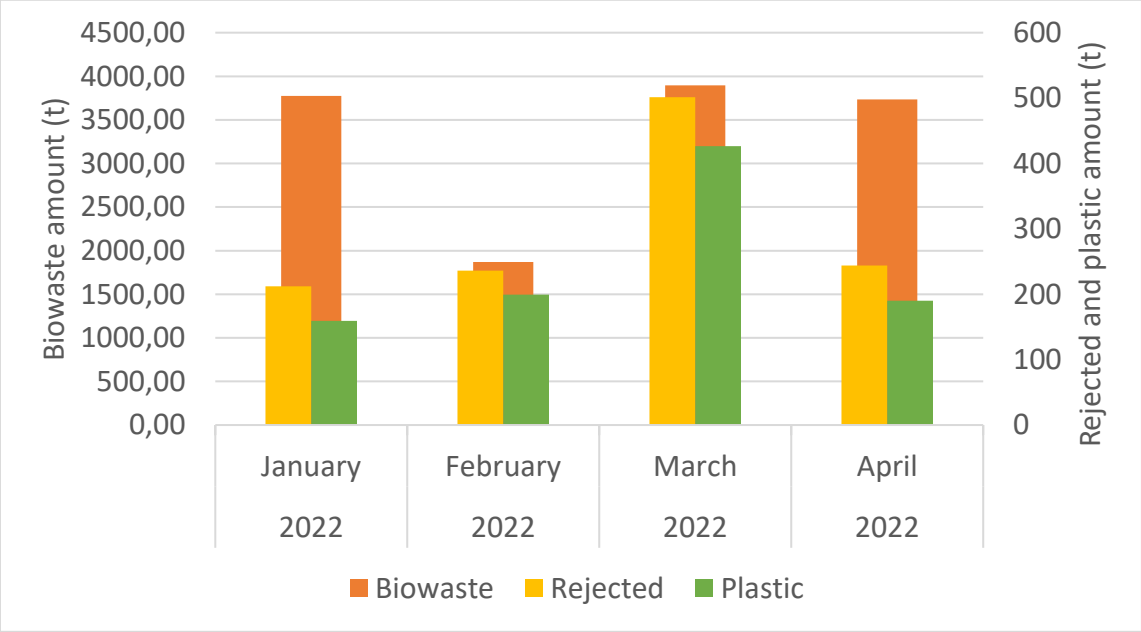

Figure 15. Rejected waste recorded in 4 months (Red: Biowaste, Purpose: Rejected, Orange: Plastic)

Based on the data in table 6, within the first four months of 2022, the total amount of plastic discharged from the biological waste pretreatment process was nearly 680 tons, a much decrease compared to the first four months of 2021 due to the

problem. The disease problem has improved, and people have been able to go to the office to work and travel, so the amount of waste has decreased. However, not much; it has also shown the use of many plastic items in the daily life of the people in the Uusimaa (New Land) area.

According to the data and graphs in Figures 14 and 15, the amount of rubbish rejected in 2021 (Figure 14) grows dramatically during public holidays and summer days when most of us are home. And, in 2021, when the COVID-19 epidemic makes travelling to workplaces difficult, and we are compelled to work remotely, the quantity of trash in daily life will grow. According to the study data in Figure 15, the amount of garbage domestic created in the first four months of 2022 was essentially smaller than in 2021. Primarily because of social distance and mobility constraints. Being eliminated, going to work, travelling, and travelling also contributes to the reduction of home garbage. In monthly meetings on waste level assessment, my college attributed the low amount of plastic waste in March because the pandemic has stabilized since March, and we are allowed to travel and back to the office. Hence, the amount of garbage collected from residential areas is relatively low.

During the monthly meeting on waste level assessment, management and technical experts gave their opinions on the growth issue of plastic waste in domestic waste. Tea Järvinen- The Operational Engineer, said:” Due to the need to stay at home and not be allowed to travel, the amount of plastic waste from households has increased. They buy food, order fast food, and buy clothes and other items. Each type will come with a plastic bag to wrap, and all that bag will be placed in a trash bag and transported to the disposal site.” This means that the use of plastic bags and wrappers in food packaging and shopping at the market is a lot, a large amount due to having to stay at home for a long time and must cook or order food.

Christoph Gareis – Operation Manager, said that in addition to people shopping, being lazy to sort trash also increases the amount of plastic waste in bio-waste bags. Every time they clean up, they put all the trash and plastic bags in the same place and throw them in the mixed trash. Therefore, when brought to the garbage classification area, the mixed waste and biological waste will be transferred to the

treatment area of biological waste. Time-consuming shopping is also a big problem in using plastic bags or other plastic materials. Plastic bags from clothing stores can be reused for the next shopping trip, but we always throw them in the trash without even sorting them out.

And when I asked why the amount of plastic waste in March is so much smaller than in January and February, they all agreed that while January and February are still the months that are not too stressed about the COVID-19 pandemic, there are still certain restrictions. Hence, people stay at home and work from home, so the amount of garbage is more than in March.

7.2 Discussions

The idea of recycling and utilizing plastic in the rejected component begins with being able to remove all impurities such as metal, wood, or other decomposers mixed with the plastic. Impurities should be removed, and the resin rinsed using a water bath with a blade. In this way, the metal and heavy substances will sink to the bottom, and we can get the clean plastic floating on the surface. After being washed, we have two ways to recycle plastic into raw materials, such as melting the plastic with natural solvents or melting them. However, to react with natural solvents, the resins in the discarded composition need to be segregated because each resin can only be dissolved in a fixed natural solvent. It is tough to categorize all of them. The way plastic is melted, and the reason that plastics are frequently not melted together and then separated is an issue of physics and economics. When any of the seven commonly used plastics are heated together, they divide and merge. As a result, the mixed resin has a fragile structure that makes it challenging to deal with.

After analyzing the sample, I obtained the composition of the waste, including PE, PET, LDPE, and PVC.

Table 7.Plastic types in rejected waste

PE	Polyethylene or polythene
HDPE	High-density polyethylene
PVC	Polyvinyl chloride

PS	Polystyrene
LDPE	Low-density polyethylene
PET	Polyethylene terephthalate

PE (Polyethylene) is the most common plastic used today; it is a polymer mainly used for packaging (plastic bags, food plastic films, and food or cosmetic containers. PE is divided into many types, and the two most commonly used types of PE are HDPE (...) and LDPE (...), and they melt at a temperature of 120-130 degrees Celsius. (Adam Augustyn at *Encyclopædia Britannica*)

PVC (Polyvinyl Chloride) is a flexible plastic that is widely used in life, and it is also used as a material in the construction or used to make plastic gloves for food processing. This kind of plastic cannot be decomposed in nature or used as energy by burning because it will release harmful compounds from combustion. So, it can only be burned at unique waste incineration plants. Otherwise, PVC waste will become mixed waste in landfills. (Charles EW an& Mark TB; 2005)

PS (Polystyrene) is a synthetic aromatic hydrocarbon polymer derived from monomer styrene. Polystyrene is a transparent, rigid, and brittle material. Polystyrene is one of the most frequently used polymers, with a yearly manufacturing capacity of several million tonnes. Protective packaging (packing peanuts and jewellery boxes used to store optical discs such as CDs and occasionally DVDs), carrying cases, lids, bottles, trays, cups, disposable cutlery, model creation, and alternate material for phonograph records are among the applications. Polystyrene is a thermoplastic polymer that is solid (glass) at ambient temperature but melts when heated beyond 100°C, its glass transition temperature. Because it can be moulded into a mould with fine detail, this temperature feature is employed for extrusion (as in foam), casting, and vacuum forming. D-limonene might dismantle polystyrene and go about as a diene monomer in thiol-endentation responses, empowering another reuse come closer from the plan. (Alexander TL et al, 2013)

So now HSY, in partnership with Vantaa energy, uses that rejected waste by generating electricity. Based on data from HSY, the amount of waste rejected from

the bio-waste pretreatment process is sent to the power plant in the city of Vantaa. Each year, it burns more than 3500 tonnes of rejected waste from HSY – Ämmässuo. The garbage utilized by the waste-to-energy office supplies about portion of the region heat expected by Vantaa in a year. Besides, the plant gives around 30% of Vantaa's yearly power use.

Figure 16. Part of the waste to energy process

Figure 16 shows essential parts and components in a waste treatment system to generate energy. The waste to energy process has eight features: (Westenergy.fi - Waste to energy plant)

1. Tipping Hall: Consistently, 30 junk trucks store their trash in the waste fortifications.
2. Waste bunker: The shelter can hold five million vehicle sacks, and a programmed snatch blends trash to keep the plant's fuel as uniform as could really be expected - this is significant for the activity's general soundness.
3. Gate and furnace: On an 80-square-meter grind, squander is singed at 900 degrees Celsius. The temperature stays high since air is continually blown onto the mesh.

4. Boiler: The heat from hot flue gases is transported to boiler water and turned to steam. Steam is heated to 400 degrees at a pressure of 40 bars.
5. Flue gas treatment system: Pipe gas cleansing occurs in stages. Acidic toxins and weighty metals are limited by lime and actuated carbon in the texture channel and sifted through. At long last, vent gas scrubbers clean the gases, while heat exchangers recuperate the intensity.
6. Generator and turbine: Steam turns the turbine, which turns the generator. The generator produces 15 megawatts.
7. District heat unit: In the locale heat unit, hot steam warms the virus area heat water. The temperature vacillates from 65 to 115 degrees Celsius relying upon the season and climate. The locale heat unit has a 40-megawatt limit.
8. Bottom ash: Bottoms debris is a blend of debris and metal. It is scooped into transports underneath the colossal and afterward into holders that change naturally.

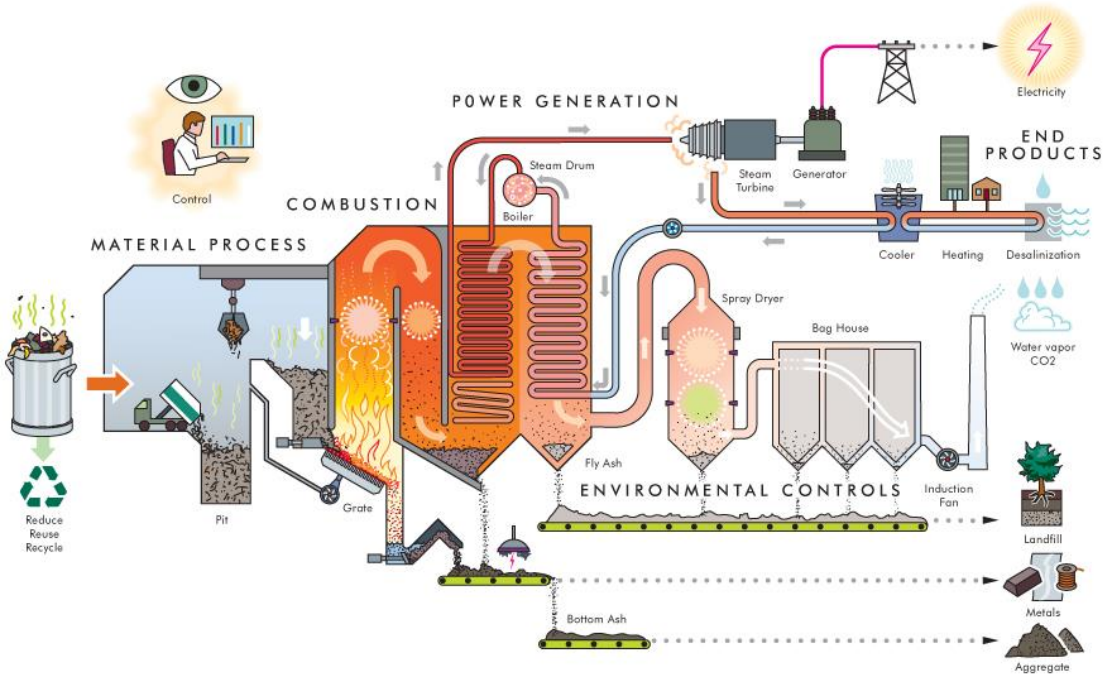

Figure 17. Waste to energy process at Vantaa Energy

The waste-to-energy conversion system consists of five main stages (Figure 17): material process, combustion, power generation, environmental controls, and end products. The waste to energy system at Vantaa Energy gets around 140 heaps

of refuse each average working day. Squander cranes at the trash shelter blend the loss into a uni-structure mass before being taken care of into the burning evaporator. The waste mass in the fortification is sufficient to go on for close to seven days. The smash feeder pushes trash to the mesh at the lower part of the feed container. Blended squander enters the ignition chamber on a pivoting grate modified to turn it over frequently to keep it uncovered and consuming, such as turning over or jabbing an open-air fire log. Total consumption is created by a directed contribution of oxygen and exhaust from the getting zone. Increasing alkali or urea to the rising burning gases kills nitrogen oxide. Dioxins and furans are taken out by uncovering exhaust gases for two seconds to an upheld temperature of 1,562°F/850°C. This technique eliminates the incredible larger part of dioxins and furans. The waste-to-energy evaporator recuperates start energy. The steam turbine generator is driven by superheated steam, which is extraordinarily effective. Cooled steam is reused in the water through the condenser or used as an intensity hotspot for structures or desalination plants. To finish the steam cycle, the chilled stream is warmed in the economizer and superheater. To hold and eliminate weighty components like mercury and cadmium, initiated carbon (charcoal treated with oxygen to increment porosity) is added to the warmed gases (Deltawayenergy.com - Waste-to-Energy: How it works).

The acidic ignition gases are killed utilizing a lime or sodium hydroxide infusion. The substance response brings about the arrangement of gypsum. This strategy takes out 94% of the hydrochloric corrosive. The electrostatic precipitator eliminates 90% of the pipe gas particles created during waste burning. The pipe gases are treated with lime during the cleaning step, which ingests sulfur dioxide and enacted carbon, retaining weighty metals. Pack channels (baghouse) eliminate toxins from pipe gases, permitting them to fulfil the breaking point values laid out. Heat is recuperated in the vent gas condenser, where corrosive gases and particles are cleaned. The intensity recuperated from pipe gases is utilized to warm the area by warming water. The enlistment fan ousts the cleaned vent gases at 50-65 degrees Celsius. Fly debris is gathered at different periods of the cycle. It will be mixed with natural controls (debasements from vent gases eliminated by a pack channel) and discarded in a landfill. The base debris will be scrubbed by disposing of metals to make the total. (Vantaa Energy.fi – Waste to Energy plant)

However, the amount shipped still does not solve the problem of too much rejected waste remaining in the landfill, and the cost for treatment companies is also more expensive if the amount of waste is more.

8. CONCLUSION

The amount of plastic waste in household waste has increased since the beginning of 2021 until now and shows no sign of decreasing. In households, due to plastic products without careful classification, the domestic waste contains a large amount of plastic of all kinds, making the pre-treatment process more necessary for the maximum variety of plastic in waste. From data analysis and test samples combined with the obtained results, in the rejected waste composition, the main types of plastics found are:

- Polyethylene (PE)
- Polyvinyl Chloride (PVC)
- Polystyrene (PS)
- Polyethylene terephthalate (PET)

During my investigation, I discovered that sorting rubbish at home also aids in the separation of pre-treatment waste. The high level of plastic trash in household waste increases the quantity of plastic waste rejected, making it even more difficult to manage. Because of day-to-day existence changes, plastic packs carry numerous accommodations in the article of clothing, refreshing, and food ventures. Plastic items augment the safeguarding of items. Items for transportation and bundling are also modest materials, so they are significantly utilized. Along these lines, as society creates, the utilization of plastic is expanding.

Unrefined substances for plastic items and offer those plastic materials to other assembling organizations. HSY shows how much plastic acquired from dismissed squander is a brilliant wellspring of recyclable materials. The aggregate sum of trash that declined consistently is exceptionally enormous, of which 80% is plastic, everything being equal. Assuming it was feasible to track down a more straightforward method for reusing would lessen the considerable measure of plastic waste in landfills. Likewise, it would increment benefits for the organization by cleaning and reusing a similar standard of plastic waste. Waste to energy offices utilize squander as a fuel source to produce power, while other power plants use

coal, oil, or flammable gas. The drinking fuel changes over water into steam, which controls a turbine. The cycle can lessen a local area's landfill limit by up to 90% while keeping away from one ton of CO2 outflows for each critical heap of trash eaten.

The recycling of the plastic waste in different ways instead of putting it in mixed waste or bio-waste; or taking it to a waste sorting and recycling facility are both sound practices to reduce the amount of plastic waste in the waste screening and treatment processes at the waste treatment plant.

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HSY	Helsingin Seudun Ympäristöpalvelut – Helsinki Regional Environmental Service
VTT	Teknologian Tutkimuskeskus – Technical Research Center of Finland
ARVI	The Materials Value Chain
EC/Europa.eu	European Commission / Europa.European Union
CSCU	Crime Scene Clean-Up company

APPENDICES

Appendix 1. Principle process scheme of the Sieving Line – line 4