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Optimization of paper collection

Case: Area Kiertokapula waste management plant

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<p>Paper collection optimization is important from cost-effectiveness viewpoint. The collection is conducted nationwide and therefore it has a large impact on the recycling culture in Finland. This thesis presents regional paper collection in Finland from point of view of Paperinkeräys Oy. How the collection is conducted, what different parties and legal obligations are involved in the process is described in the thesis. Starting point was after the author researched and analysed development suggestions.</p> <p>The research focuses on collection points in designated area called Kiertokapula. Multiple collection points and containers have been implemented since the 1940's when company was established by the forest industry association. Main problem for the company is to locate these collection points and analyse the need and added-value of certain collection points.</p> <p>Quantitative research methods and data provided by the company and the subcontractors was used for the results. Based on the analysis of the data provided, the author made development suggestions, how to make paper collection more cost-efficient in the area given. As a main conclusion, there is a surplus for collection points and containers in the area. Paper volumes input should and could be distributed more effectively.</p>	
Keywords	Paper collection point, container, drain frequency, ERP, subcontractor, waste management plant, forecasting, reverse logistics

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Terms and abbreviations

Collection point – is a location including at least one container for given material like paper, metal or glass.

Container – an object for holding recyclable material like paper. A container varies in size and appearance and if it is surface or recessed.

Drain frequency – is a numeric representation of how often given container is drained of material. For example, frequency of one means that the container is drained weekly and frequency of four means that the collection point is drained once every four weeks.

ERP – Enterprise Resource Planning system is a shared database that supports multiple functions used by different business units. (Netsuite, 2017)

1 Introduction

Finland has an excellent recycling culture and it goes far back. During the 1940's Paperinkeräys Oy company was established by the Finnish forest industry association, mainly for paper collection. Goal was to ensure citizens to have possibility to recycle paper and have an easy access to paper collection points, in the process of obtain paper for recycling and energy production. World is moving towards stronger digitalization day by day. Paper usage has decreased slowly and continues to do so. In 2013 about eight percent of the used paper and carton ended up being recycled (Hamunen, 2015) and paper production and export decreased by 3-4 percent in 2015 and continues to decrease in average by 1-2 percent annually. (Palomaa, 2016)

As time passed due to lack of proper tracking the paper collection containers were scattered across the country. However, demography and digitalization has taken a toll for the paper volumes. Nordregio's research about demography states that:

"Migration flows are of growing interest in the Nordic Region due to both unprecedented in-flows of migrants, and depopulation in many rural areas...At the regional level, Finland appears to be the only country dramatically affected by population decline." (Nordregio, 2017)

Increase in email usage, not using letters, electronic billing, electronic communications and electronic filing are just some of the reasons for digitalization. Households use less and less paper which affects the waste paper volumes. Smaller volumes mean that there is not the same kind of need for paper containers. Need of less paper affects also greatly companies. Companies do not need to archive thousands of papers in their records because they can import everything to hard-drives or into cloud service.

Paperinkeräys Oy is looking to make their collection more efficient and therefore location of the collection points needs to be optimized, mapped and studied based on the need of the individual collection points. Scope of the thesis is to introduce a regional paper collection system in Finland, clarify the current situation of the regional paper collection in Finland and provide development suggestions for optimized operations.

Data is there and it needs to be collected and analysed. The target of this research was to collect the data needed and make proposal for how to organize the current volume of the collection points and still maintain the same volumes of paper collection.

Information for this thesis is gathered in cooperation with the company's area team, area managers, subcontractors, ERP-system and from prepared data regarding to collection points. Hypothesis is that based on this mapping and collection optimization task the number of paper collection containers will be removed from the soil which is cost-effective for the company and the subcontractors.

1.1 Paperinkeräys Oy

Paperinkeräys Oy is a Finnish nationwide logistics company in a field of waste and raw material management. The company operates as a wholesaler for waste and raw materials. Total revenue in 2016 was 70,4 million euros and the company employs about two hundred employees. Company's strategy is to be the most prestigious recycling company and trendsetter in their field. (Paperinkeräys Oy, 2016)

Paperinkeräys Oy offers different services for the customers:

1. **Waste management services.** Paperinkeräys Oy collects waste produced by companies from different fields. It is aimed for store chains, trade and logistics centres, producing industry, energy producers, printing houses and office properties. The company collects paper, cardboard, energy waste, burn waste, bio waste, metal, glass and plastic and recycle material for new reusable material. (Encore, Jätehuoltopalvelu, 2016)
2. **Information safety services.** The company collects and destroys sensitive documents properly. Containers with locks are delivered to the customer. When containers are filled, the pickup is ordered. At the production unit, the lock is opened and sensitive documents are shredded to small pieces, baled and forwarded for reuse. This service properly disposes hard drives, clothes and anything that the company wants to get rid of. (Encore, Tietoturvapalvelu, 2016)

3. **Pallet service.** Paperinkeräys Oy manages over 1,5 million pallets in a year. The company offers rented and reusable pallets. Pallets are marked with RFID-tags and are recognized from green colour and from black Paperinkeräys Oy -logo. (Encore, Kuormalavapalvelu, 2016)

Paperinkeräys Oy decides with waste management companies, municipalities or with municipal establishments of the locations of the collection points and uses local subcontractors to collect and transport paper. The company guides and advises consumers how to recycle where the collection points are located.

1.2 Objectives and scope

General aim of this thesis is to introduce regional paper collection system in Finland. The thesis is based on a case study of Paperinkeräys Oy. Because of this the target of the thesis was also to clarify the current situation of the regional paper collection in Finland for the company and provide them development suggestions for optimized operations. The company operates and provides paper collection nationwide, but the scope of this thesis is southern part of Finland and focuses only on paper collection. Data for the thesis and research was collected in cooperation with the company's southern Finland area manager.

The more detailed target of the thesis was to map the current volume and locations of the collection points. By mapping locations and comparing them with third-party-location-mapping it was possible to update the status of the current situation with the collection points and make development suggestions for optimized collection.

The following research questions were answered:

1. How the paper collection process works in Finland?
2. Who are the different parties involved in the process?
3. What is their role and responsibilities and legal obligations for the collection?
4. What is the current operational situation of Paperinkeräys Oy in regional paper collection in the waste treatment plant area called Kiertokapula?
5. What is the current number and locations of the drain points?

6. How the paper collection of Paperinkeräys Oy could/should be optimized and developed?

1.3 Research structure

Introduction chapter introduces Paperinkeräys Oy where the author was working during the project. Also, company background and what kind of services are offered is introduced. Main research questions and the research methodology and limitations are stated. Chapter two explains the current situations of the regional paper collection and parties involved. Theory related to the research is described and analysed in chapter four. Results and data analysis are discussed in chapter five. This chapter unfolds the data collected and reveals the results behind suggested changes to the current situation within the paper collection. Finally, chapter six presents suggestions for development for regional paper collection, with relying on the data shown in chapter five.

1.4 Methodology

The author was working as a permanent employee since January 2017 in a logistics and development team of the company and in the development project of drain point optimization. This project involved close cooperation with the area manager, whose responsibility is southern part of Finland. Qualitative research method was used to collect the information required for the completion of the project and creation of a development suggestion for the company. Some of the information was gathered from the company's partners and third parties with help of interviews and from company's own ERP- system. To understand the big picture of the process, all the parties involved, the discussion with colleagues was conducted. For example, regional paper collection as a wide process and all the parties involved are explained. The roles and responsibilities of all the parties are clearly explained. The information gathered was used for understanding the current operations and for the development.

Development suggestions, presented in chapter five. were based on this data mentioned earlier. Secondary data sources such as books and articles were also used, an expert from the company like Field Manager, Logistics Manager and Logistics and Development

Director. One challenge with the secondary data was that the regional paper collection process in Finland is unique when compared to other nations' legal responsibilities of waste collection. Therefore, it is not a common subject and the information published about it is limited.

1.5 Limitations

Regional paper collection has a long history. The current process, how the collection runs, has rooted its place. The volume and location of the drop points is not mapped. Locations and volumes are gathered from multiple sources and the into one documentation. Most of the data regarding collection points addresses, number of paper containers and calculation for setting the drain frequency for example, are based on assumption that the data is correct. Although the results might not be as accurate as possible, it provides reliable directions for better outcomes in terms of optimization and cost-effectiveness.

2 Regional paper collection in Finland

This chapter explains the regional paper collection in its importance, key reasons for decreasing volume of paper, background history, its legal responsibilities, parties involved in it and the company's current process to conduct collection in a specific area.

2.1 Finnish Solid Waste Association

The Finnish Solid Waste Association, FSWA (fin, Jätelaitosyhdistys) represents Finnish waste management companies in regions and municipals. Members of this association take care of the waste management of over 5 million citizens in Finland. (JLY - Jätelaitosyhdistys ry, 2017) Figure 1 below shows all the members regionally (green colour, white coloured areas are not part of the association).

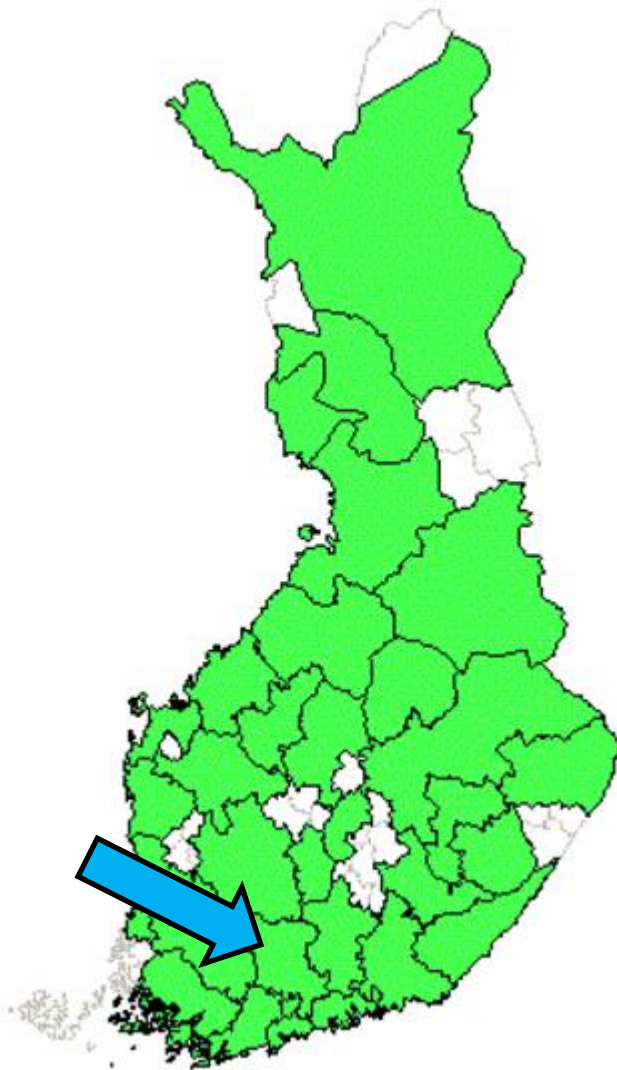


Figure 1. Members (green colour) of the Finnish Solid Waste Association regionally. (JLY - Jätelaitosyhdistys ry, 2017)

Blue arrow in the figure 1 shows waste management plant Kiertokapula's area of operation. This specific plant is introduced more in the chapters later.

2.2 Community producers

Based on the Finnish waste law, the housing companies have a responsibility to arrange collection tool and location for reclamation of paper. Community producer is responsible for emptying the collection containers and recycling the material. (Finlex, 2011)

In sparsely populated areas a producers' responsibility is to arrange collection point for single-family house residents. Usually the collection points are placed to conurbations and locations with service concentration. Producers are also responsible for organizing the collection information for the residents.

Paper producer and import companies and printed matter import companies have producer responsibility. Based on the Finnish waste law, producers must organize collection in rural areas per urban area and in planning areas in cooperation with properties. Recycling rate is stated to be 75 % of the gross amount of collection paper brought to the markets. (Paperinkeräys Oy, 2017)

2.3 Producer responsibility for waste management

Purpose of the Finnish waste law is to prevent danger and harm for occurring to people's health and environment by preventing to decrease waste volumes and harmfulness, increase the usage of natural resources, ensure efficient waste management and prevent littering. (Finlex, 2011)

Paperinkeräys Oy is part of the producer responsibility community. It denotes that the producers and importers are responsible for to organize waste disposal of products with costs included when products are withdrawn from usage. Managing the producer responsibility is adequate obligation based on the Finnish waste law, and failure to follow this law may result in a default fee. (Eduskunta, 2011)

Paperinkeräys Oy implements paper collection nationwide and is authorized by Finland's collection paper community producers. As a representative of community producers, the company is responsible for collecting writing paper and printing paper in whole Finland and it is responsible also for informing consumers properly about the paper collection. The company organizes regional, cost free paper collection points for residents in a single-family housing and sparsely populated areas and takes care of the emptying of those collection points. Regional collection covers entire Finland.

3 Current state of the regional collection in Paperinkeräys Oy

As being part of the producer responsibility community, Paperinkeräys Oy has an obligation to collect paper regionally in Finland. While other companies produce paper, Paperinkeräys Oy is responsible for collecting the paper after it is determined to be waste. Paperinkeräys Oy does not have its own truck fleet. Instead the operative paper collecting is outsourced to other companies or entrepreneurs. Finnish waste law defines the urban obligation. The law describes the size of an area where there must be a free paper collection point for the residents. Figure two below shows a common container for paper.



Figure 2. Paper collection container (Brunnen Communications Oy, 2012)

In Paperinkeräys Oy, the regional paper collection is separated into five operating areas:

- Southern Finland
- Southwest Finland
- Middle and Eastern Finland
- Bottom lands (in Finnish called Pohjanmaa)
- Northern Finland

These five areas have their own Field Managers and Area Team, whose responsibility is to ensure that regional collection functions seamlessly. With co-operation with Logistics and Development Department the Field Managers conduct optimization, route planning and make sure that the ERP system and equipment and software of the company communicate with each other. Regional collection covers whole Finland, meaning that there are tens or even hundreds of different partners working for the same goal which is paper collection. These logistics partners or subcontractors vary in size, stock and ICT such as having different software and equipment they use and therefore paper collection is regionally conducted using different tools in a different manner although the result is the same. This makes it challenging for the company to follow and compare the data collected from these regions.

3.1 Region observed

The main task of the Management plant Kiertokapula is to ensure processing of community waste and bio waste in their area of operation. Community waste is exploited for an energy and bio waste is used as a raw material in different processes which produce bioethanol for raw material for biofuel. They make agreements on the management of waste management in municipal areas and recycling of co-operation with community producers. The area is in the Southern Finland. For example, in this area Paperinkeräys Oy has paper collection points alongside with third-party operator, who has collection points containing variety of containers for different materials like metal and glass.

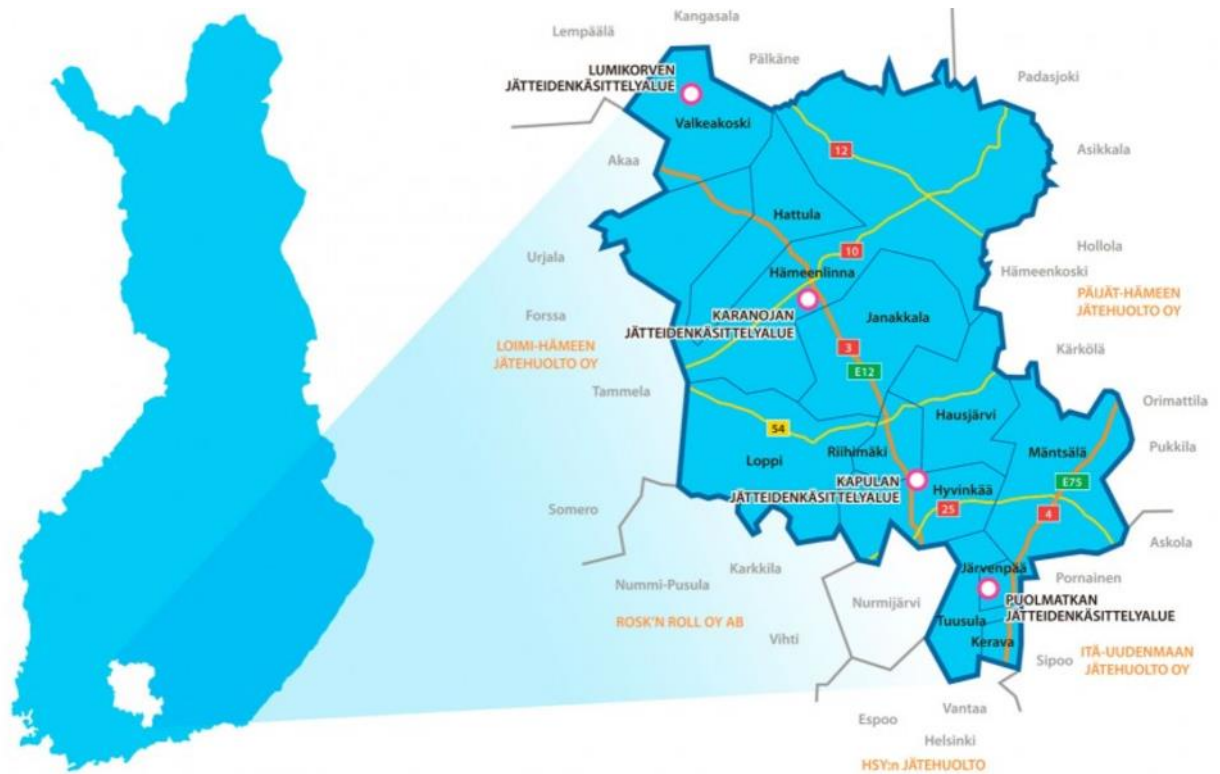


Figure 3. An area chosen for this research (Kiertokapula Oy, 2017)

Figure 3 shows the area of Kiertokapula in the southern Finland. All paper collected by the Paperinkeräys Oy in this area (blue colour) is delivered to different management plants agreed upon, due it is then treated and baled to wait for the further transportation.

In this area, paper collection for the company, is outsourced to three parties:

- Subcontractor in far south is responsible for the following municipalities:
 - Mäntsälä, Järvenpää, Tuusula and Kerava. Collected waste is then delivered to management plant in Vantaa.
- Second subcontractor is responsible for the small area in the north, the area of Valkeakoski. Collected waste is delivered to the management plant in Tampere.
- Rest of the area is the responsibility of the third subcontractor:
 - Hattula, Hämeenlinna, Janakkala, Loppi, Riihimäki, Hyvinkää and Hausjärvi. Collected waste is then delivered to the management plant in Hyvinkää.

These subcontractors collect paper for Paperinkeräys Oy and deliver it to the agreed waste management plant.

3.2 Collection points

Paperinkeräys Oy has a big amount of collection points in the Kiertokapula area. There are also a third-party collection points. These collection points offer different collection containers for different materials like glass, metal and carton. To these points consumers can drop their carton, metal and glass waste depending on the collection point what kind of services does it offer. These points could also have collection containers for paper. There is a possibility, that Paperinkeräys Oy's paper collection point is only a couple of blocks from the collection point of the third-party collection point. For consumers, it would be more practical to have these collection points in the same place, this would make recycling more attractive to them.

3.2.1 Paper collection points

Figure 4 below shows all the collection points for Paperinkeräys Oy in the Kiertokapula waste management area. Collection points are focused on the main roads and urban areas like larger cities. Some of the points are scattered around.

3.2.2 Third party collection points

Figure 5 shows collection points of the third party in the Kiertokapula waste management area. Points are focused to conurbations like Kerava, Hyvinkää, Riihimäki and Hämeenlinna, which are right next to the main roads and are easily accessible. These points are

usually right next to large groceries and offer multiple containers for different kind of recyclable material.

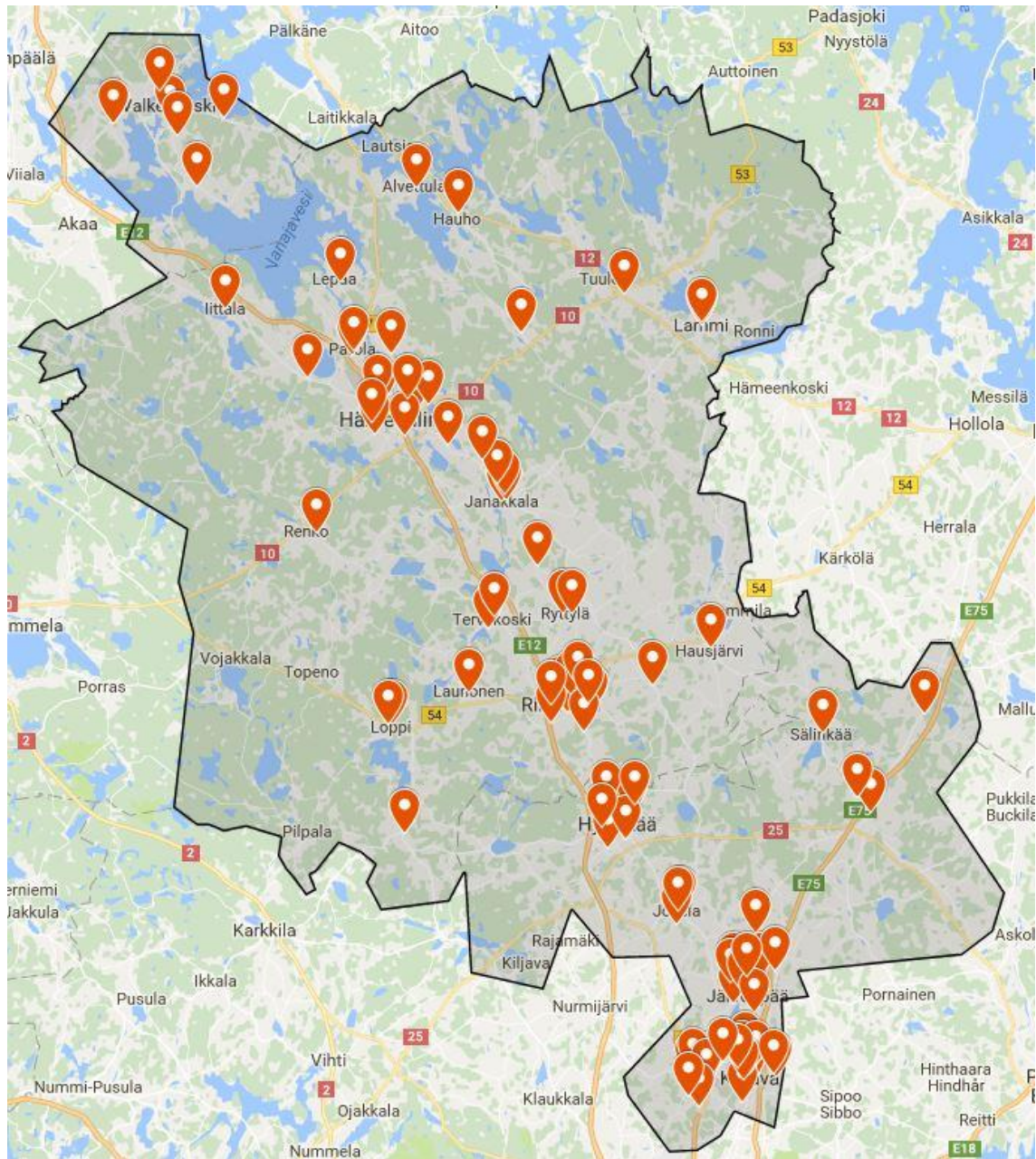


Figure 5. Third party collection points. (KIVO, 2017)

Figure 6. Paperinkeräys Oy's and third-party collection points in comparison (Blue stands for the company points and red point icon stands for third-party collection point). (KIVO, 2017)

The current number of collection points in the area for Paperinkeräys Oy is 255 not including collection points of the third-party. The occupancy level average is 75 % and drain frequency average 5 (collection point is drained every 5 weeks) in the Kiertokapula waste management area only. The total amount of paper collected in nine months (January till September) is x tons (information is confidential).

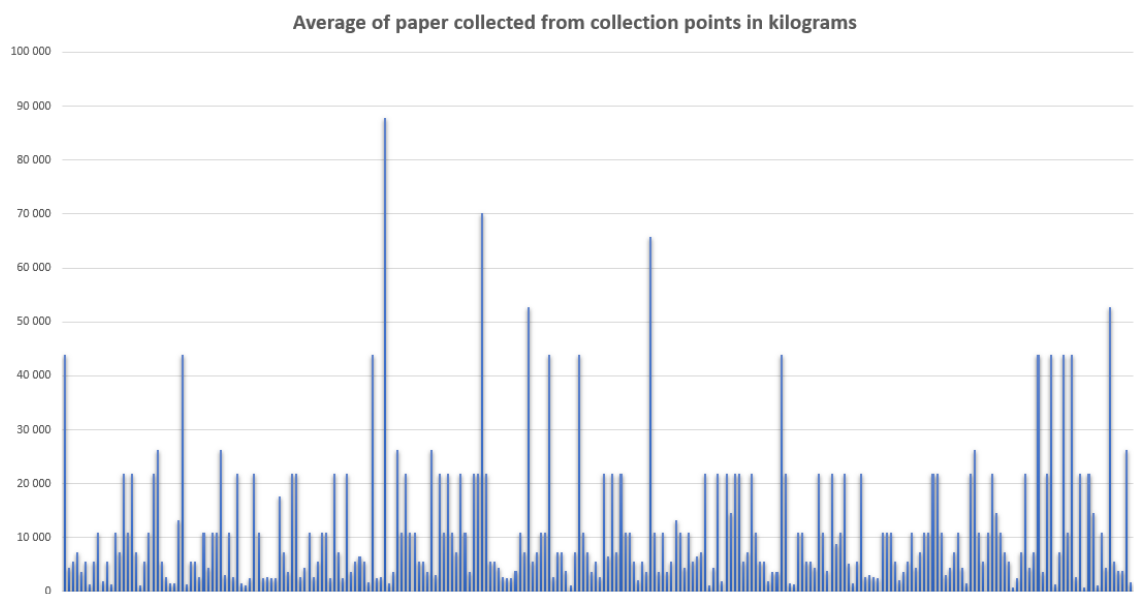


Figure 7. Average of paper collected from collection points in kilograms from January till September. (Based on collected data)

There is variation in the amount of paper collected in average between individual collection points. Figure 7 illustrates this clearly. Currently the points are drained by the subcontractor according to their own time table and Paperinkeräys Oy does not have specific draining week or frequency for the points. In other words, Paperinkeräys Oy does not have real time information, because the subcontractor uses their own ERP-system. Paperinkeräys Oy gets reports after every month. This leads to a variety in occupancy levels because when it is the most cost-efficient to drain collection points at that time the occupancy levels are high. It is a challenge to try to reach full 100 percent of occupancy levels because there is a high risk that the container would get overfilled. Depending on the high the overfill is, there is a change that third-party cleaning services are needed,

which then adds more expenses. The most optimal average occupancy level would be around 80 percent to 85 percent.

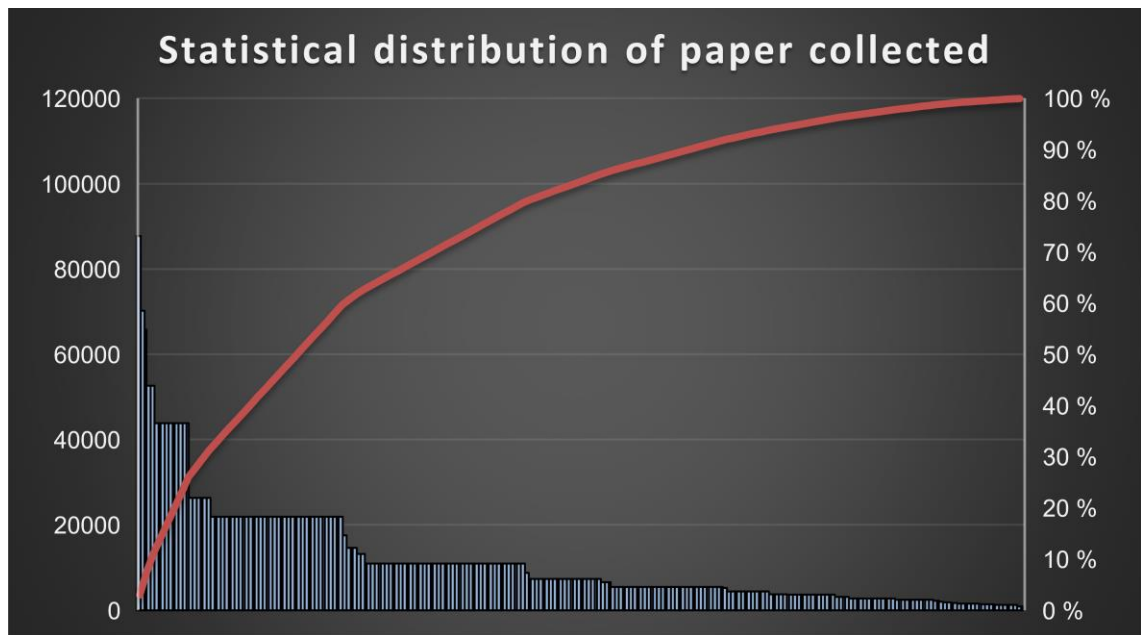


Figure 8. Statistical distribution of paper collected per collection point. (Based on collected data)

Figure 8 above shows the statistical distribution of the data from relatively big amounts to small. The secondary axis represents a percentage of the total. The figure shows that there is a small amount of paper collection points that collects large volumes of the total paper collected. Vice versa there is a large amount of collection points which collect very small amounts of paper.

4 Reverse logistics and forecasting methods

In this chapter reverse logistics and different forecasting methods are explained. They are related to the paper collection business and applied as analysis methods represented in the conclusion. Theory related to demand forecasting focuses on spatial demand, temporal demand and quantitative forecasting methods like moving average and weighted moving average.

4.1 Reverse logistics

In traditional supply chain, the forward logistics process begins from a supplier. Distributors transport materials to manufacturers, from where readymade products are distributed to retail stores. From retail stores the products end up to the end customers. This is the simplified version of supply chain, but today's forward logistics process can be more complex. Getting a more complex product to the end customer could involve multiple suppliers, multiple distributors and distribution routes, many manufacturing phases where different parts are manufactured in different factories and possibly assembled in another. In addition to multiple stages between supplier and customer, these stages include many parties. Only the transportations could include multiple subcontracts, not forgetting multiple suppliers, manufacturers and retailers. For a company managing an effective supply chain is expensive but a necessity. (Bonev, 2012)

"A supply chain consists of all parties involved, directly or indirectly, in fulfilling a customer request. The supply chain includes not only the manufacturer suppliers, but also transporters, warehouses, retailers, and even customers themselves" (Bonev, 2012)

Reverse logistics turns this logic around, so that the path of the products is from the customer to the supplier as illustrated in figure 9.

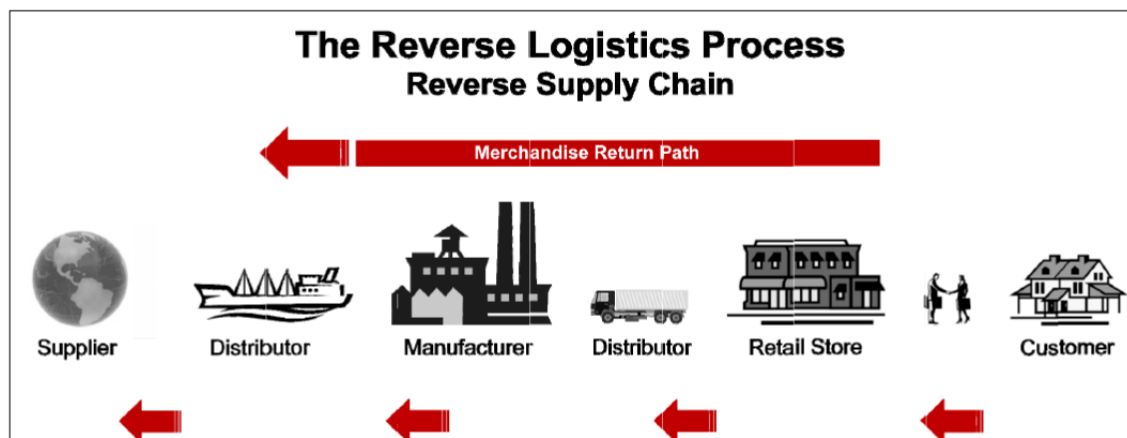


Figure 9. Reverse logistics process (Bonev, 2012)

In reverse logistics customer takes the product to the retail store, where it is transported to the manufacturer. Some of the materials in the product could be used for manufacturing a new product, but rest of the products are distributed back to the end supplier. As the traditional logistics process, reverse logistics process includes multiple parties to get the product from the customer to the supplier. American Reverse Logistics Executive Council has defined reverse logistics as:

"The process of planning, implementing, and controlling the efficient, cost-effective flow of raw materials, in-process inventory, finished goods, and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal." (Bonev, 2012)

Definition made by American Reverse Logistics Executive Council concentrates on actions with the purpose to recover value. Focus is not only on traditional logistics process, but to getting more value out of the product with reverse logistics. Bonev (2012) states that this definition differs from concepts such as:

- *waste management*, as for the products there is no new use or recovery value,
- *green logistics*, which considers environmental aspects in logistic activities, focussing particularly on forward logistics,
- *supplementary actives* such as transportation of empty materials, e.g. moving containers, is regarded as being supplementary activity.

These concepts above like waste management and green logistics are more common understanding what comes to the reverse logistics.

4.1.1 Reverse logistics in Paperinkeräys Oy

Main business concept for the Paperinkeräys Oy focuses on reverse logistics. Where for example paper moves from the supplier to the customer is traditional logistic process. Paper's raw material is collected by supplier, distributed to the manufacturer, from where prepared paper is distributed to the retail stores in form of magazines and newspapers for example. Consumer consumes the paper or the product, and delivers it to the closest paper collection point. At this point, the reverse logistics begins.

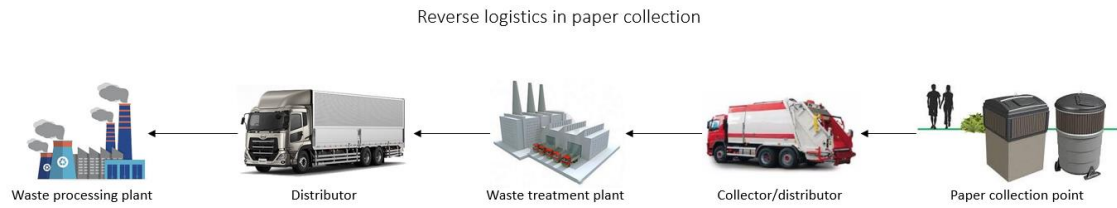


Figure 10. Paper collection's reverse logistics process in Paperinkeräys Oy

See figure 10, where consumers deliver their household paper waste to the nearest paper collection point. These points have at least one paper collection bin and its size varies between 1,3 – 5 square meters. Ideal occupancy level for bin is around 85 percent. Every individual collection point has drain frequency for example two, meaning that the collection point is drained by the subcontractor every second week. Certain amount of collection points is drained, defined by planned routes. When the truck is full, the subcontractor (collector/distributor) takes the paper load to the designated waste treatment plant. At this waste treatment plant, the paper is stored and pressed and baled to a square. Metal wires are bound around the bale keeping it square shaped. Bales are then loaded to a truck and transported to waste processing plant (supplier) by another subcontractor, where paper goes to reuse. Paper which is not reusable, like soaked paper is burned for energy. Reused paper is produced to a new product and the traditional logistics process begins and the cycle starts again.

Bonev writes that:

"...many companies engage with reverse logistics because of marketing, competition, or strategic reasons. Some companies, for example, use recovery processes to prevent other competitors from obtaining their technology, to avoid trading with brokers or simply to be prepared for future legislation." (Bonev, 2012)

For Paperinkeräys Oy reverse logistics is a business model. Revenue is created when paper is collected and distributed to waste processing plants. For the Paperinkeräys Oy reverse logistics grants direct benefits, where for many companies, reverse logistics grants indirect benefits like market protection, green image and relations, not direct benefits like materials and cost reductions. See table 1.

Table 1. Economic drivers for reverse logistics (Bonev, 2012)

Direct benefits	materials, cost reduction, value added recovery
Indirect benefits	anticipating/ upcoming legislation, market protection, green image, improved customer/ supplier relations

4.2 Spatial and temporal demand

4.2.1 Spatial demand

Spatial demand addresses the **place where** the demand occurs. Spatial location of demand is needed to plan warehouse location, to balance inventory levels across the supply chain network, and to geographically allocate transportation resources. (Li, 2014)

Spatial demand theory is applied to the regional paper collection as the company needs to decide where to place collection points to. If the paper collection point is in a remote area, with no other services near or lack of daily traffic, the consumers are less likely to take their paper waste to it. Therefore, paper collection containers are placed to areas that have high demand for paper waste and are easily available. For example, while consumers go to a grocery store, they could take paper waste with them and leave the paper to the containers located in the same property as the grocery store. This makes it easier for the consumers to recycle and grocery store properties potential locations for the collection points.

4.2.2 Temporal demand

Temporal demand addresses the **time when** the demand takes place. Timing is one of the most important outcomes of forecasting. Demand variation associated with time is a result of growth or decline in sales rates, seasonality in the demand pattern, and general fluctuations caused by a multitude of factors. (Li, 2014)

Regional paper collection containers are filled by the consumers and the occupancy varies seasonally and regionally. For example, after Christmas time there is usually a high peak of paper left to containers and during summer holidays the occupancy levels are lower. With occupancy data from the past months and years, the occupancy level could be forecasted in a certain scale.

4.3 Managing the forecast process

Ling Li (2014) explains a forecasting process with series of six steps, regardless of what product is forecasted and which method of forecasting is applied. Steps are illustrated in figure 11.



Figure 11. Forecasting process (Li, 2014)

- Step 1. *Identify forecast objectives.* Forecasting uses historical data to project future demand. Therefore, we need to decide what to forecast. Forecast units may vary at the different levels of an organization and in the supply chain.
- Step 2. *Determine forecasting variables and data.* Data used in a forecasting should be determined first.
- Step 3. *Select forecasting method.* In general, forecasting methods can be grouped into two categories: qualitative and quantitative methods.
 - Qualitative forecasting method. This method is known as judgmental forecasting. Forecasting is based on an educated guess or on expert experience. This method may be useful when a firm tries to predict the demand for a new product for which it does not have historical information.

- Quantitative methods are based on mathematical models. The most often-used methods are the time series and causal model.
- Step 4. *Examine forecast accuracy.* Accuracy is a measure of how closely a forecast aligns with observations of the series. Bias is the persistent tendency of a forecast to over-predict or under-predict demand. Bias is, therefore, a kind of pattern which suggests that the procedure being used is inappropriate.
- Step 5. *Synchronize forecast results.* Different functions in an organization prepare their own forecast which reflect their focus. Marketing focuses on trends occurring in the marketplace; the finance department emphasizes budgeting; and the sales department forecast based on sales quotas. While, in theory, these forecasts would roll up the same number, this is rarely the case. Therefore, a few forecasts can be prepared: one for production planning, one for marketing and sales, and another for accounting and finance. It is important that forecasts are synchronized collectively, to reduce forecast variation and to plan for production flexibility.
- Step 6. *Evaluate forecast outcome.* Forecast results should be evaluated periodically to refine the forecast and to determine the best component to forecast in the supply chain.

4.4 Quantitative forecasting methods

There are many forecasting methods e.g. the time series, the causal mode, simulation, and qualitative methods. The selection of the model depends on the nature of the demand observation and the type of industry. Quantitative forecasting is based on mathematical models. For the case of this thesis time series techniques were chosen. Ling Li (Li, 2014) describes the following two techniques: *Moving average* and *Weighted moving average*. These forecasting techniques could be implemented to forecasting occupancy levels and pickup cycle (date/week) for the collection point.

4.4.1 Moving average

Moving average forecasting method observes past and the data is valued equally. Moving average is the arithmetic average of a certain number of the most recent observation. As each new observation is added, the oldest observation is dropped. The value of the number of periods to be included for the average reflects responsiveness versus stability. In the following example, we are calculating how many days does it take to arrange a pick up. (Li, 2014)

$$F_{t+1} = (\sum L_t) / n$$

Where:

n	= number of periods to be included for computing average
L_t	= demand observation for period t
F_{t+1}	= demand in period $t+1$ (which is next period)

With the formula, we can forecast pick up days using the historic data we have, see table 2. If the number of periods to be included for the computing average (n) is larger, the greater the weight to past demand the forecast gives and the fewer number of periods of historical data used to predicts future demand, the better the forecast will reflect recent demand trend.

Table 2. Moving average technique forecast (data collected).

Days to next pick up	Forecast	n = 4
30		
29		
25		
33		
31	29	
27	30	
32	29	
33	31	
28	31	
25	30	
24	30	
26	28	
	26	

4.4.2 Weighted moving average

In the moving average table 2, each demand observation is weighted equally. For example, for a 4-period table, each observation is weighted 0,25. Sometimes, analysts want to give certain observations more weight to reflect the real situation. (Li, 2014) This is called a weighted moving average. The formula for weighted moving average is as follows:

$$F_{t+1} = \sum_{t=1}^n W_t * L_t$$

Where:

W_t = weight for period t; the sum of all the weights is 100%

L_t = demand observation for period t

F_{t+1} = forecast demand for period t+1 (which is next period)

Table 3. Weighted moving average technique forecast (data collected).

Days to next pick up	Forecast	
30		0,2
29		0,3
25		0,5
33	27	Sum = 1,0
31	30	
27	30	
32	29	
33	30	
28	32	
25	30	
24	28	
26	25	
	25	

First forecast result in table 3 is 27. It is calculated so that the number 25 from "Days to next pick up" row is multiplied with weight of 0,5. Added a result of 29 multiplied with weight of 0,3 and finally added with 30 multiplied with weight of 0,2. It gives the result of 27. In this similar manner, we can make new forecasts as we progress to get new real results of the days for the next pick up.

Simple average demand can conceal underlying trends, seasonality, or irregular demands, each of which requires a different approach to that needed for the control of regular demand products. (Li, 2014) Weighted moving average helps to smooth the demand curve for better trend identification. It places even greater importance on recent data than the moving average.

5 Data analyses and results

It is given that there are too many collection points and some of the points are too close to each other. Especially collection points which are isolated and have a high drain frequency. This chapter suggests ideas to Paperinkeräys Oy how to cut down the number of collection points in Kiertokapula waste management area. Decreasing the number of collection points increases the occupancy levels and results in more optimized collection.

Figures 12, 13 and 14 below show collection points with blue and black markings. Blue meaning a collection points which will do not need any changes. Black ones are collection points which will be removed. Most of the collection points marked to be removed are isolated and/or with large drain frequency. For example, in figure 13 collection points in far west are with large drain frequency like 18 or 26 and are really isolated. These points collect relatively small volumes and it is not cost-efficient for subcontracts to drain. Also, these points are in remote areas. Roads could be in bad condition during winter time for large trucks. When these points are removed, the consumers are informed about the nearest collection point where they can take their papers for recycling. In conurbation areas, there is surplus of collection points. Some of these have also a large drain frequency and therefore it's not cost-efficient to have. Removing collection points from conurbation area, a risk of overfill, too many collection points could be removed.

Collection point is removed if it has a large drain frequency and/or if the collection point is isolated and/or there is another collection point near. Drain frequencies are calculated with forecasting method from a data collected.

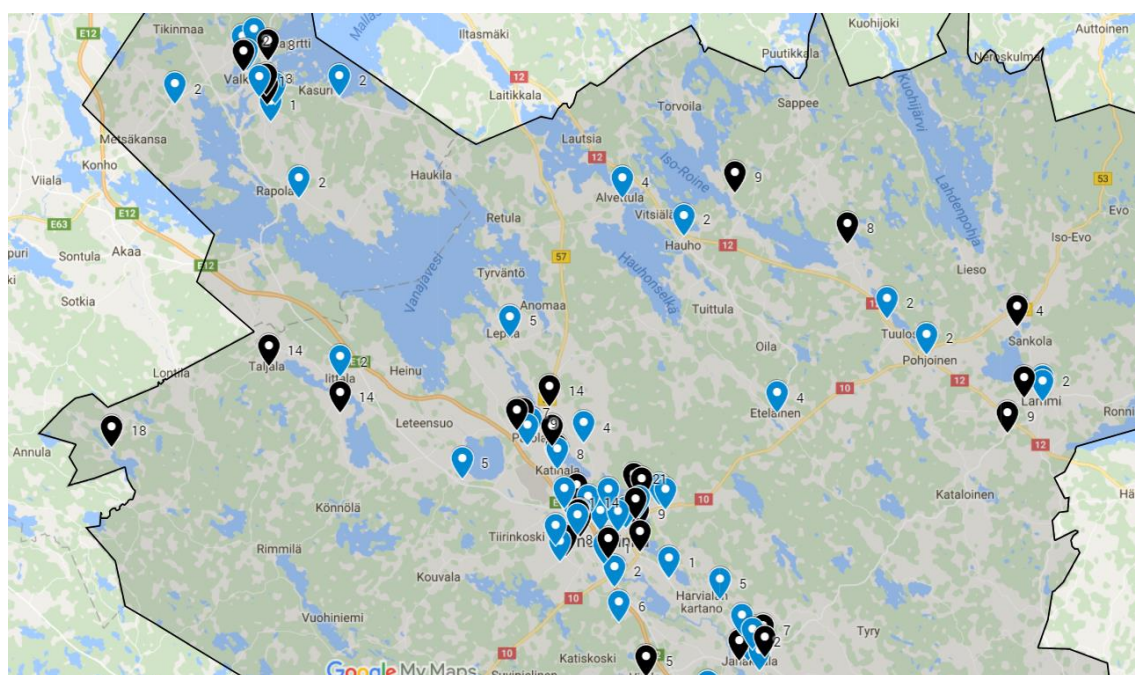


Figure 12. North part of Kiertokapula with black marks representing collection points which are removed.

With figure 15 suggested changes we forecast, that the average occupancy levels for collection points will rise. Let's assume that the new average for occupancy levels is 85 percent. With occupancy level of 85 percent, the new number of collection points in the

area for Paperinkeräys Oy will be 156. Drain frequency average of 2 (collection point is drained every 2 weeks) and the total of paper collected in nine months (January till September) is x (information is confidential). The total amount of paper collected would stay relatively the same and the company has achieved these kinds of results when they have decreased the amount of collection points in other areas. While removing collection points, it does not decrease the total amount of paper collected but instead paper is distributed along the collection points. There will be changes for driving schedules, routes and collection points individual drain frequencies. Single collection point would collect x tons of paper (information is confidential) in average, when currently the volume of paper collected is roughly x tons (information is confidential). When eliminating worthless collection points, Paperinkeräys Oy has more cost-efficient operations.

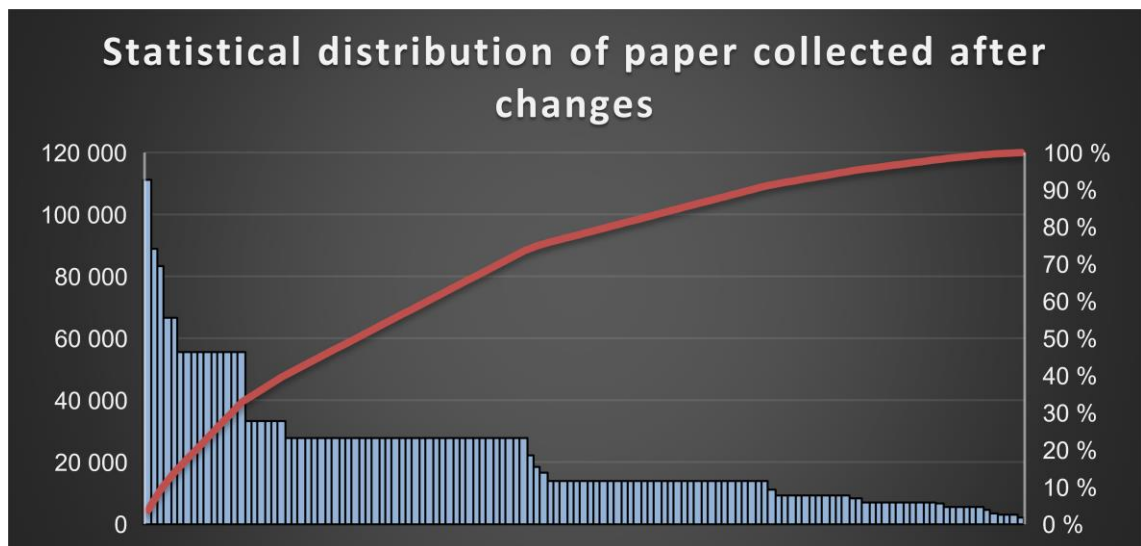


Figure 15. Statistical distribution of paper collected per collection point after removing collection points. (Based on collected data)

Figure 16 shows in percentages the difference between collection points today and after changes. The left-hand side of the figure shows that the collection points collected much less paper than in the comparison table on the right-hand side. Which collects a lot more paper per collection point.

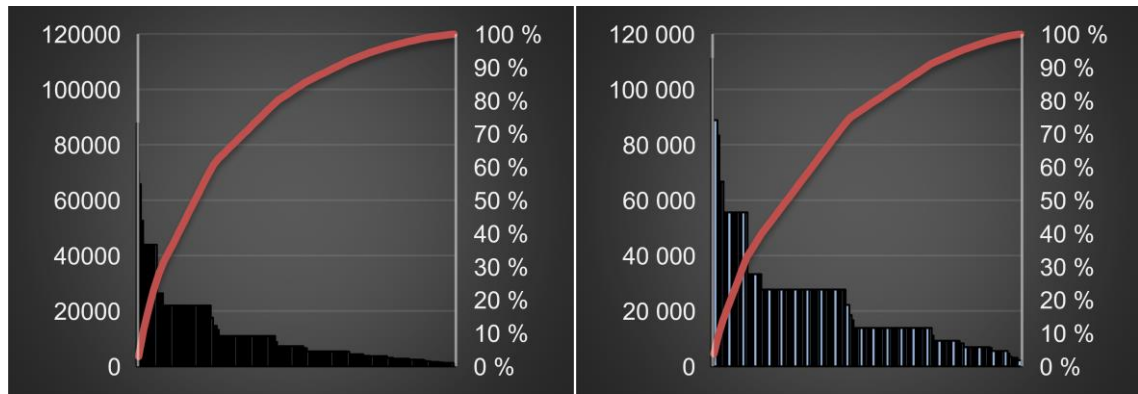


Figure 16. Statistical distribution of paper collected percentually in nine months. (based on collected data)

Figure 17 represents that there are less collection points in sparsely populated areas after changes. Collection points are concentrated to conurbation areas. In conurbation areas, there are more grocery stores and these locations have collection points of the third-party for several recyclable materials. So, it is more logical for consumers to take all their recyclable materials; paper, metal, glass etc., to the same location.

6 Conclusions and recommendations

In total, there are too many collection points in the Kiertokapula area of waste management plant. There is a lot of room for reduction. Changes presented earlier would make paper collection operation more cost-efficient for Paperinkeräys Oy. Possible changes

need to be implemented with a well-thought timetable and the process should be considered carefully before it is launched. Changes made too fast could result a lot of feedback and contacts from the consumers. It is better to proceed with piloting changes first on certain area and after successful results move to another.

Research questions defined at the beginning of this thesis were answered. The paper collection itself was introduced; what are the collection points, where are they located and who are the parties involved like the producers, waste management plants, contractors (Paperinkeräys Oy) and subcontractors. Current operational situation of paper collection was presented in chapter three that analyses showed need for optimization because that there is a large amount of collection points in rural areas and the output of the paper is relatively small compared to the ideal output. It is not cost-efficient for the subcontractor to send a truck to the isolated location to collect small amounts of paper. The current number of collection points is 255 and total of 286 paper containers.

After development suggestions, the number of collection points was reduced to 156 and total number of paper containers to 184. Consumers are informed about the nearest collection point and the distribution of paper is directed to other collection points. The fear is that when the nearest collection point is removed, the consumer's recycling motivation will decrease. Although within other areas of paper collection, the company has proved, that it does not reduce consumers motivation for recycling. The changes are well rationalized, since it is not profitable to have surplus of the collection points and paper containers.

Development suggestions were presented in chapter five. Paperinkeräys Oy should reconsider having collection points in rural areas and focus more in conurbations and more precisely to locations containing collection points of the third-party, like parking lots and grocery stores. Having possibility to recycle at those paper collection points attracts more consumers and because for the consumer it is more practical to take all the material from their household to one single collection point. When it is more practical for the consumer, the motivation for recycling could increase and even bring new consumers to the recycling culture.

6.1 Quantitative forecasting methods in forecasting in Paperinkeräys Oy

When establishing a new collection point or determining a new drain frequency, the weighted moving average method could be used. It was impossible to know the optimized drain frequency at the beginning. With weighted moving average technique, the company can manually follow the results and after collecting enough data, implement it to the ERP system and generate automatically the wanted draining frequency. Weighted moving average method takes to consideration seasoned effects, giving more weight to latest results. Days are calculated and those days can be changed to weeks which then can be transformed to drain frequencies. Moving average and specially a weighted moving average method is a good forecast technique for a new collection point, when area team is trying to find out a good drain frequency.

6.2 Statistical distribution of paper after changes

Figure 18 illustrates statistical distribution of paper collected per collection point. Blue colour indicates current paper distributed by every collection point and the red colour bars indicates how paper is distributed per collection point after changes. Wider spread of blue bars indicates that there is almost a double amount of collection points and paper is distributed so that most of the collection points collect less than x tons of paper (information is confidential) in nine months. Smaller spread of red bars indicates that there is less collection points but every collection point collects more and the paper distribution is higher per collection point. There were 256 collection points before changes and after them there are 131 collection points. The total average of paper collected per collection point was about x tons (information is confidential) and after the changes, the total average of paper collected is about x tons (information is confidential), which doubles the amount. Cutting down the number of collection points makes the paper volume input higher for individual collection point, therefore it is more cost-efficient to drain less collection points, but still maintain the same paper volumes. This is so because paper is distributed more efficiently.

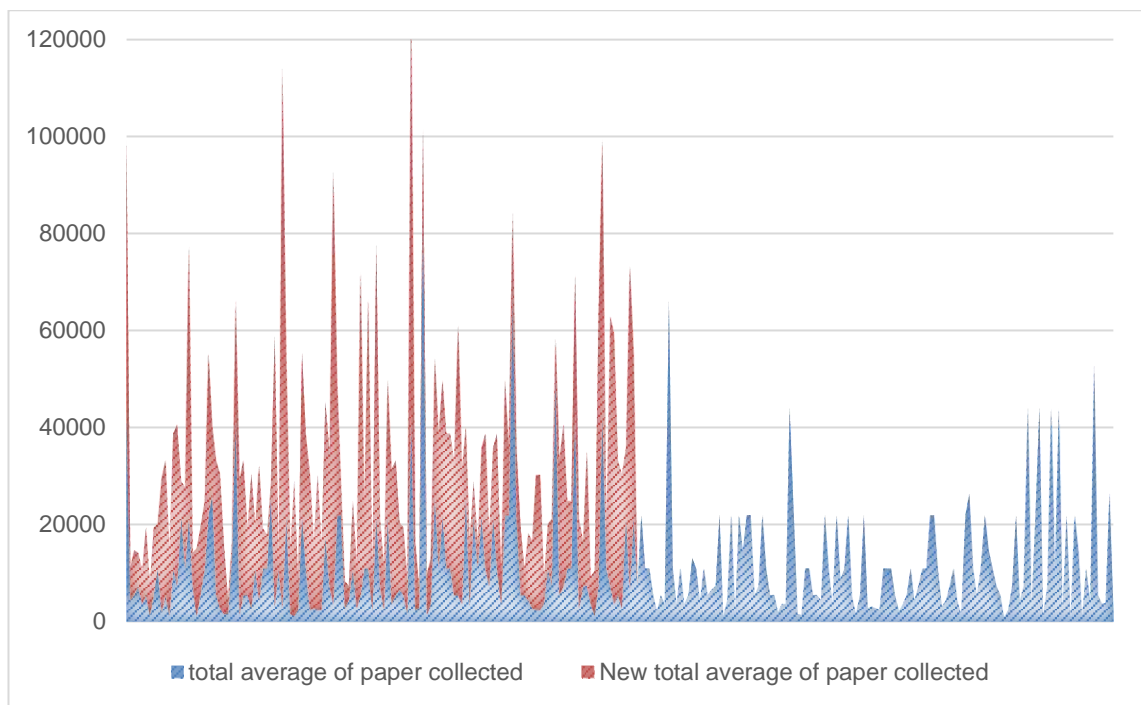


Figure 18. Statistical distribution of paper collected comparison. (Based on data collected)

Similar comparison could be done in other areas where paper is collected. Clearly, all the areas differ from each other and research and comparison is needed before decision making. Possibility to obtain data for collection network is limited and the challenges of obtaining correct data between areas vary. Smaller or larger changes could be implemented to every area where Paperinkeräys Oy operates and collects paper.

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