YRKESHÖGSKOLAN
NOVIA

Closing the Loop with Fish Processing and Agriculture

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EPS MIDTERM REPORT

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Abstract

This report aims to present the cooperation between a fish processing plant and a nearby field. An EPS group from the Novia University of Applied Science has investigated and discussed the technical aspects to ensure a successful alliance.

This partnership aims to reuse all waste produced by the processing plant. By dispersing wastewater obtained only by processing fish on the field, the company will no longer need to resort to conventional water treatment but can supply a nearby farmer with natural fertilizer. Fish waste will be exploited for their fish oil and collagen.

Methods and techniques to extract these valuable elements were discussed as well as cost management. The company will now decide how it wants to proceed knowing how it can valorize its waste.

Language: English Key words: Fish processing, fish waste, agriculture

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1 Introduction

Finding a sustainable economic system today has become a necessity to maintain our lifestyle and reduce our environmental impact on the planet. A circular economy is an economic system where recycling and reusing are at the heart of the concept. This economy aims to not rely on fossil resources and to reuse all waste. Natural resources are thus preserved, and the system is sustainable in the long run.

One method of applying this economic system is by enabling a partnership between a fish processing plant and a cultivated field. Furthermore, this partnership will aid in reducing the ecological phenomenon called eutrophication, which has negative effects in Finland. Eutrophication is when a body of water becomes excessively rich in nutrients and minerals, thus leading to algae growth and oxygen depletion.

Previously, wastewater from the processing plant was treated conventionally which did not allow to exploit the nutrition in this water and eventually leads to eutrophication. Now, with this partnership, minerals and nutrients contained in the wastewater will be fed to the nearby crops, acting as a fertilizer stimulating better plant growth. At the same time, it reduces the environmental impact by limiting the need for conventional fertilizers.

The processing plant also creates other waste that comes from inedible fish parts. These parts are mainly fish guts, heads, skin, and bones. The intention is to valorize these by-products both ecologically and economically. Collagen and fish oil are the most prized products contained in fish waste and can thus be extracted and sold as nutritional supplements.

Thanks to the Novia University of Applied Science, we can investigate this alliance as part of our EPS (European Project Semester) project. The university has found a company willing to contribute its processing plant’s wastewater to fertilize a nearby field. During the semester, we will not only investigate the technical aspects of reusing the wastewater but reusing the entire fish which is not fit for consumption. All the fish waste from the processing plant must be reused in the most efficient way possible in order the put in place a circular economy and finally, close the loop with fish processing and agriculture.

2 EPS Project

2.1 European Project Semester

The European Project Semester (EPS) is a one-semester long program where European students with different backgrounds work together on a project. Courses allowing us to better carry out the project are compulsory such as team building, project management, and cross-cultural communication. Swedish is also mandatory allowing students to adapt better here in Finland.

Each participating university proposes several projects to carry out and students can then choose which projects interest them the most. Teams then consist of 3-6 members from different nationalities and backgrounds to diversify origins and fields of study to benefit not only the project but also student experience. Students will learn not only the difficulties of working on a semester-long project but also learn to work in multi-cultural teams. This is important in the globalized world of today, where cultures and nationalities mix in everyday business life.

2.2 The Team

The team consists of 4 members from 4 different countries and backgrounds.

Stefan Rast from Germany
Studies: European Mechanical Engineering Studies (B.Sc.)
Home University: Hochschule Osnabrück

Marcel Chaillan from France
Studies: Mechanical Engineering
Home University: Ecole Nationale d'Ingénieurs de Tarbes (ENIT)

Bram Borghijs from Belguim
Studies: Process automation (Electro-Mechanics)
Home institution: Artesis Plantijn

Bartosz Sejmicki from Poland
Studies: Biotechnology
Home University: Lodz University of Technology, International Faculty of Engineering

3 Closing the Loop

3.1 Introduction

Before starting our project, we had to assess what information the cooperating company Polar Filé already has shared with us so that we have a base to start from. After looking into all the provided information, we cleared what must be done and what issues we are going to face. We brainstormed and tried to map out all the options and problems as you can see in figure 3.1.

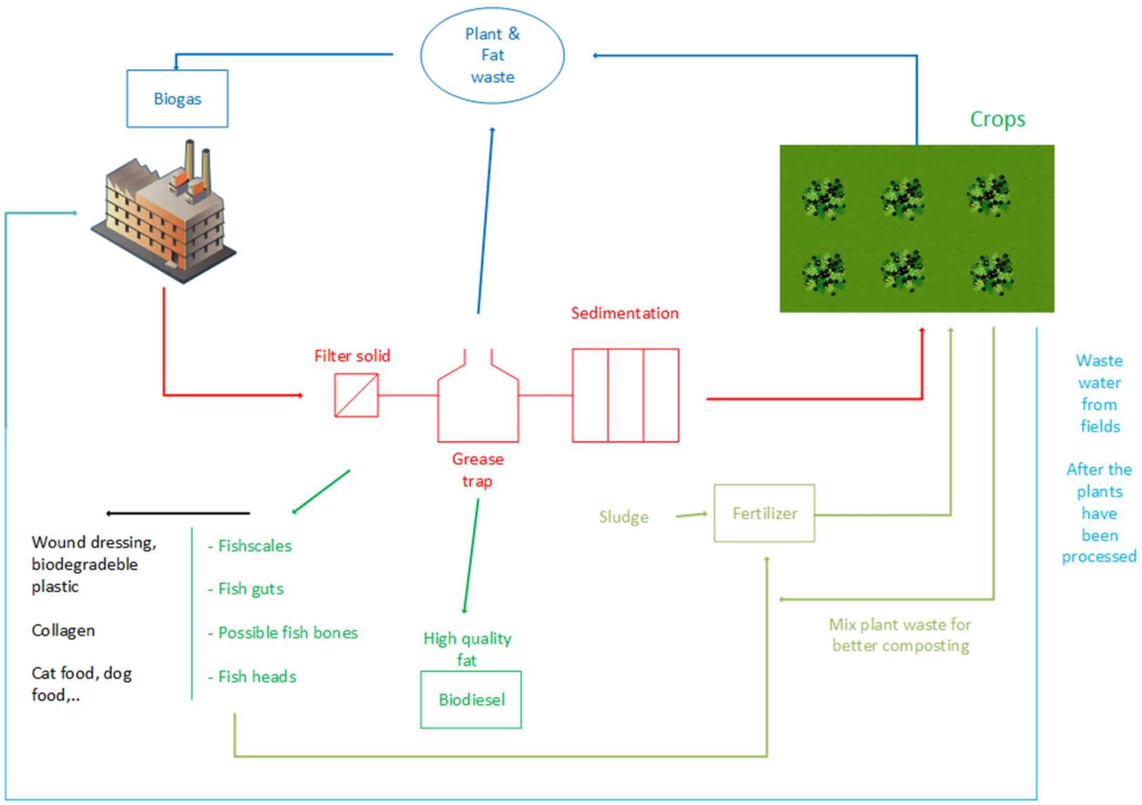


Figure 3.1: Brainstorm closing the loop

The red circuit shows what filtration steps will be held before the, so considered, wastewater enters the field. The solid filter will filter out the bigger fish pieces, like guts and fish heads. After that, the separation of fats and wastewater will be taking place in the grease trap and as final filtration step, the last particles will be selected out in the sedimentation tanks. In green, you see possible waste options that we thought can be used reused for example as fertilizer (fish waste, sludge plant waste). The light blue (bottom blue line) stands for the water circuit, which presents the option of reusing the water as well. Lastly, the dark blue line (top blue line) represents the option of mixing plant and fat waste to create Biogas.

On figure 3.2, as following shown, you can see the Polar Filé's fish processing building on the right side (black circle).

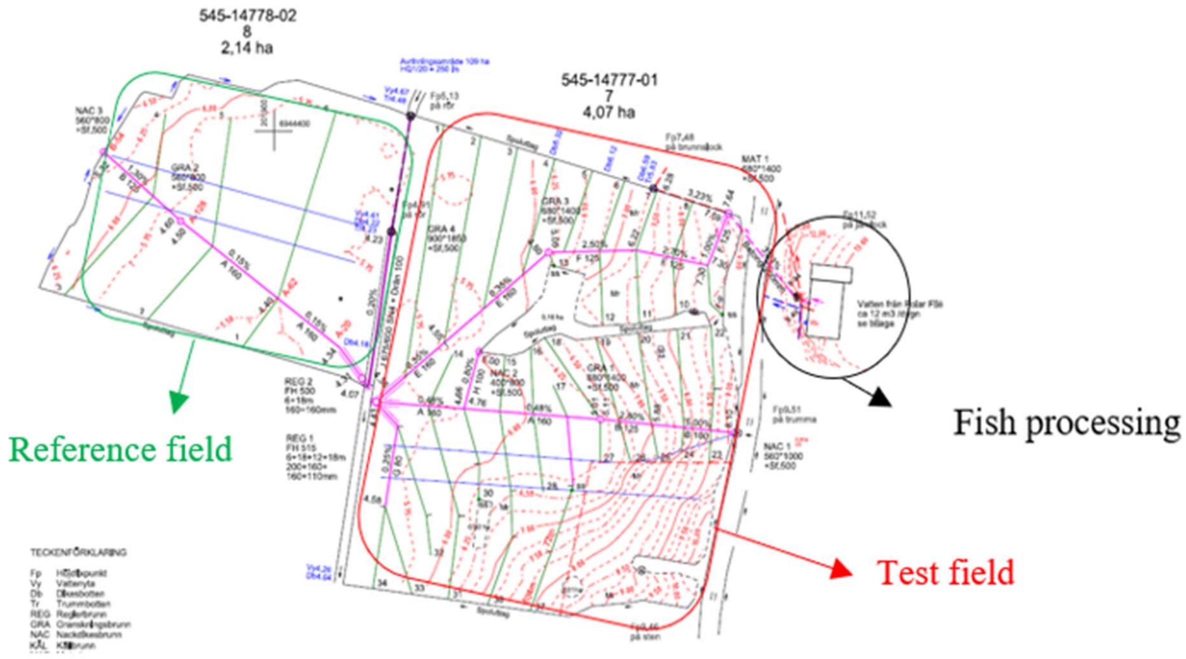


Figure 3.2: Ground plan of the site

In the middle, you find our test field. This field has been upgraded with new subsoil drainage with an adjustable water level system (pink lines through the fields). This is where the water from the fish processing can be pumped to the field. Before we pump the water underneath the soil into the field, the water first passes a solid filter, a grease trap, and sedimentation tanks. We use a reference field, where we will adjust the natural water level in the field with regular water as before, to compare the sampling results of our tested field with. This allows us to see what we have to change in other attempts. However, we must keep a close eye on the reference field as well. This normal field is the perfect reference field, because it is close by and composed of the same weather and it has the same soil.

The pink pipes are the water irrigation system. This system is already there and is used to just water the fields at the moment. In our project, we aim to fertilize (fish processing water) and water the plants at the same time. The pipes in the reference field will only be fed with regular water. The main goal of our project is to use filtered and rich in nitrate wastewater as 'fuel' for the crops. Along with this, we will also try to minimalize the waste produced by the fish processing (fish heads, fish bones, fish scales) by reusing them elsewhere. How we are planning to do this is mentioned and mapped out in figure 3.2.

In the next part, we are going to discuss the options we have. We are also going to explain a bit more about the intel we got. This is theoretical but once we can visit the processing plant in spring and take new soil samples, we will be able to start with a hands-on solution to close the loop.

3.2 The name creation of KALAGRO

At some point in every European Project Semester, each project must be named. This name will also be the title of the website that comes with it. The name KALAGRO was created by a team effort within the project group. By deciding what name would fit us we had to find a name that is short, easy to read, symbolizes the project, harmonizes while reading, and still is attractive and serious enough to establish itself as a name/brand. As the project is all about the connection with fish processing and agriculture, there was no doubt that these had to be included. Therefore, a common and internationally used word for displaying agriculture is AGRO. Which comes from the Greek word agros and means field. This is a multicultural project which is carried out in Finland. Therefore, we added the word KALA which is short for kala and means fish in Finnish, to complete the name. Using the same “A” at the end of kala and the beginning of agro was a fantastic opportunity to connect these words. KALAGRO is easy to read, symbolizes the project, is short, and carries enough seriousness and attractiveness to be remembered. We are very happy about our choice and are comfortable to share it with everyone.

3.3 Project visibility

During this EPS project, the goal was to investigate the feasibility of the operation: evaluate the compatibility between the processing plant and the field but also the recycling of produced waste. However, on a larger scale, it will be beneficial for these techniques to be implemented around the world in other fish processing plants or even slaughterhouses. For this, our project needs to have a certain amount of visibility so that other companies can be inspired and be encouraged to research on their own. Not only will this benefit them economically but also the planet from an ecological point of view.

After finding a catchy and simple name for our project, we used it to create a website. Currently, having some online presence is essential as our project will be visible anywhere around the globe at any time. More people will know about the concept and can consider applying it for themselves. On the website, we explain the concept of the project, as well as our goals. Ideas for recycling waste will be available so that interested parties need not start investigating from scratch. Most importantly, contact details are available for any queries. Our website is available at the link: *www.kalagroproject.wordpress.com*.

To help spread contact information, business card designs have been made where contact information is available.

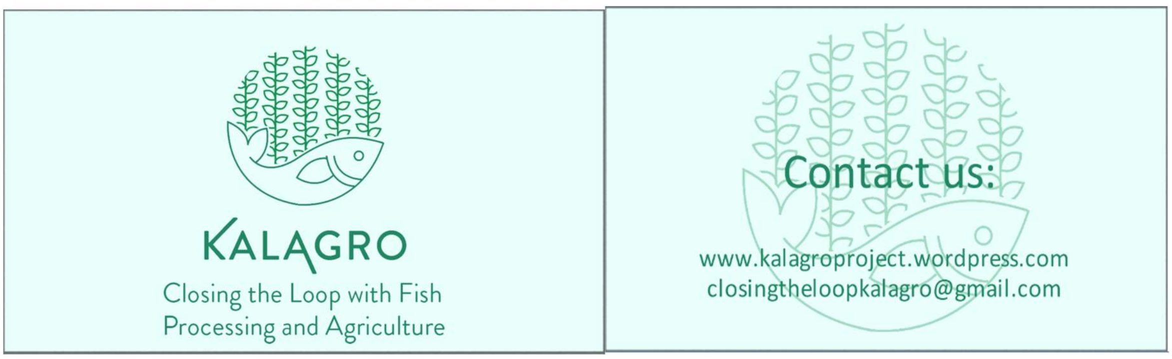


Figure 3.3.3: Business card design

3.4 Circular Economy

The circular economy is an economical and industrial system where no ending resources will be exhausted. And where waste is reused completely in the system.

Imagine that there was a world where everything was like Lego. So we could reuse everything and use it for anything else with no waste generated. That is the idea of circular economy. As this can not be realized, the aim is to get as close as possible.

We use the circular economy model in our project, standing on 4 pillars:

We try to **reduce** first because it is better to prevent than cure. Then we try to **reuse** the waste without converting it. This way we can easily use the waste without a lot of work (cost-efficient). Then we look into the **recycling** part. We use fish waste in another product by adapting the waste. Finally, we look to **recover** the remaining waste into an energy source. Aldo the order of the pillars are important, there are some things you have to keep in mind: the cost, amount of production, materials.

These things will decide which option is the most valuable. (The Explorer, 2020)

1. **Reduce: Limit waste by increasing efficiency.**

The first thing you must try is to minimalize the problem, by decreasing the amount of waste. One way of limiting waste is to fishless. This can be done by managing the fish activity. And optimizing the process of processing the fish, so we make sure we have all eatable meat after cleaning the fish. (The Explorer, 2020)

2. **Reuse: Reuse the waste without converting it.**

Using waste without converting the waste into another product, minimizing effort. for example, fish bones can be used in a further application to remove heavy metals. (The Explorer, 2020)

3. **Recycle: Make a new product from waste.**

We have our product fish (for human consumption) and we convert the waste to another product. In our case animal food from the fish scales and heads. (The Explorer, 2020)

4. **Recover: Turn waste into resources**

We take our waste to power our factory. Use the fish fats to create biofuel, that powers our factory. This may be a very green solution. But it is not easy to make and you need a lot of fish fat to make a decent amount of biofuel. (The Explorer, 2020)

3.5 Industrial Ecology

Industrial ecology is a science that studies of material and energy flow through industrial systems but also to find ways to lessen their environmental impact. It is a circular approach to reduction, where local partnerships provide, share, and reuse resources to create shared value. The by-product of one company is the raw material for another company, creating both financial and environmental benefits. The mission is to act sustainably through the tong-term responsible use of resources, in balance with economic, environmental, and social considerations. The aim is to connect all streams and reach full resource utilization. (KALUNDBORG SYMBIOSIS, 2020)

For KALAGRO, optimally 100% of the fish waste that comes into the system is fully recycled or reused in different ways. This system will support the companies to minimize their environmental impact and limit their waste. Cooperating parties, who use the KALAGRO-System, will establish and adjust to an innovative system to lower their ecological footprint responsibly.

In the current project, we have a great example with the partner Polar Filé. The fish processing plant Polar Filé does not only adjust their plant with adding this fish waste system but they also use geothermal heating to heat the plant and plan to add solar panels to reduce the need for power from power plants. They not only lower production costs by selling the waste and its products but also boost the local infrastructure by doing so and support the connected farmer with natural fertilizer.

3.6 Earned Value Analysis

Earned Value Analysis is a project management tool to measure the progress of the project. At each stage of the project, the work completed is analyzed. It provides a basis for corrections along the way and answers two key questions:

1. Is the project likely to be completed on time?

2. Is it likely that the cost will be less than, equal to, or greater than the original estimate, at the end of the project?

Simplified, every project has a planned cost which is the amount of money the project is expected to cost. A schedule, the amount of time the project should take, and the scope of the work needed to be done to complete the project. (Scott W. Cullen, 2016)

Transferred to KALAGRO:

The cumulated planned value (PV) is 133.997,50€, the schedule is 15 weeks and 2130 estimated hours to complete the work within the scope.

As the project progresses, so does the cost of all labor, material, equipment, and indirect costs. This is the actual cost (AC).

Taking a snapshot of Week 9 and looking at the attached figure 3.3 and table 3.1, it is displayed that the actual cost to this point is much lower than the estimated planned value before the project. If looking only at the PV and the AC the project is far under budget and does great.

However, the amount of actual work completed being considered as well. This is the earned value (EV) and as the name suggests it represents the value of work done at each stage of the project. Although only two-thirds of the cost was spent, 100% of the work has been completed within the project scope. That means that the project is equal to the original estimate progress and therefore not ahead or behind schedule.

Variances in the schedule and budget as the project proceeds can be analyzed as well.

The difference between earned value and planned value creates the schedule variance (SV). This demonstrates if the project is ahead or behind schedule. As the graph illustrates, the EV and PV are laying within each other. Consequently, the project is right on track. The difference between the earned value and actual cost represents the cost variance (CV). This variance of completed work cost compared and the plan. It can be assumed that the rest of the project will continue in this manner if nothing changes. As a result, the project will be completed in the estimated time but far under budget.

Knowing this information early in the project allows the project to be agile and make changes when needed before things get out of control. (Reichel, 2006)

Table 3.1: Earned value analysis values

Weeks	Planed Value			Cumulative PV	Actual Value		Cumulative AV	Earned Value
	Extras	Time	Costs		Time	Costs		
1	- €	150	9.382,50 €	**9.382,50 €**	96	6.006,60 €	**6.006,60 €**	**9.382,50 €**
2	- €	150	9.382,50 €	**18.765,00 €**	104	6.512,40 €	**12.519,00 €**	**18.765,00 €**
3	- €	150	9.382,50 €	**28.147,50 €**	93	5.821,20 €	**18.340,20 €**	**28.147,50 €**
4	- €	150	9.382,50 €	**37.530,00 €**	65	4.069,80 €	**22.410,00 €**	**37.530,00 €**
5	- €	150	9.382,50 €	**46.912,50 €**	148	9.257,40 €	**31.667,40 €**	**46.912,50 €**
6	- €	150	9.382,50 €	**56.295,00 €**	105	6.571,80 €	**38.239,20 €**	**56.295,00 €**
7	- €	150	9.382,50 €	**65.677,50 €**	109	6.843,60 €	**45.082,80 €**	**65.677,50 €**
8	- €	150	9.382,50 €	**75.060,00 €**	68	4.260,60 €	**49.343,40 €**	**75.060,00 €**
9	766,00 €	150	10.148,50 €	**85.208,50 €**	83	5.962,60 €	**55.306,00 €**	**85.208,50 €**
10	- €	150	9.382,50 €	**94.591,00 €**	120	7.506,00 €	**62.812,00 €**	**94.591,00 €**
11	- €	150	9.382,50 €	**103.973,50 €**	112	7.124,40 €	**69.936,40 €**	**103.973,50 €**
12	- €	150	9.382,50 €	**113.356,00 €**	118	7.385,40 €	**77.321,80 €**	**113.356,00 €**
13	- €	150	9.382,50 €	**122.738,50 €**	124	7.763,40 €	**85.085,20 €**	**122.738,50 €**
14	- €	150	9.382,50 €	**132.121,00 €**	150	9.446,40 €	**94.531,60 €**	**132.121,00 €**
15	- €	30	1.876,50 €	**133.997,50 €**	20	1.251,00 €	**95.782,60 €**	**133.997,50 €**
		2130	133.997,50 €		1515	95.782,60 €		

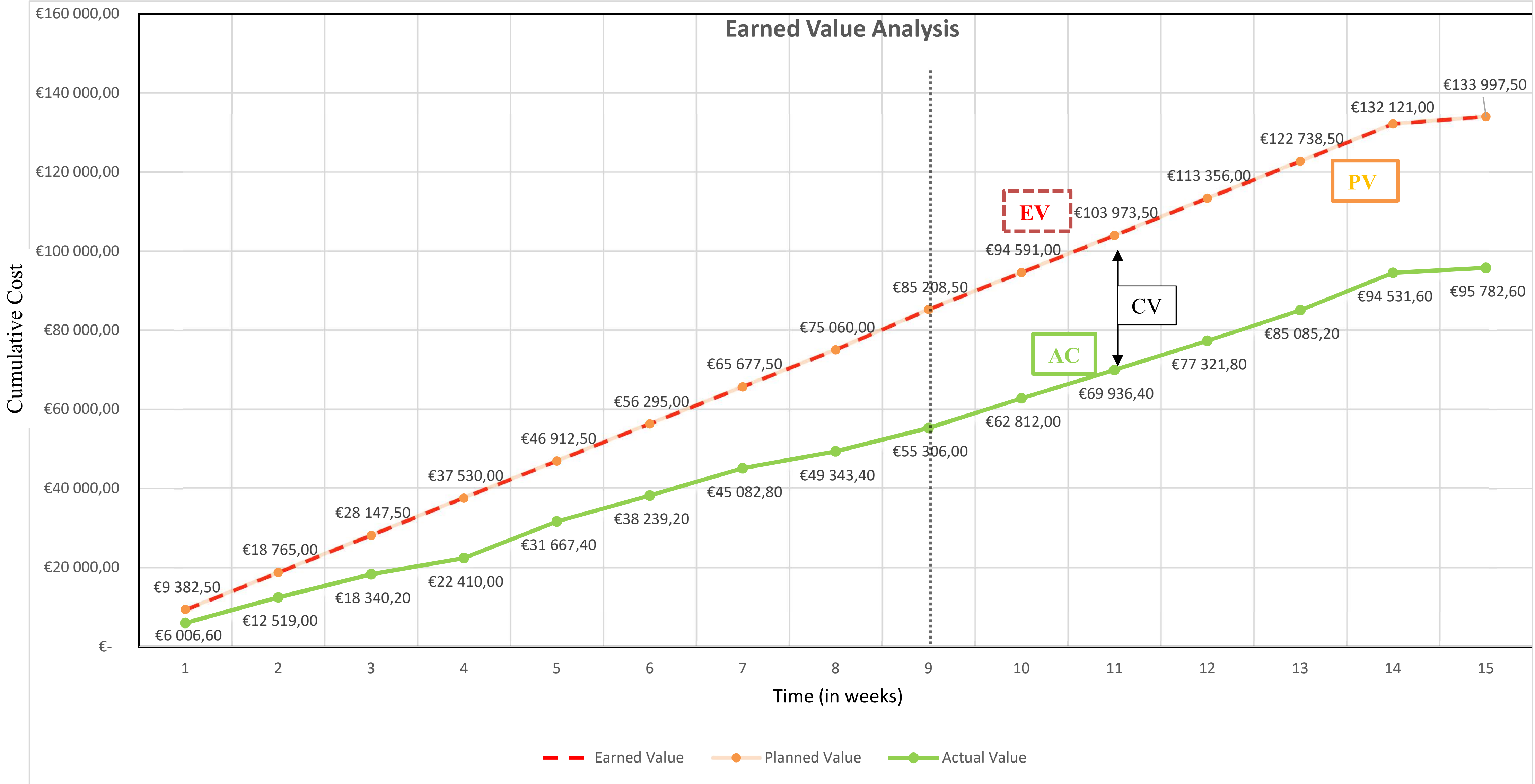


Figure 3.4: Earned value analysis graph

In addition to what the earned value analysis is and how it works, it is to mention what these numbers consist of. Accordingly, the following Table 3.2 was created:

Table 3.2: Value explanation of table 3.1

Estimated	PVE (Planned Value Extras)	Additional costs
	PVT (Planned Value Time)	37,5h a week x4 employees
	PVC (Planned Value Costs)	Mechanical Engineer Salary 35€/h x2 (ERI Economic Research Institute, Salary Expert - Mechanical Engineer Salary, 2020) Biotechnologist Salary 34€/h (ERI Economic Research Institute, Salary Expert - Biotechnologist Salary, 2020) Automation Engineer 35€/h (ERI Economic Research Institute, Salary Expert - Automation Engineer Salary, 2020)
Reality	AVT (Actual Value Time)	Actual worked hours for all employees combined
	AVC (Actual Value Costs)	Actual combined total costs of the week
Result	EV (Earned Value)	The actual value of work completed

In orange are the estimated costs illustrated which have been predicted before the start of the project. The extra costs of the planned value appeared only one time during the project. In Week 9 the team traveled to the cooperation partner and took water samples and handed them over to a certified laboratory to be tested. The costs for the samples to be tested and the trip itself cumulated to 766€. The estimated cost matches what has been paid.

The estimated time for each week has been cumulated to 150 hours in total. The workload of 37,5 hours, each team member must work for the project per week, is a guideline adopted out of the European Project Semester coursebook.

The salary of the team members is, except for the sampling, the only cost the project carries. The salary is an average salary in Finland for each profession. The weekly cost is not only based on the cost that has been paid to each team member but also on additional costs to employ someone if KALAGRO is seen as a company. This salary side cost must be multiplied to the basic salary. In Finland, an employer is obligated to make the following contributions (Teirivaara, 2017):

- withholding tax at source (according to the rate on employee's tax card)
- insurance payments (health, accident, etc.)
- pension payments

Next to these obligatory payments, employees in Finland are also entitled to an annual holiday which is fully paid without the work input of the employee. Even if not mandatory there may be a holiday bonus paid in addition to that. Moreover, sick leave days and arranging health care services for employees are additional costs the employer must carry.

Therefore, the actual expenses of employees are between 1.5 – 2.0 and in our case, we chose, with 1.8 times the amount of employee's monthly salary, a value in the middle.

Continuing with the in green marked values, the actual values. These costs are calculated by the time the team worked in reality to accomplish their work. This actual value of time multiplied with the salary and salary side cost represents the overall actual value. Also, a change in price for the laboratory must be considered here if they vary from the estimate. As before represented, the team is working fewer hours than estimated at the beginning of the project. This is contributed to the fact that the team sets goals and milestones for each week to accomplish the ultimate goal at the end of the project. Furthermore, the dependency on external information does not make it possible to go ahead in the schedule.

The result, as it is marked blue in the table and as a red-striped line in the graph, is the value of most interest. It matches the planned amount of work with what has been completed. As work is completed, it is considered "earned". Since the project is not behind nor ahead schedule, the earned value equals the cumulated estimated planed value.

4 Theoretical research

This part presents the research about waste recycling. We have looked into what the processing plant has to offer in the meaning of the filtration system and what by-products are going to be created after the fish processing. Each process step after the fish processing is presented in detail as follows.

4.1.1 Fish Types

The fish processing plant works with local fishermen that work along the Finnish west coast. These fish are wild and come from the Gulf of Bothnia. The particularity of these waters is its low salinity levels (0.4%), categorizing it as brackish water. Freshwater fish such as perch, whitefish, pike, and pikeperch can be found but also brackish water fish such as Baltic herring. The company also diversifies its products by importing other Nordic fish species such as salmon, char, and place. Even though different types of fish will emit different types of waste content, the company mainly processes locally produced fish. Due to these proportions, we will assume that the wastewater comes from brackish water fish like Baltic herring. This assumption is also beneficial to our study as saltwater fish waste is harder to use due to high amounts of salt. Baltic herring living in a low salinity level environment allows us to facilitate the filtering process and remain realistic. (Redzwan, 2017)

However, it is important to note that the Baltic Sea is the most polluted sea in the world, especially with high quantities of heavy metals. This means that these components will be present in fish and logically in their wastewater. By constantly watering the fields with this wastewater, the heavy metal concentration will inevitably increase and will thus contaminate the crops. This calls for close observation of the soil quality to ensure that the crops stay safe for consumption. (HELCOM, 2012)

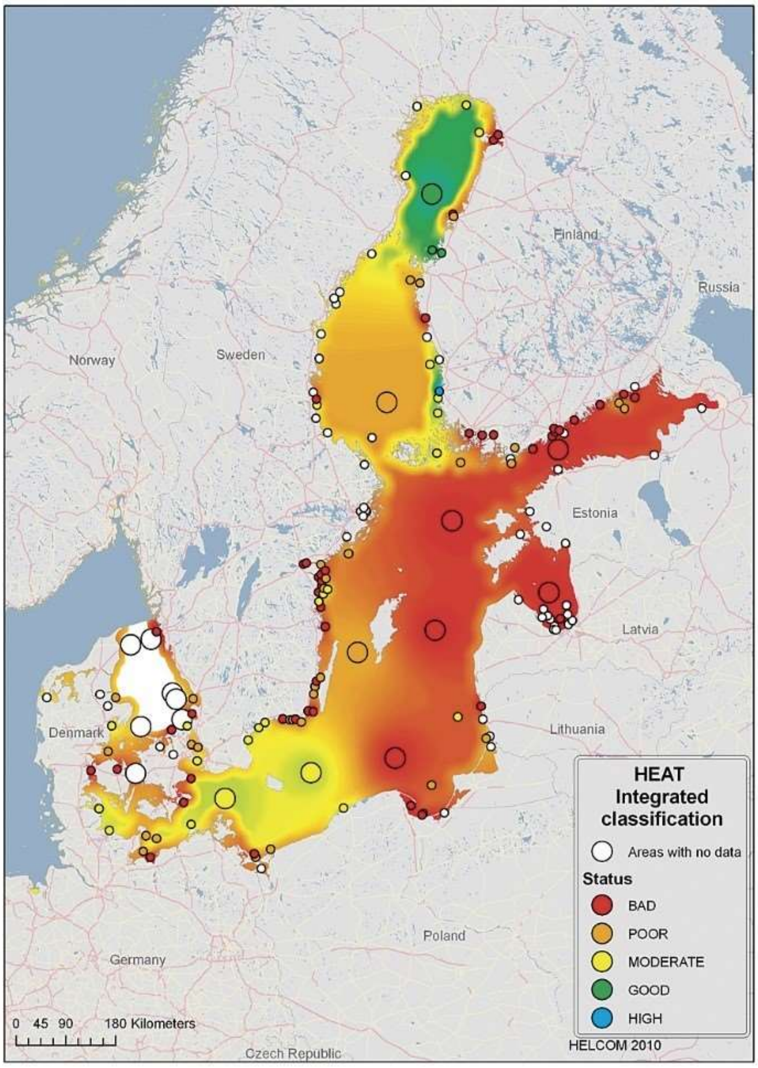


Figure 4.1: Heat integrated classification map of heavy metal pollution in the Baltic Sea (HELCOM, 2012)

4.1.2 Fish Processing Methods & Fish Processing Waste

Fish is processed by drying, salting, smoke-treatment, freezing, and deep freezing or freeze-drying. The fish waste that is left after the process depends on the process method. For example, if the processed fish is sold whole and frozen, only the viscera were removed. On the other hand, when fish files are sold, everything else has been removed (pinoyentre, 2015). As rough overview estimated more than 50% of fish tissues including skin, heads, fins, and viscera are discarded as they are considered wastes. Fish waste contains a lot of moisture and can additionally hold significant amounts of oil. It also is a valuable source of high-quality protein and energy. However, this fish waste must be treated properly before the disposal and handled with care to limit the environmental impact. Elsewise, it can cause environmental contamination and harm the groundwater. (Caruso, 2015)

4.1.3 Potential Fish Waste Utilization Methods

Nowadays, the use of food wastes as animal feed is an alternative of high interest, because it stands for environmental and public benefit besides reducing the cost of animal production.

The recovery of chemical components from these waste materials, which can be used in other segments of the food industry, is a promising area of research and development for the utilization of by-products. Researchers have shown that several useful compounds can be isolated from seafood waste including enzymes, gelatin, and proteins that have antimicrobial and antitumor capabilities (Kassaveti, 2008). Chitosan, produced from shrimp and crab shell, has shown a wide range of applications from the cosmetic to pharmaceutical industries (Inmaculada Aranaz, 2018).

Oils from fish waste are also used extensively in the food industry as raw materials and ingredients.

Among the most prominent current uses for treated fish waste are collagen and antioxidants isolation for cosmetics, biogas/biodiesel, fertilizers, dietary applications (chitosan), food packaging (gelatin, chitosan) and enzyme isolation (proteases). (Kassaveti, 2008)

4.1.3.1 **Value Pyramid**

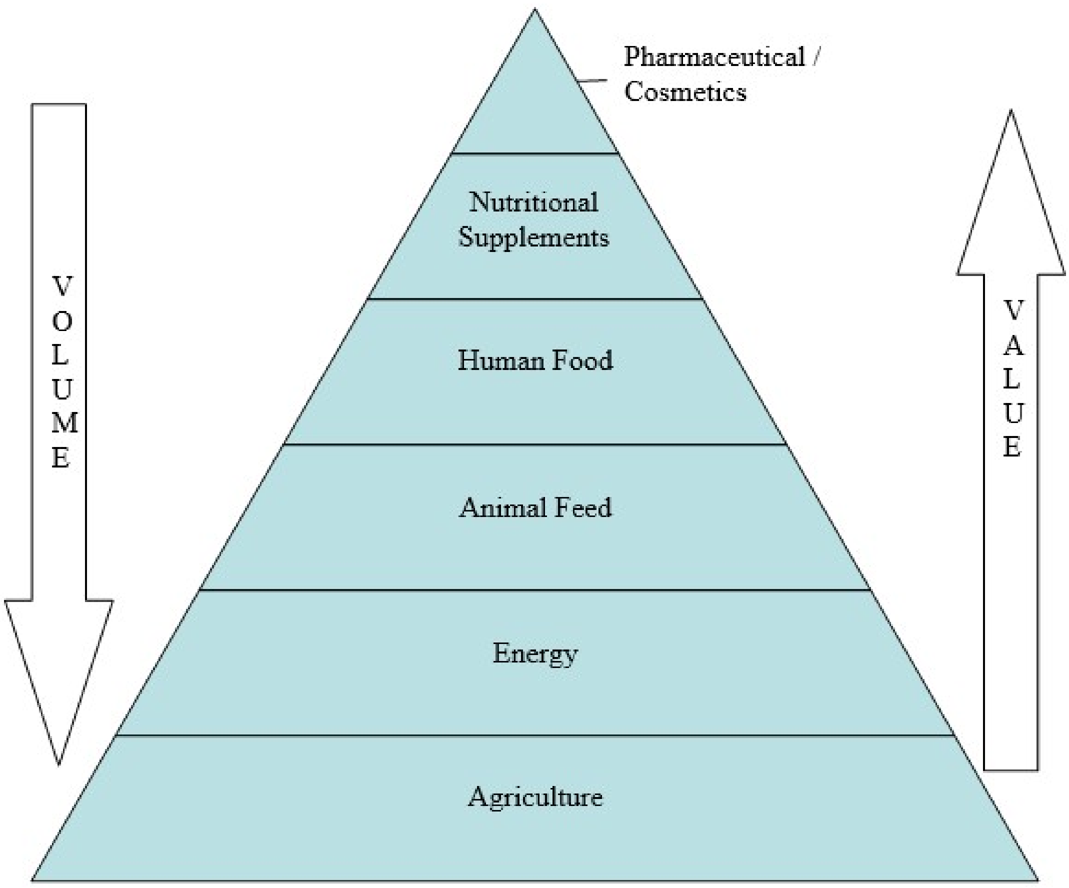


Figure 4.2: Value pyramid of processing fish waste (Mariojouls, 2012)

The above pyramid shows the relation between the volume of different fish waste and their value. The pharmaceutical industry and the cosmetic industry find value in collagen found only in fish scales. Fish oil comes later in higher quantities which are used for their nutritional values. Finally, sludge is found in great quantities that can be reused as a natural fertilizer. A value pyramid is a tool that can be used for any kind of bio-products but in this case, it is only about fish waste.

4.1.4 Solid Waste Filter

In fish processing, like in every industry, some waste is produced. The produced waste includes fish scales, fish guts, blood, grease, but can also include fish heads and fish bones. Fish scales are considered to be the most interesting waste material produced by the fish industry. They are a subject of research and present an object of economic significance as they are a source of two biopolymers: chitin and collagen. They can be applied not only in medicine, the cosmetic and food industry, but can also be used to produce biodegradable plastic, a process that was developed by Lucy Hughes, the founder of MarinaTex who received James Dyson Award in 2019 (Hughes, 2020).

Due to the rapid development of biotechnology, there is an opportunity for the improved efficiency of many industrial processes. New processing methods are available, which are cheaper, more efficient, and more friendly for the environment, improving many industrial sectors. With the new technologies, previously problematic materials, such as fish scales, can find an application.

Fish Scales and Collagen

Fish scales are built from collagen covered with calcium salts (Sionkowska, 2013). Collagen is one of the most abundant proteins in vertebrae and is the main component of the connective tissue. It can be found among others in the skin, fish scales, tendons, internal organs, cartilage, hair, and bone marrow.

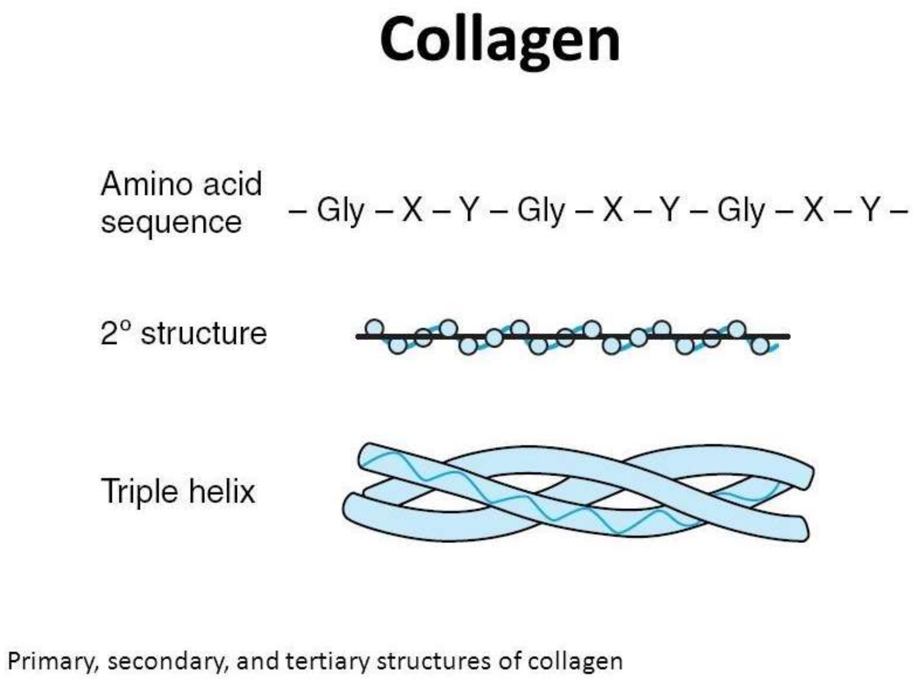


Figure 4.3: Structure of collagen (adyaniazizah, 2020)

Structure of collagen, where X and Y are amino acids. The most common motifs in collagen are glycine-proline-Z and glycine-Z-hydroxyproline. Z can be any amino acid other than glycine, proline, and hydroxyproline.

Collagen can be extracted from the fish scales using heat, acid, base, or enzyme assisted hydrolysis or a combination of all or any of these processes (Ololade Olatunji, 2017). Multiple attractive options can be considered to deal with fish scales left from the fish processing, out of which few are presented below.

Applications in medicine

Due to their rich collagen content, fish scales can be used to produce wound dressing that does not interact with the human body, making it safe to use (A Afifah, 2019). When such a wound dressing was tested on burn wounds, it was observed that the wounds on which the collagen dressing was applied, healed relatively faster and caused no pain to the test subject (A Afifah, 2019).

A biopolymer produced from the fish scales can be used to produce microneedles that can be applied in medicine. The microneedles used for drug loading can be made from cross-linked hydrolyzed collagen, using a modified low-temperature method (Ololade Olatunji, 2019). These microneedles can be used for drug delivery through the skin. Such microneedles produced from the hydrogel can have mechanical strength allowing them to pierce the skin, are biodegradable and the production has a potentially low cost (Ololade Olatunji, 2019).

Applications cosmetic industry

In the cosmetic industry, collagen can be applied as one of the ingredients in many creams as well as supplements which are said to help reduce wrinkles. Although collagen molecules are too large to be absorbed through the skin, they still work as a moisturizer. Orally taken collagen supplements can help improve skin quality, although few validated, high-quality scientific trials that confirm that claim (Marıa Isabela Avila Rodrıguez MRS, 2017).

Applications in the food industry

Fish scales can be implied in the food industry, as their addition to foods could help increase nutrition, for example, Hardtack Innovation Fish Scale cookies were developed, where the main ingredient is fish scales. Collagen contained in fish scales is a source of protein while the macronutrients, carbohydrates, and fats are fulfilled by additional ingredients like corn flour, kidney beans, and honey (Abdullah L., 2019).

Fish scales can be used as a gelling agent, for obtaining gelatin from the collagen (Boran, 2010). This way obtained gelatin can be consumed by people who cannot take pork gelatin due to religious reasons.

Production composite materials

Another possible application of fish scale is as a component of composite materials in which fish scales improve the mechanical properties of the material. When mixed with epoxy resin as filler, fish scales enhance the properties of the material. Maximum flexural strength, impact strength, and tensile strength were achieved with 30%, 25%, and 30% volume fraction of fish scales in the material respectively, making the fish scales an attractive filler (Vijayarangam, 2019).

Fish Heads and Fish Guts

From other solid waste, fish heads and fish guts can be used for the production of animal feed, or they can be used for the extraction of fish oil, producing fish meal as a byproduct. In this case, the fish meal can still be applied as animal feed, but the added value in the form of fish oil is generated.

Fish Bones

Fishbones are made of a phosphate mineral, apatite, which was found to readily combine with lead to form a stable crystalline mineral that cannot be absorbed by the human digestive system (Freeman, 2012). When tested for purification of water from lead, using pulverized fish bones from Stock Fish, Salmon, and Drum Fish, the percentage of lead purification up to 99.9 %, 99.9 %, and 99.8 % respectively (Agwaramgbo, 2015).

Grease Trap

The contained fats in our wastewater must be dealt with properly, as they can clog the pipe system. If not handled properly, they can be dangerous to the environment by producing toxic by-products or being harmful to animals and plants physically by coating and suffocating them. They can produce rancid odors, catch on fire, etc. Because these fats can linger in the environment for a long time, proper handling is crucial (Water UK, 2020).

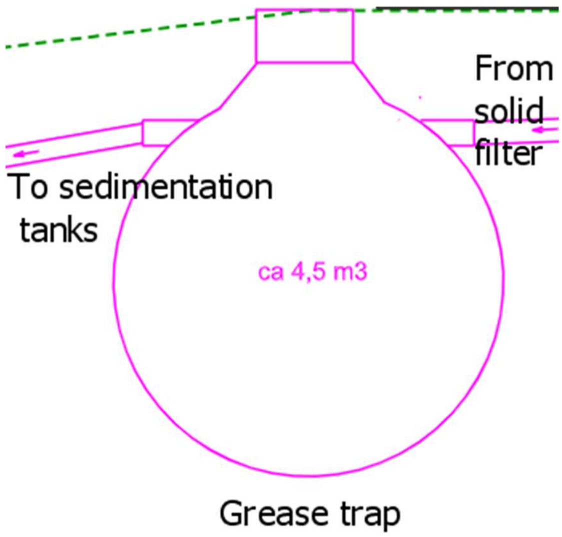


Figure 4.4: A schematic drawing of grease trap for the removal of fats from the wastewater. Drawing provided by Polar Filé.

Before entering the grease trap, the solid fish waste will be separated from the wastewater. Together with the solid fish waste a fraction of fats is removed by being attached to the surface of the solid.

The largest share of fats contained in the wastewater is collected by a grease trap. Due to gravity, the fats float on the surface while the wastewater passes below.

Lastly, a small fraction of fat can be still present in the sludge at the bottom of sedimentation tanks, as fats can stick to the small solid particles which were not separated at the previous steps.

Potential applications of the fats contained in the fish processing wastewater:

- Separation of the oils from the solid waste yields fishmeal as a byproduct, which can be used as animal feed (Quresi, 2018).
- Purified fish oil can be used to produce dietary supplements (Aidos, 2002).
- Fat liquor can be applied in the tannery industry for leather treatment (Saranya, 2020).
- Fat can be used for biofuel production, although it should be mixed with plant waste to get proper carbon to nitrogen ratio and prevent clogging of the system when it is used for biogas production.

4.1.5 Sedimentation Tank

In the wastewater treatment, sedimentation is the basic form of primary treatment of wastewater. Sedimentation tanks are applied to allow the suspended solids to settle out of water in time.

It is a time-consuming method, but the addition of coagulation chemicals, such as alum, will increase the rate at which particles settle out by combining many smaller particles into larger floc which will settle out faster (Cheremisinoff, 2001). Other options for enhancement of gravity settling include CDFs (confined disposal facilities), sedimentation basins and clarifiers.

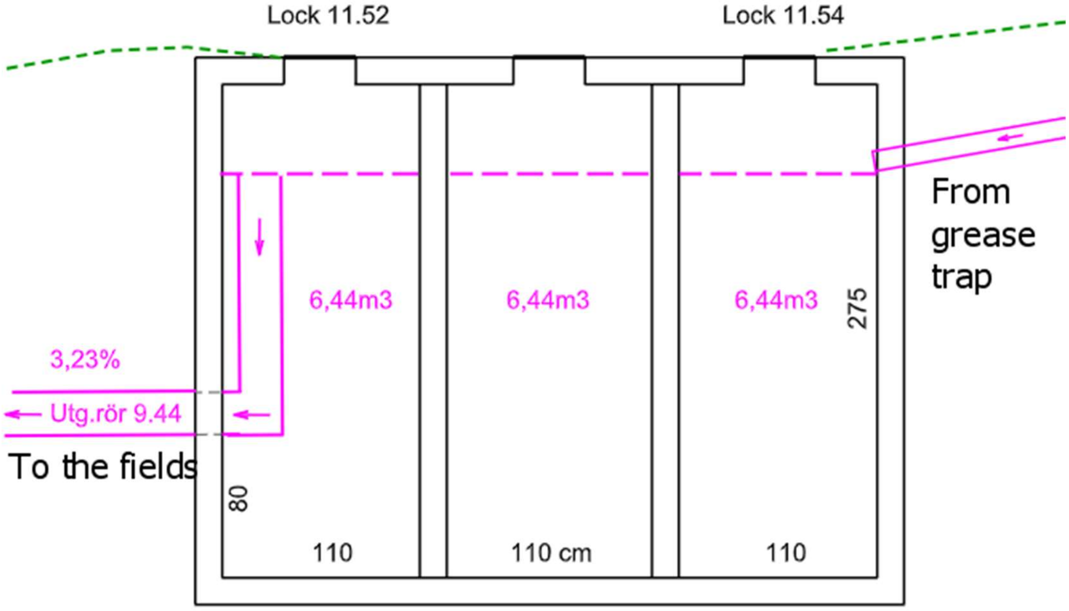


Figure 4.5: A schematic drawing of sedimentation tanks for the sludge removal from wastewater in the fish processing plant. Drawing provided by Polar Filé.

In the investigated fish processing plant a sedimentation basin was built consisting of 3 cylindrical tanks each holding 6.44m³ of wastewater with a total sedimentation time of 38.6 hours. The wastewater flows into the first tank from the grease trap. In this tank the sludge sediments on the bottom, and water moves to the next tank. After passing through the third tank, the wastewater is pumped into the fields.

Table 4.1: Some settling rates for different particles (assumed spherical) and sizes (Cheremisinoff, 2001)

Particle Diameter (mm)	Particle Type	Time to Settle One Foot
10.0	Gravel	0.3 sec.
1.0	Coarse sand	3.0 sec.
0.1	Fine sand	38.0 sec.
0.01	Silt	33.0 minutes
0.001	Bacteria	35.0 hours
0.0001	Clay particles	230 days
0.00001	Colloidal particles	65 years

Looking at the examples of the settling times of particles of different solids it can be noted that simple sedimentation is not the best method for the separation of colloidal particles, but the settling time can be significantly reduced by the addition of coagulants. Those coagulants neutralize the electrostatic charges on colloidal particles which usually carry a negative electrostatic charge. Negative charges on the particles cause the natural repulsion of similar charges, dispersing the colloidal particles. The neutralization of the charges allows the suspended solids to agglomerate. Coagulants are either water-soluble inorganic compounds, organic cationic polymers, or polyelectrolytes. The most common inorganic coagulants used in the wastewater treatment are:

- Alum - aluminum sulfate
- Ferric sulfate
- Ferric chloride
- Sodium aluminate

The dosage of coagulants depends on the water chemistry, in particular pH. The dosage of coagulants affects water chemistry and can be used to adjust the water chemistry for further treatment, as well as different coagulants, have different efficiency in a different environment (Cheremisinoff, 2001).

Sludge collected from the sedimentation tanks

At the bottom of the sedimentation tank is sludge, which is made of the settled solid particles. Depending on the composition of the sludge, it can be used as biomass for the production of biofuels or mixed with the plant material to produce fertilizer. Such fertilizer could potentially be applied in the cultivation of the crops after phytotoxicity tests performed on potted plants. Such testing would allow finding the optimal proportion of sludge to plant material for the growth of plants (Radziemska, 2018). Fertilizer could be applied in the industrial greenhouses in Finland. In 2018 the greenhouse area in Finland was equal to 393 hectares, and they produced 90 million kilograms of vegetables (Jaakkonen, 2019). Much of the greenhouse production of vegetables in Finland is concentrated in Ostrobothnia, in and around Närpes in particular (Väre, 2018). The fish processing plant is also located in this region. Thanks to that the fertilizer could be applied in the neighboring area, reducing the transport cost. Such an application could be attractive, allowing for removal of sludge, and potentially profiting from the sold fertilizer.

4.1.6 Wastewater

After filtering out solid wastes, fats and sediments, wastewater full of nutrients will remain and will be added into the field, to be absorbed by the crops. This water contains ammonia which is used in fertilizers and will increase soil quality if used correctly. Furthermore, gutted Baltic herring contains Fe, Cu, Zn, K, Mg, Ca, Na, Mn, As, and Cd (Raija Tahvonen, 2000). By comparing these elements to those already present in the field in question before starting the process, we can note that these components will be beneficial to the soil. Soil analysis has been done in October 2018 showing that the addition of Ca, Mn, and Zn will make it more fertile. Elements such as P and N which are vital for plant growth can also be found in this water. This is reassuring as these elements P and N were identified during the planning phase of the project as main components in the wastewater. This seems positive for our operation and the crops, but we must keep in mind that we should not add too many nutrients that the crops will not be able to absorb and risk saturating the soil.

The proportion of each element is the most important factor for ensuring optimal plant growth, even and especially when it comes to heavy metals. It is acceptable for plants to contain a certain amount of heavy metals but too much will be dangerous for consumers. Excess of a certain element will not be beneficial for crops the same way that a deficiency of another will not create an optimal environment. (Sustainable Agriculture Research & Education, University of Maryland, 2012) (Gergely Tóth, 2016)

4.1.7 Soil Analysis & Soil Research

The following analysis document is one of the soil samples' laboratory result. These samples were taken from the test field, which is connected to a new wastewater sewage system. This system is made to adjust the water level in the field. The sampling has been done at the end of 2018 and is the base for out following soil research. Important to notice is that these samples were taken before the new draining system was installed.
We will discuss all parts of the soil sample, but keep in mind that the most important nutrients are P,N and K.

Table 4.2: Soil sample analyzation results

Hortilab AB OY
Vasavägen 41, 64200 Närpiö/Närpes
✆ 06-3474250, hortilab@hortilab.fi
www.hortilab.fi

MARKKARTERING

Datum	Kundnummmer	Undersökningsnr.	
15/11/18	569678	59708	
Provtagningsdag	Anlänt	Påbörjad	Ant. sidor
	30/10/18	30/10/18	1/1

YRKESHÖGSKOLAN NOVIA

WOLFFSKAVÄGEN 33
65200 VASA 20

Lägenhet:
Kommun: VASA
Rådgivningsorganisation:
Provtagare:
Märke:

Provets nummer	1	2	3	4	5
Avsändarens kod	MY 1 0-30 cm	MY 2 0-30 cm	MY 3 0-30 cm		
Matjordlagrets jordart	MoMr	MoMr	MoMr		
Alvens jordart					
Mullhalt	mh	mh	mh		
*Ledningstal 10xmS/cm	1,5	1,6	1,7		
*Matjordlagrets surhet	□ 5,9	◪ 6,3	◪ 6,2		
Alvens surhet					
*Kalcium (Ca) mg/l	○ 1090	○ 923	○ 1370		
*Fosfor (P) mg/l	○ 7,3	□ 9,3	□ 9,8		
*Kalium (K) mg/l	◪ 250	■ 390	■ 370		
*Magnesium (Mg) mg/l	□ 120	□ 130	□ 190		
*Svavel (S) mg/l	◪ 27	◪ 15	◪ 25		
*Natrium (Na) mg/l					
*Bor (B) mg/l	□ 0,7	○ 0,5	□ 0,8		
*Koppar (Cu) mg/l	□ 4,8	□ 3,4	◪ 7,3		
*Mangan (Mn)	◐ 9,6	◐ 6,0	○ 15		
*Zink (Zn) mg/l	□ 2,2	◐ 1,3	□ 2,8		
*Järn (Fe) mg/l					
Kväve nitrat (NO3-N) mg/l					

Endast de bestämningar, som i denna rapport försetts med *) är ackrediterade.
Resultaten gäller endast de analyserade proven.
Rapporten får kopieras endast i sin helhet utan laboratoriets tillstånd.
Ackrediteringen gäller inte utlåtandet.

Oy HORTILAB Ab

FINAS Finnish Accreditation Service T187 (EN ISO/IEC 17025)

Bördighetsklasser

● Dålig ○ Försvarlig ◪ God ⊞ Betänkligt hög
◐ Rätt dålig □ Tillfredsställande ■ Hög

4.1.7.1 **Potassium (K)**

Role in plant growth:

- Increases root growth and improve drought resistance.
- Maintains turgor; reduces water loss and wilting.
- Aids in photosynthesis and food formation.
- Reduces respiration, preventing energy losses.
- Enhances translocation of sugars and starch.
- Produces grain rich in starch.
- Increases plants' protein content.
- Builds cellulose and reduces lodging.
- It helps retard crop diseases.
  (Rosen, 2018)

Potassium in soil

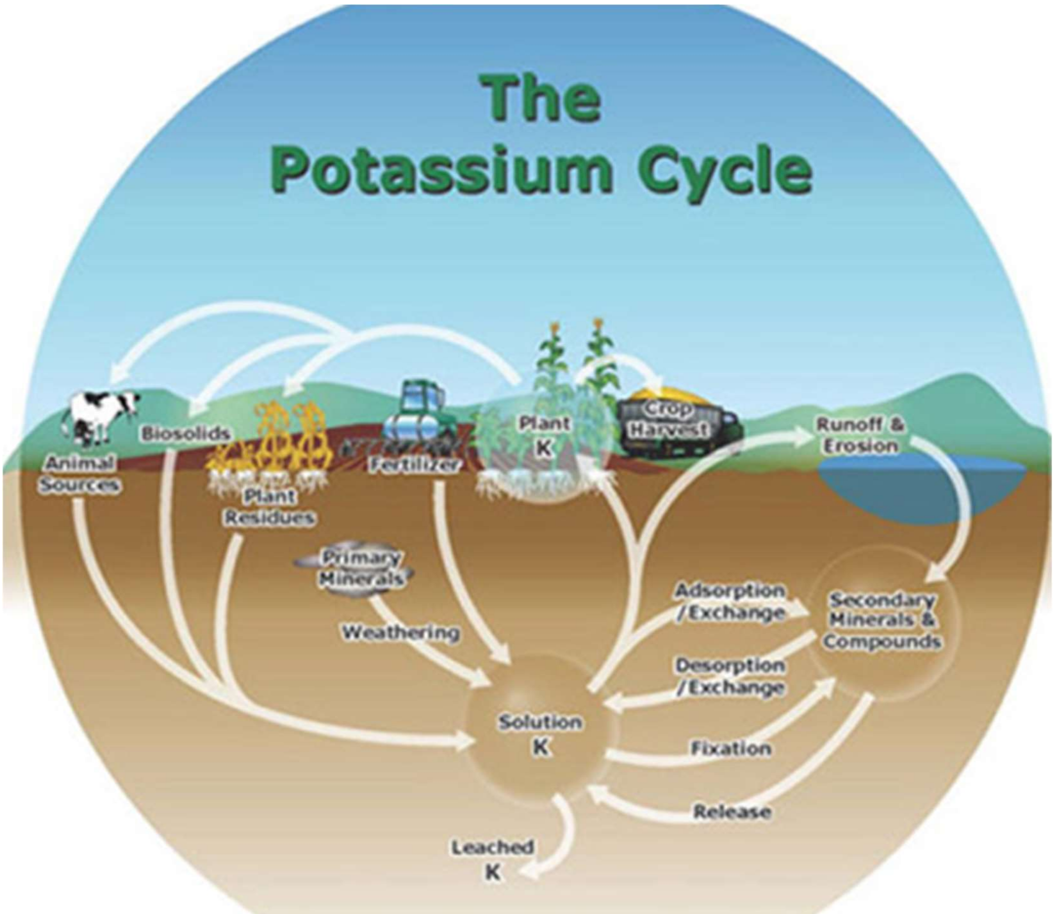


Figure 4.6: Cycle of potassium in soil (Rosen, 2018)

The supply of K in the soil is usually quite large, but relatively small amounts are available for plant growth.

There are three forms of potassium from the plants perspective: Unavailable potassium, readily available potassium, and slowly available potassium.

Unavailable potassium (Primary minerals):

Depending on the soil approximately 90 to 98 percent of the K level is found in this form.

Because it is an insoluble form, it cannot be used by plants. However, this will resolve in time and become slowly available potassium and even a small amount of readily available potassium.

Slowly available potassium (secondary minerals and compounds):

This form of K is trapped between layers of clay minerals and is fixed. (when the soil gets wet this K is released).

Some important things to notice about slowly available potassium are:

- Growing plants cannot use much of it during a single growing season.
- It is not measured by routine soil-testing procedures.
- It can serve as a reservoir for readily available K.
- While some of it can be released for plant use during a growing season, some of it can also be fixed between clay layers.
- The amount of it varies with the dominating type of clay in the soil.

Readily available potassium (Solution potassium):

This is potassium that is dissolved in soil water or held on clay particles exchange sites, which are found on the surface of clay particles.

The plans absorb the K in the soil water, as soon as the K level drops the clay minerals will give K to the soil water.

Plant uptake

The plant uptake is divided into some key factors that decide how good the uptake will be.

- **Soil moisture**: Higher soil moisture usually means more K availability.
- **Soil aeration and oxygen level**: Air is necessary for root respiration and K uptake. If the soil water is saturated, then the oxygen uptake is very low. This means that the uptake of K is low. Therefore, the soil must not be too wet.
- **Soil temperature**: The optimum soil temperature for K uptake is around 15,5 – 26,5 degrees Celsius. Potassium uptake slows down at lower temperatures.
- **Agricultural system**: Availability of soil K reduces in no-till and ridge-till planting systems. The exact cause of this reduction is not known, although research results point to restricted root growth combined with a restricted distribution of roots in the soil. (Rosen, 2018)

4.1.7.2 **Calcium (Ca)**

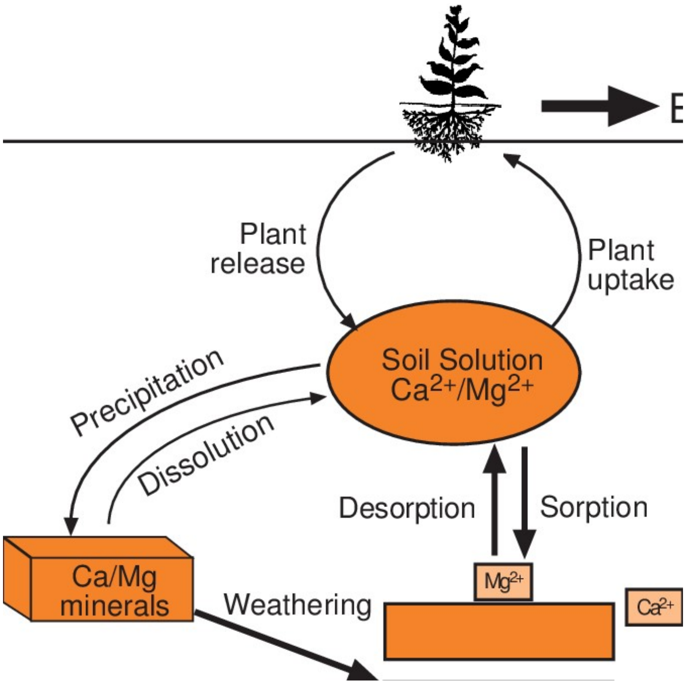


Figure 4.7: Circulation of Ca and Mg between soil and plants (Tetra chemicals, 2005-2008)

This figure shows the circulation of Ca and Mg between soil and plants.

The functions of calcium in plants

- Every plant needs Ca to grow.
- Once the Ca is attached to the tissue, it is no longer mobile in the plant. Therefore, once it runs out of Ca it cannot remobilize from older tissues. It is an important constituent of cell walls.
- If the transpiration is reduced, the Ca would soon be inadequate. Losing Ca will cause problems for the plant.

The benefits of Ca

Calcium plays a very important role in plant growth and nutrition, as well as in cell wall deposition.

- calcium helps to maintain chemical balance in the soil, reduces soil salinity, and improves water penetration.
- Calcium plays a critical metabolic role in carbohydrate removal.
- Calcium neutralizes cell acids.

Factors affecting Ca availability

Many soils will have a high level of insoluble Calcium such as Calcium carbonate, but crops grown in these soils will often show a calcium deficiency. High levels of other cations such as magnesium, ammonium, iron, aluminum and especially potassium, will reduce the calcium uptake in some crops. A common misconception is that if the pH is high, adequate calcium is present. (Tetra chemicals, 2005-2008)

4.1.7.3 **Phosphorus (P)**

Phosphorus in plants:

The function of phosphorus in plants

- Several key plant structure compounds including P, lead to converting sun energy into useful plant compounds.
- P catalysis in the conversion of several important biochemical reactions in plants
- It is also a vital component of DNA and RNA. This component reads DNA to build proteins and other compounds that are essential for plant structure, seed yield, and genetic transfer.
- Phosphorus is a vital component of ATP. It is the "energy unit" of the plant, it is formed during photosynthesis.
- Is important at any point in the life cycle of the plant

Growth factors that are associated with phosphorus

- Stimulates root development
- Increases stalk and stem strength
- Improves flower formation and seed production
- More uniform and earlier crop maturity
- Increases nitrogen N-fixing capacity of legumes
- Improvement of crop quality
- Increases resistance to plant diseases
- Supports development throughout the entire lifecycle

Phosphorus deficiency

It is not as easy to see as with nitrogen or potassium. The easiest way to see it if the plants are stunting during early growth. Some plants make it obvious like corn it just changes color.

Phosphorus in soils:

Factors that influence the amount of phosphorus in soils

- Type of parent material from which the soil is derived
- Degree of weathering and erosion
- Climatic conditions
- Crop removal and fertilization

(Mosaic, sd)

4.1.7.4 **Magnesium (Mg)**

The tree fractions of magnesium in the soil

- **Magnesium in soil solution**:
  Equilibrium with the exchangeable magnesium and is readily available for plants.
- **Exchangeable magnesium**:
  This contains the magnesium held by the clay particles and organic matter. This is the magnesium available to plants.
- **Nonexchangeable magnesium**:
  Magnesium which is a constituent of primary mineral. Not available for plants.

There are 2 ways of magnesium uptake by plants. First passive uptake, driven by transpiration. And secondly, diffusion where magnesium ions move from zones of high concentration to zones of lower concentration.

Symptoms of magnesium deficiencies

Figure 4.8: Symptoms of magnesium deficiencies (Smart fertilizer management, s.d.)

The expression of the symptoms is dependent on the intensity to which leaves are exposed to light.

Effect of pH on magnesium availability

- Low pH leads to less availability
- Too high pH leads to leaching of magnesium
- High pH leads to more manganese and aluminium uptake which leads to less magnesium uptake

(Smart fertilizer management, sd)

4.1.7.5 **Sulfur (S)**

Sulfur helps plants to form important enzymes and assists in the formation of plant proteins. It is needed in low amounts, but deficiencies can cause serious plant health problems and loss of vitality.

Sulfur can in some ways be used to lower the pH level.

Plants that are not able to intake enough sulfur will exhibit yellowing of leaves that seems remarkably similar to nitrogen deficiency.

(Gardening know how, 2019)

5 Practical aspect, company visit and sampling summary

This part contains a summary of the Team's visit to the Polar Filé processing plant where water and soil samples were taken. Further, the approaches to the problem are discussed. They were selected based on the results of the soil and water samples, the quantity of the available resources, and the value of the end product.

On the 7th of April 2020, the EPS team went to Nämpnäs, a 1-hour drive from Vaasa, to visit the company Polar Filé and to take water samples. However, due to the current COVID situation, not all members of the team could participate in this trip. The trip comprised of the team members Marcel and Stefan as well as Andreas the supervisor.

Polar Filé is a family-run company that welcomed us with open arms. They gave us a tour of the processing plant, showing us their different machines and methods to skin and fillet fish. We also saw different products that come into the company and how they are being processed. They diversify their fish products as much as possible by selling many species of fish. However, they still express interest in wanting to diversify and expand their company to be more environmentally friendly.

After answering our questions, we went to take the water sample. The first place we sampled was before all filtering was done, meaning directly after the processing plant. The next place we sampled was in two of the three sedimentation tanks. Finally, we sampled where the field discharge water into the natural drainage systems. This will allow us to evaluate what was absorbed by the field.

This trip was very interesting, and we were impressed by this company's environmental inclination and determination to create jobs in the village. We can see this ecological mindset already with their intention to reuse all parts of their produced waste. Moreover, the company is heated geothermally and considers to add solar panels additionally.

All in all, the team is even more motivated to help this company and the environment by completing this project.

6 Water samples

6.1 Introduction

The water samples are very important because these values must be between certain proportions to use the water. Since a green environment and non-polluted soil is our goal. We also have to be under certain values set by the local environmental board. The first sample we took at 3/10/19 was taken at the start of the new water system. We participated in the sampling on 7/04/20. The charts below will compare those two results. There will be more in the future to follow up the system.

6.2 Overview of the water samples

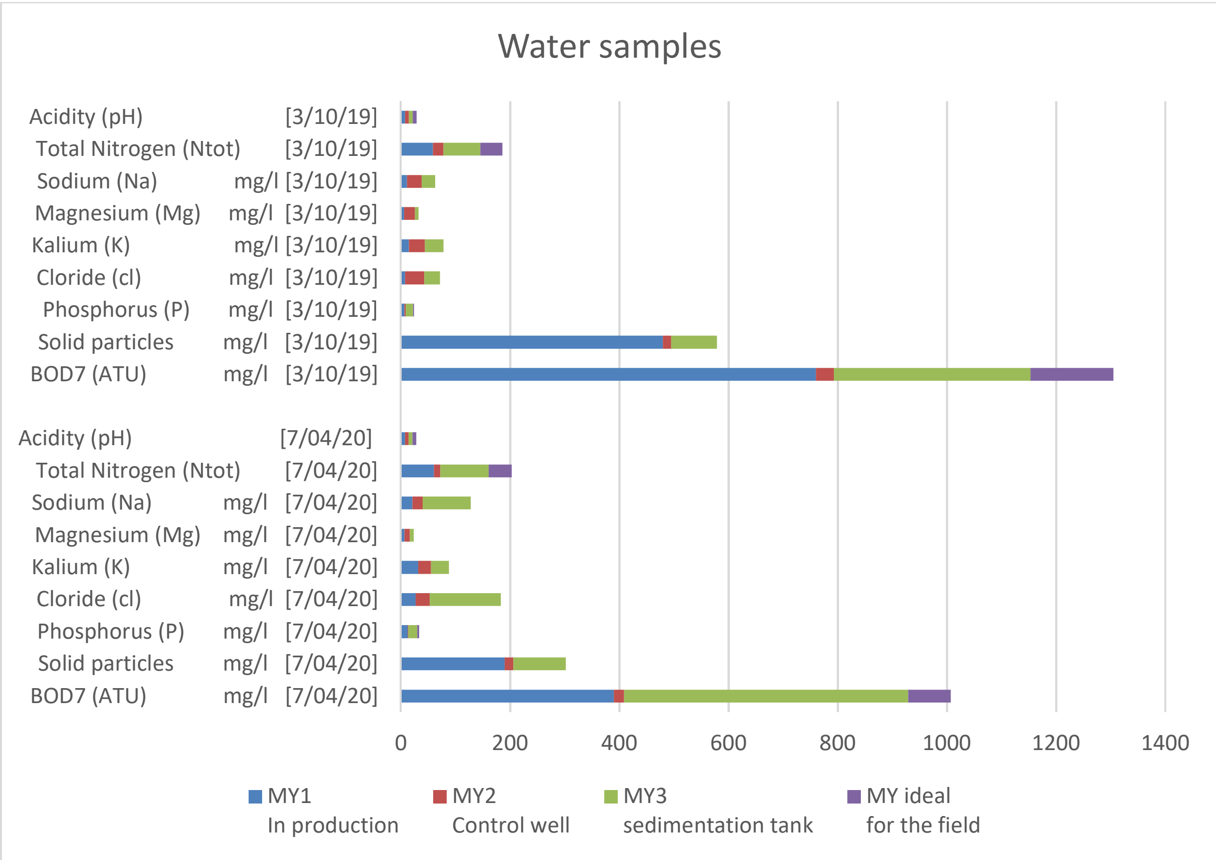


Figure 6.1: Water sample comparison

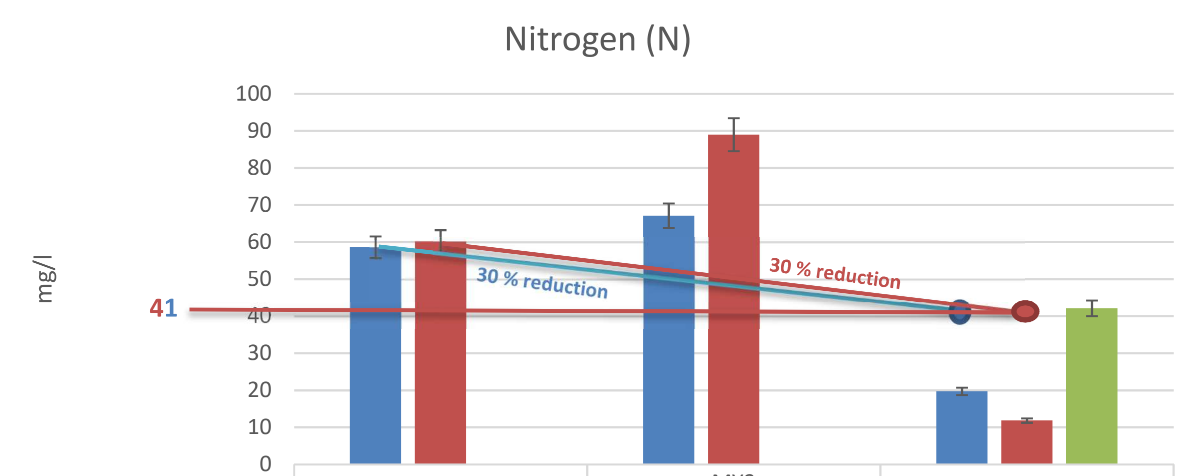
In this graph, the difference between the two samples is presented. One was taken on 3/10/19 and the other one on 7/4/20. Also, some important values to their ideal values are compared.

It has to be mentioned that the MY1 (in production) measurements were not taken at the same spot. Nevertheless, there is no process between these two sample spots and it can be assumed that it is safe to compare them.

6.3 Components

In the next part, we will discuss the different components in the water samples, as they are shown in the previous figure 6.1. The old samples will be compared with the new ones as well as the permit values. They are presented in separate graphs to give a better view of them. It is important to notice that the reduction and ideal values are based on the environmental permit requires. And that we have to stay under these values.

6.3.1 Nitrogen (N)



	MY1 In production (mg/l)	MY3 sedimentation tank (mg/l)	MY2 Control well (mg/l)
3/10/2019	58,6	67,1	19,7
7/04/2020	60,2	89	11,8
Ideal N (tot) control well			42,1

■ 3/10/2019 ■ 7/04/2020 ■ Ideal N (tot) control well

Figure 6.2: Nitrogen (N) comparison

It would be ideal (according to the permit) for the nitrogen level to reduce by 30 % after the sedimentation process. As shown in the graph, we have a great loss of N after the sedimentation tank, which is fortunate because we aim to stay under 42 mg/l according to the permit. After the nutrification takes place and when the aeration is stopped, denitrification will start. This results in lower nitrogen an phosphorous. (Versluys, 2013-2014)

6.3.2 Sodium (Na)

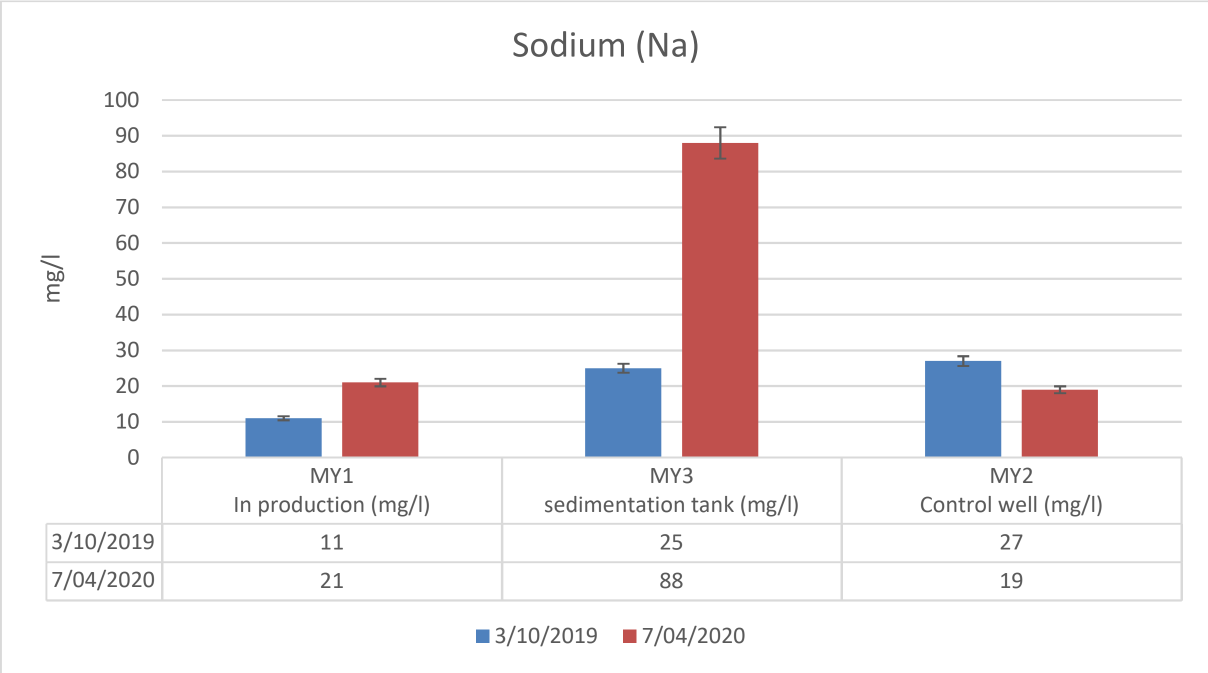


Figure 6.3: Sodium (Na) comparison

The amount of sodium remains stable comparing the beginning and the end of the process. However, there is a great increase during sedimentation, because of the sedimentation of sodium.

6.3.3 Magnesium (Mg)

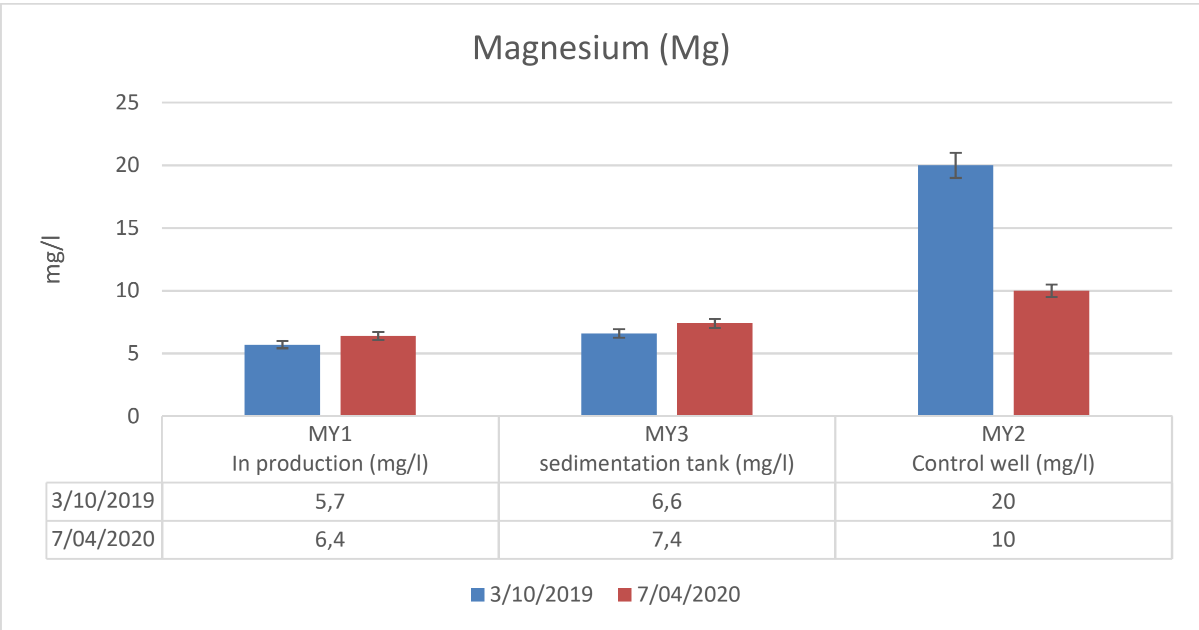


Figure 6.4: Magnesium (Mg) comparison

Magnesium increases after the sedimentation process. This could be because of the large amount of Mg in the field due to previous use of fertilizers.

6.3.4 Potassium (K)

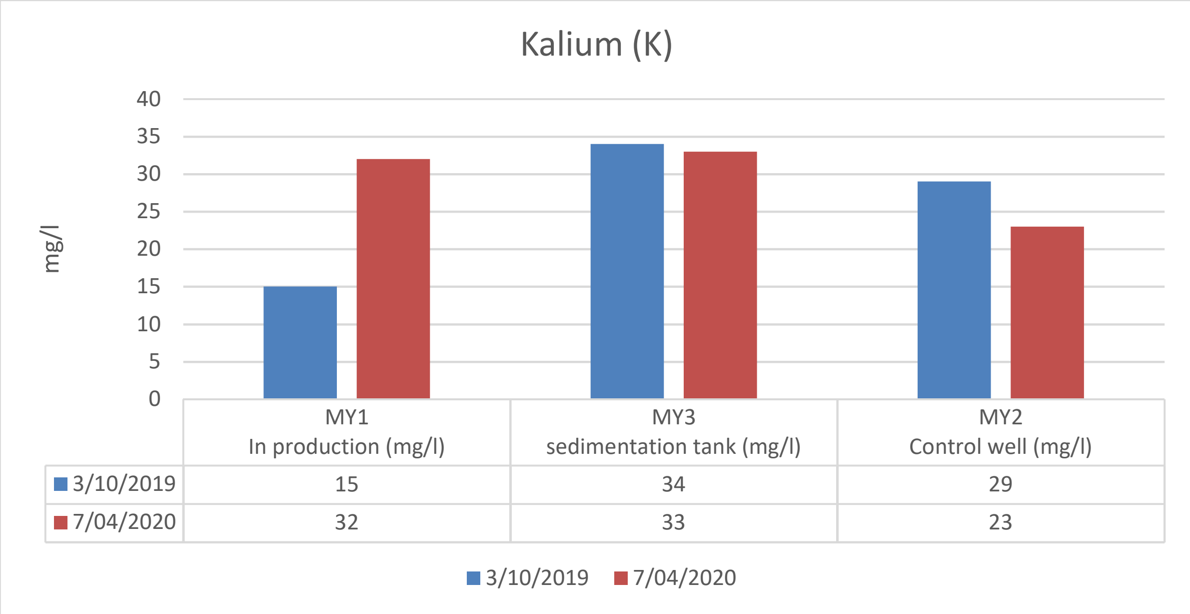


Figure 6.5: Potassium (K) comparison

The K graph is fluctuating. As we know from the soil sample analyses, is that there are large amounts of K in soils but only small amounts are accessible for the plants. By adding K we can increase the uptake of K to strengthen the roots of the plants.

6.3.5 Chloride (Cl)

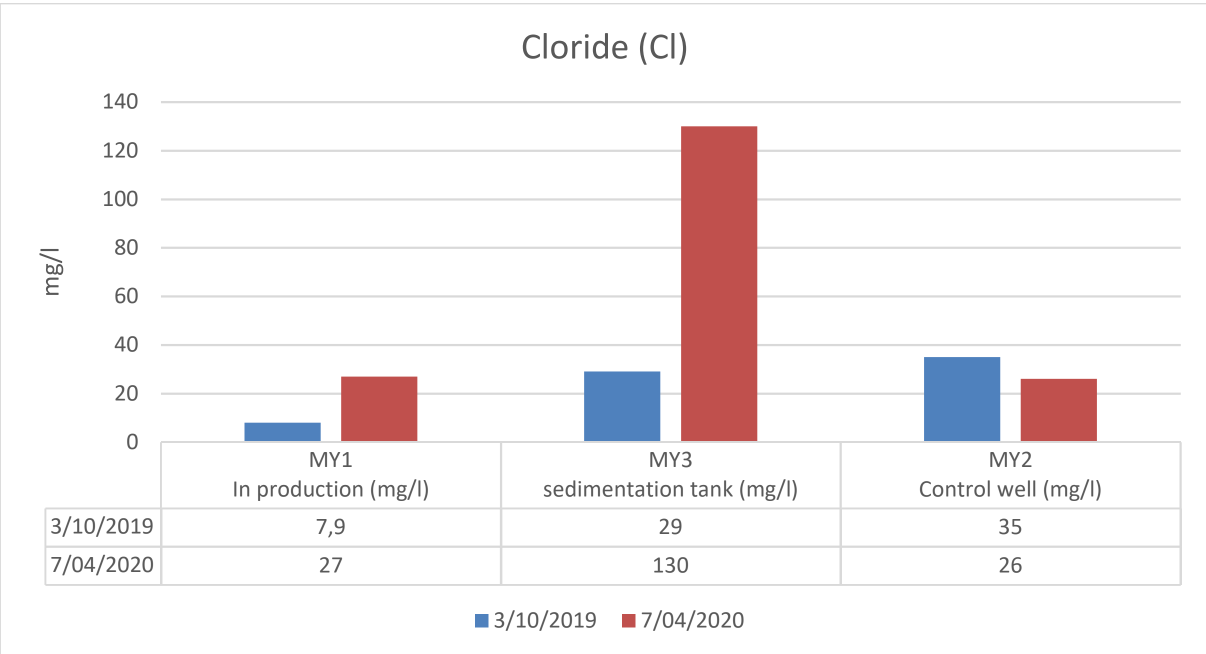


Figure 6.6: Chloride (Cl) comparison

Chloride raised but after a great increase in the sedimentation, it decreases once it passes the control well.

6.3.6 Phosphorus (P)

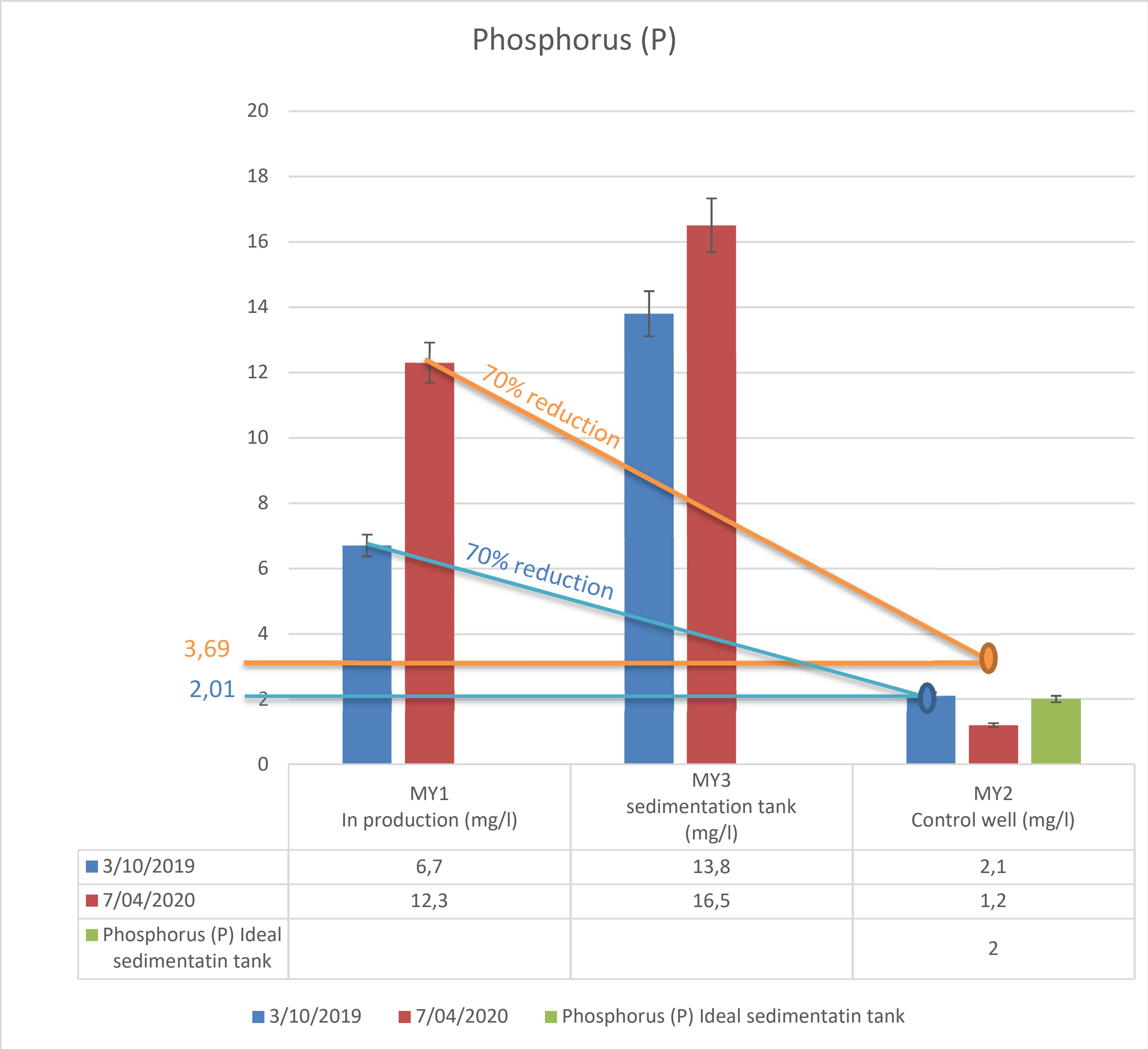


Figure 6.7: Phosphorus (P) comparison

The ideal phosphorus value would be 2 mg/l. Now the ideal reduction is 70%. Which means that the ideal P in production would be 6.67 mg/l. This is almost the amount that was measured the first time. Considering this and that the value now stays under the max level. We assume a good amount of P in our water. The amount of P is rather low in our soil, so the addition of P in the water may help in the plant growth. Because P is very important for developing the plants' roots.

6.3.7 Solid particles

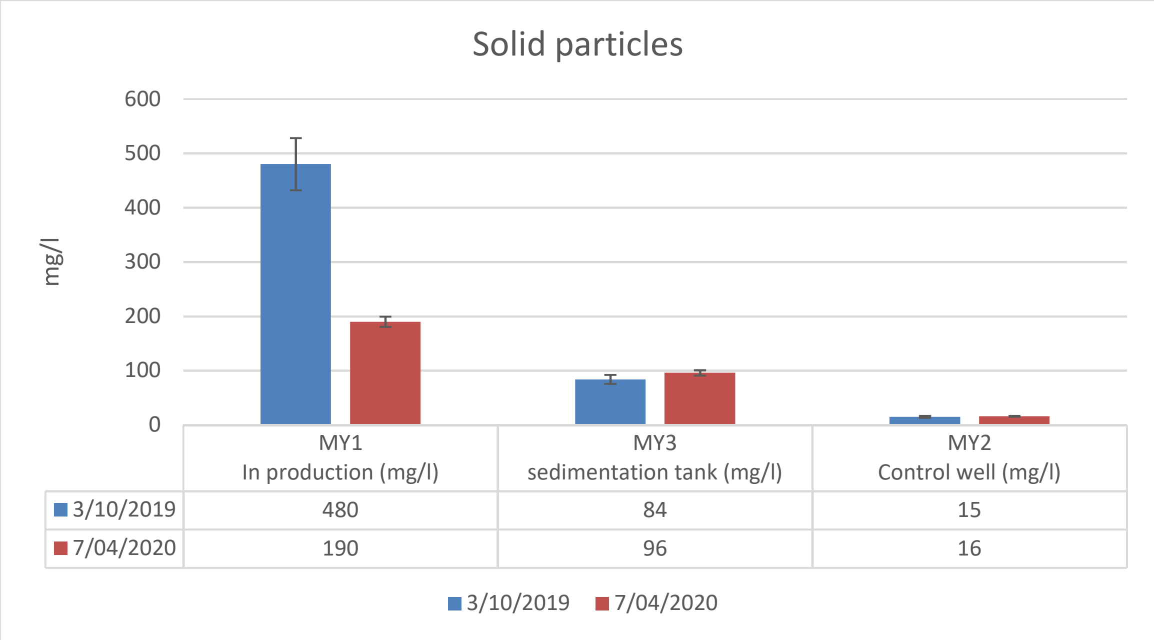


Figure 6.8: Comparison of solid particles

It is very important to reduce the solid particles because particles can clog up in the pipes. Also spreading solid particles in the field is not what is aimed for. Solid particles are in general (apart from nutrients and other valuable resources) considered waste for the field. They can be used for different applications. This is a good view of the general treatment effect.

6.3.8 Acidity (pH)

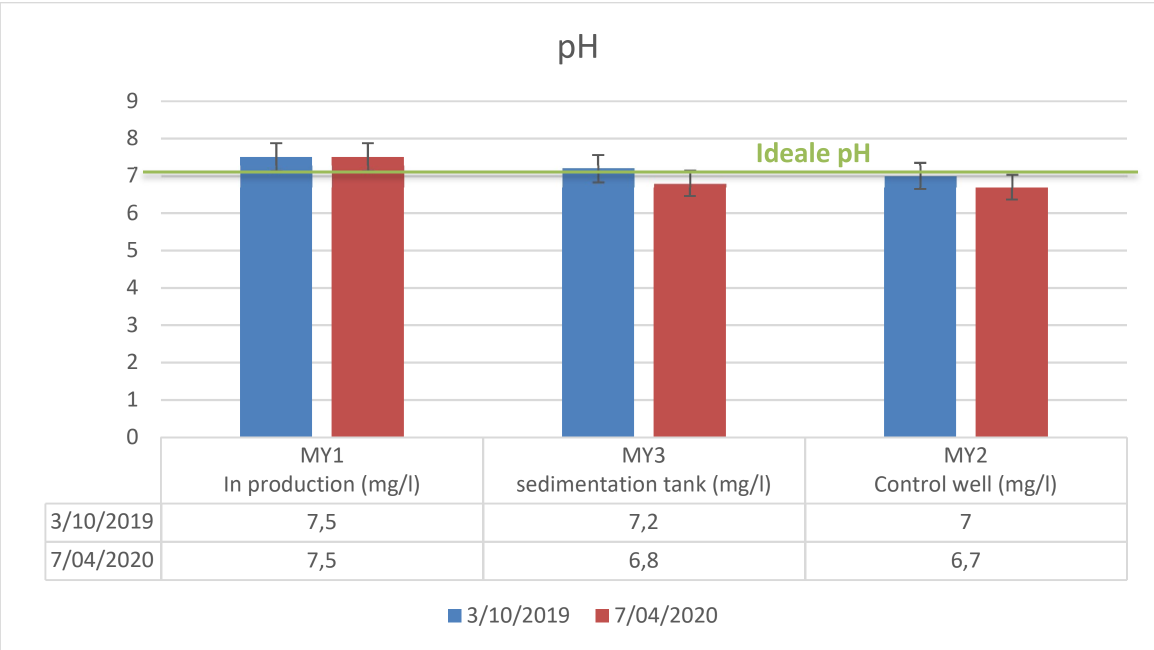
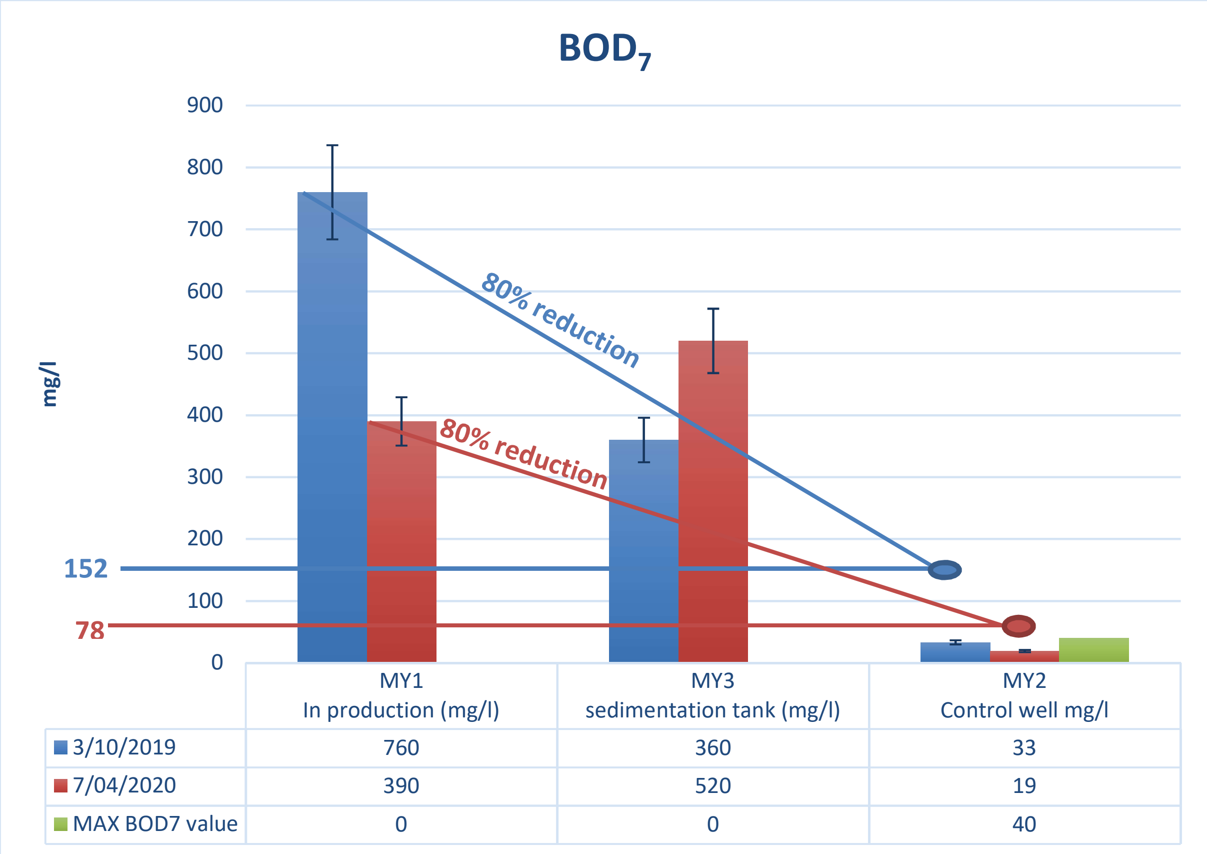


Figure 6.9: Acidity (pH) comparison

The soil's pH should not be affected. The fact that the pH stays around 7, means that the ground will not be affected.

6.3.9 BOD$_7$



	MY1 In production (mg/l)	MY3 sedimentation tank (mg/l)	MY2 Control well mg/l
3/10/2019	760	360	33
7/04/2020	390	520	19
MAX BOD7 value	0	0	40

Figure 6.10: BOD7 comparison

The biological oxygen demand also known as BOD$_7$ has to reduce by 80%. Now, our values are significantly lower than the predictions. This is good and means that the water can be used. The reason for this reduction is that the reaction in the sedimentation tank uses a lot of biological material. This is the reason why the BOD is so high in the sedimentation tank. After this reaction, the biological activity decreases, as well as the biological material's demand for oxygen since the amount of biological material decreases.

6.4 Conclusion

Out of the graphs, we can see that the water is suitable for usage. We reduced the amount of solid particles that are considered waste. With a pH level around 7, there will be no effect on the pH of the soil. We checked that every value is below the environmental permit requires. To make sure that it is legal and safe to use the water as a fertilizer/waterer. Aldo not all elements are taken into the permit, we still thought that they would be interested to follow up either because it can be associated with fish or could affect the field.

7 Fish oil extraction

The team decided that one of the most valuable products that can be extracted from waste is fish oil. Not only a fraction is captured by grease trap, but the solid waste is also rich in the fats. Fish oil is a valuable fish product as it contains high quantities of long-chain polyunsaturated fatty acids from the n-3 family which is a unique feature for fish oil. These fatty acids are known to have various health benefits, helping against cardiovascular diseases, as well as possessing anti-inflammatory effects and many others (Nalin Siriwardhana, 2012).

There are many technologies for extracting oil from fish waste which can be divided into three categories: physical extraction, chemical extraction, and enzymatic extraction. Chemical extraction requires toxic solvents, which is why it is not going to be considered in this paper. Physical extraction of fish oil from the waste can be performed via homogenizing, heating, pressing, and filtering (Quresi, 2018).

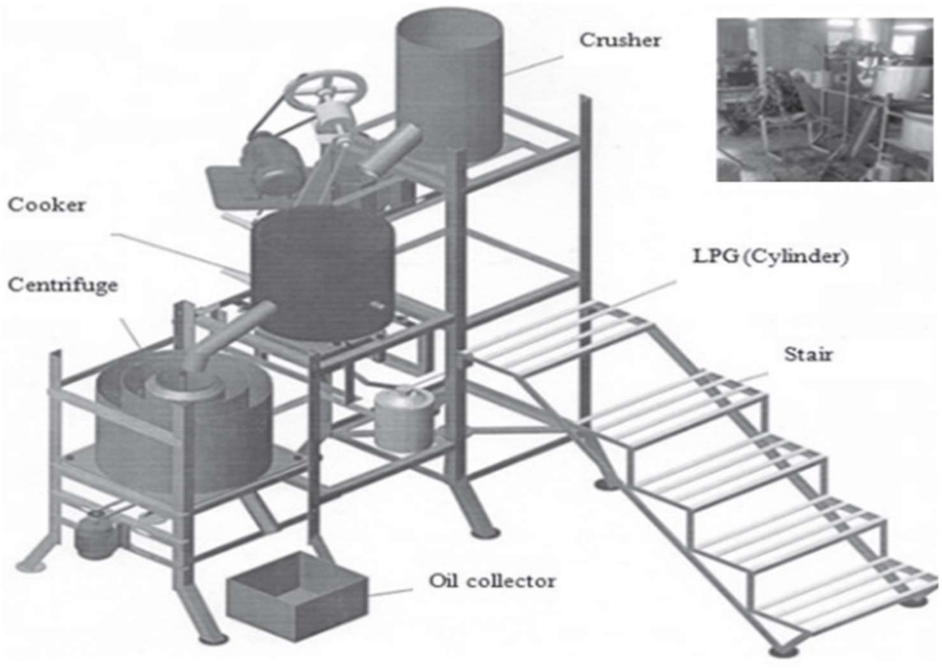


Figure 7.1: 3D CAD view of oil extraction unit (Quresi, 2018)

In this process, the solid waste is first crushed to produce a uniform mass which is then heated in a cooker for a period of time, while being stirred. Finally, the oil is extracted from the cooked mass by a centrifuge. In a research performed in Pakistan by Qureshi, Mahmood-Khan, Ahmad, Shoaib, Farid, Khan, and Sial, an experimental small scale fish-oil extraction unit was tested. Their research shows that the optimal cooking temperature for fish-oil extraction is 65 °C and that the higher waste crushing speed and higher centrifugation speed contributed to increased extraction of fish oil from waste – up to 3.66 L of fish oil and 1.75 kg of fish meal from 10 kg of solid fish waste (Quresi, 2018). In their research, Agnieszka Głowacz-Różyńska et al. (Głowacz, 2016)investigated the differences between the three procedures of extracting lipids from salmon byproducts: extraction at high temperature, “cold” extraction and enzymatic extraction. Achieved yield of extraction reached up to 73% for fish heads, where lipid content was on average 20%.

In their research, Agnieszka Głowacz-Różyńska et al. (Głowacz, 2016) investigated the differences between the three procedures of extracting lipids from salmon byproducts: extraction at high temperature, “cold” extraction and enzymatic extraction.

I. High-temperature extraction

In this procedure water of temperature 50 °C was blended with frozen raw fish heads in proportion 1:1, w/v to obtain a homogenous pulp. Next, the pulp was heated at 95 °C under pressure 0.02-0.04 MPa for 30 minutes with stirring. Then the mixture was cooled under vacuum to room temperature and centrifuged for 10 minutes at 8000×g to separate the phases (Głowacz, 2016).

II. Cold extraction

In this procedure water of temperature 50 °C was blended with frozen raw fish waste in proportion 1:1, w/v to obtain a homogenous pulp. Pulp was then centrifuged for 10 minutes at 8000×g to separate liquid and solid waste, after which the liquid waste was centrifuged for 5 minutes at 8000×g to separate oil (Głowacz, 2016).

III. Enzymatic extraction

In this procedure water of temperature 55 °C was mixed with minced fish heads in proportion 1:1, w/v. The pH of the mixture was set to 8.0 with 4 M NaOH solution. Then the Alcalase® was added at substrate mass concentration 5%. The reaction was carried out at 55 °C with continuous stirring with pH being set to 8.0 with 4M NaOH for 2 hours. After the reaction, the mixture was centrifuged at 8000×g for 30 minutes (Gbogouri, 2006) (Głowacz, 2016).

The results of each extraction method were assessed and compared in a table

Table 7.1: Characteristics of oil extracted from fish waste (Głowacz, 2016)

Procedure of extraction	Type of byproducts	Yield (%)	PV (mEq O_2/kg)	AV (mg KOH/g)	Phospholipids (% of total lipids)
I	Heads	71.1 ± 0.4^{c}	9.2 ± 0.6^{a}	1.34 ± 0.03^{a}	0.02 ± 0.00^{d}
II	Heads	71.5 ± 1.1^{c}	2.5 ± 0.2^{b}	0.18 ± 0.01^{e}	0.15 ± 0.01^{c}
	Skins	95.2 ± 2.2^{a}	0.8 ± 0.1^{d}	0.43 ± 0.01^{cd}	0.13 ± 0.01^{c}
	Backbones	82.7 ± 1.7^{b}	0.7 ± 0.1^{d}	0.85 ± 0.02^{b}	0.29 ± 0.06^{b}
III	Heads	72.1 ± 0.9^{c}	1.6 ± 0.1^{c}	0.70 ± 0.02^{c}	1.47 ± 0.11^{a}

Results are expressed as means of six measurements ± SD. The values in the columns marked with different letters (a – c) differ significantly ($p < 0.05$).

PV – peroxide value, it allows the measurement of rancidity in unsaturated oils

AV – acid value, it is used to determine the number of carboxylic groups in fatty acids.

From these results, we can see that the yield of fish oil extracted through different methods is comparable, but the concentration of phospholipids which are beneficial for human health is the highest in the enzymatic extraction, which means that the oil obtained through this method is of the highest quality and thus has the highest value. On the other hand, working with proteases may present an additional challenge as they tend to autodigest, which means that their activity will lower with time. The extraction of fish oil is a batch process, which means that the enzymes will not be reused. After each batch, they will be instead deactivated. Because of that, the only time when autodigestion would be the problem is the storage of enzymes, but as long as the instructions for storage provided by the manufacturer are followed, the enzymes should maintain their activity.

To perform the enzymatic extraction of fish oil the following processing units are required:

- Meat grinder
- Reactor
- Decanter
- Centrifuge

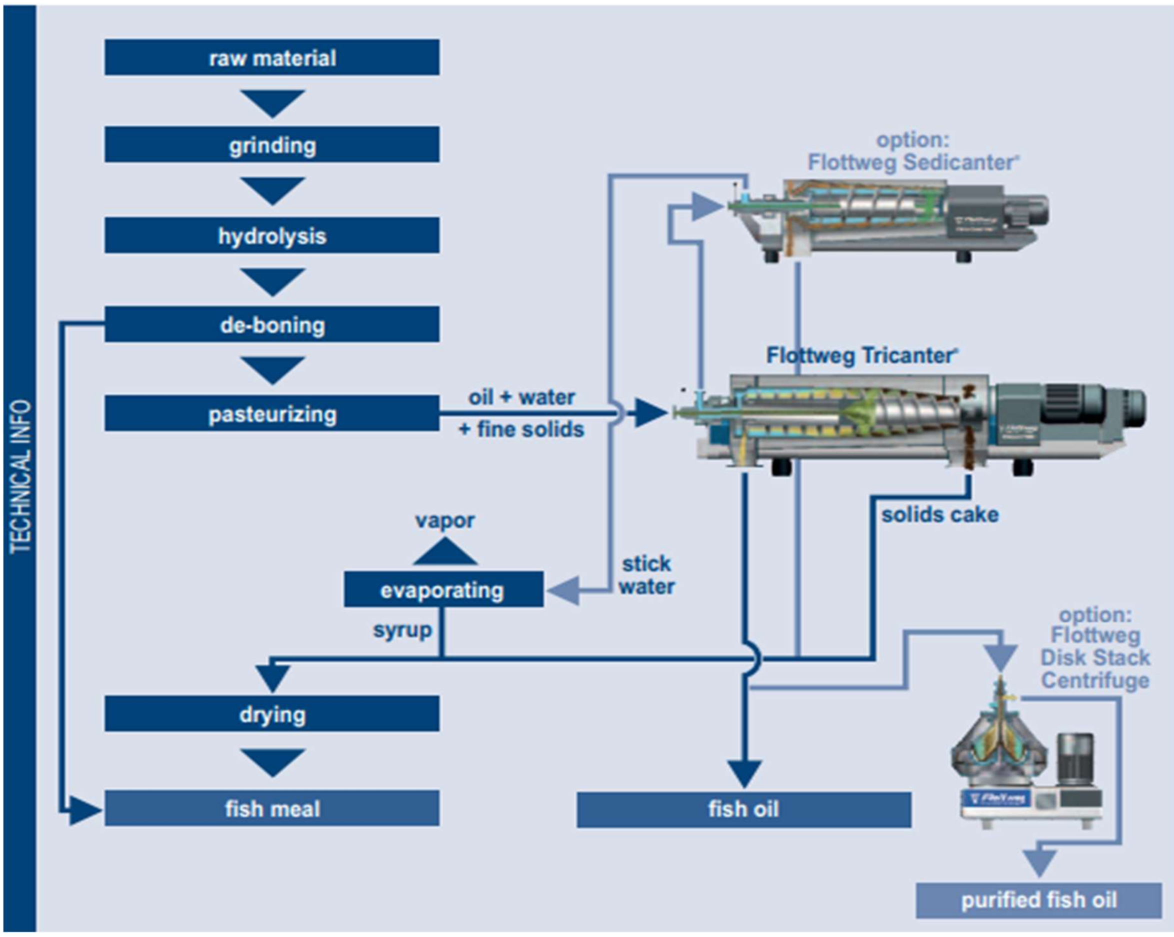


Figure 7.2: A scheme of typical fish oil extraction using enzymatic hydrolysis (Flottweg SE, 2020)

On the market, there is a variety of equipment designed for the purpose of extracting fish oil from fish waste. An example would be a Tricanter® produced by Flottweg (Flottweg SE, 2020)￼, which allows the separation of (Natural Resources Institute Finland (Luke), 2016)￼. Because the processing plant is located in Närpes, which is also in the Ostrobothnia region, the feed can be sold locally to the fur farms. Such a solution allows the reduction of the transport costs of sold fishmeal.

7.1 Quality control

Another important aspect that needs to be considered is the quality control of the produced oil. Fish oil goes through chemical changes because of oxidation which happens when it is exposed to heat, light, or oxygen. Because of that, it is important to carefully plan and execute its production and make sure that fresh fish byproducts are used. The ready product should be stored in sealed bottles to prevent contact with light and oxygen which would contribute to the oil spoilage. Additionally, it would be a good idea to store fish oil at low temperature. The application of natural preservatives should also be considered. Because it is a food product, its quality must be tested. These tests include:

- Bellier turbidity temperature
- Color on Lovibond scale
- Optical rotation
- Protein content
- Presence of bacterial toxins
- PCR (Polymerase Chain Reaction) for pathogens

For small scale production, it could be more viable to have the quality control performed at an external laboratory which specializes in food quality. The samples should be taken from every batch of oil before it can be sold (Hradesh Rajput, 2019).

7.2 Cost analysis (Fish oil extraction)

To decide if the extraction of oil from fish by-products is a viable action, potential profits and costs must be analyzed. The team has reached out to several manufacturers and their partners to learn more about the technical aspect of required equipment as well as potential costs of maintenance and investment. Due to the lack of reply, a different approach was taken. According to the quantity of raw material, the daily volume of produced fish oil was estimated. Then from the value of the product, costs of production were subtracted. The costs include the cost of enzymatic preparation, labor costs, electricity costs, and quality control costs.

Table 7.2: Input and output of the fish oil extraction process

Daily solid byproducts used [kg]	*500*
Daily oil extracted [kg]	*70*
Daily fishmeal [kg]	*85*

The table 7.2 shows the number of fish by-products used for the oil extraction, as well as its estimated products according to available data which was discussed above.

Table 7.3: Material and labor costs of the production

The market price of oil per L (with vat)	€ 84
Value of high quality fish oil [euro/l]	63,84
enzyme cost [euro/l of oil]	3,44
Global price of fish meal [euro/kg]	1,29
Salary for specialist [euro/hour]	25
Actual cost of employment [euro/hour]	30
Number of workers	2
Hours per day	8
Labor cost per day	480

As a starting point, the price of bottled fish oil which can be bought was investigated. The price varies, but the average price of fish oil is around € 84 per 1 L of fish oil using the price of herring fish oil found on the Amazon website as an example (Amazon; Fiskolia company, 2020). After subtracting the VAT the value of 1 L of fish oil is € 63,84. Additionally, during the process of extracting fish oil, fishmeal is extracted. The stock market value of fishmeal is around 1,29 per kg (IndexMundi, 2020). Next, the cost of Alcalase enzymatic preparation required for the production of 1 L of fish oil was calculated. The cost of 0,5 kg of preparation is € 81,90 (Merck KGaA, Darmstadt, 2020). Assuming that 0,15% concentration of enzyme should be used for the extraction of fish oil, fish by-products should be mixed 1:1 with water, for the extraction of 1 L of fish oil € 3,44 worth of enzyme should be used.

Another aspect is the cost of labor. Assuming that the process is automated, but bottling of the fish oil is going to be performed manually, at least two people should be employed. It is also possible that the job would not be full time if the amount of substrates is too low. Their salary is based on the average laboratory technician salary in Finland (Salary Explorer , 2018). Their duties would include overseeing the process of fish oil extraction, bottling of the fish oil, and possibly cleaning the machines.

Table 7.4: Estimated energy cost

Energy price in Finland [euros/1kWh]	0,12	
Energy consumption [kW]:		
Meat grinder motor power	5,00	kW
Reactor motor power	10,00	kW
Decanter motor power	20,00	kW
Centrifuge motor power	45,00	kW
kWh per day	100	kWh
Cost of energy per day	12	€

Next, the estimated energy cost was calculated according to the prices of energy in Finland as well as the estimated energy consumption of different components of the oil extraction setup. Due to a lack of response from the companies manufacturing and importing the components necessary for the process of extraction, the energy consumption of specific components was assumed without knowing the specifications of actual machines. The motor power of the meat grinder was assumed to be around 5 kW. It was assumed to be larger than for small meat grinders with a capacity of 220 kg/h and power of 1 kW (expondo, 2017-2019) and smaller than for 14 kW motor power meat grinder of capacity up to 14 000 kg/h (Seydelamann, 2020). To know the reactor motor power, the mixing power of the impeller must be known. It is calculated based on the density and viscosity of the fluid, as well as the geometry of the mixer. The energy consumption of the decanter and centrifuge was taken from the website of the company specializing in the production of industrial centrifuges – HAUS centrifuge technologies. The motor powers were taken for the second smallest decanter (HAUS centrifuge technologies, 2020) from the catalog and the smallest centrifuge (HAUS centrifuge technologies, 2020) the company offers. These values are not as accurate as the actual output of the machines might be larger than needed, but they help estimate the costs of running the production. The assumptions taken are the following: the time of operation of the meat grinder is up to 3 hours, the time of the reaction is 2 hours, and each of the separation steps takes up to 1 hour.

Table 7.5: Costs of quality control

Microbial test minimum cost	$ 20,00	€ 18,40
Microbial test maximum cost	$ 50,00	€ 46,00
Nutritional test minimum cost	$ 20,00	€ 18,40
Nutritional test maximum cost	$ 30,00	€ 27,60
Total Minimal cost		€ 36,80
Total Maximal cost		€ 73,60
Average cost		€ 55,20

Quality control of the products should be performed at the external laboratory because the maintenance of the proper equipment would be more expensive than contracting it to a specialized laboratory. The prices of the food quality control were based on the article from the business.com website (business.com, 2020)

Table 7.6: Value generated over time

	Fish Oil	Fishmeal	Total
Daily value generated (costs of processing not included)	€ 4 468,80	€ 109,65	€ **4 578,45**
Daily value generated (8 hours workday)	€ 3 680,80	€ 109,65	€ **3 790,45**
Value generated in 1 week	€ 18 404,00	€ 548,25	€ **18 952,25**
Value generated in 1 month	€ 73 616,00	€ 2 193,00	€ **75 809,00**
Value generated in 1 year	€ 883 392,00	€ 26 316,00	€ **909 708,00**

After the above costs were considered, the value generated over different periods was calculated. Based on these results, the purchase of the necessary equipment for the production line can be negotiated. It is important that the investment can be paid off within 5 years of making the purchase. Additional costs that have to be included: transport of the product, purchase of bottles, design of the labels for the fish oil, pH buffer for keeping the optimal pH for oil extraction.

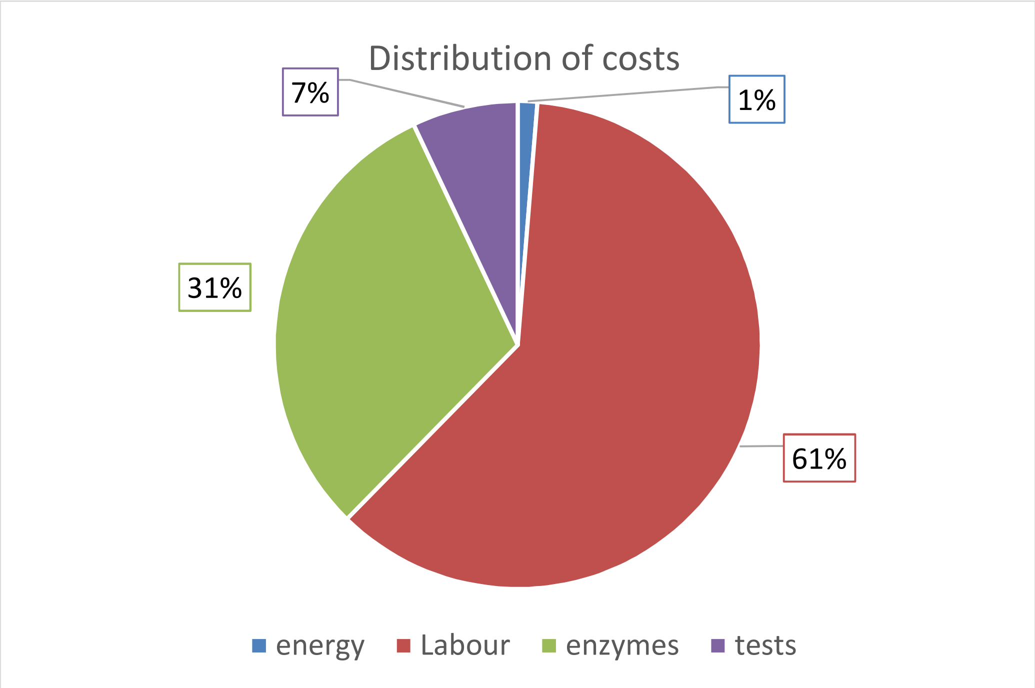


Figure 7.3: Distribution of costs over the total cost of production

At this step of the planning, the highest contribution to the costs of production is labor cost, while quality control contributes to less than 10% of total costs of production, and costs of enzymes are about 30% of all costs.

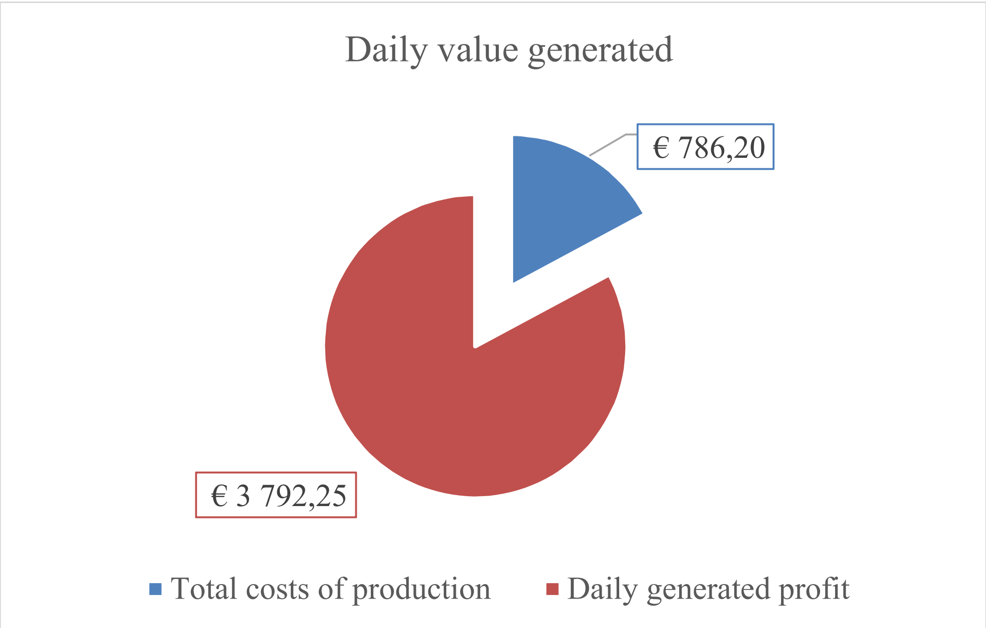


Figure 7.4: Comparison of the generated value to the costs of the process

After the identified costs of production are subtracted from the value of the generated products, about 80% of the generated value is left. According to the considered aspects and costs of the investment, extraction of fish oil from the fish by-products seems like a viable option that will allow extraction of a considerable amount of value from the fish waste.

8 Collagen extraction

8.1 Process

As seen previously, collagen is a protein that is abundant in fish skin, scales, and bones. Collagen has many applications throughout many sectors, from cosmetics to pharmaceuticals. However, after discussion, its use in nutrition will be the best way to valorize this product. By using this protein for nutritive purposes, we would be using the fish as much as possible for human consumption. This will allow us to answer a human necessity before looking into new technologies to reuse this product. Collagen is beneficial for humans in supplement form, especially for protein and fiber source. (Maya Raman and K Gopakumar, 2018)

The flow chart below shows the process for collagen extraction.

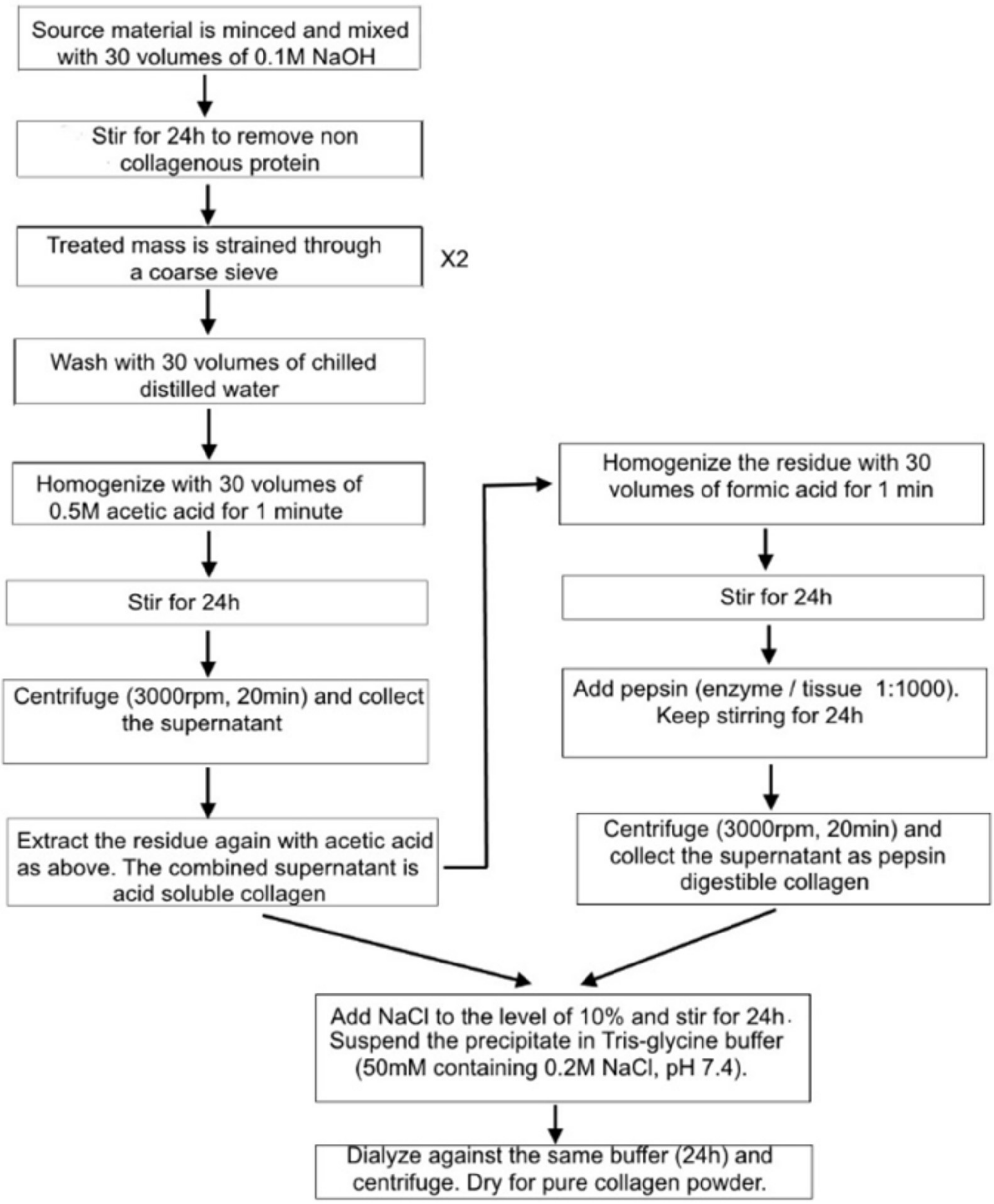


Figure 8.1: Flow chart showing collagen extraction method (Berillis, 2015)

Collagen must be extracted from the fish solids to reuse it. Firstly, fish parts must be finely milled and washed to facilitate the extraction process. For this, a meat grinder will be the most suitable tool for this job when talking in an industrial context.

Milled material must then go through pre-treatment with an alkaline and then an acid solution. The goal of these steps is first to obtain a neutral pH and more importantly to isolate the collagenous material so that the extraction process will act more efficiently. (Elizabeth Troncoso, December 2014)

The extraction process comes next. Two methods exist for this process: acidic and enzymatic extraction. Acidic extraction in acetic acid is the most common method. It permits a quicker process. However, yield, concentration, and thus the quality of collagen will not be optimal. On the other hand, enzymatic extraction, although less rapid, allows for better yield and quality. Furthermore, this high quality of collagen is essential when used in food. A combined extraction process will be used where material first goes through a quick acidic extraction phase before the thorough enzymatic extraction. (Nicholas M.H. Khong, 2018) In order to speed up the extraction process, ultrasound will be used to break bonds.

Finally, collected collagen must be dried to be reused in food.

It is important to note that in between each step of the process, it is necessary to wash the created solution in distilled water and to centrifuge it. This will homogenize the mixture and help with the extraction process.

8.2 Required equipment

During the company visit, Polar Filé has pointed out to us that they have unused rooms and space in their building and would like to exploit it. Collagen extraction requires equipment that can all be put in a single room thus utilizing vacant spaces.

A certain amount of equipment is required to ensure an efficient process.

- Tanks will be needed at different stages of the process to contain solutions.
- A meat grinder will be required to mill all input material before extraction
- A centrifuge for homogenizing the solution between steps of the process
- An ultrasonic extractor to speed up the extraction process

Most items listed are somewhat standard and can easily be found such as tanks. Meat grinders and centrifuges are also common although will require a larger investment from the company's side. Finally, an ultrasonic extractor is a specific piece of equipment that must be carefully chosen according to our needs.

Concerning the ultrasonic extractor, Hielscher, the main supplier of ultrasonic machinery has been contacted. Their solution consists of a probe that will release ultrasonic waves in the collagenous solution and will thus speed up the process and at the same time will ensure quality and repeatability of optimal results.

With all these investments, proper cost analysis is required.

8.3 Cost analysis (Collagen extraction)

Collagen is a high-value product that can be sold as nutritive supplements. It is by evaluating the value of this collagen that we can determine how beneficial this extraction process will be. For this cost analysis, as many factors as possible will be taken into account to have a more precise analysis, from the cost of equipment, even to energy consumption, without forgetting running costs.

8.3.1 Ultrasonic collagen extraction

For the extraction process, specialized equipment consists of the ultrasonic extractor. The company Hielscher that sells ultrasonicators has been contacted and can help with our extraction needs. For this, the manufacturer recommends that we first acquire a lab unit on which we can do our testing and define the optimal ultrasonic settings to obtain the best results. To ensure optimal results, lab testing and chromatography is required at Polar Filé's costs. These settings will allow for reproducible and repeatable results, thus reducing the need for regular quality control.

Figure 8.2: UP400St ultrasonicator, Hielscher 400W lab unit (Hielscher Ultrasound Technology, s.d.)

From these settings, we can opt for the scale-up and get an industrial unit for a bigger scale extraction. The lab unit can either be kept for future testing and extraction or sent back to the manufacturer with a 70% refund. However, it is important to note that with the industrial scale-up, extra-costs for a production line will be needed for continuous extraction. For reference, the lab unit costs 5500€ and the industrial model at least 12000€.

Considering the amount of investment, we can ask ourselves if the acquisition of both machines is justified. On one hand, the lab unit has 400W of power. It is a powerful machine but may not withstand the rhythm imposed by the fish processing plant. Lower quantities will be processed at a time but can easily be adjusted to obtain optimal results.

On the other hand, the industrial unit has 1kW of power but might be too costly. Logically, by buying an overly powerful machine, the price will be high, and return on investment will be longer since the machine is not used to its full capacity. The machine will be able to sonicate today's processing plant's waste and maybe even in the future if Polar Filé grows in production quantities. However, extraction will not be optimal since there was no testing phase to determine the ideal specific energy input.

It is important to note that an ultrasonicator is not an essential machine to extract collagen but speeds up the process. Due to its high price, Polar Filé must be convinced of its necessity before investing. Before deciding, it is wise to first experiment with the processing plant's by-products as results will vary depending on fish types. Furthermore, it will familiarize the company with the whole procedure and can then assess the need or not to extract faster.

8.3.2 Other costs

Standard machinery such as tanks, meat grinder, and centrifuge will be a one-time investment. The task here will be to save as much as possible and if needed, the second-hand market can be a good option in terms of budget. For this, 2000€ should be enough for a basic set that can do the job.

During all the different phases of extraction, different substances are needed such as enzymes and sodium hydroxide. Other costs to consider are salaries, bottling, and maintenance that will be required as long as collagen is extracted. Energy consumption is also an expense but will not be as significant as other factors.

Concerning salaries, around two extra employees will be required to supervise the extraction process, help the material transit from phase to phase, as well as bottling. An option for Polar Filé can be to use the same additional employees to overlook fish oil and collagen extraction.

8.3.3 Overall analysis

The cost analysis consists of many estimated values and prices that must be tested for more precise results. Variables such as costs of extraction substances, processing time, and even yield may change once the procedure is put in place in an industrial context.

High-quality collagen can fetch more than 100€ per kilogram (Amazon; Edible health, 2020) but we shall assume a lower selling price as we cannot guarantee the same quality as those already on the market. We shall estimate a price of 50€ per kilogram for our extracted collagen, after subtracting VAT we obtain 38€ per kilogram.

If Polar Filé were to buy all the described machinery, the equipment budget will go up to 20,000€.

In terms of labor costs, we shall assume the same costs as in the study on fish oil, meaning two workers paid 30 euros an hour.

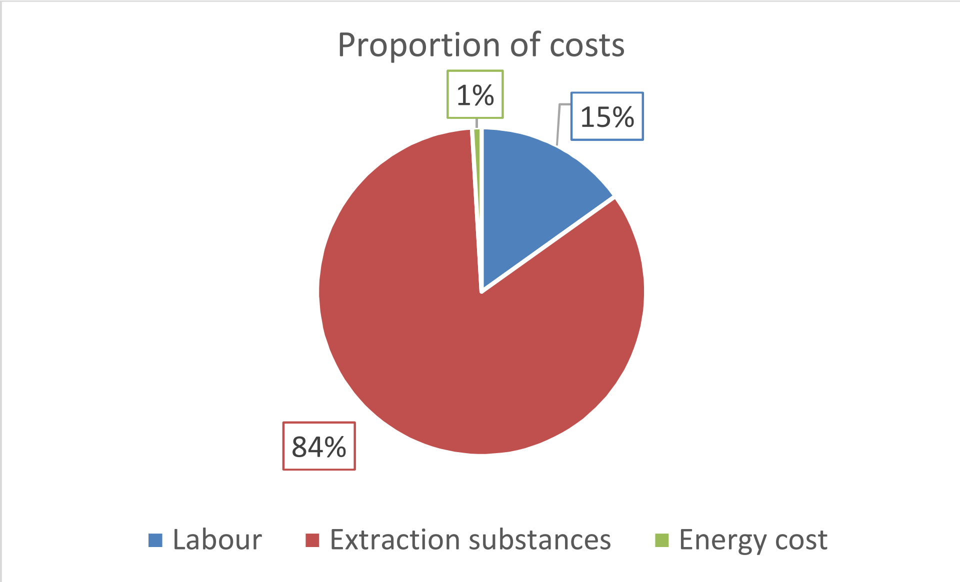


Figure 8.3: Proportion of costs

On the above pie-chart, we notice that a vast majority of the costs are spent on extraction substances. This is because collagenous material must be mixed with several different solutions. Also, according to research, the material must be diluted many times in each substance, for example, 30 times (Berillis, 2015). However, not all research shows the same dilution requirements and we can assume that in an industrial context, it is coherent to test the ideal volumes of required substances. We must note that all research encountered uses the same concentration of substances for example 0.5M acetic acid (Berillis, 2015)

Table 8.1: Generated value

Daily value generated (8 hours workday)	**€**	**3,122.23**
Value generated in 1 week	**€**	**15,611.16**
Value generated in 1 month	**€**	**62,444.64**
Value generated in 1 year	**€**	**749,335.68**

Above are the estimated amounts Polar Filé can hope to gain per period. However, with these values, the purchase of bottles, transport, labels, and testing for optimal collagen extraction must be added.

9 Conclusion

Fish processing plants produce extremely rich waste that can be recycled in different ways in order to prevent further eutrophication here in Finland. Furthermore, today it is necessary to valorize every resource we have and thus reduce extraction for ecological reasons.

After processing the fish at the plant with the existing filtering system, fish solids will be first extracted, followed by fats, and then sludge will be collected with sedimentation tanks. Finally, the water will be distributed to the crops in the nearby field.

Significant part of these by-products will be reused as much as possible for human consumption in the contrast to the current situation where all of the by-products are used as animal feed. This is to answer basic needs first before looking into new technologies.

First, by collecting fish fats with the help of the grease trap and fish solids from the processing plant, oil can be extracted using an enzymatic extraction method. This high-quality fish oil is known for its nutritional value and can be consumed as dietary supplements.

Next, by collecting fish skins, scales, and bones from the plant, collagen can be extracted using a combined acidic and enzymatic method the recuperate the valued product. Marine collagen is thus collected and can benefit humans for a supplementary fiber and protein source.

Techniques and solutions were described in the report as well as cost analyses to help Polar Filé better visualize the investment.

We must not, however, forget the partnership with the field and its farmer. Water samples were taken and analyzed to ensure that wastewater will be beneficial for the field and crops. Overall, the water composition satisfies environmental regulations and is a good sign for this partnership.

This partnership between the fish processing plant and the fed field nearby is off to a promising start as they complement each other. More specifically Polar Filé has many investment opportunities that they can choose to seize that benefit not only themselves but also the environment and even the local economy.

For the cooperation between the farmer and the processing plant, soil and water samples must continue to be taken regularly to ensure the quality of the natural fertilization through the wastewater. By doing so, the fertility of the field is also monitored. Currently, the project is still new and when more significant results appear, especially on the farmer’s side with better-growing crops, this project can be exported to other processing plants.

The group is satisfied with the outcome of the EPS, not only for the location here in Finland but also for the project topic. The innovative idea and motivated actors opened our minds to new possibilities in the fish processing business. Our multicultural enterprise was a successful and efficient one that has taught all of us lifelong skills that can only be learned here. Though there were setbacks and complications along the way, we feel gratified to be able to help local business and that we were able to accomplish more than initially planned by suggesting concrete solutions.

10 References

(n.d.).

© 2019 Hofstede Insights. (2020, March 20). *Country comparison*. Retrieved from Hofstede Insights web site: https://www.hofstede-insights.com/country-comparison/belgium,france,germany,poland/

© 2020 BELBIN Associates. (2020, March 18). *Belbin team roles*. Retrieved from BELBIN Associates website: https://www.belbin.com/about/belbin-team-roles/

© Belbin UK and © PrePearl 2020. (2020, March 20). *Belbin team roles*. Retrieved from People Power PrePearl Training Development website: https://www.prepearl.net/belbin-team-roles/

A Afifah, O. S. (2019). Utilisation of fish skin waste as a collagen wound dressing on burn injuries: a mini review. *IOP Conference Series: Earth and Environmental Science*.

Abdullah L. (2019). HIVI (Hardtack Innovation Fish Scale) cookies made from fish scales to optimally increase nutrition. *Journal of Nutritional Health & Food Engineering volume 9 issue 3*, 87-90.

adyaniazizah. (2020). *Connective tissue (Collagen)*. Retrieved from Blendspace by tes website: https://www.tes.com/lessons/jezmMDoMqDP_kw/connective-tissue-collagen

Agwaramgbo, L. &. (2015). Fish Bones Proving Their Worth in the De-leadification of Contaminated Water. *British Journal of Applied Science & Technology* , 244-249.

Aidos, I. (2002). *Production of high-quality fish oil from herring byproducts.* Ph.D. Thesis, Wageningen University, The Netherlands.

Amazon; Edible health. (2020, 05 14). *Premium Marine Collagen Powder - 5X Cheaper + 15x Stronger Than Shots or Capsules - 13,000mg - Best Hydrolysed Protein for Hair, Skin, Nails, Wrinkles, Joints, Gut. Keto, Paleo, Kosher, Halal*. Retrieved from Amazon: https://www.amazon.co.uk/Marine-Hydrolysed-Collagen-Protein-Powder/dp/B07KX2GSL5

Amazon; Fiskolia company. (2020). Retrieved 05 08, 2020, from Amazon Web Site: https://www.amazon.co.uk/Fiskolia-Pure-Orange-Omega-3-Herring/dp/B07LBFCSBM/ref=sr_1_2?dchild=1&keywords=fiskol%C3%ADa&qid=1588949955&s=drugstore&sr=1-2

Asmala E, S. L. (2010). Closing a loop: substance flow analysis of nitrogen and phosphorus in the rainbow trout production and domestic consumption system in Finland. *Ambio 01 Mar 2010, 39(2)*, 126-135.

Berillis, P. (2015). Marine Collagen: Extraction and Applications.

Boran, G. &. (2010). Fish Gelatin. *Advances in food and nutrition research* , 119-43.

business.com. (2020, 03 18). *What Are the Costs of a Food-Testing Lab?* Retrieved from Business.com Web Site: https://www.business.com/articles/food-testing-laboratories-pricing-and-costs/

Caruso, G. (2015, November 20). *Fishery Wastes and By-products: A Resource to Be Valorised*. Retrieved from https://www.fisheriessciences.com/fisheries-aqua/fishery-wastes-and-byproducts-a-resource-to-be-valorised.php?aid=8210

Cheremisinoff, N. P. (2001). *Handbook of Water and Wastewater Treatment Technologies* . B-H. Boston: Butterworth-Heinemann.

Collagen extraction process. (2015.). *International Food Research Journal 23(3): 913-922 (2016)*.

Elizabeth Troncoso, R. N. (December 2014). Acid and Enzyme-Aided Collagen Extraction from the Byssus of Chilean. *Food Biophysics*.

ERI Economic Research Institute, I. (2020). *Salary Expert - Automation Engineer Salary*. Retrieved from https://www.salaryexpert.com/salary/job/automation-engineer/finland

ERI Economic Research Institute, I. (2020). *Salary Expert - Biotechnologist Salary*. Retrieved from https://www.salaryexpert.com/salary/job/biotechnologist/finland

ERI Economic Research Institute, I. (2020). *Salary Expert - Mechanical Engineer Salary*. Retrieved from https://www.salaryexpert.com/salary/job/mechanical-engineer/finland

European Bank for Reconstruction and Development. (2009, August). *Fish Processing Sub-sectoral Environmental and Social Guideline.* Retrieved from European Bank for Reconstruction and Development Web site: https://www.ebrd.com/downloads/policies/environmental/fish.pdf

expondo. (2017-2019). *Expondo, Butchers Equipment, Meat mincers.* Retrieved from Expondo Web site: https://www.expondo.co.uk/royal-catering-stainless-steel-meat-grinder-220-kg-hr-pro-10010176

Flottweg SE. (2020). Retrieved from Flottweg web site: https://www.flottweg.com/

Freeman, K. S. (2012, January). Remediating Soil Lead with Fish Bones. *Environmental Health Perspectives, Volume 120 Number 1* , pp. 20-21.

Gantt.com. (2020). *What is a Gantt Chart?* Retrieved from https://www.gantt.com/

Gardening know how. (2019, July 16). *Sulfur Gardening Usage: Importance Of Sulfur In Plants*. Retrieved from Gardening know how: https://www.gardeningknowhow.com/garden-how-to/soil-fertilizers/sulfur-in-plants.htm

Gbogouri, G. A. (2006). Analysis of lipids extracted from salmon (Salmo salar) heads. *European Journal of Lipid Science and Technology*, 766-775.

Gergely Tóth, T. H. (2016). Heavy metals in agricultural soils of the European Union with implications for food safety. *Environment International*, 299-309.

Głowacz, A. &.-P.-Ż. (2016). Comparison of oil yield and quality obtained by different extraction procedures from salmon (Salmo salar) processing byproducts. *European Journal of Lipid Science and Technology*, 1759-1767.

HAUS centrifuge technologies. (2020). Retrieved from HAUS Centrifuge Technologies Web site: https://www.hausworld.com/model-41-Industrial-Applications--I-Series.html

HAUS centrifuge technologies. (2020). Retrieved from HAUS Industrial Technologies Web site: https://www.hausworld.com/model-48-Industrial-Applications--I-Series.html

HELCOM. (2012). *HELCOM Powers Up Baltic Sea Map Service*. Retrieved from Esri Arcnews: https://www.esri.com/news/arcnews/spring12articles/helcom-powers-up-baltic-sea-map-service.html

Hielscher Ultrasound Technology. (n.d.). *UP400St Powerful Ultrasonicator*. Retrieved from Hielscher Ultrasound Technology: https://www.hielscher.com/up400st-powerful-ultrasonicator.htm

Hovland, I. (2005). *Successful Communication a Toolkit for Researchers and Civil Society Organisations.* Overseas Development Institute .

Hradesh Rajput, J. R. (2019). *Methods for Food Analysis and Quality Control.*

Hughes, L. (2020, March 18). Retrieved from MarinaTex website: https://www.marinatex.co.uk/

IfM - Management Technology Policy. (2016). *University of Cambridge*. Retrieved from https://www.ifm.eng.cam.ac.uk/research/dmg/tools-and-techniques/belbins-team-roles/

IndexMundi. (2020). Retrieved from Index Mundi Web site: https://www.indexmundi.com/commodities/?commodity=fish-meal

Inmaculada Aranaz, N. A. (2018). Cosmetics and Cosmeceutical Applications of Chitin,Chitosan and Their Derivatives. *Polymers — Open Access Journal*.

Jaakkonen, A.-K. (2019, 03 26). *Horticular Statistics: : Luke Natural Resources Institute Finland*. Retrieved from Luke Natural Resources Institute Finland Web site: https://stat.luke.fi/

KALUNDBORG SYMBIOSIS. (2020). Retrieved from http://www.symbiosis.dk/en/

Kassaveti, A. (2008, January 31). *Fish industry waste: treatments, environmental impacts, current and potential uses*. Retrieved from https://onlinelibrary.wiley.com/doi/10.1111/j.1365-2621.2006.01513.x

Kerzner, H. (2009). *Project Managment a System Approach to Planning, Scheduling and controlling 10th edition.* Wiley.

L., A. (2019). *Journal of Nutritional Health& Food Engineering volume 9 issue 3*, 87-90.

M. Archer, R. W. (2001). *Fish Waste Production in the United Kingdom.* © The Sea Fish Industry Authority.

Marıa Isabela Avila Rodrıguez MRS, L. G. (2017). Collagen: A review on its sources and potential cosmetic applications. *Journal of Cosmetic Dermatology*, 20-26.

Marine Collagen: Extraction and. (2015).

Mariojouls, M. S. (2012). Waste not, want not: Better utilisation of fish waste in the Pacific. *SPC Fisheries Newsletter #138 - May/August 2012*.

Maya Raman and K Gopakumar. (2018). Fish Collagen and its Applications in Food and Pharmaceutical. *Ecronicon*.

Merck KGaA, Darmstadt. (2020). Retrieved from Sigma-Aldrich Inc. Web site: https://www.sigmaaldrich.com/catalog/product/mm/126741?lang=fi&region=FI

Mosaic. (n.d.). Retrieved from Mosaic: https://www.cropnutrition.com/nutrient-management/phosphorus

Moultrie, J. (2020, March 18). *Belbin's team roles*. Retrieved from University of Cambridge IfM website: https://www.ifm.eng.cam.ac.uk/research/dmg/tools-and-techniques/belbins-team-roles/

Nalin Siriwardhana, N. S.-M. (2012). Health Benefits of n-3 Polyunsaturated Fatty Acids: Eicosapentaenoic Acid and Docosahexaenoic Acid. *Advances in Food and Nutrition Research*, 211-222.

Natural Resources Institute Finland (Luke). (2016). *Natural Resources Institute Finland (Luke) web page*. Retrieved from Fur production: https://www.luke.fi/en/natural-resources/agriculture/fur-production/

Nicholas M.H. Khong, F. M. (2018). Improved collagen extraction from jellyfish (Acromitus hardenbergi) with increased physical-induced solubilization processes. *Food chemistry*.

Ololade Olatunji, A. D. (2017, September). Temperature-dependent extraction kinetics of hydrolyzed collagen from scales of croaker fish using thermal extraction. *Food Science & Nutrition*, pp. 1015-1020.

Ololade Olatunji, A. D. (2019). Production of Hydrogel Microneedles from Fish Scale Biopolymer. *Journal of Polymers and the Environment 27*, 1252-1258.

pinoyentre. (2015, March 31). *Different Methods of Fish Processing*. Retrieved from https://www.pinoy-entrepreneur.com/2010/07/12/different-methods-of-fish-processing/

Pirjo Mattila, K. K. (2017, September 4). *It's a fishy business*. Retrieved from Luke, Natural Resources Institute Finland: https://www.luke.fi/en/its-a-fishy-business/

Quresi, M. &. (2018). Design and Performance Evaluation of an Indigenously Developed Small-Scale Fish-Oil Extraction Unit; a Solution for Improving Fish Farm Environments. *Polish Journal of Environmental Studies*, 2711-2718.

Radziemska, M. &. (2018). Valorization of Fish Waste Compost as a Fertilizer for Agricultural Use. *Waste and Biomass Valorization*.

Raija Tahvonen, T. A. (2000). Mineral Content in Baltic Herring and Baltic Herring Products. *Journal of Food Composition and Analysis volume 13 issue 6*, 893-903.

Redzwan, Y. C. (2017). *Biological Treatment of Fish Processing SalineWastewater for Reuse as Liquid Fertilizer.*

Reichel, C. W. (2006). *Earned value management systems (EVMS): "you too can do earned value management"*. Retrieved from https://www.pmi.org/learning/library/earned-value-management-systems-analysis-8026

Rosen, D. E. (2018). *Potassium for crop production*. Retrieved from University of Minnesota: https://extension.umn.edu/phosphorus-and-potassium/potassium-crop-production#soil-moisture-598160

Salary Explorer . (2018). Retrieved from Salary Explorer Web Site: http://www.salaryexplorer.com/salary-survey.php?loc=73&loctype=1&job=5076&jobtype=3

Saranya, R. T. (2020). Synthesis of Fat Liquor Through Fish Waste Valorization, Characterization and Applications in Tannery Industry. . *Waste Biomass Valorization* .

Schmidt, M. M. (2015). Collagen extraction process. *International food research journal*.

Scott W. Cullen, M. (2016, 02 08). *Earned Value Analysis*. Retrieved from https://www.wbdg.org/resources/earned-value-analysis

Seydelamann. (2020). Retrieved from Reiser Web site: http://www.reiser.com/product_moreInfo/PDF/SEYDELMANN/IndustrialGrinders.pdf

Sionkowska, A. a. (2013). Fish Scales as a Biocomposite of Collagen and Calcium Salts. *Key Engineering Materials, vol. 587*, 185-190.

Smart fertilizer management. (n.d.). Retrieved from ttps://www.smart-fertilizer.com/articles/magnesium/

Sustainable Agriculture Research & Education, University of Maryland. (2012). *Crop Rotation Effects on Soil Fertility and Plant Nutrition*. Retrieved from Sustainable Agriculture Research and Education Web site: https://www.sare.org/Learning-Center/Books/Crop-Rotation-on-Organic-Farms/Text-Version/Physical-and-Biological-Processes-In-Crop-Production/Crop-Rotation-Effects-on-Soil-Fertility-and-Plant-Nutrition

Teirivaara, S. (2017, 09 19). *Salary Side Costs – What Exactly Are They?* Retrieved from Ukko.fi Web site: https://www.ukko.fi/en/general-en/salary-side-costs-exactly/

Tetra chemicals. (2005-2008). *The importants of Cacium*. Retrieved from Tetra chemicals: http://www.tetrachemicals.com/Products/Agriculture/The_Importance_of_Calcium.aqf

The Explorer. (2020, March). *How the circular economy is changing business*. Retrieved from The explorer: https://www.theexplorer.no/stories/renewable-resources/an-introduction-to-the-circular-economy/?gclid=Cj0KCQjwzN71BRCOARIsAF8pjfgZwn_ECWKGwmKleWcfSH_X7KXFO3Ui1ce8Koc_MfPXUqmM6t3pKyEaAiZYEALw_wcB&fbclid=IwAR0srGqcrW9kGZte2yLqLEyUCW0hAuL9uPA3bay8aWzUYasYg-D

The Sea Fish Industry Authority. (2001). *Fish Waste Production in the United Kingdom.*

Väre, J. N. (2018). *Agriculture and food sector in Finland 2018.* Helsinki: Luke Natural Resources Institute Finland.

Versluys, H. (2013-2014). *Primary sedimentation investigation using a.* Ugent.

Vijayarangam, S. M. (2019, August). Experimental investigation of fish scale reinforced polymer composite. *Materials today: proceedings* .

Water UK. (2020). *Disposal of Fats, Oils, Grease and Food Waste, Best Management Practice.* Retrieved from Brighton and Hove City Council Web Site: https://www.brighton-hove.gov.uk/sites/brighton-hove.gov.uk/files/downloads/food_safety_team/Best_Practice_Waste_Oil_Management_-_English.pdf

10.1 List of Figures & Tables

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11 Appendix

This chapter contains the exercises that were a part of team building and project management classes.

11.1 Team Building

11.1.1 Team Contract

TEAM CONTRACT
Closing the Loop

Important dates:

23. March 2020 -- Midterm report
18. May 2020 -- Final report

Team:

Stefan Rast
Bartosz Sejmicki
Bram Borghijs
Marcel Chaillan
Andreas Willfors (Supervisor)

Team rules:

-
- The team will have at least one group meeting without the Supervisor Mondays
- The team will meet in the Library, Bartosz’s place, or the EPS room.
- The team will be debriefing after every meeting with the Supervisor.
    - Discussing when we have extra time together.
    - Discussing new deadlines for each individual and the team progress
- Constructive criticism allowed at any point.
- All team members will respect the freedom of speech for other members.
- Everyone gives their opinion before any major decisions.
- The team will use Microsoft Teams as default documentation.
- The team will use Facebook messenger for communication within the team.

Signatures:

11.1.2 Belbin

The Belbin test, developed by Meredith Belbin in 1981, is one of the most accessible and widely used tools to support team building. It was designed to define and predict the potential success of teams, recognizing that the strongest teams have a diversity of characters and personality types (IfM - Management Technology Policy, 2016). The Belbin test is an effective way to assess the relative strengths and weaknesses of a team. Individuals have a greater self-understanding of their strengths, which leads to more effective communication between team members. Great teams can be put together, existing teams can be understood and improved, and everyone can feel that they are making a difference in the workplace. (© 2020 BELBIN Associates., 2020)

The 9 team roles as identified by Meredith Belbin:

Team Role	Contribution	Allowable Weaknesses
Plant	Creative, imaginative, free-thinking. Generates ideas and solves difficult problems.	Ignores incidentals. Too preoccupied to communicate effectively.
Resource Investigator	Outgoing, enthusiastic, communicative. Explores opportunities and develops contacts.	Over-optimistic. Loses interest once initial enthusiasm has passed.
Co-ordinator	Mature, confident, identifies talent. Clarifies goals. Delegates effectively.	Can be seen as manipulative. Offloads own share of the work.
Shaper	Challenging, dynamic, thrives on pressure. Has the drive and courage to overcome obstacles.	Prone to provocation. Offends people's feelings.
Monitor Evaluator	Sober, strategic and discerning. Sees all options and judges accurately.	Lacks drive and ability to inspire others. Can be overly critical.
Teamworker	Co-operative, perceptive and diplomatic. Listens and averts friction.	Indecisive in crunch situations. Avoids confrontation.
Implementer	Practical, reliable, efficient. Turns ideas into actions and organises work that needs to be done.	Somewhat inflexible. Slow to respond to new possibilities.
Completer Finisher	Painstaking, conscientious, anxious. Searches out errors. Polishes and perfects.	Inclined to worry unduly. Reluctant to delegate.
Specialist	Single-minded, self-starting, dedicated. Provides knowledge and skills in rare supply.	Contributes only on a narrow front. Dwells on technicalities.

Figure 11.1: The 9 belbin team roles, their contributions, and allowable weaknesses. (© Belbin UK and © PrePearl 2020, 2020)

Following the Belbin individual report results:

Stefan Rast:

Overview

	Coordinator	Shaper	Plant	Monitor	Implementer	Resource investigator	Team worker	Finisher
1	1	1	2	0	2	2	1	1
2	0	2	1	1	2	2	1	1
3	1	0	1	2	1	2	3	0
4	1	2	1	1	1	1	2	1
5	2	0	3	0	2	0	2	1
6	1	2	0	0	2	3	1	1
7	2	3	2	0	2	0	1	0
Tot	8	10	10	4	12	10	11	5

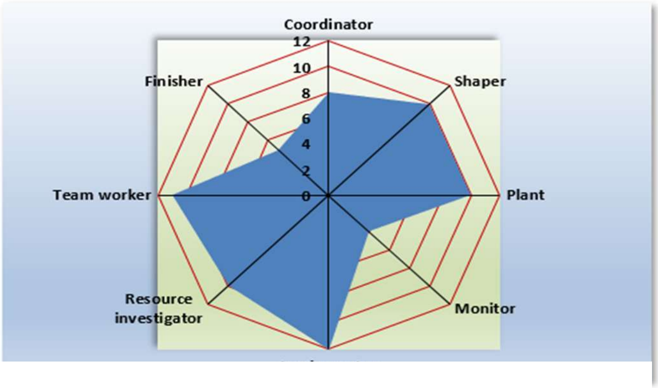


Figure 11.2: Belbin questionnaire result of Stefan Rast

Bartosz Sejmicki:

Overview

	Coordinator	Shaper	Plant	Monitor	Implementer	Resource investigator	Team worker	Finisher
1	1	1	1	2	1	1	1	2
2	0	4	2	0	1	0	1	2
3	0	0	1	1	0	2	4	2
4	3	0	1	3	2	0	0	1
5	0	0	0	0	2	3	3	2
6	3	0	2	0	0	4	0	1
7	3	0	4	0	0	0	1	2
Tot	10	5	11	6	6	10	10	12

think act

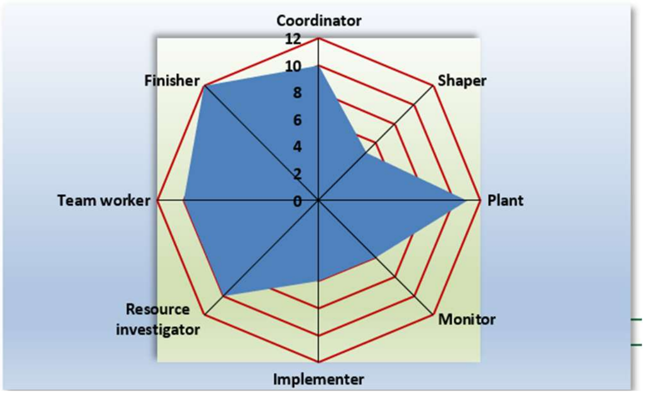


Figure 11.3: Belbin questionnaire result of Bartosz Sejmicki

Marcel Chaillan:

Overview

	Coordinator	Shaper	Plant	Monitor	Implementer	Resource investigator	Team worker	Finisher
1	1	0	2	1	2	0	2	2
2	1	1	2	2	1	0	2	1
3	0	2	3	1	1	2	1	0
4	1	2	2	2	1	1	1	0
5	2	0	1	1	2	2	2	0
6	1	0	3	1	1	1	2	1
7	2	2	1	1	1	2	1	0
Tot	8	7	14	9	9	8	11	4

think act

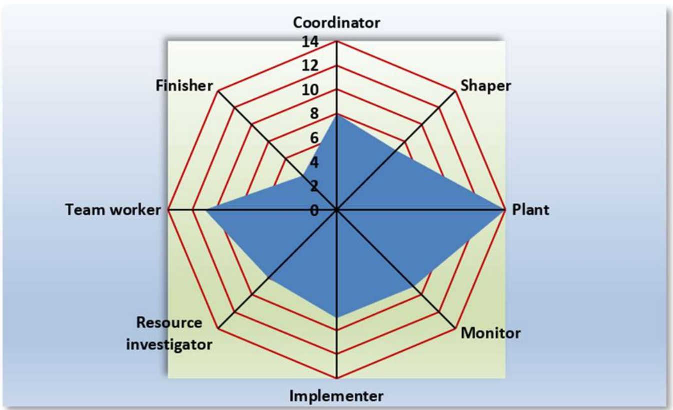


Figure 11.4: Belbin questionnaire result of Marcel Chaillan

<u>Bram Borghijs:</u>

Overview

	Coordinator	Shaper	Plant	Monitor	Implementer	Resource investigator	Team worker	Finisher
1	2	1	1	1	1	2	2	0
2	1	2	3	0	1	2	1	0
3	2	1	1	2	0	1	3	0
4	2	2	1	1	0	1	3	0
5	0	2	3	0	1	4	0	0
6	2	2	0	0	1	2	2	1
7	1	3	3	0	0	3	0	0
Tot	10	13	12	4	4	15	11	1

think ← → act

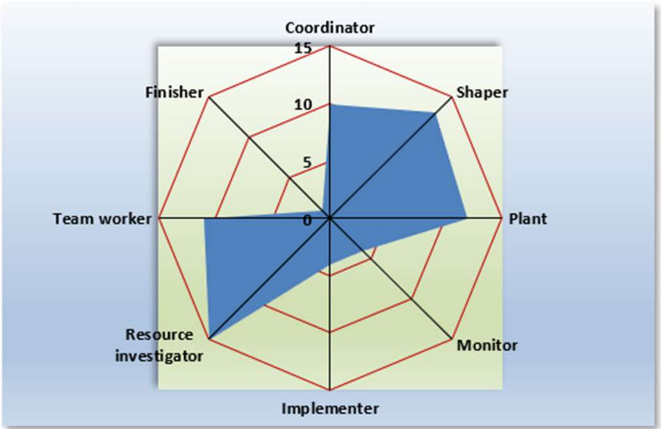


Figure 11.5: Belbin questionnaire result of Bram Borghijs

<u>Team Conclusion:</u>

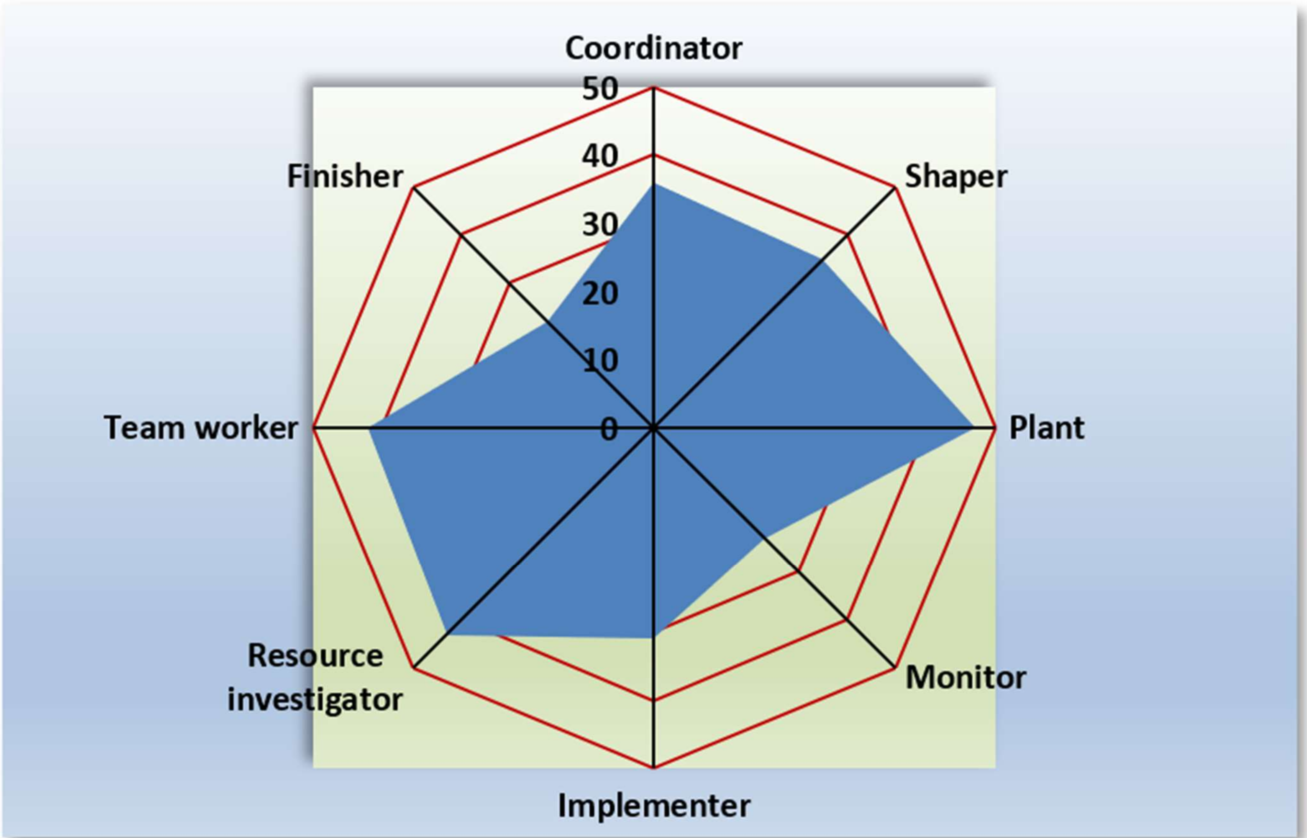


Figure 11.6: Combined belbin questionnaire result of all team members

The result of these Belbin tests combined shows a satisfying result for this team. It seems as every aspect is well covered in this team except for the roles of the Finisher and Monitor. With having a Finisher in Bartosz as his result shows, there will not be a problem in that. Only in the role of Monitor, which none of the members of the group seem to have their strength, there might appear an issue. This can cause a lag in seeing options and judgments accurately towards the project, our work, and progress. But thanks to the Belbin test we are well in the notice of that possible issue and can adjust to it as a team and be more critical, rational, and impartial in decision making now and then.

11.1.3 Hofstede

The Hofstede study about the cultural dimensions model is an internationally recognized standard for understanding cultural differences. It compares every nation and culture around a few topics and explains the most likely comportment of a person by its nationality. As a result, it monitors possible conflict areas within an international and multicultural team.

Our team consists of the following nationalities:

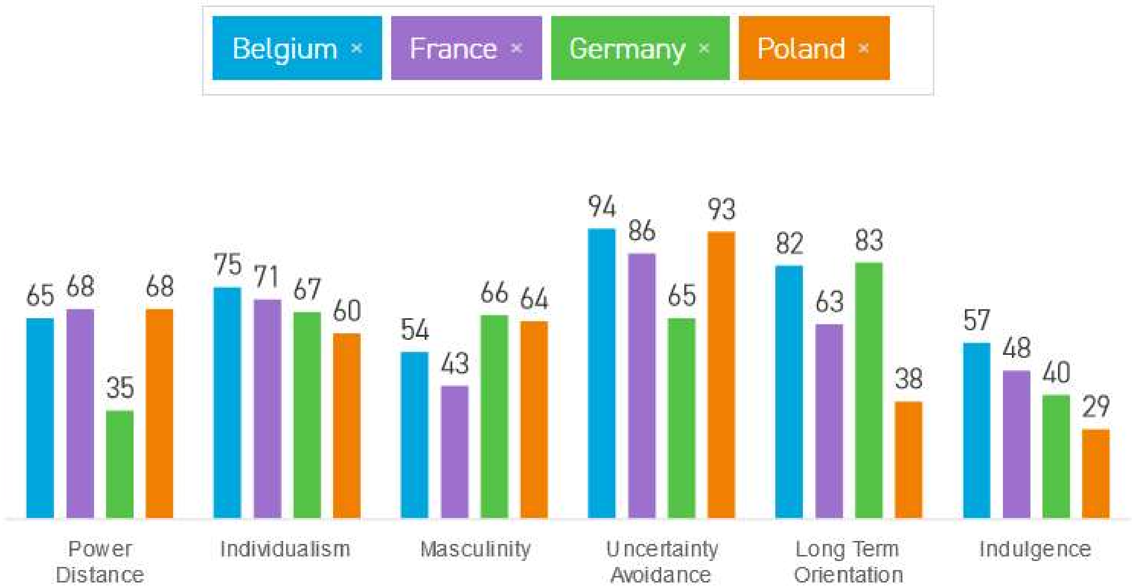


Figure 11.7: Comparison of Hofstede's dimensions with the team nationalities (© 2019 Hofstede Insights, 2020)

This graph pictures possible issues that can be expected through the Hofstede study. At first, the graph shows a lag of a high power distance in Germany that means that Germans, in this case, tend to feel closer to their supervisor and be therefore less formal. Next is the indulgence where Polish people, due to their low score, tend to be more pessimistic while people from Belgium possess a positive attitude and tend towards optimism. At last, the biggest visible difference is pictures in the long-term orientation. That means that Polish people tend to start working very close to the deadline, while German and Belgium people rather working in advance. This could lead to obvious conflicts within the team. This issue could be prevented by setting deadlines earlier for example.

11.2 Project Management

Project management is an important part of our EPS program. It helps us to identify the project and solve the puzzle. By applying all these technics on this project, we acquire skills that we can use in other projects. In Project Management we learn to assess a problem in his whole and not parts of it. By following these techniques, we make sure we do not skip anything.

Project management also investigates the way we must behave and interfere in a group. This is important, especially for groups with different cultures and backgrounds.

11.2.1 Mission, Vision, and Objectives

In the project, our group's mission is to integrate the fish processing plant waste in agriculture.

Our vision is developing an improvement to the current technological path of fish processing which will allow for the reduction of generated waste, by applying the waste for the production of valuable materials and products which can be either sold as a ready product, reused in the fish processing processes. or applied at the nearby fields.

To fulfill our mission and vision some objectives must be met:

- Research on the subject
- Investigating the quantities of fish processing by-products
- Taking the soil and water samples at the processing plant and fields
- Analysis of the soil and water samples
- Choosing the most optimal course of action – picking the best way of handling by-products of fish processing.

11.2.2 Work Breakdown Structure (WBS)

To be able to define the project, as well as view it in its full scope, a Work Breakdown Structure should be prepared. WBS is a deliverable oriented hierarchical breakdown of the project, which allows dividing projects into smaller more manageable components. The lower levels of WBS represent the more detailed definition of the project work (Kerzner, 2009). In WBS the work must be structured into small elements which are:

- Manageable, in that specific authority and responsibility can be assigned
- Independent, or with minimum interfacing with and dependence on other ongoing elements
- Integrable so that the total package can be seen
- Measurable in terms of progress

In planning the project, WBS is one of the most important elements, because it provides a common framework from where:

- The total program can be described as a summation of subdivided elements
- Planning can be performed
- Costs and budgets can be established

- Time, cost and performance can be tracked
- Objectives can be linked to company resources in a logical manner
- Schedules and status-reporting procedures can be established
- Network construction and control planning can be initiated
- The responsibility assignments for each element can be established

For the “closing the loop” project, which is focused mostly on research, the WBS was split into three main parts: project management, research, and field research. Project management consists of planning, meetings, and project management deliverables and administration. Planning includes the preparation of the project as a whole – taking the ideas and research done and putting them together as one. This includes a mid-term report and final report. Meetings are all of the meetings when the team as a whole meet with the supervisor and are documented in the form of agendas and minutes, as well as the less formal meetings which include brainstorming and researching the new ideas. Administration includes decision making, but also creating rules which should be followed by the team members.

Field research consists of taking the soil and water samples at the fish processing plant and looking into the existing setup.

The research includes the research done on the fractions of the waste produced by the processing plant as well as the fields. The following fractions are investigated: Solid waste, Fats, Sludge, Wastewater, and Plant waste.

For solid waste, several fractions can be separated for different applications. This solid waste consists of fish scales, fish bones, fish guts, and fish heads.

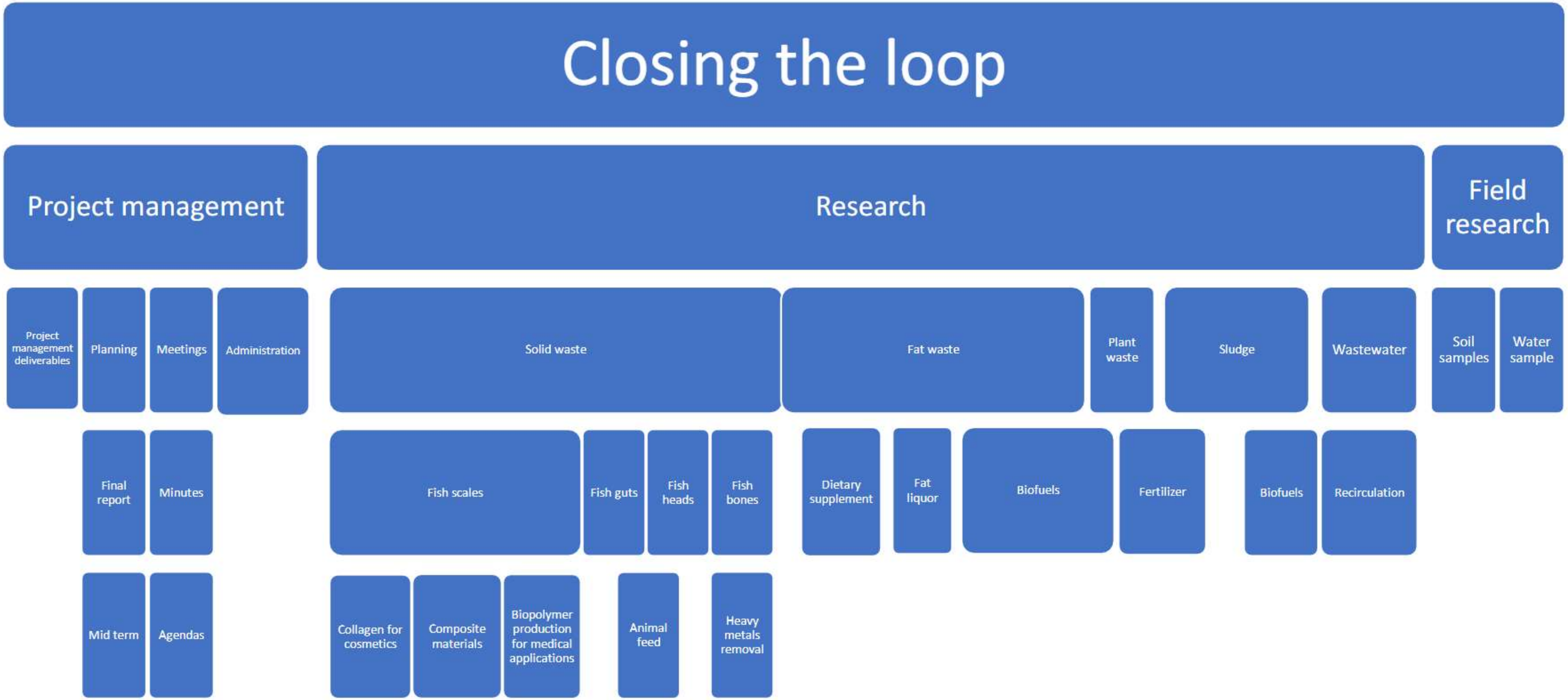


Figure 11.8: Work breakdown structure

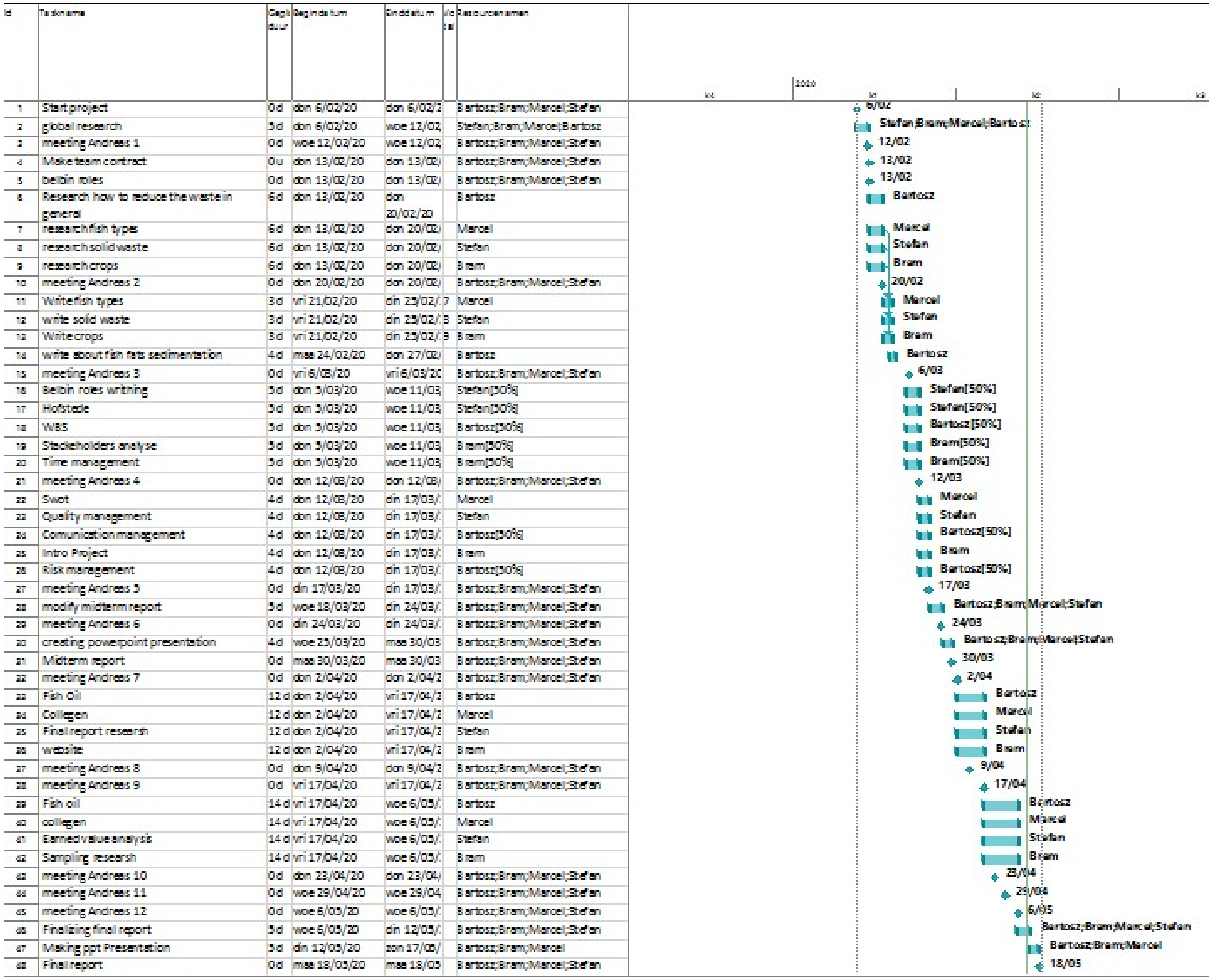
11.2.3 Gantt Chart / Time Management

A Gantt chart, commonly used in project management, is one of the most popular and useful ways of showing activities (tasks or events) displayed against time. On the left of the chart is a list of the activities and along the top is a suitable time scale. Each activity is represented by a bar; the position and length of the bar reflect the start date, duration and end date of the activity. This allows you to see at a glance:

- What the various activities are
- When each activity begins and ends
- How long each activity is scheduled to last
- Where activities overlap with other activities, and by how much
- The start and end date of the whole project

To summarize, a Gantt chart shows you what has to be done (the activities) and when (the schedule). (Gantt.com, 2020)

We use our Gantt chart to plan our work. This is important so we do not fall short on time. The way we used it is to set some deadlines as well as our milestones. The milestones are important events in our project such as sampling, midterm report, final report, and more. The deadlines help us to work on a regular base. The time after midterm is not as clear jet as you can see on the Gannt chart. It will be adjusted after the midterm, once we can plan the next tasks. Up to the current situation, we visualized our Gantt chart until this midterm report in the following Table 4.1.



Id	Taaknaam	Gepl. duur	Begindatum	Einddatum	Vo tal	Resourcenamen
1	Start project	0d	don 6/02/20	don 6/02/2		Bartosz;Bram;Marcel;Stefan
2	global research	5d	don 6/02/20	woe 12/02		Stefan;Bram;Marcel;Bartosz
3	meeting Andrees 1	0d	woe 12/02/20	woe 12/02		Bartosz;Bram;Marcel;Stefan
4	Make team contract	0u	don 13/02/20	don 13/02		Bartosz;Bram;Marcel;Stefan
5	belbin roles	0d	don 13/02/20	don 13/02		Bartosz;Bram;Marcel;Stefan
6	Research how to reduce the waste in general	6d	don 13/02/20	don 20/02/20		Bartosz
7	research fish types	6d	don 13/02/20	don 20/02		Marcel
8	research solid waste	6d	don 13/02/20	don 20/02		Stefan
9	research crops	6d	don 13/02/20	don 20/02		Bram
10	meeting Andrees 2	0d	don 20/02/20	don 20/02		Bartosz;Bram;Marcel;Stefan
11	Write fish types	3d	vri 21/02/20	din 25/02/	7	Marcel
12	write solid waste	3d	vri 21/02/20	din 25/02/	8	Stefan
13	Write crops	3d	vri 21/02/20	din 25/02/	9	Bram
14	write about fish fats sedimentation	4d	maa 24/02/20	don 27/02		Bartosz
15	meeting Andrees 3	0d	vri 6/03/20	vri 6/03/20		Bartosz;Bram;Marcel;Stefan
16	Belbin roles writhing	5d	don 5/03/20	woe 11/03		Stefan[50%]
17	Hofstede	5d	don 5/03/20	woe 11/03		Stefan[50%]
18	WBS	5d	don 5/03/20	woe 11/03		Bartosz[50%]
19	Stackeholders analyse	5d	don 5/03/20	woe 11/03		Bram[50%]
20	Time management	5d	don 5/03/20	woe 11/03		Bram[50%]
21	meeting Andrees 4	0d	don 12/03/20	don 12/03		Bartosz;Bram;Marcel;Stefan
22	Swot	4d	don 12/03/20	din 17/03/		Marcel
23	Quality management	4d	don 12/03/20	din 17/03/		Stefan
24	Comunication management	4d	don 12/03/20	din 17/03/		Bartosz[50%]
25	Intro Project	4d	don 12/03/20	din 17/03/		Bram
26	Risk management	4d	don 12/03/20	din 17/03/		Bartosz[50%]
27	meeting Andrees 5	0d	din 17/03/20	din 17/03/		Bartosz;Bram;Marcel;Stefan
28	modify midterm report	5d	woe 18/03/20	din 24/03/		Bartosz;Bram;Marcel;Stefan
29	meeting Andrees 6	0d	din 24/03/20	din 24/03/		Bartosz;Bram;Marcel;Stefan
30	creating powerpoint presentation	4d	woe 25/03/20	maa 30/03		Bartosz;Bram;Marcel;Stefan
31	Midterm report	0d	maa 30/03/20	maa 30/03		Bartosz;Bram;Marcel;Stefan
32	meeting Andrees 7	0d	don 2/04/20	don 2/04/2		Bartosz;Bram;Marcel;Stefan
33	Fish Oil	12d	don 2/04/20	vri 17/04/2		Bartosz
34	Collegen	12d	don 2/04/20	vri 17/04/2		Marcel
35	Final report reseash	12d	don 2/04/20	vri 17/04/2		Stefan
36	website	12d	don 2/04/20	vri 17/04/2		Bram
37	meeting Andrees 8	0d	don 9/04/20	don 9/04/2		Bartosz;Bram;Marcel;Stefan
38	meeting Andrees 9	0d	vri 17/04/20	vri 17/04/2		Bartosz;Bram;Marcel;Stefan
39	Fish oil	14d	vri 17/04/20	woe 6/05/		Bartosz
40	collegen	14d	vri 17/04/20	woe 6/05/		Marcel
41	Earned value analysis	14d	vri 17/04/20	woe 6/05/		Stefan
42	Sampling reseash	14d	vri 17/04/20	woe 6/05/		Bram
43	meeting Andrees 10	0d	don 23/04/20	don 23/04		Bartosz;Bram;Marcel;Stefan
44	meeting Andrees 11	0d	woe 29/04/20	woe 29/04		Bartosz;Bram;Marcel;Stefan
45	meeting Andrees 12	0d	woe 6/05/20	woe 6/05/		Bartosz;Bram;Marcel;Stefan
46	Finalizing final report	5d	woe 6/05/20	din 12/05/		Bartosz;Bram;Marcel;Stefan
47	Making ppt Presentation	5d	din 12/05/20	zon 17/05/		Bartosz;Bram;Marcel
48	Final report	0d	maa 18/05/20	maa 18/05		Bartosz;Bram;Marcel;Stefan

Figure 11.9: Gantt chart (Gantt.com, 2020)

11.2.4 Quality Management

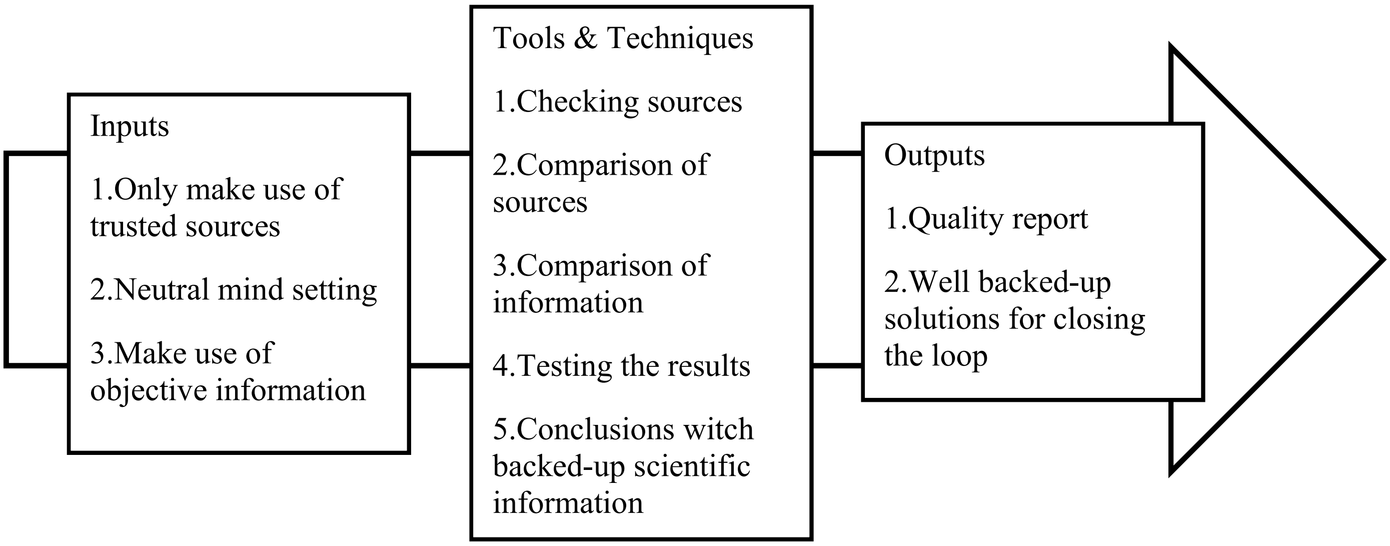


Figure 11.10: Inputs/ tools & techniques/ outputs draft

Inputs:

You must make sure that you only use trusted sources. Which means that they have a good reputation. For instance, other universities or scientific magazines. It is also important to have a neutral mindset about things, so you are open to new information. And you do not get stuck on one thing. We also must make sure that the sources are objective which means that the writer is not just defending is the point, but also gives the weaknesses.

Tools and Techniques:

To be sure that our sources are trusted we have to check them and see if they are valid. If we want to see if a source is an objective, then we can compare it with other sources. Comparing information is a good way to verify if something is valuable. Testing the results can be a good way to verify the information. Check if the conclusion is backed up by scientific information, to get a trustworthy result.

Outputs:

If we use these tools and technics with the right inputs. Then we will have a quality report and well backed-up solution for closing the loop.

11.2.5 Communication Management

To achieve good productivity and avoid misunderstandings between team members and between the team members and stakeholders, a good exchange of information is necessary. To assure the smooth flow of information, the project team established the following means of communication. For the exchange of information between the students, a messenger group was created. Additionally, Microsoft Teams group was made where all team members and team supervisor could post announcements and upload the work done as well as a document was created there where all the resources used were linked. This way everyone could view any work done during the project, add corrections, and post resources at any time. During the project, weekly meetings with Andreas were scheduled, which in most cases happened on Thursdays at 10 am. Additionally, team members would meet on most of the days to work together.

Table 11.1: Stakeholder communication table

Stakeholder	Shared information	Medium	Frequency
Project group	Constant exchange of all information concerning the project	Messenger group Meetings Microsoft Teams	Daily
Andreas Willfors	Updates on progress, and decisions which are being considered or made	Meetings Microsoft Teams E-mail	Weekly
Roger Nylund	Information contained in the mid-term report and final report	Mid-term report Final report	Twice
Customers	General information	Final report Home page	After delivery of the final report - constant
Novia UAS	General information	Final report	Once
Industrial sector	General information	Home page	Constant

11.2.5.1 **Stakeholder Analyses**
In projects, a stakeholder analysis is a method to identify all people who have some concern with the project and can affect it. It is a useful tool for determining how to communicate with the involved groups to ensure a smooth flow of information, which will keep all involved parties satisfied.

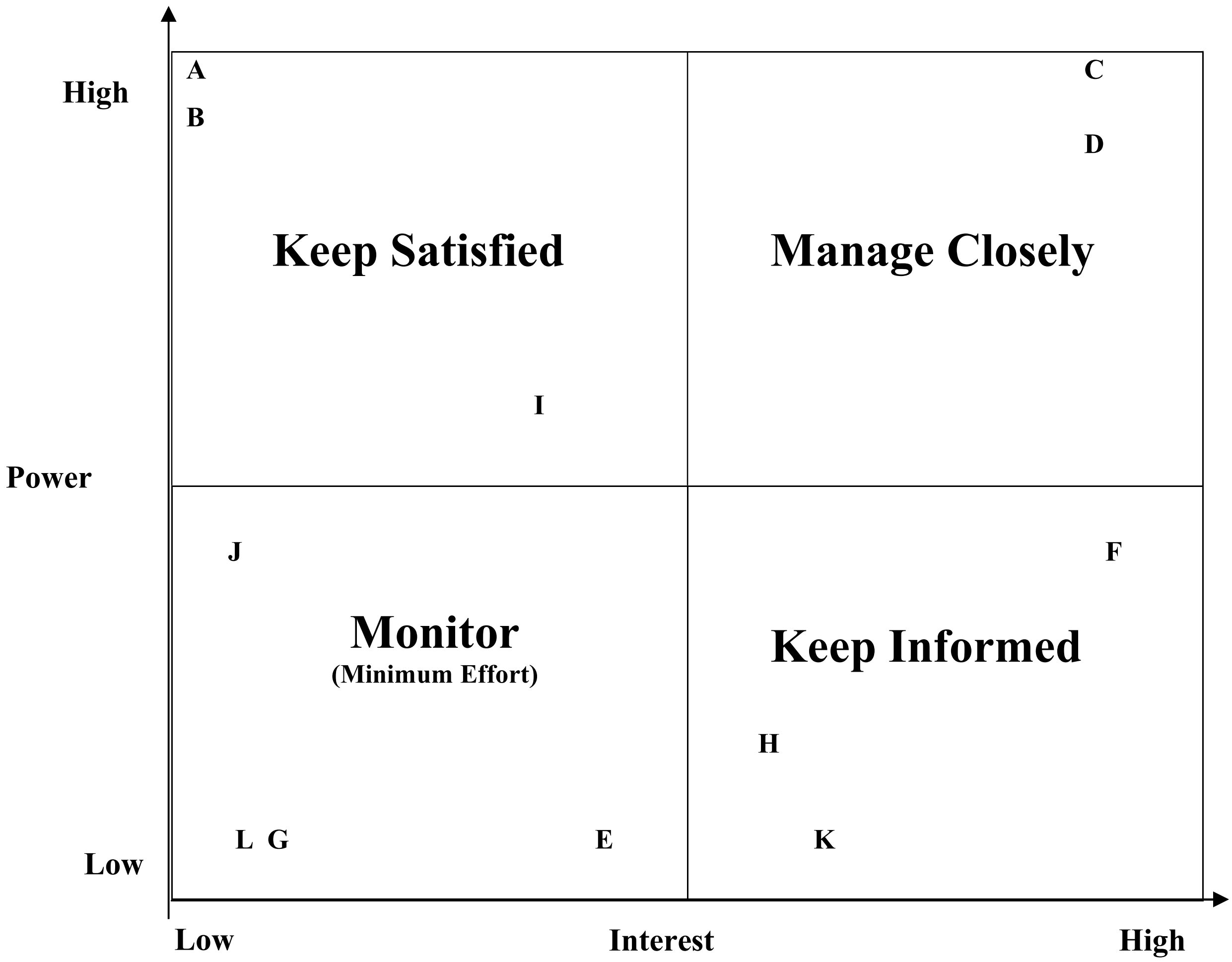


Figure 11.11: Stakeholder graph according to Hovland (Hovland, 2005)

This is the stakeholder's analysis according to (Hovland, 2005).

Company (A): The company has a high amount of power because they can shut us down. On the other hand, what we mean with low interest. Is the fact that they do not have much input during the process of the project. They have to be kept satisfied with us. This is important to keep in mind when you advance in the project and make important decisions.

Government (B): They have a high amount of power. Because they lay restrictions on our way of working and solutions. However, they will not be involved in the project. We need to keep the government satisfied in other words abbey the law.

Team leader (C): The team leader has the highest interest and power. He makes the decisions in consensus with the members and steers the project. He has to be managed closely by the members. This is a result of the way we divided leadership in our group.

Members (D): The members are similar to the team leader because of the flowing leadership.

Roger (E): He has low power because he is not affecting the project. He has a fair amount of interest in the project. Especially the project management part.

Andreas (F): He has the power to steer the project. He has a lot of interest. We need to keep him informed. This happens on a weekly base.

People who live nearby (G): They have a low interest in the way we solve the problem. Aldo if we cause other problems. Then we can have trouble with them. We have to keep them in mind.

Companies in the same field of resource (H): If we find a solution to the problem then we have to inform them.

Farmers who own the field (I): We have to keep them satisfied, which means that we have to optimize their harvest.

Environmental organizations (J): They will not affect our research, but we have to keep them in mind because they bring some restrictions with them.

Potential users of the application (K): We want to keep them informed, by using our website as a communication tool towards them. This way we can keep our potential clients up to date.

Hospitals (L): They might be interested in buying wound dressings produced by fish scales. Biopolymer manufactured from fish scales for the production of drug delivery systems.

11.2.6 S.W.O.T.

Table 11.2: SWOT analyses

Strengths	- A team composed of people coming from different backgrounds and nationalities allows for an innovative approach - An unbiased view of the problem
Weaknesses	- Lack of experience - Limited time and resources - Lack of knowledge
Opportunities	- An increasing need for recycling produced waste - A new approach to handling fish waste - Few competitors -Fish waste can be a source of high-value products (collagen, fish oil, …) - Establish a system that can also be transferred to other fish processing plants or even similar companies such as slaughterhouses
Threats	- Keep in mind existing regulations - Possible unexpected effects on the local environment which have to be carefully considered - A great number of recycling solutions to analyze

11.2.7 Risk Management

In any project, there is always a possible risk and it is crucial to define it. If the risks have been identified, a proper course of action can be taken which can prevent or minimalize the chance of the risk becoming reality. Even if the risk does become reality, a proper course of action can be planned ahead of time, possibly saving the team's resources.

Step 1: Identification of possible risks

- Coronavirus
- Not meeting deadlines
- Sickness
- Miscommunication
- Lack of motivation
- Lack of leadership
- No soil sample analysis results
- Not enough time
- Lack of knowledge

Step 2: Evaluation of possible risks

Description Probability

Table 11.3: Description of probability's rating and its meaning

Rating	**Meaning**
Low	Unlikely
Medium	Quite likely
High	Risk cannot be avoided

Description Impact

Table 11.4: Description of impact's rating and its meaning

Rating	**Meaning**
Low	No effect or minor effect on the project, the problem is easy to fix
Medium	Significant effect on the project (causes a significant setback, may require a lot of additional work to fix)
High	It can cause the failure of the project, making the completion of the project impossible.

Table 11.5: Risk management table

Risk	**Negative impact**	**Probability**	**Prevent or mitigate**	**Actions to be taken if the risk becomes reality**
Miscommunication	Medium	Low	P	Clearing any misunderstandings and trying to get back on track with work
Lack of Motivation	Medium	Low	P	
Lack of Leadership	Low	Low	P	
Not meeting deadlines	High	Low	P	
Not enough time	High	Low	M	
Lack of knowledge	Medium	Low	M	Doing proper research and contact experts on the subject if necessary
No soil sample analysis results	High	Low	M	
Sickness	Low	Medium	M	Working remotely from home to get better as soon as possible
Coronavirus	High	High	M	Minimalizing the risk of contracting the virus, working remotely.
Laws and regulations interfering with the project	High	Low	P (work keeping in mind the law regulations and restrictions)	

11.3 Working hours of the team members

11.3.1 Bartosz Sejmicki

6	Thrusday	6/02/2020	4	
	Friday	7/02/2020	0	
	Saturday	8/02/2020	0	
	Sunday	9/02/2020	2	
	Total		6	
7	Monday	10/02/2020	8	PM&Swedish, Project work in the group
	Tuesday	11/02/2020	2	Meeting preperation
	Wednesday	12/02/2020	6	Meeting with Supervisor, Project work, Presentation Preperation English, Presentation Peperation PM
	Thursday	13/02/2020	3	Lesson: English, Project work, English assignmet
	Friday	14/02/2020	2	Project research
	Saturday	15/02/2020	0	
	Sunday	16/02/2020	2	Project research
	Total		23	
8	Monday	17/02/2020	8	PM&Swedish, Project work in the group
	Tuesday	18/02/2020	2	Project research
	Wednesday	19/02/2020	4	Lessons: Teambuilding, Project research
	Thursday	20/02/2020	4	Meeting with supervisor, Team meeting, Project research
	Friday	21/02/2020	0	
	Saturday	22/02/2020	2	English assignment, Swedish homework
	Sunday	23/02/2020	2	Teambuilding activity with the EPS group
	Total		22	
9	Monday	24/02/2020	5	Project research in the Team (Applications of fishscales)
	Tuesday	25/02/2020	5	Project research in the Team (Sedimentation tanks, sludge)
	Wednesday	26/02/2020	6	Project research in the Tean (Fish oil separation from the waste, applications of the fish oil) English assignment
	Thursday	27/02/2020	3	english assignment
	Friday	28/02/2020	0	
	Saturday	29/02/2020	0	
	Sunday	1/03/2020	3	project management studying Swedish
	Total		22	
10	Monday	2/03/2020	2	project management class
	Tuesday	3/03/2020	3	midterm preparation
	Wednesday	4/03/2020	0	
	Thursday	5/03/2020	2	meeting + wbs
	Friday	6/03/2020	4	Research and swedish meeting
	Saturday	7/03/2020	0	
	Sunday	8/03/2020	3	studying
	Total		14	
11	Monday	9/03/2020	8	classes, midterm preparation
	Tuesday	10/03/2020	7	Midterm preparation, swedish
	Wednesday	11/03/2020	6	english, swedish, midterm preparation

	Thursday	12/03/2020	4	meeting, midterm
	Friday	13/03/2020	6	midterm
	Saturday	14/03/2020	5	midterm
	Sunday	15/03/2020	1	swedish
	Total		37	
	Monday	16/03/2020	6	midterm, project management, swedish.
	Tuesday	17/03/2020	2	Team meeting
	Wednesday	18/03/2020	3	midterm report
12	Thursday	19/03/2020	4	midterm report
	Friday	20/03/2020	3	midterm report
	Saturday	21/03/2020	3	midterm report
	Sunday	22/03/2020	3	english presentation preparation
	Total		24	
	Monday	23/03/2020	1	English presentation preparation
	Tuesday	24/03/2020	6	meeting, business cards, preparation of midterm presentation
	Wednesday	25/03/2020	4	preparation of midterm presentation
13	Thursday	26/03/2020		preparation of midterm presentation
	Friday	27/03/2020		preparation of midterm presentation
	Saturday	28/03/2020		preparation of midterm presentation
	Sunday	29/03/2020	2	Midterm rehersal
	Total		13	
	Monday	30/03/2020	8	swedish + midterm
	Tuesday	31/03/2020	0	Preparation for going back to Poland
	Wednesday	1/04/2020	0	Preparation for going back to Poland
14	Thursday	2/04/2020	4	Midterm debrief
	Friday	3/04/2020	0	Going back to Poland
	Saturday	4/04/2020	0	Going back to Poland
	Sunday	5/04/2020	1	
	Total		13	
	Monday	6/04/2020	3	Team meeting and project work
	Tuesday	7/04/2020	2	Research on fish oil properties
	Wednesday	8/04/2020	4	Research on mechanical extraction of fish oil
15	Thursday	9/04/2020	2	Team meeting
	Friday	10/04/2020	3	
	Saturday	11/04/2020	1	Swedish
	Sunday	12/04/2020	3	Swedish, english
	Total		18	
	Monday	13/04/2020	5	cultural presentations, research on fish oil extraction methods other than hot extraction
	Tuesday	14/04/2020	3	meeting, research fishoil
	Wednesday	15/04/2020	3	Swedish
16	Thursday	16/04/2020	5	English + project work
	Friday	17/04/2020	4	Project work
	Saturday	18/04/2020	2	Swedish
	Sunday	19/04/2020	8	Swedish +english
	Total		30	

	Monday	20/04/2020	5	English + swedish
	Tuesday	21/04/2020	7	English + project work
	Wednesday	22/04/2020	8	English + project work
17	Thursday	23/04/2020	4	Meeting, Working on final report
	Friday	24/04/2020	5	Project work, business cardm english exercises
	Saturday	25/04/2020	0	
	Sunday	26/04/2020	3	English assignment
	Total		32	
	Monday	27/04/2020	7	Final report - Fish oil extraction
	Tuesday	28/04/2020	5	Team meetinng without supervisor
	Wednesday	29/04/2020	3	Team meeting
18	Thursday	30/04/2020	4	Final report - Fish oil extraction
	Friday	1/05/2020	5	English assignments
	Saturday	2/05/2020	0	
	Sunday	3/05/2020	3	English assignments
	Total		27	
	Monday	4/05/2020	4	Final report - Fish oil extraction
	Tuesday	5/05/2020	5	Final report - food safety
	Wednesday	6/05/2020	2	Team meeting
19	Thursday	7/05/2020	3	Final report - food safety
	Friday	8/05/2020	8	Team meeting, Final report - cost analysis
	Saturday	9/05/2020	0	
	Sunday	10/05/2020	6	Team meeting Finising the final report
	Total		28	
	Monday	11/05/2020	4	Finishing the final report
	Tuesday	12/05/2020	9	Team meeting, Finishing the final report
	Wednesday	13/05/2020	2	Adjusting the final report
20	Thursday	14/05/2020	6	Adjusting the final reprot, Final presentation
	Friday	15/05/2020	4	Final presentation
	Saturday	16/05/2020	7	Final presentation
	Sunday	17/05/2020	5	Final presentation
	Total		37	
21	Monday	18/05/2020		!!! Final Presentation !!!
			346	

Figure 120: Working hours Bartosz Sejmicki

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11.3.2 Bram Borghijs

Week	Day	Date	Hours	Work
6	Thrusday	6/02/2020	4	group meeting
	Friday	7/02/2020	0	
	Saturday	8/02/2020	0	
	Sunday	9/02/2020	0	
	Total		4	
7	Monday	10/02/2020	8	Lessons: PM & Swedish, Project Work in the Group
	Tuesday	11/02/2020	4	Meeting preperation
	Wednesday	12/02/2020	8	Meeting with Supervisor, Project work, Presentation Preper
	Thursday	13/02/2020	5	Lesson: English, Project work, English assignmet
	Friday	14/02/2020	3	research about the crops
	Saturday	15/02/2020	0	sick
	Sunday	16/02/2020	0	sick
	Total		28	sick
8	Monday	17/02/2020	8	sick
	Tuesday	18/02/2020	2	sick
	Wednesday	19/02/2020	6	sick
	Thursday	20/02/2020	5	Meeting with supervisor, Team meeting, Project research (F
	Friday	21/02/2020	4	English assignment
	Saturday	22/02/2020	2	Project research (crops)
	Sunday	23/02/2020	2	Teambuilding activity within the EPS Group
	Total		29	
9	Monday	24/02/2020	5	Project research in the Team (my part: Crop diffining and se
	Tuesday	25/02/2020	6	Project research in the Team (my part: Crop diffining and se
	Wednesday	26/02/2020	7	Project research in the Team (my part: Crop diffining and se
	Thursday	27/02/2020	3	Studying swedish, English homework
	Friday	28/02/2020	4	writhing the crop part+ extraresearching
	Saturday	29/02/2020	5	writhing the crop part
	Sunday	1/03/2020	3	writhing the crop part
	Total		33	
10	Monday	2/03/2020	3	start researching how to make time management and stack
	Tuesday	3/03/2020	4	start researching how to make time management and stack
	Wednesday	4/03/2020	5	start researching how to make time management and stack
	Thursday	5/03/2020	5	Meeting without Supervisor, summarize team's Belbin Rules
	Friday	6/03/2020	5	Meeting with Supervisor,making time management
	Saturday	7/03/2020	4	making stackeholder analyses
	Sunday	8/03/2020	4	Swedish homework and studying
	Total		30	
11	Monday	9/03/2020	8	Lesson: Project Management, English and Swedish
	Tuesday	10/03/2020	7	making gantt chart and writhing about it
	Wednesday	11/03/2020	7	Lesson: English and Swedish, Project group work (Gantt Cha
	Thursday	12/03/2020	4	working on Midterm report
	Friday	13/03/2020	9	working on Midterm report
	Saturday	14/03/2020	8	working on Midterm report

	Sunday	15/03/2020	2	Swedish homework and studying
	Total		45	
	Monday	16/03/2020	6	Lesson: English online, Project Management, working on the
	Tuesday	17/03/2020	4	Team meeting with Supervisor, Swedish homework
	Wednesday	18/03/2020	4	Midterm work (rewriting Belbin and Hofstede), English assig
12	Thursday	19/03/2020	2	English presentation preperation cultural differences, Midte
	Friday	20/03/2020	2	Team Meeting without Supervisor
	Saturday	21/03/2020	5	Team Meeting without Supervisor, Midterm work (Layout, C
	Sunday	22/03/2020	4	English presentation preperation cultural differences, Midte
	Total		27	
	Monday	23/03/2020	1	English presentation preperation cultural differences
	Tuesday	24/03/2020	10	Team meeting with Supervisor, Team meeting without supe
	Wednesday	25/03/2020	4	Team meeting without supervisor, Swedish homework
13	Thursday	26/03/2020	4	Midterm presentation preperation
	Friday	27/03/2020	8	Midterm presentation preperation, making logo
	Saturday	28/03/2020	3	Team meeting without supervisor, Midterm presentation pr
	Sunday	29/03/2020	5	Team meeting without supervisor, Midterm presentation pr
	Total		35	
	Monday	30/03/2020	8	!!! Midterm Presentation !!!
	Tuesday	31/03/2020	0	
	Wednesday	1/04/2020	0	
14	Thursday	2/04/2020	3	Team meeting with supervisor,Swedish homework
	Friday	3/04/2020	2	English presentation preperation cultural differences
	Saturday	4/04/2020	3	English assignment, Project work (circular economie)
	Sunday	5/04/2020	3	English presentation preperation cultural differences, Englis
	Total		19	
	Monday	6/04/2020	4	Team meeting without supervisor, Project work (circular ec
	Tuesday	7/04/2020	5	making
	Wednesday	8/04/2020	4	Project work (making website, recapture and review compa
15	Thursday	9/04/2020	4	Team meeting with supervisor, Updating timetable
	Friday	10/04/2020	3	adjusting website
	Saturday	11/04/2020		
	Sunday	12/04/2020	5	swedish + site
	Total		25	
	Monday	13/04/2020	7	site + swedisch learning
	Tuesday	14/04/2020	4	Team meeting without supervisor, site update
	Wednesday	15/04/2020	5	news on site
16	Thursday	16/04/2020	3	about on site
	Friday	17/04/2020	2	Team meeting with supervisor
	Saturday	18/04/2020	7	
	Sunday	19/04/2020	4	
	Total		32	
	Monday	20/04/2020	8	Research water samples
17	Tuesday	21/04/2020	4	Research water samples
	Wednesday	22/04/2020	5	Research water samples
	Thursday	23/04/2020	2	Research water samples

	Friday	24/04/2020	6	Making graphs water samples
	Saturday	25/04/2020	1	Making graphs water samples
	Sunday	26/04/2020	4	Making graphs water samples
Total			30	
	Monday	27/04/2020	8	circular economy
	Tuesday	28/04/2020	5	English
	Wednesday	29/04/2020	6	English
18	Thursday	30/04/2020	5	English
	Friday	1/05/2020	6	English
	Saturday	2/05/2020	4	English
	Sunday	3/05/2020	0	
Total			34	
	Monday	4/05/2020	2	writhing water samples + website
	Tuesday	5/05/2020	4	writhing water samples + website
	Wednesday	6/05/2020	1	writhing water samples + website
19	Thursday	7/05/2020	3	writhing water samples + website
	Friday	8/05/2020	6	writhing water samples + website
	Saturday	9/05/2020	7	writhing water samples + website
	Sunday	10/05/2020	8	writhing water samples + website
Total			31	
	Monday	11/05/2020	5	Polishing final report
	Tuesday	12/05/2020	6	Polishing final report
	Wednesday	13/05/2020	7	Polishing final report
20	Thursday	14/05/2020	8	Polishing final report
	Friday	15/05/2020	4	Polishing final report ppt
	Saturday	16/05/2020	5	ppt making
	Sunday	17/05/2020	7	ppt practice
Total			42	
21	Monday	18/05/2020		!!! Final Presentation !!!

Figure 11.11: Working hours Bram Borghijs13

11.3.3 Marcel Chaillan

Week	Day	Date	Hours	Work
6	Thrusday	2/6/2020	4	
	Friday	2/7/2020	2	
	Saturday	2/8/2020	0	
	Sunday	2/9/2020	0	
	Total		6	
7	Monday	2/10/2020	8	Lessons: PM & Swedish, Project Work in the Group
	Tuesday	2/11/2020	1	Meeting preperation
	Wednesday	2/12/2020	6	Meeting with Supervisor, Project work, Presentation preperation PM
	Thursday	2/13/2020	3	Lesson: English, Project work, English assignment
	Friday	2/14/2020	2	Project research (Fish types)
	Saturday	2/15/2020	0	
	Sunday	2/16/2020	0	
	Total		20	
8	Monday	2/17/2020	8	Lessons: PM & Swedish, Project Work in the Group
	Tuesday	2/18/2020	4	English assignment
	Wednesday	2/19/2020	4	Lessons: Teambuilding, Project research (Fish types)
	Thursday	2/20/2020	4	Meeting with supervisor, Team meeting
	Friday	2/21/2020	2	English assignment
	Saturday	2/22/2020	0	
	Sunday	2/23/2020	2	Teambuilding activity within the EPS Group
	Total		24	
9	Monday	2/24/2020	5	Project research in the Team (waste water)
	Tuesday	2/25/2020	5	Project research in the Team (waste water)
	Wednesday	2/26/2020	6	Project research in the Team (summarizing and writing down the previous research)
	Thursday	2/27/2020	3	Swedish and English homework
	Friday	2/28/2020	0	ESN Trip: Lapland
	Saturday	2/29/2020	0	ESN Trip: Lapland
	Sunday	3/1/2020	0	ESN Trip: Lapland
	Total		19	
10	Monday	3/2/2020	0	ESN Trip: Lapland
	Tuesday	3/3/2020	0	ESN Trip: Lapland
	Wednesday	3/4/2020	0	ESN Trip: Lapland
	Thursday	3/5/2020	2	Meeting without Supervisor, summarize team's Belbin Rules, finished team contract
	Friday	3/6/2020	4	Meeting with Supervisor, summarize and write down team's Belbin Rules, writing down Hofstede within the team
	Saturday	3/7/2020	0	
	Sunday	3/8/2020	0	
	Total		6	
11	Monday	3/9/2020	8	Lesson: Project Management, English and Swedish
	Tuesday	3/10/2020	4	working on Midterm report
	Wednesday	3/11/2020	6	Lesson: English and Swedish, Project group work (Midterm report)
	Thursday	3/12/2020	6	Meeting with supervisor, working on Midterm report (SWOT)
	Friday	3/13/2020	4	working on Midterm report, Swedish and English homework

	Saturday	3/14/2020	0	
	Sunday	3/15/2020	0	
	Total		28	
	Monday	3/16/2020	4	Lesson: English online, working on Midterm report
	Tuesday	3/17/2020	6	Team meeting with Supervisor, English
	Wednesday	3/18/2020	6	Midterm work (Introduction and conclusion)
12	Thursday	3/19/2020	2	Midterm Work (Continued)
	Friday	3/20/2020	4	Team Meeting without Supervisor, adjustments to report after meeting
	Saturday	3/21/2020	5	Team Meeting without Supervisor, Midterm work
	Sunday	3/22/2020	0	
	Total		27	
	Monday	3/23/2020	4	English presentation preperation cultural differences
	Tuesday	3/24/2020	6	Team meeting with Supervisor, Team meeting without supervisor, Swedish
	Wednesday	3/25/2020	4	Team meeting without supervisor
13	Thursday	3/26/2020	4	Midterm presentation preperation
	Friday	3/27/2020	4	Midterm presentation preperation
	Saturday	3/28/2020	4	Team meeting without supervisor, Midterm presentation preperatior
	Sunday	3/29/2020	4	Team meeting without supervisor, Midterm presentation preperatior
	Total		30	
	Monday	3/30/2020	8	!!! Midterm Presentation !!!
	Tuesday	3/31/2020	0	
	Wednesday	4/1/2020	0	
14	Thursday	4/2/2020	3	Team meeting with supervisor
	Friday	4/3/2020	6	English homework, Project research (collagen extraction)
	Saturday	4/4/2020	0	
	Sunday	4/5/2020	0	
	Total		17	
	Monday	4/6/2020	4	Team meeting without supervisor, Project work (Collagen extraction)
	Tuesday	4/7/2020	5	Visit Polar Filé with Marcel and Supervisor
	Wednesday	4/8/2020	4	Project work (collagen extraction, preparing meeting)
15	Thursday	4/9/2020	2	Team meeting with supervisor
	Friday	4/10/2020	3	Project work (company visit write-up), Swedish
	Saturday	4/11/2020	2	Project work
	Sunday	4/12/2020	0	
	Total		20	
	Monday	4/13/2020	4	English presentation, Project research (collagen extraction)
	Tuesday	4/14/2020	4	Team meeting without supervisor, Project work (Collagen extraction)
	Wednesday	4/15/2020	2	Project research
16	Thursday	4/16/2020	3	Update timetable, meeting preparation
	Friday	4/17/2020	4	Team meeting with supervisor
	Saturday	4/18/2020	0	
	Sunday	4/19/2020	6	Project research and Swedish
	Total		23	
	Monday	4/20/2020	8	Team meeting without supervisor, english assignment, Swedish lesso
17	Tuesday	4/21/2020	4	Project research (collagen extraction machine)
	Wednesday	4/22/2020	6	Meeting preperation, project research (collagen extraction machine)

	Thursday	4/23/2020	3	Team meeting with supervisor, english
	Friday	4/24/2020	4	Project work, english assignment
	Saturday	4/25/2020	0	
	Sunday	4/26/2020	4	Project work, english assignment, final report
	Total		29	
	Monday	4/27/2020	4	English assignment
	Tuesday	4/28/2020	4	Team meeting without supervisor, meeting preperation
	Wednesday	4/29/2020	6	Team meeting with supervisor, hielscher meeting
18	Thursday	4/30/2020	6	Collagen extraction cost analysis
	Friday	5/1/2020	4	English finals, Collagen extraction cost analysis
	Saturday	5/2/2020	3	English finals
	Sunday	5/3/2020	1	English finals
	Total		28	
	Monday	5/4/2020	6	Final report, Collagen extraction cost analysis
	Tuesday	5/5/2020	6	Final report, Collagen extraction cost analysis, meeting preparation
	Wednesday	5/6/2020	5	Team meeting with supervisor, final report
19	Thursday	5/7/2020	8	Final report, Collagen extraction cost analysis
	Friday	5/8/2020	6	Team meeting without supervisor, Final report, Collagen extraction cost analysis
	Saturday	5/9/2020	0	
	Sunday	5/10/2020	8	Team meeting without supervisor, Final report
	Total		39	
	Monday	5/11/2020	8	Meeting preparation, final report
	Tuesday	5/12/2020	8	Team meeting with supervisor, final report
	Wednesday	5/13/2020	0	
20	Thursday	5/14/2020	6	Final report, team meeting without supervisor, final presentation
	Friday	5/15/2020	5	Final presentation
	Saturday	5/16/2020	3	Final presentation
	Sunday	5/17/2020	3	Final presentation
	Total		33	
21	Monday	5/18/2020	5	!!! Final Presentation !!!

Figure 11.14: Working hours Marcel Chaillan

11.3.4 Stefan Rast

Week	Day	Date	Hours	Work
0	Thrusday	06.02.2020	4	
	Friday	07.02.2020	0	
	Saturday	08.02.2020	0	
	Sunday	09.02.2020	0	
	Total		4	
1	Monday	10.02.2020	8	Lessons: PM & Swedish, Project Work in the Group
	Tuesday	11.02.2020	4	Meeting preperation
	Wednesday	12.02.2020	8	Meeting with Supervisor, Project work, Presentation Preperation English, Presentation Peperation PM
	Thursday	13.02.2020	5	Lesson: English, Project work, English assignmet
	Friday	14.02.2020	0	ESN Trip: Helsinki - Tallinn
	Saturday	15.02.2020	0	ESN Trip: Helsinki - Tallinn
	Sunday	16.02.2020	0	ESN Trip: Helsinki - Tallinn
	Total		25	
2	Monday	17.02.2020	8	Lessons: PM & Swedish, Project Work in the Group
	Tuesday	18.02.2020	2	English assignment
	Wednesday	19.02.2020	6	Lessons: Teambuilding, Project research (Fish solid use)
	Thursday	20.02.2020	5	Meeting with supervisor, Team meeting, Project research (Fish solids)
	Friday	21.02.2020	4	English assignment
	Saturday	22.02.2020	2	Project research (Fish oil filtration)
	Sunday	23.02.2020	2	Teambuilding activity within the EPS Group
	Total		29	
3	Monday	24.02.2020	5	Project research in the Team (my part: Fish processing waste & methods)
	Tuesday	25.02.2020	6	Project research in the Team (my part: Fish processing waste & methods), Swedish homework
	Wednesday	26.02.2020	5	Project research in the Team (my part: summarizing and writing down the previous research)
	Thursday	27.02.2020	4	Studying swedish, English homework
	Friday	28.02.2020	0	ESN Trip: Lapland
	Saturday	29.02.2020	0	ESN Trip: Lapland
	Sunday	01.03.2020	0	ESN Trip: Lapland
	Total		20	
4	Monday	02.03.2020	0	ESN Trip: Lapland
	Tuesday	03.03.2020	0	ESN Trip: Lapland
	Wednesday	04.03.2020	0	ESN Trip: Lapland
	Thursday	05.03.2020	5	Meeting without Supervisor, summarize team's Belbin Rules, finished team contract
	Friday	06.03.2020	4	Meeting with Supervisor, summarize and write down team's Belbin Rules, writing down Hofstede within the team
	Saturday	07.03.2020	0	

	Sunday	08.03.2020	6	Swedish homework and studying, finishing the Belbin group conclusions
	Total		15	
5	Monday	09.03.2020	8	Lesson: Project Management, English and Swedish
	Tuesday	10.03.2020	0	
	Wednesday	11.03.2020	7	Lesson: English and Swedish, Project group work (Gentt Chart, discussing current situation for Midterm report)
	Thursday	12.03.2020	4	working on Midterm report
	Friday	13.03.2020	9	working on Midterm report
	Saturday	14.03.2020	8	working on Midterm report
	Sunday	15.03.2020	2	Swedish homework and studying
	Total		38	
6	Monday	16.03.2020	6	Lesson: English online, Project Management, working on the Layout for the Midterm report
	Tuesday	17.03.2020	4	Team meeting with Supervisor, Swedish homework
	Wednesday	18.03.2020	4	Midterm work (rewriting Belbin and Hofstede), English assignment
	Thursday	19.03.2020	2	English presentation preperation cultural differences, Midterm Work (Layout)
	Friday	20.03.2020	2	Team Meeting without Supervisor
	Saturday	21.03.2020	5	Team Meeting without Supervisor, Midterm work (Layout, Quality Management)
	Sunday	22.03.2020	4	English presentation preperation cultural differences, Midterm Work (Quoting)
	Total		27	
7	Monday	23.03.2020	1	English presentation preperation cultural differences
	Tuesday	24.03.2020	10	Team meeting with Supervisor, Team meeting without supervisor, Group work presentation preperation
	Wednesday	25.03.2020	4	Team meeting without supervisor, Swedish homework
	Thursday	26.03.2020	4	Midterm presentation preperation
	Friday	27.03.2020	4	Midterm presentation preperation
	Saturday	28.03.2020	3	Team meeting without supervisor, Midterm presentation preperation
	Sunday	29.03.2020	5	Team meeting without supervisor, Midterm presentation preperation, Swedish homework
	Total		31	
8	Monday	30.03.2020	8	!!! Midterm Presentation !!!
	Tuesday	31.03.2020	0	
	Wednesday	01.04.2020	0	
	Thursday	02.04.2020	3	Team meeting with supervisor,Swedish homework
	Friday	03.04.2020	2	English presentation preperation cultural differences
	Saturday	04.04.2020	3	English assignment, Project work (Industrial Ecology)
	Sunday	05.04.2020	3	English presentation preperation cultural differences, English assignment
	Total		19	
9	Monday	06.04.2020	4	Team meeting without supervisor, Project work (Industrial Ecology)

	Tuesday	07.04.2020	5	Visit Polar Filé with Marcel and Supervisor
	Wednesday	08.04.2020	4	Project work (Industrial Economy, recapture and review company visit, preparing meeting)
	Thursday	09.04.2020	4	Team meeting with supervisor, Updating timetable
	Friday	10.04.2020	0	
	Saturday	11.04.2020	6	Project work (Re-writing texts for final report)
	Sunday	12.04.2020	0	
	Total		23	
10	Monday	13.04.2020	6	English presentation preperation, English presentation, Project work (Earned Value Analysis research)
10	Tuesday	14.04.2020	4	Team meeting without supervisor, Project work (Collegan extraction)
10	Wednesday	15.04.2020	5	Project work (Earned Value Analysis)
10	Thursday	16.04.2020	3	Project work (Collegan extraction)
10	Friday	17.04.2020	6	Team meeting with supervisor
10	Saturday	18.04.2020	9	English assignments and exercises, Swedish exercises
10	Sunday	19.04.2020	5	Project work (Earned Value Analysis)
	Total		38	
11	Monday	20.04.2020	7	Meeting without supervisor, English assignments and exercises
11	Tuesday	21.04.2020	2	Swedish exercises
11	Wednesday	22.04.2020	3	English assignments and exercises
11	Thursday	23.04.2020	2	Meeting with supervisor
11	Friday	24.04.2020	5	Project work (writing about project`s name)
11	Saturday	25.04.2020	0	
11	Sunday	26.04.2020	4	Project work (Final report layout)
	Total		23	
12	Monday	27.04.2020	6	Project work (Final report layout, Earned Value Analysis)
12	Tuesday	28.04.2020	6	Team meeting without supervisor, Project work (Final report layout)
12	Wednesday	29.04.2020	2	Team meeting with supervisor
12	Thursday	30.04.2020	2	English assignments and exercises, Project work (Earned Value Analysis)
12	Friday	01.05.2020	7	Project work (Layout)
12	Saturday	02.05.2020	0	
12	Sunday	03.05.2020	6	English assignments and exercises, Project work (Earned Value Analysis, Layout)
	Total		29	
13	Monday	04.05.2020	4	English assignments and exercises, Project work (Earned Value Analysis)
13	Tuesday	05.05.2020	0	
13	Wednesday	06.05.2020	5	Team meeting With and without supervisor, Project work (Layout)
13	Thursday	07.05.2020	5	Project work (Layout)
13	Friday	08.05.2020	5	Team meeting without supervisor, Project work (Layout)
13	Saturday	09.05.2020	2	Project work (Layout)
13	Sunday	10.05.2020	6	Team meeting without supervisor, Project work (Layout)

	Total		27	
14	Monday	11.05.2020	5	Project work (Layout)
	Tuesday	12.05.2020	3	Team meeting with and without supervisor, Project work (Layout)
	Wednesday	13.05.2020	7	Project work (Layout)
	Thursday	14.05.2020	8	Team meeting without supervisor, Project work (Final Presentation)
	Friday	15.05.2020	5	Project work (Final Presentation)
	Saturday	16.05.2020	3	Project work (Final Presentation)
	Sunday	17.05.2020	3	Project work (Final Presentation)
	Total		34	
15	Monday	18.05.2020	5	!!! Final Presentation !!!
		Total hours:	387	

Figure 11.15: Working hours Stefan Rast