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Market research of wastewater treatment unit

Raita Environment domestic biofilter project

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This thesis was done for Raita Environment to evaluate market and performance of a new prototype wastewater treatment unit for areas of dispersed settlement. This prototype, dubbed domestic biofilter, can utilize old concreate septic tanks as pre-treatment. The market research was done to gain information about market size and to list potential competition. Legislation concerning wastewater treatment was important to explain, as it controls both markets and purification levels. Performance evaluation was done by field measurements using a portable colorimeter and three water laboratory analyses together with Valonia. Field measurements allowed quick response to changes and were also compared to water laboratory measurements.

Competition is fierce in the market and several companies have their own options. Household wastewater treatment requirements are treated in two different legal documents; Environmental protection act 527/2014 and Governmental decree on treating domestic wastewaters 209/2011. Government of Juha Sipilä has stated intensions to clarify the legislation.

A domestic biofilter uses a well-established, but in Finland not widely used used trickling filter principle to treat wastewaters. A trickling filter works by spraying pre-treated wastewater on packaging material. Microorganisms grow on the packaging material and form a slime layer where biodegradation of organic substances happens.

Data from measurements were promising, although some nitrate field measurements failed and could not be used in comparisons. This could have been due to measurement errors or substance interfering with colorimeter reagents. According to Valonia statements, removal efficiency of biological substances and phosphorus great, fulfilling required levels in all three tests. Phosphorus levels also stayed well below limit values in the field measurements, demonstrating that Raita Environment’s biofilter substantially reduced nutrient loads to environment. The pH data further supported water laboratory measurement results that indicated biological activity in the prototype bioreactor. Nitrogen results showed that there is still potential to improve the treatment in terms of ammonia nitrogen. All in all, according to the data produced the prototype demonstrated good results in a relatively short timeframe

Keywords	wastewater treatment, dispersed settlement, market research, reporting

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Tämä insinöörityö tehtiin Raita Environmentille, jotta yritys saisi tietoa uuden haja-asutusalueiden jätevesiyksikön markkinoista ja puhdistustuloksista. Prototyyppiyksikkö nimeltään Domestic Biofilter voi käyttää vanhoja saostuskaivoja hyödyksi esikäsittelynä. Markkinatutkimus käsitteli markkinoiden kokoa ja listasi mahdollisia kilpailevia tuotteita. Jätevesilainsäädäntöä on käyty työssä läpi, sillä se vaikuttaa olennaisesti markkinoiden kokoon ja mahdollisten asiakkaiden määrään. Puhdistustuloksia analysoitiin kannettavalla kolorimetrillä tehtyjen kenttämittausten, sekä kolmen laboratoriomittauksen kautta. Kenttämittauksilla pystyttiin reagoimaan nopeasti muutoksiin ja niitä verrattiin laboratoriotuloksiin.
Kilpailu jätevesimarkkinoilla on kovaa ja monella yrityksellä on omat ratkaisunsa. Puhdistusvaatimuksia haja-asutusalueille on käsitelty kahdessa eri oikeudellisessa asiakirjassa; ympäristönsuojelulaissa 527/2014 ja valtioneuvoston asetuksessa 209/2011. Juha Sipilän hallitus on ilmoittanut aikeista yksinkertaistaa lainsäädäntöä.
Domestic Biofilter käyttää hyvin todennettua, mutta Suomessa harvinaisempaa trickling filter – menetelmää. Puhdistusteho perustuu mikrobitoimintaan puhdistusmateriaalissa, johon esikäsiteltyä jätevettä ruiskutetaan.
Tulokset mittauksista olivat lupaavia, vaikkakin osa kenttänitraattimittauksista epäonnistui. Tämä on voinut johtua esimerkiksi häiritsevistä yhdisteistä tai mittausvirheestä. Valonian mukaan biologisen hapenkulutuksen ja fosforin poistotulokset läpäisivät vaatimukset kaikissa kolmessa laboratorionäytteessä. Fosfori-arvot pysyivät myös alle vaatimusten kenttäkokeissa, joten domestic biofilter prototyyppi näyttäisi vähentäneen ravinnekuormaa ympäristöön merkittävästi. Ph mittaukset tukivat muita mittauksia indikoiden biologista toimintaa tämän bioreaktorin prototyypissä. Typpimittauksten perusteella reaktorin puhdistustehoa ammoniumtypen osalta voisi olla mahdollista nostaa. Kokonaisuudessaan domestic biofilter näytti toimivan hyvin lyhyen testausajanjakson aikana tuotetun datan perusteella.

Keywords	jätevedenpuhdistus, haja-asutusalue, markkinatutkimus, raportointi

Contents

1 Introduction

World is changing constantly and markets follow right behind. Market knowledge that was fresh a year ago might not be useful at all in the next year because of large market changes. This is especially true for the Finnish markets when it comes to wastewater purification solutions offered to private houses and summer cottages in rural areas. Changes to legislation in recent years, followed by extension periods, have created confusion amongst people and also in companies involved in wastewater business.

1.1 Raita Environment

This thesis was done by request from Managing Director Ilkka Raita of Raita Environment Oy. Environmental technology forms the core of Raita Environment's business, ranging from manufacture, design and maintenance of equipment. Environmental technology solutions offered by Raita Environment (Raita) include environmentally friendly toilets, wastewater treatment units, greywater purifiers and odour removal by means of preventing hydrogen sulphide from forming. Raita is operating from three places situated in southern Finland. These places are situated outside two major Finnish population centres, Helsinki and Turku, giving the company a easy access to large potential customer base. Raita Environment offices are listed below:

- Karuna, showroom, some 50 km from Turku city center
- Rajamäki, main office and production, some 55 km from Helsinki city center
- Vantaa, showroom, some 17 km from Helsinki city center

1.2 Goal and scope

The goal of this thesis was to produce relevant and useful information to Raita Environment, in order to aid them in their decisions regarding this wastewater treatment unit. Information was gathered regarding the market; competition, potential customers and distribution methods. To understand changes in market and the reasons why these kind of wastewater units are produced, it is vital to know also the relevant legislation.

Analysing and monitoring the performance of the domestic biofilter project was also a goal of this thesis. This was to be done by performing field measurements using the

equipment of Raita Environment to evaluate effectiveness and to quickly respond to possible negative changes. Field measurements were also supplemented by slower, but more accurate lab measurements done by a water laboratory. Results from both field measurements and water laboratory were then compared to gain more comprehensive information.
Testing and analysis of water parameters was conducted together with Valonia on the prototype device at Rajamäki offices. Valonia is a nonaligned organisation focused on sustainable development and energy issues. Working mainly in Southwest Finland, Valonia offers services to public sector, consumers and private companies. Services include seminars, courses, and info packages for customers, with basic services being free. Professional guidance in wastewater treatment and energy efficiency matters, tailored to suit customers' needs are an exception (Valonia, 2015).

2 Domestic biofilter project

This prototype device, simply called *domestic biofilter* in this thesis, is a wastewater treatment device designed and built by Raita Environment at Rajamäki production plant. The domestic biofilter is designed to provide additional option to supplement Raita Environments current line-up of wastewater treatment units. Before going into the project details, it is necessary to explain two key elements of this project, *trickling filter* and *septic tank*.

2.1 Septic tanks

Septic tanks are watertight single or multi-piece mechanical devices designed to separate settleable solids and such substances that are lighter than water. Wastewater is lead through the septic tanks so that flow speed is decreasing allowing for solids to settle. Semi solid slurry, sludge, forms into the bottom of the tank, composing of different kind of organic substances and nutrients. Settled solids accumulate faster than they decompose by anaerobic degradation (Tilley et al, 2014). It is necessary to dimension the septic tank according to the flow rate, sludge formation rate and sludge removal method (Kujala-Räty, Santala,and Mattila, 2008).

Areas of dispersed settlement commonly have such devices, and they are designed with average retention times of 1-2 days. When designing septic tanks, care should be taken to prevent wastewater shortcuts between different sections and sludge wash ups with the clarified effluent. Previously two-piece septic tanks were used to treat greywaters and three-piece septic tanks to treat all household wastewaters (Kujala-Räty, Santala, and Mattila, 2008).

2.2 Trickling filters

Trickling filters are biological wastewater treatment units that have been used for nearly 100 years in different municipal and industrial treatment applications. They employ a fixed-film bioreactor with packaging on which wastewater is evenly distributed. This packing is contained in a structure, which also houses the dosing system and an underdrain (Burton, Stensel, and Tchobanoglous, 2004). Packing material should have a desired specific surface area between 30 and 900 m2/m3. Material such as rocks, gravel, shredded pvc and special pre-formed filters are commonly used. (Tilley et al, 2014).
Microorganisms grow on the packaging material and form a slime layer where biodegradation of substances happens. Facultative bacteria are usually dominant bacteria present in the slime, but the biological community can also host fungi, algae and protozoans (Burton, Stensel, and Tchobanoglous, 2004).

2.3 Domestic biofilter prototype

The project started with meetings of Raita Environment employees who were given written instructions on how to build such a device. Meetings were then followed by an initial building phase which lasted several days. I helped with the building phase, by performing various tasks, including fitting pipe angles and seals. As the project was scheduled to run during winter time, insulating several key areas was also priority work for me.

Project was initiated to replace an existing wastewater treatment unit at Rajamäki, an activated sludge testing unit for Raita multi process. This model was installed in 3 plastic wells and most of the piping needed for domestic biofilter was already present. Several components not needed in this project at the time were removed, including the aeration disk and some wiring.
Inspection of the plastic wells was done in this phase before installation, as well as cleaning using pressure washer. This was done before installing the larger main components, which would greatly increase the tediousness of such work after in place.

Wastewater comes into the unit from the two halls present in Rajamäki, with water being pumped from a concreate well into the first plastic well. This plastic well serves as a

septic tank, performing mechanical removal as settleable solids settle into the bottom by gravity. Floatable liquids such as grease and oil remain in the top layer and exit the first well through T-junction.
Second well has a cone on top of it, which serves as a heart of the process. This cone is a fixed bed biological trickling filter, filled with a porous, large-internal-surface-area material to allow a biofilm to form. Water from the second well is sprayed on the porous material and over time bacteria oxidise organic material into different oxidized products. Bacteria present in trickling filters are usually facultative, being able to produce cellular energy units (ATP) in aerobic and anaerobic conditions.
Raita RAKE chemical was pumped continuously into the second well to act as a primary coagulant. This would then cause suspended solids with opposing negative charges to be neutralized. Small neutral particles can then begin to form larger particles and flock, which eventually settles into the bottom.
Reactor effluent enters the final well through a pipe which flows into two monitoring vessels. These monitoring vessels overflow into the well, from where it finally exits the system into sewer. Third well acts as a secondary sedimentation tank, where final treatment takes place as cells from biological oxidation settle.

Process maintenance, such as cleaning of the material and changing components was done through a hatch on top of the cone. The first and the last wells had a thick lid that would lock when rotated. The First lid was used to monitor the incoming wastewater daily, and larger floating objects such as Styrofoam chunks were removed. Lid on the last well was opened every day to perform sampling and visual monitoring of the effluent.

3 Market research

The main purpose of this market research was to get information about the numbers of potential customers to the Raita Environment’s new product. This required assessment of placements and numbers of premises on areas of dispersed settlement. Also competitive solutions were researched and compared to get best possible market knowledge.

3.1 Definition of market research

Current dominant socio-economic system, capitalism, is based on markets. Markets mean that buyers and sellers freely negotiate term of exchange of products in question (Doyle 2002) (Callingham 2004). Those researching these markets, the market researchers, are people making up the questions. Instructions for these specific questions are derived from clients of varying background i.e varying markets (Roe 2004).
Term market research can be described as systematic handling of data and findings relevant to a situation a company faces (Pettit, Monster 2002)

Market research is used by private commerce and public sector i.e suppliers to discover how their offer might be accepted, utilized or perceived in the market (Roe 2004).

As put by Professor Martin Callingham in his book *Market Intelligence*:

> ‘’…market research does not in itself drive the company. It is the people in it who do this. Market research is more like the oil of an engine, enabling it to run smoothly and well.’’ (Callingham 2004, p 42-43)

3.2 Competition

Competition in the field of wastewater treatment in Finland is fierce due to large number of companies working either only on this market or at least having some products for certain customer groups of the market. Understanding of the principles of small scale wastewater treatment seems to be good as most competing products use very similar technologies and methods.

3.2.1 Green Rock IISI KIVI

Green Rock is a Oulunsalo based company, founded in 1998, that specialises in wastewater treatment and oil spill clean-up. Their product IISI KIVI is wastewater treatment unit that can be installed in households with old septic tanks (Figure 1).
IISI KIVI – unit can treat either all household wastewaters or just lighter greywaters. According to Green Rock, removal efficiency is enough for all wastewaters if there are 3 concreate-made septic tanks or any similar three chamber septic tank solution and IISI KIVI is installed on top of the third one. For greywaters, two concreate septic tanks or equivalent are enough with IISI installed on top of the final department. Trickling filter technology is used to remove biological matter and ammonia nitrogen inside the IISI KIVI. Trickling filter works so that water is pumped up into IISI KIVI and sprayed over plastic medium, where biological activity by microorganisms happens (Green Rock, 2014).

Figure 1. Green Rock IISI Kivi (Green Rock, 2014)

3.2.2 Biolan kaivopuhdistamo

Biolan is an Eura based company, founded in 1974, that specialises in garden products and also has several wastewater treatment solutions. Biolan's Kaivopuhdistamo is a product sold to households with old septic tanks. According to Biolan homepages, it seems that Kaivopohdistamo needs to be installed into households with three-chamber septic tanks (Figure 2).

Kaivopuhdistamo uses a bio-chemical process to treat influent wastewaters. The First septic tank works to settle incoming wastewaters so that heavier elements in water settle into the bottom of the tank, while grease and other light substances rise on to the surface. The First septic tank works as part of Kaivopuhdistamo basically with only small modifications to its original form. The clarifier unit and the aeration plate are installed into the second septic tank. Aeration is performed in the second tank to produce activated sludge via microbial activity as the microbes require oxygen to multiply. The clarifier unit separates activated sludge from water leaving the tank using gravitation. Clear water leaves the tank as more new untreated water enters the tank. Inflow into the third settling tank collects into container with pump. Water is lifted by the pump into another container directly above the first one, where it is mixed with aluminium based coagulation agent. Now this mixture is lead down into the settling tank where heavy floc consisting of reacted phosphorus and the coagulation agent, settle into the bottom to form sludge. This sludge is pumped back into the first settling tank twice a day. Clarified water rises to the surface and exits the third settling tank through a T-junction (Biolan, 2015).

Figure 2: Biolan kaivopuhdistamo (Biolan, 2015)

3.2.3 Rotomon saneerauspaketti 550

Rotomon is a Kangasniemi based company, specialising in plastic products like different types of pipes and septic tanks. Rotomon's Saneerauspaketti 550 is a package containing one septic tank of 550l and 35 meters of piping needed to make infiltration field. Filter fabric with area of 36 m2 and two aeration hats are also included (Rotomon, n.d.). The package is shown in Figure 3.

Saneerauspaketti can be used along with old concreate septic tanks so that with only one old septic tank it is used to treat grey waters. When used with two concreate septic tanks they form a system that can be used to treat all household waters. Rotomon's septic tank is placed so that I comes after the concrete septic tanks and then guides incoming water into the infiltration field (Rotomon, n.d).

Figure 3: Rotomon Saneerauspaketti 550 (Rotomon, n.d.)

3.2.4 Goodwell saneerauspaketti

Goodwell infradev Oy is a company focusing on regional wastewater systems and their monitoring systems. Wastewater treatment systems for households are supplementary products for the company. Goodwell has a product, Saneerauspaketti, for use in sites with minimum of two old septic tanks. Saneerauspaketti contains necessary technology, like pumps and pipes, to turn old septic tanks into a new wastewater treatment unit. Figure 4 illustrates 2 concreate septic tanks fitted with the saneerauspaketti.

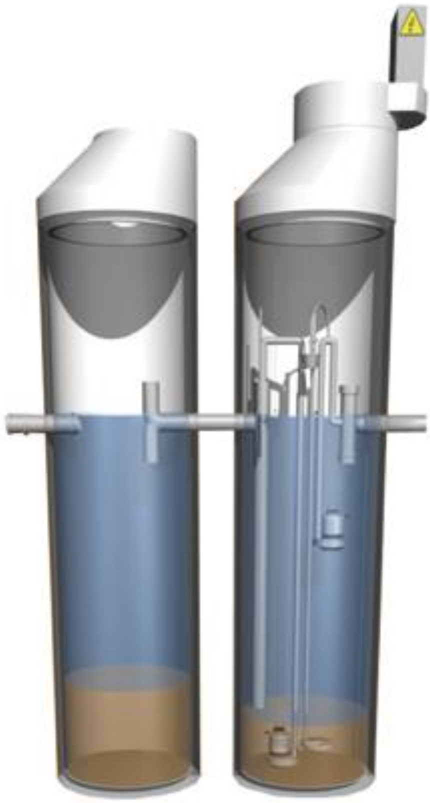

Figure 4: Goodwell's saneerauspaketti (Goodwell Infradev, n.d)

3.2.5 Raita PA kaivo

PA Kaivo is Raita Environments own model for sites with existing old septic tanks. It uses same principles and equipment as Raitas other PA-models, mainly PA 0.8 MULTI, with the exception of that there is no need for plastic wells. Package comes with all purification technology needed to turn the tanks into a wastewater treatment system.

In the case of leaking old septic tanks, smaller plastic wells can be installed inside these septic tanks to provide frame for PA Kaivo (Raita Environment, 2015).

Raita Pa Kaivo package comes equipped with automatic system for renewal of biological activity in the case of long stoppage of the process. This system pumps nutrient rich water from the first septic tank into the process side, allowing stoppage times of up to two months. Raita Pa series treatment systems have been tested according to EN 12566-3:2005 standard (Raita Environment, 2015). Simple schematic is shown in Figure 5.

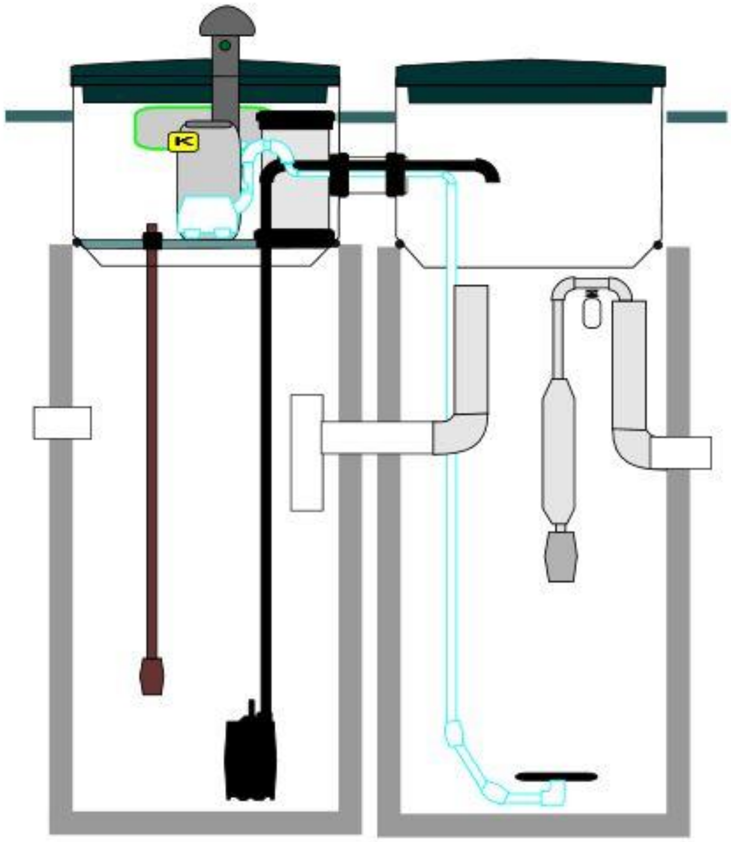

Figure 5: Raita PA Kaivo schematic (Raita Environment, 2015)

3.2.6 Other competition

When competition is looked from a wider perspective, basically every company in Finland offering wastewater treatment options for areas of dispersed settlement could be included.

This would, however, mean that the customer had chosen to ignore any existing well structures and simply build a completely new system. This was not in the scope of this thesis, but it is worth mentioning that virtually every manufacturer has a treatment unit employing biological and mechanical treatment inside its own superstructure. Such units use activated sludge method to treat incoming wastewater in cycles, often using aeration and coagulation chemical to achieve purification results.

3.3 Market size

To be properly able to estimate market potential for product like Domestic biofilter, the number of potential customers must be estimated. Finland does not have systematically compiled statistics on wastewater treatment in areas of dispersed settlement. This is, even as wastewater treatment system requires a permit from municipality's construction office.

The term area of dispersed settlement is not clearly defined, but usually it is an area outside city plan and is loosely populated (Tuomikoski, 2012).

Area of dispersed settlement was a 250 m x 250 m area that houses less than 200 inhabitants in study by Kallio and Nurmio (2014).

Data is, to some extent, available thanks to wastewater counsellors that have provided free counsel to residents, including site visits, from which most of the data is from.

During these visits, the counsellor assesses the wastewater treatment system being used by its state of operational state and efficiency in terms of relevant wastewater treatment legislation. These requirements are discussed in detail in the chapter 4 of this thesis.

According to Statistics Finland (Tilastokeskus, 2015), a Finnish public authority for statistics, there were 500 400 summer cottages in Finland in 2014. The average age of the owner was 62 years; with owners below age 40 amounted for 7 % of summer cottages. New summer cottages built in 2000s had an average area of 72 m2, and the average area of all cottages was 48 m2 (Tilastokeskus, 2015). Largest amount of summer cottages were found from Varsinais-Suomi region, a slightly below 50 000. Etelä-Savo region has several hundred cottages less, while Pirkanmaa has several thousand less. Only other region other than the abovementioned to surpass 40 000 cottages was Uusimaa region. All regional amounts of summer cottages are shown in Figure 6.

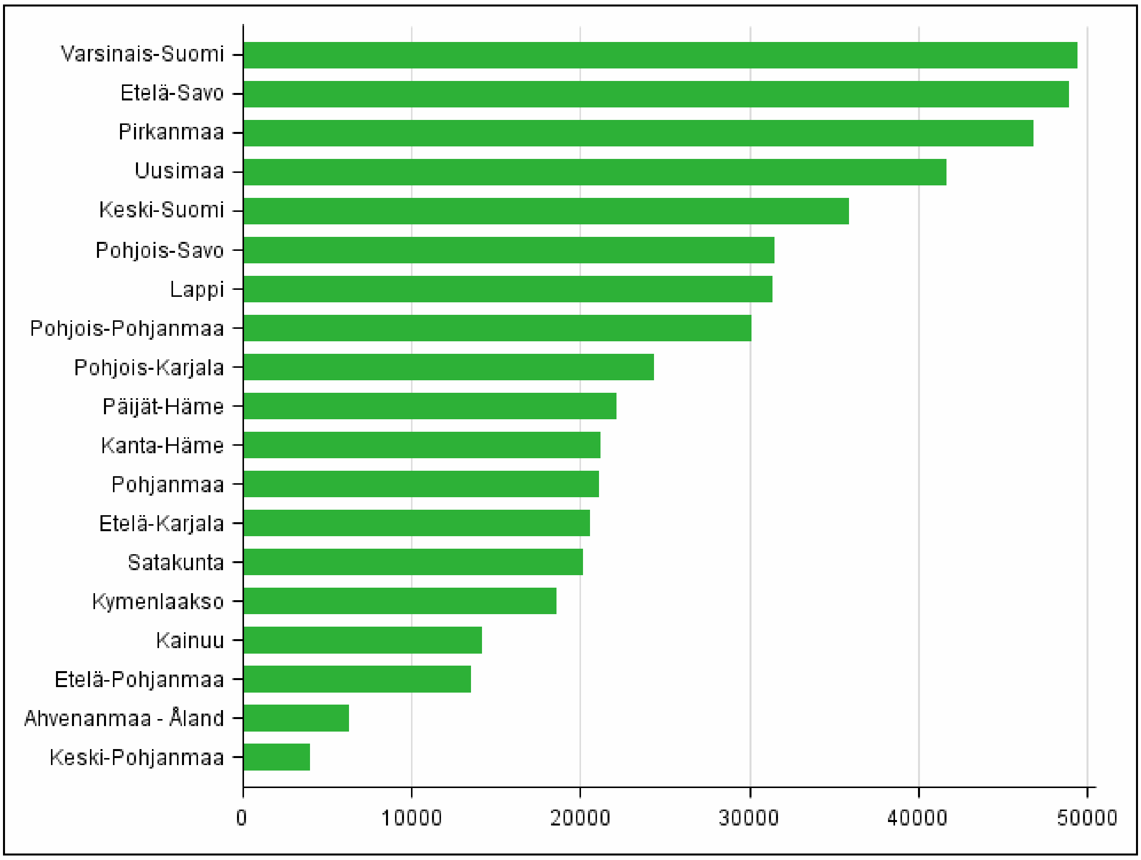

Figure 6: Summer cottages in Finland by region in 2014 (Tilastokeskus, 2015)

Finnish parliament required that the state would provide improved wastewater counselling after changes to the law on 2011. There is data available on this counselling after it spread to whole Finland in 2012. Total of 15 000 premises were visited by wastewater counsellors during years 2012 and 2013, with assessments done using common criteria in whole Finland. Residents were provided with written assessment of the current wastewater treatment system and also if needed, suggestions of how to improve the systems. Counselling was done with close co-operation with regional authorities and organisations. Wastewater treatment events have been organized to give general information about requirements, and there has also been help available through phone services (Kallio, 2014).

Table 1: Counselling results from 2013-2014 (Kallio, 2014)

	Assessment on the operational state of the wastewater treatment system	2012	2013
	Insufficient system	67%	67%

	Minor action required	17%	13%
	Sufficient system	14%	17%
	Only minor amounts of wastewater	2%	2%

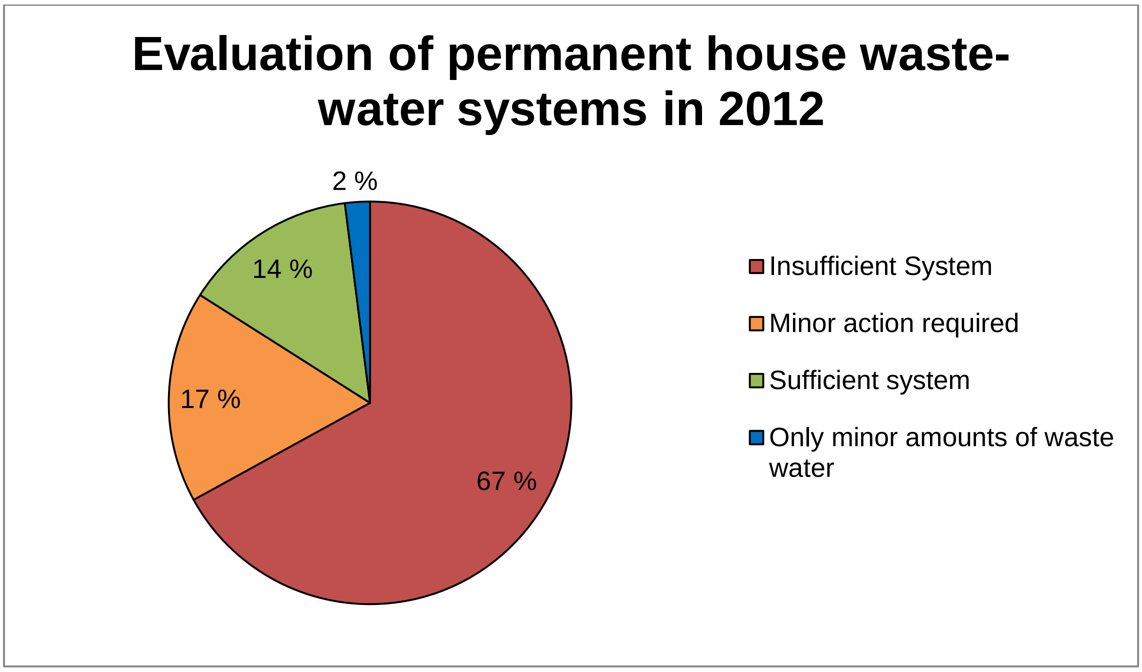

Figure 7: 2012 Situation of permanent houses (Kallio, 2014)

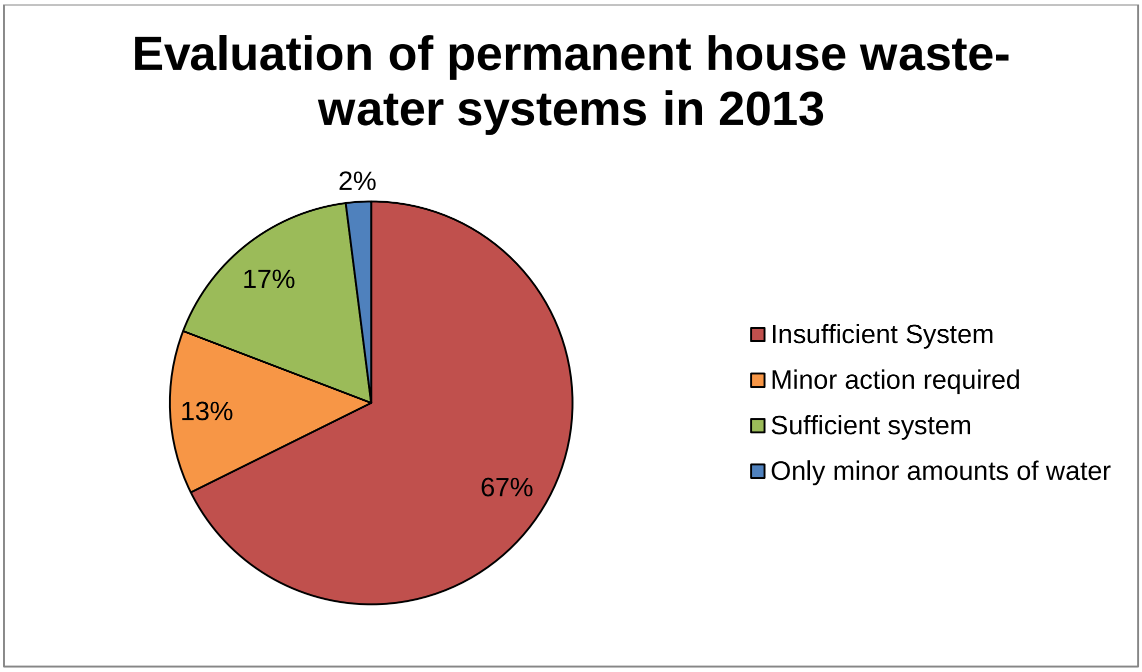

Figure 8: 2013 Situation of permanent houses (Kallio, 2014)

Situation in counselled permanent houses 2012 is shown in Figure 7 and the situation in 2013 in Figure 8. Most common form of the insufficient systems amongst permanent houses in areas of dispersed settlement was system with several septic tanks from which wastewater is lead into the soil (Kallio 2014). These kinds of houses are likely to be over 20 years old, as houses build or renovated since early – 90s started using infiltration systems. Tightening laws required all new houses, upon which building permit has been applied after 1th of January 2004, to use more efficient systems. Vacational houses with insufficient system often had a working water toilet, with septic tank treatment. Houses with minor action required often were often categorized by the counsellors to be using too much water compared to the treatment system (Kallio, 2014). Figures 9 and 10 show only minor changes between the different states. This might indicate that situation didn't improve but could also be just because of the small sample size.

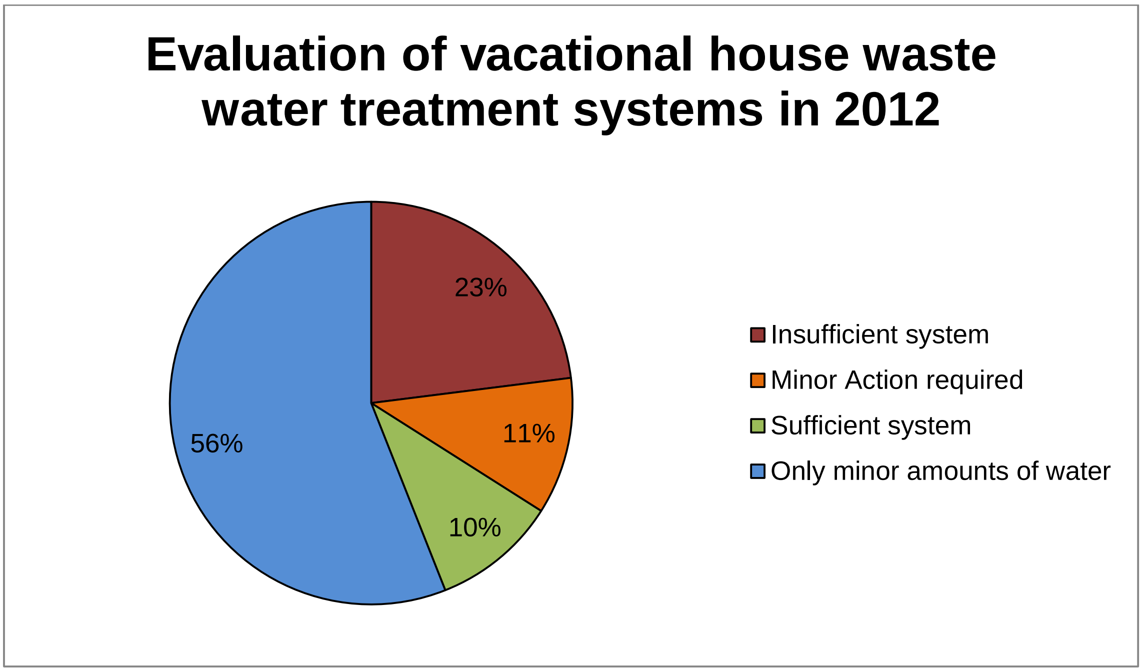

Figure 9: 2012 Situation of vocational houses (Kallio, 2014)

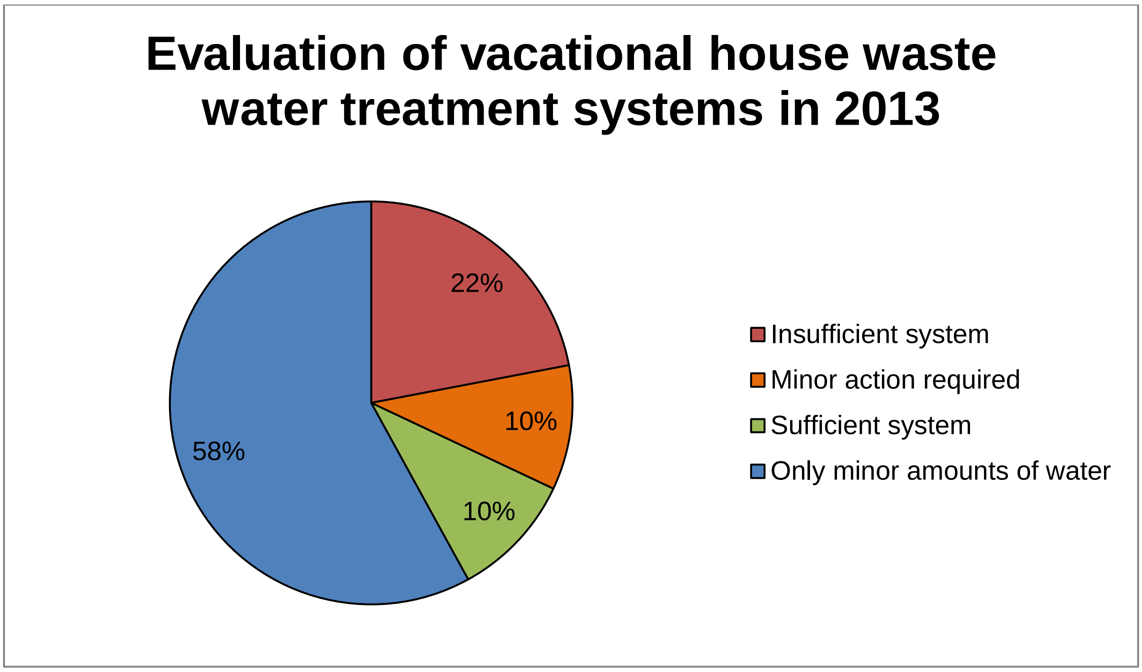

Figure 10: 2013 Situation of vocational houses (Kallio, 2014)

3.4 Situation example: Southwestern Finland

Southwestern Finland is a sizable region with plenty of coastlines and a large archipelago. It has substantial population, with most summer cottages of any region in Finland. Valonia has done multiple wastewater guidance projects in southwestern Finland during recent years. These projects, dubbed controlling dispersed settlements wastewater load by counselling, have offered nonaligned information and services for free. There is currently similar project ongoing for year 2015, but its data was not available at the time, mainly because the data gathering would continue to 2016. Data from 2014 is illustrated in the Figure 11 below.

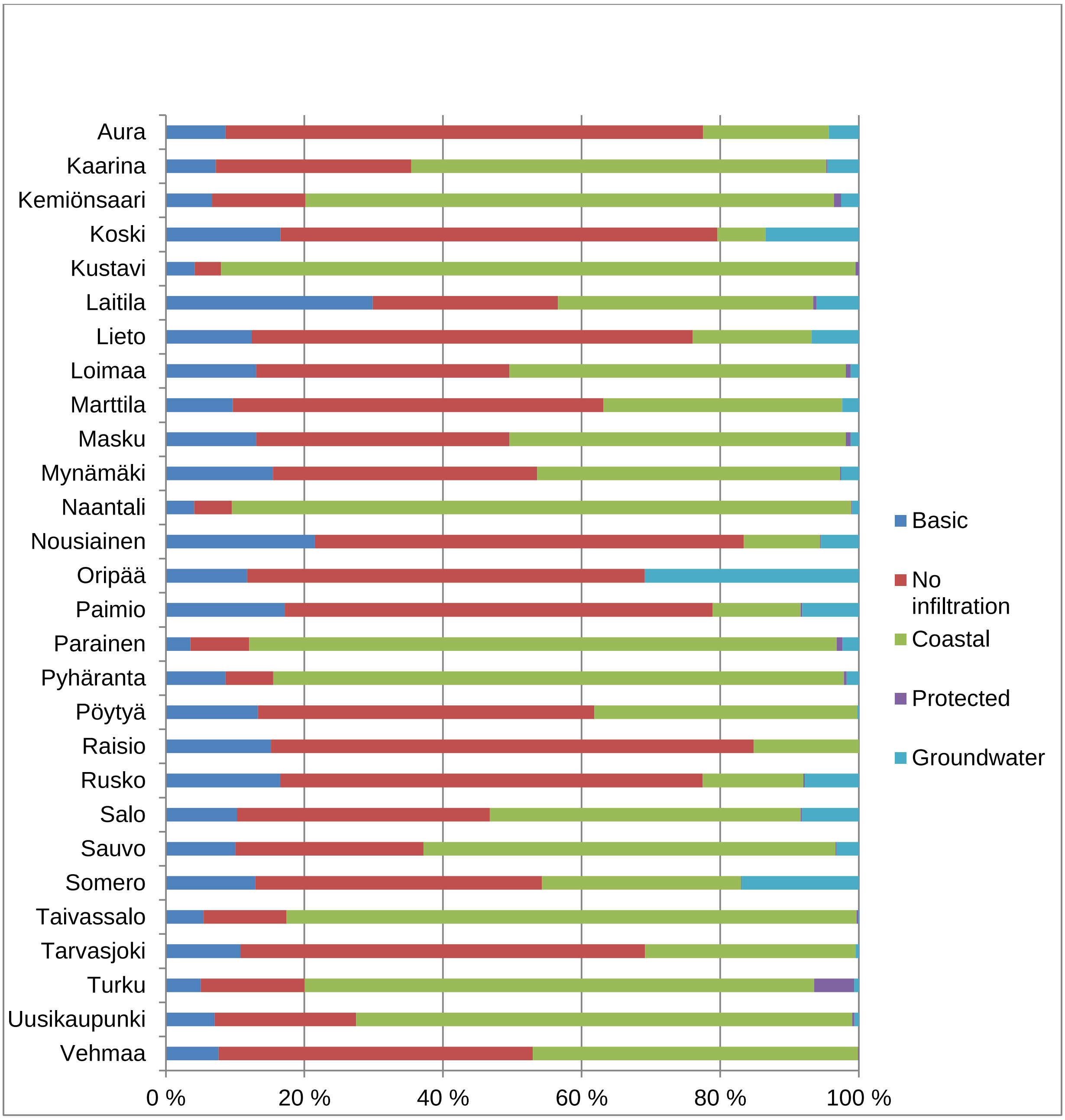

Figure 11: Buildings on areas of dispersed settlement in Southwestern Finland

There was total of 67 110 premises in areas of dispersed settlement in whole Southwestern Finland, with 40 466 of these being in vocational use or otherwise used only for part of the year.

Premises on groundwater areas are recommended to use cesspools which are then emptied using suitable machinery and transferred into municipal treatment (Hannuksela, M & Ryynänen, 2012).

Most of the premises were not situated near groundwater areas, but as large amounts were on coastal regions, would still be situated on sensitive area. Sensitive areas are subject to more demanding purification levels and the term is futher opened in the legislation part of this thesis.

In Southwestern Finland it appears to be common that infiltration methods cannot be used, with nearly 30% (19649) of premises falling into this gategory.

Premises located on ‘basic’ areas, are subject to the basic treatment levels and can use wide variety of different treatment options. Protected category refers to premises that belong to conservation areas, such as Natura 2000. These areas are recommended to use either small scale wastewater treatment unit or 3-way septic tank system followed by a drainage pipework (Hannuksela and Ryynänen, 2012).

Figure 12: Map of Southwestern Finland (Kela, 2015)

3.5 Market situation in whole Finland

According to Syke, in 2014 small residential homes in areas of dispersed settlement number at around 314 000, with 23 300 built after 2004 (Nurmio and Kallio, 2014). Groundwater areas contain total of 19 300 of these older homes. Sensitive areas i.e Coastal regions, when distance is set to 0 -300 meters, contain 46% or 113 600 homes (Nurmio, and Kallio, 2014). Table 2 shows the distribution of these 113 600 homes, when divided into distance groups.

Table 2: Residential homes in coastal regions (Nurmio, K & Kallio, J, 2014)

Distance to water	Percentage	Amount
0-50m	19,8 %	22 500
50-100m	20,9 %	23 700
100-200m	32,4 %	36 800
200-300m	26,9 %	30 600

Usually sensitive areas defined by metric distances to closest body of water or groundwater aquifer. Association of Finnish local and regional Authorities recommends that sensitive areas are defined by geographic data instead of the metric distances (Nurmio, and Kallio, 2014).

When results from wastewater counselling are applied to whole Finland, several facts need to be remembered. Firstly, counselling during 2012-2013 was done to total of 15 000 premises, which although a substantial amount, is nowhere near the total number of residential homes. Secondly, according to water protection association of river Vantaa and Helsinki region, residents partaking in the counselling in Tuusula tended to have more inefficient systems. Memorandum of wastewater situation by Syke (Kallio, 2014) estimated that this would lead to 55-67 % of dispersed settlement premises needing some sort of improvements. Residents exempt from requirements due to advanced age number at around 51 000, new sewer lines are connected to around 5000 permanent houses in dispersed areas. Making the number of permanent houses with at least minor modifications needed to the treatment system at around 89 000 to 124 000 (Kallio, 2014).

Working life of infiltration systems is something between 15-30 years. As infiltration systems became more and more popular in the 90s, the first systems are thus likely to be near the end of their working lives. Domestic biofilter can be used to update out of date system, possibly allowing the usage of the old infrastructure in the process.

Concrete septic tanks used in older houses, with or without infiltration system, need to be inspected properly if they are to be used as pre-treatment for domestic biofilter unit. Should the concreate tanks be in insufficient condition, for example because of rings moving out of place, attempts of refitting and sealing can be tried. In the case that such action is not feasible, plastic wells can be installed either inside the old wells or into a completely new location. Cost savings and less construction work should make usage of sound concreate wells an appealing option.

Summer cottages required to improve water treatment were estimated to be 22%, out of which 40 % required only to improve greywater systems (Kallio, 2014). This would be 8,8 % or 44 035 of the total 500 400 summer cottages. Water toilet with insufficient septic tank treatment was in around 13,2 % or 66 052 summer cottages (Kallio, 2014). These cottages with water toilet have potential to be customers to domestic biofilter, should they choose to keep the toilet in use.

Even remotely accurate estimation of potential yearly customers was not possible. Data about new treatment units per year could not be found for either permanent or vocational housings.

Several unanswered questions affect future market development:

-Can all areas of dispersed settlement maintain their population?

-How much will water service networks expand in the future?

-Average owner age is high; will all summer cottages remain in use?

-Does increased summer cottage area lead to better equipped cottages?

-How will water toilet amounts in summer cottages change?

4 Relevant legislation

4.1 Background

Water toilets gained popularity in areas of dispersed settlements in the late 50s. These lead officials to demand usage of settling tank systems to treat related pollutions. Water act 264/1961 concerning septic tank treatment came into effect 1st of April 1962 (HE 179/2010). Water authorities released technical drawings of concreate septic tanks to be used as model solution, leading to widespread usage (Ympäristöministeriö, 2011).
Environmental protection act 86/2000 set a common responsibility to lead and treat household wastewaters so that they don't cause pollution of environment. Water toilets and other household waters had to be treated before being lead into soil, water body or any other reservoir. Minor amounts of non- toilet waters could be lead into soil if there was no risk of environmental pollution (Ympäristöministeriö, 2015a). Finnish government gave a decree 542/2003 on household water treatment in areas without sewer systems, which became effective 1st of January 2004. This decree provided transition time of 10 years for wastewater treatment systems that were in operational condition, so that by 1st of January 2014 all systems were to fulfil requirements of decree 542/2003.

4.2 Current legislation concerning dispersed settlement

Water services act 119/2001 states that water service network should cover areas where it is necessary to connect in due to development or planned development of community. Obligation to join such networks doesn't apply if it would become unreasonably expensive, exemption doesn't jeopardize water services and hazards to environment can be avoided (11§, 119/2001).
Household wastewater treatment requirements are treated in two different legal documents; Environmental protection act 527/2014 and Governmental decree on treating domestic wastewaters 209/2011 (ELY, 2014). Environmental protection acts purpose is to prevent pollution of environment, along with reducing emissions and to remove problems caused by contamination. Act further aims to provide people with safe, enjoyable and sustainable environment. It promotes sustainable use of natural resources along with

reduction of waste amounts and hazardousness. Preventation of climate change and improved evaluation of potential environmental polluting activities

Governmental decree uses load numbers for areas of dispersed settlement, against which the minimum removal levels must be achieved. Load numbers are a reference point, resembling untreated wastewaters from areas of dispersed settlement. These load numbers are listed in the table 3. To calculate removal levels for a wastewater treatment system, estimations of inhabitants and their daily water consumption must be done. Measurements of organic substances, total phosphorus and total nitrogen from effluent samples are also needed.

Substance load number is multiplied by inhabitants, and load result is in grams per day. Measurement results are multiplied by daily water consumption and compared to the load result. Removal level obtained this way is compared to desired treatment level. Minimum treatment levels are listed in table 4 and sensible area levels in table 5.

Table 3: Load numbers for areas of dispersed settlement (2§, 209/2011)

Environmental load	Load numbers
Organic substances	50g / BOD_7
Total Phosphorus	2,2g / day
Total Nitrogen	14g / day

Table 4: Household water minimum treatment levels (3§, 209/2011)

Environmental load	Minimum removal level
Organic substances	80%
Total Phosphorus	70%
Total Nitrogen	30%

Table 5: Sensitive area requirements (4§, 209/2011)

Environmental load	Minimum removal level
Organic substances	90%
Total Phosphorus	85%
Total Nitrogen	40%

A term sensitive area is no longer used in the newest Environmental protection act of 527/2014, even though Governmental decree 209/2011 specifically refers to such areas and to their explanation in the act.

Currently wastewater treatment legislation of dispersed settlement states that all premises in the areas should have proper systems by 15th of March 2018. There are several cases where exceptions can be made including if owner is born before 9th of March 1943. Authorities can also grant exemption from the requirements due to life condition, such as long-time unemployment or medical condition (Ympäristöministeriö, 2015b).

4.3 Future legislation

Legislation regarding wastewater treatment in areas of dispersed settlement is set to face changes by the new Finnish government of 2015 lead by Prime Minister Juha Sipilä (Valtioneuvoston Kanslia, 2015).
Government programme records state that the environmental protection act would be made more reasonable and clear with changes specifically to chapter 16. It is written in the government programme records that households build before 2004 would no longer have deadline for wastewater treatment modifications. Household treatment systems would be inspected when work requiring building permit is done in the premises (Valtioneuvoston Kanslia, 2015).

Committee set by Ministry of the Environment to assess the changes has given three suggestions on how to moderate wastewater treatment requirements. All three options would include a incentives for treatment unit renovations and to include design work to household deductions. First suggestion is similar to the government programme, allowing premises built before 2004 to delay improvements until work requiring building permit is done. Sensible area criteria would be stated in environmental protection act, but municipalities could define areas themselves (Ympäristöministeriö, 2015a).

Second suggestion doesn't differ from the first, except that the sensible area criteria would be defined in detail in the act and purification requirements would be same as in regular areas. Municipalities could still impose more strict requirements for both purification levels and distancing (Ympäristöministeriö, 2015a).

Third suggestion would be to loosen criteria for exceptions in cases with advanced age or unemployment involved. This would make even a single condition, like age, enough reason to grant the exception. Included in the legislation would also be possibility to grant exceptions in case of low number of residents. It is stated in the committees report that the third suggestion could be used together with the first or the second one (Ympäristöministeriö, 2015a).

5 Measurements

Measurements were done to acquire data that could be used to determine whether the prototype Domestic biofilter at Rajamäki was working as intended, and if any modifications had to be done. Modifications could be because of design fault or because the prototype was built on top of old wastewater treatment testing unit with multiple existing in and output lines, making it non-deal in a sense that it required a lot of extra components to make it work as a testbed for the prototype.

5.1 Water quality parameters

Several different types of substances were analysed from samples taken from the Domestic biofilter. Raita Environment had Hach DR 890 Portable Colorimeters that had previously been used for monitoring purposes. These colorimeters were now turned to provide this thesis with constant flow of indicative data about the performance of the prototype device. Also data was obtained from Valonia, who took samples which were then analysed at Rambol's water laboratory in Lahti. Analysis results for samples of given three days are found from appendixes 1-3. These samples were more thorough fully analysed in a qualified water laboratory in order to obtain information regarding parameters that could not be measured with colorimeters for various reasons.
These reasons include the fact that there is no laboratory in any of Raita's offices and thus no equipment and chemicals to make necessary corrections needed for some of the colorimeters programs. Sufficient amounts of Hach reagents were available the three programs mentioned below.

The following measurements were made a total of 28 times with the colorimeter:

- Ferrous Iron
- High Range Nitrate
- Reactive Phosphorus, Orthophosphate

Measurements done in the water laboratory, total of 3 times

- Enterococci
- Pre-treatment filtration
- pH
- Suspended Solids
- BOD 7-ATU
- Nitrate as nitrogen, NO3-N
- Ammonia as nitrogen, NH4-N
- Total Phosphorus
- Soluble Phosphorus

5.2 Key parameters

5.2.1 BOD 7 ATU

BOD or ‘Biological oxygen demand’ is a parameter used to monitor organic pollution in surface and wastewaters. Determining the BOD requires measurement of the dissolved oxygen that is used by microorganisms to biochemically oxidize organic matter.
BOD is used widely to measure efficiencies of treatment processes and to dimension wastewater treatment facilities, along with approximating quantity of oxygen needed to biologically stabilize organic matter (Burton, Stensel, and Tchobanoglous, 2004).

5.2.2 Suspended solids

Wastewater has several important physical characteristics, with total solids content being one of them. There is usually is a wide variety of solid materials in wastewater from colloidal materials to larger objects such as rags. In larger plants coarse materials are removed in the first steps of the purification process. It is unlikely that larger objects would become concern for single apartment treatment systems because the process is usually taken care by the residents themselves. Different kind of particles from various sources are, however, likely to be present in most wastewaters (Burton, Stensel, and Tchobanoglous, 2004).
Total suspended solids (TSS) are measured using filters of varying pore size to separate TSS from total suspended solids (TDS). Whatever solids remain in the filter after filtration

are then dried in preweighted container at constant temperature to determine TSS. Significance of TSS tests used can be considered low due to non-standard types of pore size and filter paper used, as well as due to unknown number and size distribution of particles contributing for the measured value. Tests for TSS are widely used in conventional treatment processes, despite the many problems associated with them (Burton, Stensel, and Tchobanoglous, 2004).

5.2.3 Enterococci

Bacteria that is abundant in human and animal feces, but also found in soil and vegetation. Enterococci live in the gastrointestinal tracts numerous different warm-blooded animals, including humans. Term 'Enterococci' refers to a group of gram positive and non-spore forming bacteria. They are regularly used as fecal indicator bacteria to assess water quality. It has been found that there is a correlation with high concentration of enterococci in recreational waters and gastroenteritis cases on humans (Burton, Stensel, and Tchobanoglous, 2004).

5.2.4 Definition of pH

Simply put, the pH means negative logarithm of hydrogen ion concentration. Its importance derives from many different factors when looking from wastewater engineering viewpoint. Most biological life exists in pH range of 6 to 9, with extreme pH wastewaters being very difficult to treat with biological means (Burton, Stensel, and Tchobanoglous, 2004). Solubility of chemical constituents and their biological availability in water is determined using pH, with basic range of pH being from 0 - 14. Values below 7 are considered to be indication of acidity with values greater indicating alkalinity (USGS, 2015).

5.2.5 Forms of nitrogen & nitrogen cycle

Nitrogen is present in terrestrial and aquatic environments in several different forms. It makes up to up to 76% of earth's atmosphere by weight % and 78 % by volume (O'Neill, 1998).

Most common forms in wastewaters include ammonia (NH3), nitrates (NO3) and nitrites (NO2). Fertilizers containing inorganic nitrogen and wastes containing nitrogen are decomposed in soil to form ammonia. Ammonia can then oxidize to form the two other common forms, nitrate and nitrite. Decaying plants contain complex molecules that are converted by biological organisms to simpler ones. This process is called *Ammonification*, and it results in either ammonia or ionic ammonia, ammonium (NH4-). For example, conversion of urea to ammonia can be used as example of such process (equation (1)).

$$(NH_2)_2CO + H_2O \rightarrow 2NH_3 + CO_2 \quad (1)$$

Conversion of ammonium (NH4-) to nitrate, also called *Nitrification*, (eq 4.2 and 4.3) is a major part of nitrogen cycle.

$$4NH_4^+ + 6O_2 \rightarrow 4NO_2^- + 8H^+ + 4H_2O \quad (2)$$

$$4NO_2^- + 2O_2 \rightarrow 4NO_3^- \quad (3)$$

Nitrates are both beneficial and harmful to the environment. Many plants use nitrates in synthesis of organic nitrogenous compounds, thus nitrogen is major contributor to plant growth. They can, however, cause water quality problems if present in significant amounts due to their eutrophication accelerating property (O'Neill, 1998).

Nitrate can be used by organisms to produce dinitrogen (N2). This can occur in both aerobic and anaerobic conditions, in anaerobic; some organisms can replace oxygen with nitrate. This reaction is called *denitrification* (e.q 4.4)

$$5CH_2O + 4NO_3^- + 4H^+ \rightarrow 2N_2 + 5CO_2 + 7H_2O \quad (4)$$

5.2.6 Phosphorus

Phosphorus is essential to all life due to being component of energy transferring molecules such as ATP and genetic information molecules DNA & RNA. It can be limiting factor in soil and ocean fertilities. Large amounts of soluble phosphorus to water bodies will often cause fast-growing algae to bloom. This causes greenish colour to the surface and limits light transmission. Sewage disposal, phosphorus containing detergents and suspended particles by erosion are possibly one of the major sources (O'Neill, 1998).
Three common forms for element Phosphorus in aquatic solutions include orthophosphate, polyphosphate and organic phosphate. These forms are all of some importance to establishing the water quality, with orthophosphate being the most important. In this experiment Orthophosphate was measured, since it can be used in biological metabolism without further breakdown (Burton, Stensel, and Tchobanoglous, 2004).

Soluble phosphorus of the water lab measurements is filterable or soluble orthophosphate, with total phosphorus being both orthophosphate and organic phosphates (FAO, 1987).

Common forms of orthophosphate (Burton, Stensel, and Tchobanoglous, 2004)
PO_4^{3-} HPO_4^{2-} $H_2PO_4^{-}$ H_3PO_4

5.3 General factors affecting the measurement results

Measurements made by the author himself, for example colorimeter and infrared sensor measurements, were done with uttermost care. Nevertheless, human error in results cannot be left out, especially as most of the work was of repeating nature and done in the end of the workday. Also the author, an engineering student, even with some laboratory experience, is by no means equal to an experienced chemist or sampler.
As the measurements were field measurements, there were great many factors that could have affected the results.
Shaking and mixing of samples was done by hand, making every mixing occasion unique. Sampling routine changed from 30th of September onwards to include proper cleaning of the sampling vessel, as build-up of residues to the walls could affect measurement results.
Measurements done by the author served only to follow trends and as indicative of changes, and because of these reasons, the exact numerical results were not of great importance.

5.4 Measurement methods

Field measurements were done from using Hach DR890 portable colorimeter and accompanying 25mm round glass sample cells. Water pH was estimated with pH paper having range of 6,0 to 7,7 pH.
Timeframe of the field measurements was from 7th of September to 2th of December.
Measurements were done twice a week, on Mondays and Wednesdays. These field measurements were also done during the three Valonia Exact times of the measurements varied, but total time spent on each occasion was approximately one hour. During first weeks they were done around 5 pm, but this was later changed to start at 3 pm to follow changes in authors working hours.
Samples were taken from domestic biofilter projects third well, from which the water is then lead into sewer system. Pipe leading into the third well had a 10l bucket for sampling

and a smaller jar for monitoring. Sampler was a rod with length of 1.5 meters ending into a half litre bottle with top cut off.
Sampler was dipped into the bucket couple of times and was then lifted off full of effluent water. After two full sampler bottles were emptied into clean jar, the sample was taken inside and analysis begun.

The typical procedure was following:

1) Inspecting glassware & equipment condition
2) Cleaning of equipment
3) Taking water sample from the third well
4) Pouring sample into glass jug
5) Sampling of Iron
6) Sampling of Nitrate
7) Sampling of Phosphorus
8) pH measurement with pH paper
9) Through cleaning of the equipment

5.5 Measurement data and results

Actual data obtained can be found from appendixes, as it is not beneficial to show it among the text. Graphs made out of the data are found below to illustrate changes and for explanationary purposes. Total amount of water that had been used in the two halls at Rajamäki was 24,4113 m3 during a period of 7th of August to 2nd of December. Some water was used for cleaning purposes and thus didn't go through the full process. Raw estimation of such cleaning water amounts could be somewhere between 1,5-2,0 m3.

Rajamäki facility was occupied and mainly used during work hours from 8-16, but sometimes there were people staying all night. Wastewater entering the system varied greatly, both in amounts as seen in Figure 16 and in contents. Main wastewater source was thought to be use of water toilets by workers of the facility. Urine contains organic matter, including large amounts of nitrogen-rich urea.

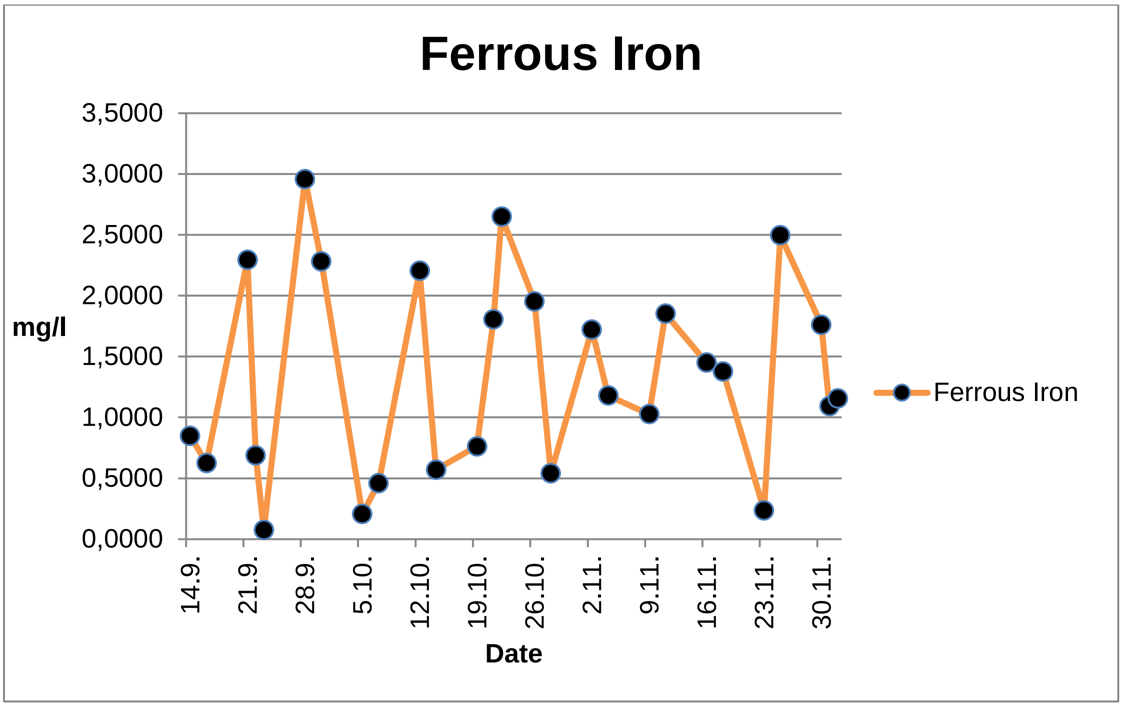

Figure 13: Ferrous iron field measurements sorted by date

Ferrous iron produced reasonable results throughout the testing period, with all values falling between 0,075 mg/l and 2,95 mg/l. Average ferrous iron concentration was 1,33 mg/l and median value was 1,16 mg/l. Data shown in Figure 13 above lead to several different actions, that changed or modified the prototype, in case of ferrous iron these modifications were mainly related to chemical input. During early part of the measurements, emphasis was placed on finding correct amount of Rake chemical fed into the system and to ensure that the domestic biofilter project would start to operate as intended.

No iron or iron compounds were tested from the three Valonia samples, so they cannot be analysed for accuracy and validity through that way. Analyses of the Ferrous iron relationship to orthophosphate were done, however, and the results are displayed in the Figure 14. Orthophosphate results are not directly comparable to total phosphorus removal required by the legislation in chapter 4 of this thesis. Orthophosphate is, however, the most readily available phosphorus source for algae and plant growth. Calculated legislation limit for total phosphorus and the orthophosphate measurements are shown in Figure 15.

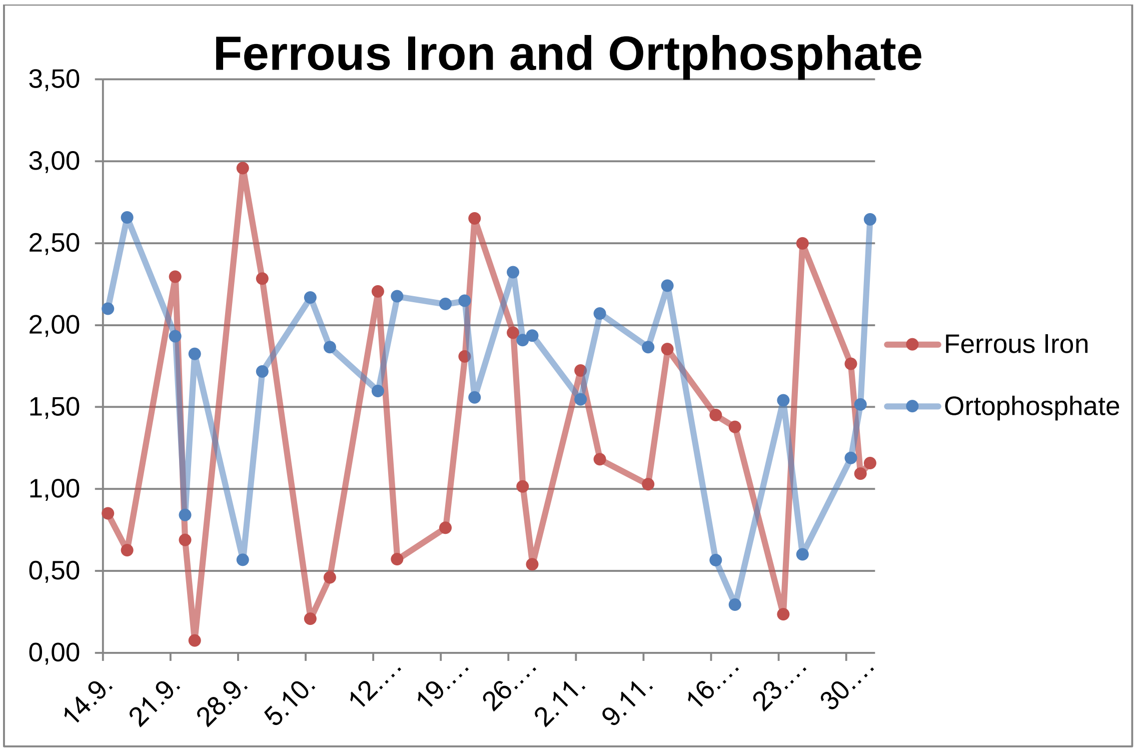

Figure 14: Ferrous Iron and orthophosphate sorted by date

From the Figure 14 above, some correlation between ferrous iron and orthophosphate levels can be seen. Several measurement results cannot be explained with the data collected from the experiments. Orthophosphate levels should not be high, if ferrous iron levels were also in the upper range. Different iron sulphates are a primary coagulants used widely in wastewater treatment to remove phosphorus.

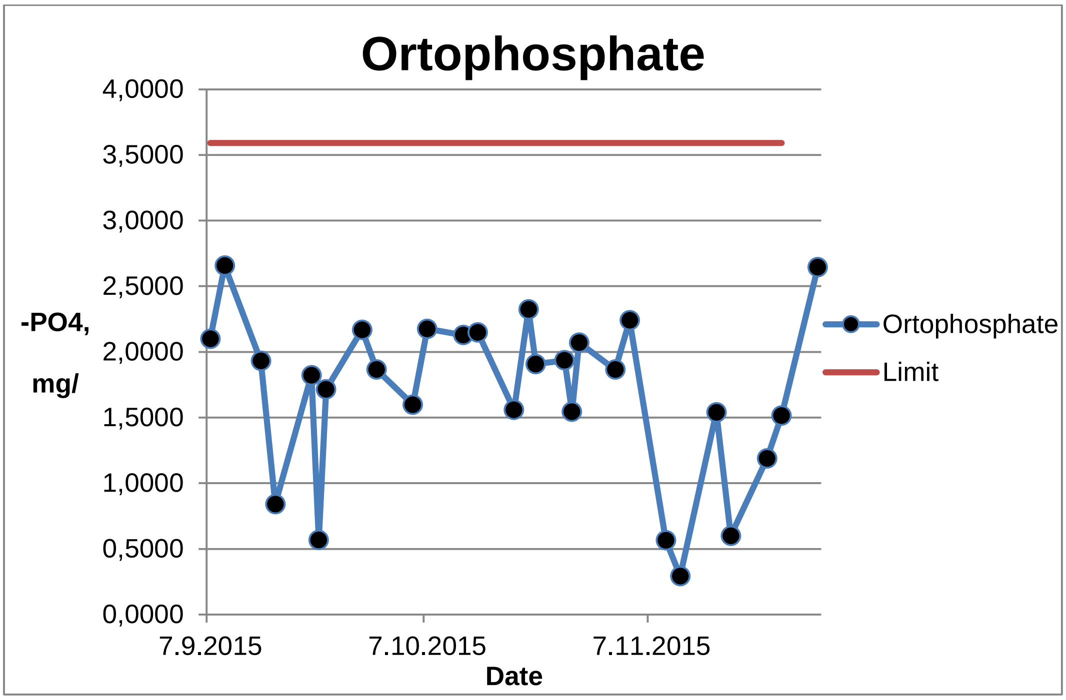

Figure 15: Orthophosphate field measurements sorted by date

At first the amount of chemical entering the system was extremely high because of a mistake in the building part. Because of the mistake, the chemical pump dosed ferric sulphate into the system at great pace, which emptied an entire 20 litre canister during a period of one day. This much ferric sulphate disturbed the measurements of 14th and 16th of September, with at least nitrate results being completely useless. Ferric sulphate is highly acidic and caused the pH to decrease below 6. These accidents lead into cleaning of second and third wells using fire hose and additional pumps on 22th and 23th of September. Ferrous Iron concentrations were, however, not decreasing, and it was decided on 28th of September to replace Rake Chemical with regular tap water, as it was likely that some amounts iron compounds were still present. Also additional adjustments were done to decrease the chemical pump dose rate. Ferrous iron levels dropped significantly in measurements of 5th and 7th of October after ending the chemical dosing, indicating relationship between the two. Most ferrous iron could thus be from the Rake Chemical and not introduced from soil by rainwaters. Chemical dosage was continued 12th of October, using a 1 litre container with measuring scale.

There appears to be clear correlation between Rake chemical dosing levels in Figure 16 and Orthophosphate measurements in Figure 17. Whenever chemical was dosed in large amounts relative to the flow rates the orthophosphate levels dropped. Flow rate and chemical relationships are not straightforward, as some of the water usage shown in the flow meters didn't necessarily end up going through the system.

Phosphorus levels in wastewater, when field measurements are compared to lab results, demonstrated correlation as well by similarity in trends. Orthophosphate and soluble phosphorus correlate as shown by Figure 18. Field measurements were several orders of magnitude higher than lab results, which might be due to interference or measurement error. Total phosphorus stayed well below 3,587 mg/l, which would be the legislative limit value for treatment unit in sensitive area working with on average 3,5 persons and 92 litres per day per person.

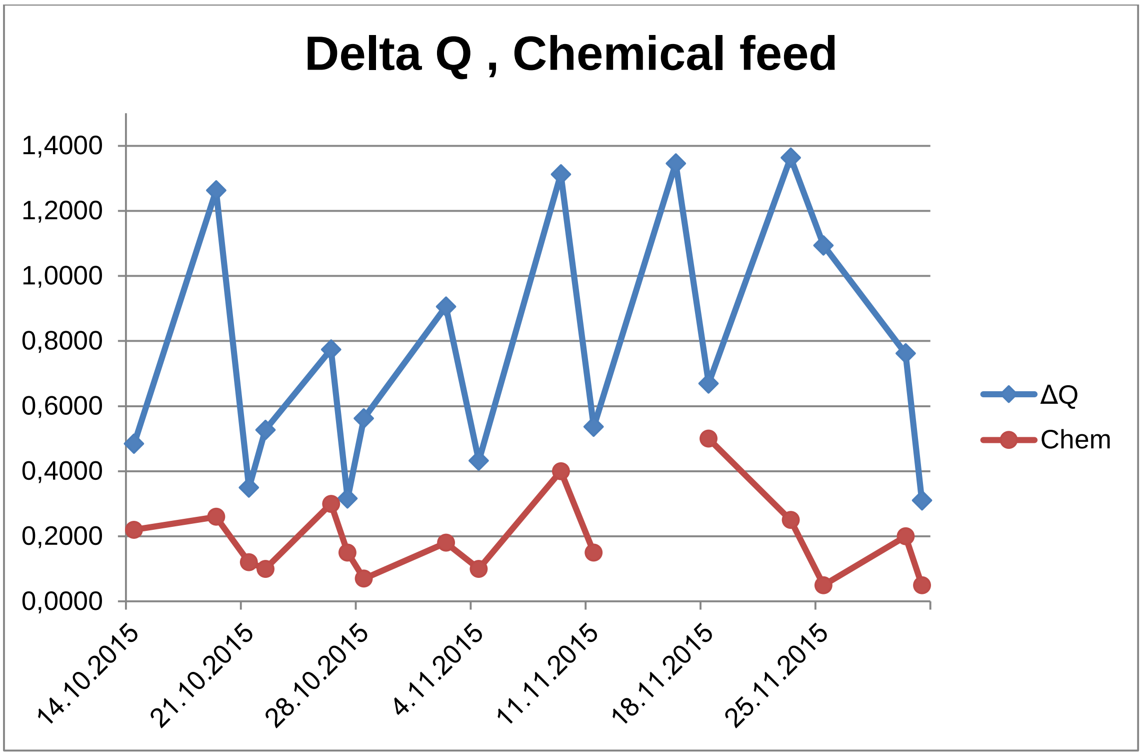

Figure 16: Water usage and chemical dosing 14.10 onwards

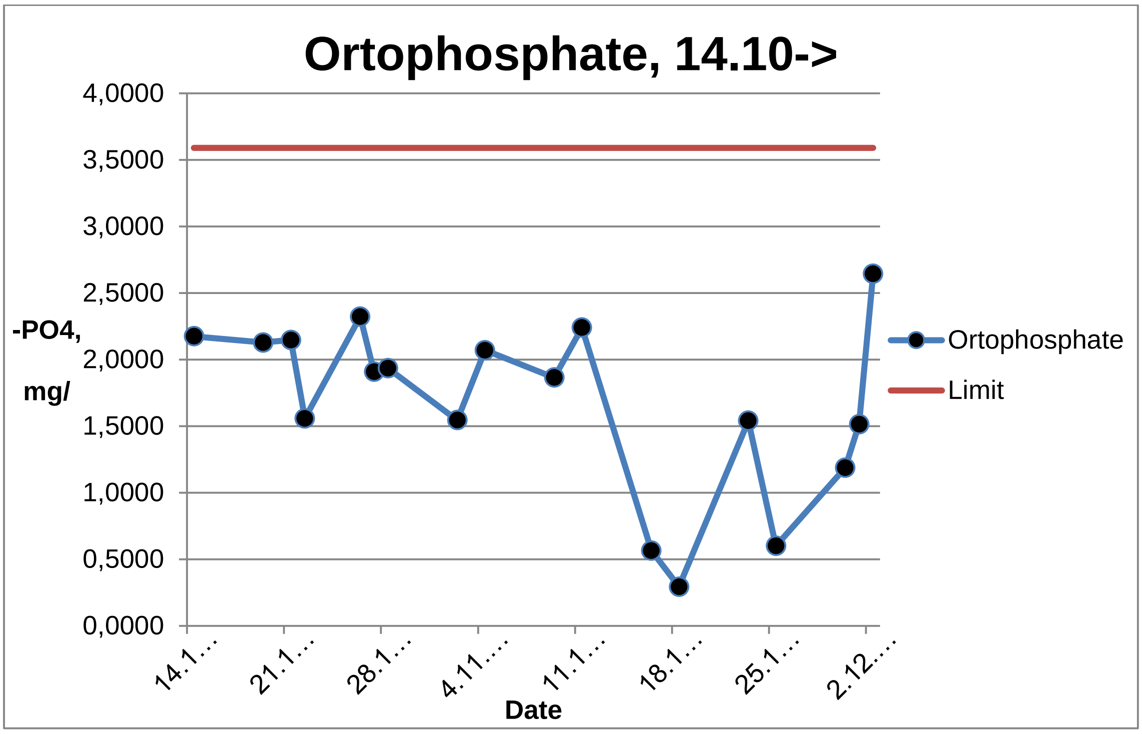

Figure 17: Orthophosphate measurements 14.10 onwards

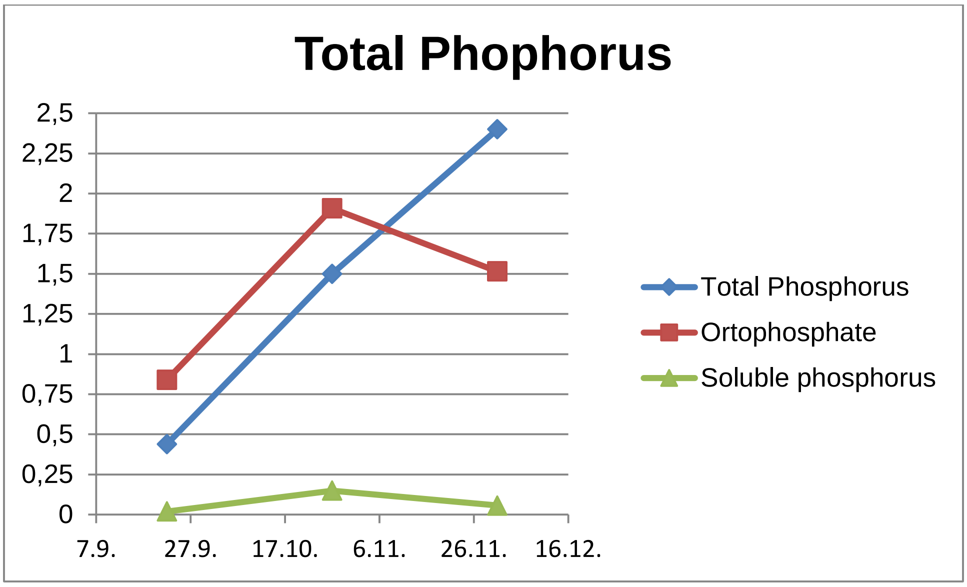

Figure 18. Phopshorus field and lab measurements

Effluent water pH data is shown in the Figure 19. Field measurements and lab measurements were quite close, with only difference of 0,2 pH. Lab result from 22 of September, pH 3, is not show in the figure for illustrative reasons. Field pH measurement of the date indicated very clearly that pH was low and the lab result confirmed this. After 21th of September and the extensive cleaning operation and dosing of water the pH remained within acceptable values. Comparison gives no reason to suspect paper accuracy and thus it can be stated that pH was within optimal range after the chemical accident.

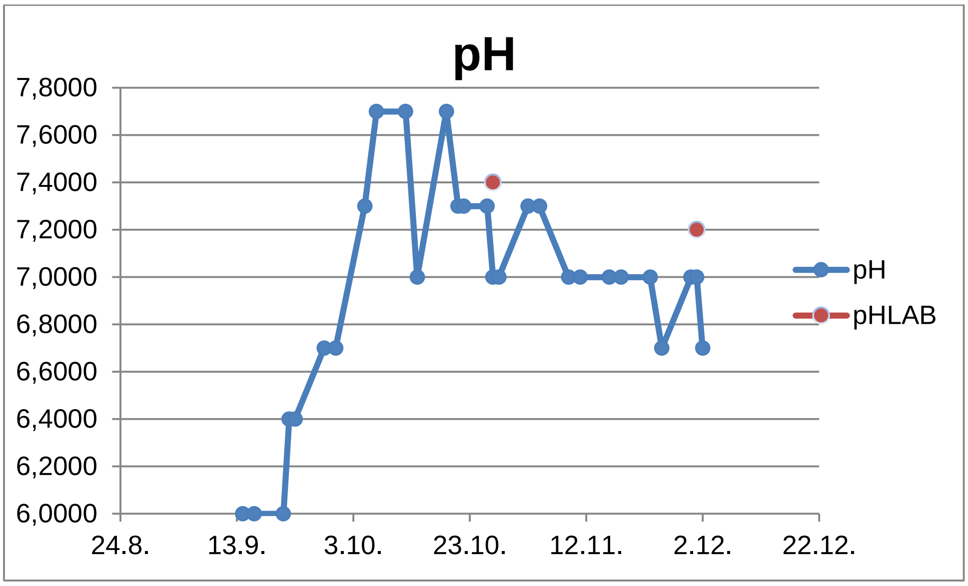

Figure 19. pH field and lab measurements

Nitrate (NO3-N) measurements yielded several times values below the lowest measurable value of the Hach field device (Lim 0,0 – error). This might be due to measurement error or some substance in the effluent interfering with the reagent. It is stated in the Hach manual (Hach Company, 2013) that at least extreme sample pH or high buffering capacity, along with ferric iron concentration can cause interference. It is, nevertheless, also possible that domestic biofilter's bioreactor is just working better than expected when it comes to amounts of Nitrogen in Nitrate form. Nitrate results are shown in Figure 20.

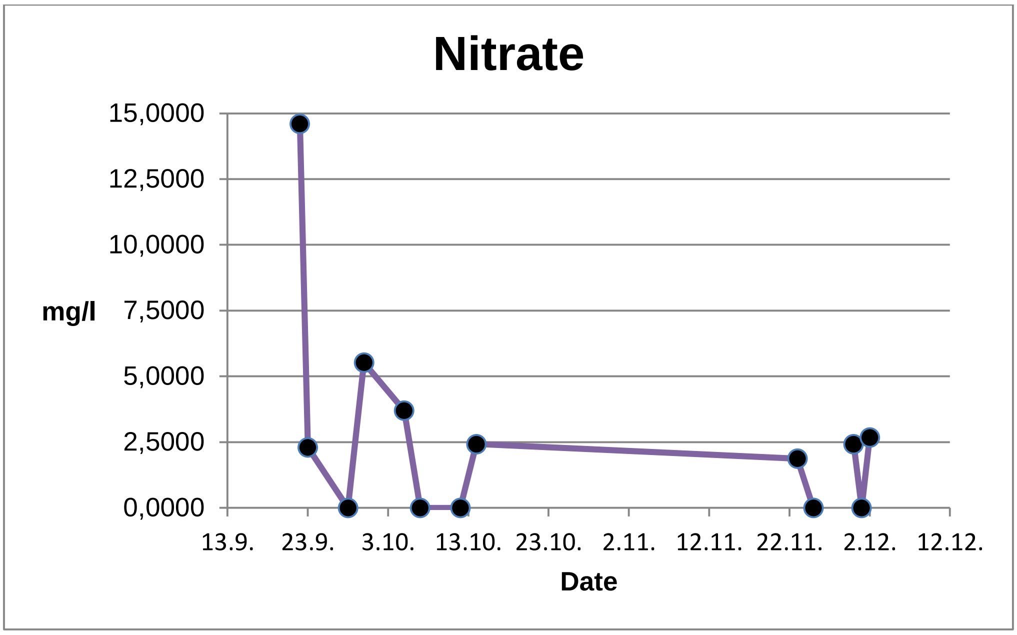

Figure 20. Nitrate field measurements

Nitrogen results from Valonia, shown in table 6, indicate that most nitrogen is in ammonia-nitrogen form, at least during lab sample days. Nitrate-nitrogen was below 0,25 mg/l, indicating that *Nitrobacter* bacteria populations that convert nitrite to nitrate might not have formed properly. It is, however, possible that this might indicate denitrification activity, which could have turned nitrates into nitrogen gas (e.g 4.4). (EPA, 2000).

Table 6: Water laboratory measurements

	22.9.	27.10.	1.12.	
Enterococci	2000	29000	7600	pmy/100ml
pH	3	7,4	7,2	
Solids	77	73	110	mg/l
BOD 7	**3,6**	**61**	**48**	**mg/l**
Total Nitrogen	**7,5**	**110**	**79**	**mg/l**
NO3-N	0,25	0,25	0,25	mg/l
NH4-N	6,7	110	72	mg/l
Total Phosphorus	**0,44**	**1,5**	**2,4**	**mg/l**
phos, solub	0,02	0,15	0,057	mg/l

Calculations regarding Governmental decree 209/2011 were done by Valonia using 3,5 persons per day, leading into average water consumption of 92 litres per person each day. Sample statements by Valonia are shown in appendixes 5-7. Overall all three Valonia samples showed very good results, numerical results are shown in table 6. According to Valonia statements, two out of three samples passed the required purification levels even for sensitive areas! Valonia sample statement of 27.10.2015 showed Nitrogen removal level of slightly below minimum requirements, but good to excellent results with BOD and Phosphorus.

Enterococci and Nitrogen amounts of 27.10 might indicate that the system had received wastewater containing large amounts human waste in short period of time. It might also indicate that the bioreactor hadn't received optimal amounts of air and was in anaerobic state.

Further testing could be done with some modifications and equipment checks to see if this affects the results. Field measurement gear and reagents should be thoughtfully inspected before new tests. Bioreactor medium could also be lifted and condition of the material checked. Small scale aeration could be attempted in the first septic tank of the prototype to counter possible excessive organic loadings that can cause odours. Ideally before the domestic biofilter, there would be more than one septic tank to reduce organic load by anaerobic digestion, but this was not possible in the testing ground. Tests with different non-acidic and non-iron based coagulation agents could be tried to see if it would affect purification results.

6 Conclusions

Project Domestic Biofilter seemed to go mostly well. Building part was finished in time, but the author should have checked the instructions better to avoid time consuming modifications and measurement errors during the first weeks.

There is definitely going to be markets for any derivatives of this project prototype. Even with fierce competition of different types of overlapping wastewater methods, the advantages of such technology package using well tested and established trickling filter principles are undeniable. Systems with old concreate septic tanks were widely used in the past but do not meet today's requirements. Customers could potentially save time and reduce the amount of work by installing Raita Environment's domestic biofilter to these systems.

The possibility of using same product with small modifications for either large amount of greywaters or to treat all household waters should provide satisfactory market size. Permanent houses in areas of dispersed settlement without adequate system could have been as high as 124 000 in 2014. Summer cottages needing some kind of treatment system improvements were around 110 088, with 44035 needing improvements to greywater system. Estimation of potential yearly customers could not be determined, due to lack data, such as the number of wastewater treatment unit installation per year.

The domestic biofilter project did suffer from some drawbacks with the measurement results, with a large amount of nitrate field measurements failing. Nitrogen types measured in water laboratory did, however, show promising purification results. Removal efficiency of biological substances and phosphorus was great, fulfilling required levels in all three tests. Orthophosphate levels also stayed well below total nitrogen limit values in the field measurements, demonstrating that Raita Environment's biofilter substantially reduced nutrient loads to the environment. Field pH data further supported water laboratory measurement results that indicated biological activity in the prototype Bioreactor.

There is potential to increase total nitrogen removal substantially by concentrating attention to ammonia-nitrate removal. Introducing a different coagulation agent that does not affect pH so drastically, and improving dissolved oxygen levels could be a starting point (EPA, 2000). Also care must be taken to properly insulate the system for winter time usage to allow bacteria to function. These kind of improvements would need further testing with a similar or longer timeframe.

As the prototype demonstrated good to excellent purification results in an unorthodox testing environment comprising of two industrial halls, it is likely to perform equally well in more conventional places.

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Appendix 1. Research certificate 22.9.2015

Ramboll Analytics

Tutkimustodistus

Projekti: 1510010632/50

Pvm: 9.10.2015

1/1

RAMBØLL

Turun kaupunki, ympäristösuojelutoimisto / Valonia
Jarkko Leka
Vanha Suurtori 7
20500 TURKU

Tutkimuksen nimi:	Valonia, Näytteenotto 2014-16, jätevesinäytteet		
		Näytteenottopvm:	22.9.2015
Näytteenottopiste:	Rajamäki (Tuotantolaitos)	Näyte saapui:	23.9.2015
Näytteenottaja:	Jarkko Leka	Analysointi aloitettu:	23.9.2015

Jätevesi

Määritys	**15JJ02036**	**Yksikkö**	**Menetelmä**	
Enterokokit	2000	pmy/100 ml	ISO7899-2*	L
Esikäsittely, suodatus (0,45 µm)	ok			L
pH	3,0		RA2000*	L
Kiintoaine (GF/A)	77	mg/l	RA2029*	L
BOD 7-ATU	3,6	mg/l	RA2006*	L
Typpi (N), kokonais-	7,5	mg/l	RA2021*	L
Nitraattityppi (NO3-N)	<0,25	mg/l	RA2018*	L
Ammoniumtyppi (NH4-N)	6,7	mg/l	RA2034*	L
Fosfori (P), kokonais-	0,44	mg/l	RA2009*	L
Fosfori (P), liukoinen	<0,020	mg/l	RA2009*	L

* FINAS -akkreditoitu menetelmä. Mittausepävarmuus ilmoitetaan tarvittaessa. Akkreditointi ei koske lausuntoa.

Ramboll Analytics

Ilpo Lahdelma
FL, kemisti, +358 40 074 5295

Tämä tutkimustodistus on allekirjoitettu sähköisesti ja varmennettu sertifikaatilla.

Lisätiedot Raita BioBox XL

Laboratoriot L Analysoitu Lahdessa

Jakelu jarkko.leka@valonia.fi

Appendix 2. Research certificate 27.10.2015

Ramboll Analytics
Tutkimustodistus
Projekti: 1510010632/54

Pvm: 17.11.2015
1/1

RAMBØLL

Turun kaupunki, ympäristösuojelutoimisto / Valonia

Tutkimuksen nimi:	Valonia, Näytteenotto 2014-16, jätevesinäytteet, Rajamäki, Raita Environment Oy		
		Näytteenottopvm:	27.10.2015
Näytteenottopiste:	Rajamäki, Raita Environment Oy	Näyte saapui:	28.10.2015
Näytteenottaja:		Analysointi aloitettu:	28.10.2015

Jätevesi

Määritys	15JJ02333	Yksikkö	Menetelmä	
Enterokokit	29000	pmy/100 ml	ISO7899-2*	L
Esikäsittely, suodatus (0,45 µm)	ok			L
pH	7,4		RA2000*	L
Kiintoaine (GF/A)	73	mg/l	RA2029*	L
BOD 7-ATU	61	mg/l	RA2006*	L
Typpi (N), kokonais-	110	mg/l	RA2021*	L
Nitraattityppi (NO3-N)	<0,25	mg/l	RA2018*	L
Ammoniumtyppi (NH4-N)	110	mg/l	RA2034*	L
Fosfori (P), liukoinen	0,15	mg/l	RA2009*	L
Esikäsittely, mikroaaltohajotus, kuningasvesi	ok		RA3007	L
Fosfori (P)	1,5	mg/l	RA3000*	L

* FINAS -akkreditoitu menetelmä. Mittausepävarmuus ilmoitetaan tarvittaessa. Akkreditointi ei koske lausuntoa.

Ramboll Analytics

Tämä tutkimustodistus on allekirjoitettu sähköisesti ja varmennettu sertifikaatilla.

Laboratoriot L Analysoitu Lahdessa
Jakelu

Appendix 3. Research Certificate 1.12.2015

Ramboll Analytics

Tutkimustodistus

Projekti: 1510010632/56

Pvm: 16.12.2015
1/1

RAMBOLL

Turun kaupunki, ympäristösuojelutoimisto / Valonia

Tutkimuksen nimi:	Valonia, Näytteenotto 2014-16, jätevesinäytteet, Raita, Rajamäen tuotantolaitos		
Asiakkaan viite:		Näytteenottopvm:	1.12.2015
Näytteenottopiste:	Raita, Rajamäen tuotantolaitos	Näyte saapui:	2.12.2015
Näytteenottaja:		Analysointi aloitettu:	2.12.2015

Jätevesi

Määritys	15JJ02565	Yksikkö	Menetelmä	
Enterokokit	7600	pmy/100 ml	ISO7899-2*	L
Esikäsittely, suodatus (0,45 µm)	ok			L
pH	7,2		RA2000*	L
Kiintoaine (GF/A)	110	mg/l	RA2029*	L
BOD 7-ATU	48	mg/l	RA2006*	L
Typpi (N), kokonais-	79	mg/l	RA2021*	L
Nitraattityppi (NO3-N)	<0,25	mg/l	RA2018*	L
Ammoniumtyppi (NH4-N)	72	mg/l	RA2034*	L
Fosfori (P), liukoinen	0,057	mg/l	RA2009*	L
Esikäsittely, mikroaaltohajotus, kuningasvesi	ok		RA3007	L
Fosfori (P)	2,4	mg/l	RA3000*	L

* FINAS -akkreditoitu menetelmä. Mittausepävarmuus ilmoitetaan tarvittaessa. Akkreditointi ei koske lausuntoa.

Ramboll Analytics

Tämä tutkimustodistus on allekirjoitettu sähköisesti ja varmennettu sertifikaatilla.

Laboratoriot L Analysoitu Lahdessa

Jakelu

Appendix 4. Field measurement Data

Project	Domestic	Biofilter	Measurements			
			Nitrate,	**Phospho-rus,**	**Iron,**	**pH**
Date	Flow Q (m3)	Total Q	High range	Reactive	Ferrous	
7.9.2015						
9.9.2015	0,2948					
14.9.2015	0,2943	0,5891		2,1000	0,8500	6,0000
16.9.2015	0,9207	1,5098		2,6567	0,6250	6,0000
21.9.2015	0,8523	2,3621		1,9300	2,2950	6,0000
22.9.2015	3,5395	5,9016	14,6000	0,8400	0,6883	6,4000
23.9.2015	0,6564	6,5580	2,3000	1,8225	0,0750	6,4000
28.9.2015	1,1265	7,6845	0,0000	0,5675	2,9575	6,7000
30.9.2015	1,4096	9,0941	5,5250	1,7150	2,2825	6,7000
5.10.2015	0,9521	10,0462	3,7000	2,1675	0,2075	7,3000
7.10.2015	0,6477	10,6939	0,0000	1,8650	0,4600	**7,7000**
12.10.2015	0,5514	11,2453	0,0000	1,5975	2,2050	**7,7000**
14.10.2015	0,4845	11,7298	2,4250	2,1750	0,5700	7,0000
19.10.2015	1,2624	10,6301		2,1275	0,7625	7,7000
21.10.2015	0,3493	13,3415		2,1475	1,8075	7,3000
22.10.2015	0,5269	13,8684		1,5575	2,6500	7,3000
26.10.2015	0,7742	14,6426		2,3225	1,9525	7,3000
27.10.2015	0,3159	14,9585		1,9075	1,0150	7,0000
28.10.2015	0,5627	15,5212		1,9350	0,5400	7,0000
2.11.2015	0,9060	16,4272		1,5450	1,7225	7,3000
4.11.2015	0,4320	16,8592		2,0700	1,1800	7,3000
9.11.2015	1,3125	18,1717		1,8650	1,0275	7,0000
11.11.2015	0,5364	18,7081		2,2400	1,8525	7,0000
16.11.2015	1,3457	20,0538		0,5650	1,4500	7,0000
18.11.2015	0,6697	20,7235		0,2925	1,3775	7,0000
23.11.2015	1,3637	22,0872	1,8750	1,5400	0,2350	7,0000
25.11.2015	1,0940	23,1812	0,0000	0,6000	2,4975	6,7000
30.11.2015	0,7616	23,9428	2,4250	1,1875	1,7625	7,0000
1.12.2015	0,3099	24,2527	0,0000	1,5150	1,0925	7,0000
2.12.2015	0,1586	24,4113	2,6750	2,6450	1,1575	6,7000

Appendix 5. Valonia statement 22.9.2015

LAUSUNTO

RAMBOLL ANALYTICS OY:N TUTKIMUSSELOSTEESEEN

PROJEKTI 1510010632/50 PVM 9.10.2015

KOHDE Rajamäen tuotantolaitoksen koepuhdistamo, Raita Environment Oy

Kiinteistönne vedenkulutukseksi on laskettu olevan 92 l/as*d. Tässä tapauksessa Valtioneuvoston asetuksen nro 209/2011 mukaiset puhdistusvaatimukset täyttyvät, kun puhdistamosta lähtevän veden pitoisuudet ovat alle seuraavien arvojen:

	vähimmäistaso	pilaantumiselle herkät alueet
BOD_{7ATU} :	109 mg/l	54 mg/l,
kokonaisfosfori:	7,2 mg/l	3,6 mg/l
kokonaistyppi:	107 mg/l	91 mg/l

Rajamäen tuotantolaitoksen koepuhdistamosta 22.9.2015 otetun näytteen perusteella puhdistamo toimi erittäin hyvin. Puhdistamo täytti orgaanisen aineen (BOD), kokonaisfosforin ja kokonaistypen osalta pilaantumiselle herkkien alueiden ohjeellisen puhdistustason.

Puhdistamonne puhdistustehokkuus (%): BOD_{7ATU} = 99 %, kokonaisfosfori = 98 %, kokonaistyppi = 95 %.

Asetuksen (209/2011) vaatimus (%):

vähimmäistaso: BOD_{7ATU} >80 %, kokonaisfosfori>70 %, kokonaistyppi>30 %.

pilaantumiselle herkät alueet: BOD_7 >90 %, kokonaisfosfori>85 %, kokonaistyppi>40 %.

Turussa 14.10.2015

VALONIA
VARSINAIS-SUOMEN KESTÄVÄN KEHITYKSEN JA ENERGIA-ASIOIDEN PALVELUKESKUS

Vesiasiantuntija
VALONIA

VALONIA
Varsinais-Suomen kestävän kehityksen ja energia-asioiden palvelukeskus **Vesihuolto ja vesiensuojelu**
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Appendix 6. Valonia Statement 27.10.2015

LAUSUNTO

RAMBOLL ANALYTICS OY:N TUTKIMUSSELOSTEESEEN

PROJEKTI 1510010632/50 **PVM** 16.11.2015

KOHDE Rajamäen tuotantolaitoksen koepuhdistamo, Raita Environment Oy

Kiinteistönne vedenkulutukseksi on laskettu olevan 92 l/as*d. Tässä tapauksessa Valtioneuvoston asetuksen nro 209/2011 mukaiset puhdistusvaatimukset täyttyvät, kun puhdistamosta lähtevän veden pitoisuudet ovat alle seuraavien arvojen:

	vähimmäistaso	pilaantumiselle herkät alueet
BOD_{7ATU} :	109 mg/l	54 mg/l,
kokonaisfosfori:	7,2 mg/l	3,6 mg/l
kokonaistyppi:	107 mg/l	91 mg/l

Rajamäen tuotantolaitoksen koepuhdistamosta 27.10.2015 otetun näytteen perusteella puhdistamo toimi melko hyvin. Puhdistamo täytti kokonaisfosforin osalta pilaantumiselle herkkien alueiden ohjeellisen puhdistustason ja orgaanisen aineksen osalta vähimmäistason vaatimukset. Kokonaistypen poistotehokkuus jäi hieman alle vähimmäistason.

Puhdistamonne puhdistustehokkuus (%): BOD_{7ATU} = 89 %, kokonaisfosfori = 94 %, kokonaistyppi = 28 %.

Asetuksen (209/2011) vaatimus (%):

vähimmäistaso: BOD_{7ATU} >80 %, kokonaisfosfori>70 %, kokonaistyppi>30 %.

pilaantumiselle herkät alueet: BOD_7 >90 %, kokonaisfosfori>85 %, kokonaistyppi>40 %.

Turussa 18.11.2015

VALONIA
VARSINAIS-SUOMEN KESTÄVÄN KEHITYKSEN
JA ENERGIA-ASIOIDEN PALVELUKESKUS

Vesiasiantuntija
VALONIA

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Appendix 7. Valonia Statement 1.12.2015

LAUSUNTO

RAMBOLL ANALYTICS OY:N TUTKIMUSSELOSTEESEEN

PROJEKTI 1510010632/56 PVM 16.12.2015

KOHDE Rajamäen tuotantolaitoksen koepuhdistamo, Raita Environment Oy

Kiinteistönne vedenkulutukseksi on laskettu olevan 92 l/as*d. Tässä tapauksessa Valtioneuvoston asetuksen nro 209/2011 mukaiset puhdistusvaatimukset täyttyvät, kun puhdistamosta lähtevän veden pitoisuudet ovat alle seuraavien arvojen:

	vähimmäistaso	pilaantumiselle herkät alueet
BOD_{7ATU} :	109 mg/l	54 mg/l,
kokonaisfosfori:	7,2 mg/l	3,6 mg/l
kokonaistyppi:	107 mg/l	91 mg/l

Rajamäen tuotantolaitoksen koepuhdistamosta 1.12.2015 otetun näytteen perusteella puhdistamo toimi erittäin hyvin. Puhdistamo täytti orgaanisen aineksen, kokonaisfosforin ja kokonaistypen osalta pilaantumiselle herkkien alueiden ohjeellisen puhdistustason.

Puhdistamonne puhdistustehokkuus (%): BOD_{7ATU} = 91 %, kokonaisfosfori = 90 %, kokonaistyppi = 48 %.

Asetuksen (209/2011) vaatimus (%):

vähimmäistaso: BOD_{7ATU} >80 %, kokonaisfosfori>70 %, kokonaistyppi>30 %.

pilaantumiselle herkät alueet: BOD_7 >90 %, kokonaisfosfori>85 %, kokonaistyppi>40 %.

Turussa 17.12.2015

VALONIA
VARSINAIS-SUOMEN KESTÄVÄN KEHITYKSEN JA ENERGIA-ASIOIDEN PALVELUKESKUS

Vesiasiantuntija
VALONIA

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Varsinais-Suomen kestävän kehityksen ja energia-asioiden palvelukeskus **Vesihuolto ja vesiensuojelu**
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