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ENERGY EFFICIENCY FROM THEORY TO PRACTICE: CASE HUITTISTEN PUHDISTAMO OY WASTEWATER TREATMENT FACILITY

Degree Programme in Environmental Engineering
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ENERGIATEHOKKUUS HUITTISTEN PUHDISTAMO OY: LLÄ TEORIASTA TOTEUTUKSEEN.

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Tämän opinnäytetyön aiheena oli tutustua Huittisten Puhdistamo Oy:n uuden jätevedenpuhdistamon energiatehokkuuteen ja tuoda esiin käytännön keinoja energiatehokkuuden parantamiseksi. Huittisten, Sastamalan sekä Punkalaitumen alueiden jätevedenpuhdistus on tähän asti toteutettu 10 pienemmän jätevedenpuhdistamon voimin. Viimevuosina yhdeksän näistä kymmenestä jätevedenpuhdistamosta on ajettu alas ja puhdistamoille tullut vesi ohjattu siirtoviemäreillä Huittisten uudelle puhdistamolle. Puhdistamo oy on aloittanut siirtoviemärien rakentamisen 2012 Punkalaitumen siirtoviemäristä ja 2016 valmistui Sastamalan siirtoviemäri. Puhdistamo käynnistettiin kesän 2016 aikana, josta lähtien laitos on hoitanut alueiden jätevedenpuhdistuksen.

Energiatehokkuutta tutkittiin käyttämällä apuna puhdistamon kirjanpidosta sekä laitoksen sähkömittareista saatua dataa syyskuun 2016 sekä maaliskuun 2017 väliseltä ajanjaksolta. Koska mittarit eivät pysty erittelemään sähköpääkeskukseen liitettyjä kulutuskohteita, jokaista mittaria käsiteltiin yhtenä kokonaisuutena ja keskuskohtaisen energiatehokkuuden parantamiseksi annettiin enemmänkin ehdotuksia suoranaisen ohjeistuksen sijaan. Tutkimukseen tarvittava teoriatieto kerättiin alan julkaisuja ja internetiä, sekä opinnäytetyön tekijän omaa, laitosmiehen kesätyöstä saatua tietämystä hyväksikäyttäen. Myös Puhdistamo Oy luovutti laitokseen liittyvää materiaalia työssä käytettäväksi.

Jäteveden puhdistusprosessi on käynnistynyt hyvin ja purkuvesi on täyttänyt ympäristöluvan laatuvaatimukset typpeä lukuun ottamatta. Laitoksen työntekijöille muutos pienempien jätevedenpuhdistamoiden manuaalisista prosesseista yhden suuremman automatisoidun prosessin hallitsemiseen on oma askeleensa. Tämä siirtymä on syytä tehdä huolella ennen jatkamista suurempaan laitoksen energiatehokkuuden parantamiseen. Kun prosessi on saatu kunnolla haltuun, voidaan keskittyä laitoksen energiankulutukseen ja tehokkaisiin ajotapoihin. Ilmastuskompressorit osoittautuivat laitoksen suurimmaksi energiankuluttajaksi. Ensimmäisen puolen vuoden aikana kompressorit ovat kuluttaneet 41% koko laitoksen energiankulutuksesta.

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The purpose of this thesis was to find out how the energy consumption is divided in Huittinen Puhdistamo wastewater treatment facility and to find out how the workers can improve the energy efficiency of the facility in their daily tasks. The Huittinen-Sastamala-Punkalaidun region has in the recent years gone through substantial modernization in which nine out of the original ten facilities have been demolished and the wastewater now travels into the new Puhdistamo Oy facility in Huittinen. This facility was started in the summer of 2016 and is now run by three facility workers who previously were in charge of the Huittinen-Vampula area plants and pumping stations.

The study was conducted by examining the total energy usage in the facility from September 2016 to March 2017 from the company accountancy as well as the electric meters. The meters were unable to distribute the individual energy consumers connected to them, so the study considered each meter as a whole and gave more guidance-like possibilities for enhancing the energy efficiencies of each. The theory for this thesis was gathered from the industry publications and internet. Also thesis writers´ own professional knowledge and material provided by Puhdistamo Oy was used.

The wastewater treatment process has begun well and the discharge water has met the environmental permit quality requirements with the exception of nitrogen. The change from the previous manual process to the new facility's automated process is challenging for the facility workers. The best way is to get the new routines in order before thinking about the energy efficiency of the facility too much further. Later on the focus can be turned to energy efficient use of the compressors, which proved to be the single biggest consumer of the facility, having a 41% share of the total consumption.

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TERMS AND ABREVIATIONS USED IN THIS THESIS

•	ACTIVATED SLUDGE	Small organisms that use the organic mass in the effluent for their growth, transforming it to carbon dioxide and water.
•	AEROBIC	Oxygen environment
•	ANAEROBIC	Total absence of free oxygen (O_2) and bound oxygen (NO_2, NO_3)
•	ALKALINITY	The capacity of aqueous solution to neuralize an acid
•	ANOXIC	Absence of free oxygen (O2), presence of bound oxygen (NO2, NO3)
•	AUTOTROPHIC	Obtain energy from oxidation of inorganic matter. (CO_2, NH_4, H^+)
•	BOD	Biological Oxygen Demand is the amout of oxygen required by the wastewater´s bacteria to consume the nutrients in the wastewater. [mg/l]
•	COD	Chemical Oxygen Demand is the amount of oxygen required by the wastewater´s bacteria in chemical reactions. As the industrial wastewaters can contain chemicals that inhibit the biological process, COD can give a more accurate result of the wastewaters oxygen demand. [mg/l]
•	DENITRIFICATION	Biological process where anaerobical denitrification bacteria break down nitrates and nitrites into nitrogen gas.
•	HETEROTROPHIC	Obtain energy from oxidation of organic matter. (inorganic carbon)
•	NITRIFICATION	Biological process where aerobic nitrification bacteria use chemical reactions to transform ammonium nitrogen into nitrates and nitrites.
•	PAO	Phosphate-Accumulating Organisms
•	PHA	Polyhydroxyalkanoates are linear polyesters produced in nature by bacterial fermentation for the carbon and energy storing of the bacteria.

1 INTRODUCTION

1.1 The need of energy saving

In the recent years the need for energy savings has become more and more important. Global climate agreements such as Renewable Energy Directive, which requires the EU to full fill at least 20% of its total energy needs with renewables by 2020, have been made and the overall understanding for energy efficiency has grown significantly. This trend can also be seen in the design of the wastewater purification plants from which Puhdistamo Oy is a perfect example.

1.2 The new central wastewater purification plant

Before this new facility, the wastewater purification in Huittinen-Sastamala -region was divided between 10 different facilities built in the 1970´s. This arrangement was highly inefficient both labour and energy wise. Although the old facilities could have also been redeveloped and this way upgraded to better meet the modern standards, they were dismantled and the wastewaters from the whole region were centralized to this new treatment facility. This arrangement can be seen in figure 1.

In Huittinen the process runs in an energy efficient way, as all of the facility functions are in one place. As Sastamala is higher above the sea level than Huittinen, the water line from Sastamala was designed to run downhill all the way to Huittinen purification plant and only if there is need, outside energy is used to push the water faster with a booster station. This kind of booster pump station is designed to boost the pressure of the wastewater within a long pipeline without an ordinary pumping station well stopping and collecting the wastewater.

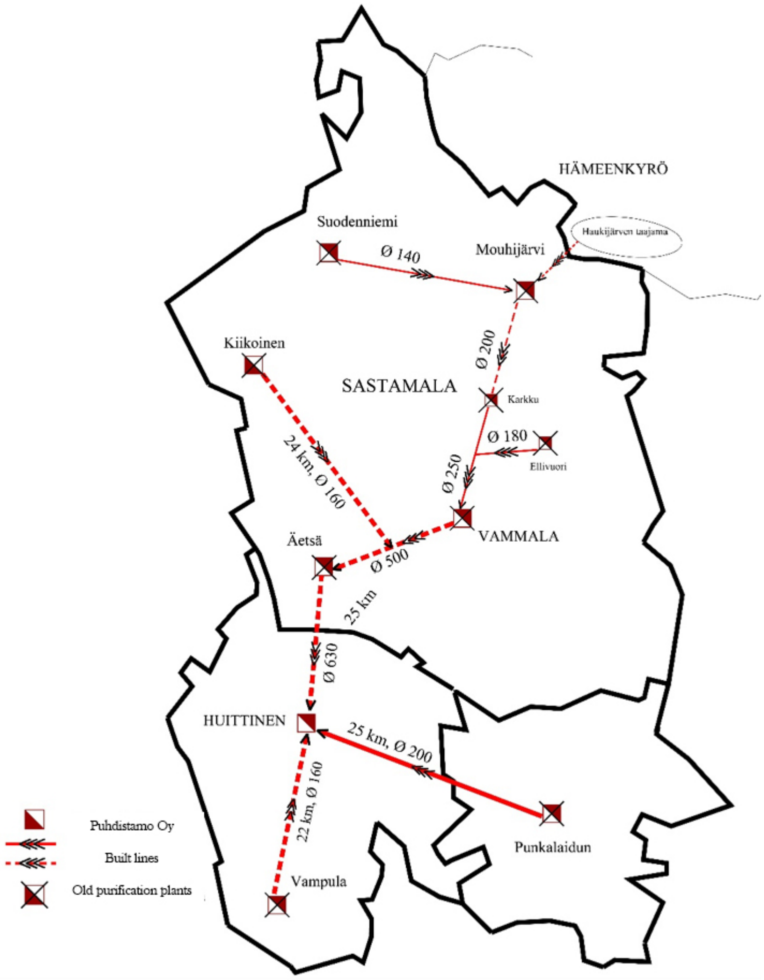

Figure 1. The whole area where wastewater is pumped to the wastewater treatment plant in Huittinen

Since the developed ways for the facility´s energy efficiency have been taken into account already in the facility design with motion activating led-lights and heat recovery air conditioning to name a few, this study will be focusing on the daily routines of the facility workers and how they can make the facility energy consumption lower.

2 THEORY

2.1 The need of water treatment

Wastewater treatment is part of the modern society and needs to be done to prevent the pollution of the environment. In Finland community wastewater treatment has been active from the 1960´s. Water treatment prevents the spreading of intestinal diseases, eutrophication of water systems and it keeps the waters clean. As the water we are using in our daily lives is just part of the whole circulation of our natural waters, wastewater treatment is becoming more and more crucial in the prevention of eutrophication. It is stated in the Finnish environmental protection that wastewaters must be managed and treated in a way that they present no risk of environmental pollution. (The Environmental Protection Act 2014/527 section 16)

The degradation of organic material consumes oxygen and may therefore cause oxygen depletion in the surface waters which in time can cause fish and other aquatic animals´ deaths and in the end this oxygen depletion leads to death of the whole water base. As on average us Finns use 155 litres of water per day, the nutrient load we would pose to nature without water cleaning would be critical (Website of energy consumer advice 2017). The composition of our average daily water consumption can be seen in figure 2.

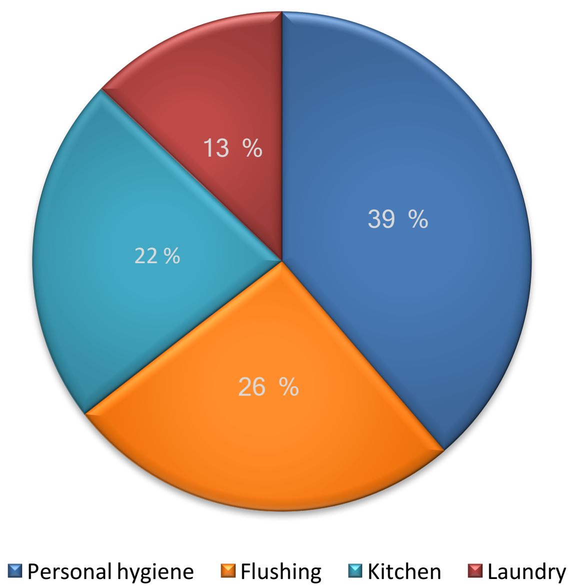

Figure 2: Average Finnish person wastewater usage per day (Motiva website 2017).

The wastewater treatment process includes the separation of the suspended solids and removal of the biodegradable organic material, nutrients such as phosphorus and nitrates. Wastewater is first treated physically to remove the coarse particles. Phosphorus is then removed usually as iron precipitates. BOD and nitrogen are removed biologically in the process called activated sludge.

Nitrogen removal from the wastewaters has been improved significantly through the years. In the treatment plants in the 1970´s the removal percentage was around 30%, the modern facilities remove around 60% of the nitrogen. This improvement is from the utilization of Denitrification-Nitrification process, when in the old facilities the nitrogen was simply engaged in the growing biomass in a nitrification process. Still the discharge amount of nitrogen has stayed rather the same, which is because of the urbanization and the increase in the nitrogen amounts in the wastewaters. The legislation for the nitrogen removal has been tightened in the 90´s first in the Helsinki capital area, and from there it has gradually applied to concern the whole coastal region of Finland and areas from where wastewater will eventually run to the Baltic sea. (Säylä, 2015, p.16.)

2.2 Pre-treatment

There are 9 pressurised sewers where the water comes into the facility (Huittinen Purification Plant Process Plan 2014, p. 3). For effective sampling and flow metering, these sewers are in separate basins from which the incoming effluent flows to the screening. As the water pH levels can reach too alkaline or acidic levels regarding the activated sludge process, this inlet is equipped with its own automated control valves, which can direct the flow to equalization basin. (Puhdistamo Oy methods of control 2014, p. 2)

2.2.1 Screening

Screening, or fine screening, is the first stage where impurities are removed from the water. In Huittinen there are two screening lines and one bypass line (Huittinen Purification Plant Process Plan 2014, p. 3). The screening device is made by Andritz and it is a perforated plate step-screen and its structure can be seen in figure 3.

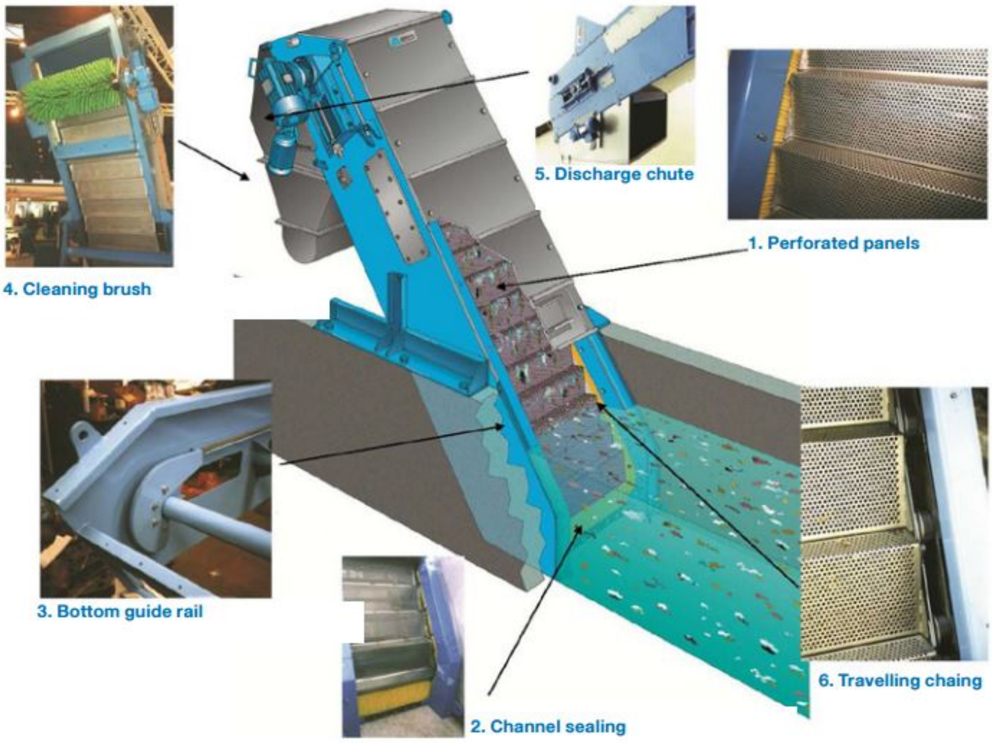

Figure 3. Andritz perforated plate screen structure. (Website of JCI 2016)

Screens can be controlled from the integrated control panels. The basins located between the screeners are equipped with coarse bubble diffusers in order to keep the impurities in the water suspended. Screening effectively erases solid debris from the wastewater and delivers it through a screw conveyor to a transportation container. This conveyor dries the waste while delivering it to the containers. Screening waste can´t be reused due to its mixed contents, which can be any debris people managed to flush down from their toilets. Since it is unfit for recycling, the screening waste is transported to burning.

Screeners are automatized, which means that they rise and wash the screener steps according to the waste build up. The screens are equipped with a relatively loose mesh, which lets fairly coarse objects through. This is why some waste build up is needed so that the waste itself acts as an extra thickener for the mesh. (Puhdistamo Oy methods of control 2014, p. 3)

2.2.2 Grit and grease separation

After the screening, water flows into two grit and grease separation basins, aligned side by side. Before entering the basins, ferrous sulphate is added in a small pre-aeration basin to enhance the settling of the sludge later in the process. In the grit and grease separation pool there are automated scrapers both in the surface and at the bottom of the basin (seen in the figure 4.) for transporting the stood out grease and settled grit away from the wastewater and for further treatment.

Figure 4. Grit and Grease separation basin with grease trough and surface scrapers, grit scrapes and pre-aerator visible.

As the water flows through this basin, coarse bubble aeration is introduced to help the heavier grit to sink to the bottom of the basin as it reduces the buoyancy of the water (Stevens 1985, p. 6). Grit is then swiped with the bottom-scrapers to a hollow from where it is pumped to the sand washer, and on to a transportation container (Puhdistamo Oy methods of control 2014, p. 4). This aeration also helps the dissolved grease to separate from the water and rise to the surface of the basin in heaps from where the surface scrapers sweeps the grease into a trough and onwards to a grease- and surface-slurry basin. From the grease- and surface-slurry basin this sludge is sucked up with a pump truck and transported to a biogas factory (Huittinen Purification Plant Process Plan 2014, p. 3). Water from the bottom of the basin continues with gravitational force to the facility´s inner pumping station from where it is circulated back to the process.

2.2.3 Pre-settling

Figure 5. Empty pre-settling basin with troughs and scrapes visible.

From the grit and grease separation basins, the water flows into two pre-settlers, where the formed iron salts are precipitated as a primary sludge. Ferrous sulphate - after reacting with the wastewaters´ phosphorus in the pre-aeration- has time to form the settling sludge. The sludge settles to the bottom of the basins where it is swept with bottom-scrapers into an outlet and pumped to a thickener basin. Figure 5 shows the end of the pre-settling basin with bottom scrapes and water troughs. From the pre-setting wastewater is evenly distributed to the three aeration basins via lime feed basin (Puhdistamo Oy methods of control 2014, p. 6).

2.3 Aeration

Aeration harnesses the natural microbes found in the wastewater to carry out aerobic bio-degradation of the pollutant components. In Huittinen there are three equal sized aeration basins equipped with diffused air aerators. All three basins are also divided into six sections for controlling the biodegradation. Sections 2 to 5 are equipped with oxygen meters and certain limits are put into the automation program which actively controls the aeration valves according to the measured oxygen levels.

2.3.1 Different parts in Aeration pool

All of the six sections are equipped with diffused air aerators and sections are controlled individually according to the need for aeration in the process. Sections 1,2,3 and 6 are also equipped with mixing plates to ensure that sludge stays dispersed. These sections can be used for biological phosphorus removal with the aeration plates turned off as this reaction occurs only in anaerobic state. Only the first section can be anaerobic, the second, third and last sections can be run as anoxic. The first section has an input from lime feed, which is located between pre-settling and aeration pools, and return sludge from secondary settlement. This section is anaerobic so that the microorganisms can gather the organic matter, including phosphorus, for the denitrification-nitrification (DN) -process.

Sections 2, 3 and 6 are anoxic denitrification sections. In these sections part of nitrogen is removed from the wastewater and the buffer capacity of the water increases. Also most of the organic biological oxygen demand (BOD) load is used during the anoxic process. As aeration is kept off in these sections, hyperboloid mixers are used to keep the sludge from settling. These mixers and the aeration plate system can be seen in figure 6. After this denitrification, sections 4 and 5 are used to aerate the ammonium nitrogen into nitrate nitrogen.

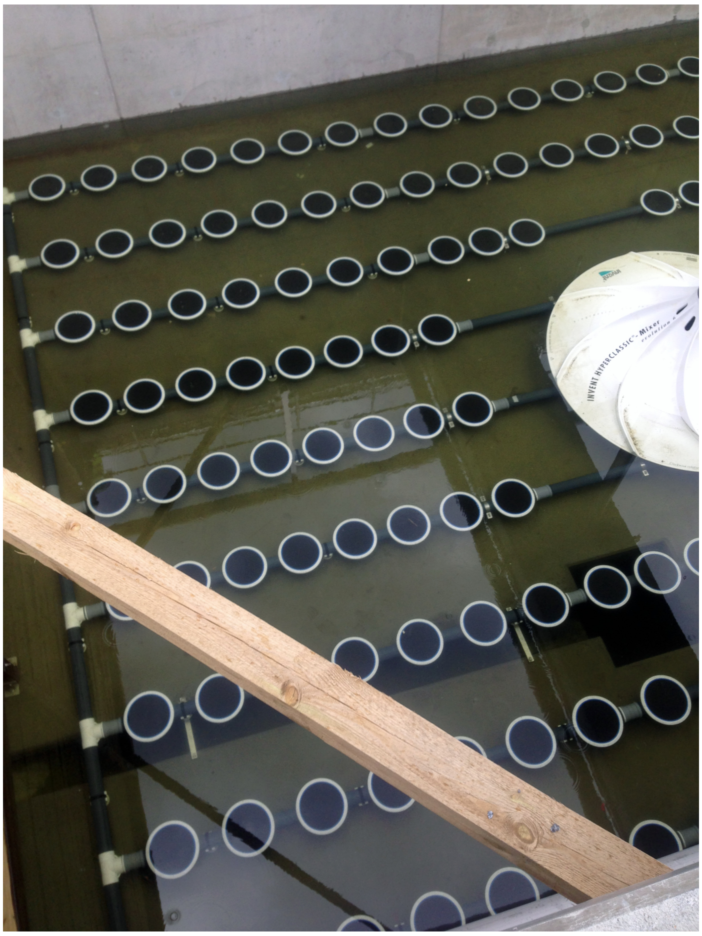

Figure 6. Aeration basin with aeration discs and hyperboloid mixer visible.

The last section is again anoxic denitrification where the nitrates formed in previous aeration sections are harnessed to an oxygen source. As the nitrogen removal is relying on these nitrates, a propeller pump is used to recycle part of these nitrates to the first section of the aeration pool. From aeration water flows next to secondary settlement basins, of which there are two new ones and one refurbished.

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2.3.2 Organic carbon removal

The carbon removal from the effluent occurs when the living organisms, heterotrophic bacteria, consume organic matter (i.e. BOD) and convert it to carbon dioxide, ammonium bicarbonate(ammonia) and new microorganisms.

$$\mathbf{CHONS + O + Nutrients \rightarrow CO_2 + NH_3 + C_5H_7NO_2}$$
$$\mathbf{C_5H_7NO_2 + 5O_2 \rightarrow 2H_20 + NH_3 + Energy}$$

(Dankhara. 2012. p. 35)

When all the organic mass has been consumed, the nitrification process takes place.

2.3.3 Nitrification

As stated in the aeration chapter, DN-process is used to remove nitrogen from the wastewater in a biological process. Nitrification is a bio-chemical reaction, where under aerobic conditions bacteria is used to oxidize ammonium nitrate to nitrite and ultimately to nitrate according to following formula.

$$\mathbf{NH_4^+ + 2O_2 \rightarrow NO_3^- + 2H^+ + H_2O}$$

(Wiesman, Choi & Dombrowski 2007, p. 229)

This reaction requires oxygen as the two species of bacteria, *Nitrosomonas* and *Nitrobacter,* need aerobic environment for growth and metabolism of nitrogen. These bacteria, known as nitrifiers, are autotrophic so they get their carbon source from inorganic carbon or carbon dioxide. In order to have stable population of nitrifiers, following aspects must be taken care of:

- Dissolved oxygen (DO) levels should be between 0,5 and 3,0 mg/l as below this the nitrification ceases and the maximum nitrification happens at 3,0mg/l. So if the sections are aerated over this value, it will only show increase in electric consumption. To ensure effective nitrification, DO level should be kept above 1,5mg/l at all times.

- Nitrification is also susceptible to temperature changes as following table indicates. What can also be seen from this table is that the optimum temperature for nitrification is 30°C.

Table 1. Temperature effect on nitrification

Temperature °C	Affect on Nitrification
>45	Nitrification ceases
28-32	Optimal range
16	Approximately half of the nitrification rate compared to 30 °C
10	Approximately 20% of the nitrification rate compared to 30 °C
< 5	Nitrification ceases

- Bacteria growth can happen between pH levels 6.0 to 9.0, but optimal growth is found at pH levels between 8.0 and 8.5. When optimal oxygen uptake is also considered, the desired pH level is between 7.2 and 8.0. Between these values the growth percentage from maximal nitrification rate is between 45 % and 70 % (Website of Environmental Consultants 2016).

- Recycling of sludge from the end of the aeration basin and secondary settlers is important to achieve high mean cell residence time as this increases the number of nitrifying bacteria in the sludge process. The normal age for the activated sludge ranges between 10 and 20 days. As the aeration basins are situated outdoors and the nitrifier activity decreases when temperature drops, it is highly important to keep this sludge recirculation sufficient enough for the process. The nitrate recycling inside the aeration basins ranges from 50 % to 200 %.

2.3.4 Denitrification

Denitrification is a process, where heterotrophic bacteria are used to convert nitrates back to nitrogen gas thus diminishing the available usable nitrogen and returning it back to the atmosphere. These bacteria use nitrites and nitrates instead of oxygen for respiration. Nitrate and nitrite reduce to nitrogen gas according to following formula:

$$\mathbf{2NO_3^- \rightarrow NO_2^- \rightarrow NO + N_2O \rightarrow N_2}$$

(Wiesman, et al. … 2007 p. 238)

These heterotrophic bacteria use biogenic compounds for their carbon and energy sources. When activated sludge is recycled, as is done in Huittinen, the nitrate needed for denitrification is acquired from the nitrate-rich activated sludge. The organic carbon source is then found in the effluent. When DN-process is used, 0,07 mol of alkalinity is gained and 3 - 5 grams of organic mass is consumed for every gram of reduced nitrate nitrogen. The total nitrogen removal can be managed with the sludge recycling. The limiting factor here is the carbon found in the effluent to nitrogen ratio, or C: N. Nitrogen removal with this technique varies between 50 % and 75%. Denitrification is not so susceptible to temperature changes as nitrification as the denitrify bacteria can function in a wider temperature range.

2.3.5 Phosphorus removal

Phosphorus removal is done in Huittinen in a biological reaction with the growth of Phosphate-accumulating organisms, PAOs. This reaction is based on the alternation between anaerobic and aerobic zones, where more phosphate is stored by PAOs, than released into it.

The reaction begins in an anaerobic zone, where PAOs take in polyhydroxyalkanoates, PHAs. These PHAs are used for carbon and energy source by the PAOs later in the process. In the anaerobic zone PAOs need polyphosphate for their energy in the PHA indigestion. These polyphosphates are formed by PAOs in aerobic zones and this is why the activated sludge circulation is so vital for the process.

In the aerobic zone, PAOs take in orthophosphate and polymerize it to polyphosphate, which is stored into the cells. This way the phosphate amount of the liquid decreases in aerobic zones and the PHAs stored in aerobic zones is used for cell growth. This way the amount of phosphor-rich sludge increases and the water is one step safer to the environment.

2.4 Secondary settlement

Secondary settlers are to clarify the effluent and recirculate the settled sludge back to the aeration. This sludge is called activated sludge and recirculating it to the aeration helps in keeping the process as stable as possible. The water entering secondary settlers is fairly clean from debris and entrained nutrition, but as some debris surfaces even at this stage, sludge scrapers guide the surface debris to a trough from which it is pumped back to screening. These same scrapers make a full circle from the surface to the bottom where the settled activated sludge is scraped to sludge pits at the end of the basins.

From the secondary settlers the sludge is pumped back to the first sections of the aeration basins. If there is need, polymer can be added again to the water as it is flowing from aeration to secondary settlers for enhancing the sludge settling. The discharged surface water from the secondary settlers is already rather clear to the eye and could be even released back to nature´s circulation as the amount of nutrients has now significantly decreased.

2.5 Sludge treatment

There are two types of sludge to be considered when speaking about wastewater sludge. One is called raw sludge and it is the excess solid material that stands out from effluent already in the pre-settler. The second one is the bacteria grown biological mass called surplus sludge. The surplus sludge is pumped out of the last section of the aeration basin, equal amount compared to its growth. This mass includes phosphorus and nitrogen removed from the water and as a biological mass it is valuable to secondary use.

In Huittinen both sludge types are pumped from their initial basin first to the thickener basin for another settling process. From the thickener basin the clarified water is pumped to the inner pumping station and from there on to the screening and back to the process. The sludge mixture is pumped to the dryer facility from the bottom of the thickener basin. In the dryer facility, polymer is added to the sludge to enhance the drying which is executed with two Noxon decanter centrifuges. These centrifuges and polymer dispensers can be seen in figure 7.

Figure 7. Drying facility with Noxon decanter centrifuges and polymer dispensers.

From the centrifuges this now soil-like dried sludge is pumped to two silos from where it is transported by trucks for biogas production. If the truck is equipped with a trailer, both the tractor and trailer can be loaded without the need of moving the truck. The loading can be seen in figure 8.

Figure 8. Dried sludge is loaded on a truck.

2.6 Heat pump

The heat energy contained in the wastewater can be utilized by the use of heat pumps and as the wastewater temperature should be around 30 degrees for optimal nitrification process, this energy should not be wasted by discharging the water without making use of the energy. This energy recovery is making its way to the wastewater cleaning facilities in Finland and in addition to the Puhdistamo Oy, facilities in Turku, Loimaa and Joensuu are cutting down their energy need with this technology. The heat pump system uses a refrigerant to produce energy for heating- and cooling from low temperatures. The refrigerant has much lower vaporisation point than water, which enables the refrigerant go through phase change in relatively low temperatures. The heat pump principle is illustrated in figure 9. In Puhdistamo the system is an Oilon ChillHeat –system.

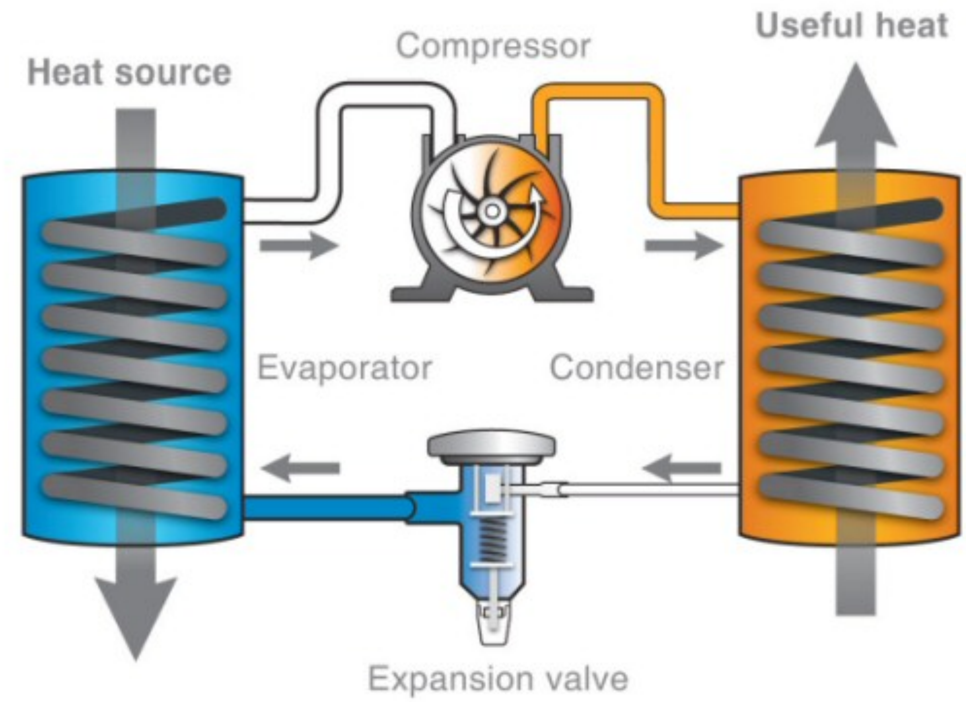

Figure 9. Heat pump principle.

3 USE OF ENERGY

As the treatment plant is brand new, energy efficiency has been taken into account from the first steps of the facility design. Heat pumps harness the heat energy from the discharge water and use it for the facility heating and cooling. LED lighting is installed in the whole facility and motion sensors in the hallways and toilets ensure that no area is lit unnecessarily. Automation controls that minimal energy is used to the cleaning process throughout the facility. The facility is also designed so that the water flows gravitationally forwards from one basin to another this way also saving energy that would otherwise be spent day and night to pump the water.

The data available from the energy usage from this first six months is rather fluctuating as all the equipment and basins have been taken into use gradually.

Figure 10. Schneider PM5300 meter

The consumption figures are gathered from the facility´s own metering devices such as the one in figure 10 showing the all-time average voltage (Vavg), -current (Iavg), total power (Ptot) and delivered energy (E Del). These meters each have a variety of equipment behind them. Unfortunately, these meters cannot divide the energy consumption by the different consumption points so in this study the energy consumption will be viewed in following chapter by each meter.

From the start up in late summer of 2016 until mid-March, the facility had used a total of 1,94 GWh energy according to the meters. This will be referred to as the total consumption figure in the following chapters. The total consumption is divided by the facility´s five electric meters into figure 11.

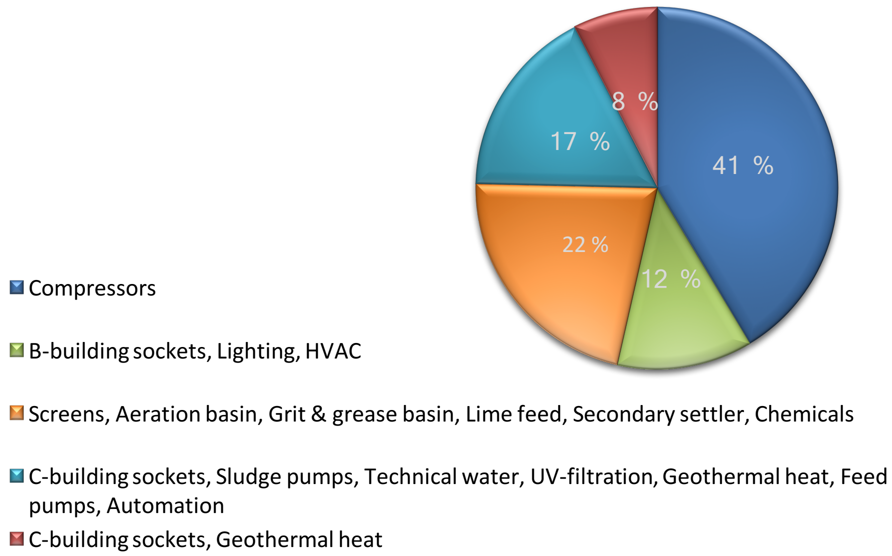

Figure 11. Shows the division of energy consumption in the facility.

The information from figure 11 is specified in the following sections.

Compressors. 804 MWh

As expected, the aeration is the biggest single consumer of the facility as the compressors used 41% of the total consumption. With the current water flow, the smallest of the three compressors is already providing sufficient aeration running at the low end of its optimal range.

B-building sockets, Lighting, HVAC. 236MWh

The lighting, HVAC system and electric sockets in this group consume 12% of the total facility consumption.

Screens, Aeration basin, Grit & grease basin, Lime feed, Secondary settler, Chemicals. 423MWh

Roughly one fifth of the energy consumption is due to the different valves and chemical pumps in the basins.

C-building sockets, Sludge pumps, Technical water, (UV-filtration), Heat pumps, Feed pumps, Automation. 332MWh

The first These C-building groups are packed so that combined they use just a bit under a quarter (24,6%) of the whole facility consumption. The energy efficient heat pump system is located and connected to the electricity mains in the C-building. Most probably the biggest consumers in this group are the sludge and technical water pumps, from which sludge pumps work almost all the time.

C-building sockets, Heat pumps. 145MWh

The second C-building group is quite small factor with about 8% of the whole facility consumption.

Used energy / Treated COD

The energy consumption per kg COD load -information was taken from February 2017 report provided by KVVY. Daily the plant receives 7158 m^3 of untreated water and discharges 7268 m^3 of treated water. Daily in- and outflow rates of COD are 7482 kg and 240kg respectively. These amounts can be seen in table 2.

Table 2. COD flow in February 2017

COD Flow in February	IN						OUT
From	Huittinen	Sastamala	Punkalaidun	Saarioinen	Pre-clarified	Mid-clarifier	Puhdistamo Oy
/ day	1 950	32	210	1 780	3 200	310	240
Whole month	54 600	896	5 880	49 840	89 600	8 680	6 720
Total COD in / day	7 242						
Total COD in / month	202 776						

This means a significant 97% drop in the COD load. From table 3 we see the metric tonnes of COD and the energy consumption in KWh per every metric ton of treated COD.

Table 3. The energy usage in the facility in February 2017. This table presents the amount of COD in tonnes and used energy in KWh.

Energy / Treated COD	/day	Whole month
Energy consumed in KWh	6 637	185 841
Tonnes of COD	7	203
KWh / COD (tonnes)	916	916

4 THE ENERGY DISTRIBUTION AND WAYS TO IMPROVE THE OVERALL EFFICIENCY OF THE PLANT IN DAY-TO-DAY WORKING ROUTINE.

Unfortunately, moment the water flow to the facility is rather small compared to the maximum capacity it is designed to handle. With this flow rate the smallest of the three compressors can handle the aeration need by itself, running on the low-end of its optimal range. The energy efficiency of this compressor could still be better as the current settings for the aeration system are so that the aeration valves are constricting the airflow to provide sufficient resistance for the compressor. If there would not be any drag, the compressor could not stay on as its own safety precaution would consider it to be running on idle. So even if the aeration need will rise, the compressor can gain better energy efficiency with the aeration valves fully opened.

With the other B-building energy consumers, there are not that many possibilities for smaller energy consumption or enhanced energy efficiency. The obvious ways for minimising the energy consumption are of course to keep the doors closed when possible, and to keep the excess electrical appliances unplugged when not used. Also the movement around the facility should be conducted in such way that the distance from the outside door to the desired object should be as short as possible. As the rest of the consumption in the B-building is from the process-related devices, screens, pumps, valves, scrapes etc. connected to the automation, the usage is what it is, depending on the water flow.

In the C-building, which includes the thermal heat pumps and sand filtration systems, the possibilities for better energy efficiency are even smaller. The thermal heat pumps utilize the heat energy from the outflowing water and use it to warm the facility which in this kind of a facility is a highly energy efficient choice since the thermal energy trapped in the warm wastewater would otherwise be wasted. The only easy possibility for energy savings in the C-building comes from the electric sockets, which would be better to keep free from any unused electrical appliances. The technical water from the C-building is needed in the occasional washing of the whole facility. It is important to do this washing properly because doing it only halfway would cause possible health risks to the workers, not to mention the unpleasant visual sight and possible odour the sludge spread on the facility floor would cause. As the UV-filtration is only made ready for possible future need, it uses no energy. The sludge and feed pumps as well as automation are also dependent on the water quality but they can also be thought to be unavoidable energy consumers.

5 CONCLUSION

The plant and the whole Sastamala-Huittinen wastewater entirety is still on the beginning of its lifetime. This poses challenges both for the facility and the workers as the daily tasks have changed from the before mostly manual work more on the automated side. Also the brand new plant with its equipment has had its down days which have affected the energy consumption and the overall performance of the process and the plant. This is why at this point, the main focus on should be on getting the plant running without hitches on a routine-like fashion and on the upkeep of the equipment. After these affairs are in order, the focus can be turned on finding the energy efficient ways on the daily tasks. Although the aeration runs mostly with automation, learning the possible daily/weekly fluctuation in the incoming effluent and predicting the aeration need in advance could be one of the ways in cutting down the aeration need in advance thus also saving energy.

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