Pått wastewater treatment plant

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1 Introduction

The wastewater purified in Pått is used water which is everything you flush down the toilet and rinse down the drain, but also rainwater and surface runoff which goes down the gully and wastewater from industries. All this water has to be treated so it won´t cause pollutions of surrounding water sources. The water going to Pått is mainly coming from Vaasa. Only 10% of it is from Korsholm and 3% from Malax. All in all 750km pipeline brings the water to the treatment plant where they treat the water from about 65000 inhabitants. The amount of wastewater varies annually depending on the amount of rain and meltwater. In 2011 they treated 7 003 563m^3 of wastewater. The daily number of purified water is depending on the season. For example in the spring when all the snow melts they have much more surface runoff to treat than usual. At Pått in Vaasa are 15 people working. They have also been renovating the plant in 2010-2012. New are the two Presedimentation basins and the Sand filtration.

In this report, you will find a brief overview of how Pått treats the waste water and you will also find some Finnish requirements they have to fulfil. We will also show you some graphs on how good they followed these requirements in 2011 and how they control that everything is going smoothly.

In our report you won´t find any references. This is due to our cooperation with Pått. We got all the information and materials from Maria Tanninen, who works there as a processing engineer.

2 Waste water treatment process

Step 1 Pre-treatment

When effluent first arrives at the plant it goes to the pre-treatment, which includes step screens and sand and oil removal. Step screens remove all the solid materials out of the waste water such as paper and towels. Sand usually comes to the treatment plant with rain and meltwater. In the sand and oil removal process, the sand will sink to the bottom of the basin. The Basin is also aerated a little bit so that the oil will rise to the surface.

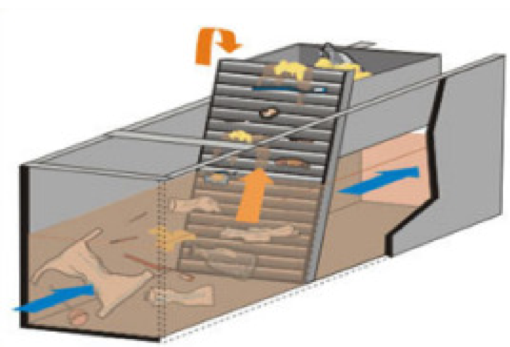


Figure 1: Step screens

Figure 2: Sand from the sand and oil removal

Step 2 Pre-sedimentation

In the pre-sedimentation stage, they calm the flow so that the suspended solid fall down at the bottom of the basins. This process takes a lot of suspended solid out of the waste water before it comes to the aeration basins. It’s also possible to add some flocculation chemical in the pre-sedimentation process to further reduce the charge. In addition, the raw sludge is lead to the thickeners in the sludge treatment.

Figure 3: Presedimentation basin

Step 3 Aeration

The biological treatment takes place in aeration tanks. The plant has bacteria growing in the basins and these bacteria are “good” bacteria. They eat a lot of organic material in the waste water by breaking down organic matter. There is a venting system at the bottom of the aeration basins so that there is enough oxygen and bacteria can be reproduced. On the other hand, a nitrification process takes place in these aeration basins. Nitrification is a part of the total nitrogen removal, which includes nitrification and denitrification. In the nitrification process, bacteria convert toxic ammonia nitrogen into less harmful nitrate nitrogen, and is then followed by denitrification, which takes place in the sand removal.

Figure 4: Aeration basins

Step 4 Sedimentation

They calm again the waste water flow in the sedimentation tanks where sludge will sink to the bottom and the purified water remains on the surface. A portion of the sludge at the bottom is pumped into the distribution tank, where it is mixed with water from the presedimentation basins so that the bacteria in the aeration basins have fresh food. The excess sludge is taken to the sludge treatment where it is having a dewatering process.

Figure 5: Sedimentation basins

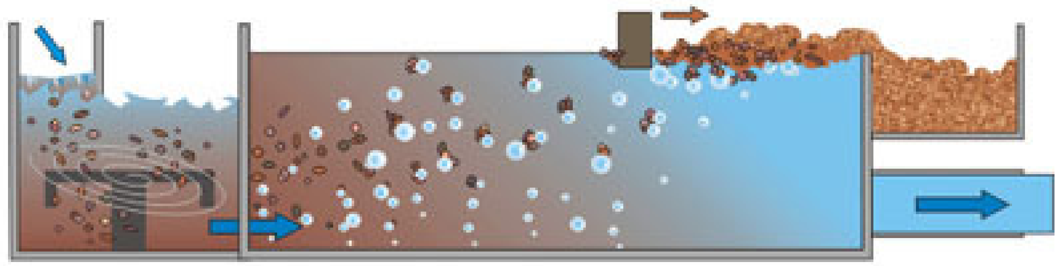
Step 5 Sand filtration

Pått haven't had a denitrification in 2011, that's why they haven't had the total nitrogen removal before. But according to the new environmental permit requirements, the percentage of nitrogen concentration must be reduced to 70% from the 1st of July, 2012. Now they have built some new buildings and new processes including denitrification, which is a sand filtration to reduce nitrogen to reach the requirements. Denitrification converts nitrate to nitrogen gas, which has low water solubility and finally it goes into the air as gas bubbles. Free nitrogen is the major component of air, thus its release doesn't cause any environmental concern and that's how all the nitrogen is removed out of the waste water. There are 4 meters of sand and about 2 meters of the free space in sand filtering stage. The waste water comes under the sand layer and move upwards in a circle. So it filtrates the suspend solid and phosphorus out of the waste water. The clean water then flows at the surface.

Step 6 Flotation

They don't have the flotation process on unless there is much of rain and melt water. The biological treatment is dimensioned to the flow of 2000 m^3/h. If the flow increases over that, the bacteria may be flushed away. In the case of an unusually high incoming flow rate, the waste water will be taken to the flotation plant right after the pretreatment and treated chemically once more. They also get a lot of water from industries. The toxic substances in the emissions may kill the bacteria growing in the aeration basins and the treatment usually

results badly in that way. To process such water in the flotation can guarantee a good quality of the water discharged into the sea. The flotation process works as that the waste water is mixed with an aluminium-based chemical and dispersion water, which lifts the dirt to the surface with the help of air bubbles. The impurities on the surface can be taken away



and the clean water from the bottom of the pool is lead out into the sea.

Figure 6: Flotation

Step 7 Sludge treatment

The excess sludge from both the pre-sedimentation and the after-sedimentation is pumped into thickeners. The thick slurry accumulated at the bottom and then polymers are added, which makes the sludge easier to dewater. It then is pumped into the centrifuges. After this, the dry sludge is pumped into a sludge silo, from where it is transported by trucks to S [illegible] en the sludge first goes in and then it's up to 20% dry when it comes out of the sludge treatment.

Figure 7: Sludge treatment

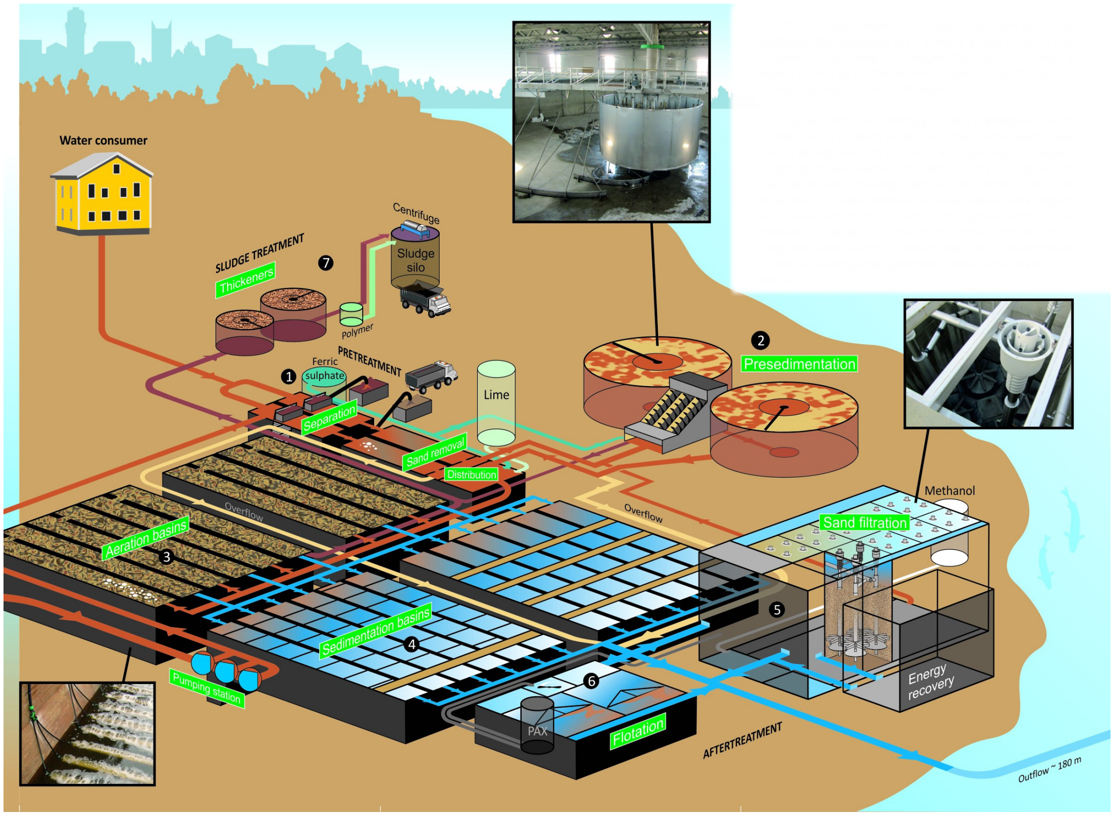


Figure 8: Overview of the treatment plant

The overall waste water treatment process is shown in figure 8. The waste water from water consumers passes through the pumping station and reaches the step screens and the sand and oil removal first. After this, it flows to the pre-sedimentation basins, of which they have two. There is normally only one basin in use; the other one is used when there is a lot of rain and melt water. There are 5 pairs of aeration basins and 6 pairs sedimentation basins in the plant. The outflow then goes to the sand filtration and flotation. The excess sludge is taken to the sludge treatment located at the top of the figure. Finally the treated water is discharged into the sea.

3 Capacity and flow

The maximal capacity is seen separately from every different stage in the cleaning process. The first stage, the step screens does not have a maximal capacity since that stage is not an actual basin. The other step is the sand and oil removal. This step is having two separate basins, each with a volume of 200 m^3. The next step is the pre-sedimentation, which also has two basins, with a volume of 2124 m^3 per basin. As next the water goes to the aeration basins. The volume of a single aeration basin is 1100 m^3 and Pått have 5 pairs of these. The next step is the sedimentation, of these there are six basins which have a maximal capacity of 720 m^3 water and six more basins which can take 550 m^3. The water then goes to the sand filtration, which is usually the last stage before the water is led into the sea. This stage can take up 240 m^3 of water. There is also the extra step used is special occasions, the floatation step. This step is made up from two basins, both having a maximal capacity of

182 m^3. If all these capacities are added to each other, the total capacity of all basins would be: 18372 m^3.

Every stage in the cleaning process is also having a maximal flow; this is the speed in which the water can pass through a process, so that the process is still be able to work. The maximal flow is having the unit m^3/h, which stands for cubic meter of wastewater per hour. The pretreatment stages are not having a maximal flow for them to work. But the pre-sedimentation is having a maximal flow, which is 2500 m^3 of wastewater per basin and hour. When the water passes the aeration tanks it can have a maximal flow of 2000 m^3/h. In the sedimentation basins the water can have a flow of 2200 m^3/h. The next process which the water passes through is the sand filtration. At this stage the waters flow is 2000 m^3/h as a maximum. In the last stage, the floatation, the waters maximal flow is 800-1100 m^3/h for the process to still work properly. The average income flow of water is 1200 m^3/h, and a flow between 500 and 1500 m^3/h is considered normal. This value differs a lot from for example during nighttime, when the income flow can be 500 m^3 per hour compared to mornings when the value is several times higher than the average.

Process	Maximal capacity / m^3	Maximal flow / m^3/h
Step screens	-	-
Sand and oil removal	$2 \cdot 200$	-
Pre-sedimentation	$2 \cdot 2124$	2500 (per basin)
Aeration	$5 \cdot 1100$	2000
Sedimentation	$6 \cdot 720 + 6 \cdot 550$	2200
Sand filtration	240	2000
Floatation	$2 \cdot 182$	1100

Table 1: The maximal capacity and maximal flow for the wastewater treatment plant

4 Requirements and degree of purification

The environmental authority sets the level of purification of the wastewater. Pått wastewater treatment plant got new requirements from 1.7 2012. In these requirements the degree of purification got even higher compared to the ones they had before.

Before 1.7 2012 the requirements where: for BOD_7 90 percent, for COD_{Cr} it was 75 percent, for the phosphorus it was 90 percent and for nitrogen there were no requirements at all. The new environmental requirement sets that the BOD_7 has to be 95 percent reduced, which means that there cannot be more than 10 mg/l in the outgoing water. The COD_{Cr} has to be 85 percent reduced, which sets the limit to 75 mg/l in the outgoing water. The phosphorus has to be 95 percent reduced, so the total amount of phosphorus in the outgoing water can be 0.3 mg/l but not higher. For the nitrogen the reduction has to be 70 percent.

4.1 Biological oxygen demand 2011

Figure 9 shows the BOD_7 results from January 2011 to December 2011 as a monthly average. On the left side of the diagram is the amount in mg/l and on the right side is the reduction in percent. The columns which are blue and white striped are the incoming BOD_7 and the once dark blue are the outgoing BOD_7. After November 2011 there are also two purple columns, this is due to the new pre-sedimentation basins, which have been taken into use at this time, the purple columns therefor show the amount of BOD_7 reduced due to this process. In the upper part of the diagram are the requirements and the actual reduction of BOD_7.

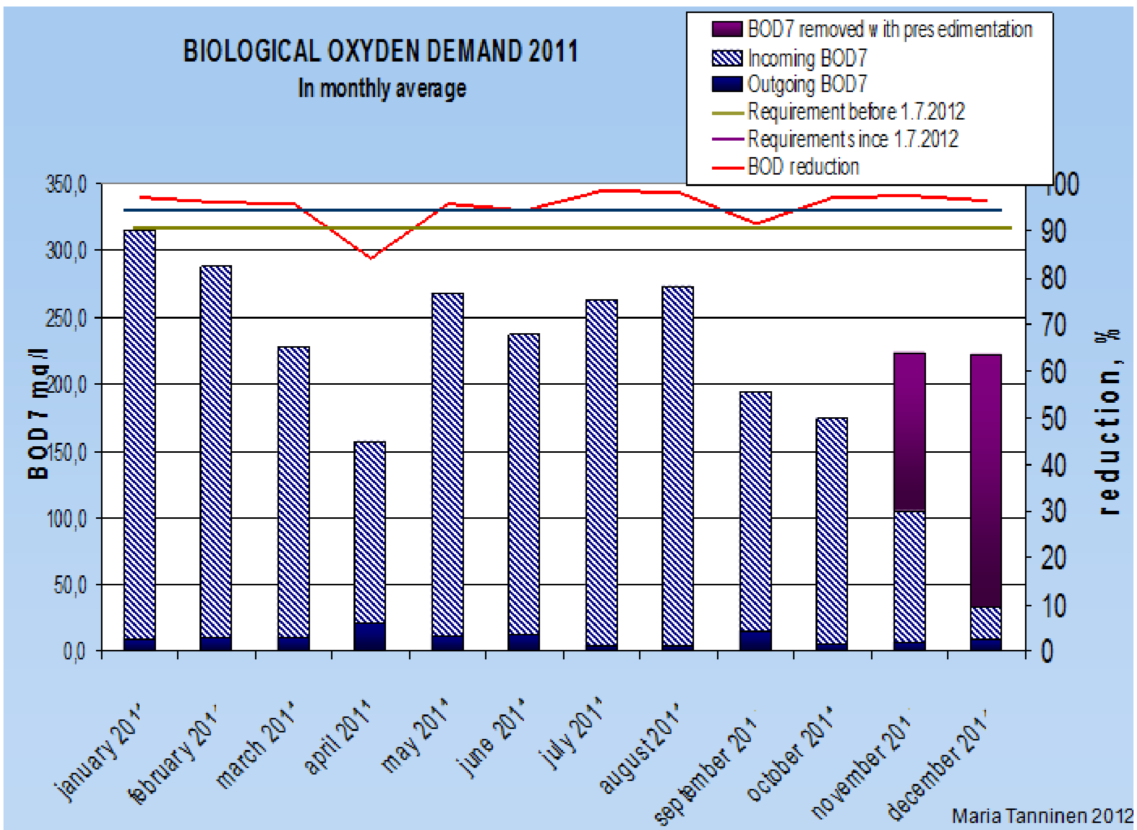


Figure 9: Diagram showing the amount and the reduction of BOD during 2011.

The green line shows the requirements before the new environmental requirements. The purple line shows the requirements after 1.7 2012 and the red line show the actual reduction of BOD_7.

From figure 9 it is possible to see that in the three first months of 2011 the reduced amount is according to the requirements fulfilled, but in April the reduction went down to about 85 %. This is because of the increased amount of water which at this time of the year comes to the wastewater treatment plant due to the melting snow on the streets. With the new pre-sedimentation process the treatment plant hopes to avoid this problem in the future. The figure also shows that the amount of BOD in the incoming water is less compared to the

rest of the year. This is also because of the amount of melting snow, which dilute the wastewater.
As seen in the diagram the amount of BOD is first reduced to about half of the incoming amount and in November 2011 and in December 2011 the reduction from the pre sedimentation was even better. The rest of the BOD is reduced in the aeration process.

4.2 Chemical oxygen demand 2011

Figure 10 shows the same kind of diagram but instead of BOD it shows the amount of COD during last year. From the figure one can see that the amount reduced COD have been fulfilled even for the new requirements during the whole year, except during April, when the amount reduced went down to about 65 %. This is explained in the same way as for BOD; the amount of melting snow is first diluting the wastewater and it makes the processes in the plant less efficient.

From the diagram one can see that more than half of the incoming COD had been reduced in the pre-sedimentation step. The COD is also being reduced in the aeration basins.

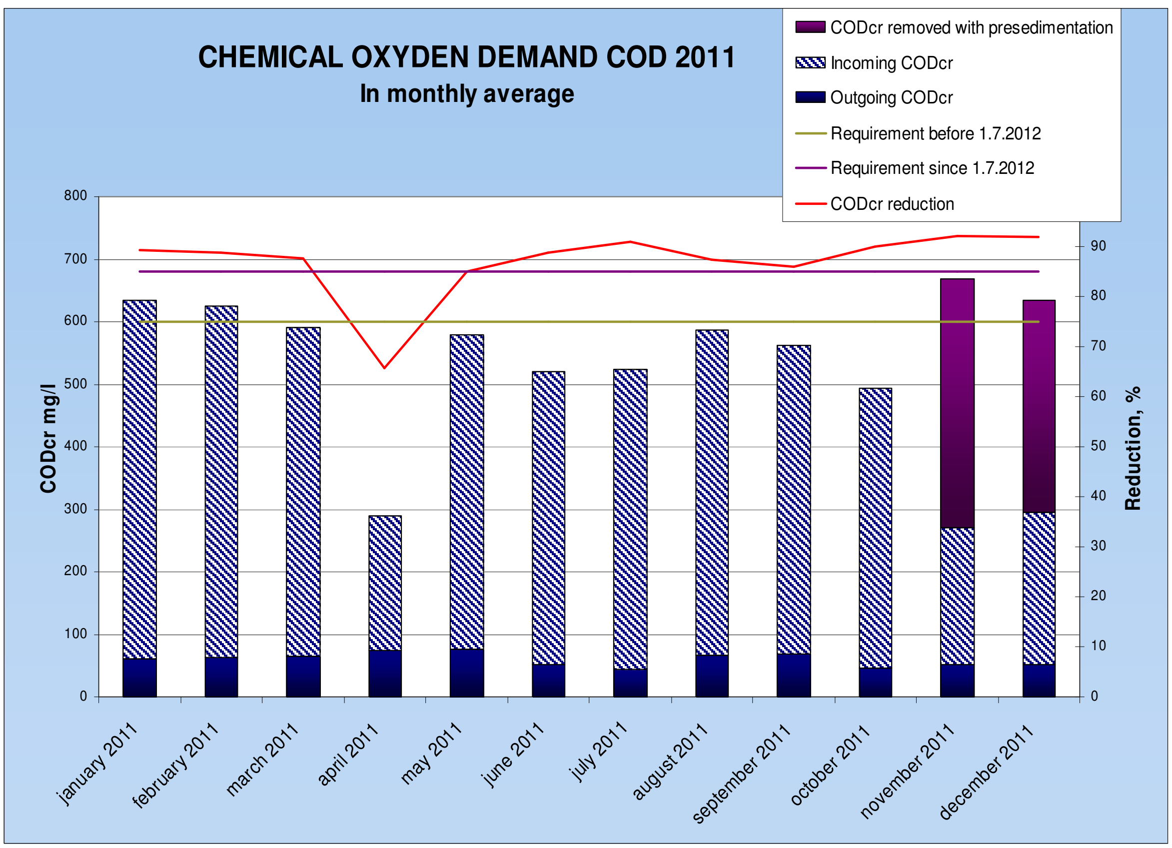


Figure 10: Chemical oxygen demand, COD 2011

4.3 Phosphorus 2011

Figure 11 is also a same kind of diagram but it shows the phosphorus, P, concentrations during 2011 as a monthly average. The reduced amount of P have fulfilled the requirements for that time and almost fulfilled the new requirements except of April. As in the previous two tables this is also caused by the increased amounts of incoming water due to all the melting snow. The table also shows that about half of all removed P is due to the pre-sedimentation process. The phosphorus is being reduced also a bit in the aeration process and in the sand filtration.

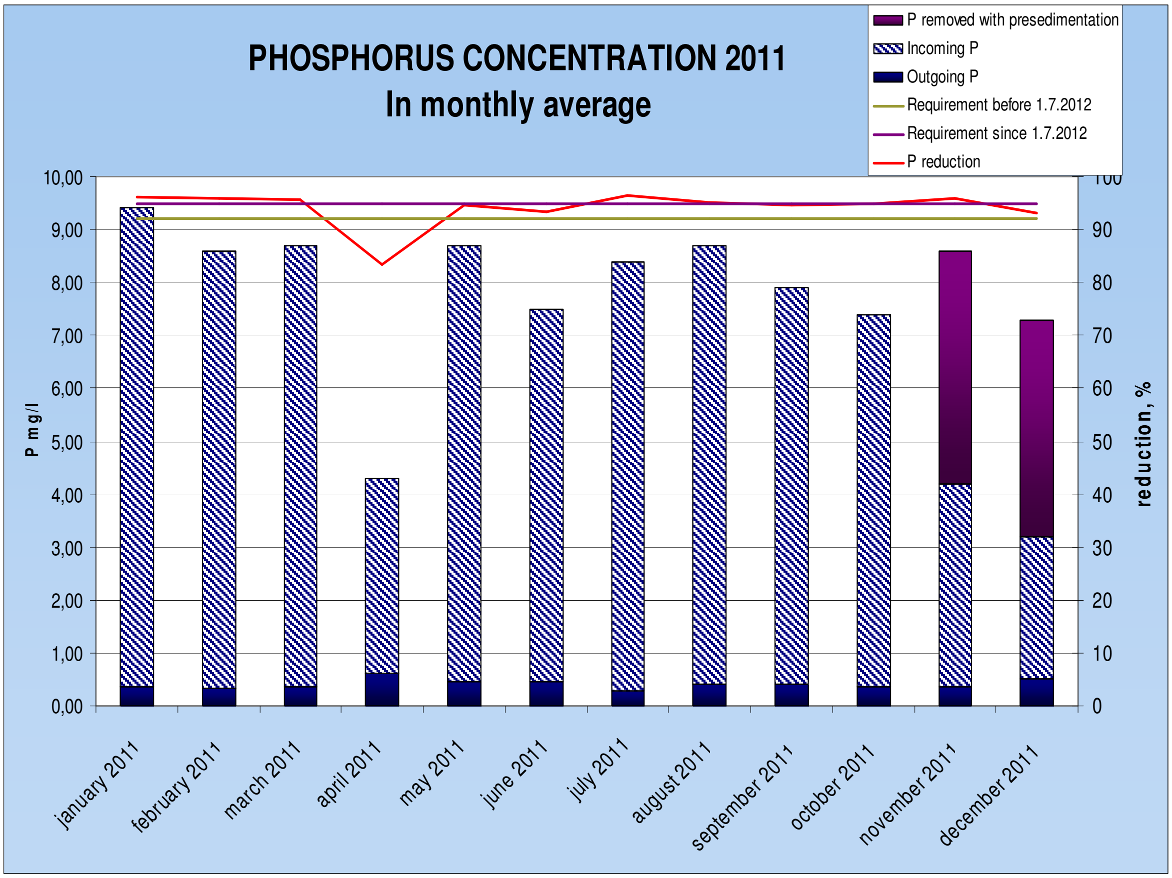


Figure 11: Phosphorus concentration 2011

4.4 Nitrogen 2011

Figure 12 shows the nitrogen concentrations 2011 on a monthly average. This diagram differs a bit compared to the previous ones. The columns show the incoming amount of nitrogen and the part which is totally light blue shows the amount of outgoing nitrogen. The diagram also includes the required reduction from 1.7 2012, as a red line, and the reductions during 2011, as a purple line. The diagram shows that the average reduction of nitrogen has been between 25 to 45 percent and the requirement starting from 1.7 2012 is at 70 percent.

The diagram only shows the total amount of nitrogen but the reduction of nitrogen happens today in two stages, which should remove the nitrogen by at least 70 percent. During 2011 there was only the nitrification part of the nitrogen removal. This step is combined with the aeration. In this process ammonium nitrogen is decomposed to nitrate nitrogen. This is a

pH sensitive stage so the pH has to been adjusted with the help of lime to make it more alkaline. During 2011 400 tons of alkaline adjusting substance was added to the wastewater.

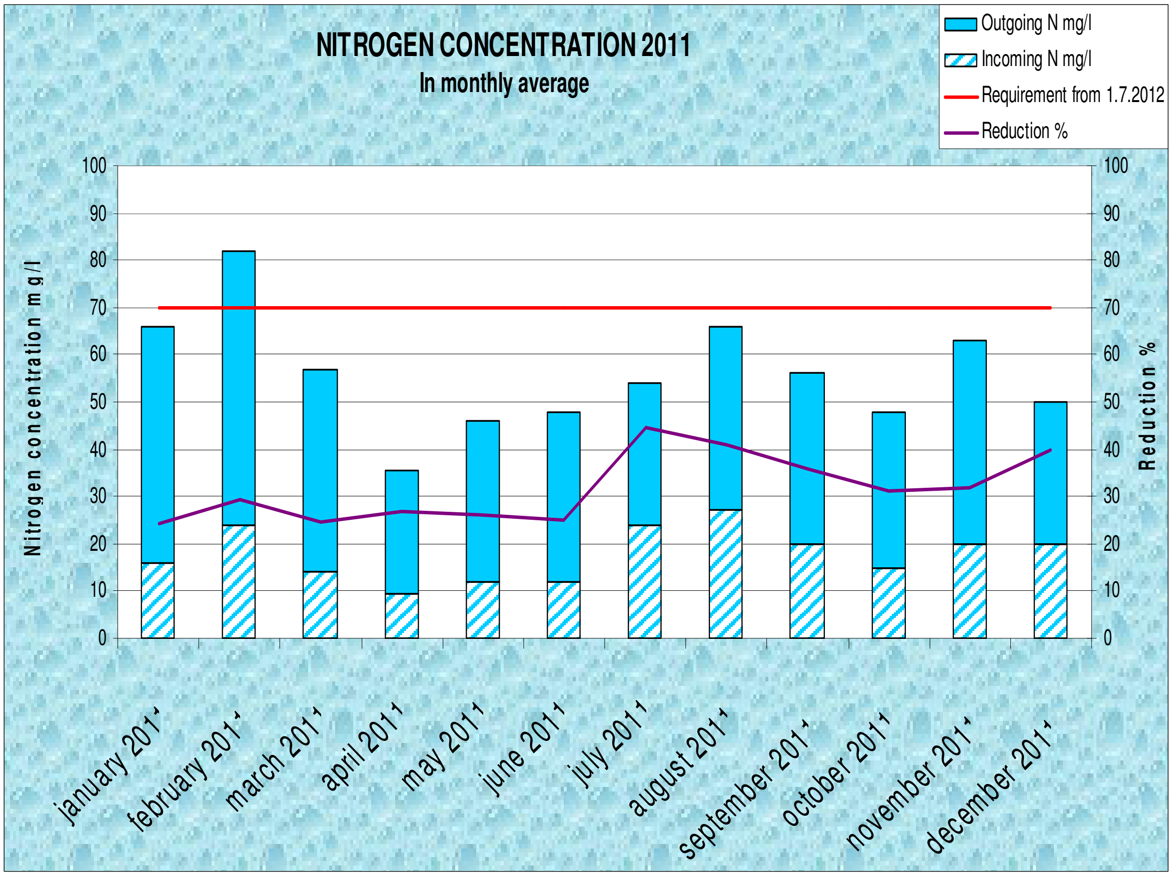


Figure 12 Nitrogen concentration 2011

Today there is also the denitrification process running at the wastewater plant. This stage is combined with the sand filtration. In this stage the nitrate nitrogen is further decomposed into nitrogen gas. This process has to be anaerobic, which means there can't be any oxygen present for this to work.

5 Further use and treatment of the end products

5.1 Water

As already mentioned in the second chapter, the treated water is led by a pipe into the sea. This pipe makes sure that the water is put into the sea about 180 meters from the coast. In this way, ocean currents can spread any remaining nutrients out in a larger area and its damaging effects therefore remain small.

5.2 Sludge

The treated sludge with about 17.7% dry substance content is transported by trucks from the treatment plant to Stormossen. They receive between 4 and 6 truckloads every day. In 2011 it was 12643m³ of sludge. At Stormossen the sludge then is mixed with water so that its dry sludge content is between 6% and 7%. After that it is put into the bio reactor to produce methane gas, which is used for heating and to make electricity. The leftover in the bio reactor is dewatered and blend with wood chips and soil. The soil is after two years highly nutritious and sold. The excess water from this process is partly reused and it partly goes to Stormossens own water treatment and then back to Pått.

5.3 Solid matter, sand and oil

The solid material which is removed by the step screens are for example diapers, papers and textiles. This solid matter and the sand from the sand and oil removal are gathered together and transported to Stormossen, where it then is put on the landfill. In 2011 they removed 55.8 tons from the screens and 110,84 tons of Sand. Also the oil is brought to Stormossen, where it is collected and then send for further treatment.

6 Process control and measurements

The treatment plant has in every basin a measuring tool which sends, depending on the basin, with a frequency ranging from every minute to every half hour, the results of the water quality to a controlling station. There are several computers which show the measured results and if the pumps and everything else is working correctly. If something is not in order you can see it immediately and can react, for example by stopping a pump. One time a day they measure from the incoming and outgoing water COD, pH, alkalinity, amount of solids, dissolved phosphorous, ammonium nitrogen, nitrate nitrogen, total amount of nitrogen and conductivity. With these measurements they can see if they fulfil the requirements and if there is something in the water which doesn´t belong there, like some toxic or something other harmful to the environment.

The Vasa environmental laboratory takes about 2 times a month samples of first the incoming water and then, half a day later, the outgoing water. These samples are taken automatically and they are analysing BOD_7, total phosphor, total nitrogen, ammonium nitrogen, amount of solid substances, COD_{Cr}, pH, conductivity and alkalinity. Only in the outgoing water they also measure dissolved phosphorous, iron, nitrate nitrogen and Escherichia coli. Eight times a year they also take samples on heavy metals in the incoming and outgoing water and in the dry sludge.

7 Main challenges

The main challenges the treatment plant has to deal with are poisonous water and too much water from for example heavy rains or melting snow. If this is the case, they lead the water either after the sand and oil removal or after the presedimentation directly to the flotation basin and from there into the sea. If it is poisonous water, the bacteria in the aeration basins would die and it would take them about 3 weeks to recover. If there is too much water the

treatment plant would have too small basins to treat all the water the normal way. In the flotation basin the water is then chemically treated and discharged into the sea.