

**A study of the effect of the amount of
phosphorus on the amount of cyanobacteria
related to the phosphorus load on the Baltic
Sea**

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1. Introduction

“The Baltic Sea has reached such a state, that even if the release of nutrients into its waters would be dramatically reduced, it cannot be saved.”

These were the words every single person in Finland heard as they were pronounced in the national news, quoting a recent Swedish study performed by an expert group in order to determine the present state of the Baltic Sea.

The research stated that the Baltic Sea was in much worse a condition than previously thought and that even though reductions in the release of nutrients into the sea had been of some help, the amount of this help was still small and insufficient. The research presented two possible future scenarios for the Baltic Sea, the first one predicting that continuing to reduce the release of nutrients into the sea would indeed help it recover and the latter stating that due to eutrophication the ecosystem of the Baltic Sea would have already changed so much and gotten into a cycle of internal loading that only extreme measures could fix the situation. (Rantajärvi, 2005)

Eutrophication is the “excess supply of nutrients leading to increased biological productivity” (Lehtoranta, 2003, 7). Since the nutrient-loaded waters from lakes, streams and rivers of a large part of Northern Europe, inhabited by 85 million people, all end up in the Baltic Sea it is not hard to understand why its ecology has been altered in such a dramatic way (Rydén et al., 2003, 30-31).

Internal loading constitutes to part of the phosphorus load on the Baltic Sea. The natural cycle of phosphorus (**Figure 1**) is quite different from that of the other important nutrient involved in eutrophication: nitrogen. Phosphorus enters aquatic environments usually through mineral weathering from soil. Unlike nitrogen, which is recycled back into the atmosphere through a process called denitrification, phosphorus is “fixed” into the bottom sediments of the sea usually by binding with iron. In anoxic conditions considerable amounts of this phosphorus may be released. This is referred to as internal loading, since it increases the phosphorus loading on the body of water regardless of the amount of external loading. Internal loading is the result of the input of nutrients of many years into a body of water. What makes it such a problematic phenomenon is that it increases eutrophication and is hard to stop.

When a body of water has entered the cycle of internal loading it means that reducing external nutrient input will not have such a dramatic effect on the level of eutrophication and this is exactly what has happened to the Baltic Sea. (Lehtoranta, 2003, 7 Rydén et al., 2004, 260-261)

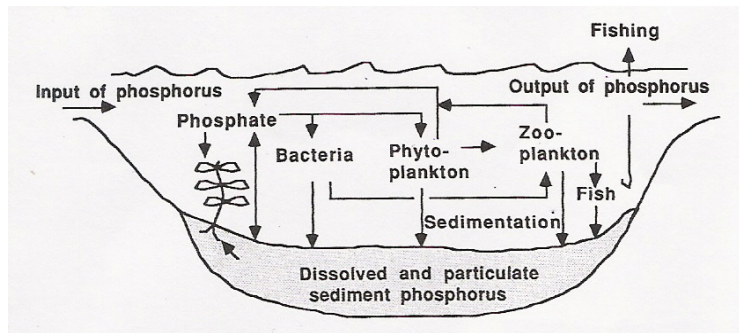


Figure 1: "A simplified phosphorus cycle" (Rydén et al., 2003, 261)

The Baltic Sea (**Figure 2**) is a very unique environment since it is a brackish water body, meaning that its water is less salty than that of a normal sea, but saltier than that of a normal lake. Because of the brackish qualities of the sea, the water column is divided into very clear stratifications, or layers, by temperature (thermocline) and salinity (halocline). These stratifications quite efficiently prevent the bottom waters from mixing with surface waters. The problem related to this is that when dead organic matter sinks to the bottom of a body of water the decaying processes use up oxygen from the water, which in the case of the Baltic Sea leads to oxygen depletion, because the deoxygenated water is not able to mix with the oxygen-rich water. This



Figure 2: "The Baltic Sea" (Wikipedia, 2005)

then again leads to the release of phosphorus from the sediments, which accelerates eutrophication, and since eutrophication increases the amount of “new particulate organic matter in water and the subsequent sedimentation” leading to even more dead organic matter sinking to the bottom of the sea, the hopelessness of the whole situation becomes

apparent. (Lehtoranta, 2003, 7, Ryhänen (ed), 2003, 28-29, 31-32)

So “internal loading” is the key word in this problem and phosphorus being the nutrient involved it was quite natural to pick phosphorus as the nutrient investigated in my study.

Cyanobacteria are nitrogen fixing prokaryotic organisms, meaning that they are able to convert atmospheric nitrogen gas (N_2) into usable forms, unlike other algae. They include characteristics from both plants and bacteria, but are still closer to bacteria and are hence classified as bacteria. This is why the term cyanobacteria defines the group of organisms more accurately than their older name: blue-green algae. In fact, not all species of cyanobacteria are blue-green at all, but can also vary in colour.

It is important to understand that nitrogen-fixing organisms are essential to the productivity of ecosystems and are a natural part of it, but their mass development in nutrient-enriched habitats like the Baltic Sea has become a problem, since they provide increased amounts of nitrogen promoting eutrophication and are sometimes toxic causing health problems in humans and other organisms leading to even deaths. (Finnish Institute of Marine Research (FIMR), 2001, Rogers and Gallon (eds), 1988, 292-293)

Algae need both phosphorus and nitrogen in a certain ratio for growth and since cyanobacteria are able to fixate atmospheric nitrogen, their growth is not limited by its amount in water but by that of phosphorus instead, taking that other variables affecting the growth are optimal. (e.g. Whitton and Potts (eds), 2000, 128)

Thus it is very probable that the amount of phosphorus would affect the amount of cyanobacteria in water in a relatively direct manner, even though there are many other environmental factors affecting this as well, such as temperature, light intensity and climate (e.g. Räsänen et al., 2001, 5).

Sources of phosphorus for cyanobacteria are varied. Phosphorus, however, is only usable in its phosphate-form. Inorganic phosphate in water, which is already plant-available, is called orthophosphate. This is energetically the best and also primary source of phosphorus for cyanobacteria. It has been debated that cyanobacteria living in the open sea could actually store phosphate left over from the spring and also make use of phosphate brought up into the surface waters by turbulence. In inner eutrophic bays phosphate is also released from the bottom sediments. (Vahtera et al., 2005, 68)

In addition to being able to use inorganic phosphate, cyanobacteria can also obtain phosphate from organic matter using enzymes (Vahtera et al., 2005, 68). In my study I decided to determine the total amount of phosphorus in water, since it includes all of its forms. This is perhaps the safest choice since the importance of different sources of phosphorus to cyanobacteria is not that well known yet. Taking only the values of orthophosphate would give a distorted picture, since they only partially contribute to the actual amounts of phosphorus used.

The most common bloom-forming algae found in the Baltic Sea are *Aphanizomenon flos-aquae* (Figure 3), *Anabaena lemmermannii* (Figure 4) and *Nodularia spumigena* (Figure 5). Out of these three only *Nodularia spumigena* has always shown to be toxic, whereas the genus *Anabaena* has been discovered to include both toxic and non-toxic strains. *Aphanizomenon flos-aquae* on the other hand is classified as non-toxic in the Baltic Sea even though this is not the case in all parts of the world (Räsänen et al., 2003, p.4).

The reason I decided to concentrate only on the common bloom-forming cyanobacteria is because they are relatively easy to recognise and being the most common species represent the whole cyanobacterial population inhabiting the Baltic Sea region quite well. The amounts of other species found are generally quite small.

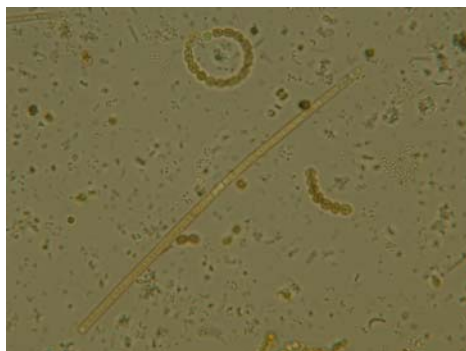


Figure 3: (above) *Aphanizomenon flos-aquae* in a sample from Seurasaarenselkä Bay 2005, Tiia Metiäinen



Figure 4: (above) Spiral-shaped *Anabaena lemmermannii* in a sample from Seurasaarenselkä Bay 2005, Tiia Metiäinen

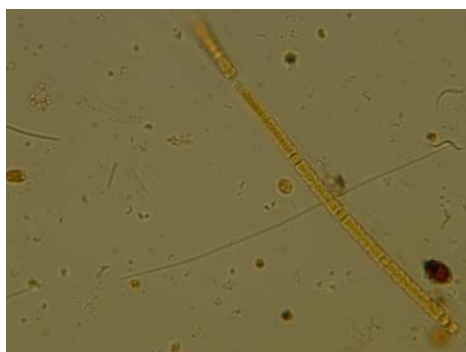


Figure 5: (on the left) *Nodularia spumigena* in a sample from Katajaluoto 2005, Tiia Metiäinen

***The pictures were taken using a light microscope camera.**

This research thus concentrates on the effect of the amount of phosphorus on the amount of common bloom-forming cyanobacteria in water samples obtained from the Helsinki coastal area, relating the results to the phosphorus load on the Baltic Sea and its possible effects in connection to eutrophication.

My accurate research question is: “Does the amount of phosphorus in water have an effect on the amount of common bloom-forming cyanobacteria?”

I believe that the amount of phosphorus in water will indeed have an effect on the amount of cyanobacteria. This is because as I explained before, phosphorus is usually the limiting nutrient of the growth for this group of organisms. It is important to make sure that there are present as few other major factors affecting the growth of cyanobacteria as possible so that the results would be optimal. Factors like these include the time of the year and that is why I decided to perform my research in July-August, which is best time for cyanobacterial growth (e.g. Kononen et al. 1996, 99).

It has been stated that the amounts of certain species of cyanobacteria are a direct indication of eutrophication (Heinonen, 1974, 131). This suggests that if there would indeed exist a correlation between the amount of phosphorus in water and that of cyanobacteria, a link could also be drawn between the phosphorus load on the Baltic Sea and its eutrophication.

2. Materials and Method

The research was conducted at three research stations, namely Laajalahti Bay, Seurasaarenselkä Bay and Katajaluoto, which are a part of the northern archipelago of the Baltic Sea, the Gulf of Finland to be more specific. They are all located in the coastal waters of Helsinki and are in a somewhat eutrophic state thus representing the current condition of the Baltic Sea. The exact locations of the research stations in relation to each other can be seen in **Figure 6**, where they have been circled.

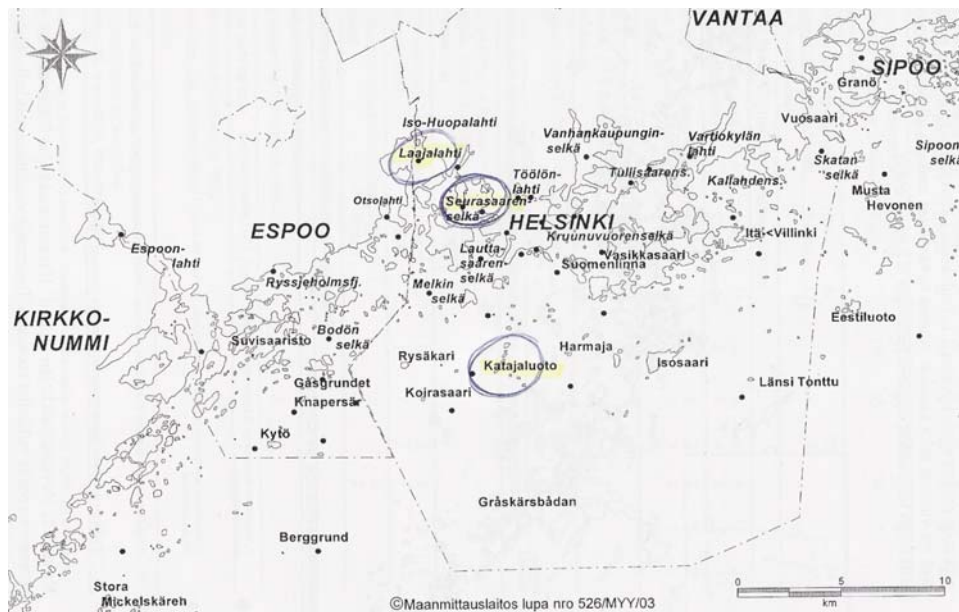


Figure 6: The location of the research stations in the Helsinki coastal area (Autio et al., 2003, 11)

In order to obtain as detailed information as possible about the places studied in my research and to move relatively long distances on water to get to them, I was kindly given the possibility to obtain my water samples from research stations used by the City of Helsinki Environment Centre. All the equipment needed was also supplied even though I carried out my research independently.

The samples of water were retrieved from the research stations on three different dates, with a few weeks between each time, the dates being 11.7, 27.7 and 16.8.2005. The dates are referred to as **day 1, 2 and 3** of the experiment, respectively, in the rest of the study.

Samples of seawater for determining the amount of phosphorus were obtained with a Ruttner sampler (**Figures 7 and 8**) from the depth of 0m (surface water) and placed into a 1l labelled plastic bottle. The samples for determining the amount of cyanobacteria were obtained with a tube sampler (**Figure 9**) (2m long) from 0-4m (by first taking a sample of 0-2m and mixing that with the sample of 2-4m, then pouring some of the mixture into a labelled brown glass bottle with preservative in it). This ensured that the water sample represented the whole water column meaning that there was no need to take various samples from the same place to obtain an average result.

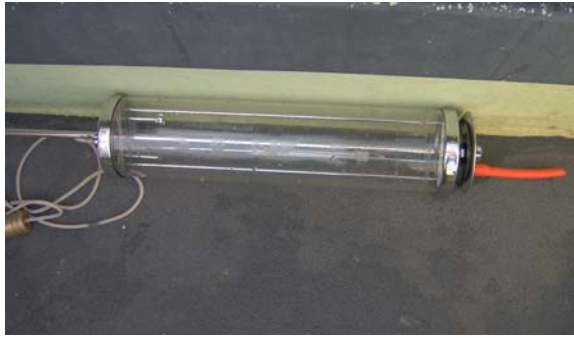


Figure 7: A Ruttner sampler, 2005, Tiia Metiäinen



Figure 9: A tube sampler, 2005, Tiia Metiäinen



Figure 8: The author is taking a sample of water using a Ruttner sampler, 2005, Liisa Autio

The amounts of phosphorus were determined (in the laboratory of the City of Helsinki Environment Centre) automatically using the Lachat Quickchem analyser (**Figure 10**). I determined the amount of common bloom forming cyanobacteria by counting their average amount in each sample using a light microscope. This procedure is explained more thoroughly in the following paragraph.

Since the samples of water for determining the amount of cyanobacteria were preserved in the bottles they had originally been put in and kept in a cold environment they had to be prepared for microscopy. This was done by compiling a settling chamber (see **Figure 11**) for each sample, then shaking each bottle and pouring enough sample into a separate sedimentation chamber to fill it next placing a glass lid on top of it. The size of the sedimentation chamber required is based on estimation and previous knowledge. If there appear to be, or usually are a lot of algae in a sample, a smaller sedimentation chamber is used and vice versa. The volumes of sedimentation chambers used in my experiment were 5, 10 and 25 ml.



Figure 10: The Lachat Quickchem analyser, 2005, Tiia Metiäinen

Next the samples were left to settle for one day, so that all the dead phytoplankton, cyanobacteria amongst it, would land into the bottom-plate chamber (which is a type of a glass slide with a round-shaped depression in the middle) in order to form a sample of the population inhabiting the place where the water taken from.

The following day the amount of cyanobacteria was counted for each sample. This was done by placing the bottom-plate chamber under a light microscope, scanning down a line transect of the sample and counting the amount of cyanobacteria in 20 randomly picked fields of view (to ensure that a procedure of random sampling was used) (**Figure 12**). The average amount of cyanobacteria was then derived by adding up the values obtained from each field of view and dividing the result by the amount of values (20).

Since cyanobacteria form chains of small bacteria their amount was counted by having 10 micrometers of (μm) correspond to one unit of cyanobacteria. Thus a chain of 20 μm of common cyanobacteria corresponded to two units of cyanobacteria. The lengths were estimated using the microscope's scale of 480 μm .

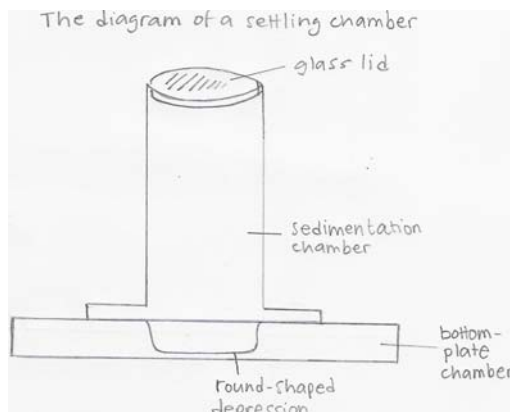


Figure 11: A diagram of a settling chamber (not in proportion), Tiia Metiäinen

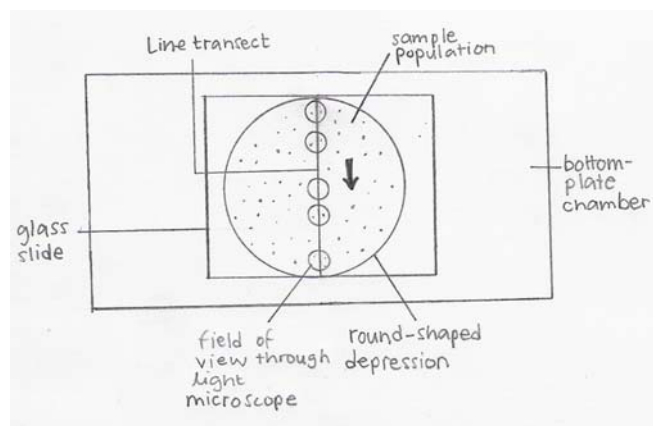


Figure 12: 20 fields of view were randomly picked along a line transect, Tiia Metiäinen

After coming up with the average amount of cyanobacteria in a sample the results had to be put into proportion so that they would be comparable, since the sedimentation chambers used for samples from different places were of different volumes. As the results of the amount of phosphorus were presented in litres it seemed logical to convert the results concerning cyanobacteria into units per litre as well. All samples from Laajalahti Bay were prepared using 5ml sedimentation chambers with the exception of the sample of day 3, which was prepared using a 10ml sedimentation chamber. This meant that the average amount of cyanobacteria from samples of day 1 and 2 had to be multiplied by 200 in order to get the result in units per litre. Samples from Seurasaarenselkä Bay, like that of day 3 from Laajalahti Bay, were prepared using 10ml sedimentation chambers, so next the results had to be multiplied by 100 to get the result in litres. Similarly, since sedimentation chambers of 25ml were used with samples from Katajaluoto they had to be multiplied by 40 to get the results in the right units. All calculations described above concerning the samples are included in the **Appendix**.

3. Results

In addition to the amount of cyanobacteria in water samples the total amount of phosphorus was determined. These results are shown together with the average amounts of all common bloom-forming cyanobacteria in **Tables 1, 2 and 3**.

When the values obtained from the water samples are plotted into a graph, not in chronological order according to date, but in order of increasing amount of phosphorus, it can be seen whether some sort of a trend exists and whether there is a correlation between the amount of cyanobacteria and the amount of phosphorus at all. **Figure 13** presents the results from samples obtained from all research stations comparing them with each other. As mentioned before, one unit of cyanobacteria corresponds to 10 μm of cyanobacterial chain.

3.1 Laajalahti Bay

Table 1: The values determined from samples obtained from Laajalahti Bay

Day	Average amount of common cyanobacteria (units/l)	Total amount of phosphorus ($\mu\text{g/l}$)
1	520	47
2	1210	83
3	220	61

3.2 Seurasaarenselkä Bay

Table 2: The values determined from samples obtained from Seurasaarenselkä Bay

Day	Average amount of common cyanobacteria (units/l)	Total amount of phosphorus ($\mu\text{g/l}$)
1	120	25
2	885	45
3	695	37

3.3 Katajaluoto

Table 3: The values determined from samples obtained from Katajaluoto

Day	Average amount of common cyanobacteria (units/l)	Total amount of phosphorus ($\mu\text{g/l}$)
1	188	13
2	60	_*
3	540	22

***Due to a failure in the connection between the device used for determining the amount of phosphorus and the computer where the final results were shown no results were obtained for the amount of phosphorus on day 2**

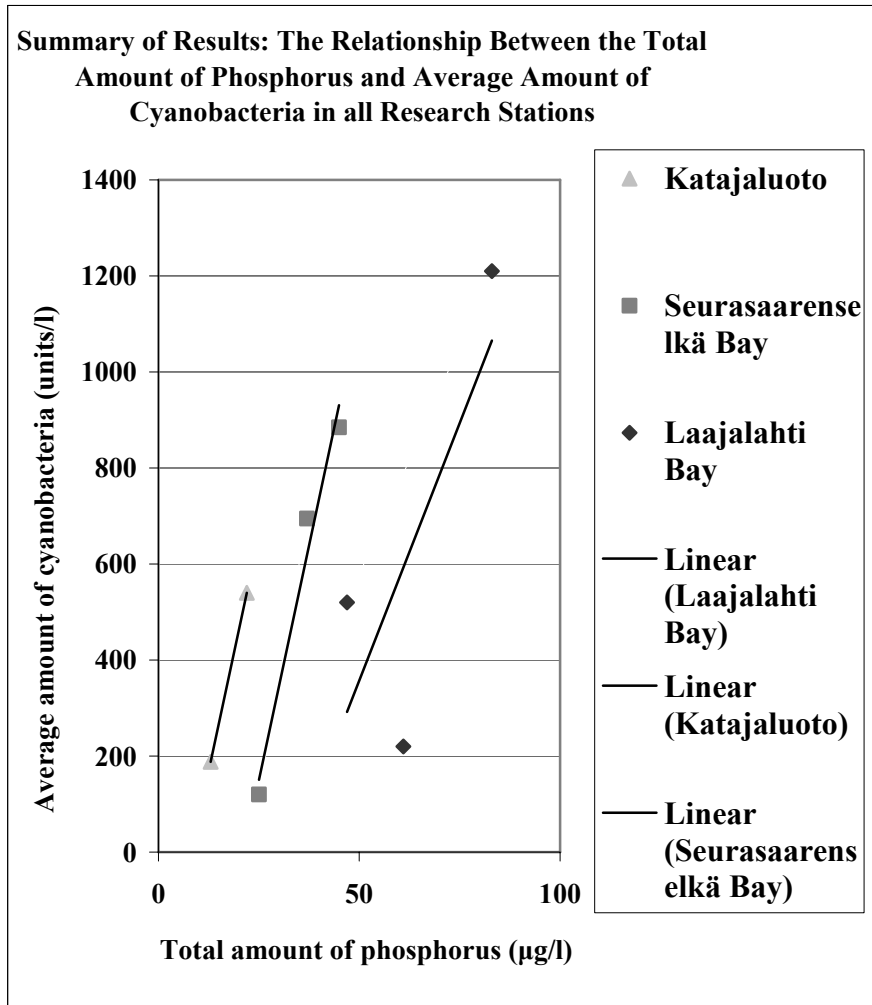


Figure 13: Summary of results: the relationship between the total amount of phosphorus and the average amount of cyanobacteria in all research stations

4. Conclusion and Evaluation

As can be seen from **Figure 13** there exists a clear relationship between the amount of phosphorus and common bloom-forming cyanobacteria in water. This can be derived from the trend lines of the graphs, even though they cannot be considered all that accurate, due to the small amount of samples, making them easily distorted by freak values. In most cases the amount of cyanobacteria is indeed proportional to the total amount of phosphorus in the water sample, since an increase in the amount of phosphorus can also be seen as an increase in the amount of cyanobacteria. The only

exception to this is the result obtained from Laajalahti Bay (**Table 1**) on day 3, which suggests a smaller value for the amount of cyanobacteria than on day 1, even though the amount of phosphorus is larger. This result could be explained by the fact that only the amount of the three most common cyanobacteria was determined and thus if there would have been a larger number of another species of cyanobacteria or microalgae, it would not show in the results. If this outlier would not distort the trend line of the Laajalahti Bay results, the gradients of the trend lines for each research station would be almost identical. This can be observed in **Figure 13** quite well. This indicates that the results concerning the relationship between the amount of phosphorus and cyanobacteria are similar regardless of the location of the research station, supporting the proposition that they could be generalised to the whole Baltic Sea.

However, it cannot be claimed that total amount of phosphorus and that of common cyanobacteria would or should be directly proportional to each other, since not all of the phosphorus in water is in a form available for cyanobacteria. The total amount of phosphorus does not also tell the percentages of the different forms in which phosphorus is found, so it cannot be derived whether a certain form would have a stronger impact on the amount of cyanobacteria than others.

Deciding to use the total average of all common bloom-forming cyanobacteria instead of that of the different species was a wise choice considering that the possibility of recognising a species wrong was reduced making the results more reliable, taking into account that this was the first time I have ever had to recognise species of cyanobacteria.

However, it has been said that there are great differences in the ways in which different species of cyanobacteria utilize phosphate (Vahtera et al., 2005). This means that combining results of three different species may have distorted the final results. Especially when considering the possibility that cyanobacteria can store phosphate, which affects the ability to draw direct connections between current amounts of phosphorus in water and corresponding amounts of cyanobacteria. In addition to this, there exist other individual differences between species of cyanobacteria as well.

The samples of water were collected on different dates, so on the day they were analysed some had been kept in cold for a longer period of time affecting the quality

of the samples. A smaller amount of preservative was also used with samples of day 1 meaning that they were not as well preserved. This results in the fact that the amounts of cyanobacteria in water samples collected on day 1 might have actually been larger, since the chains of cyanobacteria could have broken down into smaller bits lowering the results (because only chains of over 10µm were taken into account).

Also the fact that the amounts of cyanobacteria were based on estimation of the length of the chains affects the results. This made it impossible to attempt calculating exact error percentages for the results. Consequently, they can be estimated to be quite high. Results concerning the species *Anabaena lemmermannii* could be considered most unreliable, since its chains often form a spiral-shaped pattern making estimating their length even harder. In more professional circumstances the average amount of cyanobacteria is also counted even more precisely, ending up with the actual cell volumes. I decided to keep my calculations simple, since they are adequate enough to show whether there exists a relationship between the amount of phosphorus and the amount of cyanobacteria or not. This however means that my results might be a little out of proportion since for example *Nodularia spumigena* has quite a large cell volume compared to that of the two other species, which is not taken into account in my calculations concerning merely the length of the chain of cyanobacteria.

Other possible factors affecting the results could be that the amount of phosphorus was only determined from surface water meaning that the value might have been different deeper in the sea. This concerns especially the results of day 1, which was a very sunny day lacking any wind, resulting in the fact that the sea water was not probably evenly mixed resulting in uneven nutrient and cyanobacteria distribution. Also since the results were taken from one place only instead of many different, there is a possibility that the sample was not representative of that area. These potential sources of error could have been avoided by taking several samples of water and coming up with an average value for them. The fact that the amount of phosphorus in Katajaluoto on day 2 could not be obtained affected the result as well, since the presence of a very different value might have changed the graphs derived from the results. The error percentage of the amounts of phosphorus obtained using the Lachat Quickchem analyser has been defined to be 15%. Added to the other possible sources of error and the error percentage in the amounts of cyanobacteria, which has been estimated relatively high, it can be concluded that the results are not very

accurate. However, since specific values are not the ultimate subject of research rather than the trends according to which they increase or decrease, the results can be considered sufficiently accurate. They present the relationship between the two variables reliably enough and that is what is studied in this research.

Since this was a field experiment constant variables could not be monitored that well. In order to investigate the relationship between the amount of phosphorus and cyanobacteria without any interfering factors a laboratory experiment could be constructed. Other limitations related to the experiment being a field experiment is that the possibility to replicate the study precisely becomes impossible. However, a way to achieve more reliable results, when studying the relationship between the two variables in a natural environment, would be to continue the study for a number of months or even years.

Regardless of the possible sources of inaccuracies the results of this research can be related to as guiding and reliable enough to point out trends in the relationship between the amount of phosphorus and cyanobacteria. My conclusion is that even though the amount of cyanobacteria is not directly proportional to the amount of phosphorus in water, there definitely exists a correlation between the two variables. This confirms my hypothesis that the amount of phosphorus has indeed an effect on the amount of common cyanobacteria in water. My conclusion is also supported by various sources and studies promoting also the reliability of the results obtained in this research (e.g. Vahtera et al., 2005, Kononen et al., 1996, Lehtoranta, 2003, Rogers and Gallon (eds), 1988).

These results can then be generalised to conclude that the phosphorus load on the Baltic Sea must have an effect on eutrophication (which is shown by a consequent increase in the amount of cyanobacteria). Various models have been developed in order to understand factors and processes leading to eutrophication, and the future does not look too good (e.g. Eloranta (ed.), 2004, 57-60). Even if external loading of nutrients is dramatically decreased the effects will become visible only relatively slowly. The basic aim in achieving better nutrient management is to stop linear nutrient flows and come up with a way to recycle nutrients in the society. This idea can be put into practice in various ways, but there is still a lot to improve.

In the introduction of this research I talked about the obligation of the citizen of the Baltic Sea region. Becoming aware of the whole situation is only the first step. Next comes taking action. Environmental problems like this are confronted most efficiently when they are fought on many levels: personal, national and international level. Not only should strong policies be made to reduce the consumption of nitrogen and phosphorus, choices in the everyday life make a difference as well. Every human being living in the Baltic area is estimated to produce 1 kg of phosphorus annually (Rydén et al., 2003, 287). This does not seem like much, but considering that the Baltic Sea region is inhabited by 85 million people, the value suddenly becomes of a whole new calibre. Similarly, composting organic waste does not feel like a big thing to do, but if 85 million people do it as well the impact will be inevitable. It is this sort of mentality the future of the Baltic Sea relies upon.

5. Acknowledgements

Many thanks to Mr Ilppo Kajaste, Mrs Liisa Autio, Mrs Marjatta Paasila, Mr Jyrki Muurinen, Mr Hannu Salonen and Mr Tapio Riiheläinen from the City of Helsinki Environment Centre for all the information and resources provided. In addition I wish to express my gratitude to Mr Emil Vahtera from the Finnish Institute of Marine Research for providing valuable information and IB biology teacher Ms Mari Juuti for her constant guidance and support throughout the process of making this Extended Essay.

6. Appendix

Table 4: The sum of the amounts of cyanobacteria in samples obtained from Laajalahti Bay

Day	<i>Nodularia spumigena</i>	<i>Aphanizomenon flos-aquae</i>	<i>Anabaena lemmermannii</i>	Total
1	8	16	28	52
2	0	83	38	121
3*	0	19	25	44

*On day 3 the results were obtained using a 10ml sedimentation chamber

Table 5: The average amount of each species of common cyanobacteria (including calculations) in water samples from Laajalahti Bay

Day	<i>Anabaena lemmermannii</i> (units/l)	<i>Aphanizomenon flos-aquae</i> (units/l)	<i>Nodularia spumigena</i> (units/l)	Total (units/l)
1	280 $(\frac{28}{20} \times 200 = 280)$	160 $(\frac{16}{20} \times 200 = 160)$	80 $(\frac{8}{20} \times 200 = 80)$	520 $(\frac{28}{20} \times 200 = 280)$
2	380 $(\frac{38}{20} \times 200 = 380)$	830 $(\frac{83}{20} \times 200 = 830)$	0 $(\frac{0}{20} \times 200 = 0)$	1210 $(\frac{121}{20} \times 200 = 1210)$
3	125 $(\frac{25}{20} \times 100 = 125)$	95 $(\frac{19}{20} \times 100 = 95)$	0 $(\frac{0}{20} \times 100 = 0)$	220 $(\frac{44}{20} \times 100 = 220)$

Table 6: The sum of the amounts of cyanobacteria in samples obtained from Seurasaarenselkä Bay

Day	<i>Nodularia spumigena</i>	<i>Aphanizomenon flos-aquae</i>	<i>Anabaena lemmermannii</i>	Total
1	2	21	1	24
2	0	92	85	177
3	0	114	25	139

Table 7: The average amount of each species of common cyanobacteria (including calculations) in samples obtained from Seurasaarenselkä Bay

Day	<i>Anabaena lemmermannii</i> (units/l)	<i>Aphanizomenon flos-aquae</i> (units/l)	<i>Nodularia spumigena</i> (units/l)	Total (units/l)
1	5 $(\frac{1}{20} \times 100 = 5)$	105 $(\frac{21}{20} \times 100 = 105)$	10 $(\frac{2}{20} \times 100 = 10)$	120 $(\frac{24}{20} \times 100 = 120)$
2	425 $(\frac{85}{20} \times 100 = 425)$	460 $(\frac{82}{20} \times 100 = 460)$	0 $(\frac{0}{20} \times 100 = 0)$	885 $(\frac{177}{20} \times 100 = 885)$
3	125 $(\frac{25}{20} \times 100 = 125)$	570 $(\frac{114}{20} \times 100 = 570)$	0 $(\frac{0}{20} \times 100 = 0)$	695 $(\frac{139}{20} \times 100 = 695)$

Table 8: The sum of the amounts of cyanobacteria in samples obtained from Katajaluoto

Day	<i>Nodularia spumigena</i>	<i>Aphanizomenon flos-aquae</i>	<i>Anabaena lemmermannii</i>	Total
1	29	58	7	94
2	1	20	9	30
3	10	246	14	270

Table 9: The average amount of each species of common cyanobacteria (including calculations) in water samples from Katajaluoto

Day	<i>Anabaena lemmermannii</i> (units/l)	<i>Aphanizomenon flos-aquae</i> (units/l)	<i>Nodularia spumigena</i> (units/l)	Total (units/l)
1	14 $(\frac{7}{20} \times 40 = 14)$	116 $(\frac{58}{20} \times 40 = 116)$	58 $(\frac{29}{20} \times 40 = 58)$	188 $(\frac{99}{20} \times 40 = 188)$
2	18 $(\frac{9}{20} \times 40 = 18)$	40 $(\frac{20}{20} \times 40 = 40)$	2 $(\frac{1}{20} \times 40 = 2)$	60 $(\frac{30}{20} \times 40 = 60)$
3	28 $(\frac{14}{20} \times 40 = 28)$	492 $(\frac{246}{20} \times 40 = 492)$	20 $(\frac{10}{20} \times 40 = 20)$	540 $(\frac{270}{20} \times 40 = 540)$

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