Erken Laboratory

Benthic animals as indicators: from Lake Erken to the Baltic Sea

Research in limnology

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Content

Introduction

Nowadays people are thinking more and more about water quality because drinkable water is becoming rare. Human pollution and modifications of the environment and climate are now so pervasive that no aquatic environment of the biosphere is unaltered in some manner by these disturbances. Human influences vary greatly and change with time but nonetheless often dominate regulation of biotic productivity and biogeochemical cycling. The reasons could be human influence in industrial and agricultural activities[1]. Clean water is an essential physiological requirement of humans for survival and for provision of food and basic living needs[2] and that is why we are investigating how different benthic animal species are living in various types of waters. We are trying to estimate the pollution level by using benthic invertebrates, because they can characterize not only the pollution level[3] but also the level of oxygen, nutrients etc. As a basic step, the values of the biological quality elements must be taken into account when assigning water bodies to any of the ecological status and ecological potential classes. In order to ensure comparability the results of the biological monitoring systems shall be expressed as ecological quality ratios for the purposes of ecological classification[4]. We are also considering how biodiversity and living conditions are affected by water constituent.

We chose six places from near Lake Erken were we thought that taking samples would be the most useful and resourceful. Two of them are lakes (Lake Erken, Lake Gillfjärden) on the way three are situated in streams (outlet of Lake Erken, Broströmmen, Broströmmen inlet Norrtäljeviken) and the last site is in the Baltic Sea (Bay of Norrtälje) (see figure 1.).

We are using wind exposed areas, where the bottom is typically composed of stones, gravels and sands and the oxygen level is usually high[5]. Thus the differences in living conditions would be less in wind exposed areas in lakes and streams, compared to wind sheltered littoral zones, which are richer in plants and have a bottom that is richer in nutrition and decomposed material, compared to streams.

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[1] Robert G. Wetzel, 2001
[2] Robert G. Wetzel, 2001
[3] Water Farmework Directive, 2000
[4] Water Farmework Directive, 2000
[5] The Erken report, 2007

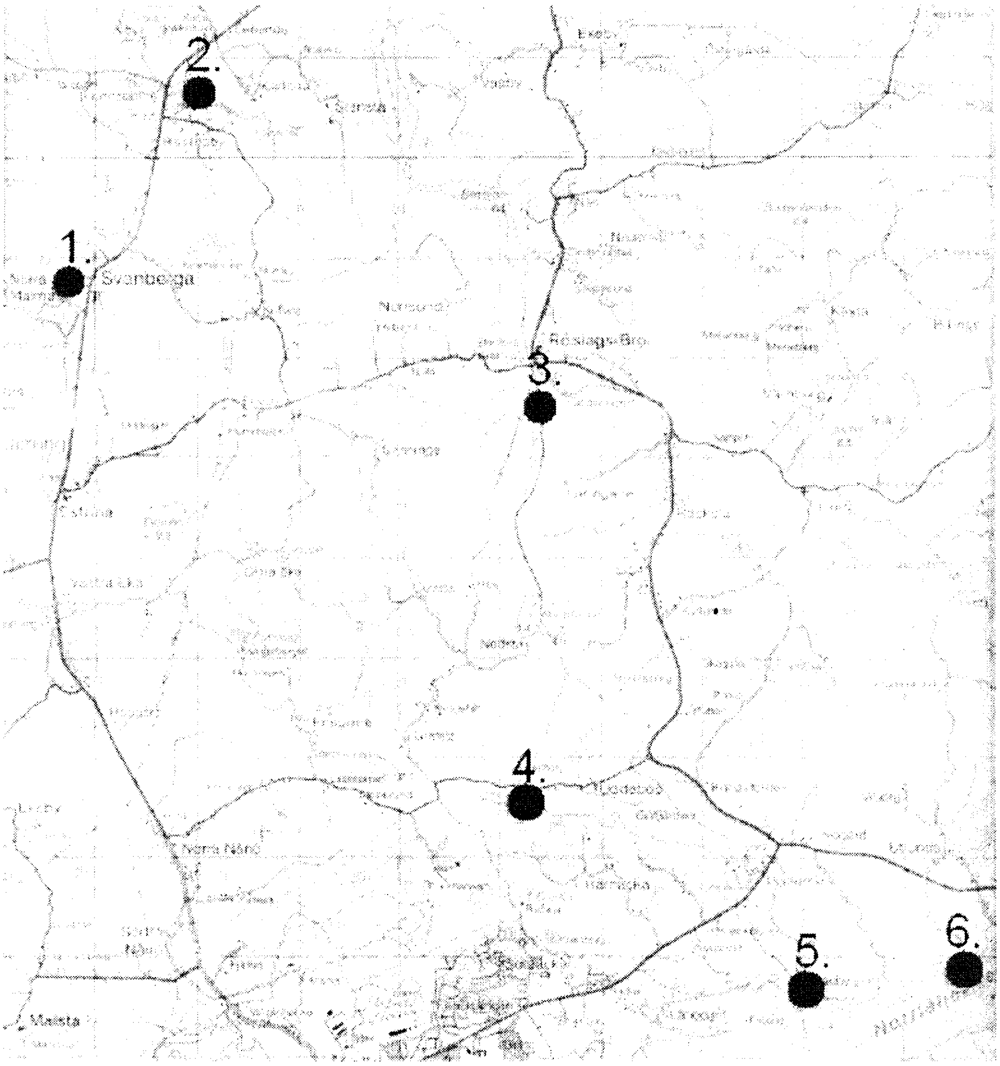

Figure 1. The sites that we took under investigation

Aim

The aim of this project is finding out how polluted the water from Lake Erken to the Baltic Sea is by using benthic invertebrates as indicators. We would also like to figure out what happens when fresh water becomes brackish water and see if there are differences in diversity depending on closeness to the sea, and why those differences might be. In some ways our aims are similar WFD (Water Framework Directive). We are taking under observation the road from Lake Erken to the Baltic Sea (Bay of Norrtälje). The objects of our research project are various species and amount of animals in different types of water (lakes, streams and sea). In our project we use different kinds of animal species, and the diversity of species, as an indicator (Look into extra 1) for quality of water in brackish and fresh water.

Hypothesis

At the beginning of our project we made some hypothesis, because we want to know how the different concentration of salt in the water and the level of pollution are affecting the biodiversity. As a result we wanted to investigate the following hypothesis:

- There are more species in lakes and less in streams
- There are more animals in lakes than in streams
- Lake Erken is richer in diversity of species than Lake Gillfjärden.
- There are differences in diversity of species in fresh and brackish water
- Throughout all water-roads of our investigation there is at least one common specie
- The concentration of salt and pollution level in the water affects the amount of the species.

Methods and materials

Materials

To collect the samples we needed some equipment. We used:

- tape measure (1)
- strainers (2)
- landing nets (2)
- plastic jars (in one place 40)
- bowls (2)
- wading pants (2)
- aqua scope (1)
- tweezers (2)
- thermometer (1)
- indicator papers (15)
- little plastic bottles (12)

* Pipette (2)

* Conductivity meter (1)

* Microscope (2)

* Different books for indicating (look into references)

Methods

We started our research project with 2 days of field work but first we had to find suitable places for our project. We took under investigation the water roads from Lake Erken to the Baltic Sea (Norrtäljeviken). We chose 6 spots on this water road: first of them is Lake Erken (near Norr Malma), second outlet of Erken, third Broströmmen, forth Gillfjärden, fifth Broströmmen inlet Norrtäljeviken and sixth Norrtäljeviken. In choosing our research spots we considered with circumstances that we would have a wind exposed areas (lake) and the places would be easily accessed.

At each site we measured 30 metres on the shore. We divided the 30 meters into 6 points and after every 5 metres there was one point. One point was also divided into 3 smaller points. Measurements for taking samples in the river were like this:

1) the first one was situated quite near the shore, the third one was in the middle of the river and the second one was in between first and third one

2) the first one was situated near the shore, the second one was after one meter from the first one and the third one was after one meter from the second one

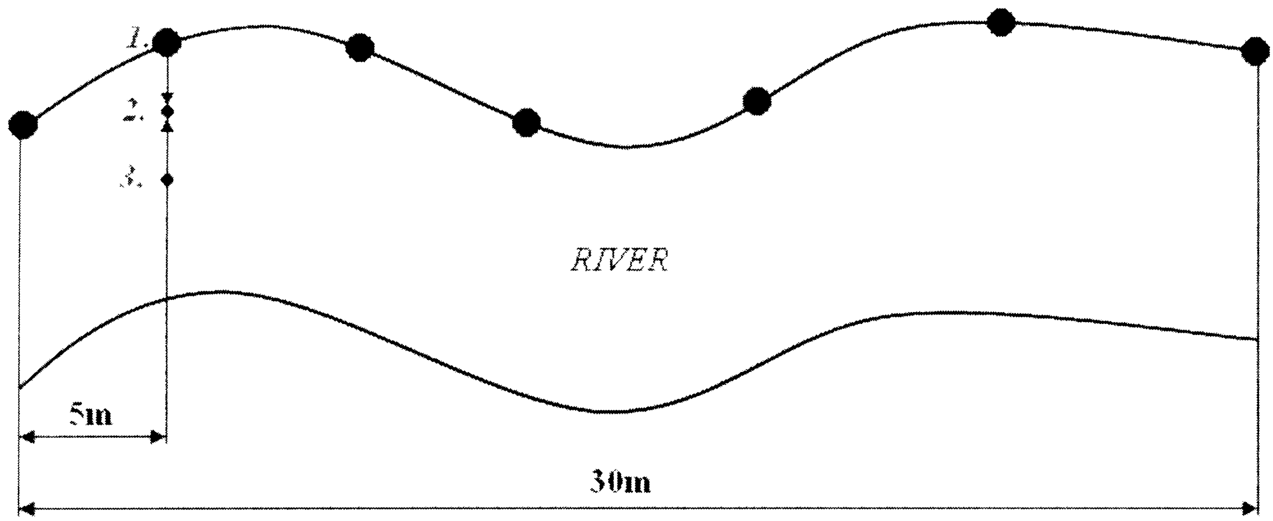

Diagram 1. Placement of the points in the river

The scale for lakes was different: the first one was still near the shore but two followings were situated after every one meter[6].

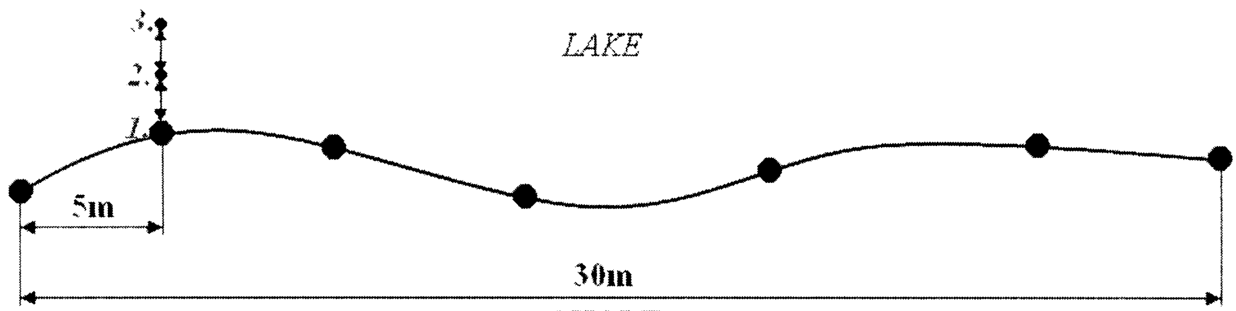

Diagram 2. Placement of the points in the lake

Before we went out in the field we took our equipment with us (look under 'materials'). From our research sites (lake and stream areas) we collected samples in the first point (closest to the shore) with a strainer, in the second point (used the same technique in the third point) we used a strainer or a landing net (depending on the depth; with a diameter ...). To get the samples

[6] The little people in Broströmmens and Skeboåns water systems, 1989

we had to scrape up the bottom area. By doing this we got a better overview of benthic animals. In every smaller point we took more than one sample but all together we took as a maximum 35 samples. In every spot we spent as a maximum 3 hours. After we had collected samples we divided them by their species by using tweezers into small plastic jars (with a diameter 7 cm; numbered before). After we had taken all the samples and divided them we counted animals from spots one and two in the laboratory and spots three to five in the field. Beside that we took some samples of the water from 1^{st} and 30^{th} meter that we put into small plastic bottles and measured conductivity. We also measured water temperature (used a glass thermometer) and pH level in the water by using indicator papers.

The animals that we collected we brought back with us to the laboratory for indication. To indicate animals we used a microscope with 10x zoom and different kinds of books (look into references). After that we released all animals back into the water. The water samples that we took from the water we brought to the laboratory where we measured the conductivity of the water, which indicates the amount of ions (salt) in the water.

Results

We carried out our investigation during two days and description of each research day we describe in table 1.

The 1. research Day		**The 2. research Day**	
Date	*16.06.2008.*	**Date**	*17.06.2008.*
Time		**Time**	
10:34	*13:04*	*10:41*	*12:20*
LAKE ERKEN	**OUTLET OF ERKEN**	**BROSTRÖMMEN**	**GILLFJÄRDEN**
Weather conditions		**Weather conditions**	
• *cloudy* • *warm* • *windy*	• *cloudy* • *warm* • *windy*	• *cloudy* • *not quite warm* • *looks like rain*	• *sunny* • *rained a bit*
		BROSTRÖMMEN INLET NORRTÄLJEVIKEN	**NORRTÄLJEVIKEN**
		Time	
		13:15	*14:17*
		Weather conditions	
		• *cloudy* • *sunny* • *warm*	• *cloudy* • *sunny* • *warm* • *rained a bit*

Table 1. Description of each research day

All together we found 66 species and 411 specimens. The species and specimens that we found are represented in extra 2. The most frequent species that we found were *Bithynia leachi* (65), *Micronecta sp* (45) and *Sphaerium corneum* (37). *Sphaerium corneum* and *Bithynia leachi* were also represented in four spots together with *Asellus aquaticus*. One of our hypotheses were that we were supposed to find common specie in each spot but four common spots (*Bithynia leachi)* was the highest frequency of common sites.

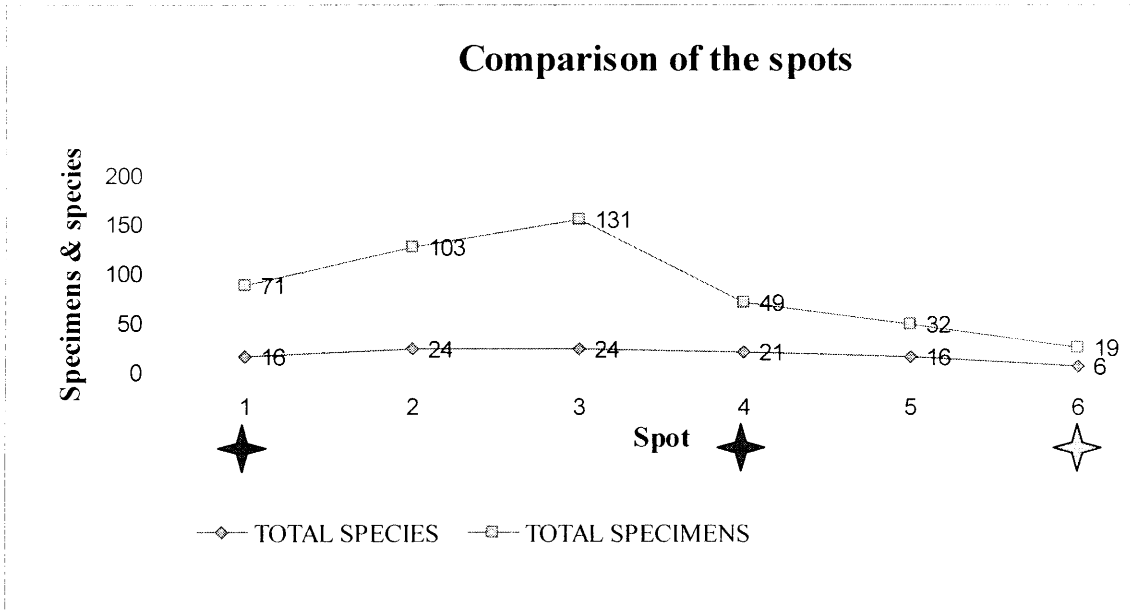

Diagram 3. Number of species and animals representation in different spots. On the diagram red stars are representing lake areas and the yellow star stands for Baltic Sea (brackish water).

Benthic animals were divided between points quite unequally but species were on the same line. The most animals were found in the third spot (Broströmmen) – 131 and in this point we also had the highest amount of species – 24. This number of species was also represented in the second spot (outlet of Lake Erken). The lowest amount of species and specimens were in sixth spot (Norrtäljeviken) – 6 different species and 19 benthic invertebrates (look at 3. diagram).

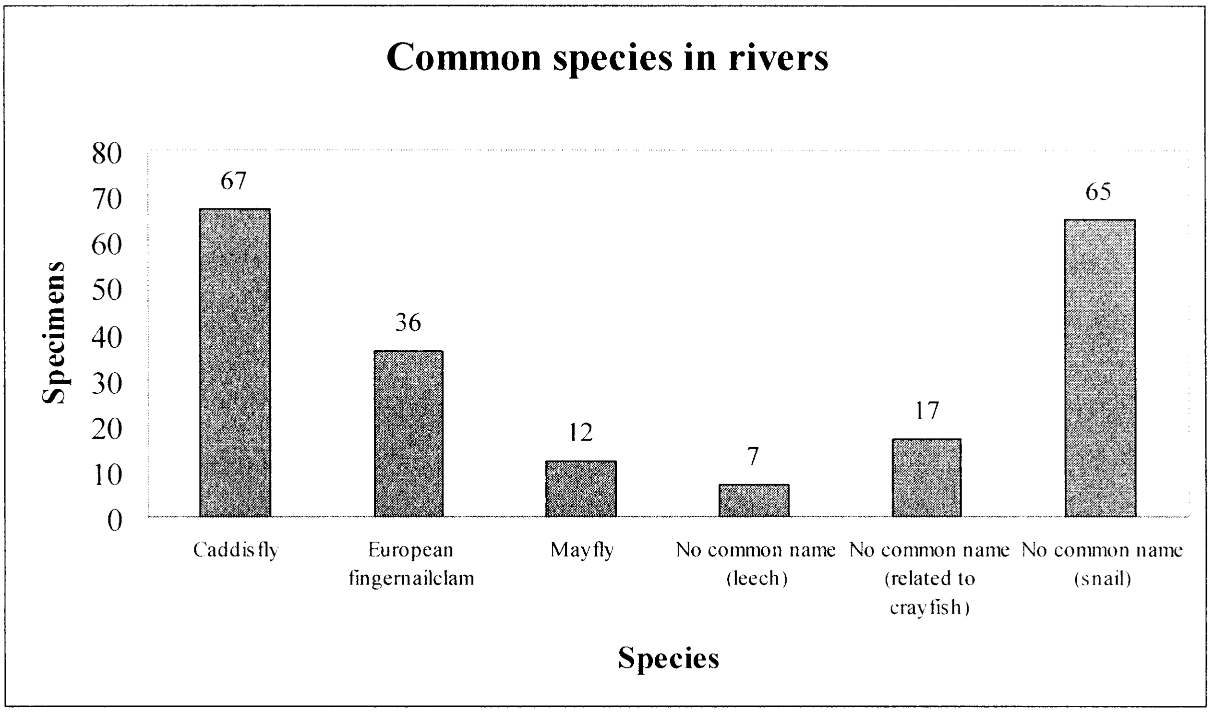

Diagram 4. Species that were found in rivers (spots 2, 3 and 5)

Altogether we found 52 different species and 272 specimens in river areas. 6 of the found species were common in all sites. 3 of the common species were represented more than the others. Caddisflies were dominating in rivers but at the same time different species of snails were also numerous (e.g. *Bithynia leachi*). European fingernailclam was also found a lot in river areas. The most Caddisflies were found in the second spot (outlet of Lake Erken) and *Bithynia leachi* was numerous in third spot (Broströmmen). Same was with European fingernailclam (numerous in third spot) (look at 4. diagram).

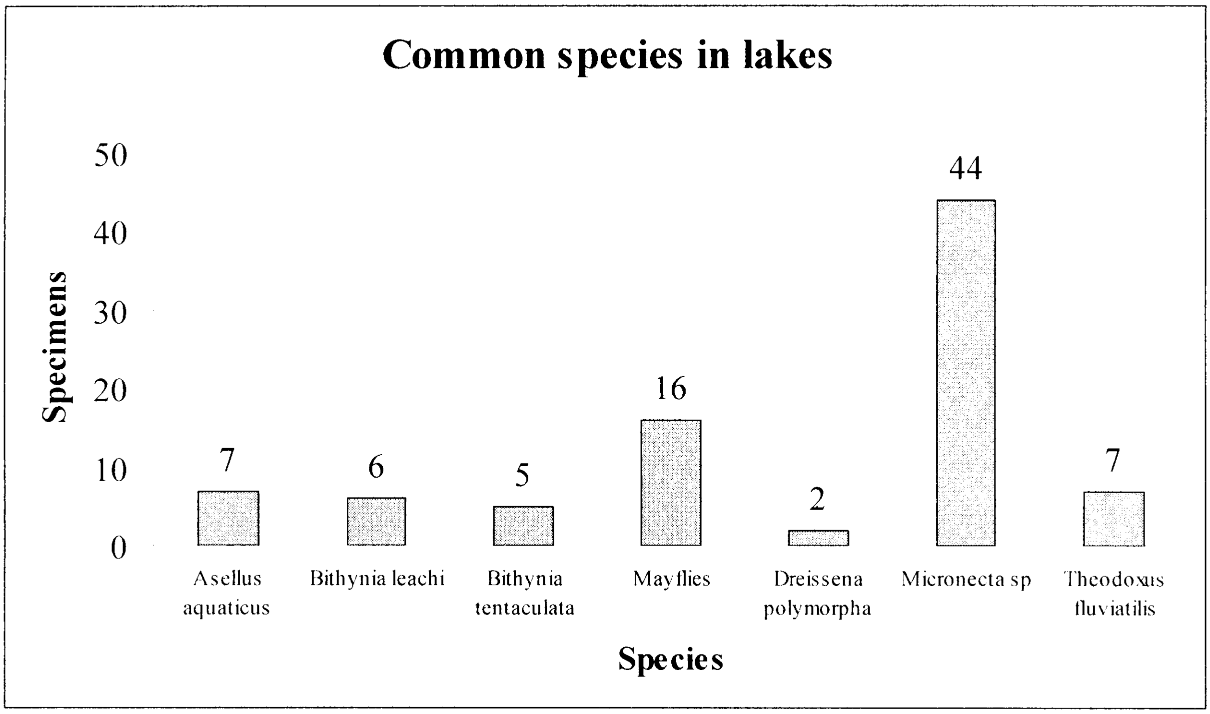

Diagram 5. Common species that were found is lakes

In lakes we were able to find 30 different species and 120 specimens. Among 30 species 7 were common in all lake sites and among those seven were 2 species that dominated – *Micronecta sp* and different species of Mayflies. *Micronecta sp* was mostly found in first spot (Lake Erken) – 38 and the most Mayflies were found in forth spot – 12 (look at 5. diagram).

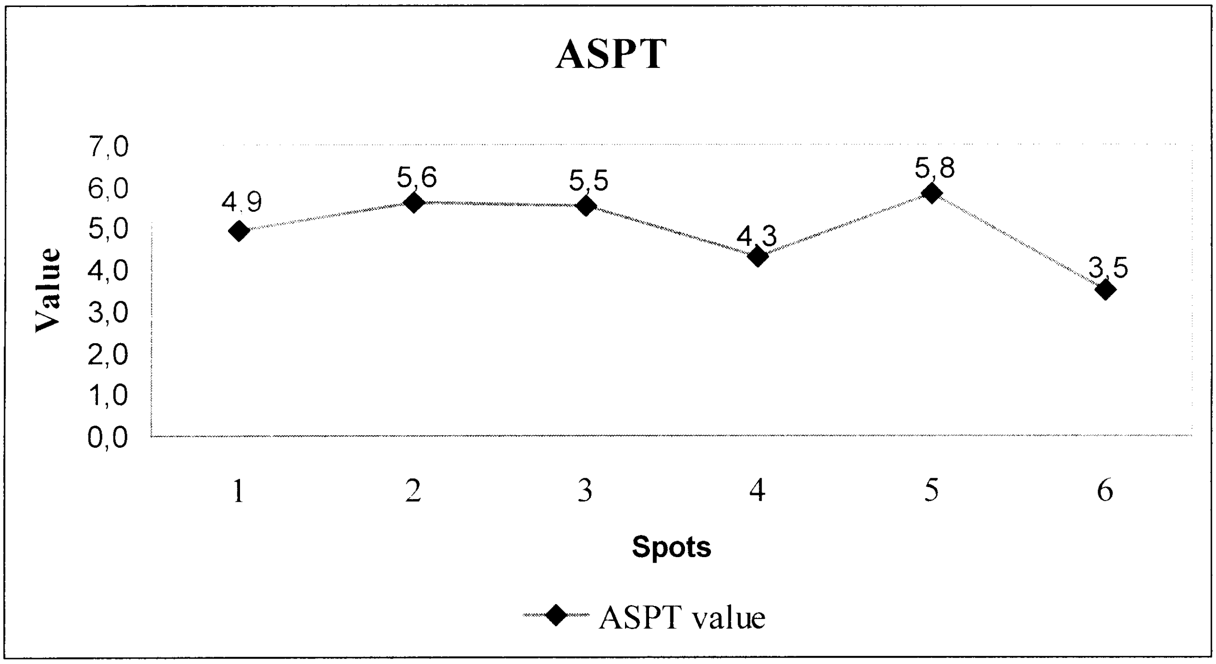

Diagram 6. ASPT values in different spots after calculations

The level of pollution can also be estimated by the ASPT-value (Average Score Per Taxon), as different species are more or less sensitive to pollution and changes in water quality. By calculating the ASPT-index (see attachment 3 and 4 for indicator species and values) for each site, we can show that in our investigation, the index showed the highest quality of water in spot 5 (Broströmmen inlet Norrtäljeviken) where it was 5,8 (very good water quality). The lowest ASPT index was as expected in spot 3 (Norrtäljeviken) where it was 3,5 (bad water quality). ASPT was also very good in spot 2 (outlet of Lake Erken) – 5,6 which means that the water is with high quality. Lake Erken ASPT value was 4,9 which describes water with poor quality.

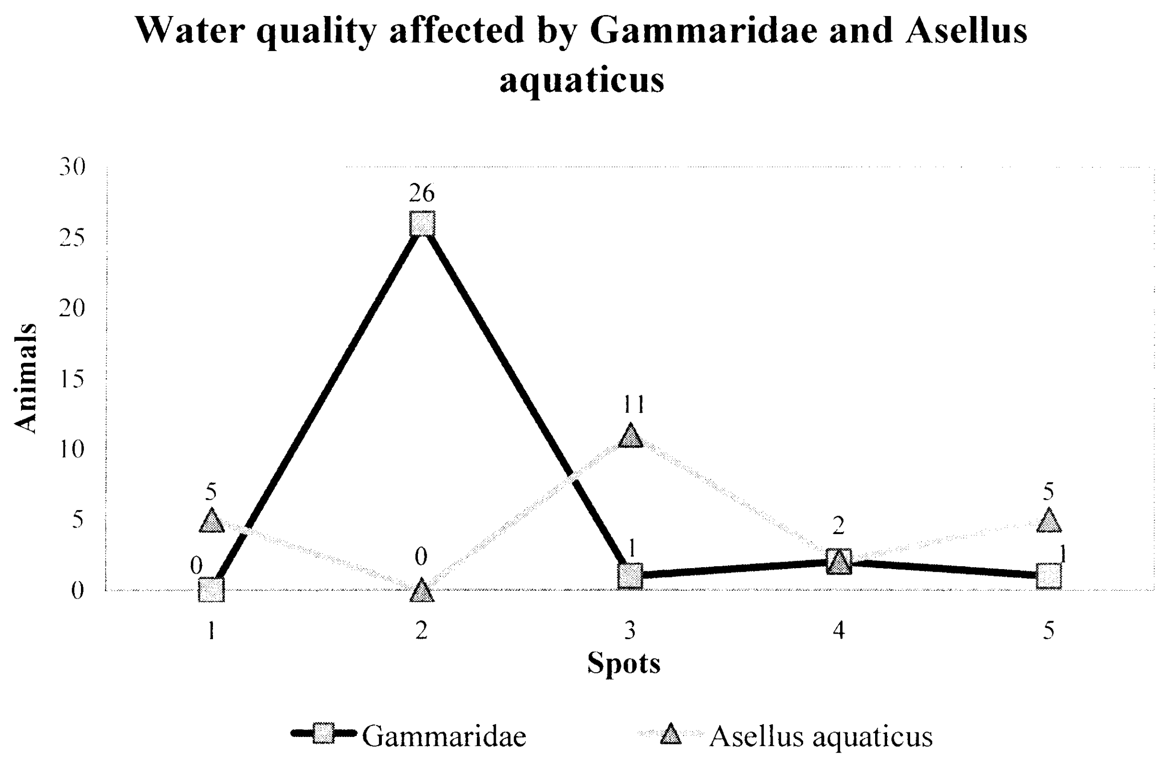

Diagram 6. Comparison of *Asellus aquaticus* and *Gammaridae* specimens in spots

Asellus aquaticus is found in rivers, streams and standing water particularly where there are plenty of stones under which it hides although not where the water is strongly acidic. *Asellus aquaticus* relatively tolerant of a range of pollutants and has been used as an indicator of bad water quality[7].

Family *Gammaridae* has a high variability although it is not found in severely polluted waters. Sometime found in moderately polluted waters, although some species very sensitive and used as important indicators for water quality[8].

The most *Gammaridae* animals were found in outlet of Lake Erken – 26 specimens which means that water is very clean. The water cleanness is also shown with a fact that we did not find no animals of specie *Asellus aquaticus*. The lowest level of family *Gammaridae* was in spot 1 (Lake Erken) – 0 specimens. This could be explained due to the fact that this area is well used beach. In spot 6 (Norrtäljeviken) there were found no *Gammaridae* and *Asellus aquaticus* specimens which is the reason why it is not on the diagram 9 but still water is with a bad quality according to low ASPT level shown before.

[7] http://en.wikipedia.org/wiki/Asellus_aquaticus
[8] www.epa.gov/bioindicators/html/amphipods.html

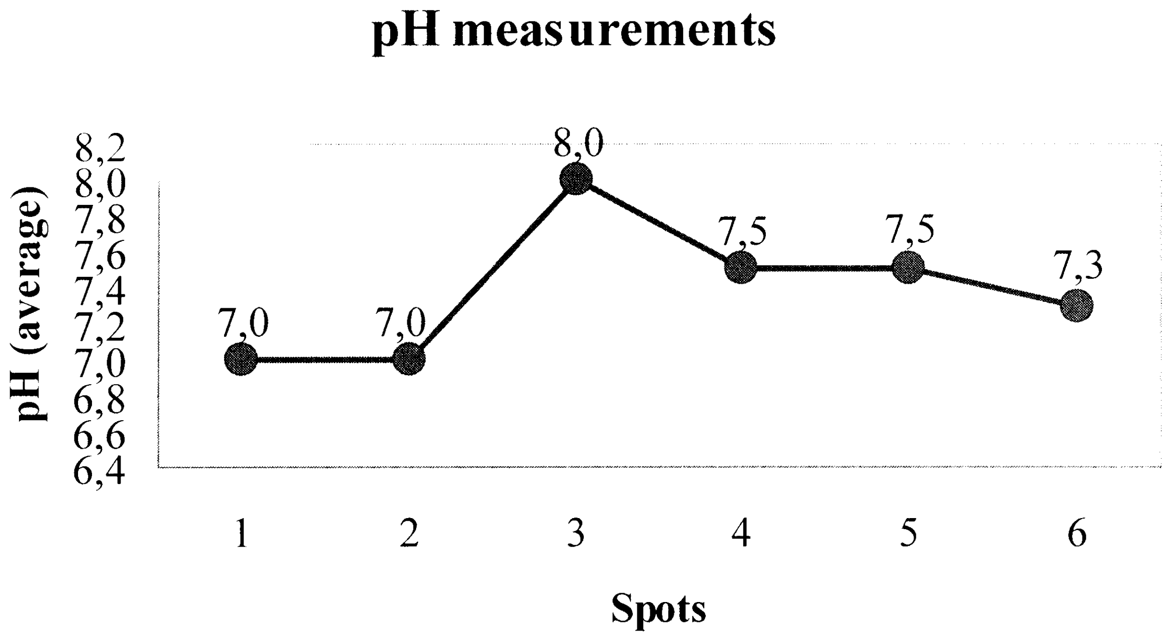

Diagram 8. pH measurements (average) made in each point

The measured pH varied from 7,0 to 8,0. The lowest pH 7,0 was measured in the first (Lake Erken) and from the second spot (outlet of Lake Erken). The highest pH was measured in the third spot (Broströmmen) – 8,0 (look at 8. diagram).

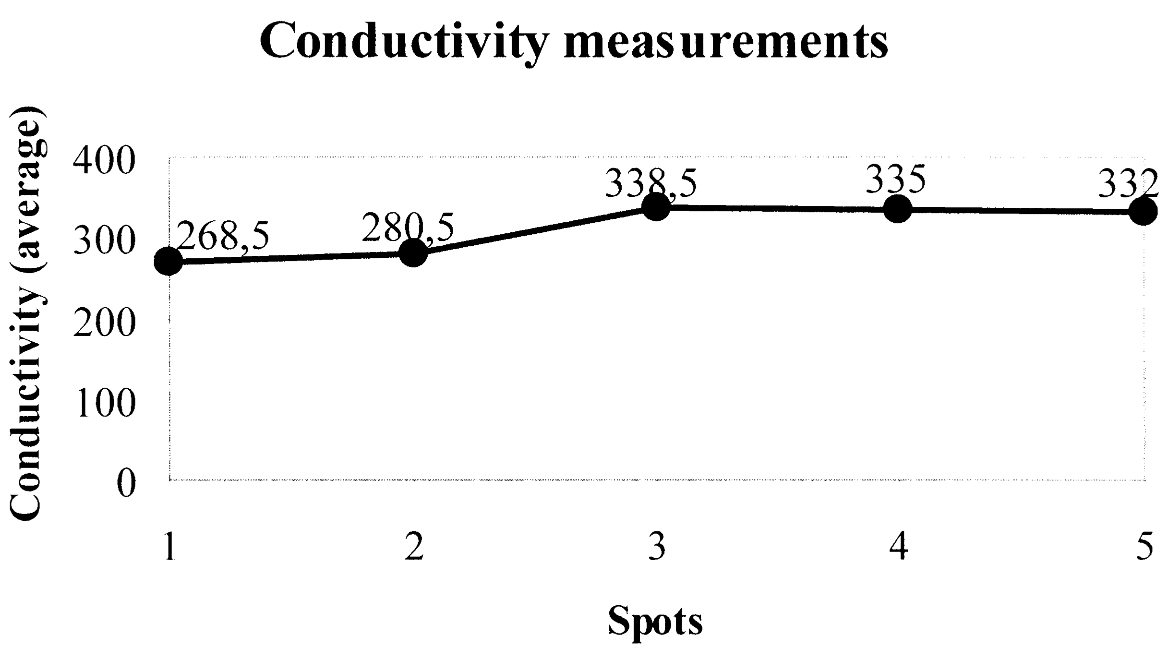

Diagram 9. Conductivity measurements (average) made in fresh water

Conductivity did not vary so much (from 268,5 to 338,5) in the fresh water but the measurement variation between fresh (spots 1 to 5) and brackish water (6. spot) was very big – in fresh water the unit was µS/cm but in brackish water it was mS/cm. The average conductivity in sixth spot (Norrtäljeviken) was 9,195 mS/cm. It was the also the highest conductivity what we found. We had to leave the last spot out of our diagram because the conductivity was too high and diagram would have not be so informative – would have not gave such precise picture. The lowest conductivity was measured in the first spot (Lake Erken) - 268,5 µS/cm (look at 9. diagram).

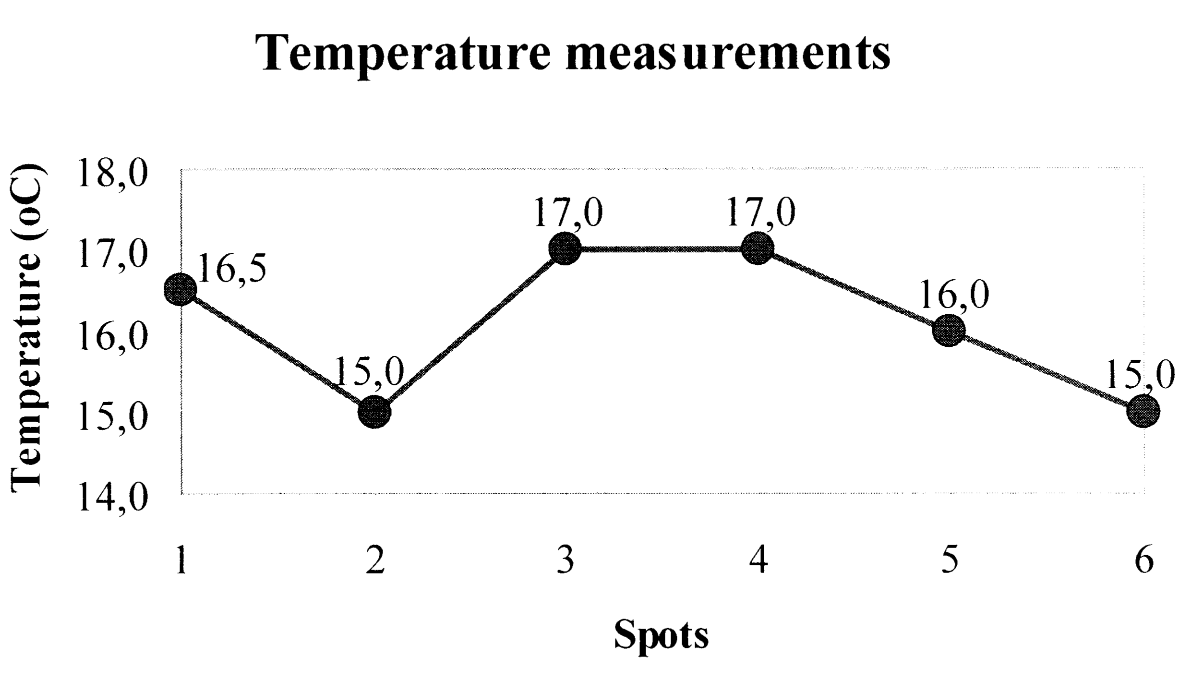

Diagram 10. Temperature measurements made in each point

Temperature measurements had a range of variation from 15,0 to 17,0 ^{o}C. The lowest measurements were taken from second (outlet of Lake Erken) and sixth spot (Norrtäljeviken) witch was 15,0 ^{o}C. The highest measurements were taken from third (Broströmmen) and forth (Broströmmen inlet Norrtäljeviken) spot (look at 10. diagram).

Discussion

The distribution, abundance, and productivity of benthic organisms are determined by several ecological processes: the historical events that have allowed or prevented a species from reaching a habitat, the physiological limitations of the species at all stages of the life cycle, the availability of energy resources and the ability of species to tolerate competition, predation and parasitism[9]. Before named characteristics are affecting amount of species and specimens in our research. Features that also affect frequency are weather conditions, usability of the area, quality of used equipment and our experience on this field of work.

At the beginning of our research we made six hypotheses which are discussed in accordance to our results below:

- **There are more species and animals in lakes than in streams.**

After we had indicated and counted all the animals we falsified this hypothesis due to the fact that we found 30 different species (120 animals) from lakes and 52 different species (272 animals) in streams. From this we can conclude that the distribution of the diverse fauna within lakes and streams is extremely diverse. This is in part a product of variable requirements for feeding, growth and reproduction. As lakes become more productive and the hypolimnetic water strata undergo periods of oxygen reduction and increases in the metabolic products of microbial decomposition, the number of animals adapted to these conditions decreases precipitously. Commonly observed community structure consists of a rich fauna with high oxygen demands in the littoral zone above the metalimnion. Substratum heterogeneity is much greater in the littoral, and species diversity and competitive interactions are more complex. Composite densities of benthic invertebrates are often lowest during summer, especially among insect-dominated communities, both in streams and in the profundal zone of lakes. In general, biomass and productivity of benthic fauna increases as the overall fertility and productivity of lakes and streams increase[10].

- **There are differences in diversity of species in fresh and brackish water.**

Our results show that this hypothesis is true because we found only 6 different kind of species in brackish water (the Baltic Sea) and 3 species were common with other spots. The reason is the fact that the Baltic Sea has uniquely low species diversity because of low concentration of salinity, recent origin and harsh climate[10]. Even though salinity is low it is still enough to have

[9] Robert G. Wetzel, 2001
[10] Robert G. Wetzel, 2001

an affect on biodiversity[11]. Its flora and fauna consists of a mixture of marine, fresh and brackish water species[12]. This last one is the reason why we have three species in common. One of the reason that we were not able to find so many species was the fact that the place is sandy beach and people are using that for swimming – thus it is often disturbed by people.

- **The concentration of salt and pollution level in water affects the amount of the species.**

We can say that this hypothesis is true because the Baltic Sea is one of the most polluted seas in the world and the low concentration of salt is also one of the factors that there are unsuitable living conditions for most of benthic invertebrates. Our diagram 3 proves that amount of specimens and species are starting to decrease after the third spot where it is a quite high conductivity level and also could be some pollution for the fact that we measured the highest pH measurements of our spots (diagram 8) there. In our opinion the pollution level is the consequence of human activity in that certain area.

The level of pollution can also be estimated by the ASPT-value (Average Score Per Taxon), as different species are more or less sensitive to pollution and changes in water quality. By calculating the ASPT-index (see attachment 3 and 4 for indicator species and values) for each site, we can show that in our investigation, the index showed the highest quality of water in spot 5 (Broströmmen inlet Norrtäljeviken) where it was 5,8 (very good water quality). The high ASPT level was due to the fact that the bottom was heavily covered with rocks which are very suitable conditions for living for animals that are indicated by high ASPT level. The lowest ASPT index was as expected (brackish water that needs animals who have special adaptations to live in that kind of water) in spot 3 (Norrtäljeviken) where it was 3,5 (bad water quality). ASPT was also very good in spot 2 (outlet of Lake Erken) – 5,8 which means that the water is with high quality. Lake Erken ASPT value was 4,9 which describes water with poor quality. This value is the result of the fact that the place is well used beach area.

- **Lake Erken is richer in diversity of species then Lake Gillfjärden.**

Lake Gillfjärden is 0,7 m above sea level which results in occasional infows of salt water from the Baltic Sea. Also Lake Gillfjärden has a large catchment area which gives high inflow of nutrients. Due to this fact there are relatively productive (eutrophic) conditions in the lake[13].

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[11] Robert G. Wetzel, 2001
[12] Rupert F.G. Ormond, Johan D. Gage, Martin V. Angel Marin Biodiversity, 1997
[13] Uppsala university, 1996

This hypothesis is false because Lake Erken had 16 species and Lake Gillfjärden had 21 species. Nonetheless Lake Erken had more animals (71) and Lake Gillfjärden had 49 animals. The spot in Lake Erken was a well used beach area which could be the explanation why we found lesser animals but the reason why Lake Erken had more animals was the fact that Lake Erken is a mesotrophic lake and Gillfjärden is a eurtrophic lake. If lakes become extremely enriched, to the point that the population densities of the phytoplankton and epiphytes become so great that they shade out the submersed macrovegetation, then the habitats diversity of the littoral decreases. Correspondingly, the diversity and often a maximum in animal biomass can be observed only in the lower profundal zone. With further increases in eutrophication and lengthening of the period of hypolimnetic oxygen reduction and associated chemical changes, the rates of respiratory activity of the adapted benthic animals are reduced. Rates of growth and survival also decline, and some insect larvae increase their life cycles from 1 to 2 years. As hypolimnetic strata of hypereutrophic waters undergo extreme eutrophicational or pollutional loading of organic matter, essentially all of the aquatic insects may be eliminated[14]. Low content of dissolved oxygen in the water and sediments are certainly an important factor limiting most benthic animal species in Lake Gillfjärden[15].

There are several reasons why diversity should be measured. One mentioned earlier is the ASPT-index, but there are also specific species that indicates water quality just by prescience – specie *Asellus aquaticus* (describes bad water quality) and family *Gammaridae* (describes good water quality). The results of animals that we collected from the spots are shown in diagram 6.

The most *Gammaridae* animals were found in outlet of Lake Erken – 26 specimens which means that water is very clean. The water cleanness is also shown with a fact that we did not find no animals of specie *Asellus aquaticus*. The lowest level of family *Gammaridae* was in spot 1 (Lake Erken) – 0 specimens. This could be explained due to the fact that this area is well used beach. In spot 6 (Norrtäljeviken) there were found no *Gammaridae* and *Asellus aquaticus* specimens which is the reason why it is not on the diagram 9 but still water is with a bad quality according to low ASPT level shown before.

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[14] Robert G. Wetzel, 2001
[15] Uppsala university, 1996

Conclusion

The aim of this project was finding out how polluted the water from Lake Erken to the Baltic Sea is. After we had collected our samples, indicated the benthic invertebrates, made our conclusions and discussed them we can say that there is the change when the water comes from Lake Erken and reaches the Baltic Sea. There is noticeable changes in diversity of species, amount of animals and overall the quality of water. According to ASPT calculations the water road what we had chosen showed a drop after the second spot. There was a huge growth of ASPT level but nevertheless polluted water due to the high amount of *Asellus aquaticus*. We did not get so good results from Lake Erken because the place was disturbed by humans all the time so the animals that are habitats of Lake Erken have difficult living circumstances.

In conclusion we would like to say that humans do not have a right to water but rather have a responsibility for wise and optimal use of available water. To understand the fundamentals of water science for it is responsible use and the effective management of water resources for both hydrological availability and acceptable water quality. Humans must learn what the nature's dynamic capacities are because excessive violation without harmony will only unleash her intolerable vengeance. We are using Arthur Stringer words:

"*Society, my dear, is like salt water, good to swim in but hard to swallow.*"

By society is meant in this context that it is benthic invertebrates and if one should try to swim in this water and accidentally swallows it then it should be clean and not dangerous to health because we are dependent on water and we should be respectful with it.

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Extra 1

Quality elements to be used for the assessment of ecological status/potential based on the list in Annex V, 1.1. of the Directive.

Annex V 1.1.1. **RIVERS**	**Annex V 1.1.2.** **LAKES**	**Annex V 1.1.3.** **TRANSITIONAL WATERS**	**Annex V 1.1.4.** **COASTAL WATERS**
BIOLOGICAL ELEMENTS			
• Composition and abundance of aquatic flora • Composition and abundance of benthic invertebrate fauna • Composition, abundance and age structure of fish fauna	• Composition, abundance and biomass of phytoplankton • Composition and abundance of other aquatic flora • Composition and abundance of benthic invertebrate fauna • Composition, abundance and age structure of fish fauna	• Composition, abundance and biomass of phytoplankton • Composition and abundance of other aquatic flora • Composition and abundance of benthic invertebrate fauna • Composition and abundance of fish fauna	• Composition, abundance and biomass of phytoplankton • Composition and abundance of other aquatic flora • Composition and abundance of benthic invertebrate fauna

Extra 2

Species and frequency of specimens in different spots.

English name	Latin name	Amount of animals	Frequency in spots
No common name (snail)	*Anisus vortex*	1	1
The Banded Demoiselle	*Calopteryx splendens*	1	1
Ladybird	*Coccinellidae*	1	1
Variable Damselfly	*Coenagrion pulchellum*	1	1
No common name (looks like a tick)	*Diplodantus despiciens*	1	1
Common Club-tail	*Gomphus vulgatissimus*	1	1
Horse leech	*Haemopis sanguisuga*	1	1
No common name (looks like a tick)	*Hydrachna geographica*	1	1
No common name (water beetle)	*Laccobius sp*	1	1
Broad-bodied Chaser	*Libellula depressa*	1	1
Four-spotted chaser	*Libellula quadrimaculata*	1	1
Caddisfly	*Limnephilus extricatus*	1	1
Marsh pond snail	*Lymnaea palustris*	1	1
Mayfly	*Metretopus borealis*	1	1
Phantom midge	*Mochlonyx culiciformis*	1	1
Common backswimmer	*Notonecta glauca*	1	1
Bladder snail	*Physa fontinalis*	1	1
Ertemusling	*Pisidium sp*	1	1
Great ramshorn	*Planorbarius corneus*	1	1
Jenkins' spire shell	*Potamopyrgus antipodarum*	1	2
No common name (small water beetle)	*Scarodytes halensis*	1	1
Alderfly	*Sialis lutaria*	1	1
No common name (related to crayfish)	*Siphonophanes grubei*	1	1
No common name (worm)	*Stylodrilus heringianus*	1	1
Midge	*Tanytarsus sp*	1	1
Caddisfly	*Tinodes pallidulus*	1	1
Caddisfly	*Tinodes waeneri*	1	1
Caddisfly	*Trichostegia minor*	1	1

English name	Latin name	Amount of animals	Frequency in spots
Mayfly	*Baetis sp*	2	1
No common name (snail)	*Cardium fasciatum*	2	1
Caddisfly	*Cyrnus sp*	2	1
Mayfly	*Ephemera danica*	2	1
No common name (leach)	*Erpobdella octoculata*	2	2
No common name (insect)	*Hydropsyche angustipennis*	2	1
No common name (snail)	*Lymnaea truncatula*	2	2
Caddisfly	*Molanna augustata*	2	2
Water scorpion	*Nepa cinerea*	2	1
Southern hawker/Blue darner	*Aeschna cyanea*	2	2
Caddisfly	*Ryacophila sp*	2	2
Mayfly	*Siphlonurus aestivalis*	2	1
Crane-fly	*Tipula maxima*	2	2
Sludge worm/Sewage worm	*Tubifex tubifex*	2	2
European valve snail	*Valvata piscinalis*	2	2
Caddisfly	*Ecclisopteryx dalecarlica*	3	1
Earthworm	*Eiseniella tetraedra*	3	1
No common name (insect)	*Stylaria lacustris*	3	1
Caddisfly	*Limnephilus rhombicus*	4	1
Wandering snail	*Lymnaea peregra*	4	2
No common name (mussel)	*Unio crassus*	4	3
Zebra mussel	*Dreissena polymorpha*	5	3
No common name (snail)	*Viviparus fasciatus*	5	2
Caddisfly	*Anabolia sp*	6	2
Non-midge	*Chironomus plumosus*	6	1
No common name (water mite)	*Limnochares aquatica*	6	1
Caddisfly	*Polycentropus sp*	6	1
No common name (leech)	*Erpobdella testacea*	7	3
River nerite	*Theodoxus fluviatilis*	7	2
No common name (related to crayfish)	*Pallasea quadrispinosa*	15	3

English name	Latin name	Amount of animals	Frequency in spots
No common name (small snail)	*Bithynia tentaculata*	16	3
No common name (related to crayfish)	*Gammarus lacustris*	17	3
Caddisfly	*Neophylax sp.*	17	1
Caddisfly	*Phryganea sp*	20	2
Mayfly	*Caenis horaria*	21	3
Aquatic sowbug	*Asellus aquaticus*	23	4
European fingernailclam	*Sphaerium corneum*	37	4
Water boatman	*Micronecta sp*	45	3
No common name (small snail)	*Bithyinia leachi*	65	4

Extra 3

ASPT values per spot and family.

Latin name (family)	Evaluation of family according to ASPT	The number of animals in each spot					
	1...10	1. spot	2. spot	3. spot	4. spot	5. spot	6. spot
Aeshnidae	8	**1**	0	**1**	0	0	0
Apoidea	*	**1**	0	0	**1**	**3**	0
Asellidae	3	**5**	0	**11**	**2**	**5**	0
Baetidae	4	0	**2**	0	0	0	0
Bithniidae	3	**5**	**4**	**55**	**6**	0	**11**
Caenidae	7	**4**	0	0	**11**	**6**	0
Calopterygidae	8	0	1	0	0	0	0
Cardiidae	*	0	0	0	0	0	**2**
Chaoboridae	*	0	0	0	0	**1**	0
Chirocephalidae	*	0	0	0	0	**1**	0
Chironomidae	2	0	0	**6**	**1**	**1**	0
Coccinellidae	*	0	0	0	0	0	**1**
Coenagriidae	6	**1**	0	0	0	0	0
Corixidae	5	**38**	0	**1**	**6**	0	0
Cylindrotomidae	*	0	**2**	0	0	0	0
Cyrinidae	5	0	**5**	0	0	0	0
Dytiscidae	5	1	0	0	0	0	0
Ephemeridae	10	0	0	**2**	0	0	0
Erpobdellidae	3	**1**	0	**2**	**1**	**5**	0
Gammaridae	6	0	**26**	**1**	**2**	**1**	0
Gomphidae	8	0	0	0	0	**1**	0
Hirudinidae	3	0	**1**	0	0	0	0
Hydrachnidae	*	0	0	**1**	0	0	0
Hydrobiidae	3	0	**1**	0	**1**	0	0
Hydrodromidae	*	0	0	0	**1**	0	0
Hydrophilidae	5	0	0	0	**1**	0	0
Hydropsychidae	5	0	0	0	0	2	0
Libellulidae	8	0	0	**1**	0	**1**	0
Limnephilidae	7	0	**20**	**11**	0	0	0

Latin name (family)	Evaluation of family according to ASPT	The number of animals in each spot					
	1...10	1. spot	2. spot	3. spot	4. spot	5. spot	6. spot
Limnocharidae	*	0	0	0	**6**	0	0
Lumbricidae	*	0	**4**	0	0	0	0
Lymnaeidae	3	**1**	**1**	**1**	**1**	0	**3**
Metretopodidae	*	0	0	0	**1**	0	0
Molannidae	10	0	**1**	**1**	0	0	0
Naididae	*	**3**	0	0	0	0	0
Nepidae	5	0	**2**	0	0	0	0
Neritidae	3	**5**	0	0	0	0	0
Notonectidae	5	0	0	**1**	0	0	0
Phryganeidae	10	**3**	**23**	0	0	0	0
Physidae	3	0	0	0	**1**	0	0
Pisidiidae	3	0	0	0	0	0	**1**
Planorbidae	3	0	**1**	**1**	0	0	0
Polycentropodidae	7	0	**6**	0	0	0	0
Psychomyiidae	8	0	0	0	0	**2**	0
Rhyacopilidae	7	0	**2**	0	0	**1**	0
Sialidae	4	0	**1**	0	0	0	0
Siphlonuridae	10	0	**2**	0	0	0	0
Sphaeriidae	3	**1**	**7**	**28**	0	**1**	0
Tipulidae	5	0	0	0	**1**	0	**1**
Tubificidae	*	1	0	0	0	1	0
Unionidae	6	0	0	**1**	**2**	**1**	0
Valvatidae	3	0	0	**1**	**1**	0	0
Viviparidae	6	0	0	**4**	**1**	0	0
	ASPT value	4,9	5,6	5,5	4,3	5,8	3,5

Extra 4

ASPT (Average Score Per Taxon) calculation

British animalgroup tolerants value (*t*) (by Armitage *et al*., 1983):

10 - *Siphlonuridae, Heptageniidae, Leptophlebiidae, Ephemerellidae, Potamanthidae, Ephemeridae, Taeniopterygidae, Leuctridae, Capniidae, Perlodidae, Perlidae, Chloroperlidae, Aphelocheiridae, Phryganeidae, Molannidae, Beraeidae, Odontoceridae, Leptoceridae, Goeridae, Lepidostomatidae, Brachycentridae, Sericostomatidae*

8 - *Astacidae, Lestidae, Calopterygidae, Gomphidae, Cordulegasteridae, Aeshnidae, Corduliidae, Libellulidae, Psychomyiidae* or *Ecnomidae, Philopotamidae*

7 - *Caenidae, Nemouridae, Rhyacophilidae* or *Glossosomatidae, Polycentropodidae, Limnephilidae*

6 - *Neritidae, Viviparidae, Ancylidae* or *Acroloxidae, Hydroptilidae, Unionidae, Corophiidae, Gammaridae, Platycnemidae, Coenagriidae*

5 - *Mesoveliidae, Hydrometridae, Gerridae, Nepidae, Naucoridae, Notonectidae, Pleidae, Corixidae, Haliplidae, Hygrobiidae, Dytiscidae* or *Noteridae, Gyrinidae, Hydrophilidae, Clambidae, Helodidae, Dryopidae, Elmidae, Chrysomelidae, Curculionidae, Hydropsychidae Tipulidae, Simuliidae, Planariidae, Dendrocoelidae*

4 - *Baetidae, Sialidae, Piscicolidae*

3 - *Valvatidae, Bithyniidae, Lymnaeidae, Physidae, Planorbidae, Sphaeriidae* or *Pisidiidae, Glossiphoniidae, Hirudinidae, Erpobdellidae, Asellidae*

2 - *Chironomidae*

1 - *Oligochaeta*

ASPT = Σ (t/ n), where n is the number of animalgroups who have *t* (British animalgroup tolerants value).

Very good quality - ASPT>6, good quality - 5-6, poor quality - 4-5, bad <4.

Extra 5

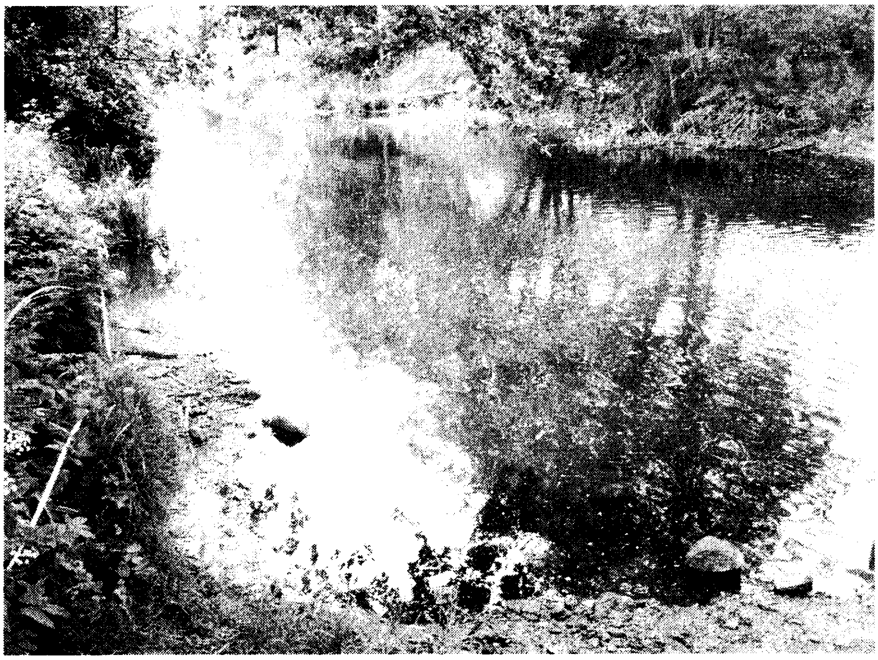
Pictures of sampling places.

1. picture

1. spot – Lake Erken

2. picture

2. spot – outlet of Lake Erken



3. picture

3. spot – Broströmmen

4. picture

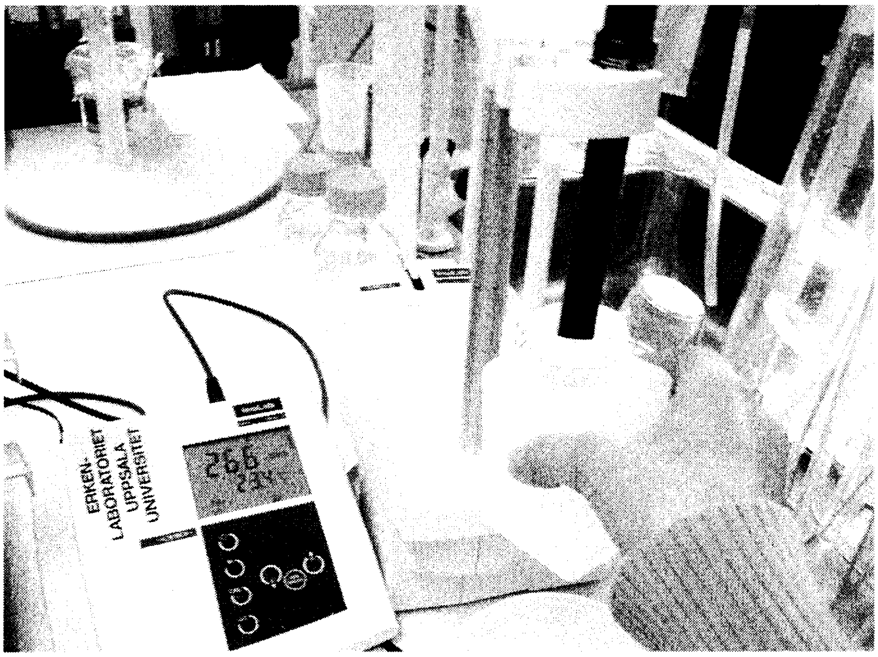
4. spot – Lake Gillfjärden

5. picture

5. spot – Broströmmen inlet Norrtäljeviken

6. picture

6. spot – Norrtäljeviken



7. picture

Conductivity measurements

8. picture

Authors with stylish wading pants