



# Sanitation of lakes in Otepää for landscape restoration

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## Abstract

Otepää is a small town in the well-known Estonian resort area. Lake Neitsijärv, an inlet to lake Pühajärv and a historically important breeding area for young fish, is suffering from heavy eutrophication due to natural processes remarkably enhanced by human activities. Sanitation of the lake has been offered, bringing an increase in the value of the surrounding landscape.

The landscapes around Otepää were analysed with the main attention on the possible use and values of the watershed of the Lake Neitsijärv. Landscape analysis was done by map analysis and field investigations. Different landscape values were analysed with regard to possible uses in the area. The area has some value as a residential region; agricultural use is of decreasing focus and recreational (emotional) use of the territory is becoming more and more of value. Possible zoning of different regions around Otepää was suggested. A nature trail was suggested and analysed, with most attention paid to the values of nature and tourism objects related to the trail. After sanitation of the lake the area could become an important recreational area for weekend tourism and quiet relaxation, so adding to the diversity of the recreational area of Otepää, increasingly well known as a ski and sport resort.

However, an essential presumption for more intensive use of the area is sanitation of the lake. Partial removal of mud has been suggested. The environmental impacts of the lake reconstruction are first of all related to regulation of the water table and removed bottom mud store, as well as iron and phosphorus release from the sediments. Increasing the volume of free water in the lake is crucial for the fish. A combined method of removing part of the sediments and raising the water level has been selected as the best option.



## 1 Introduction

This paper aims to give an overview of some of the results gained by a project *Assessment of the State and Possibilities of Sanitation of Lake Neitsijärv and Other Small Otepää In-town lakes (ASPSLNOSOIL)* (Project No BSPF/98-03/086), which was supported by the Phare/Tacis Cross Border Co-operation Small Project Facility.

The Project was launched because of the need to protect one of the most beautiful lakes of Estonia - Lake Pühajärv - from being polluted by the inflow from Lake Neitsijärv, as well as because of the necessity to develop the lakescape of Otepää for recreational purposes.

In the course of the Project Lake Neitsijärv and its upstream lakes of the catchment area were studied from ecological, landscape, and geological points of view. The necessary geodetical, geological and limnological investigations were carried out. The information obtained enabled the experts to propose sanitation alternatives for Lake Neitsijärv, analyse them and suggest landscape restoration measures.

## 2 Material and methods

### 2.1 Study area nature

Otepää is situated in Southern Estonia, on the Otepää Upland which was formed 15,000–10,000 years ago during the recurrent onset and recession of the glacial sheet covering Estonia. The variable landscape was created when isolated ice fields melted up and moraine was deposited.

The need to preserve and protect the beauty of one of the most beautiful areas in Estonia has been recognised and propagated by many well-known writers, poets, and painters as early as the end of the 19th century.

Lake Pühajärv and the surrounding park were taken under protection in 1929, and in 1957 the Pühajärve Landscape Reserve was founded. In 1979 the reserve was enlarged to 232 km<sup>2</sup> and renamed into Otepää Landscape Reserve (at present Otepää Nature Park).

Half of the territory of the Nature Park is covered with mixed forests, and it has a rich flora and fauna. The forests provide habitat for elk, wild boar, beavers, roe deer, red foxes, badgers, wolves, and lynxes. Over 130 bird species nestle in the area. The most attractive species for birdwatchers include the crested grebe, black-headed gull, partridge, tawny owl, white stork, kingfisher, and woodpeckers. Even the endangered black stork and spotted eagle can be sighted by the forest rivers.

There are about 65 lakes in the Nature Park, 40% of them being smaller than 10 ha in area and only 5-6 m deep. The largest and most attractive one is Lake Pühajärv (286 ha) with its picturesque shoreline and five islands. The shores of the lakes are mostly swampy and covered by forests, but sandy beaches can also be found.

The hilly mosaic landscape of the Nature Park has seen the impact of human activities for over two thousand years. Most of the present 27 villages came into being in the beginning of the 12<sup>th</sup> century.

## **2.2 Otepää Town and rural areas**

Otepää was first mentioned in 1116 in the Novgorod Chronicle as "Medvezhya Golova", translated as the Bear's Head. Being located at the crossroads of merchant routes to Russia, Latvia, and North Estonia, the Otepää stronghold was the centre of the ancient Ugandi County. Otepää Town (2500 inhabitants) is located 227 km from Tallinn and 50 km from Valga, the centre of Valga County. The nearest town is Tartu (40 km).

Otepää is surrounded by the former Pühajärve Commune. As the development and everyday life of the town and commune were closely connected, the two administrative units became united in October, 1999 to form Otepää Commune with about 4500 inhabitants. There are 53 lakes and 14 small rivers and streams in the commune, two thirds of its territory are situated in the Otepää Nature Park area. There is no large-scale industry in the Otepää region, the main activities being forestry, tourism, and recreation-related services.

## **2.3 Lakescape**

The numerous lakes around Otepää nestle between moraine hills and therefore their water is mainly hard or very hard (the mean alkalinity of the studied waterbodies is  $250 \text{ mg} \cdot \text{l}^{-1}$  while the average of Estonian lakes is  $150 \text{ mg} \cdot \text{l}^{-1}$ ). The lakes are fed by springs, and apart from the high lime content they are also rich in iron. For example, the iron concentration in the bottom water layer of Lake Kumakese ( $28,3 \text{ mg} \cdot \text{l}^{-1}$ ) is the highest value measured in Estonian lakes.

**Lake Neitsijärv** is the second large lake near Otepää and it lies in the close vicinity of Lake Pühajärv. It is, however, in such a state that in summer only a knowledgeable seeker can find it. According to Aleksander Audova the waterbody (7,5 ha, depth 2,5 m, only 1.2 m of which is water) in 1919 was densely overgrown already at the beginning of the 20<sup>th</sup> century. In the early 1930s Harald Haberman (1931) stated that Lake Pühajärv was middle-aged but Lake Neitsijärv had reached senility: "gyttja has filled the lake basin to such an extent that it may become totally overgrown". Although the percentage of the catchment area of this lake is only 15% of that of Lake Pühajärv, a large amount of nutrients is discharged from Lake Neitsijärv into Lake Pühajärv. In order to reduce this load, urgent measures are needed.

**Lake Kukemäe** (4 ha, 1.3 m) lies in a depression upstream of Lake Neitsijärv and is practically invisible from the Pedajamäe-Pühajärve road. It is difficult to approach this overgrowing and almost forgotten lake. Unlike Lake Neitsijärv, quaggy ground constitutes most of its shore. Like Lake Neitsijärv, the lake presents a quiet habitat for numerous waterfowl.

**Lake Jaanuse** (L. Pikkjärv) is the next and the largest (9.4 ha) as well as the deepest (6.3 m) lake in the upstream lake cascade of Lake Neitsijärv. It is a typical eutrophic waterbody with extensive open water and a band of

macrophytes along the shore. Unlike the macrophytic lakes Neitsijärv and Kukemäe, this lake has a rich biota in which plankton plays the main role.

**Lake Kurnakese** (Kurnakse), the uppermost and smallest lake (1.8 ha, 4.8 m) of the cascade, is the only one that is well-exposed and visible, although shaded by an alder thicket from the Otepää-Palupera road. It is fed by spring and precipitation water. The water is extremely hard and, despite its small depth, stratified. The lake is considered to be polluted, first of all due to the richness in organic matter.

## 2.4 The Project

The Project implements a part of the environmental programme of Otepää, initiated in 1990. At that time the main priority in the development of Otepää was environmental protection. The town began to construct a new wastewater treatment plant and to develop its water supply system. Economic difficulties after the restoration of independence in Estonia brought these activities to a standstill.

In 1993 Otepää was involved in a Swiss aid programme and construction activities were resumed. With the support of Switzerland in 1996, Stage I of the new wastewater treatment plant was put into operation and the discharging of sewage into Lake Neitsijärv was stopped. In 1998 Stage II of the wastewater treatment plant was completed, and the drinking water purification plant was put into operation. This completed the *first stage* of the Otepää environmental programme, which made it possible to commence the implementation of the *second stage*: reduction of the pollution load and restoration of the town-related natural and semi-natural waterbodies.

Renovation of the lakes and lakelets would make it possible to launch the *third stage* of the programme, i.e. to include the restored waterbodies and green areas of the town in the network of recreational landscapes of Otepää Nature Park, and Lake Pühajärv.

Lake Neitsijärv, which is connected with Lake Pühajärv, one of the most attractive and beloved lakes in Estonia, has for decades served as an oxidation pond for the sewage of Otepää, and is at present choked by weeds. The lake acted previously as a fish nursery for Lake Pühajärv, but the fish stock has strongly diminished in the last ten years. To restore the fish stock, Lake Neitsijärv should be rehabilitated.

### 2.4.1 General aims and objectives

The general aim of the Project was to improve the condition of the waterbodies as well as to preserve the diversity of the biota and landscapes of the Otepää region as one of the most important tourist and recreational areas of Valga County and South Estonia as a whole.

The main objective of the Project was to elaborate optimal technological solutions for minimising the pollution load of Lake Pühajärv and restoring Lake Neitsijärv as well as other small waterbodies of Otepää.

## 3 Results and discussion

### 3.1 The ecological state of Lake Neitsijärv

Investigations of the ecological state were carried out by the experts from the Institute of Zoology and Botany, Estonian Agricultural University.

In the middle of the lake the dry matter profile is quite even (mean value 12.2%), but in the two other cores taken near the inlet and outlet of the lake a denser layer (ca 0.5 m) could be detected: near the inlet at the depth 3-3.5 m (avg. 16.8%), and near the outflow at a depth 2.25-2.75 m (avg. 16%).

The range of **organic matter content** (as percentage of dry matter) was quite similar in all three cores: in the middle of the lake 24.8% to 49.7%, near the inlet 21.9 to 49.3% and near the outlet 22.2 to 48%.

The sediments of Lake Neitsijärv are rich in phosphorus. Near the inflow, where the total phosphorus content was the highest, the extractable with NaOH phosphorus dominates (avg. 63.7%). As for the rest, there is more residual (21.8%) than extractable with HCl phosphorus (11.4%) [1].

Lake Neitsijärv is a hard-water waterbody with a relatively intensive water exchange. Its total nitrogen content is on the hypertrophic level, but its total phosphorus content is on the eutrophic level. It is important to notice that according to the content of both nutrients, the lake does not act as an efficient purifying waterbody anymore. The oxygen conditions in winter are poor. During our investigations the water under the ice was anoxic already in the middle of February. Owing to the small water volume and the great amount of organic matter the depletion of oxygen resources in winter is very rapid.

Lake Neitsijärv is totally overgrown by macrophytes and phytoplankton, and it has some peculiar features of macrophyte lakes. The reed grows everywhere outside the water border because the thick mud layer impedes rooting near the quagmire edge. In spite of some improvement, the nutrient content in this lake, at least in sediments, is high.

The fish community of Lake Neitsijärv is predominated by the roach, followed by the perch, rudd, and pike. In winter most of the fishes except for the tench and crucian carp migrate to Lake Pühajärv or die because of anoxic conditions [1].

### 3.2 Sanitation of Lake Neitsijärv

The aim of sanitation is to make Lake Neitsijärv a plankton waterbody and suitable habitat for young fish. For this purpose the amount of open water needs to be increased. Removal of the deeper layers of the sediments might result in dangerous release of nutrients, in particular phosphorus.

#### 3.2.1 Technical solutions

The limnological investigations demonstrated that the water quality of Lake Neitsijärv is largely influenced by the inflow water from Lake Kukemäe. It means that the two lakes should be regarded as an integrated system. This was taken into account in the elaboration of possible technical solutions.



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A four-stage sanitation programme was elaborated by Mr. Enno Kirt, where the implementation of each following stage depends on the accomplishment of the prior stages:

**A.** The lake shores will be cleared of brushwood and views opened, no sediments will be removed at this stage. To demonstrate various lake types, the lake aging processes, and the biota, a nature trail along the lake cascade Kurnakese - Jaanuse - Kukemäe - Neitsijärv will be laid out. To create patches of open water, a part of the aquatic vegetation will be removed from the lake surface.

**B.** The lake is to be deepened to the bottom elevation of by 2.5 m from average water level. Dredging spoils (sediments and macerated vegetation) are to be disposed onto the area between the lakes Kukemäe and Neitsijärv, and onto a large wetland adjacent to Lake Kukemäe. The proposed disposal and dewatering technology has been tested on a pilot area.

**C.** The water level of Lake Neitsijärv is to be elevated to the maximum spring level. To control the water level, an overflow weir and a fish pass are necessary at the outlet (between the lakes Neitsijärv and Pühajärv). The enlargement of the lake's capacity by 60,000-120,000 m<sup>3</sup> would allow to store most of the spring runoff from the lake's catchment area and improve the self-purification capacity of the lake.

**D.** To eliminate the phosphorus load from Lake Kukemäe this lake should also be sanitised at a later stage. For planning technical solutions additional geodetical and geological investigations are needed. The outflow from Lake Kukemäe to Lake Neitsijärv is to be controlled by an overflow weir.

### 3.3 **Landscape values**

The functions of landscape and related values can be viewed from many points of view [2]. First, landscape serves as an economic value - a production area which in the case of rural landscape means both agricultural and forestry use. Both of them are of some importance for the Otepää region. However, for the region another possible value of landscape - recreational (emotional) - is of much higher importance. Otepää has been a tourist and recreational area for a long time, and the landscape value is increasing because the agricultural value of the landscape is on the decrease rather than on the increase. The recreational value of the Otepää region is high both in the winter and summer periods - the best Estonian ski resorts are located in the Otepää Upland. However, the major skiing centres for both cross-country and alpine skiing are located east and south of Otepää. The small watershed of Lake Neitsijärv west of Otepää has no high hills, and the potential of this region is probably first of all weekend and longer-term recreation allowing a quiet refuge for town people. Small motels and ecotourist farms could widen the use of the area which has so far been left out of active recreational use. The region, which is located very close to Otepää, as close as the well-known Pühajärve Beach or the Tehvandi skiing complex, has been so far forgotten. The recreational use of the landscape, however, depends on the ecological conditions of the lakes, first of all that of Lake Neitsijärv.



Further landscape values can be related to areas, which could be of some importance for providing a high-quality residential region. However, the construction of houses in the region should not block the openness of the landscape as this can lead to a fast decrease of its recreational value. Residential zones can be located in areas further from the roadside, which are a little away from the roads but still be very close to the town centre and pride themselves on a very nice view over the undulating landscape.

There is probably no need for industrial areas in this region; also, the need for transportation land is limited to the existing roads.

Another possible function of any landscape may be that of defence, but taking into account the location of the area in Estonia and the relatively dense population such a use is highly improbable.

An important value of a landscape is aesthetic, and this is closely related to the recreational use of landscape. In the case of Otepää there are at least two extremely important aspects that need to be considered. These are the diversity of the landscape and its openness. The natural conditions of the region are diverse. The region's relief with hills, wetlands between the hillsides, and many lakes, Lake Pühajärv with its islands and developed shoreline creates very nice views from the hills and roads leading across the hills. The forests of the area are patchy because for centuries the population has been dense and the agricultural use of the area has been intensive. During the last fifty years, however, the forested area in Estonia has increased, and this is also true for Otepää. It is good to have some forests between the hills from the point of view of diversity. However, many nice views that were open ten or twenty years ago have become closed due to the growth of the forest area. To preserve the aesthetic value of the landscape and the high recreational potential of the region, it is important to ensure that the landscape were semi-open and variable.

A landscape can also serve as a compensatory area for the neighbouring intensive economic regions - a part of the ecological network. In these terms, the Otepää region forms an important ecological area. Again, the ecological value of the region is related to its recreational use. On the one hand, a higher ecological value raises the recreational potential of the region, on the other hand too intensive recreational use or construction activities for recreational purpose could decrease the ecological value of the landscape. Deforestation of steep slopes in this region can cause intensive erosion and thus lower the ecological value.

The catchment area of Lake Neitsijärv and the related landscape have not been in intensive recreational use. This has kept the ecological value of the region higher than that of the surroundings of the intensive skiing centre east of Otepää. The region is therefore very suitable for less intensive and more nature and environment-related activities. A possible use of the area is education (another value of landscape). Creating a nature trail in the region could be an additional use of the region, whereas this can be realised at a low cost and in a short time and would not interfere with other possible uses of the area in the future, including the sanitation of Lake Neitsijärv. A possible nature trail to demonstrate the natural processes of lake eutrophication, wetlands, and different types of lakes is depicted on the inside of the back cover.



A landscape may also serve as an object of scientific interest and the end-moraines with a high diversity of natural ecosystems have provided much interest to geologists, ecologists, botanists, limnologists, zoologists, mycologists, and other scientists. The cultural history of the Otepää region adds interest from the point of view of social sciences [1].

## 4 Conclusions

The realisation of the Project supplied the town of Otepää, Pühajärve Commune, and Otepää Nature Park, with useful information about lake restoration. The local authorities of Otepää gained knowledge in conducting their activities in a way necessary for joining the European Community. The results of the Project can be implemented in restoring a number of South-Estonian lakes.

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