Examples of Water protection measures in Lake Pyhäjärvi (Southwest Finland)

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PYHÄJÄRVI INSTITUTE

Started 1989

**Food production** and **water protection**

Implementing research and development projects, further education and expertise services

Maintained by a foundation established by the local municipalities and companies
WATER PROTECTION

Themes in projects

- Agricultural runoff treatment
- Lake and river restoration
- Wastewater treatment

Intensive co-operation with stakeholders

National and international research projects

Customers: primary producers, entrepreneurs, authorities, inhabitants

Various lakes and rivers

Pyhäjärvi Restoration Program (Pyhäjärven suojeluohjelma)

Eurajoki-Köyliönjoki Program (JOKI ohjelma)
First signs of eutrophication were observed in the beginning of 1990’s.
In order to guarantee the necessary actions and funds for the restoration of Pyhäjärvi, the local municipalities, companies and other organisations founded Pyhäjärvi Protection Fund in 1995.
Voluntary participation.

The fourth term 2014-20
- 18 members
Säkylän Pyhäjärvi
Surface area 155 km²
Mean depth 5.4 m
Maximum depth 26 m
Coastline 80 km (47.71 mile)
Water residence time 3-5 y

Drainage basin area
Total 615 km²
River Yläneenjoki 234 km²
River Pyhäjoki 77,5 km²
Remaining area (small sub-basins) 149,5 km²
Mesotrophic, GOOD ecological state (at risk of eutrophication)
1. Management of the catchment area
   - basic water protection measures
   - new innovations tested
   - rural area waste water treatment
   - Local people are participating

2. Management of the lake
   - commercial fishery
   - biomanipulation

3. Education and communication

4. Research and monitoring
MANAGEMENT OF THE CATCHMENT AREA
LAKE PYHÄJÄRVI PHOSPHORUS BALANCE

- Remain in the lake: 56%
- From the ditches in the nearest drainage area: +24%
- From Pyhäjoki: +12%
- From Yläneenjoki: +54%
- From the air: +10%
- To Eurajoki: -18%
- Contained in the catch of fish: -26%
Water protection measures taken in the Lake Pyhäjärvi catchment

- Tens of wetlands
- Tens of sedimentation ponds
  - single, small sedimentation ponds
  - chain of small dam ponds
- Large areas of buffer zones
- Sand filters
  - Phosphorus binding amendments and sand
- Combination of ponds, wetlands and filters
- On-site wastewater treatment units
- Cattle yard renovations
- etc.

COST-EFFECTIVENESS, EASY MAINTENANCE, RECYCLIBILITY OF MATERIALS
Wetlands and sediment traps/ponds

- From upstream to downstream
- SS and nutrient mitigation
- Water retention and flood control

Maintenance and restoration of wetlands is needed!
Filters with various structures of different scale since 1990’s

• techniques were used for wastewater treatment but not for runoff waters before

Filter along the river besides buffer zone, Top-down filtering

Filter bed, Bottom-up filtering
In 2000's new filters with new commercial nutrient adsorbing materials
Ditch bottom filters
Reduction of

- suspended solids 37 – 94 %
- total phosphorus 37 – 82 %
- nitrogen 4 - 28 %
Experimental small-scale filter cartridge

For the treatment of subsurface drainage waters

- CaOH – granules and sand
Changes in concentration:

**Total P**: DS – 56%

**PO4-P**: DS – 94%
CLIMATE CHANGE - PRECIPITATION

Pyhäjärvi

Annual precipitation
- Variation has change in the course of time
- More precipitation with reduced yearly rainy days (decline 10.6d/10 yr 1953-2013) has lead to heavier rains
- Soil erosion increase

Seasonal precipitation
- Increasing trend

Variation increased
CHALLENGES IN P LOAD REDUCTION

- annual load is too much linked to precipitation, Ventelä et al. 2015
- extreme events
MAIN FOCUS IN THE FUTURE — "GAZING AT THE FIELDS"

- Farming technics and solutions
- Soil structure
- Challenges related to changing climate
MANAGEMENT OF THE LAKE: FISHERY
Professional fishermen working in the lake = top predators of the system!

Pyhäjärvi has 20 professional fishermen

Total catch 600 000 – 800 000 kg/year
FISHING METHODS

Tradionally most of the catch has been fished during the winter with seine net
- The catch is transported to harbour in a ice-water in transboxes
- Very cost efficient and effective method
- Catches 20 000 kg/day/group of fishermen

During the open water season the main (professional) fishing methods are the fyke net and open water seine
LONG-TERM BIOMANIPULATION IN PYHÄJÄRVI =

Commercial catch, especially planktivores vendace (Coregonus albula) and whitefish (Coregonus lavaretus)

Planktivores:
- Vendace
- Whitefish
- Smelt
- Roach (increasingly commercial since 2013)

Fishing of commercially unwanted fish species:
- Smelt (in France 2017)
- Bream
- Ruffe
- Roach (increasingly commercial since 2013)
Total biomanipulation catch 1995-2015
8,490,608 kg

Total catch 1995-2015
14,368,732 kg
HOW BIOMANIPULATION IS WORKING IN PYHÄJÄRVI?
1. VIA FOOD CHAIN

Strong **planktivorous fish stocks**, strong predation pressure on zooplankton

- Number and body size of *Daphnia* decreases

- Phytoplankton not controlled by zooplankton, becomes more abundant

*Sarvala et al. 1999, Ventelä et al. 2016*
PREDATORY FISH CRUCIAL ROLE
Effect on phytoplankton biomass

- 0.00
- 0.50
- 1.00
- 1.50
- 2.00
- 2.50
- 3.00
- 3.50
- 4.00

Year:
- 1964
- 1967
- 1971
- 1980
- 1982
- 1984
- 1986
- 1988
- 1990
- 1992
- 1994
- 1996
- 1998
- 2000
- 2002
- 2004
- 2006
- 2008
- 2010
- 2012
- 2014
- 2016

Phytoplankton biomass (g m$^{-3}$)

Intensive biomanipulation started + low external load

- OTHERS
- CHLOROPH
- EUGLENOPH
- DIATOMOPH
- CHRYSOPH
- DINOPH
- CRYPTOPH
- CYANOBACTERIA

The graph shows the biomass of different phytoplankton groups over the years, with a notable increase starting in 1980.
26% of the annual phosphorus load is removed from the lake with the fish catch!

Total commercial catch 1995-2015
14 368 732 kg → ~ 93 000 kg removed phosphorus

2. VIA NUTRIENT REMOVAL

Ventelä et al. 2007, 2011

- 18% to Eurajoki
+ 10% from the air
+ 12% from Pyhäjoki
+ 54% from Yläneenjoki

remain in the lake 56%
from ditches in the nearest drainage area + 24%

the catch of fish – 26%
3. VIA SEDIMENT RESUSPENSION

Ruffe, roach, bream
Tarvainen et al. 2005, Freshwater Biology
NEW CHALLENGES
Pyhäjärvi seasonal trends for water temperature (1982-2014)

1-May
+2.25°C per decade ($p<0.001$)

1-June
+1.34°C per decade ($p<0.001$)

1-July
+0.66°C per decade ($p=0.037$)

1-August
+0.59°C per decade ($p=0.029$)

1-September
+0.46°C per decade (NS)

July-August (mean)
+0.61°C per decade ($p=0.002$)

1-October
+0.32°C per decade (NS)

1-November
+0.86°C per decade (NS)

Source: Lathrop, Kasprzak, Ventelä, Tarvainen, et al., unpubl. data
Duration of the ice cover

- Mean 1958-1999: 147 days
- 2000-2015: 116 days

Ventelä et al. 2011, updated
Deng et al. (2016):
- increasing wind speed decreased Secchi depth, promoting shade-tolerant taxa such as *Planktothrix*.
- increased mixing reduced the loss rate of the heavy taxa such as *Tabellaria*.
- Increased nutrient concentrations and water temperature would also promote both *Planktothrix* and *Tabellaria*. 
MONITORING

We are monitoring the lake for:

- Nutrients
- Secchi depth
- Chlorophyll a
- Fish catch
- Phytoplankton
- Zooplankton

Also:

- Efficiency of the water protection measures
- Flow rates in the catchment ditches

Co-operation with authorities and several universities in Finland (Turku, Helsinki, Jyväskylä…)
INTERNATIONAL RESEARCH CO-OPERATION

- Japan
  - Tohoku University
  - Okayama University

- China
  - NIGLAS
  - Taihu Basin Authority
  - Ministry of Water Resources
  - Shanghai Ocean University
  - Changjiang Water Resources Protection Institute

- Sweden
  - Swedish Agricultural University
  - Royal Technical University

- Estonia, Latvia
  - Estonian Agricultural University
  - Tallinn Technical University
  - Riga Technical University
  - Institute for Environmental Solutions

- Denmark
  - Aarhus University
  - Eurofish

- USA
  - Wisconsin University

- Vietnam
  - Institute of Environmental Science and Engineering (Hanoi University of Civil Engineering)
  - Department of Agriculture and Rural Development (Ho Chi Minh City)
  - Ho Chi Minh University of Technology and Education.
THANK YOU!

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