

Reducing nutrient load from catchments

2. Loading



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Nutrient load from the catchment area comes from many different sources. Some sources can more easily be defined and controlled than others. Many things affect the loading: e.g. the type and area of the catchment, the land use and hydrology.

2.1. Types of loading

External loading

- Nutrients and organic matter in the water that come from:
 - the catchment area
 - from waste water released directly to the water body
 - fallout from the air

Internal loading

- The bottom sediment of a lake serves as a storage of bound nutrients. The release of nutrient from sediments to waterbody is called internal loading.
- In a healthy lake, more nutrients are settled to the bottom than what are released from the bottom.

2.2. Types of external loading

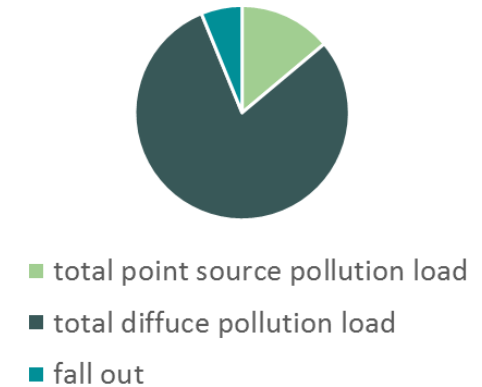
Point source

- Pollution arising from an identified single point
- For example effluent from a factory and municipal waste waters from a sewage plant
- Pollution from a point source is much easier to treat than pollution from diffuse load

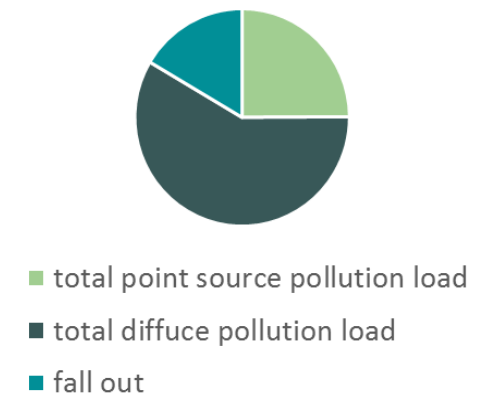
Diffuse load

- Input of a substance emitted from moving sources, from sources with a large extension or from many sources
- For example load from agriculture, storm waters, forestry and traffic
- Atmospheric fall out (deposition)

Phosphorus load sources in Finland in 2016 in %



Nitrogen load sources in Finland in 2016 in %



Source: [SYKE](#) (FI)

2.3. Internal loading of phosphorus

Many things affect the leaching of P from sediment:

- The amount of P in the sediment
- The binding capacity of sediment (amount of Fe, Al, Ca, clay minerals, which can bind P)
- Redox potential = oxidation – reduction potential (The electric potential required to transfer electrons from one compound or element (the oxidant) to another compound or element (the reductant))
- In normal situations, the surface of the sediment is oxidized and phosphate is usually bound to ferric (Fe^{3+}) (Ferro) phosphate
- In reducing conditions, when oxygen concentration is low (below 3 mg/l), Ferric (Fe^{3+}) reduces to Ferrous (Fe^{2+}), and phosphate and iron are dissolved back to the water
- decomposition of organic matter in the bottom consumes oxygen (biological oxygen demand) and it might lead to oxygen deficiency and to release of phosphate
- normally the water near the bottom is re-oxygenized in spring- and fall turn over of the water and Fe^{2+} is oxidized back to Fe^{3+} (if there is free Fe left...)
- If there is a lot of SO_4^{2-} , the Fe^{3+} will bound to iron sulphite

2.3. Internal loading of phosphorus

pH

- High (> 8 or > 9) pH can lead to phosphorus release from the sediment
- In a shallow very eutrophic lakes and rivers, production is so intensive, that the pH on the sediment surface can get very high (the CO_2 is fixed in photosynthesis by phytoplankton) and P is released from iron compounds.
- Also P bound to Al or clay minerals can get released when pH is high
- Humic substances also bind P more effective when pH is low

- [Learn more:](#)



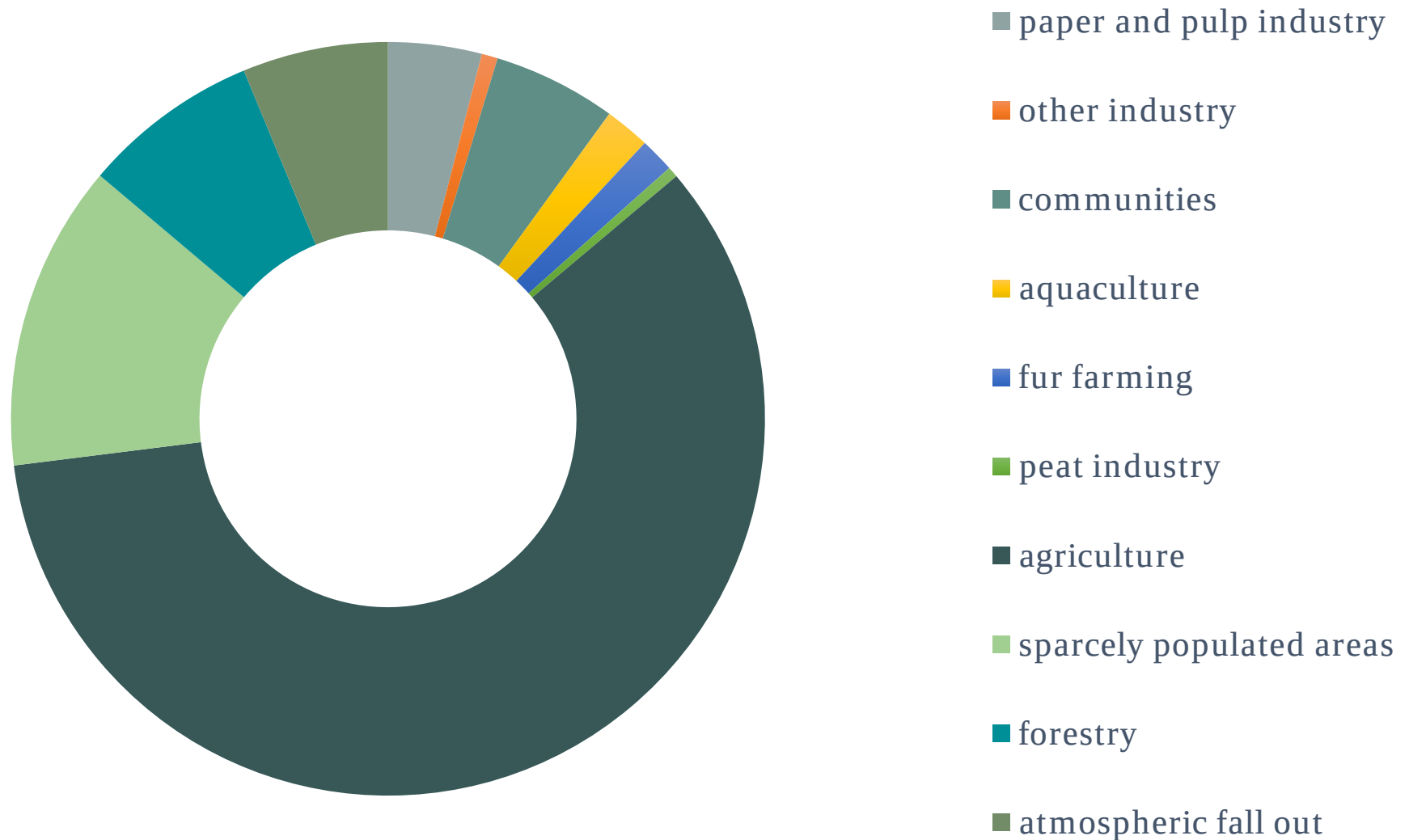
2.4. Sources of nutrients

- Agriculture
- Forestry
- Sparsely populated areas
- Build-up areas/storm water
- Peat soil/peat industry
- Municipal waste waters
- Industry
- Aquaculture and fur farming

- [Learn more:](#)

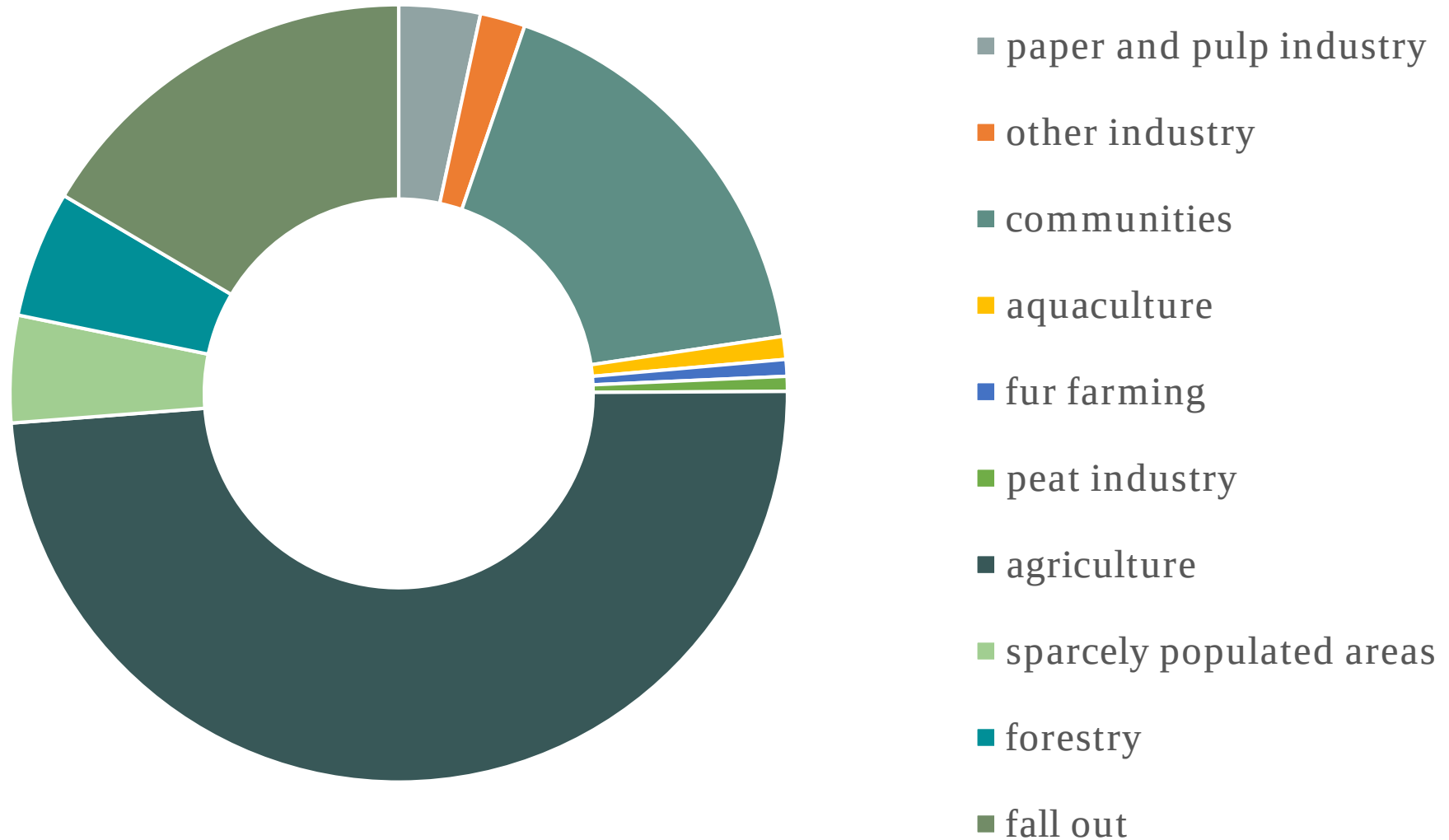


Sources of phosphorus load in Finland 2016



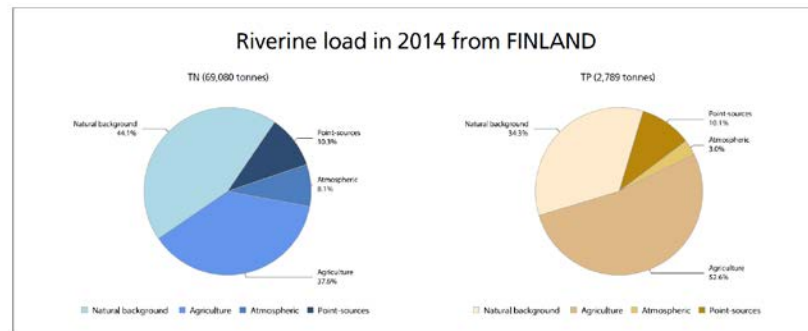
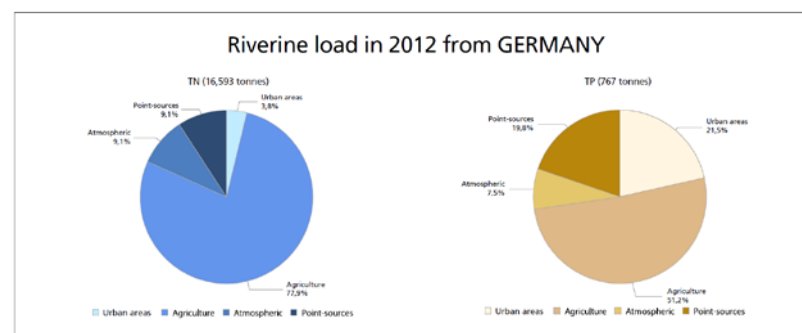
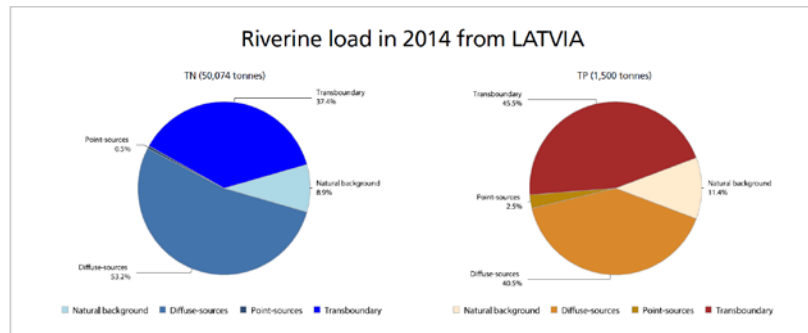
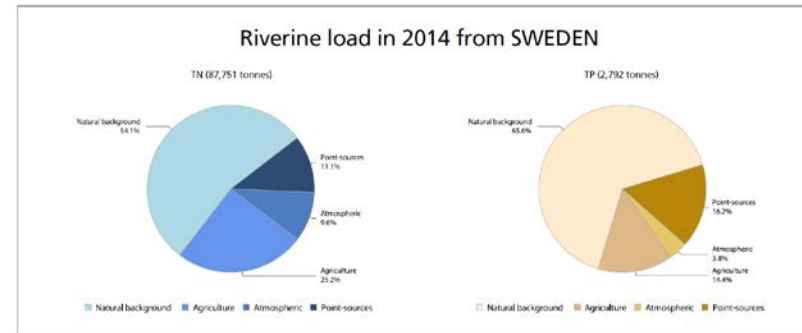
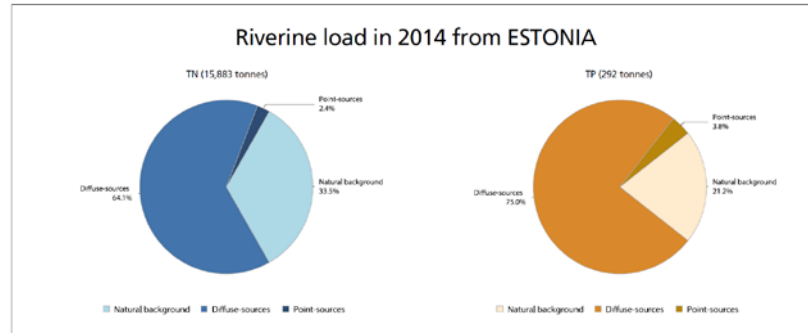
[Data: SYKE 2017](#) (FI)

Sources of nitrogen load in Finland 2016



[Data: SYKE 2017](#) (FI)

Nutrient loads to the Baltic sea from some countries in 2014:



Read more on source: [HELCOM 2018](#)

2.4.1. Load from agriculture

Reducing nutrient loads from agriculture is more complicated than controlling loads from point sources.

Although there are measures to reduce nutrient loads from agriculture, there is a time lag between the implementation of agricultural water protection measures and visible effects in water bodies

The load from agriculture comes from many sources and is affected by many factors.



Photo: TUAS Water Engineering



Photo: TUAS Water Engineering

Distribution of P losses from agriculture within the Baltic Sea catchment area kg/km²

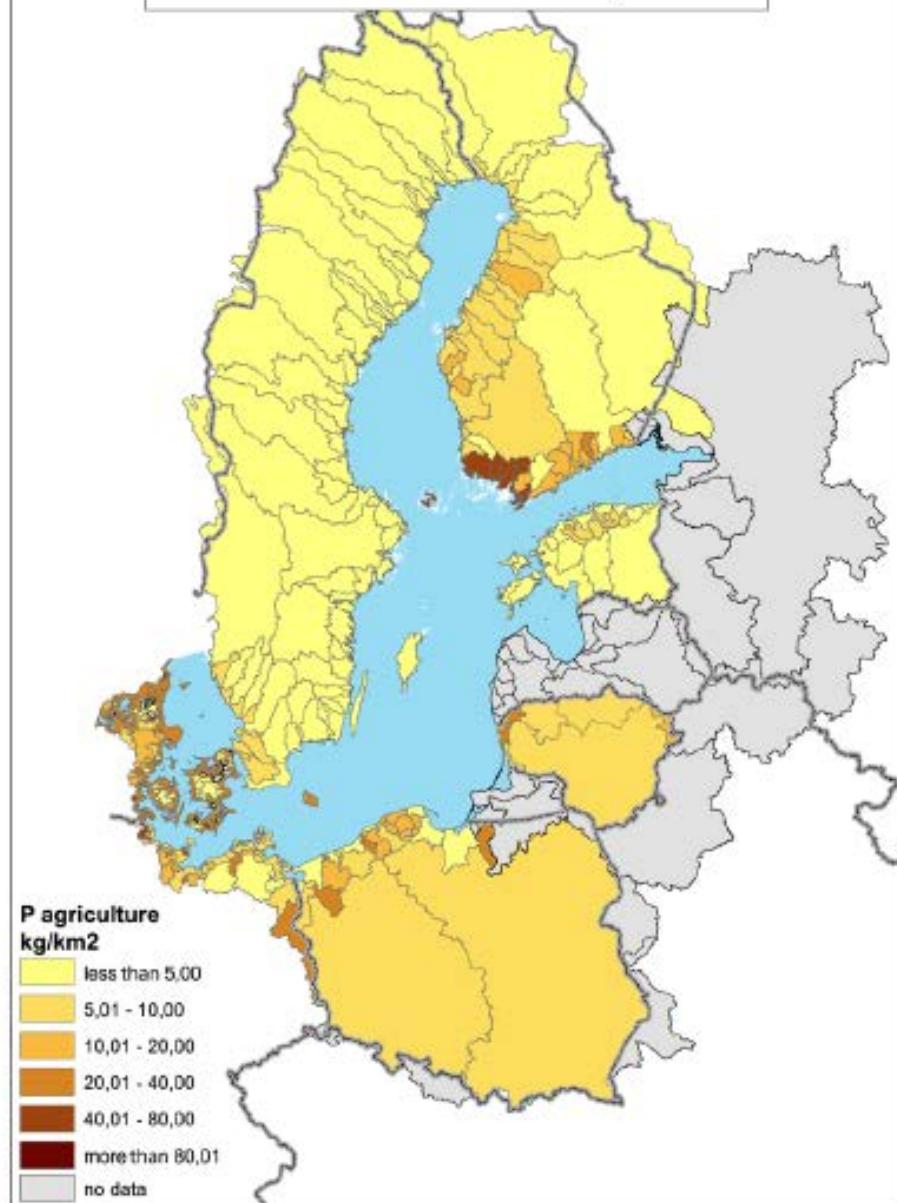
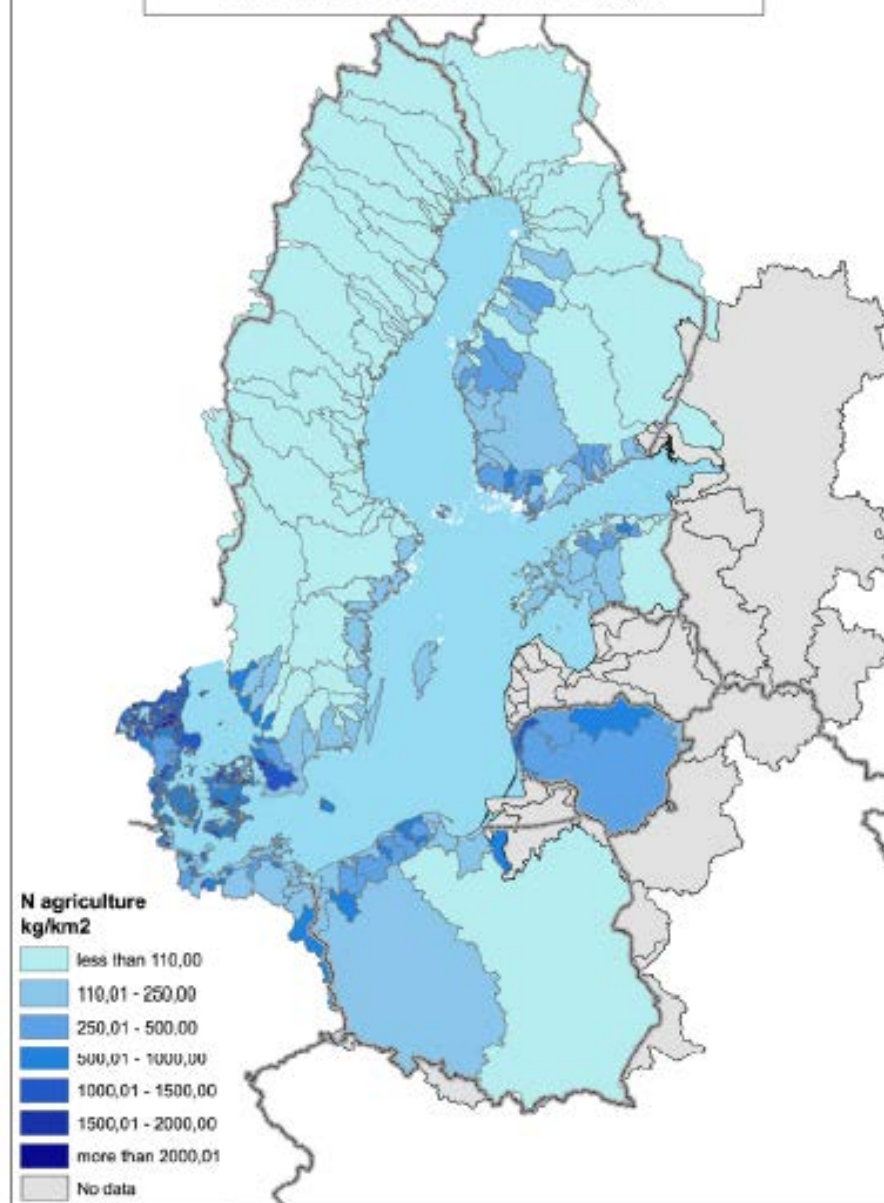


Figure 55

Distribution of N losses from agriculture within the Baltic Sea catchment area kg/km²



The nutrient losses from agriculture vary a lot in the catchment area of the Baltic sea.

Source: [HELCOM 2018](#)

2.4.1.1. Drainage of agricultural fields

- The farmland fields have to be drained to adjust the water balance
- Draining is performed either by ditches or by underground drains
- Through drains, nutrients reach watersheds quickly

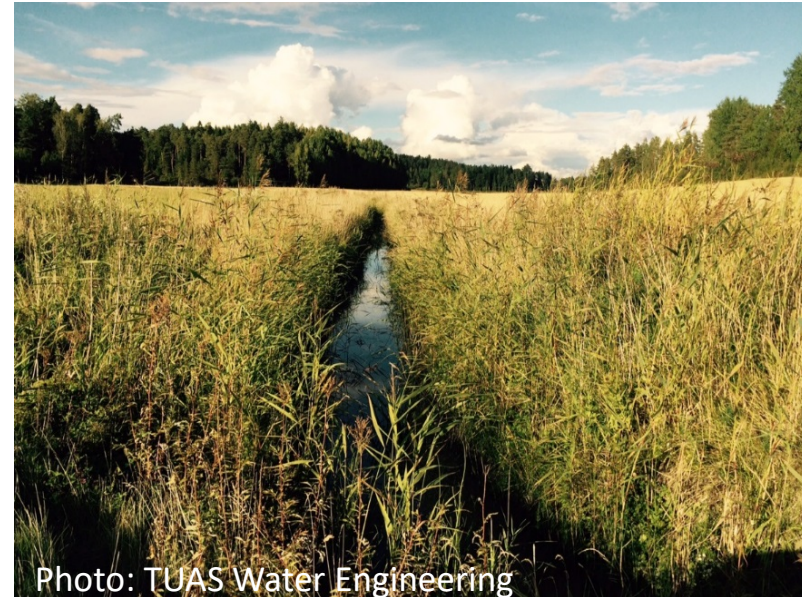


Photo: TUAS Water Engineering



Photo: TUAS Water Engineering

2.4.1.2. Erosion

- Traditional ploughing of fields in the autumn leaves the field without plant cover for the winter and spring
- Most of the nutrient and solid matter load occurs during autumn and spring, due to autumn rains and melting of snow
- In fine grained fields, most of the phosphorus load is bound in the solid matter (bounded to soil particles)
- Climate change increases the nutrient and solid matter loads, because the time of snow cover and ground frost gets shorter and the runoff increases



2.4.1.3. Fertilizing

The use of **fertilizers (or manure)** should be in balance with the crop, to minimize the loss of nutrients from the field (to the surface waters)

Photo: TUAS Water Engineering

Nutrient
balance

=
is

Nutrient
input
(manure, fertilizers,
nutrient content of
the seeds

–
minus

Nutrient content
of the crop

Solid matter load **from mineral soil fields** in Finland varies from 50 to 5000 kg/ha/a

- loading of total N is 6-22 kg/ha/a
- loading of total P is 0,5-2,5 kg/ha/a

([Tattari & Linjama 2015, Väisänen & Puustinen 2010](#)). (FI)

Natural run off in Finland is estimated to be:

3 – 7 kg/km²/a **Phosphorus**

- 70 – 200 kg/km²/a **Nitrogen**

([Tattari & Linjama 2004](#)) (FI)



Photo: TUAS Water Engineering

2.4.1.4. Matters affecting the load from agricultural fields

- The amount of fields in the catchment area
- Distance between the fields and water bodies
- Topography (sloping or plain)



Photo: TUAS Water Engineering



Photo: TUAS Water Engineering



Photo: TUAS Water Engineering

...matters affecting the load from agricultural fields

- Use of the field
- Soil type
- Cultivation techniques
- The amount of organic matter in the soil
- The use of fertilizers (amount, how and when they are spread)
- Water balance of the field (in very compact (tight) fields the load is bigger)
- Storage, handling and using of manure and urine
- Rain and flow rates
- Crop species



Photo: TUAS Water Engineering



Photo: TUAS Water Engineering

2.4.1.5. Animal husbandry (animal farming)

- Production of cattle, pigs and poultry in the Baltic Sea catchment area contributes significantly to nutrient loads
- Proper manure management is important in controlling the load
- [Learn more:](#)



2.4.2. Loading from forestry

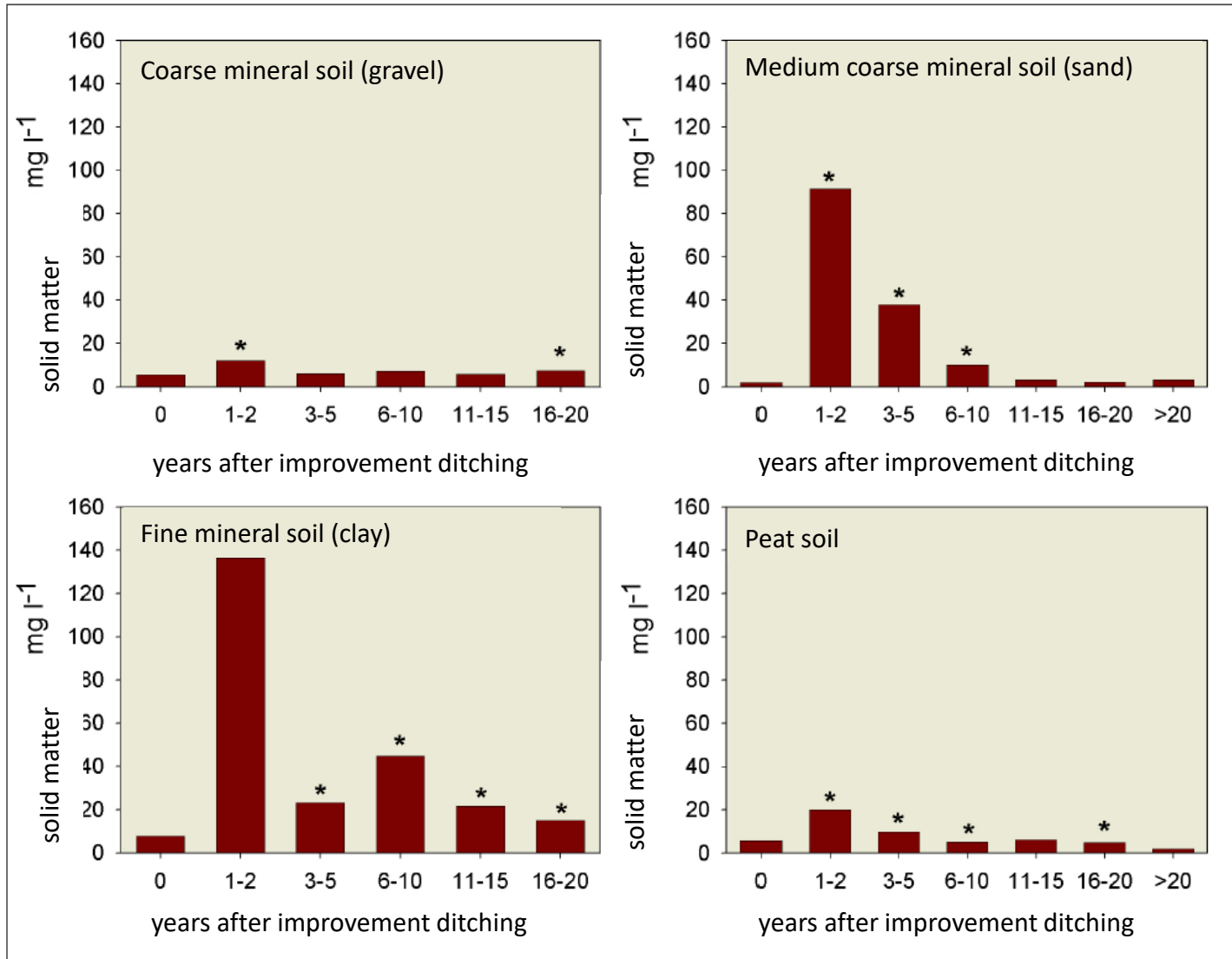


2.4.2.1. Erosion and increased run off caused by forestry

- Managed forests (commercial forests) cause more loading than natural forests
- Forestry measures increase erosion and runoff and nutrient load to surface waters:
 - Ditching – both new ditches and maintenance of existing ditches (some forests have to be drained to manage the water balance)
 - Soil preparation accelerates decomposition and destroys ground vegetation



Photo: [Ympäristö.fi](https://ymparisto.fi)



Mean solid matter concentrations in runoff from different soil types before repair (improvement) ditching (0), 1-2, 3-5, 6-10, 11-15, 16-20 and over 20 years after repair ditching (Joensuu 2013). Statistical significant differences are shown with a star.

([Palviainen and Finér 2013](#)) (FI)

2.4.2.2. Logging

- Nutrient loads in receiving watersheds increase after clear-cutting – because the trees no longer take up water and nutrients from the soil
- Soil temperature rises after clear cutting
- Nitrification and mineralization in the soil speed up
- Nutrients release from decomposing logging residuals



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2.5.2.3. Fertilizing

- Especially drained peatlands usually are fertilized, because the lack of nutrients reduces the growth of trees (Mostly P, also N and other nutrients)
- Fertilizing naturally increases nutrient load to watersheds

2.4.3. Loading from sparsely populated areas

- In some cases, waste water load from sparsely populated areas may constitute a significant part of total nutrient load to a water body.
- Over one million people in Finland live in areas with no common sewer network
 - about 300 000 houses are unconnected to sewage systems in Finland
 - there are about 400 000-500 000 summer cottages in Finland (most of them without connection to sewer network) ([Tattari et al 2015](#)) (FI)

2.4.4. Loading from stormwaters

Rural stormwater:

- Nutrients and organic matter are washed out to water bodies with rain and melting snow
- Only a minor part is treated through infiltration or discharge to combined sewers
- Nutrient load comes mainly from gardens, agriculture and industrial areas
- The discharge of water and associated loading varies significantly, depending on season, land use and rain intensity

2.4.4. Loading from stormwaters

Urban stormwater:

- Nutrients originate mainly from traffic and urban green areas, but also from animal droppings
- Nutrients and other pollutants are leached from permeable surfaces or washed off from impermeable surfaces.
- Nutrients are usually bound to smaller particles, e.g. dust and road and tire wear
- Only some part is treated through infiltration or discharge to combined sewers



2.4.4. Loading from stormwaters

Urban stormwater:

- The largest quantities of nutrients are often transported with the “first flush”, peak runoff after a prolonged dry period.
- First flush concentrations of nutrients and other pollutants might be harmful or toxic to organisms (Lind et al. 2001)



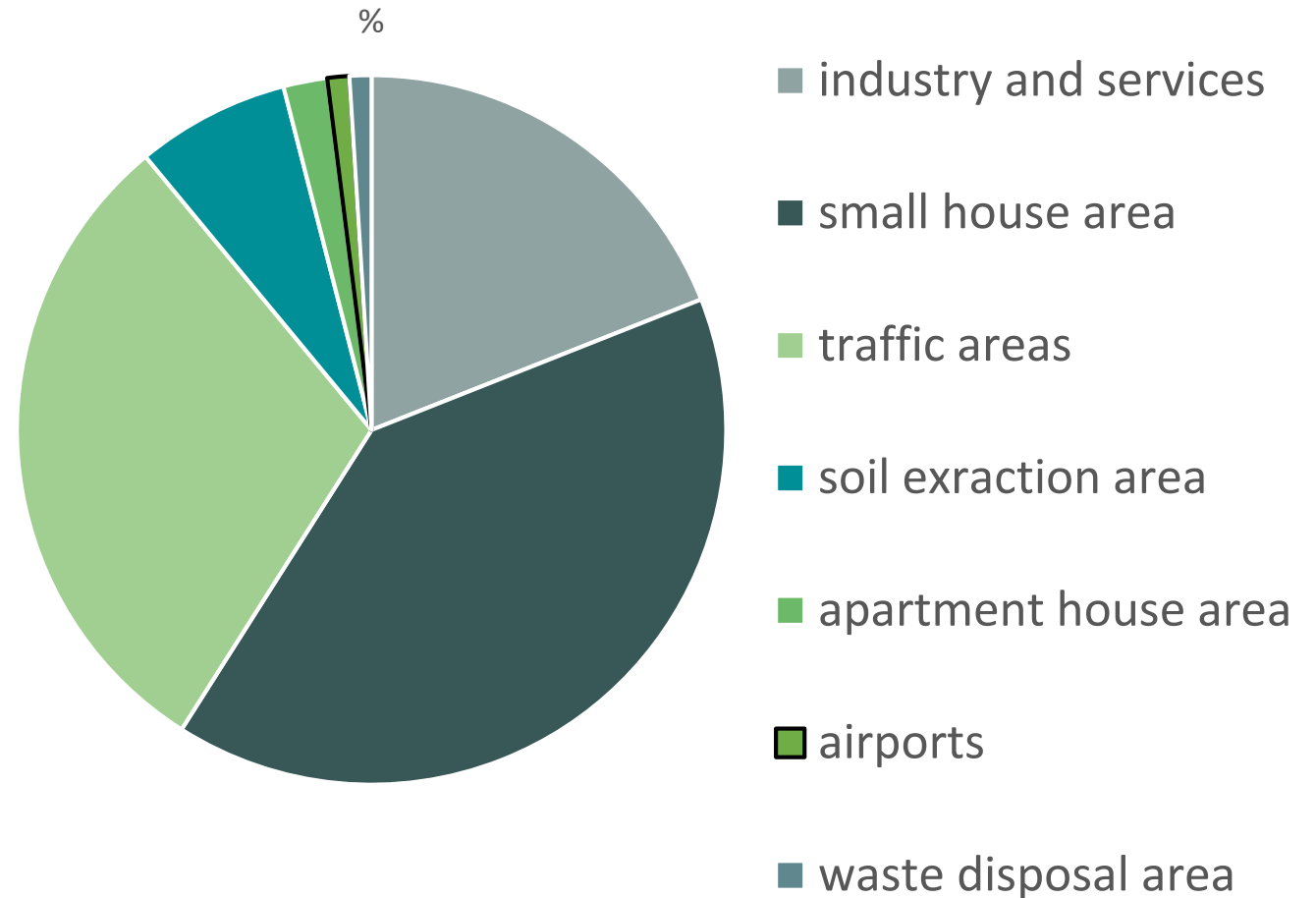
Photo: TUAS Water Engineering

Example nutrient concentrations in urban road runoff in Sweden (Trafikverket, 2011). ADT = average daily traffic

Nutrient	Source	Concentration [mg/l]		
		10 000-15 000 ADT	15 000-30 000 ADT	>30 000 ADT
Phosphorous	Exhaust fumes, oil	0.15	0.20	0.25
Nitrogen	Exhaust fumes, oil	1.2	1.5	2.0

Sectors in built up land in Finland:

- The land use affects the loading from stormwaters
- Land use of built-up areas in
- Finland in 2012 (recreation areas not included)
- ([Tattari et al 2015](#)) (FI)

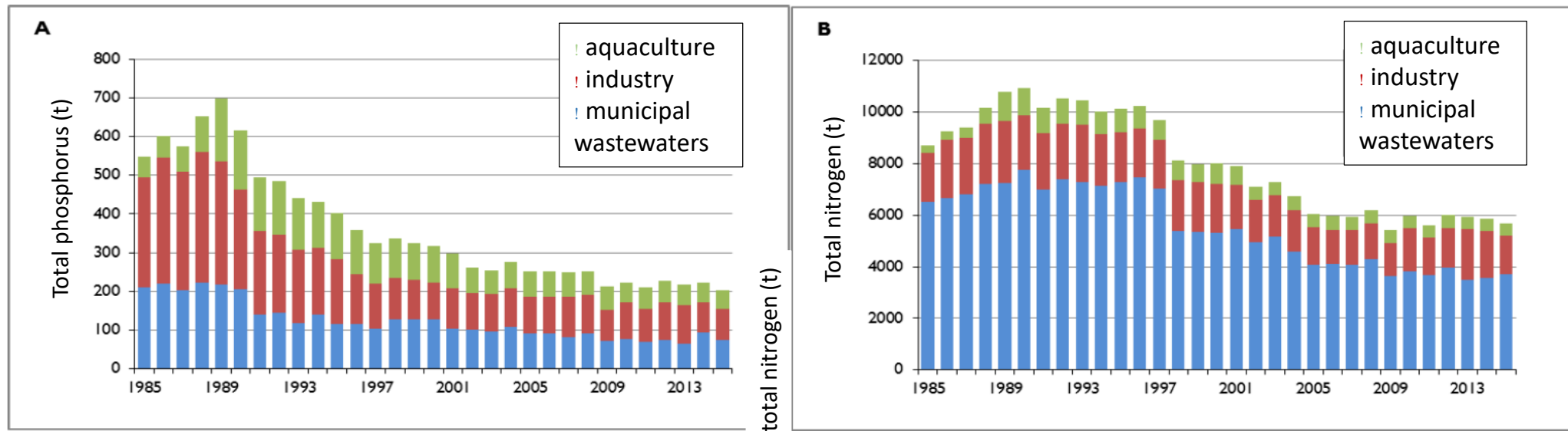


2.4.5. Loading from peat industry

- Water coming from peat industry areas is usually more nutritious, darker and has more soluble organic matter than the water coming from natural swamps (marsh)
- 30 % of land in Finland is peat soil, of which 0,6 % is under peat industry (GTK)
- Locally significant source of loading of nutrients and organic matter
- The runoff increases, fine organic matter is washed to watersheds

2.4.6. Loading from municipal wastewaters

- Municipal wastewaters are treated in sewage treatment plants (point source loading)

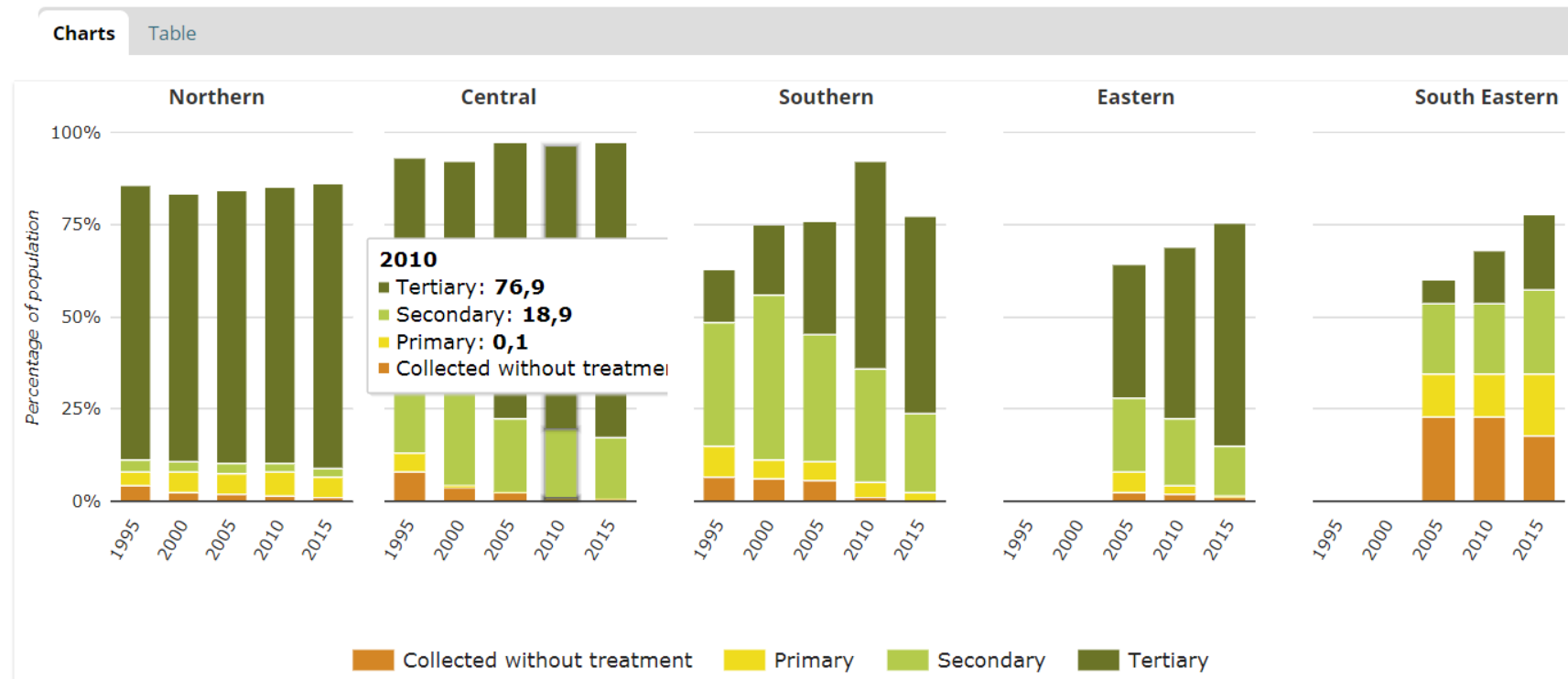


Point source loading (A = Phosphorus and B = Nitrogen (t/a) to the sea area of Finland in years 1985-2015. ymparisto.fi 2018 (in Finnish)

The situation of waste water treatment in different European countries during the last 20 years

(Click the link in the picture)

Fig. 1: Changes in urban waste water treatment in Europe



Primary treatment of wastewater:
Involves sedimentation of solid waste within the water. This is done after filtering out larger contaminants within the water.

Secondary treatment of wastewater:
makes use of oxidation to further purify wastewater

Tertiary Wastewater Treatment:
is mostly comprised of removing phosphates and nitrates from the water supply

European environment agency 2018

2.4.7. Loading from industry

- Point source loading
- Water is treated in waste water treatment plants, sometimes together with municipal wastewaters
- Paper and pulp industry is the most significant source of (industrial load) in Finland (though it has diminished remarkably in the last 30 years) – mostly organic matter load
- Also mining industry and fertilizer industry cause significant loading

2.4.8. Loading from aquaculture and fur farming

- Aquaculture and fur farming cause locally important loading
- Nutrient loading comes mainly from droppings from fish or fur animals and uneaten feed
- Loading from aquaculture happens mainly in growing season (fish are cold blooded and grow and eat mainly when the water is over 5 degrees)



Photo: TUAS Water engineering

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