NATUR VÅRDS VERKET

SWEDISH ENVIRONMENTAL PROTECTION AGENCY

Wastewater treatment in Sweden 2018

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Glossary

Combined sewage systems are sewers that are designed to collect storm water and sewage in the same pipe.

Duplicate or separate sewage systems are sewers where sewage and storm water are collected in separate pipes. In this case, storm water does not enter the wastewater treatment plant, except for when it infiltrates through leakage into the sewage systems.

Gross load is the volume of nutrients released to a river or lake via a wastewater treatment plant or agricultural field, for example.

Net load is the part of the gross load that reaches the sea, i.e. after retention of nutrients in the water system.

Persistence is the ability of a substance to resist degradation. A persistent substance is difficult to break down (organic environmental toxins for example) or cannot be broken down at all (for example metals).

Population equivalent (pe) corresponds to the amount of degradable organic material with a biochemical oxygen consumption of 70 grams of dissolved oxygen per day over seven days (BOD7). In the directive concerning urban wastewater treatment pe is defined as the organic biodegradable load having a five-day biochemical oxygen demand (BOD5) of 60 g of oxygen per day.

Overflow happens when wastewater is released to the recipient untreated or without having undergone full treatment. This occur when the capacity of the sewage system or wastewater treatment plant is exceeded, for example.

Recipient is a river, lake or sea that receives untreated or treated wastewater or storm water.

Retention is the degradation of nutrients and other substances in water systems by means of natural biogeochemical processes. Retention takes place in soil and groundwater, and in rivers and lakes.

Roof and drainage water is water that is discharged by means of drainage from the land around building foundations and other lands, and from the roofs of houses.

SMED (Swedish environmental emission data) is a consortium where organisations such as IVL Swedish Environmental Research Institute, SCB (Statistics Sweden), SLU (Swedish University of Agricultural Sciences) and SMHI (Swedish Meteorological and Hydrological Institute) are collaborating.

Turtles were found in the incoming wastewater water laying on the inlet screens at Himmerfjärdsverket. They were then about 5 centimeters and have today grown to full size. Photo: Swedish EPA.

Storm water is temporary flows of rainwater, meltwater and flushing water, as well as emerging groundwater.

Supernatant is water that arise when sludge, from the treatment process that has gone through a digestion process, is dewatered.

Wastewater or sewage is wastewater collected in sewage systems. Domestic wastewater comes from households and consists of water used to flush toilets and water from baths, washing-up and laundry facilities. Industrial wastewater is the wastewater discharged from areas used for commercial or industrial activities, and that is not domestic wastewater or storm water.

From latrine to water closet

By the late 19th century the larger cities in Sweden began building sewage systems for the first time. Piping was laid underground to transport wastewater from kitchens and newly installed modern water closets into nearby lakes or coastal waters. In time, this wastewater disposal system replaced the historical latrine management systems where household waste was collected in pits and barrels, and then used as fertilizer on local farms. In areas where using this waste for fertilization was not possible, the waste was simply buried underground. By 1880, twelve Swedish cities had underground sewer systems. Water closets were being introduced, primarily to improve sanitary conditions in housing and urban areas. Wastewater systems became predominant first in larger cities in the 1920s and later in smaller towns and communities (Bernes and Lundgren, 2009).

Wastewater entering Himmerfjärdsverket is led through inlet screens where tops, condoms and rags, amongst other things, are separated from the water.
Photo: Swedish EPA

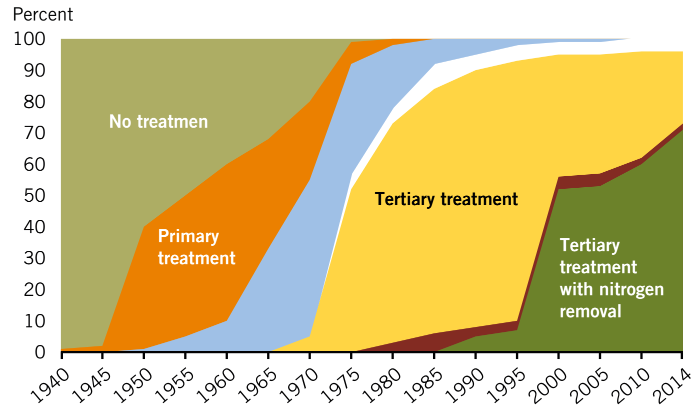
PROBLEMS WITH POLLUTION INCREASES

At first, both urban and industrial wastewater was discharged entirely untreated. Over time lakes, rivers and coastal areas became increasingly polluted. The bodies of water in Sweden were experiencing hypoxia and fish death as a result of discharge of nutrients, oxygen demanding pollutants and pathogens. At times the discharge even brought waterborne epidemics. Water pollution was regarded as a municipal concern until the 1940s, which limited the potential for comprehensive action. The progression of building new municipal sewage treatment plants was slow. By 1940 only 15 municipal wastewater treatment plants were operating countrywide. This number were doubled to 30 by 1955, but it was far from sufficient (Bernes and Lundgren, 2009).

THE 1960S – A TURNING POINT

The eutrophication of the bodies of water in Sweden gained public attention in the 1960s. By then, the water quality of many lakes and streams nearby larger urban areas had been severely degraded by decades of effluent discharge. Lakes became overgrown and algae drifted towards shores that previously was considered as prime bathing sites. Heavy metals or other chemicals were found in sediments in some lakes and rivers, mostly a legacy from historic industrial activities. Environmental alarms were raised regularly, soon leading to national governmental action against water pollution. The Swedish Environmental Protection Agency (Swedish EPA) was established in 1967; and a year later, national funding for wastewater treatment was introduced to decontaminate municipal wastewater and the Environmental Protection Act came into force in 1969 (Bernes and Lundgren, 2009).

Share of different treatment methods for the urban population connected to municipal wastewater treatment. Source: Swedish EPA.



EXPANSION OF WASTEWATER TREATMENT IN THE 1970S

The national government invested over SEK 1.5 billion in expanding municipal wastewater treatment capacity (corresponding to some SEK 7–8 billion in 2018 value), from 1971 to 1979. In the early 1970s, several industries also received government grants for environmental improvements. These were largely spent on improving wastewater treatment. Industries with their own wastewater treatment plants have also been making significant investments since then, in order to reduce their discharge. However, discharges from small properties with on-site wastewater systems have not decreased in a similar manner. The extensive investments, made mostly in the 1970s, resulted in an increase in water quality in lakes and rivers in the country, bathing areas reopened, and fish began to return.

THE CURRENT SITUATION

Essentially all households in urban areas are connected to municipal wastewater treatment plants. Over 97 per cent of urban wastewater undergoes both biological and chemical treatment. Many larger industrial and mining facilities have their own wastewater treatment plants (Swedish EPA and Statistics Sweden, 2020). There are also approximately a million households in Sweden that do not have municipal water and sewage services. Roughly 700,000 of these have water closets, while 130,000 have wastewater facilities for water from bath, washing-up and laundry. In addition, several properties used primarily for leisure purposes have no water or sewage system connected at all. Many of these small-scale systems fail to meet legal requirements and are a significant source of phosphorus and nitrogen emitted into lakes, rivers and coastal waters (SMED, report 6 2018). During 2018 the Swedish government initiated a temporary grant for treatment of pharmaceutical residue and other micro pollutants.

Wastewater sewage systems

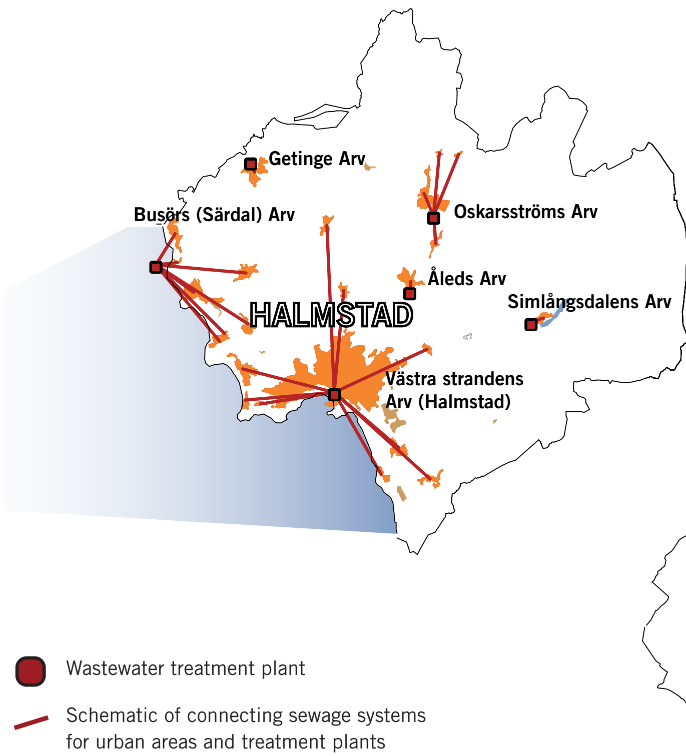
Wastewater treatment plants with sewage systems and pumping stations have been built to treat wastewater from urban and built-up areas throughout Sweden. According to Statistics Sweden (2020), more than 8.8 million people in Sweden had access to municipal wastewater treatment in 2018.[1] The situation is changing constantly as new housing areas are connected and smaller treatment plants are replaced with pumping stations that transfer sewage to larger treatment plants. As a result, there is a reduction of the number of treatment plants over time.

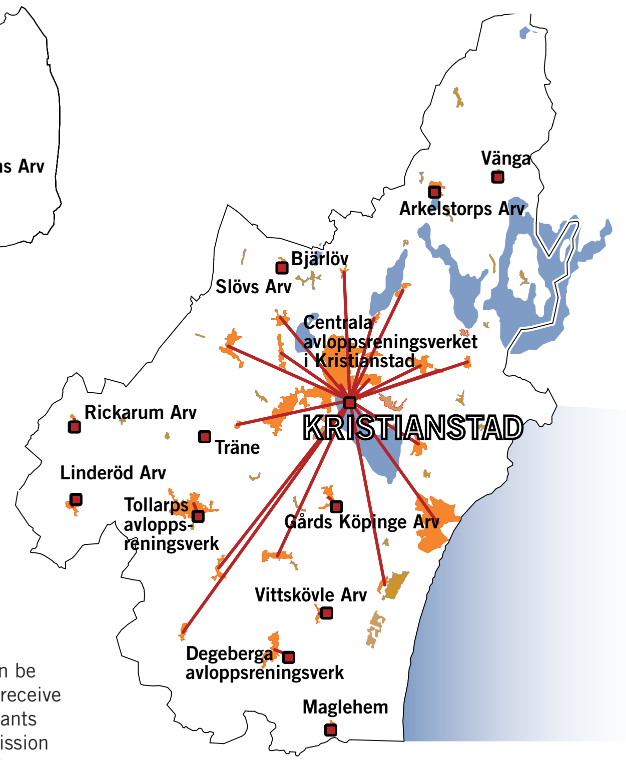
In Sweden, the total sewage system length in 2017 exceeded 100,000 km (Lundin et al., 2017). In separate or so-called duplicate sewage systems, stormwater and sewage are collected in separate pipes. In this case, stormwater does not enter the wastewater treatment plant, which means that the stormwater doesn't get "more than necessary" polluted. However, there is a high frequency of leakage of stormwater into the sewage systems. In combined sewage systems, stormwater is discharged to the treatment plants using the same pipes as sewage. Combined sewage systems are found mainly in older urban areas and were constructed until the mid-20th century. Combined sewage systems account for around 13 percent of the sewage system in Sweden (SWWA, 2016). Sewage systems were included as part of a technology inventory of municipal wastewater treatment plants with an input load of 2,000 population equivalents or more. This work was carried out by the organization *Swedish Environmental Emission Data* (SMED) in 2017, on behalf of the Swedish EPA (Olshammar and Persson, 2018). In this inventory, 305 treatment plants of a total of 453 contacted responded to questions relating to sewage systems. These had a total pipe length of 42,952 km, with duplicate systems being the most common.

Besides domestic and industrial wastewater, stormwater and other waters enter the wastewater treatment plant through leakages in the sewage systems. The leakage occurs in both municipal sewage systems and private pipes connecting to municipal systems. The amount of stormwater and other waters fed into the treatment plant varies depending on the sewage system and the wastewater treatment plant. Stormwater and other waters contribute to a dilution of the contaminated wastewater, which may cause overflows (diluted wastewater is released to the recipient untreated or without having undergone full treatment). This also result in a reduction of the effect of the purification process provided by the wastewater treatment plant due to a lower water temperature, a shorter

1. www.statistikdatabasen.scb.se

hydraulic retention time and dilution. Furthermore, the purification processes in the treatment plants are not made to purify the water from the kind of pollutants that are found in stormwater. As a result, stormwater discharged into combined sewage systems, besides causing overflows and impairing the purification process at wastewater treatment plants, also affect the quality of the sludge separated at the wastewater treatment plants.





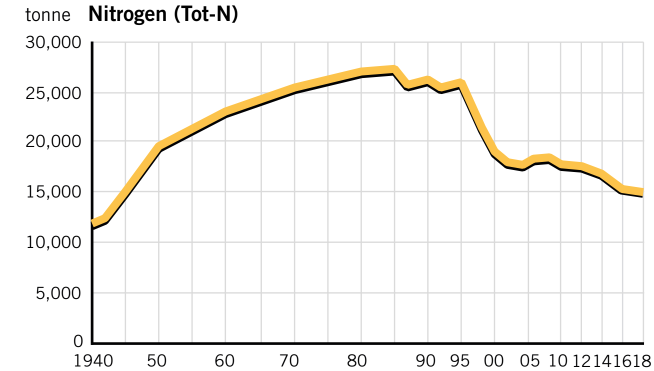
The maps are showing how more densely populated and urban areas can be connected to wastewater treatment plants. Some treatment plants only receive wastewater from the area where the plant is located. Other treatment plants receive wastewater from more distant areas. The maps illustrate transmission of sewage water on a larger as well as on a smaller scale. The areas that are connected to the same wastewater treatment plant are all considered part of the same agglomeration. There are also situations where more than one treatment plant serve the same agglomeration. The latter is however not depicted in this example.

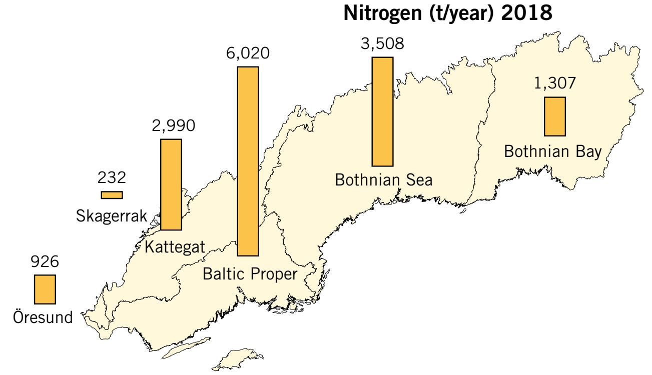
The municipalities connected to Himmerfjärdsverket are Botkyrka, Salem, Nykvarn, the main part of Södertälje, parts of Huddinge and southwest Stockholm. The purified wastewater from Himmerfjärdsverket is released into Himmerfjärden, 1.6 km south of the treatment plant at a depth of 25 meters. Himmerfjärden is thus a recipient for the purified wastewater. Photo: Jennifer Nemie/SYVAB (above) and Swedish EPA (below).

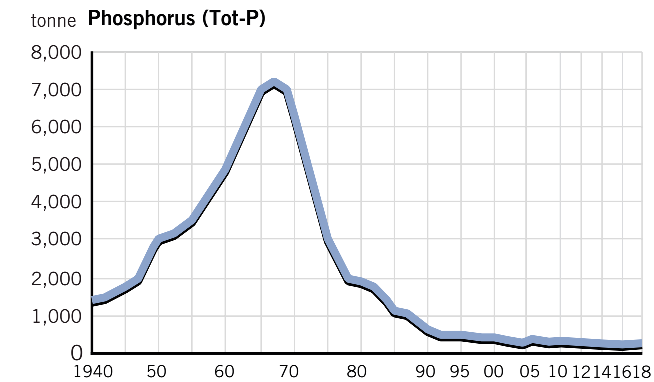
Discharges via municipal wastewater treatment plants

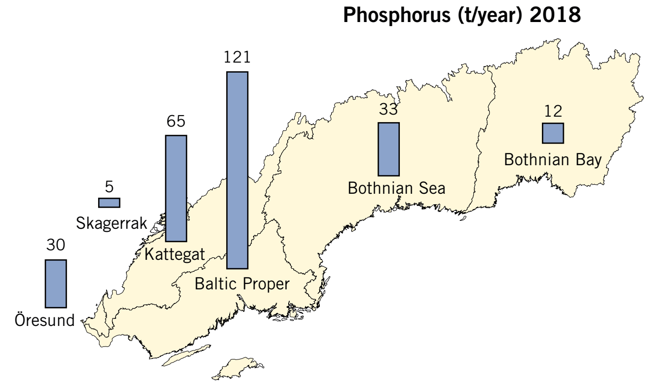
Measured discharges of nutrients via municipal wastewater treatment plants increased dramatically until the 1960s as more urban communities installed wastewater treatment plants. This may seem as a paradox, but it is a result of previously untreated wastewater starting to be fed to wastewater treatment plants instead of being released without any control whatsoever. At this time, the discharges began to be reported. A system of modern wastewater treatment plants was built in the late 1960s and 1970s in order to remove phosphorus and organic matter, which meant a significant decrease in the discharges of these substances. From the mid-1980s new treatment methods have also been added in order to reduce nitrogen levels.

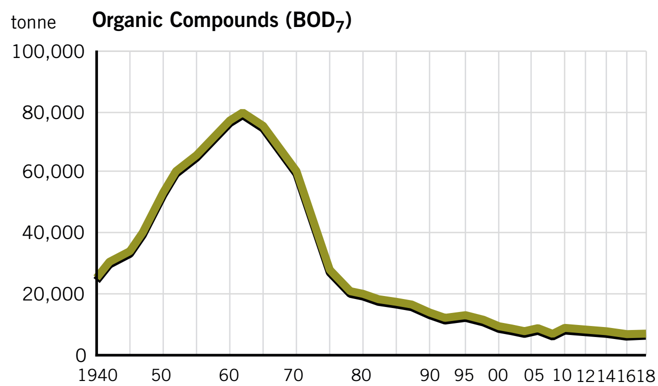
According to the Swedish EPA and Statistics Sweden (2020), the degree of purification of phosphorus and biochemically degradable organic matter (BOD7) has remained at around 96 percent for the last decade, for wastewater treatment plants larger than 2,000 population equivalents. The degree of purification of nitrogen is lower, but it has improved of late for larger wastewater treatment plants that discharge into nitrogen sensitive recipients. The average treatment level for nitrogen among the biggest wastewater treatment plants (over 100,000 population equivalents) amounted to 4 per cent in 2016. Except for phosphorus, for which there has been a slight increase, has the total releases via municipal wastewater treatment plants with at least 2,000 people connected, or a BOD7 load of at least 2,000 population equivalents, decreased in 2018 in comparison with 2016. Despite the fact that the input load in respect of phosphorus and BOD7 has increased. The average treatment levels have decreased for phosphorus, remain unchanged for BOD7 and has increased for nitrogen since 2016. Discharges of nitrogen and phosphorus to inland waters are significantly reduced by means of retention (removal of nutrients and other substances through natural biogeochemical processes) especially in lakes as the water travels towards the sea. This means that only a part of the gross load within a catchment area reach the sea.

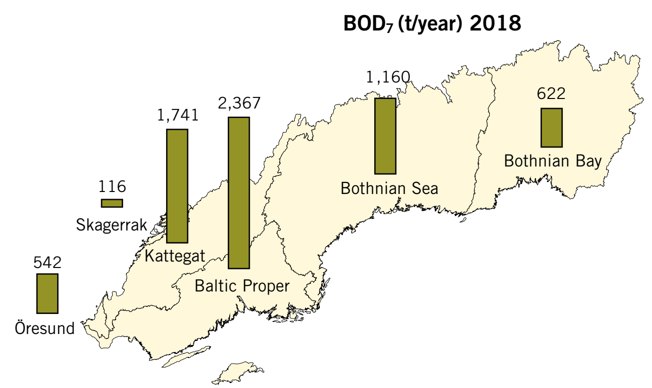












The maps and diagrams show discharge statistics from 2018 for nitrogen, phosphorus and biochemical oxygen-consuming material from wastewater treatment plants to the larger seas. Emissions of nitrogen and phosphorus are greatest for the Baltic Proper. Source: Swedish Environmental Protection Agency and SCB (2020).

Knowledge of small on-site wastewater systems is increasing

Almost a million households in Sweden have no access to municipal wastewater treatment facilities, relying instead on small on-site wastewater treatment systems, either for one or more households. Roughly 700,000 of households with no municipal wastewater treatment facilities have water closets, of which at least 26 per cent merely use some form of sludge separation as a treatment method (SMED, report 6 2018) and therefore fail to meet legal requirements. Furthermore, around a quarter of a million households are not connected to the municipal water or sewage systems, but of these around 90 per cent are holiday cottages that are not used regularly (Statistics Sweden, 2018). An inadequate treatment of wastewater means a risk of transmitting bacterial and viral diseases if a contamination of drinking water and bathing sites occurs. This also contributes to the eutrophication of our waters. The responsibility falls on the property owner when it comes to the function and service of on-site wastewater treatment plants.

The Swedish Agency for Marine and Water Management (SwAM) is the supervisory guidance authority for small-scale wastewater systems up to 200 population equivalents and advises on environmental and public health requirements that municipalities should be implementing. Swedish municipalities are both inspection and licensing authorities for small-scale wastewater facilities.

Many municipalities are still lacking comprehensive information on the number of small wastewater facilities and their treatment functions. However, according to SMED (Report 6 2018), the state of knowledge is improving. Infiltration and drain field systems are the most common treatment techniques. Technical solutions, such as small site assembled wastewater treatment systems and enhanced biological phosphorus reduction, are increasing but still make up just a few per cent of the total number.

Discharges from Sweden's small-scale wastewater systems were estimated to amount to 300 tonnes of phosphorus and 3,000 tonnes of nitrogen in 2017. However, soil retention, which often is significant, was not included in these calculations. On-site wastewater systems with only sludge separation contribute to the emissions of nutrients (SMED, report 6 2018).

Stormwater from urban communities

Historically, the desire to get rid of stormwater, has mainly been due to avoid flooding and water damage in society. Stormwater has been discharged to soil, seas, lakes and rivers, essentially without undergoing any form of treatment. The view on stormwater begun to change in favor of more sustainable stormwater management, as the knowledge of the kind of contaminants that are transported in stormwater increased, along with the anticipation of an increase in flows as a consequence of climate change and an increase of paved areas. Today, there is an ongoing increase in treatment systems for stormwater and combined sewage systems are partly separated, although the process is very slow.

The need for treatment is dependent on how contaminated the stormwater is and what the recipient can withstand. Stormwater from busy roads and urban environments, e.g. industrial areas and trading sites, contains a relatively high level of contamination, that is hazardous to health and the environment, and it needs to be treated to a greater extent than is currently the case (Swedish EPA, 2019).

There is no quality assured national data on how much of the stormwater is treated, delayed of infiltrated. The issue regarding stormwater is complex with several involved stakeholders. There is a variation in both what kind of contaminants the water contains and in the degree of contamination, as well as a variation in quality and quantity over time depending on precipitation, rain intensity and season.

STORMWATER

There is, in Sweden, currently no unambiguous definition of the term "stormwater" – its meaning varies depending on the legislation. One definition that has been used by the Swedish EPA and that can be found in the government bill for the Public Water Services Act is as follows: *Temporary flows of rainwater, meltwater and flushing water, as well as emerging groundwater.*

Common contaminants found in stormwater are particulate matter, nutrients, heavy metals (copper, zinc, lead, chrome, nickel, cadmium), road salt, oil and PAHs (polycyclic aromatic hydrocarbons), as well as indicator bacteria. Microplastics and a range of organic contaminants such as alkylphenols, phthalates, highly fluorinated substances, organic tin compounds, pesticides and PCB may be found in stormwater.

A range of different techniques can be used to treat and delay stormwater. To use rainwater as a resource, to delay water on vegetated roofs, to infiltrate clean stormwater in permeable soil, treat and delay in diches, wells, in wetlands, stormwater ponds and in plant beds are just a few examples. Or treat stormwater with the help of filter techniques if needed.

Stormwater is managed locally within private as well as municipal estates and through onsite treatment systems that are governed by the industries themselves. Stormwater collected from urban areas are normally led through systems governed by the municipalities. Companies that conduct operations, within an economical area for stormwater, are responsible for treating the stormwater, if needed, before it is led via the municipal system to the recipient.

Within the municipal systems for stormwater the responsibility for treatment falls on the municipalities. Stormwater can be treated in different ways. Common methods are sedimentation in roadside diches, in wells with sand traps and in water ponds. Even more advanced filter techniques do occur, and it is common that different techniques are combined. Only a small fraction of all storm water is treated in locally adjusted, well controlled and managed storm water treatment systems. Sufficient dimension, self-monitoring, operation and maintenance are key to the efficiency of the treatment.

A surface water drain is designed to drain stormwater away from impervious surfaces such as streets, parking lots, sidewalks and dikes. Photo: Swedish EPA

Total treatment plants, effluent volumes and concentrations

The tables on the next two pages show statistics from Swedish EPA and Statistics Sweden (2020) and include the number of treatment plants and output volumes (in tonnes) and average concentrations in (mg/l) of phosphorus, nitrogen and organic substances at municipal wastewater treatment plants. The statistics include all wastewater treatment plants requiring permits, i.e. those with at least 2,000 people connected or with a BOD7 load of at least 2,000 population equivalents in 2018. Discharges are presented according to treatment method, the dimension of the treatment plant and the recipient marine basin.

			Concentration mg/l		
	Total treatment plants	Water volume 1000 m³	Nitrogen	Nitrogen	BOD_7
Treatment method					
Biological	4	1,784	0.23	35.6	18.7
Chemical	39	34,338	0.25	27.0	15.8
Bio-Chem (conv.)	247	253,474	0.24	24.3	7.7
Bio-Chem (supple.)	23	20,507	0.19	19.8	7.0
Bio-Chem (Nitrogen)	113	790,341	0.24	9.4	4.9
Size in pe					
2 000–9 999	251	120,222	0.21	20.4	9.0
10 000–99 999	152	386,841	0.22	16.4	6.0
100 000–	23	593,381	0.26	10.4	5.3
Inland	**308**	**448,806**	**0.20**	**16.8**	**6.2**
Coastal	**118**	**651,638**	**0.27**	**11.4**	**5.8**
Bothnian Bay	8	18,140	0.33	32.5	14.1
Bothnian Sea	29	62,380	0.29	29.9	8.5
Baltic Proper	45	320,795	0.27	9.2	4.4
Danish Straits	6	70,935	0.36	10.6	6.6
Kattegat	13	162,215	0.23	6.6	6.1
Skagerrak	17	17,172	0.28	12.0	6.2
Total 2018	**426**	**1,100,444**	**0.24**	**13.6**	**6.0**
Total 2016	416	1,078,652	0.22	14.3	6.1
Total 2014	431	1,217,093	0.21	12.9	6.2
Total 2012	411	1,269,131	0.22	13.5	6.3
Total 2010	467	1,186,767	0.22	14.7	6.7
Total 2008	467	1,258,539	0.25	14.6	5.9
Total 2006	475	1,239,805	0.29	14.8	6.9
Total 2004	479	1,185,223	0.27	15.0	6.6
Total 2002	479	1,228,000	0.29	14.7	6.6
Total 2000	478	1,362,917	0.31	13.9	7.2

	Release (t/year)			Removal efficiency (%)		
	Phosphorus	Nitrogen	BOD_7	Phosphorus	Nitrogen	BOD_7
Treatment method						
Biological	0	63	33	96	18	91
Chemical	9	926	543	95	23	90
Bio-Chem (conv.)	62	6,159	1,949	95	33	95
Bio-Chem (supple.)	4	405	143	96	48	97
Bio-Chem (Nitrogen)	192	7,429	3,879	95	75	98
Size in pe						
2,000–9,999	26	2,454	1,081	95	34	94
10,000–99,999	86	6,342	2,337	95	55	97
100,000–	155	6,187	3,130	95	74	98
Inland	**90**	**7,543**	**2,798**	**96**	**55**	**97**
Coastal	**176**	**7,440**	**3,750**	**94**	**70**	**97**
Bothnian Bay	6	589	257	93	17	92
Bothnian Sea	18	1,868	533	94	19	95
Baltic Proper	85	2,954	1,398	95	77	98
Danish Straits	26	754	467	93	76	97
Kattegat	37	1,069	989	95	79	97
Skagerrak	5	206	107	93	62	96
Total 2018	**266**	**14,982**	**6,548**	**95**	**64**	**97**
Total 2016	237	15,414	6,612	96	62	97
Total 2014	260	15,743	7,549	95	62	96
Total 2012	275	17,120	7,993	95	59	96
Total 2010	267	17,419	7,908	95	59	96
Total 2008	313	18,433	7,447	95	56	96
Total 2006	362	18,347	8,570	95	57	96
Total 2004	318	17,779	7,869	96	57	96
Total 2002	351	18,036	8,158	95	56	96
Total 2000	424	18,977	9,784	95	54	95

Sources of Effluent Discharge

The degree of removal at Swedish wastewater treatment plants nowadays is high for nutrients and is gradually improving. Nevertheless, effluent discharge from households and Urban communities via sewage systems are a significant source of eutrophic substances (such as phosphorus and nitrogen) and organic matter in our waters. Municipal wastewater treatment plants primarily treat wastewater from urban areas, while many permanent and holiday homes outside urban areas often have their own small-scale wastewater systems. Industrial activities are also a significant source of effluent discharge.

SOURCES OF NITROGEN AND PHOSPHORUS THAT REACHES THE COAST

The net load of nitrogen and phosphorus reaching the sea may be either anthropogenic – caused by human activities such as leakage from agriculture and discharges from wastewater treatment plants – or be what is known as background load, i.e. the natural load that would take place independently of humans. SMED (Report 6 2018) present an investigation of the source distribution for the net load of nitrogen and phosphorus. Agriculture was responsible for most of the anthropogenic net load to sea in 2017; 19 470 tonnes of nitrogen and 710 tonnes of phosphorus. After that come municipal wastewater treatment plants with 14,050 tonnes of nitrogen and 234 tonnes of phosphorus, and industrial activities with 3,220 tonnes of nitrogen and 210 tonnes of phosphorus. Small-scale sewers are also a significant source of anthropogenic net load: 2,010 tonnes of nitrogen and 200 tonnes of phosphorus.

Of the total net load – both anthropogenic and background load together – forestry and agriculture are the greatest sources (see figure on the next page). Stormwater also contributes to discharges of nutrients, resulting in 460 tonnes of nitrogen and 140 tonnes of phosphorus in 2017, which is slightly less than wastewater treatment plants, industrial activities and small wastewater systems (SwAM, 2019:20). However, stormwater is a source of many other contaminants, more information about this can be found in the section entitled Stormwater from urban communities.

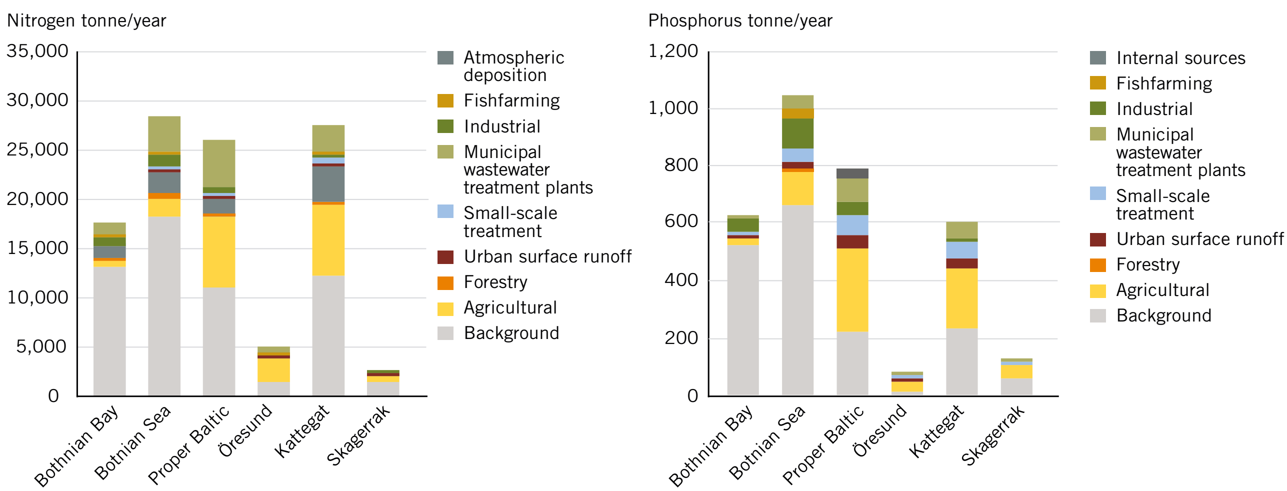
METALS AND OTHER CONTAMINANTS

Many chemicals that are widely used today are also released into the wastewater and can be found in the sludge and the discharge. Most metals, with a few exceptions, that end up in wastewater treatment plants settle in the sludge, therefore metal levels in the discharge are relatively low. The total discharge of metals to water from wastewater treatment plants increased slightly in 2018 compared to 2016. Levels of lead and chrome decreased in 2018 in comparison with 2016. Copper nickel and zinc have all increased since 2016. This information is based on statistics from wastewater treatment plants designed for more than 20,000 population equivalents. These wastewater treatment plants process nearly 80 per cent of Sweden's wastewater (Swedish EPA and Statistics Sweden, 2020).

Wastewater treatment plants also receive other unwanted substances from the use of chemicals and products within households, wastewater from industries and polluted stormwater that leak into the wastewater system. Amongst these substances are organic pollutants such as nonylphenols, brominated flame retardants, polyaromatic hydrocarbons (PAHs), PCBs, hexachlorbenzene (HCB) and dioxins. Some substances are present in our wastewater despite an existing ban on using them in Sweden or the EU. Nonylphenols can for example be found in textiles that are imported from countries outside of the EU. When the cloths are washed the chemicals in the textiles get into the wastewater.

The dominant flow of pharmaceuticals to the environment takes place via medication of humans, as these substances are excreted in the urine or faecal matter and discharged to wastewater treatment plants; and, to a certain extent, to the water recipient as well. More information on the treatment of pharmaceutical residues can be found in the section entitled Advanced treatment. Read more about pharmaceutical residue and other micro pollutants in wastewater under Advanced treatment.

Sources of nutrient load divided into major ocean basins, both background and anthropogenic load, in 2017.
Source: SwAM (2019:20)



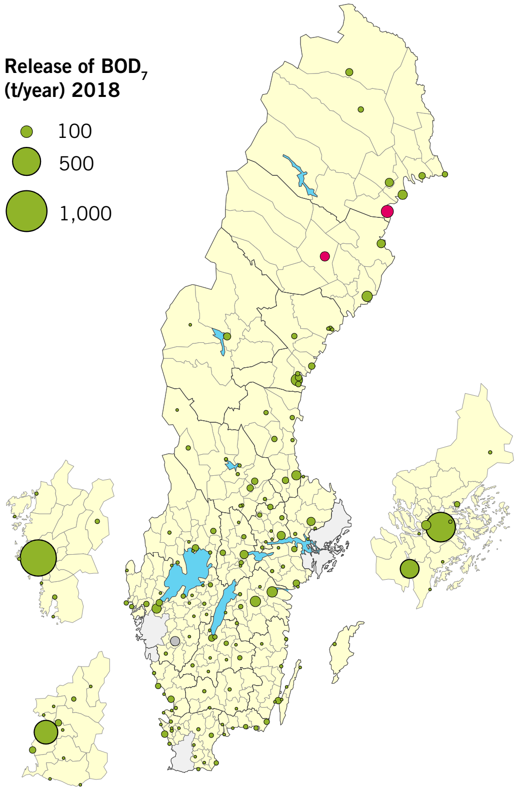
Impact on sensitive areas

The treatment plants have permits that regulate the operation, including requirements for emission levels for some substances. Beyond the requirements in the permits, emission levels are also regulated through the Swedish EPA's regulations on the treatment of wastewater from urban communities (NFS 2016:6). These regulations constitute a key element in the implementation of the Directive on Urban Wastewater Treatment in Sweden. Within the scope of the Directive on Urban Wastewater Treatment, read more about this under Regulatory Frameworks in Sweden and the EU. Sweden has specified areas that are sensitive to emissions of nutrients or at risk of becoming so unless action is taken. All waters in Sweden, including all coastal areas, has been designated as being sensitive to phosphorus discharges. All coastal areas from the Norwegian border up to the municipality of Norrtälje – Skagerrak, Kattegat, Danish straits and Baltic Proper – have been identified as sensitive to the discharge of nitrogen. Emission levels of phosphorus are regulated through permits. Emission levels of nitrogen are at different degrees regulated through permits and the Swedish EPA´s regulations.

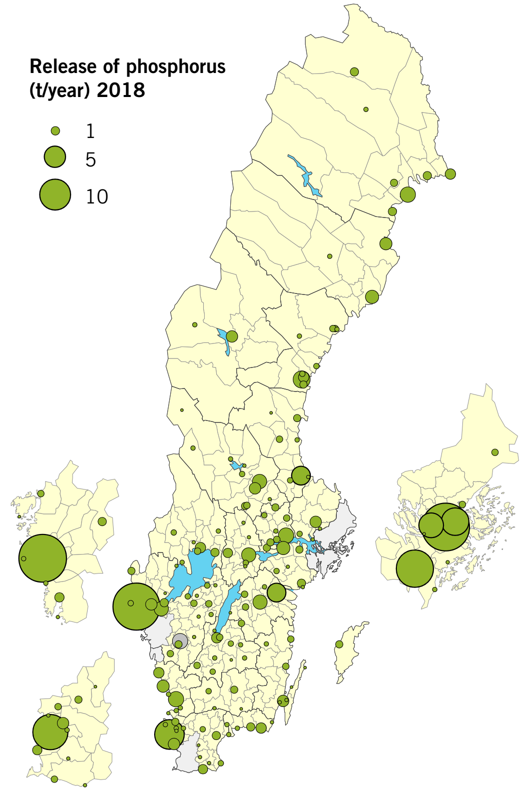
The NFS 2016:6 regulations specify discharge requirements for total nitrogen for agglomerations with 10,000 population equivalents and upwards and that have discharge points in the coastal area from the Norwegian border up to and including the municipality of Norrtälje or in the runoff areas to this coastal area. Compliance with discharge requirements in respect of total nitrogen can be achieved in several ways. Either as a minimum reduction of 70 per cent as an annual mean value, or as a maximum permitted level as an annual mean value (15 mg/l for urban communities between 10,000 and 100,000 population equivalents, or 10 mg/l for urban communities larger than 100,000 population equivalents). If the reduction requirement is applied, natural degradation (retention) before the residual discharge reaches the coast may also be included. However, it is always possible to specify stricter requirements according to the Environmental Code in licensing processes in individual cases, depending on local needs.

- Wastewater treatment plants compliant with Directive requirements treatment in 2018.
- Wastewater treatment plants noncompliant with Directive requirements removal for 2018.
- Release from wastewater treatment plants do not impact marine areas that are sensitive to nitrogen. This applies to the Bothnian Sea or its northern arm, the Bothnian Bay.

Release of BOD_7 (t/year) 2018



Release of phosphorus (t/year) 2018



The maps show discharges of BOD_7, phosphorus and nitrogen from agglomerations with a size of 10,000 population equivalents or more, via municipal wastewater treatment plants (expressed as maximum average weekly load). Source: Swedish EPA and Statistics Sweden (2020).)

Release of nitrogen (t/year) 2018

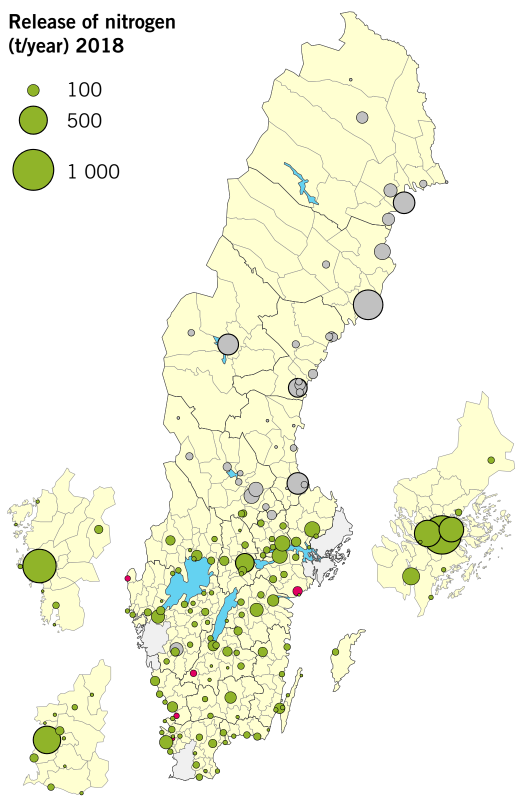


PHOTO: SWEDISH EPA.

Eutrophication – a critical issue

Eutrophication is caused by excess amounts of nitrogen and phosphorus in relation to natural conditions. Phosphorus is often the most important nutrient in freshwater and some coastal areas. Nitrogen is an important nutrient in some coastal areas and maritime areas. The primary reason as to why eutrophication occurs are leaching of phosphorus and nitrogen from forests and farmland, along with discharges from, municipal wastewater treatment plants, industrial activities and small wastewater systems. Stormwater also contributes to the discharge of phosphorus: see the section entitled Effluent discharge sources for more information. Nitrogen can also come from the atmosphere and have an impact on the amount in different waterbodies.

THE MARINE ENVIRONMENT

The environmental situation in the seas surrounding Sweden has received significant attention in recent years. Eutrophication is regarded as perhaps the single largest problem in the Baltic Sea. Eutrophication occurs when there is an excess phosphorus or nitrogen. Consequences as algal bloom depend on which substance is limiting to algal growth. Levels of both nitrogen and phosphorus in marine waters are raised compared to 50-60 years ago, and the issue of anoxic bottoms in the Baltic Sea has not decreased, but rather seems to have increased despite significant measures.

In November of 2007, the environmental ministers of all coastal countries around the Baltic Sea decided within the Helsinki Commission (HELCOM) on a joint action plan for the Baltic Sea including the Danish Straits and Kattegat (the BSAP, Baltic Sea Action Plan). Sweden's action plan for the implementation of the BSAP can be found on the government website.[2] The BSAP was revised by the HELCOM ministerial meeting in 2013. The agreement's objective is to restore a healthy ecological status in the marine environment by 2021. There is an ongoing update of the action plan because the objective within the BSAP will not be obtain by 2021. The update will be finished by 2021. The updated version of the action plan will hold the same ambition level as before, at least. In addition, the updated action plan will also contain new actions. This was stated in the minister declaration that was realised in

2. www.regeringen.se/informationsmaterial/2010/06/m2010.23/

PHOTO: SWEDISH EPA.

2018. The biggest challenge in this regard is to reduce total nutrient loads. The action plan, therefore, includes reduction targets for the signatory countries and the different various marine basins in the Baltic Sea.

As part of the project Pollution Load Compilation 7 (PLC-7), Helcom evaluated each country's nutrient load to each marine basin. The result of the project shows that the Swedish inflow of nitrogen was higher than the under the load ceiling in the Baltic Proper basin and the Finish bay. The inflow of phosphorous to the Baltic Proper exceeds what the load ceiling allows by more than double the amount.

Work on the action plan (BSAP) is linked with the Marine Strategy Framework Directive (2008/56/EG), which was incorporated in Swedish legislation by means of the Marine Environment Ordinance (2010:1341) in 2010. The SwAM is responsible for practical implementation of maritime governance in Sweden. The SwAM formally determined the characteristics of a healthy ecological status in 2012, and a decision was made on an action programme in December 2015. The action programme was implemented by specified authorities and municipalities, and it began in 2016. Work within the management of marine environment run in cycles of six years and a new assessment of the status of the environment was done in 2018. The is an ongoing process of updating the action plan and it will be finished in 2021.

Although the external load of nutrients has decreased overall in the Baltic Sea, a mix of old and new nutrients that were previously bound in sediment – known as internal load – is released every year under anoxic conditions. As part of the effort to remedy eutrophication problems, the SwAM announced funding for awareness-raising initiatives in 2018, focusing on the internal load of phosphorus in lakes and coastal waters and recirculation of nutrients. The funding is a part of an effort from the Swedish government, called "Clean sea" and it has resulted in ten projects that proceed from 2018 to 2020.

The time that the environment needs to recover is long. It will take time before the status of the environment in the seas improve, even if the inflow of nutrients decreases. One reason is that there is an internal load of nutrients that release from the sediment when there is a lack of oxygen. Modelling shows that it will take different amount of time to reach good environmental status for eutrophication in different parts of the Baltic sea if the objective for discharge levels are met, from decades in some basins to centuries in others.

Monitoring of Environmental Status

Discharges from municipal wastewater treatment plants and industrial facilities impact the environment to differing degrees, from local streams to the entire Baltic Sea or North Sea. Establishing where an impact originates requires that every effluent discharge affecting a specific aquatic environment – the recipient – can be calculated. In small lakes or bays, pollution can frequently be linked to specific sources; but in the case of seas and larger recipients, winds, currents and atmospheric precipitation are of major significance to where various substances end up, which makes it more difficult to trace the origin.

MONITORING RECIPIENTS

All operations requiring permits pursuant to the Environmental Code, including wastewater treatment plants, conduct self-monitoring. This normally includes monitoring the function of the plant itself, managing chemicals and waste, water effluents and atmospheric deposition and, in certain cases, measurements in the recipient as well to determine how the activities at the plant in question are affecting the environment. All this information is reported annually in environmental reports. The Swedish EPA's Pollutant Release and Transfer Register shows the discharges produced by larger wastewater treatment plants and other facilities subject to permit.[3]

The monitoring – rivers, lakes or coastal areas – for the impact of discharges from a facility can be conducted by means of participation in what is known as Coordinated Recipient Monitoring. Coordinated Recipient Monitoring is organised primarily on a voluntary basis, for example by means of water conservation associations or in some cases by formation of water conservation associations by county councils in accordance with Swedish law (1976:997). Members of these associations normally include municipalities, industrial facilities and trade organisations. The Society for Water Conservation for lake Vänern is one example of an association performing Coordinated Recipient Monitoring.[4]

ENVIRONMENTAL MONITORING

Environmental monitoring is used to document changes in the environment. The Swedish EPA coordinates national and regional environmental monitoring efforts together with the SwAM and manages the national environmental monitoring programme comprising ten programme fields. The SwAM is responsible for water-related environmental

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3. https://utslappisiffror.naturvardsverket.se/
4. www.vanern.se

PHOTO: SWEDISH EPA.

monitoringexcept for the monitoring of environmental pollutants, which the Swedish EPA is responsible for. County councils are tasked with coordinating regional and local environmental monitoring. On a municipal level, environmental monitoring is conducted in order to meet their own specific needs for environmental information.

Many chemical substances used in modern society are released into the wastewater and enter treatment plants. Of these, discharges of heavy metals are monitored regularly as part of the mandatory screening programmes required in the Swedish EPA's NFS 1990:14 regulations. That said, most organic pollutants are not analysed regularly by wastewater treatment plants due to the difficulty and expense involved. Sludge and water discharge from nine Swedish wastewater treatment plants are analysed each year as part of the environmental monitoring programme known as the Toxic Substances Coordination Programme, focusing on a large number of environmental pollutants.

The Swedish EPA has a specific screening programme that performs occasional sampling surveys and analyses focused on newly identified environmental pollutants. This makes it possible to see the extent to which such substances are present in the environment, what their sources are and whether there is a risk of people being exposed to them. This frequently involves sampling sludge and water discharge from wastewater treatment plants, as these collect pollutants from many different sources. Screening operations at wastewater treatment plants include screening for pharmaceuticals, microplastics, flame retardants and highly fluorinated substances, known as PFAS substances.

BATHING WATERS

Discharge from wastewater and stormwater may also impact bathing water quality. More information on water quality at our bathing sites can be found at the portal: *Quality of Bathing Water in Sweden*.[5]

5. https://www.havochvatten.se/hav/fiske--fritid/badvatten.html

Treatment methods

Part of an Archimedes´ screw pumping water to a higher level at Nykvarn wastewater treatment plant, Tekniska verken AB, Linköping. Photo: Staffan Ågren/Swedish EPA.

Swedish wastewater treatment plants commonly combine mechanical, biological and chemical treatment in various ways. Invariably, wastewater treatment begins some form of mechanical treatment. The most common combinations at wastewater treatment plants, in addition to mechanical treatment, include:

- Biological-chemical treatment (conventional three-stage treatment)
- Biological-chemical treatment with separate denitrification processing
- Biological-chemical treatment with supplemental treatment (for example filtration)

The treatments, mentioned above, are designed to ensure an effective treatment of the substances that can contribute to eutrophication. If combined, the effect will be even greater. These treatment measures contribute to, even though there not specifically designed for it, an effective separation of other unwanted substances that exist in the wastewater in particles, e.g. micro plastics. Techniques for enhanced separation of other unwanted substances, called micro pollutants, are also available. As a result of the Swedish governments grants for funding installations of techniques for treatment of pharmaceutical residue, these techniques will be used more frequently on Swedish waste-water treatment plans in the following years. Read more under *Advanced treatment*.

MECHANICAL TREATMENT

This treatment stage separates larger debris such as stones, sand, grit, pieces of wood, paper, hair, textiles and plastics. This is done using a screen and grit chamber and primary sedimentation.

- Inlet screens separate rags and larger objects that would otherwise clog the pumps or cause concerns later in the treatment process.
- The grit chamber is a basin-like section with a well for collecting sand, gravel and other heavier particles that sink to the bottom.
- Primary sedimentation separates particles that were not intercepted in the screens or grit chamber and that should not be involved in later biological-chemical treatment. Heavier particles sink to the bottom, where scrapers remove them to what is known as a collection well for sludge. The sludge is pumped from here fortreatment.

BIOLOGICAL TREATMENT

Biological treatment uses microorganisms to remove phosphorus, nitrogen and organic matter from the water. The removal occurs by the organisms eating the substances, growing in size and then removed. The most common method is known as an active sludge process where microorganisms live in flocs that are held in suspension – that is to say, they do not dissolve in the water in the basin. The other type of biological treatment involves bacteria that grow on a surface, known as a biofilm.

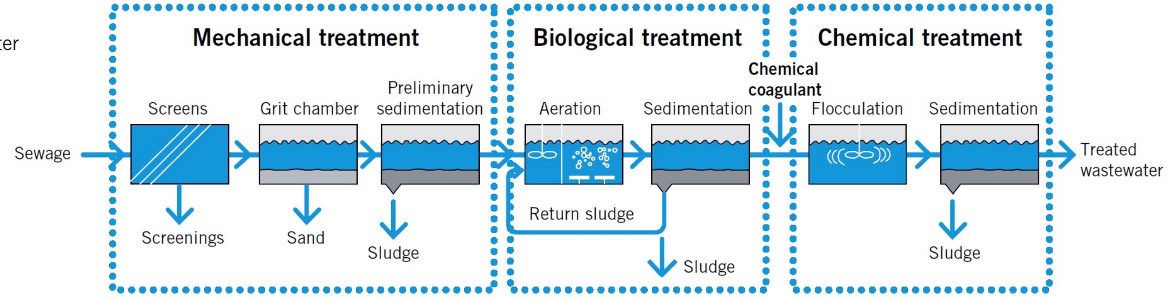
NITROGEN REMOVAL

Nitrogen removal frequently takes place in the biological treatment stages. Nitrogen removal takes place in various zones, where oxic (with oxygen) zones are followed by anoxic (without oxygen) zones in order to create favorable environments for various types of microorganisms. Nitrifying bacteria oxidize ammonia to nitrates in the presence of oxygen. Denitrifying bacteria requiring anoxic conditions can then convert the nitrates into nitrogen gas. The nitrogen removal process normally removes approximately 50 to 75 per cent of the nitrogen in the wastewater. A higher level of separation can be achieved by adding a carbon source that promotes the denitrifying microorganisms. Nitrogen removal is also possible on a partial flow at the wastewater treatment plant; for example, to treat supernatant from sludge treatment.

CHEMICAL TREATMENT

Precipitation chemicals such as aluminum or iron compounds are added during the chemical treatment stage in order to precipitate phosphorus. The precipitate lumps together and settles to the bottom. It can then be separated as sludge which is then pumped to the sludge treatment facility at the treatment plant. Chemical precipitation may take place as pre-precipitation during primary sedimentation, simultaneous precipitation during biological treatment or as post-precipitation. Some 95 per cent of the phosphorus is removed.

Treatment steps in a conventional wastewater treatment plant.
Source: Swedish EPA



FILTRATION

Filtration is a final stage in the treatment, with the purpose to increase treatment levels at wastewater treatment plants with particularly strict requirements. Thru filtration – which frequently involves filtration of wastewater in sand filters – an additional separation of particles can be obtained.

SLUDGE TREATMENT

The sludge created at the treatment plant is separated and undergoes subsequent treatment. This treatment aims to stabilize the sludge prior to dewatering. The most common stabilization method used in Sweden involves anaerobic digestions, where microorganisms degrade the organic material and form biogas. The sludge is then dewatered to reduce the amount of sludge that needs to be transported from the treatment plant. The supernatant separated during sludge dewatering is returned to the wastewater treatment plant.

Advanced Treatment

The dominating flow of pharmaceuticals into the environment occur through medication of humans, because residues are excreted through urine and faecal matter and are led via the wastewater treatment plants out into the recipient. Other substances that we can use in our everyday life, or in industries, can also end up in our wastewater. There is a risk that some of these substances, even in small amounts, can have a negative effect on the environment. These substances are together with pharmaceutical residue called micropollutants.

Wastewater treatment plants are usually not made to treat micropollutants. As a result, these pollutants pass through the treatment plant, basically unaffected, into nearby water bodies. This motivates an evolvement of more advanced treatment techniques.

An exception is microplastics[6]. The treatment level of microplastics are high because wastewater treatment plants have an effective separation of particles. 95-100 percent of microplastics, bigger than 300 µm, are separated from the wastewater (Baresel m.fl, 2017).

There are several techniques that can be used as a complement to existing treatment measures. The development of new promising techniques is on the rise. For example, techniques that are seen as being able to give a broad separation and work in full-scale are ozonation and filtration. Either activated carbon or membrane can be used for filtration (Swedish EPA, 2017a). The need to use advanced treatment techniques differ between treatment plants, depending on what kind of micropollutants that have to be treated and the sensitivity of the recipient.

The Swedish EPA distribute investment funds for installation of techniques, for treatment of pharmaceutical residue and other micropollutants, in Swedish wastewater treatment plants as an assignment from the government. The funds have been granted since 2018 and seeks to increase the conversion rate and at the same time stimulate the enhance the knowledge and experience. Municipalities can apply for up to 90 percent of the investment both in pilot study and full-scale installation. In 2018 the Swedish EPA granted 85 million Swedish crowns in total in funds. 10 pilot studies and 6 investment projects were granted funds.[7] The investment funds will be granted until 2023 or until the money runs out.

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6. ”Microplastics” includes small plastic fragments, up to 5 millimeters, that are formed, amongst other ways, when plastic subjects are warn and plastic particles are released.
7. www.naturvardsverket.se

Nykvarnsverket in Linköping was the first wastewater treatment plant in Sweden to install advanced treatment, in full scale, for removal of pharmaceuticals. The facility has been in place since September 2017. Photo: Tekniska verken

The problem with societies emissions of micropollutants to water bodies will not be solved solely by installing techniques for advanced treatment of wastewater. There is also a need for work upstream. This entails an effort to stop the spread of micropollutants already at the source by for example decrease the use of and replace hazardous chemicals. To be able to identify and replace substances, in an early phase, that are associated with the highest risks is an important component in the work upstream. This work also includes changing consummation habits and behaviours. Directed information campaigns to the public have, as an example, been a way to enhance the publics knowledge of what the households flush down in the toilet and pour into the sink.

There are several initiatives in Sweden that seek to decrease the presence and emissions of micropollutants. Examples on initiatives are "Centre of knowledge of pharmaceuticals in the environment" lead by The Swedish Medical Products Agency, "The national collaboration function against resistance to antibiotics" lead by the Public Health Agency of Sweden and the Swedish board of Agriculture together with other authorities and "Client group for advanced treatment" lead by The Swedish Water and Wastewater Association with financing from The Swedish EPA. Projects that has been granted funds can be followed on client groups website[8].

8. www.svensktvatten.se

Wastewater sludge at the Ryaverket wastewater treatment plant. Ryaverket is certified under the Swedish Revaq system, which means the sludge is quality assured. Photo: Emelie Asplund.

Sludge from wastewater treatment plants

Our wastewater treatment plants are built to reduce nutrients such as phosphorus and nitrogen from the water phase and bind them in the sludge. In other words, sludge is a biproduct from the treatment plants treatment of wastewater. The sludge is used in different ways. The most common areas of use are production of plant soil, land fill cover and as fertilizer on fields. The use of sludge as fertilizer on fields is a necessity to achieve a sustainable food production. In addition to sludge from wastewater treatment plants nutrients are also added to fields in Sweden through mineral fertilizer, soil improvement and feed to animals (Swedish EPA, 2013). The amount of sludge that is used as fertilizer has basically been the same for a decade, but during the last years it has increased. During 2018, 39 % of the sludge produced in wastewater treatment plants were used as fertilizer on fields. (Swedish EPA and Statistics Sweden, 2020)

In addition to nutrients, sludge can also contain unwanted substances such as metals and organic substances in varying amounts and pathogens. Many of the metals and organic toxins that exists in society end up in the wastewater and are found in the sludge and in the effluent discharge. Some of these unwanted substances, as an example, comes from our food and other products that we import. In order to use sludge as fertilizer on fields there are requirements for the amount of unwanted substances, such as heavy metals, both the soil and the sludge can contain. There are also requirements on how much heavy metals that can be added to fields during a certain amount of time. For a long time, Sweden has worked to improve the quality of the sludge as well as the treatment of the wastewater.

The quality of the sludge has increased, significantly, during the last decades. This has been achieved through, amongst other things, preventive action, which means working upstream to reduce the amount of unwanted substances that reach the wastewater in the first place. An example of this is a quality control system, within the wastewater industry, called REVAQ-certification. By getting a REVAQ-certification the treatment plants commit to systematically work to reduce the amount of unwanted substances before they end up in the wastewater treatment plant, through investigating the origin and make demands on companies, there use of chemicals and emissions of unwanted substances. Diffuse sources that discharge to sewers – for example, from households – are more difficult to reduce. Around half of Sweden's wastewater is currently treated at REVAQ-accredited wastewater treatment plants.

Regulatory frameworks in Sweden and the EU

The EU has enforced several acts on the environment. Since Sweden's accession to the EU in 1995, Sweden has gradually incorporated EU directives into national legislation, either by law, ordinance or government regulations. Several of the EU acts on the environment are enforced on an overall level in the Environmental Code, which is the main Swedish environmental legislation. The most significant EU directives in respect of wastewater discharges requirements are the Directive concerning urban wastewater treatment (91/271/EEC) and the Framework Directive on water (2000/60/EG). Other EU directives with varying degrees of importance to wastewater discharge requirements are the Marine Strategy Framework Directive (2008/56/EC), the Directive on bathing water quality and repealing (76/160/EEC), the Directive on quality of water intended for human consumption (98/83/EC), the Directive on the protection of groundwater against pollution and deterioration (2006/118/EC) the Nitrates Directive (91/676/EEC), the Directive on environmental quality standards in the field of water policy (2008/105/EG) and the Directive on industrial emissions (2010/75/EU).

THE URBAN WASTEWATER TREATMENT DIRECTIVE

The Urban Wastewater Treatment Directive aims to protect the environment from adverse effects from urban wastewater discharges and wastewater discharges from certain industrial processes. This includes the following requirements:

- All agglomerations with more than 2,000 population equivalents must have a collecting system for urban wastewater. The requirements were introduced step by step for different sizes of agglomerations and entered into force at the latest by the end of 2005.
- All wastewater entering the collecting system must before discharge be subject to at least secondary treatment. This means that the discharge must comply with requirements for discharge of organic matter, or other oxygen-consuming substances, that are supervised through the parameters BOD and COD. To achieve this, treatment plants usually use a biological treatment method. There are other alternatives and they can be used as long as the requirements for emission levels are met. I coastal areas there can occur some exceptions from this ground rule.
- When wastewater is discharged to areas identified as sensitive by the member state, the directive sets particularly strict requirements.

• The most common type of sensitive areas are those sensitive to nutrient release – phosphorus or nitrogen or both.

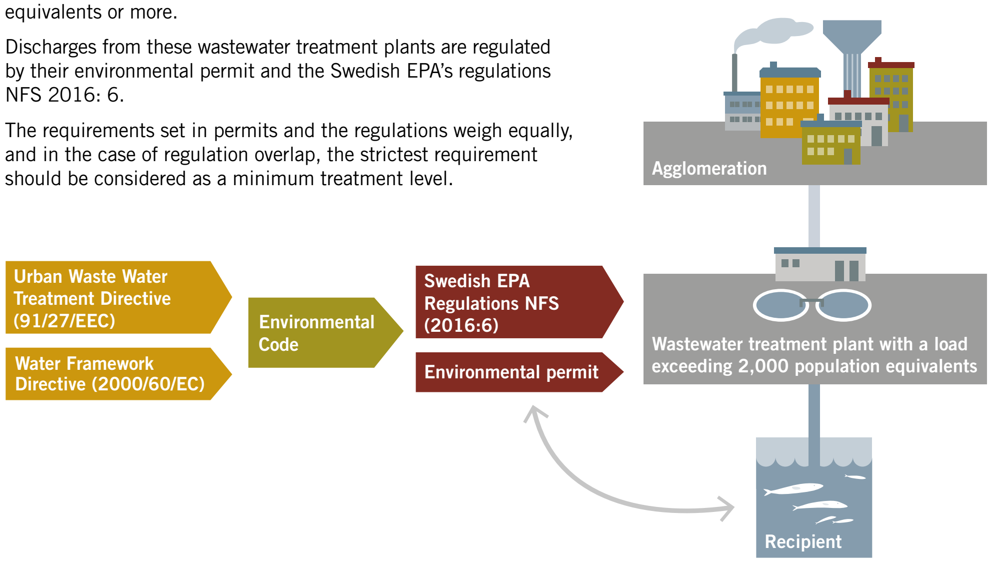
• When wastewater is discharged to an area identified as sensitive to phosphorus or nitrogen, or in a drainage area to such a sensitive area, the directive sets specific requirements to these substances.

Sweden has incorporated the Urban Wastewater Directive mainly in Swedish legislation within the framework of the Environmental Code and its ordinances and regulations. The concrete requirements set, on wastewater treatment, in the directive are mainly incorporated in Swedish legislation by the Swedish EPA's regulations (NFS 2016: 6) on the treatment and control of wastewater discharge from urban areas. The Environmental Assessment Ordinance (2013:251) defines which wastewater treatment plants are subject to licensing. All wastewater treatment plants covered by the Urban Wastewater Directive's requirements are subject to licensing.

The figure gives a simplified description of how the Environmental Code and EU directives, incorporated into Swedish legislation, place require-ments on wastewater treatment plants, collecting wastewater from an agglomeration with a size of 2,000 population equivalents or more.

Discharges from these wastewater treatment plants are regulated by their environmental permit and the Swedish EPA's regulations NFS 2016: 6.

The requirements set in permits and the regulations weigh equally, and in the case of regulation overlap, the strictest requirement should be considered as a minimum treatment level.



The Swedish EPA's regulations contain, inter alia, specific requirements for nitrogen and biochemically degradable organic matter (BOD_7) in discharging wastewater, as well as rules for inspection and sampling. The regulations contain no requirements for phosphorus, as discharge requirements for phosphorus are determined in wastewater treatment plant's permit, which, as per practice, are significantly stricter than the Urban Wastewater Directive's requirements.

WATER FRAMEWORK DIRECTIVE

According to the Framework Directive for water, which was passed in 2000, all surface and groundwater bodies in the EU should have achieved "good status" by 2015, as long as no exceptions have been granted. A long with this, the directive also requires that now decrease are allowed on the existing status. Maps and information on status and environmental quality standards (including exceptions) for all water bodies in Sweden can be found on the *Water Information System in Sweden* (VISS) database.[9]

The Framework Directive on water has been incorporated in Swedish legislation primarily by provisions of the Environmental Code and the Ordinance for Water Management (2004:660). The SwAM and the Swedish Geological Survey have issued regulations including detailed provisions on how Sweden's five water authorities should assess the status of surface and groundwater bodies and determine which environmental quality standards will apply to each water body. Current water status and the environmental quality standards are important instruments in the licensing process and should be, inter alia, decisive in the assessment of discharge requirements, decided in wastewater treatment plants' permit.Some wastewater treatment plants can get higher requirements within the licensing process depending on the what state of the water environment is required within the water directive. These increased requirements can include parameters that already are treated in the treatment plant, but eventually it can also include other parameters that is not covered within the normal requirements for emission levels. Read more under Advanced Treatment.

DEDICATED INDUSTRIAL TREATMENT FACILITIES

Discharges from industrial operations with dedicated wastewater treatment facilities are regulated in the terms of their operating permits issued under the Environmental Code. Within the EU, the Industrial Emissions Directive (2010/75/EU), also known as the IED, provide for a comprehensive licensing process that considers the impact of atmospheric emissions and water discharges from specified major industrial activities,

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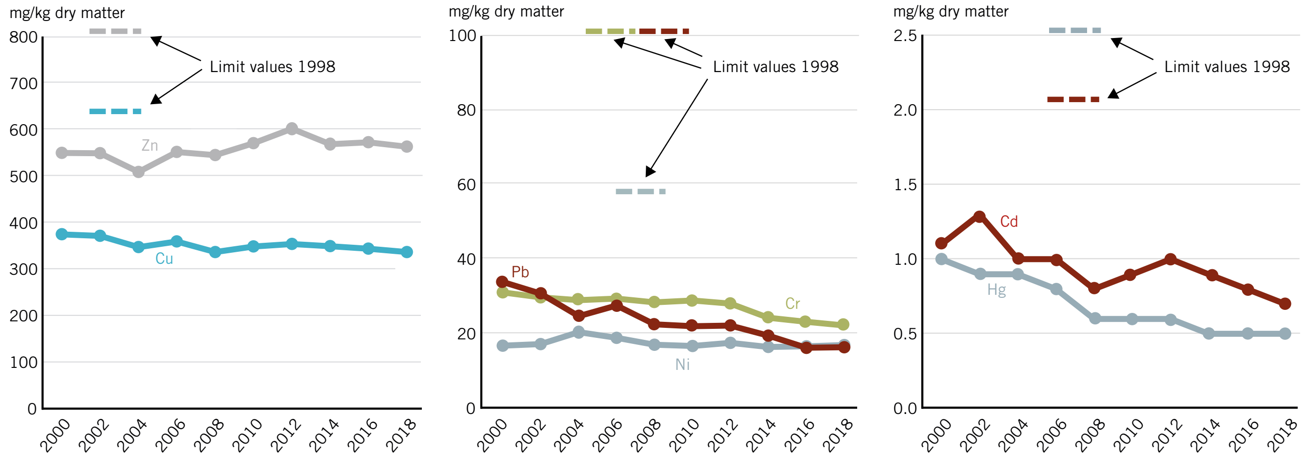
9. www.viss.lansstyrelsen.se



The diagrams show heavy metals in sludge from municipal wastewater treatment plants 1987–2016. Median values for Wastewater treatment plants designed for 20,000 to 100,000 population equivalents. (Zn=Zinc, Cu=Copper, Pb=Lead, Cr=Chromium, Ni=Nickel, Hg=Mercury, Cd=Cadmium) Source: Swedish EPA and SCB (2018).

waste management and agriculture. The IED is incorporated in Swedish legislation by means of the Industrial Emissions Ordinance (2013:250), which requires industries to comply with specific “BAT conclusions” (Best Available Technology). BAT conclusions apply not only to the technology used, but also to how the facility is designed, constructed, maintained and phased out.

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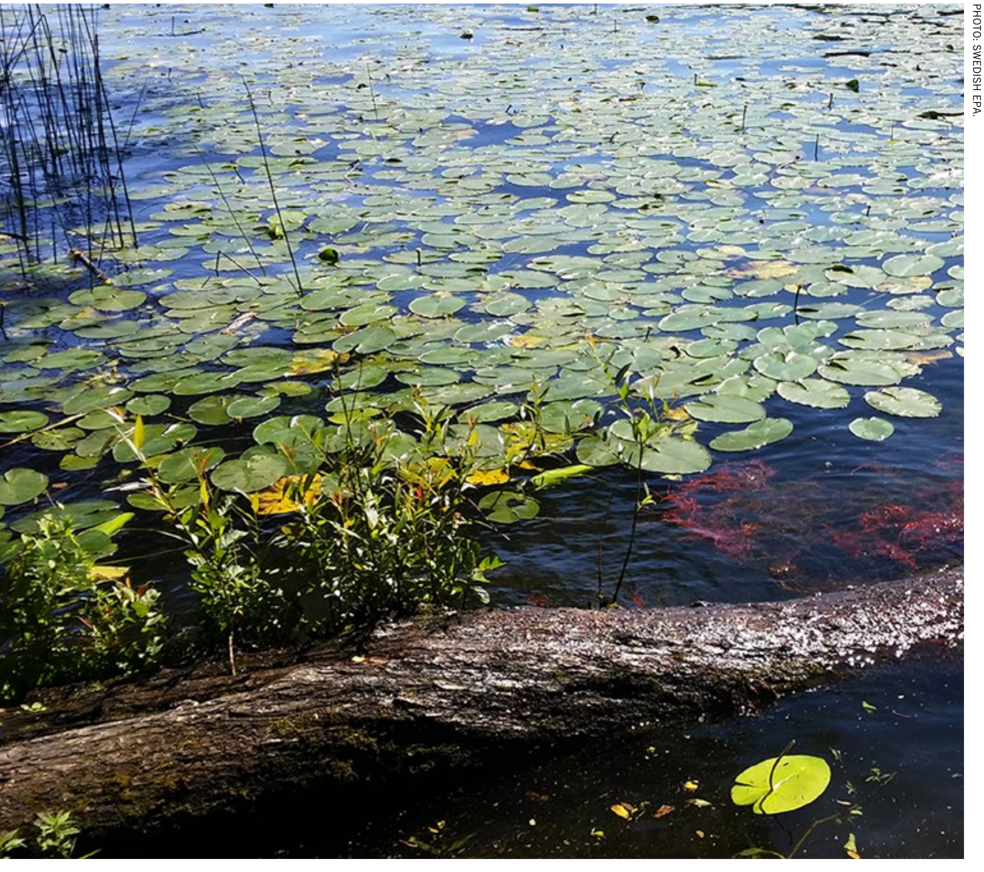

PHOTO: SWEDISH EPA.

Development over the last 200 years has taken Swedish society from dugout latrines, to underground sewers flowing into lakes or coastal waters, to advanced wastewater treatment plants. Wastewater issues have changed from resolving local sanitary problems to a global environmental issue.

This paper 'Wastewater Treatment in Sweden' is published by the Swedish Environmental Protection Agency (Swedish EPA) to provide an historical overview of development of urban wastewater treatment from 1900s to the present. The paper is published biannually and includes the most recent statistical data from 2016 for releases and sludge from wastewater treatment plants.

This information is published in accordance with Article 16 of the Urban Wastewater Treatment Directive (91/271/EEC). The Directive applies to all wastewater collected in sewage systems, but specific requirements apply only to treatment plants serving more than 2,000 persons. For Sweden, this corresponds to over 400 wastewater treatment plants.

NATUR VÅRDS VERKET

SWEDISH ENVIRONMENTAL PROTECTION AGENCY

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