Urban Waste Water Treatment

Urban waste water treatment for 21st century challenges

It is easy to take water for granted. Clean water comes out of a tap, we use the water and then 'dirty' water disappears down the drain. In this way, the water that leaves our homes, schools and workplaces is contaminated. For most European citizens, such waste water is collected, transported and then treated at an urban waste water treatment plant, to remove components harmful to the environment and human health, before the water is returned to nature (EEA, 2018). The importance of access to clean water and sanitation is embedded in Goal 6 of the United Nations' Sustainable Development Goals (UN, n.d). Supplying clean water and collecting waste water has required huge investment across Europe in recent decades. In this briefing, we show that challenges to securing sustainable water in future, such as climate change, present new opportunities for resource efficiency and improved environmental protection.

Key messages

- Collection and treatment of urban waste water is essential to protect human health and the environment.
- Across Europe, urban waste water treatment plants address widely varying conditions, such as the different substances in sewage, the size of the population being served, the requirements of the receiving waters and the local climate.
- Much has been done to provide collection and treatment of urban waste water, but new pressures such as adapting to climate change, providing facilities in urban and rural areas, and tackling newly identified pollutants all require substantial investment in addition to maintaining existing infrastructure.
- Energy costs and scarce resources should be reasons to promote water efficiency. They also provide opportunities for urban waste water treatment to contribute more to the circular economy, for example, through energy generation, water reuse and materials recycling.

Urban waste water treatment

For most European citizens, sewage from our toilets, sinks and washing machines goes down pipes to be treated, reducing disease-causing organisms and the nutrient load that would otherwise cause pollution and the proliferation of algae.

Waste water from households and industry creates significant pressure on the aquatic environment because of the loads of organic matter and nutrients it contains. If released into waterways, ammonia and natural processes break down organic matter in the water but can use up the oxygen, making the river uninhabitable for fish and invertebrates. Meanwhile, excess nutrients, such as nitrogen and phosphorus, can cause plants and algae to grow excessively, cutting out light and using up the oxygen in the water through respiration or when the plants decay (Picture 1). The widespread introduction of effective waste water treatment during the 20th century has greatly improved human health and environmental quality.

Picture 1 – Excess nutrients cause plants and algae to grow excessively

Image © Caroline Whalley

The proportion of households connected to waste water treatment facilities varies across Europe. In western-central Europe, for example, the connection rate is 97 %. In southern, south-eastern and eastern European countries, it is generally lower, although it has increased over the last 10 years to reach about 70 % (EEA, 2017a). Despite these significant improvements in recent years, around 30 million people are still not connected to waste water treatment plants in Europe. In areas where people live far apart, it may be more practical to use individual treatment methods like septic tanks to deal with sewage.

How does urban waste water treatment work?

Sewers need to be built to collect sewage and transport it to a waste water treatment plant. There, differing levels of treatment can be applied and usually include:

- Pre-treatment, which physically removes large objects like rags and plastics, and smaller objects like grit from the waste water. This prevents damage to the equipment further along the treatment process.
- Primary treatment, which removes fine particles. Waste water is held in a tank where heavier solids can settle to the bottom, while any lighter solids and fat float to the surface. The settled and floating materials are separated, while the remaining liquid proceeds to secondary treatment or is discharged to the environment.
- Secondary treatment, also known as biological treatment, removes the remaining organic matter, suspended solids and some of the bacteria, viruses and parasites, and to some extent nutrients and chemical substances.
- More stringent treatment is applied to remove the remaining nutrients when discharging into sensitive waters. Specific treatment techniques, such as disinfection, can be used to further remove bacteria, viruses and parasites harmful to public health, or any remaining chemicals and harmful substances.

More information about treatment types in specific urban waste water treatment plants is available: EEA urban waste water treatment maps

Sludge management

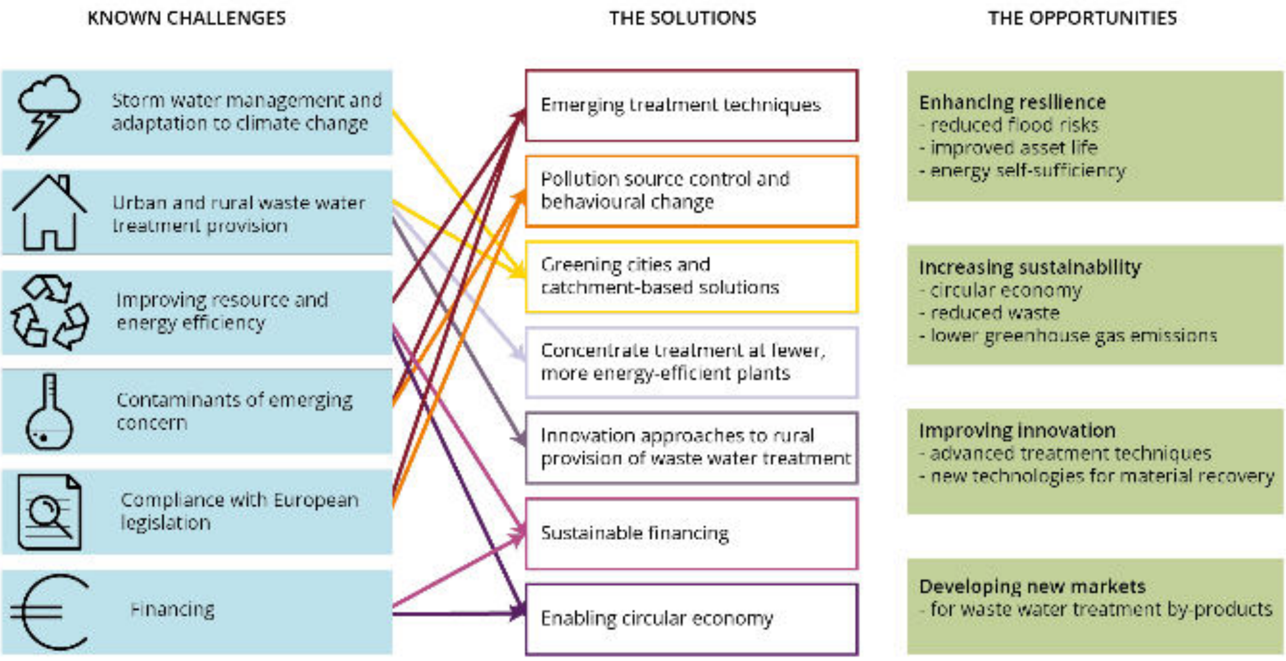
Sewage sludge, formed by bacteria as a result of the consumption of organic pollution, arises as a by-product of waste water treatment. A range of treatments allow the safe disposal of the sludge. Liming and aerobic or anaerobic digestion stabilise the sludge, avoiding odour and reducing pathogenic organisms. Anaerobic digestion reduces the amount of sludge and produces biogas, while dewatering removes excess water, decreasing the weight and reducing transportation costs.

Different disposal routes exist, depending mostly on national regulatory frameworks and sludge quality. Approximately half the sewage sludge produced by EU Member States is spread on land as fertiliser and a quarter is incinerated (Eureau, 2017). Sludge can contain high concentrations of metals, pathogens and persistent trace organic pollutants, so its use on land may be restricted to protect the environment.

Challenges for the 21st century

Past decades have seen billions of euros invested across Europe in the collection and treatment of urban waste water to remove harmful microorganisms, oxygen-consuming substances and nutrients (EC, 2017). This investment means that most Europeans no longer need to worry about the quality of their drinking water or local waterways (EEA, 2016, 2017b). However, our understanding of the challenges faced by urban waste water treatment has improved, for instance, in our knowledge of climate change and of the presence of hazardous substances. As we address these, we can use the opportunity to implement more sustainable solutions (Fig 1).

Figure 1 – Challenges, solutions and opportunities for urban waste water treatment plants



Source: EEA

Storm water management and adaptation to climate change

In some areas, climate change means heavy rainfall will be more frequent. In urban areas — where rainwater drains into the sewers carrying domestic sewage and industrial waste water (so-called 'combined sewers') — the rain enters the combined sewer network faster than it was designed for. This can cause overloading of the sewer network, leading to surface water flooding and overflow at urban waste water treatment plants, with untreated sewage flowing into rivers, lakes or coastal areas. Sustainable urban drainage systems can provide a solution, as they are designed to manage runoff in a sustainable way.

In other areas, climate change will lead to reduced rainfall. As a first step, improving water efficiency to reduce unnecessary use can conserve both water and the energy used in its transport and treatment. However, waste water treatment itself can play an important role in increasing the water availability. High level treatment can remove pollutants, so that the treated water can be reused. The EU is, in 2019, preparing a regulation on the reuse of urban waste water for agricultural irrigation.

The challenge	Solutions implemented by countries
Storm water management: adapting to climate change 	Waste water treatment plants in Malmö, Sweden, discharge to coastal areas. An open storm water system designed to accommodate a 15-year rainfall event includes 6 km of canals and water channels, 10 retention ponds, 30 green roofs and a botanical roof garden on an old, industrial roof. Rainfall is collected in natural ditches and reservoirs before being directed into a conventional sewer system. The system is integrated within green spaces that can be temporarily flooded to help manage water by slowing its entry into the conventional storm water system. This system avoids energy use by diverting storm water away from collection systems and waste water treatment.
Seasonal increases in population and water scarcity 	In Malta, the Ta'Bakrat urban waste water treatment plant serves 434 000 population equivalent (p.e.), treating approximately 80 % of all waste water in Malta. It is subject to particular pressures during the tourist season. Investment in treatment technology helps address the issue of water scarcity, as the installation aims to provide 7 billion litres of reclaimed water for agricultural irrigation and aquifer recharge each year. New treatment construction costs EUR 20 million, with a further EUR 20 million invested in irrigation infrastructure.

Urban and rural waste water treatment provision

In urban areas it can be a challenge to find space to install new treatment plants or upgrade existing ones. There can be public opposition to development near residential areas, owing to noise and odour concerns.

In rural areas, population densities, the nature of the ground and surface water characteristics are key to deciding the type of collection and treatment system needed. Individual treatment systems, like septic tanks, are often used, since investment in sewers and treatment is generally costly and may impact heavily on a few users. The treatment plant needs to be able to operate with low volumes of water. Moreover, it can be difficult to find suitably qualified personnel to operate the treatment plant.

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The challenge	Solutions implemented by countries
Small, rural area with seasonal increase in population	The Rowy treatment plant in Poland deals with urban waste water from 5 000 p.e in winter and three times as much in the summer. It discharges directly into the Łupawy river. With increasing numbers of tourists, the plant was upgraded to increase capacity and introduce more efficient technologies. It was rebuilt to operate in two modes: part operation in 'winter' mode when there is less waste water to process; and full operation in 'summer' mode to deal with higher quantities of waste water. The upgrade cost approximately €7.5 million, with energy savings recorded in the winter.

Improving resource and energy efficiency

In recent years, efforts have been put in place to reduce the energy consumption of infrastructure. Many urban waste water treatment plants have invested in technologies to better control processes and use less electricity, with non-CO2 greenhouse gas emissions decreasing by 20% between 2005 and 2017 (EEA, 2019a). The capture of biogas resulting from the processes and the implementation of anaerobic digestion can be used to support the plants' energy needs. Energy efficiency measures include the recovery of heat from waste water processes and the use of space to accommodate wind turbines and solar panels, providing renewable energy.

The challenge	Solutions implemented by countries
Improving resource and energy efficiency	In the Netherlands, the Amersfoort urban waste water treatment plant (315 000 p.e.), receives domestic and light industrial effluent. The treatment process comprises physical treatment, and carbon, nitrogen and phosphorus removal. The final effluent is discharged to the River Eem. In 2016, Amersfoort was converted into a regional sludge processing hub for several waste water treatment plants in the area, supported by the EU LIFE programme (with EUR 10.5 million). It uses innovative technologies to recover phosphorus and nitrogen from sludge for commercial nutrient use, producing a fertiliser as well as biogas. It is 100 % energy self-sufficient and exports energy to power 600 city dwellings.

Discharge into sensitive areas — compliance with European legislation

In some cases, where the receiving water is particularly sensitive, treated effluent must meet a very high standard. This is done, for instance to avoid nutrients that cause excessive algal growth when discharged into Nutrient Sensitive Areas under the Water Framework Directive; to kill pathogens if discharge is near bathing waters; upstream of drinking water abstraction; or in watercourses with European or international protection.

The challenge	Solutions implemented by countries
Discharge into sensitive area and provision for broader infrastructure	The Arad urban waste water treatment plant in Romania has a treatment capacity of 225 000 p.e. It discharges effluent into a highly sensitive stretch of the Mures River, designated a Special Protection Area for birds and a Nutrient Sensitive Area. Upgrades to seven treatment plants — co-financed by the EU Cohesion Fund — rehabilitated the plants, as well as reservoirs, water transmission pipes and the sewerage network. The waste water treatment plant upgrade cost EUR 18 million. This resulted in a significant reduction in the organic and nutrient pollution load entering the River Mures.
Protection of drinking water aquifer	The Wulpen urban waste water treatment plant in Belgium has a capacity of 74 700 p.e. The aquifer of St-André needed to be protected from saline intrusion as a result of over-abstraction. The upgraded plant includes more stringent treatments to remove phosphorus and disinfect the effluent. The treated water is of superior quality — similar to that of drinking water — is free of micropollutants and pathogens, and is used to recharge the aquifer. The project cost EUR 6 million and was financed by the EU's 7th Framework Programme.

Issues of emerging concern

In recent years, concern has increased regarding the presence of many chemicals at low concentrations within the water environment. With so many different substances in use, many chemicals reach surface waters via urban waste water treatment plants applying traditional treatment methods. Research has shown that many of the chemicals in waste waters now arise from use in our homes and leaching from products, or are directly added in the case of cleaning products and excreted pharmaceuticals (UKWIR, 2018). Concern is growing over the presence of mixtures of chemicals in the environment — the so-called 'cocktail effect' — that may be impacting aquatic life (EEA, 2019b).

An example of a possible new concern is antimicrobial resistance (AMR), which arises from the use of antimicrobials, such as antibiotics, in human and veterinary medicine. Use and excretion of antimicrobial agents has resulted in the evolution of resistant bacteria, viruses and microbes, which can cause disease and are now resisting medicinal treatment. As a consequence, it has become increasingly difficult to tackle certain infections (WHO, 2018). Urban waste water treatment plants could be transferring AMR genes to the environment, but currently there is very limited information on the pathways for AMR in the environment to reach humans and the significance of this (EEA, 2019c).

Continued vigilance will be needed to tackle new issues for waste water treatment as they are identified.

European legislation

In the EU, the main objective of the Urban Waste Water Treatment Directive (91/271/EEC) and equivalent national legislation for non-EU countries, is to protect the environment from the adverse effects of waste water discharges. This is achieved through the collection and treatment of waste water in settlements and areas of economic activity with a p.e. of more than 2 000. In most cases, the Directive sets out that waste water must be subject to secondary treatment but in catchments with particularly sensitive waters, more stringent waste water treatment may be required. Currently the European Commission is evaluating the Directive to see if works well and is adequate for current and newer issues.

The Water Framework Directive (2000/60/EC) established a framework for the protection of rivers, lakes, transitional waters (estuaries), coastal waters and ground water. It aims to ensure that all surface water bodies are at good chemical and ecological status, displaying minimal signs of impact from human development. Meeting the requirements of the Urban Waste Water Treatment Directive is the baseline for water pollution coming from urban areas.

Key

Symbol	Brief explanation
	Storm water management — adapting to climate change
	Resource and energy efficiency
	Operating in areas with seasonally high population
	Operating in water scarce regions
	Compliance with European legislation — discharging into sensitive waters
	Urban and rural waste treatment provision

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electricity, with non-CO_2 greenhouse gas emissions decreasing by 20% between 2005 and 2017 (EEA, 2019a).

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