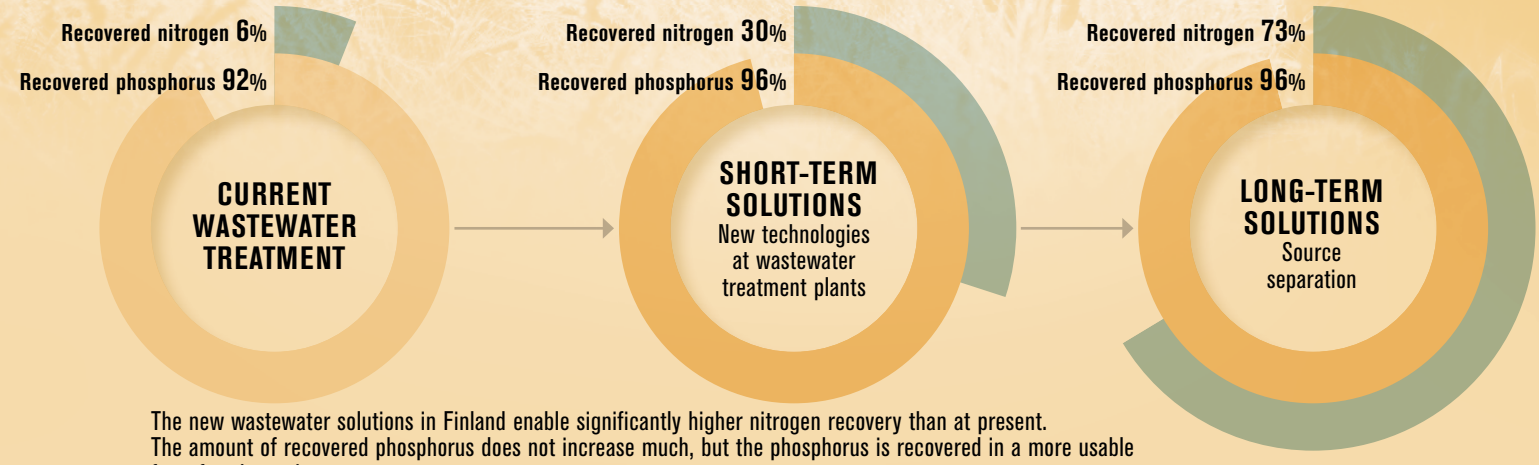
Enhanced utilization of wastewater nutrients

Water management solutions need to be improved. New technologies in wastewater and sewage sludge treatment would enable more efficient nutrient recovery, allowing them to be utilised in food production and industry due to their greater degree of purity. This would also reduce negative environmental impacts. The recovery of nutrients would increase security of supply in an uncertain world situation, where the availability of nutrients can become even more difficult.



The new wastewater solutions in Finland enable significantly higher nitrogen recovery than at present. The amount of recovered phosphorus does not increase much, but the phosphorus is recovered in a more usable form for plants than at present. LEHTORANTA ET AL. 2022[8], SYKE 2022[9]

Recommendations for cities and municipalities

- New technologies should be introduced in wastewater treatment plants and in sewage sludge processing, especially for nitrogen recovery. Nitrogen is a critical nutrient in food production and in industrial processes.
- In new residential areas, and when renewing old sewage networks, source separation of wastewater should be introduced whenever possible. Source separation can be implemented with double drainage, where nutrient-rich wastewater, such as blackwater, is treated separately from other wastewater.
- The criteria for public procurement should include criteria that promote nutrient recovery and recycling. For example, in the procurement of sludge treatment it would be good to set a requirement for nitrogen recovery.

For legislators

- Clear obligations should be set for the recovery of nutrients in both EU and national legislation.
- More comprehensive limits values and monitoring requirements should be set for harmful substances in recycled nutrients, to ensure safe nutrient recycling.

Improved nutrient recovery

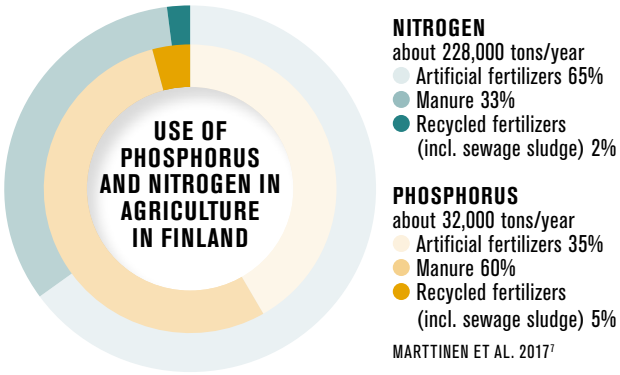
Improving the recovery of wastewater nutrients would enable production of essential raw materials for agriculture and industry. With new techniques, nitrogen recovery could be tripled in wastewater treatment plants and sludge treatment plants compared to the current situation. At the same time, phosphorus could be recovered in a more suitable form for agricultural use than at present.[1]

For example, in 2020, nearly 140,000 tons of artificial nitrogen was used in agriculture. In principle, 5–15 percent of this could be replaced with nitrogen recovered from municipal wastewater. Correspondingly, nearly 11,500 tons of artificial phosphorus was used, of which about 20 percent could be replaced with phosphorus recovered from wastewater.[2]

Industry uses nitrogen in many of its processes, for example in the removal of flue gases. The urea used in forest industry wastewater treatment could be partially replaced with nitrogen recovered from sludge treatment.

Nitrogen recovery could be enhanced by recovering the nitrogen from reject water formed during sludge treatment. This would reduce the nitrogen load coming to the wastewater treatment plant, as well as the greenhouse gas emissions caused during nitrogen removal, as currently, reject water is usually returned to the wastewater treatment plant.

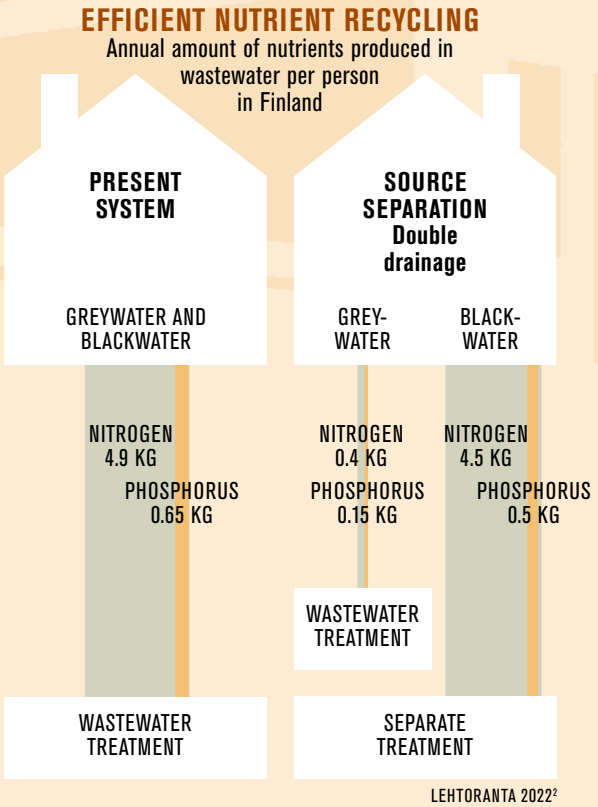
Nearly 80 percent of sewage sludge goes to anaerobic digestion[3]. Anaerobic digestion should be increased in the future, as it enables the conversion of nitrogen into a usable form for plants and the recovery of the energy contained in the sludge as biogas. In addition, anaerobic digestion reduces greenhouse gas emissions caused by sludge treatment.



MARTTINEN ET AL. 2017[7]

After the recovery of nutrients, the anaerobically digested sewage sludge should be processed with, for example, thermal methods instead of composting in order to reduce the occurrence of harmful substances.

The current municipal wastewater treatment process has been developed to reduce pollution of waterways. The process is based on the removal of nutrients and organic matter, not on their recovery and utilisation. Current wastewater treatment methods cause greenhouse gas emissions. The emissions are mainly caused by the volatile nitrogen compounds of the denitrification process and the energy used in the process. Emissions are also caused by the production of chemicals used in the phosphorus precipitation.



LEHTORANTA 2022[2]

Source separation of wastewater

A long-term objective in wastewater management should be source separation of wastewater. Source separation uses double drainage. Consequently, blackwater from households and nutrient-rich wastewater generated in some industries can be sewered separately from nutrient-poor wastewater containing high concentrations of harmful substances, such as greywater from households and wastewater from landfills and industrial plants. This prevents nutrient-rich wastewater from being diluted into nutrient-poor wastewater with a high water volume, from which nutrient recovery is more difficult.

The processing of separated nutrient-rich wastewater enables efficient and safe recycling of nutrients for use in agriculture and industry. In connection with processing, biogas can also be produced from sewage sludge. Source separation reduces the load on wastewater treatment plants and the treatment plants' consumption of chemicals and energy.

Source separation of urban residential wastewater would reduce greenhouse gas emissions from wastewater treatment in urban areas to about half of their present levels. The climate benefits would be even greater if the nutrients and energy recovered through source separation reduces the use of artificial fertilizers and fossil energy.[2]

Solutions based on source separation of wastewater are already in use in some sparsely populated areas. Such solutions have been introduced in new urban residential areas in Sweden and the Netherlands, for example. The experiences have been good and the costs have been reasonable, and bigger systems are being planned.

Accelerating the introduction of new technologies

New techniques for recovering nutrients from wastewater have been developed in Finland and abroad. Some of the techniques are still under development.

The high price of fertilizers and nutrient products improves the profitability of investments in the production of recycled nutrients. The Ministry of the Environment grants support for research and investments promoting the recovery of nutrients and the production of safe fertilizer products[4]. The aim of the support is to improve nutrient and energy self-sufficiency and to develop the recycled nutrient market. Research is still needed into matters such as how government can best promote solutions that support the achievement of security of supply and sustainability goals.

Highly processed nutrient products are most likely to end up in industrial use. From the point of view of the security of food production, it would be important that, if necessary, enough nutrients are also steered to agricultural use.

Forty percent of Finland's sewer network will need renovation by 2040[5]. This would require investments of more than EUR 200 million. In connection with renovations, it should be examined whether it would be appropriate to switch to source separation of wastewater.

The introduction of new techniques at wastewater treatment and sludge processing plants should be accelerated by establishing criteria for the procurement of sewage sludge processing services. Criteria can be set for promoting nutrient recycling, utilisation of final products, energy efficiency, and reducing greenhouse gas emissions.

Good experiences have been gained from circular economy criteria, for example, in the tenders for Porvoo's water procurement, and Turku region's sewage treatment plant's sludge treatment service. New circular economy technologies have been introduced at the sludge incinerator in Rovaniemi.

The utilisation of nutrients in wastewater promotes security of supply and sustainability transformation

Managing harmful substances

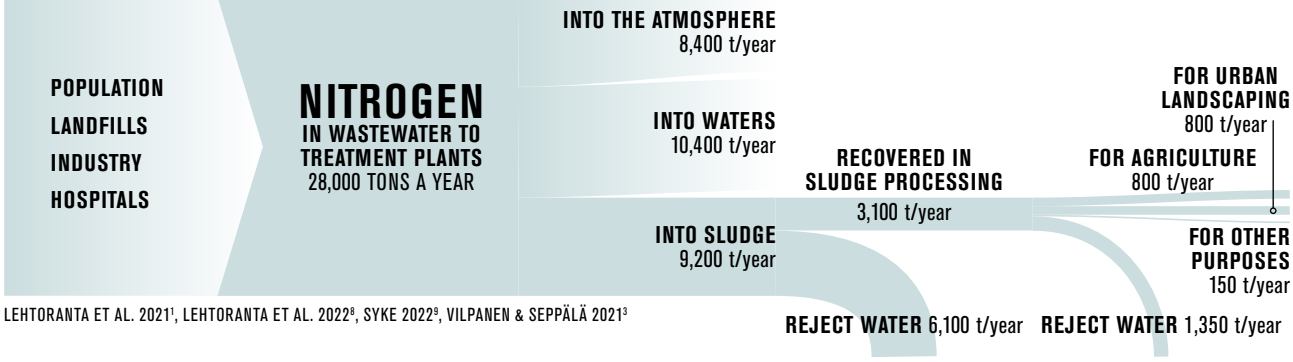
Municipal wastewater treatment plants receive wastewater from different sources, and the wastewater contains a wide range of harmful substances. Current wastewater and sludge treatment processes have not been designed to remove compounds that are harmful to the environment. Fertilizer products produced from sludge have been shown to contain harmful substances[6]. Especially persistent compounds, such as PFAS compounds, can reach the soil environment through the use of sludge-based fertilizers.

Harmful substances can accumulate from the soil to cultivated plants, soil organisms and further up the food chain. Long-term impacts and combined effects of harmful substances on the environment are poorly known. Information on the occurrence, behaviour, and effects of many compounds is incomplete. In addition, the abundance of various compounds makes risk assessment difficult.

The new techniques of nutrient recovery and source separation of wastewater reduce the spread of harmful substances into the environment in fertilizers. The introduction of these solutions is a prerequisite for the safe utilisation of nutrients contained in wastewater, for example in agriculture. In order to increase the use of wastewater-based nutrients, their safety must be guaranteed. It is important that more comprehensive criteria are set for the occurrence of harmful substances in fertilizers and for their environmental monitoring, which take into account their intended use.

ONLY A SMALL PORTION OF NITROGEN FROM WASTEWATER IS CURRENTLY RECOVERED

In the current wastewater treatment process in Finland, on average, about a third of the nitrogen ends up in sludge left over in the process. About a third evaporates into the atmosphere primarily as harmless nitrogen gas, in addition to which a small amount of dinitrogen oxide, a very strong greenhouse gas, is formed. About a third of the nitrogen ends up in waterways. Depending on the further processing of the sludge, a variable proportion of the nitrogen returns via reject water back to the wastewater treatment plant. Calculation of the flow of nitrogen is based on the average wastewater treatment methods.



LEHTORANTA ET AL. 2021[1], LEHTORANTA ET AL. 2022[8], SYKE 2022[9], VILPANEN & SEPPÄLÄ 2021[3]

The worthwhile recovery of wastewater nutrients

Wastewater nutrients can replace artificial fertilizers used in agriculture and nutrients used in industry. This improves security of supply.

Dependence on fossil fuels and imports is reduced. Natural resources are saved.

The infiltration of harmful substances into the food chain and environment is reduced.

Source separation of wastewater reduces the formation of sewage sludge, which has low fertilizer value and is problematic due to harmful substances.

Renewal of EU directive

The European Union is currently renewing its directive on the treatment of municipal wastewater. The proposed directive emphasises circular economy in the recovery of valuable materials. According to the proposal, minimum requirements should be set for the recovery of nutrients in sewage sludge treatment. Microplastics in the sludge, as well as harmful substances in non-domestic wastewater should also begin to be monitored.

The directive should set clear and ambitious requirements for nutrient recovery. It should consider nutrients from sewage sludge processing and those recovered directly from wastewater.

It is important to monitor the implementation of the minimum requirements for nutrient recovery. The monitoring should also cover source-separated wastewater, which is not processed at municipal treatment plants. This requires a new kind of monitoring and reporting.

European Commission 2022. Proposal for a revised Urban Wastewater Treatment Directive

Utilization of wastewater nutrients

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Publisher: Finnish environment institute SYKE

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ISBN 978-952-11-5536-9 (PDF) • ISBN 978-952-11-5537-6 (nid.)

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