GHG and Energy Consumption: The Overlooked Challenges in Wastewater Treatment

By Evina Katsou and Vasileia Vasilaki*

Sustainable water management systems are in the heart of low-carbon and energy resilient economies. However, wastewater treatment plants (WWTPs) are vigorous energy consumers. For many European municipalities, they are the largest energy consumers with a share of 20% of the municipality's electrical load. On top of that, wastewater treatment facilities also emit greenhouse gases (GHGs). The direct GHG emissions, mainly connected to the treatment process, include methane (CH_4) and nitrous oxide (N_2O). Indirect emissions occur due to the use of energy. With a global warming potential (GWP_{100}) of 265 times higher than that of carbon dioxide (CO_2), N_2O is a potent GHG and the most significant contributor to ozone depletion.[1] WWTPs are responsible for 6% of the global anthropogenic N_2O emissions.[2] In the sewer system conveying wastewater to the treatment plants anaerobic conditions prevail, resulting in the emission of CH_4 (GWP_{100} CH_4 = 28).

Scale-up of low-carbon footprint MAterial Recovery Techniques in existing wastewater treatment PLANTs: SMART-Plant is an EU-funded project (Horizon 2020 programme, running from 2016 to 2020) that will prove the feasibility of circular management of urban wastewater and environmental sustainability of the systems and co-benefits of scaling-up water solutions.

Organic matter contained in wastewater has the potential to produce up to five times the energy required to treat the same wastewater. Through wastewater treatment and nutrient recycling up to 20% of the global phosphorous consumption can be extracted from wastewater; the nitrogen loads in wastewater are equal to 10-30% of the nitrogen required in agriculture. Considering that phosphorus was recently identified as a critical raw material for the European Union the need to pursue more energy and resource efficient waste water treatment practices becomes more important. We can recover and recycle these valuable nutrients from sewage and make use of them, thus reducing our needs for new (non-renewable / fossil) resources. A report by the United Nations Environment Programme and Stockholm Environment Institute[3] confirms this picture as it indicates that advances in wastewater management can facilitate European countries to accomplish up to 32 Sustainable Development Goals (SDGs) targets.

The opportunity

Luckily, the water sector is already shifting towards a philosophy of considering waste as a resource and recovering valuable materials and energy from wastewater streams. Zero-carbon, energy efficiency improvement and resource recovery are the dominant approaches that are currently implemented to improve the sustainability of WWTPs and boost the circular economy.

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1 Ravishankara, A.R., Daniel, J.S., and Portmann, R.W. (2009). Nitrous oxide (N_2O): the dominant ozone-depleting substance emitted in the 21st century. Science 326, 123–125.

2 Palut, M.P.J. and Canziani, O.F. (2007). Contribution of working group II to the fourth assessment report of the intergovernmental panel on climate change. Cambridge University Press.

3 Andersson, K., et al (2016). Sanitation, Wastewater Management and Sustainability: from Waste Disposal to Resource Recovery. Nairobi and Stockholm. United Nations Environment Programme and Stockholm Environment Institute.

The urgency to implement and upscale these approaches in the water sector throughout the EU will be massive in the coming years. This transition will on the one hand be powered by water utilities, which are seeking to increase their revenues by recovering compounds and materials from sewage, which are currently lost. On the other hand water utilities are struggling to comply with the Urban Waste Water Treatment Directive (91/271/ECC) and seeking to increase efficiency and reduce operating costs. In the EU alone, the investment required for compliance with the directive and for upgrading existing infrastructure is projected to be equal to ~$25 billion in 2018 alone.[4]

A great transition is ahead of us. We can choose to replace aging infrastructure with new generation wastewater recovery facilities, equipped with state-of-the-art technologies that would not only provide clean water, but also recover resources nutrients and energy. These facilities recover valuable materials, reduce the cost, lower the environmental impact and provide energy to the local community.

SMART-Plant: wastewater as a resource

The SMART-Plant project involves 25 water utilities, companies and universities, to transform the water services from norm followers to leading biorefineries of the 21st century. The project showcases a challenging endeavor: to design, construct, operate and optimise technologies that recover energy and valuable materials from wastewater. Materials (e.g. biopolymers, cellulose, nutrients including struvite, and phosphorus rich compost) will not only be recovered, but also transformed into commercial products, namely fertilisers and biocomposites, or used to recover energy.

For example, in the Netherlands, the municipal WWTP of Geestmerambacht is working together with Cirtec and Brunel University to recover dry toilet-paper pellets from raw wastewater and transform it to an energy source and to a new type of sludge plastic composite with applications in the automotive and construction industry. Other demo/pilot projects include: the Short-cut Enhanced Phosphorus and Polyhydroxyalkanoates Recovery (SCEPPHAR) scheme at Manresa-site in Spain; the sidestream short-cut nitritation-denitritation demo called SCENA (Short-cut Enhanced Nutrient Abatement) at the Carbonera-site in Italy; the sidestream SCENA enhanced by thermal hydrolysis pre-treatment at the Psyttalia-site in

Greece; the secondary mainstream anaerobic treatment by polyfoam biofilter and biogas recovery at the Karmiel-site in Israel; and the tertiary nutrient recovery by ion exchange at Cranfield (UK).

In order to overcome the sustainability challenges of the water industry, SMART-Plant aims to dynamically integrate crucial environmental performance variables, such as GHG emissions and energy consumption into the monitoring and control system of the wastewater treatment technologies demonstrated in this project. Energy consumption and GHG emissions will be continuously monitored and introduced into a cost-effective, dynamic and robust carbon-footprint assessment platform. The SMART-Plant project will use the methodologies developed earlier under two other EU-funded projects. The C-FOOT-CTRL project has developed a software tool that enables sewage treatment plant operators to track and limit GHG emissions at their plant and pinpoint the most environmentally harmful activities. The ENERWATER project develops and validates an innovative standard methodology for assessing, labelling and improving the overall energy performance of WWTPs.

We will investigate dependencies and patterns between direct GHG emissions, energy consumption, and operating variables monitored online in WWTPs in order to identify combinations of operating variables that optimize the environmental performance of the systems. The SMART-Plant energy and carbon footprint platform will improve the effectiveness of the water governance by delivering sustainable water treatment processes that improve wastewater treatment in terms of sustainability and energy consumption. The developed methodological framework is transferrable to any new/existing plant and will provide a guide towards applying operating conditions that lead to energy and carbon efficiency. SMART-Plant 'smart-metering' solutions will benefit the water sector by reducing energy consumption.

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* European Commission (2016). Facts and Figures about Urban Waste Water Treatment (link).