Low greenhouse gas emission wastewater treatment

DETAILS
SECTOR | Water and Waste
STAGE | Operations and Maintenance
TECHNOLOGIES | Sensors / IoT, Data & Analytics, Treatment Technologies

SUMMARY
This use case explores technologies that change the standard emission-heavy wastewater treatment processes into more sustainable processes.

Greenhouse gas emissions of methane (CH₄) and nitrous oxide (N₂O) from wastewater treatment can be reduced through better monitoring technologies and optimising treatment processes. Data from monitoring technologies, such as atmospheric emission sensors or wastewater sensors, to measure dissolved CH₄ or N₂O will be critical to find short- and medium-term mitigation solutions and downstream technologies that use existing infrastructure and control systems to reduce or eliminate the emissions. Long-term solutions will look at alternative low greenhouse gas emission wastewater treatment processes that are not restricted by the current centralised treatment model.

Climate change is a critical challenge for the entire global community and natural environment. Reducing the generation of greenhouse gas emissions from wastewater treatment is one of the steps cities and countries can take to lessen their impact on the environment.

The amount of greenhouse gas emissions from wastewater treatment plants is often underestimated. Due to the physical and chemical reactions involving carbon and nitrogen in standard wastewater treatment process, CH₄ and N₂O are an inevitable by-product. N₂O is 300 times more potent as a greenhouse gas compared to carbon dioxide (CO₂), so even a low emission levels will contribute significantly to a wastewater treatment plant’s greenhouse gas footprint. Similarly, methane is 25 times more potent than CO₂. N₂O emissions from wastewater handling is estimated to contribute 26% to the total greenhouse gas emissions of the whole water supply chain (drinking water production, distribution, wastewater collection and treatment). This totals to approximately 330,000 tonnes of N₂O globally, which is equivalent to nearly 100 million tonnes of CO₂ in the atmosphere.

1Matthijs R. J. Daelman et al. (2012) Methane emission during municipal wastewater treatment, Water Research 46(11), 3657-3670
The desired outcome is better monitoring technologies to better quantify emissions. This information can then be used to inform treatment alterations and optimise existing systems to mitigate emissions. These steps can reduce CH₄ and N₂O oxide emissions from current wastewater treatment plant configurations.

In the long term, the standard wastewater treatment process may need to be challenged to eliminate emissions. These future treatment processes will also need to be energy efficient; adaptable to climate change; as well as scalable with population growth. These types of solutions are still in research phase and may be in the form of different types of centralised or decentralised treatment.

**VALUE CREATED**

**Enhancing economic, social and environmental value:**
- Decreasing greenhouse gas emissions and associated benefits of climate change mitigation.
- Contributing to achieving local, national and international emissions reduction targets.

**Reshaping infrastructure demand and creating new markets**
- A focus on reducing greenhouse gas emissions from wastewater treatment will open up drivers for novel treatment types that do not emit greenhouse gases.
- It also has the potential to incentivise moves away from capital intensive centralised wastewater treatment and create demand for decentralised infrastructure.

**POLICY TOOLS AND LEVERS**

*Legislation and regulation:* Legislation on emissions reductions targets are already driving the change to lower emission wastewater treatment plants. Governments can ensure their policy is up to the highest standard and include clear regulations on wastewater treatment standards. Policy can include monitoring and measuring of greenhouse gases from wastewater treatment.

*Procurement and contract management:* Procurement for new projects and upgrade projects should allow for the use of innovative treatment methods. Contracts could include a requirement for greenhouse gas consideration in the form of measurement and reduction.

*Funding and financing:* Technologies that shift towards a low or zero emission wastewater treatment will be an added capital expenditure to water operators. Financial incentives and subsidies from government agencies on low emission technologies will assist in accelerating the shift in both publicly and privately owned treatment facilities.
### IMPLEMENTATION

**Ease of Implementation**

Monitoring and optimisation technologies are short- and medium-term solutions that will be an iterative process of quantification and plant upgrade. As wastewater treatment is an essential service, gradual optimisation is needed to ensure sewage is treated to environmental and health standards. Long-term solutions may not be able to utilise current centralised infrastructure and require substantial infrastructure development and investment.

**Cost**

Low greenhouse gas wastewater treatment processes will have large associated costs in terms of integration into existing processes and development of new infrastructure. They will need to be thoroughly piloted and tested over a considerable time period to guarantee quality of water and sludge being released matches or exceeds with current methods to reduce environmental and health risks.

**Country Readiness**

Developing countries may have a unique opportunity to leapfrog current wastewater technologies and invest in low emission technologies before investing in standard processes which may be obsolete within the infrastructure lifespan. Developed countries will be more inclined to invest in solutions that utilise and optimise current wastewater infrastructure rather than forgo the sunk cost of current assets.

**Technological Maturity**

Currently, there is substantial research into novel treatment methods that prevent the formation of CH₄ and N₂O. These are still in lab scale pilots and need further development to be feasible at scale. Monitoring and optimisation technologies are further developed and can be implemented into treatment plants today.

### RISKS AND MITIGATIONS

**Implementation / Economic risk**

Risk: New technologies may not be suited for current wastewater infrastructure, and there is a risk of not realising the full return on the substantial investment into current wastewater treatment plants.

Mitigation: Focus on treatment augmentation and monitoring programs that utilise the wastewater treatment infrastructure. Start planning for more diverse technologies when current infrastructure is reaching the end of its life. The decreased economic impact of climate change from reduced emissions may offset investment into new infrastructure.

**Environmental and social risk**

Risk: Changing and optimising wastewater treatment plants have the risk of affecting the quality of water or sludge being discharged and disposed of into the environment. This can be harmful to local water ecosystems and affect wildlife and increase health risks downstream.

Mitigation: Appropriate piloting programs are needed to ensure all changes to treatment processes do not result in a negative change to discharge sludge or water into environment.
### EXAMPLES

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<th>Example</th>
<th>Implementation</th>
<th>Cost</th>
<th>Timeframe</th>
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<tr>
<td><strong>Cobalt Water</strong></td>
<td>AI and machine learning N₂O risk model to identify emission mitigation strategies has been implemented in wastewater treatment plants in the Netherlands. 40% and 70% reductions in overall greenhouse gas emissions were achieved at the Eindhoven and Land van Cuijk plants, respectively, by focusing on N₂O emissions and proposing minor process adjustments.</td>
<td>Approximate costs of annual software subscription is USD 10,000 to identify and implement a mitigation strategy. A one-time greenhouse gas reduction fee is assessed based upon ton CO₂e reduced.</td>
<td>Using SaaS tool, strategies can be developed and implemented within 2-3 months.</td>
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<td><strong>Organics</strong></td>
<td>The thermal ammonia stripping technology has been installed on a 200 tonne per day food waste anaerobic digestion facility in Hong Kong, removing ammonia from the digester centrate, preventing N₂O formation and ensuring discharge compliance.</td>
<td>Cost are highly dependent on the volume of wastewater and ammonia concentration being treated. For example, to treat 500 m³/hr of wastewater with an ammonium concentration of 2000mg/l to a level of 100mg/l would cost approximately USD 2 million.</td>
<td>A fully operational facility typically takes 10 - 12 months to deliver.</td>
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<td><strong>Cranfield University</strong></td>
<td>A novel way of removing nitrogen and carbon containing compounds from wastewater using membranes and media filters to avoid the formation of N₂O and CH₄. This is currently in the pre-commercial phase and has not been applied to wastewater infrastructure yet.</td>
<td>Cost will vary depending on the size of treatment plant and volumes of wastewater.</td>
<td>This solution can be implemented within existing wastewater treatment infrastructure.</td>
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3 Information for Examples in this use case was gathered via communications with commercial technology stakeholders.