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# Covering Wastewater Treatment Plant Basins for Detection of Nitrous Oxide Emissions

## Summary

Nitrous oxide emissions from wastewater treatment account for the majority of greenhouse gas emissions from municipal wastewater treatment. These emissions are not normally measured today, but continuous monitoring requirements are likely to be introduced due to climate goals, the irregular and highly dynamic nature of emissions over daily and seasonal cycles, and the fact that general emission factors are insufficient.

Current wastewater treatment takes place in outdoor basins, where exhaust air — including nitrous oxide — is released directly into the atmosphere. The technology currently available on the market for emission measurement uses floating hoods that cover a limited area of the total basin surface. However, there is no established methodology for optimal hood placement, and developing one is very difficult. Ideally, the basins would be covered to collect all exhaust air, enabling measurement of nitrous oxide concentrations in the collected air. There are many advantages to covering the basins, but the process is costly. Furthermore, the covers must be designed to allow smooth operation and maintenance.

An Innovation Workshop addressing this challenge aims to achieve dramatically reduced costs for covering wastewater treatment basins — through innovative material choices, simple ventilation solutions, and effective access solutions for maintenance during operation.

# 1 Problem definition

Nitrous oxide emissions currently account for between **10–40% of the direct greenhouse gas emissions** from municipal water and wastewater systems (Gustavsson et al., 2024). According to an estimate by the UN's Intergovernmental Panel on Climate Change (IPCC), **1.6% of the incoming nitrogen** to municipal wastewater treatment plants is converted into nitrous oxide and released into the atmosphere. This corresponds to roughly **0.6% of Sweden's total direct emissions**. However, the uncertainty in these estimates is significant, mainly due to poor data quality regarding nitrous oxide measurements in treatment plants.

Nitrous oxide emissions mainly occur from biological treatment processes and vary with several factors, making them difficult to model or predict with the current level of knowledge. The EU's new Urban Wastewater Treatment Directive requires reduced greenhouse gas emissions from wastewater treatment, and work is underway to establish methodologies to ensure this reduction.

Continuous measurement is therefore necessary to obtain reliable estimates. At present, such measurements are rare and the methodology is still under development. To measure nitrous oxide emissions effectively, the air must be collected in a way that accurately represents real emissions. Ideally, all air rising from a basin would be captured and analyzed for nitrous oxide concentration and airflow (if not already measured). However, most municipal treatment plants are outdoors with open basins, making representative measurement difficult.

Currently, continuous nitrous oxide measurement takes place at **four treatment plants in Sweden**, three of which are underground or inside rock caverns, enabling measurement of nitrous oxide in the exhaust air from entire facilities or process units. Most plants, however, have **open-air basins**.

# 2 Definition of problem

Nitrous oxide emissions occur mainly from **aerated basins**, though some may also be produced in **non-aerated basins**. Commercially available measurement systems focus on **floating hoods** installed on aerated basins (see Figure 1 below), which channel exhaust air from parts of the basin surface to an analyzer. Air is continuously drawn from hoods placed in different zones, and a valve system ensures that air from only one zone is measured at a time.

A key challenge with these measurements is the **lack of knowledge about emission variation across the process surface**, and thus the **lack of methodology for optimal hood placement** to ensure representative measurements.

By covering the basins, exhaust air from each basin could be measured in its entirety, leading to **more reliable emission measurements**. Additionally, it would be possible to channel the collected air for **nitrous oxide destruction**, a technology currently under development in several parts of the world. **Figure 2** shows an example of covered basins.



**Figure 1.** Installed floating hoods and associated measurement equipment at the **Klagshamn wastewater treatment plant**, south of Malmö.



**Figure 2.** Example of covered basins.

For accurate nitrous oxide measurements, the covers must be **airtight** and may also require a **ventilation system** to maintain slight negative pressure. There must be **easy access** to the basin contents for sampling, placement of in-water

concentration sensors, and operation and maintenance of these sensors. Maintenance and installation of aeration equipment or mixers must also be possible under the covers.

There are many different basin designs, though most are either **rectangular or circular**.

Besides nitrous oxide, exhaust air is typically analyzed for **oxygen, carbon dioxide, and methane**. Oxygen concentration can be used to calculate **aeration efficiency**, which is valuable since aeration is a major electricity consumer at wastewater treatment plants. Carbon dioxide levels provide information about **organic matter degradation**, which can help **optimize biogas production**. Methane, like nitrous oxide, is a potent greenhouse gas, and although it is not usually produced in large amounts during wastewater treatment, **incoming wastewater and side streams** can lead to methane emissions from aerated basins.

Other **benefits of covering basins** include:

- Reduced odor problems — exhaust air can be treated or released at a controlled location.
- Reduced aerosol emissions, improving workplace air quality.
- Reduced risk of foam drift from basins, minimizing **exposure and infection risks** for staff.
- Reduced **risk of fall and drowning accidents**.
- Eliminated risk of **antibiotic-resistant gene spread** by birds landing or feeding on open basin surfaces.
- Possibility of **installing solar panels** on the covers.

### 3 Previous Attempts and Challenges

Several projects have investigated covering **urban wastewater treatment plants**. In most cases, the goal was to cover entire facilities and construct new structures above or nearby. Two Swedish examples are the **Källby plant in Lund** and the **Öresund plant in Helsingborg**.

The Källby plant is now planned for closure, while at the Öresund plant only the **pre-sedimentation basins** — the main source of odor — were covered by a building. The cost of full coverage was too high to justify project implementation.

To collect only exhaust air, **simpler covers** would suffice. Previously, one argument against covering basins was the need for **visual inspection of the surface** to verify even aeration distribution. However, this can now be addressed by **installing cameras** beneath covers, and any aeration failures can generally be detected through **online monitoring of airflow and pressure drop**.

Another argument has been the need for **instrument access to the basins**, but this can also be resolved with suitable design. Notably, **many agricultural manure storage tanks** are already covered — solutions that could **inspire similar approaches** here.

## 4 Desired outcome

To **dramatically reduce the cost** of covering wastewater treatment basins through **innovative material selection, simple ventilation designs**, and **effective access solutions** for operation and maintenance.

## 5 References

Gustavsson, D.J.I., Persson, F., Stark Fujii, K., Lindblom, E.U., Björk, A., Ekström, S., Sundström, K., Christensson, M. & Baresel, C. (2024). *Slutrapport – Minska utsläppen av lustgas från industriell och kommunal vattenrening.*