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N_2O monitoring highlights potential for GHG emissions reduction

Spernal, Severn Trent's Resource Recovery and Innovation Centre

Severn Trent is the UK's second biggest water company, serving 4.4 million private and business customers in England and Wales. Spernal STW is a medium sized sewage treatment works in Warwickshire with a dry weather flow capacity of 27,760 m³/day. With a discharge consent on ammonia, and resulting focus on nitrification in nitrogen treatment, it is a typical site for the UK and other parts of the world.

Spernal Sewage Treatment Works serves as Severn Trent's "Urban Strategy Demonstration Site", where emerging technologies that are compatible with a low energy, circular economy approach are being evaluated. As such, it was Severn Trent's first site to be equipped with dissolved nitrous oxide sensors. The goal of installing the sensors was to gain a better understanding of the site's scope 1 climate impact and the potential for reducing emission by means of process optimizations. While this study shows a short period of data collection, long term monitoring is implemented to fully understand GHG emissions and triggers for N_2O formation.

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Case Study: Nitrous Oxide Monitoring in a Typical Nitrifying Activated Sludge Process

N_2O Monitoring in the Activated Sludge Tanks

The activated sludge lanes at Spernal are divided into a short anoxic zone followed by 3-pass aerated zones (Fig. 1), where most of the nitrification takes place.

Severn Trent implemented N_2O monitoring in the aerated part of the sludge tanks. The sensors are maintained as part of the site's regular measuring routine. The two N_2O sensors are approx. 25% and 50% into the aerated zone, collocated with DO sensors (Fig. 1). These locations provide a representative value for the emissions of a whole aeration zone. Depending on the layout of the zones and mode of aeration used, a period of scouting with one sensor (while keeping the other in position as reference can be advantageous.

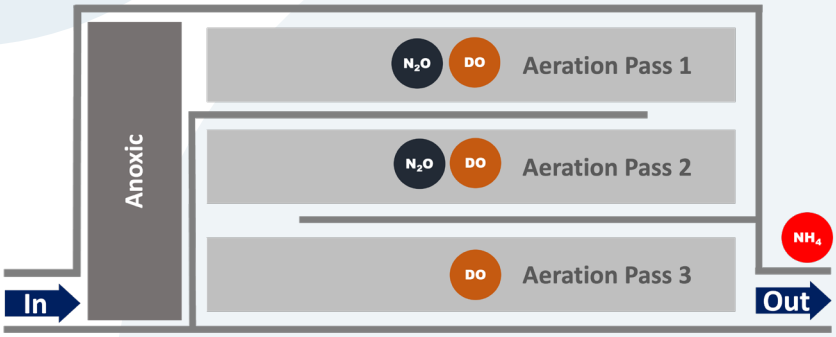

Figure 1: Schematic drawing of the activated sludge tank under research with direction of water flow and sensor locations.

Results from One Month's Data Collection

The data discussed here is based on one month's data collection and is shown in Figure 2. By comparing the measured parameters, it can be concluded that N_2O formation is mainly dependent on ammonium loading. During the first 17 days, N_2O concentrations were high in both passes, with the highest values in pass 2. This is likely due to an accumulation of nitrites, which coupled with local zones of low oxygen can trigger nitrifier denitrification to produce N_2O.

From day 17 onward there is a significant drop in the mean inlet NH_4 concentration. Subsequently, N_2O concentrations in pass 1 are almost negligible, with lower N_2O concentrations in pass 2 as well. With a lower load, the ammonium-based aeration controller safely moves the ammonium load toward the second pass. This results in a slower ammonium turnover and reduced nitrite accumulation. This combination leads to a lower N_2O production. The load change is also reflected in the reduced effluent ammonium concentrations (Fig. 2).

Reducing greenhouse gas emissions

After analyzing the data, two potential methods for reducing N_2O emissions where identified: The first is to improve load balancing to reduce overloading where possible, while the second is to distribute NH_4 turnover throughout the lane by using aeration cascading that relies on N_2O sensor input. Continuous monitoring of N_2O will help quantify the full extent of scope 1 N_2O emissions from this site and validate any mitigation measures that may be trialed.

Severn Trent has ambitious plans to be at the forefront of the UK Water Sector's Net Zero initiative and the circular economy. This includes investments in energy savings and energy production as well as advanced nutrient recovery – all while reducing the carbon footprint of their operations. With the implementation of real-time N_2O monitoring, Severn Trent is now gathering in-depth knowledge and understanding of their sites' performance and can realize opportunities to reduce greenhouse gases while optimizing the use of energy and resources to the benefit of their customers and the environment.

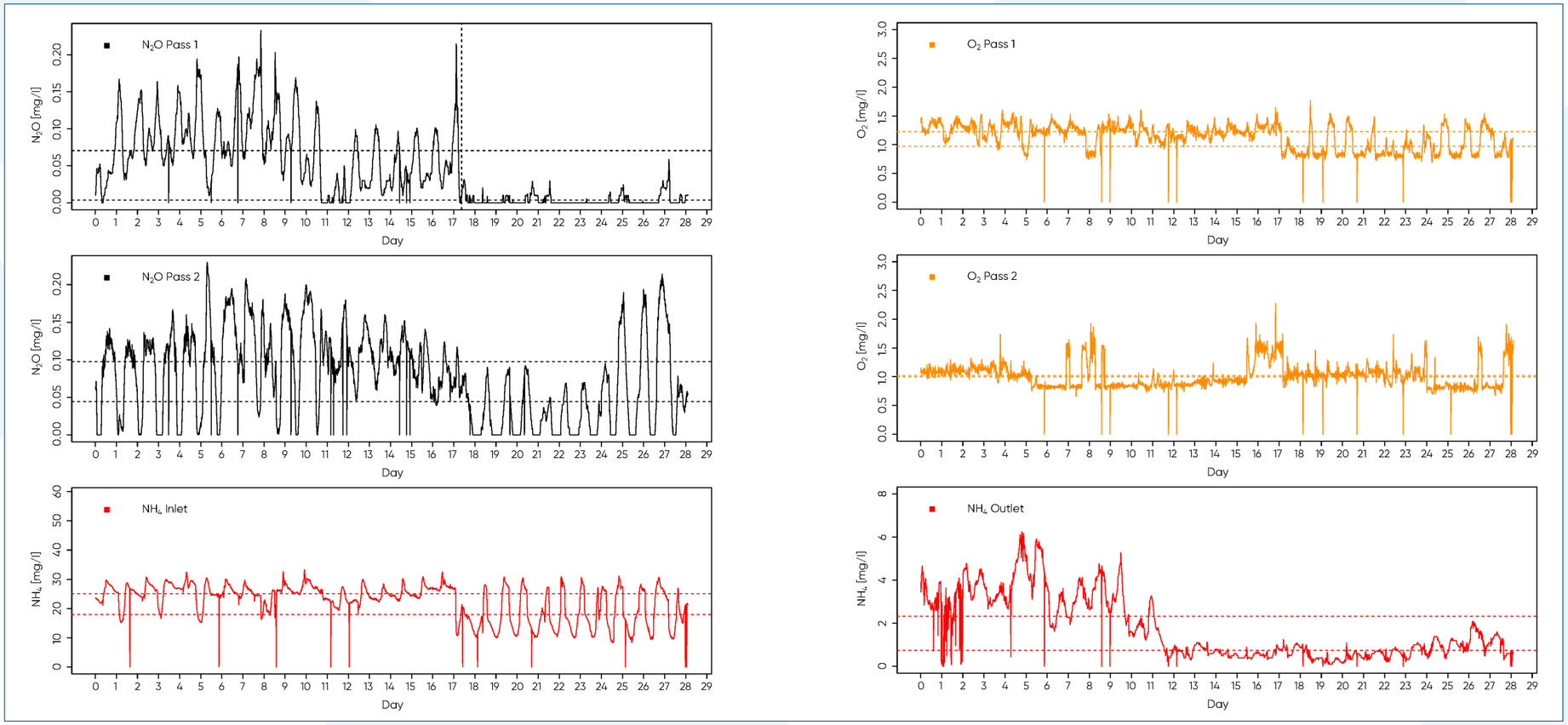

Figure 2: Key parameters of performance for the activated sludge tank under research. 1 month of measurements is shown. Refer to Fig. 1 for sensor locations. The dotted lines in each figure represent different mean values, explained by the shift in load. Upper dotted line: day 0-17; lower dotted line: day 17-29

What to kN$_2$Ow about N_2O emissions?

N_2O (nitrous oxide) is a potent greenhouse gas (GHG), with a global warming potential that is 273 times higher than that of carbon dioxide. Wastewater treatment plants are a significant source of N_2O emissions, as sludge bacteria create N_2O when experiencing sub-ideal conditions. High ammonia loading, accumulation of nitrite and low O_2 levels are the most common trigger conditions during nitrification.

Studies have shown that N_2O can make up 50-90% of a single treatment plants' GHG emissions. On a global scale, total GHG emissions from wastewater treatment plants are considered as significant as those from air traffic. Reducing the N_2O emissions at wastewater treatment facilities is therefore a sustainability target of highest importance for all modern water utilities.

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Nitrous Oxide process sensor for online wastewater treatment optimization, low-cost greenhouse gas reduction, and reliable sustainability accounting

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