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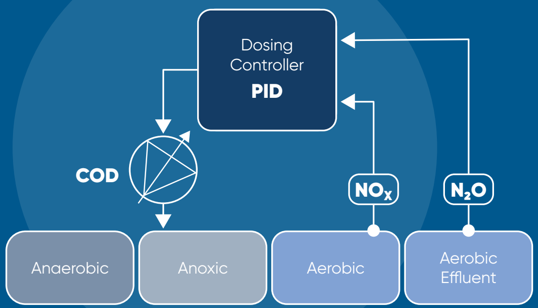
Case Study: N_2O Wastewater Sensor as tool for Carbon Dosage Control

N_2O produced in Denitrification

Full biological nitrogen removal in wastewater is achieved through a combination of nitrification and denitrification. N_2O is an obligate intermediate in denitrification where a lack of carbon source will stop the process prematurely.

Optimizing economy and environmental footprint

Incomplete denitrification is a source of N_2O emissions, while a well operated denitrification can significantly reduce a WWTP's emissions.



By using NO_X-triggered and N_2O-limited carbon dosing (as in schematic above), operators can ensure optimal use of external carbon source and achieve significant financial savings while ensuring tight effluent control.

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Dosage of external carbon source is a common method to enhance denitrification, especially on sites with very low N-limits in their effluent. In practice the amount of carbon is often not based on real time measurements, leading to regular overdosing.

The amount of carbon available relative to nitrogen to denitrifying bacteria limits their ability to complete the last step of denitrification and to produce N_2 from N_2O (Fig 1).

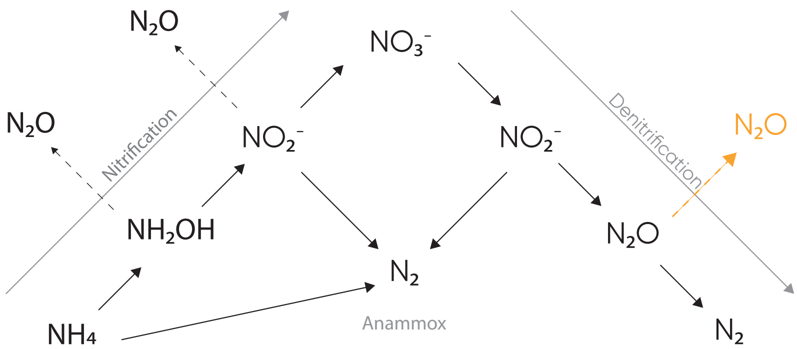

Figure 1: Pathways of N_2O production in the nitrogen conversions found in wastewater treatment

The connection between carbon dosage and nitrous oxide

Applied research has shown that a low COD/N ratio can lead to increased N_2O production and that a ratio below 3.5 can lead to significant N_2O emissions[1].

Figure 2 demonstrates the relationship between COD/N and N_2O. The bell-shaped relationship between N_2O and COD/N makes it possible to avoid excessive N_2O emission by aiming for either a high (>3.5) or a low (<1) COD/N ratio.

From a process control standpoint, the slope of the N_2O curve in response to the different COD/N-ratios can be used as an indicator for the dominating sludge process. If aiming at complete denitrification to N_2, the N_2O sensor can be applied to monitor N_2O concentration and increase the carbon load when the N_2O concentration is increasing to ensure a COD/N ratio above 3.5. Once N2O falls under a given setpoint, carbon dosing can again be stopped, ensuring optimal process efficiency and resource use.

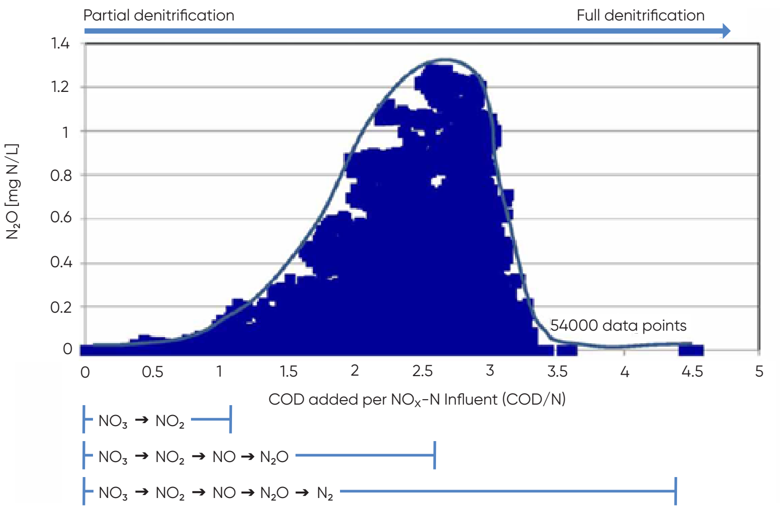

Figure 2: Correlation between COD/$N_{INFLUENT}$ ratio and N_2O concentration[1].

N_2O sensor feedback prevents carbon overdosing

Andalib et al. 2017 demonstrated the carbon dosage automation in full scale at four American wastewater treatment plants. The researchers applied real-time control of carbon dosing based on NO_X and N_2O sensors.

The study showed that nitrogen oxide (NO_X) probes of both UV and ISE types alone were less dependable when concentrations fell below 1-1.5mg/L, leading to an overdosing of carbon source.

By using the N_2O sensor as feedback parameter, the WWTPs avoided overdosing, resulting in high potential savings – both financially and in terms of greenhouse gas emissions.

References

[1] Andalib et al. 2017. Correlation between nitrous oxide (N_2O) emission and carbon to nitrogen (COD/N) ratio in denitrification process: A mitigation strategy to decrease greenhouse gas emission and cost of operation. Water Science & Technology 76. 10.

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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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