

## Nitrous oxide emissions from trickling filters

Nitrous oxide ( $N_2O$ ) is a greenhouse gas (GHG) which is released from wastewater treatment plants (WWTP) during nitrogen removal. Removing nitrogen is an essential function of WWTPs and there are many ways of constructing plants to achieve this. Therefore, it is important to understand the  $N_2O$  emission triggers in order to implement mitigation controls through changes of process parameters. The triggers for  $N_2O$  release are well understood in some type of plants but information is scarce for other types of plants.

In the UK, trickling filters account for between 60-70% of the biological wastewater treatment units but information regarding  $N_2O$  emissions from trickling filters is limited, partly caused by the difficulties in capturing off-gases. Implementing a hood for gas collection and analysis has been applied to provide an estimate of  $N_2O$  emissions. Unisense  $N_2O$  sensors have mainly been used for  $N_2O$  analysis in liquid but have also been applied for off-gas measurements (Marques et al. 2016) and thus present an opportunity for cost-effective monitoring off-gas  $N_2O$  concentrations. The  $N_2O$  Wastewater Sensor can be implemented for gas phase analysis in a hood as well as for liquid monitoring of the effluent to quantify the emissions from trickling filters (see Fig. 1).

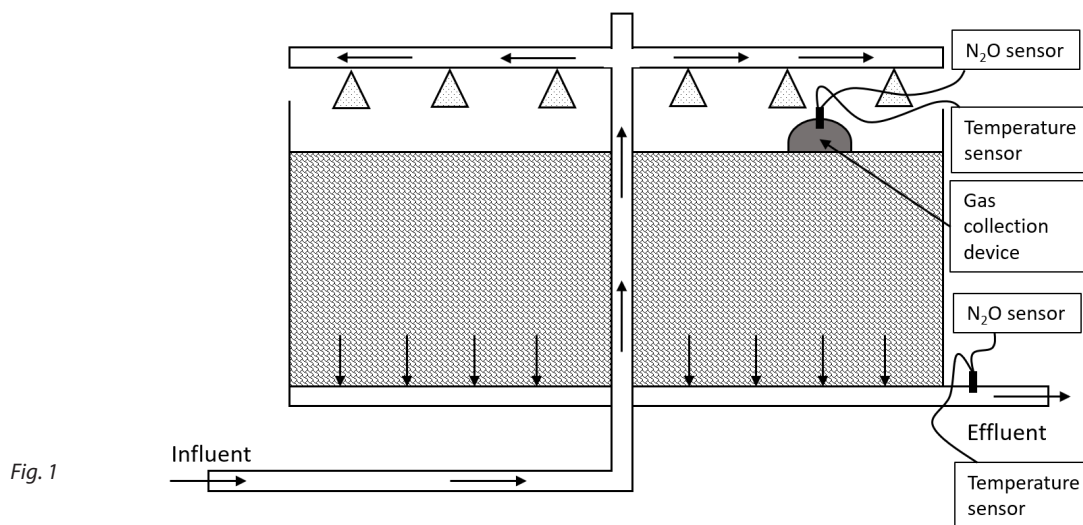


Fig. 1

One of very few studies is Wang et al. (2014) who investigated the effect of temperature on  $N_2O$  emission from a trickling filter treating domestic wastewater. The  $N_2O$  emission was monitored during a year and it was observed that the emission was higher during the summer compared to winter. In trickling filters, where air is supplied through natural ventilation, the ventilation is driven by temperature differences. With limited temperature differences between air and water during summer, temperature becomes the governing factor for  $N_2O$  release since low air flow and oxygen limitation leads to incomplete nitrification and  $N_2O$  release. A low COD/N ratio has been shown to lead to  $N_2O$  formation during denitrification but as nitrification is the dominant process in the trickling filter, it is not a significant factor for  $N_2O$  release. Søvik and Kløve (2007) also found that the  $N_2O$  release from a trickling filter was related to nitrification.

The air flow used for calculating  $N_2O$  emission was calculated according to  $AR = \epsilon \cdot u_s \cdot f$ , where  $AR$  is the airflow ( $m^3 \cdot s^{-1}$ ),  $\epsilon$  the surface fluid velocity ( $m \cdot s^{-1}$ ) and  $f$  the area of the trickling filter ( $m^2$ ). They estimate an emission of 20.5-554 g  $N_2O/(m^3 \cdot year)$ , corresponding to 0.1%-0.8% of the oxidized ammonia released as  $N_2O-N$ . Studies are limited but Søvik and Kløve (2007) and references therein **report that 0.004-8% of the nitrogen load was released as  $N_2O-N$** . Wang et al. (2014) suggest that a solution to limiting  $N_2O$  emission could be to control the  $O_2$  supply to the trickling filter biofilm by relying on controlled ventilation instead of natural ventilation.

In conclusion, the lack of data and high reported emissions emphasize the need for further monitoring  $N_2O$  emissions from trickling filters. To implement  $N_2O$  monitoring, it is important to further develop a method for implementing  $N_2O$  measurements and constructing a  $N_2O$  emission model for this type of system. Monitoring the  $N_2O$  emission using the  $N_2O$  Wastewater Sensor will drive a deeper understanding of the  $N_2O$  release triggers in trickling filters and mitigate the  $N_2O$  emission.

### References:

- Marques et al. 2016. Assessment of online monitoring strategies for measuring  $N_2O$  emissions from full-scale wastewater treatment systems. *Water Research* 99, 171-179.
- Søvik and Kløve. 2007. Emission of  $N_2O$  and  $CH_4$  from a constructed wetland in southeastern Norway. *Sci. Tot. Environ.* 380, 28-37.
- Wang et al. 2014. Impact of temperature on nitrous oxide emission in a trickling filter. *Zhongguo Huanjing Kexue/China Environmental Science* 34, 2796-2804.