Nitrite formation in continuous backwash filters for post-DN

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in cooperation with the municipality of Tjörn

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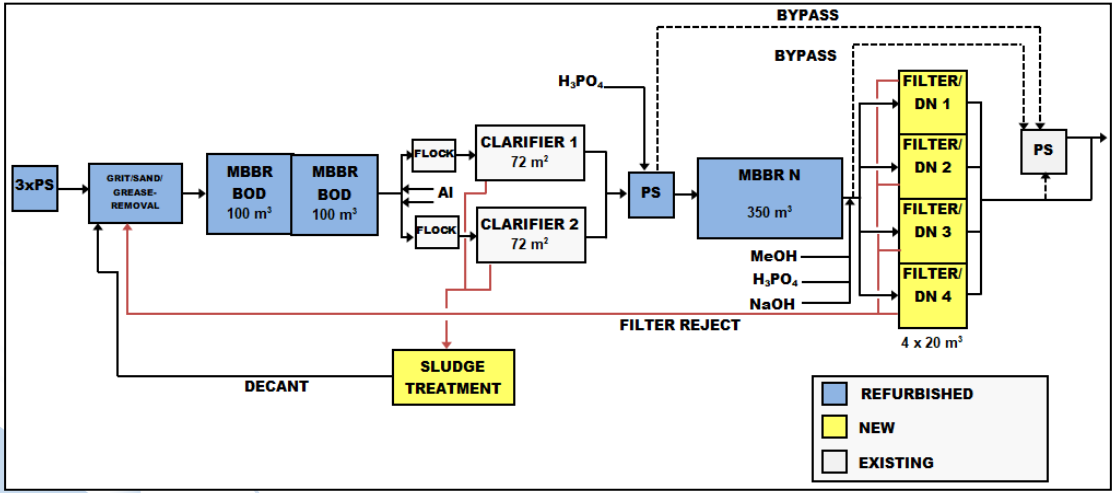
Background

- Compact WWTP on the eastern coast of the island Tjörn, on the west coast of Sweden
- Demand on nitrogen treatment from authorities because of a sensitive recipient
- 8 500 pe, designed for 300 m^3/h

Process

- Very compact with high loaded MBBR-BOD, post-nitrification in MBBR & post-denitrification in continuous backwash filters
- Methanol is used as carbon source



Process scheme of the WWTP of Höviksnäs

Nitrite formation

$$NH_4^+ + \left(\frac{3}{2}\right) O_2 \rightarrow NO_2^- + 2\,H^+ + H_2O$$

$$NO_2^- + \left(\frac{1}{2}\right) O_2 \rightarrow NO_3^-$$

$$NO_3^- + \left(\frac{1}{3}\right) CH_3OH \rightarrow NO_2^- + \left(\frac{1}{3}\right) CO_2 + \left(\frac{2}{3}\right) H_2O$$

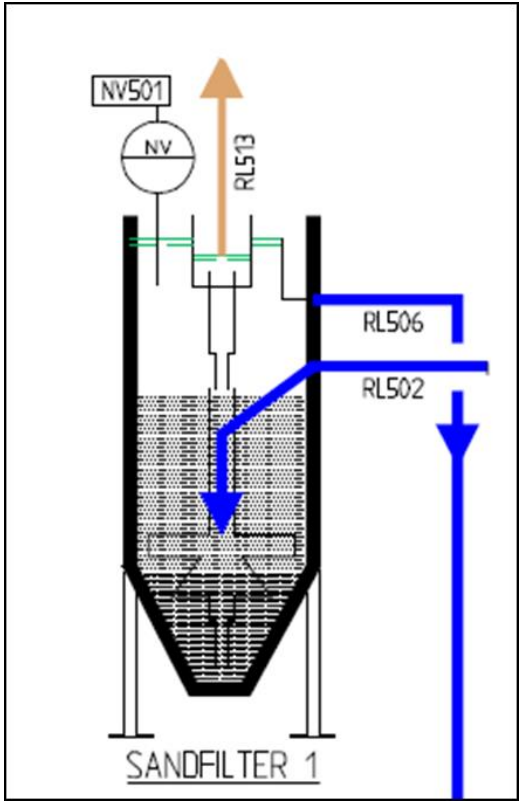
$$NO_2^- + \left(\frac{1}{2}\right) CH_3OH \rightarrow \left(\frac{1}{2}\right) N_2\,(gas) + \left(\frac{1}{2}\right) CO_2 + \left(\frac{1}{2}\right) H_2O + OH^-$$

Nitrification

Denitrification

Dyna Sand filters

- Carbon source: methanol
  - Dosage controlled by nitrate load coming in to the filters and correction by concentration of nitrate in effluent
- The four filters has a total volume of 80 m^3
- Dimensioned for 200 m^3/h
- Relatively small residence time, often < 1 hr

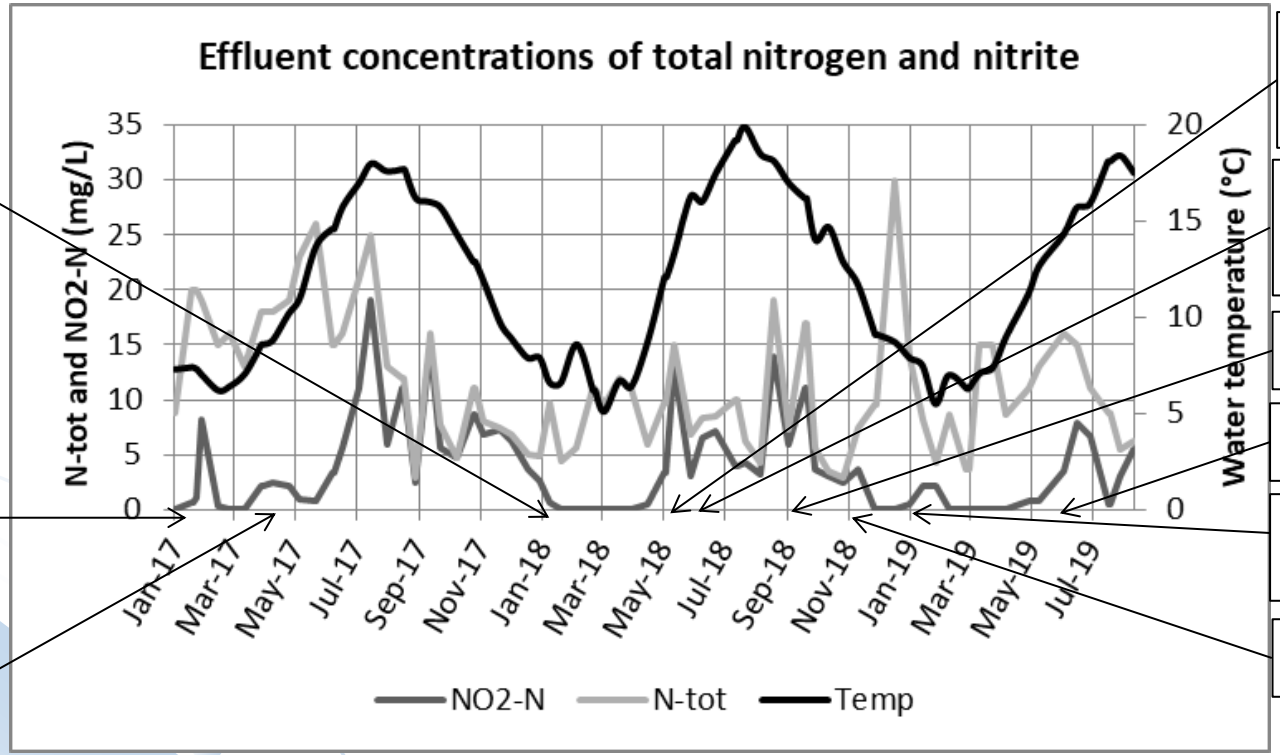


Nitrite production

Phosphoric acid to the filters, 3/1 2018 (earlier point before MBBR N)

Caustic soda to the filters, 25/1 2017

Point of adding caustic soda changed to before MBBR-N due to technical problems, 4/4 2017



Change of control system which led to overdosing of methanol, may-june 2018

2 filters were out of order due to incoming water from a fire extinguishing, 6/6-2018

Intermittent washing of filters, started 6/9 2018

Moved point of dosage of methanol, w. 24 2019

Added phosphoric acid dosing point to before MBBR-N, 8/1 2019

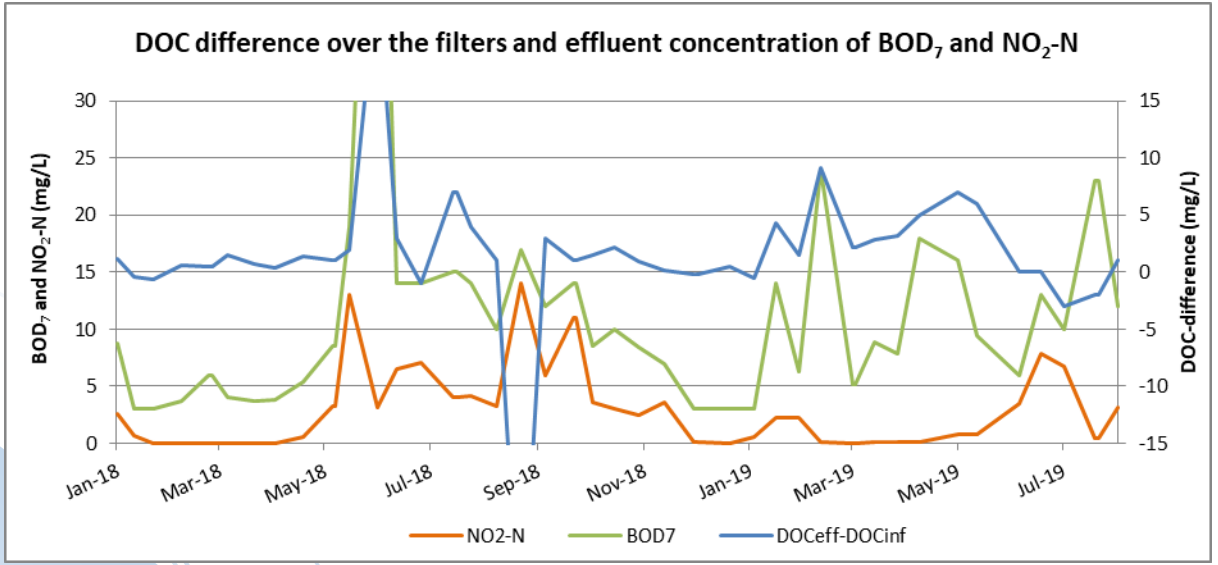
Caustic soda to the filters again, 7/11 2018

Nitrite production

Denitrification inhibitors		Measures taken
• Lack of phosphorous	→	Adding phosphoric acid
• Low pH and alkalinity	→	Adding caustic soda
• Residual oxygen in filters	→	Minimizing air inflow to MBBR N
• Inaccurate methanol dosage and unsatisfying mixing	→	Dosage control of methanol on both influent and effluent nitrate. Instruments are calibrated every week. The point of dosing has been changed to ensure good mixing
• Low MLSS	→	Increasing active biomass in filters by backwash intermittently

Results

Average nitrate load: 0,39 kg NO_3-N/m^3



Nitrite production

During summer 2019,
nitrite was still produced …

Cleared up factors:

- Lack of phosphorous
- Low pH
- Residual oxygen
- Low MLSS

Remaining theories:

- The hydraulic distribution over the filters might be uneven
  - Unlikely since the filters works well during the winter
- Different grow rates for different bacterial communities
  - Nitrate to nitrite bacteria seems to grow faster than nitrite to N2O/N2 bacteria at high temperatures
- Methanol dosing strategies.
  - Methanol is controlled by the load of nitrate in the influent and the nitrate content in the effluent. No consideration is taken to eventual nitrite in effluent.
  - A nitrite online instrument is about to be installed and included in methanol dosing control

Conclusions

- Nitrite can be produced during denitrification due to a lot of different circumstances.
- Nitrite gives, unfortunately, an increase of the BOD7 in the effluent.
- To minimize nitrite, the methanol dosing has to be controlled on nitrite also (not only nitrate), especially during summer/autumn (water temperature >10 – 15 ˚C)

Thank you!

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