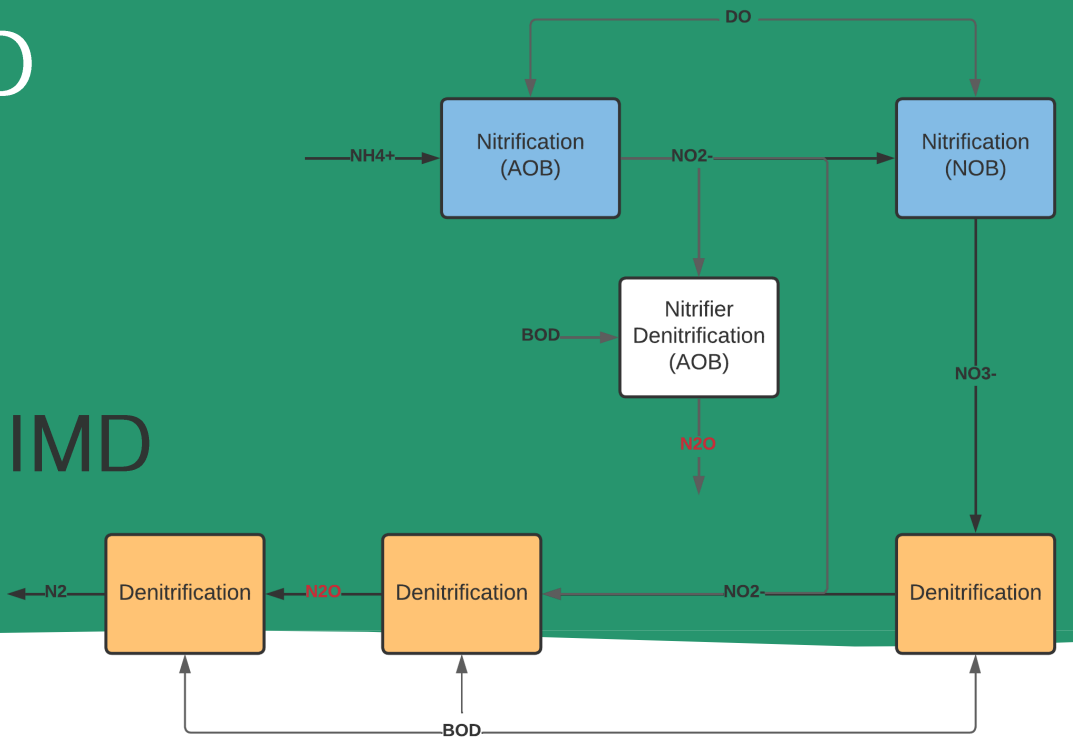
Measuring and mitigating N_2O in (nitrification-denitrification) aeration tanks

By Floris de Heer, Consultant at IMD



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Agenda

I. Sensor allocation
II. Sensor management
III. Data analysis

Sensor allocation

1. Which WWTP?
2. (Which unit operation within the WWTP?)
3. Where inside the aeration tank?

Measuring – Which WWTP (first)?

- IPCC's emission factor: 1.6 % of influent tot-N.
- STOWA's risk estimation: Three emission factors.

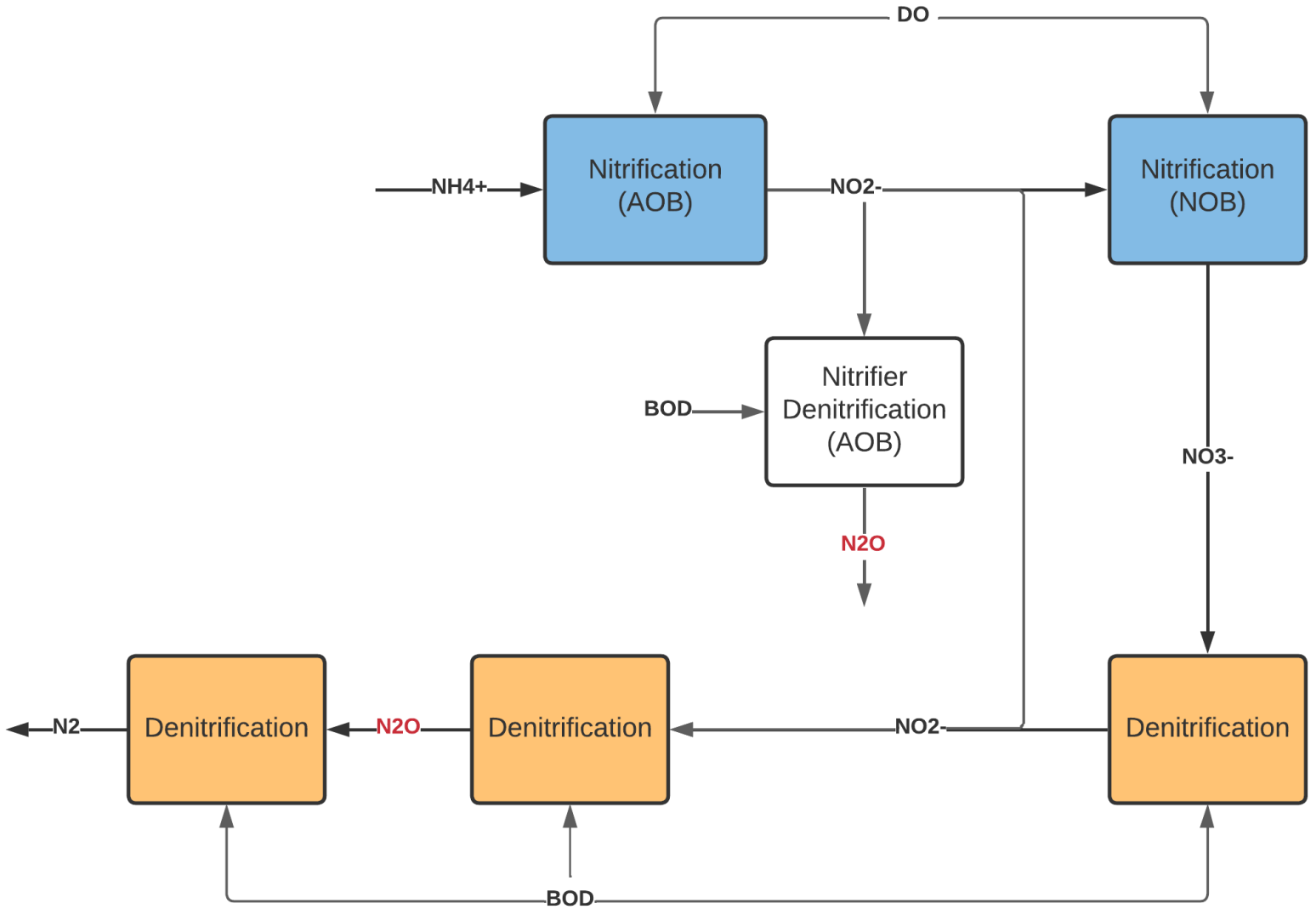
NH_4^+ effluent conc. [mg-N/L]	Score
< 1	1
1 – 2	2
> 2	3

+

NO_2^- effluent conc. [mg-N/L]	Score
< 0.2	2
0.2 – 0.5	4
> 0.5	6

=

Score	Risk of N2O	Emission factor (% of influent Kj-N)
≤ 3	Low	0.05
4 – 5	Medium	0.5
≥ 6	High	3


DO
NH4+
Nitrification (AOB)
NO2-
Nitrification (NOB)
BOD
Nitrifier Denitrification (AOB)
N2O
NO3-
N2
Denitrification
N2O
Denitrification
NO2-
Denitrification
BOD

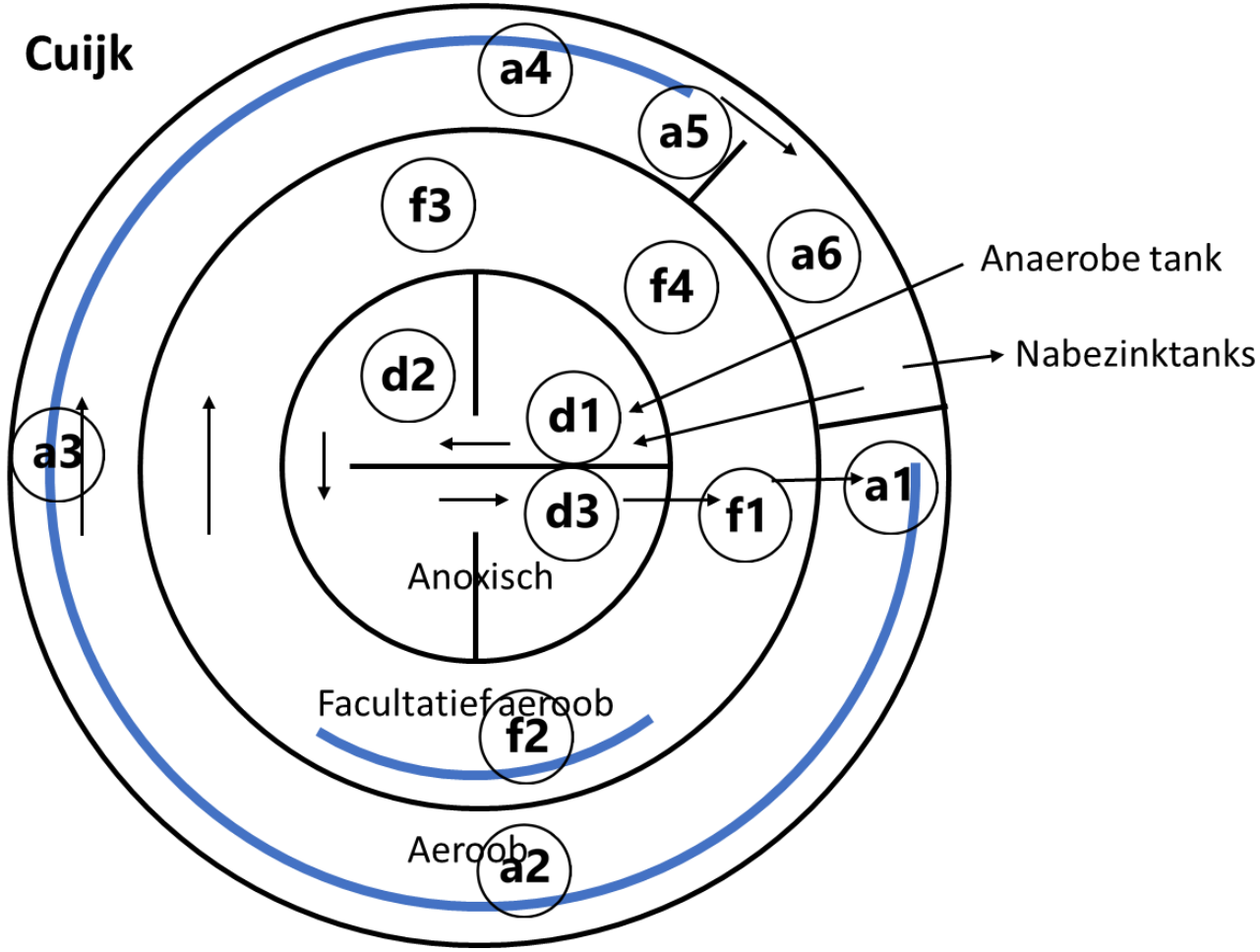
Measuring – Which unit operation?

1. **Aeration tank** (both aerated and anoxic zone).

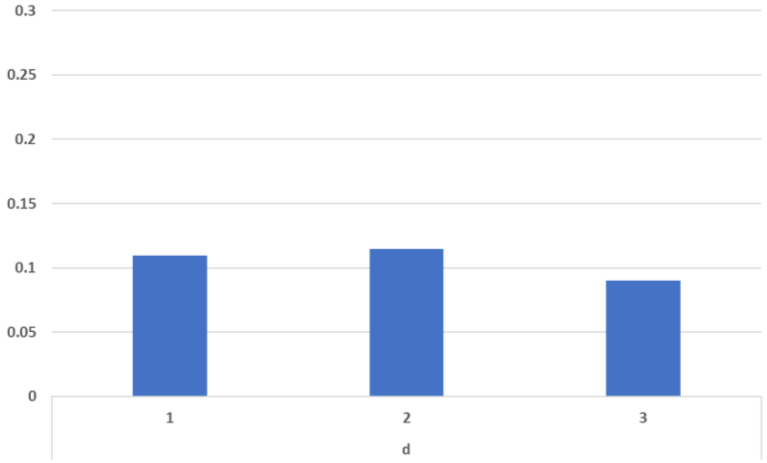
2. Side-stream N removal, e.g., partial nitritation anammox reactor.

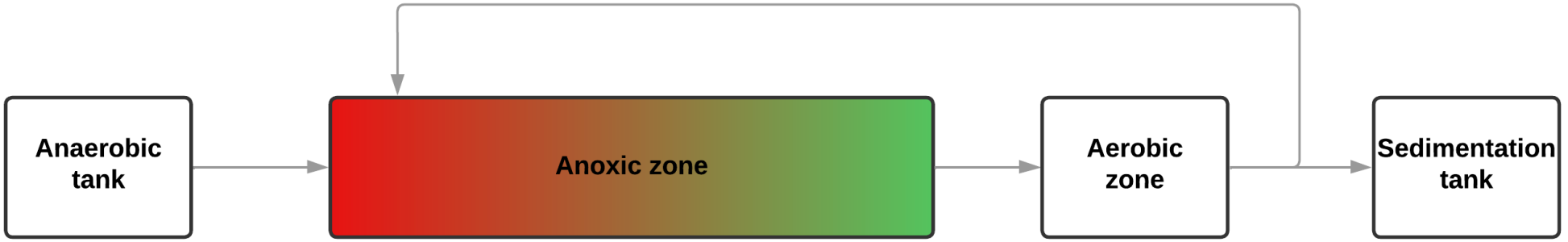
Measuring – Where inside the aeration tank?

- Ideally mixed or Plug-flow?
- Identify possible sensor locations.
- Determine N_2O profile (e.g., by nitrite sampling / sensor measuring campaign).



N_2O profile in plug-flow anoxic zone

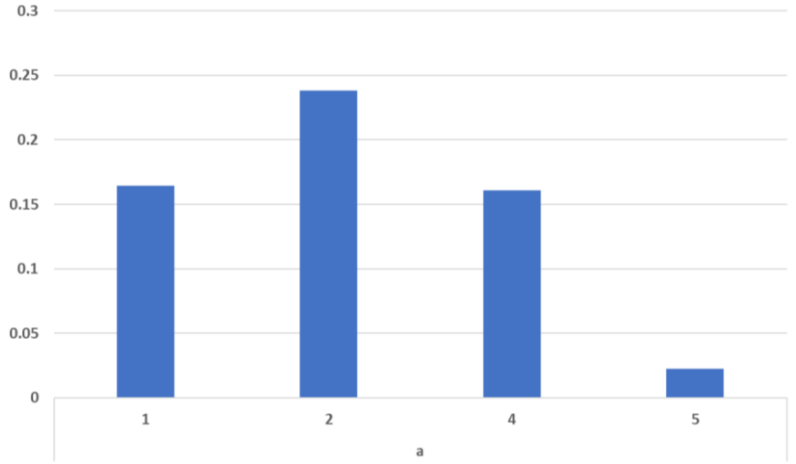


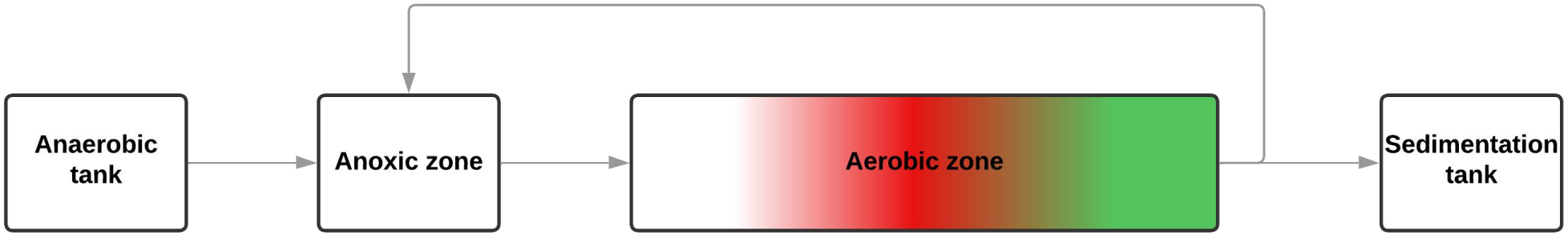


(Phase 1)
- Conversion of left-over DO
- Limited denitrification
- High risk of N2O

Phase 2
- Denitrification
- N2O sink effect
- Low risk of N2O

N_2O profile in plug-flow aerobic zone





Phase 1
- BOD removal
- NH4+ production
- Limited nitrification
- Low risk of N2O

Phase 2
- High nitrification rate (AOR)
- High risk of N2O

Phase 3
- NH4+ low
- Low risk of N2O

Sensor management

1. Cleaning
    1. Choose sensor holder design limiting attachment of fibers.

2. Calibration
    1. Use two buckets to combine calibrations.
    2. Use isolated buckets.

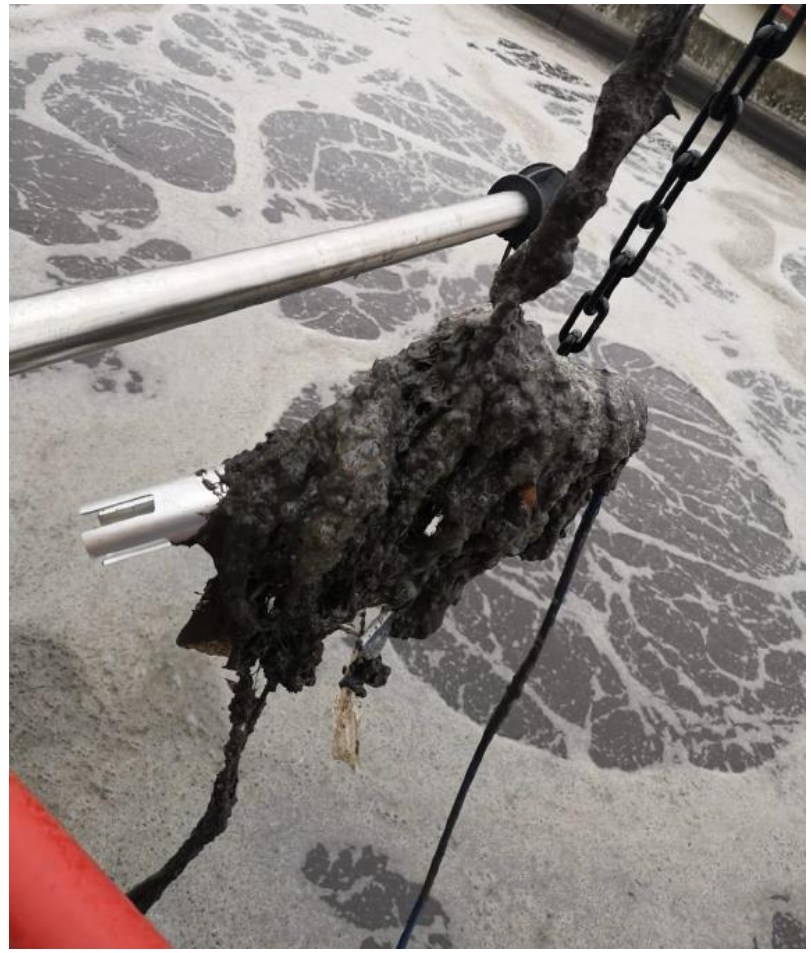
3. Sensor head replacement
    1. Possibly applicable for >6 months.

General: Have attention for data quality.

Cleaning (skipped)

Required to prevent:

- High weight on armature or sensor cable.
- Micro-environment near sensor tip → Non-representative measurement.



Cleaning (skipped)

Reduce cleaning frequency by sensor holder design covering connection point.

Calibration (skipped)

Some advices:

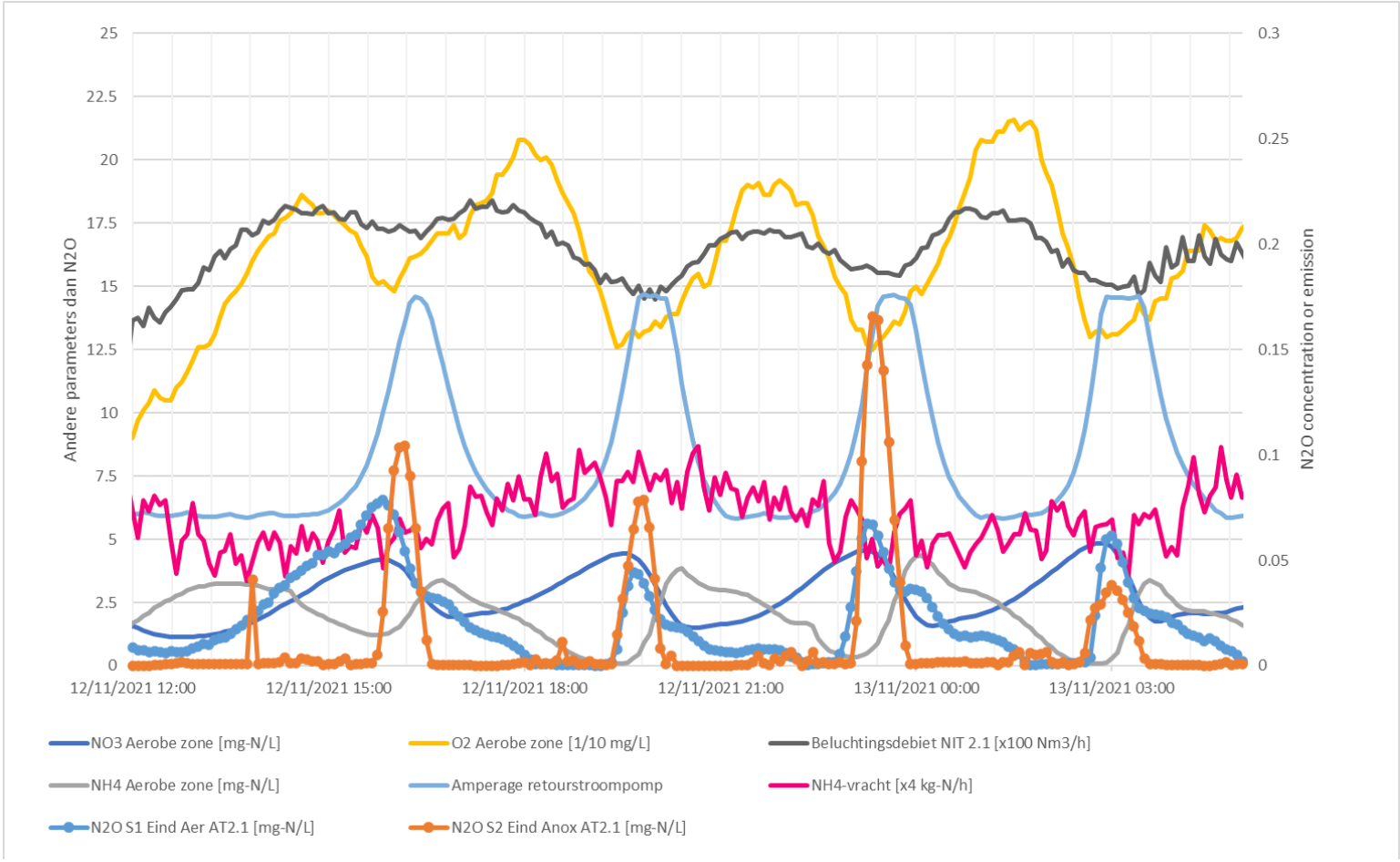
- Use 2 buckets: one for zero-point, one for standard concentration.
- Use isolated dispensers.
- For mixing, it suffices to rotate the sensor ~10 x.
- Waiting for 2nd calibration point should take ~2 minutes. If value drops earlier, stay patient. If value keeps increasing after 5 minutes, sensor head likely worn out.

Data analysis

1. Observation
2. Interpretation
3. Application (Mitigation)

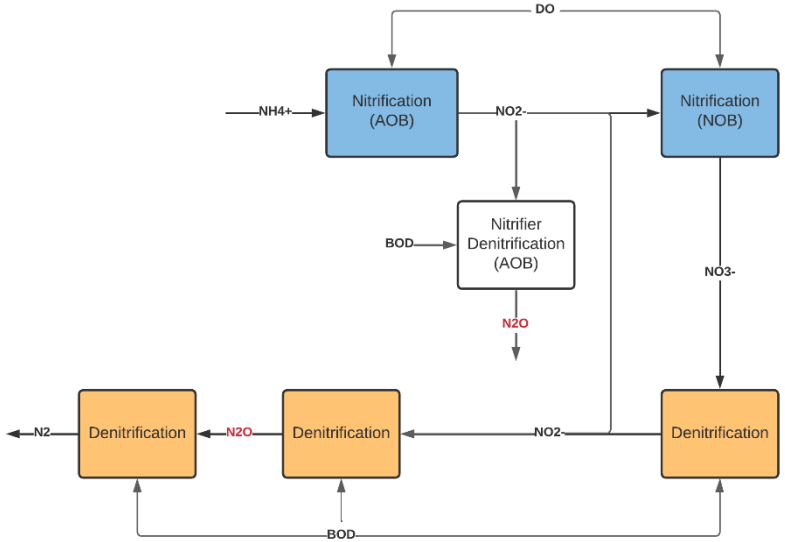
Observation

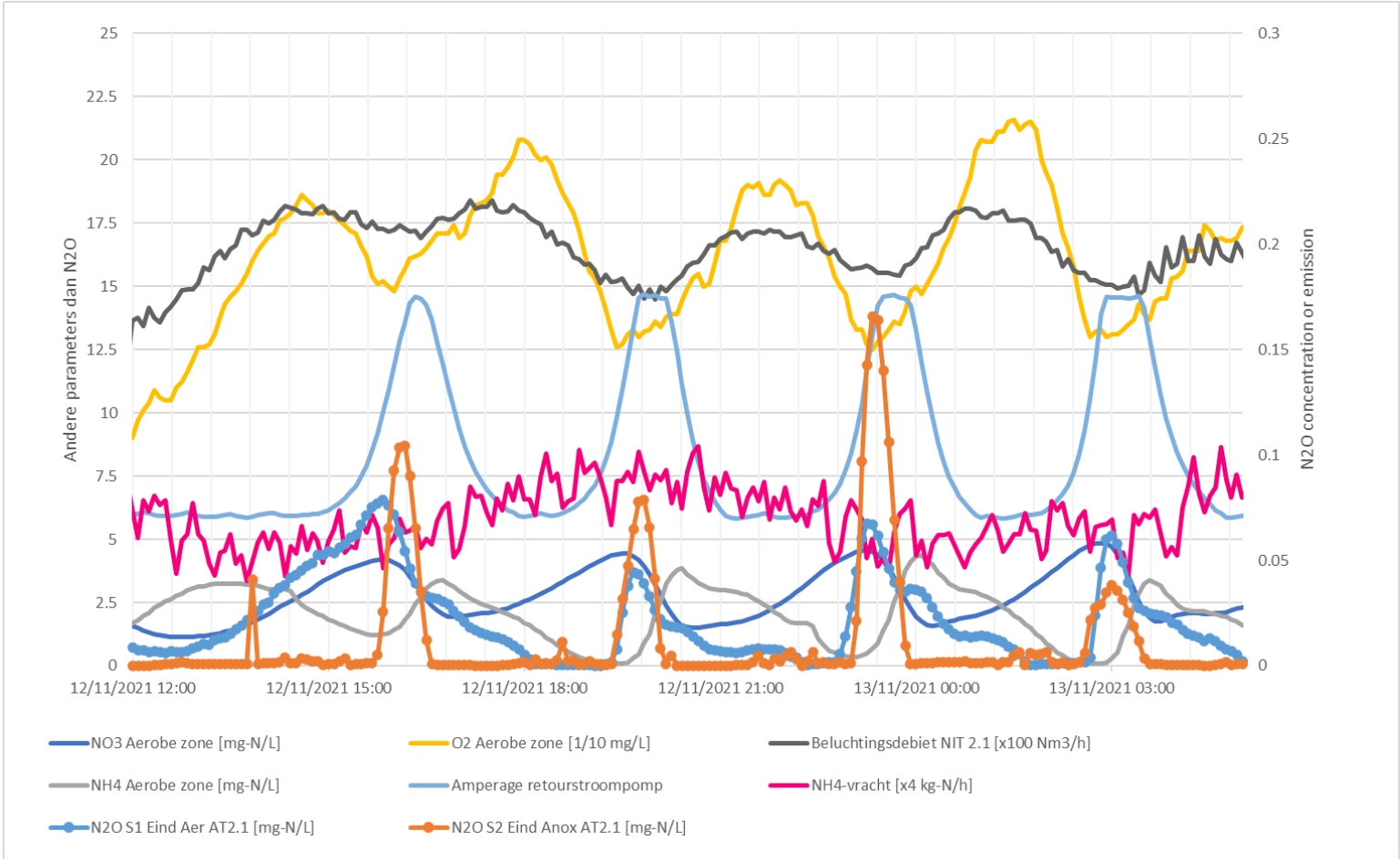
1. Plot N_2O data (concentration / emission) with other might-be relevant parameters (NH_4^+, NO_3^-, NO_2^-, DO, flowrate, aeration flowrate, pumps inside AT, etc.).
2. Search for patterns.



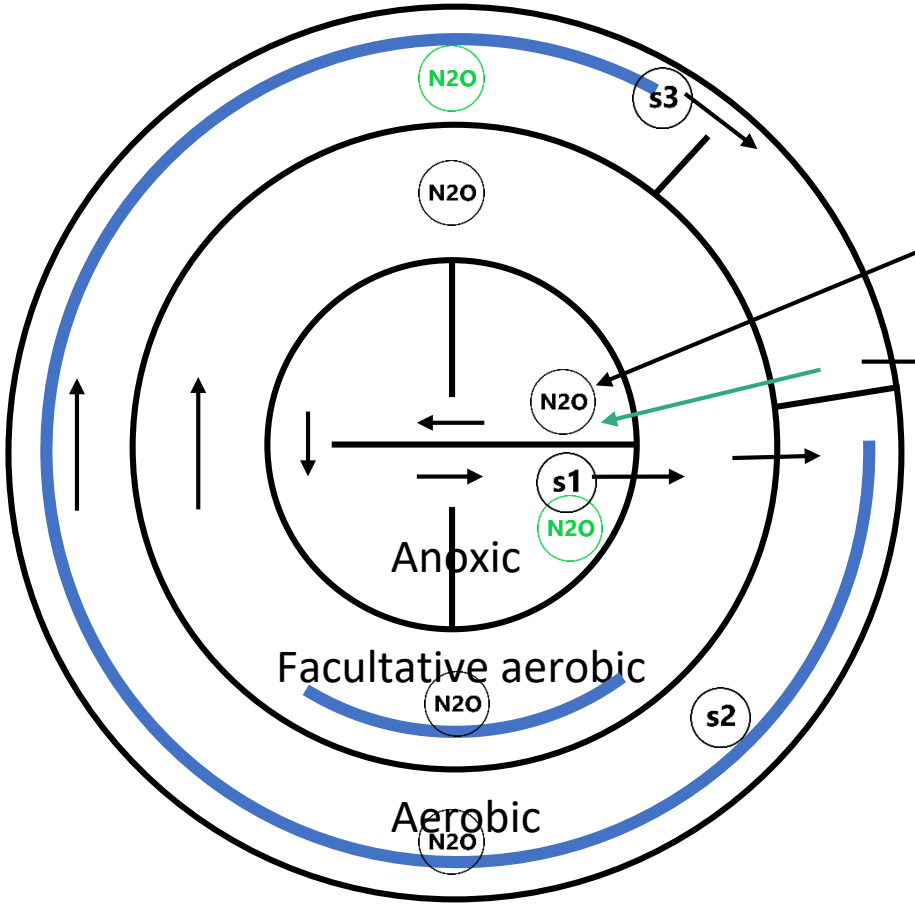
Interpretation

1. Recognizing current nitrogen removal strategy (control and configuration).
2. Understanding N_2O production.





Process configuration WWTP Land van Cuijk

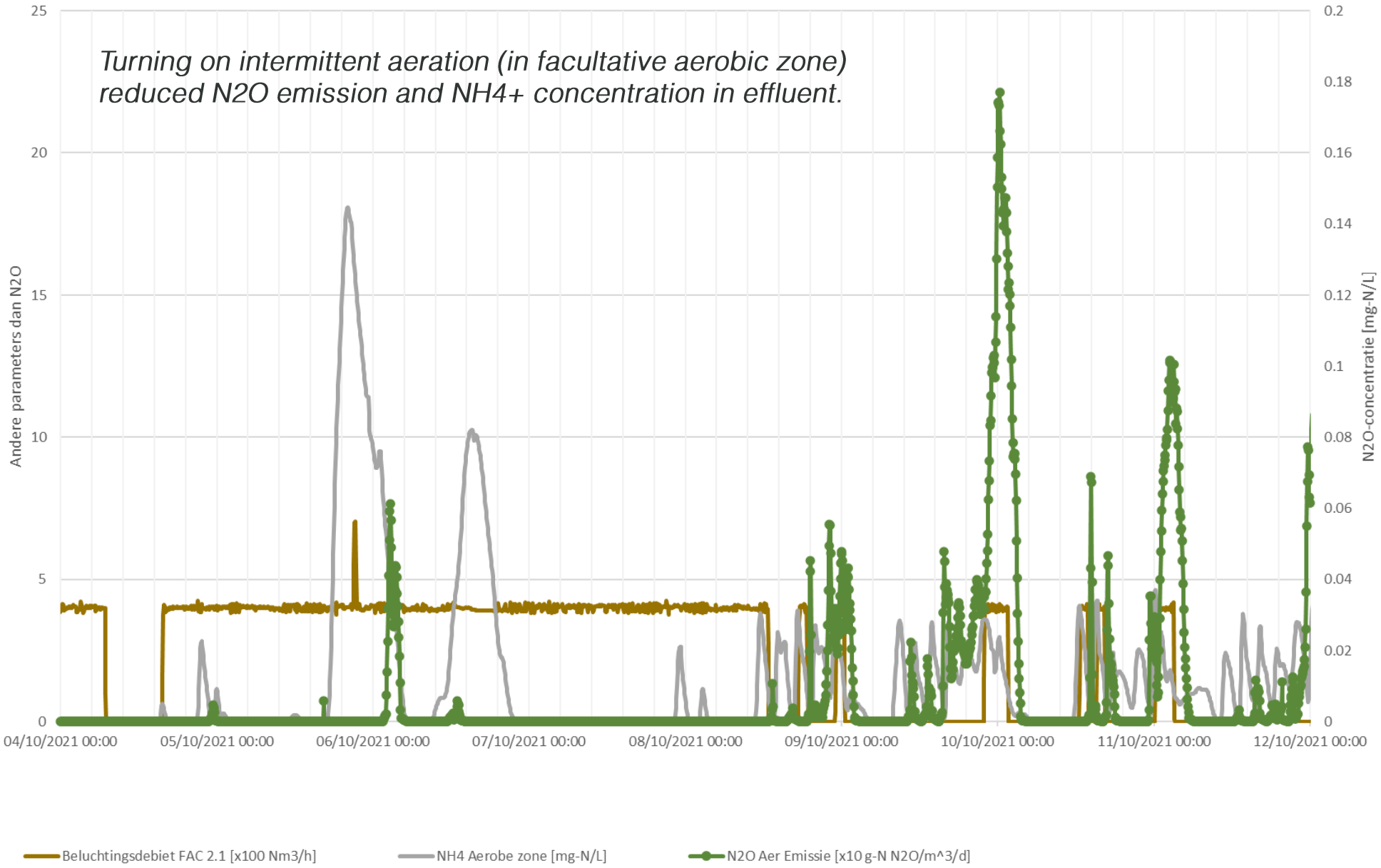


Legend
s1: NO_3^-
s2: DO, Temp
s3: NH_4^+, NO_3^-, ortho-P, DM
Blue line: Aerators

Application (Mitigation)

1. Identify potential solutions, e.g.,
    1. **Slow down PID control.**
    2. **Pinch amplitude of recycle flowrate.**
    3. **Base aeration flowrate on recycle flowrate, next to NH_4^+.**
2. Experiment, compare with reference lane.
3. Identify effects on N_2O production and other processes (N and P removal).

Another example (skipped)



Thanks for listening.
Questions?

Questions may also be sent to …

f.deheer@imd-ma.nl

+31 6 5171 5411

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