Field study and model simulations of sulfur and nitrogen transformations in a rising main receiving nitrate dosing

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Aquafin

• Collection and treatment of municipal waste water in Flanders, Belgium
• 247 wastewater treatment plants, 1174 pumping stations and 4735 km of (mainly concrete) collector sewers
Hydrogen sulfide / \( \text{H}_2\text{S} \) in sewers

Sulfide is formed under anaerobic conditions, \( \text{e.g.} \) in pressure mains

\[
\text{SO}_4^{2-} \rightarrow \text{H}_2\text{S}
\]

\( \bullet \) HRT
\( \bullet \) \( \phi \) + A/V-ratio
\( \bullet \) T
\( \bullet \) BOD
\( \bullet \) \( \text{SO}_4^{2-} \)
\( \bullet \) …

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**Diagram:**
- mg/L
- \( \text{O}_2 \)
- \( \text{Sulfide build-up} \)
Hydrogen sulfide / $\text{H}_2\text{S}$ in sewers

Consequences of $\text{H}_2\text{S}$ formation

- Odor complaints
- Concrete corrosion
- Health hazards

Diagram showing the gravity sewer, pumping station, pressure main, manhole, and gravity sewer connected with arrows indicating the flow of the concept.
How to deal with $\text{H}_2\text{S}$?

Dosing of chemicals in pumping station

Dosing of chemicals in pumping station

$\text{Ca(NO}_3\text{)}_2$  $\text{SO}_4^{2-} \rightarrow \text{H}_2\text{S}$

mg/L

gravity sewer  pumping station  pressure main  manhole  gravity sewer
Site description

Nitrate dosing tank:

- Required dose: 140 ton/year
- Cost price: 40,000€/year
- Dynamic model to describe nitrogen transformations

Odor complaints

- H₂S

Diagram details:

- 7055 PE
- Ø355 mm
- 4096 m
- 700m
- Pressure main in high pressure PE
- Gravity sewer in vitrified clay
- Pumping station
Aquafin’s model library for Simulating Sulfides in Sewers (Donckels, 2012)

**Model approach**

Aerobic + anaerobic carbon and sulfur transformations: existing WATS model

Nitrate dosing

- A shift in active bacterial population
- Stimulation of sulfide-oxidizing nitrate-reducing bacteria

Mohanakrishnan et al. (2009), Water Research 43: 4225-4237
Model approach

Aqua3S: Aquafin’s model library for Simulating Sulfides in Sewers (Donckels, 2012)

Anoxic transformations

- Two step denitrification processes: formation of intermediate nitrite
- Sulfide oxidation not included
Calibration and validation

1/hour

- Nitrate
- Nitrite
- COD
- BOD
- VFA
- sulfate

Grab samples:
- Nitrate
- Nitrite

Pressure main in high pressure PE

Gravity sewer in vitrified clay
Field campaign 1&2

CAMPAIGN 1

$S_{NO3}$ (mg N/L)

Time (d)

CAMPAIGN 2

$S_{NO3}$ (mg N/L)

Time (d)

$S_{NO2}$ (mg N/L)

Time (d)
• Denitrification rates are underestimated: additional anoxic processes:
  • Oxidation of sulfides by nitrate
Conclusions

• Model concept based on two-step denitrification not sufficient to describe field data
• Include sulfide oxidation in model concept

Thank you for your attention!