Software sensors for urban drainage and wastewater

Jonas Wied Pedersen
DTU Miljø

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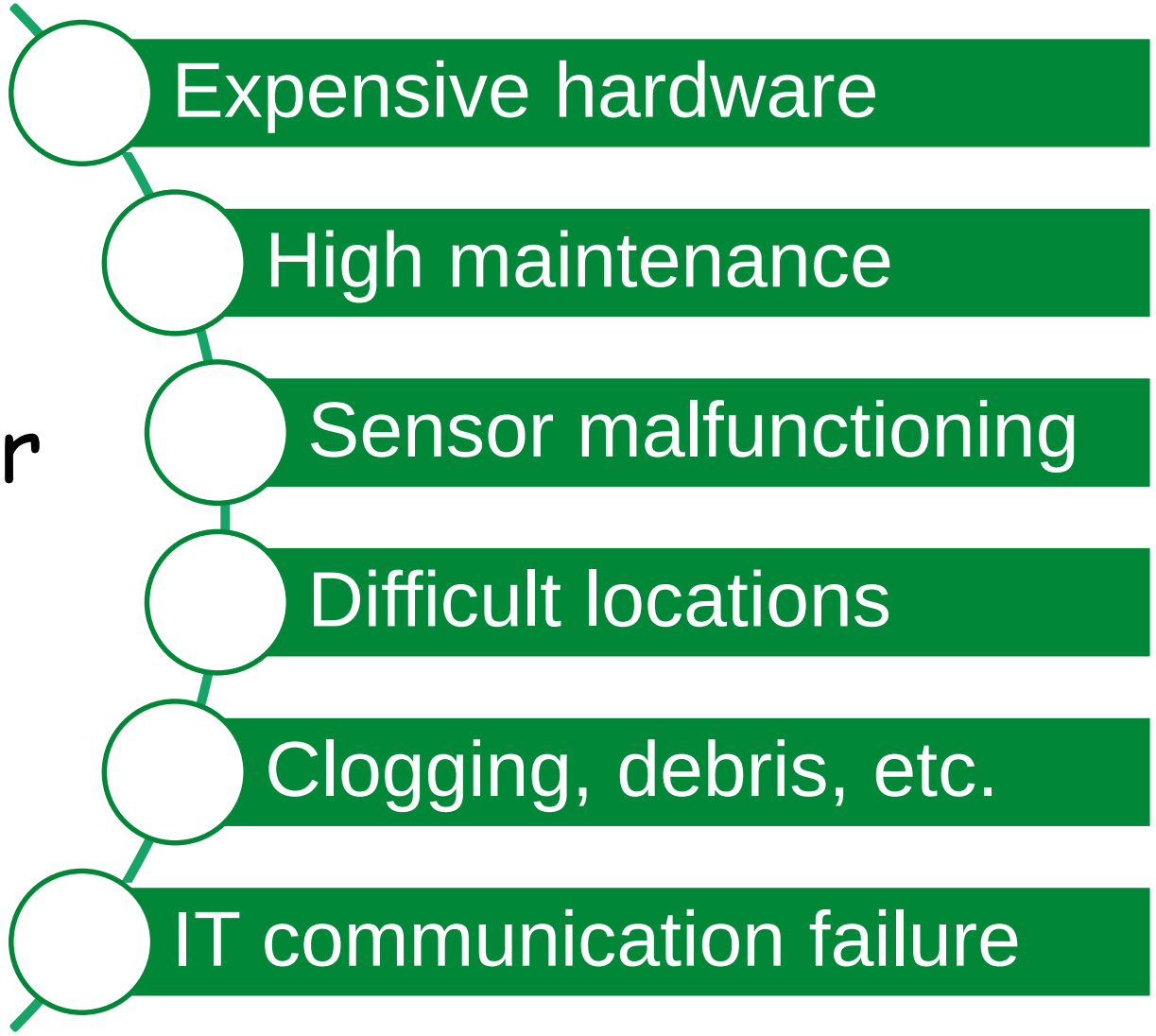
Smart, digitalized, real-time monitoring

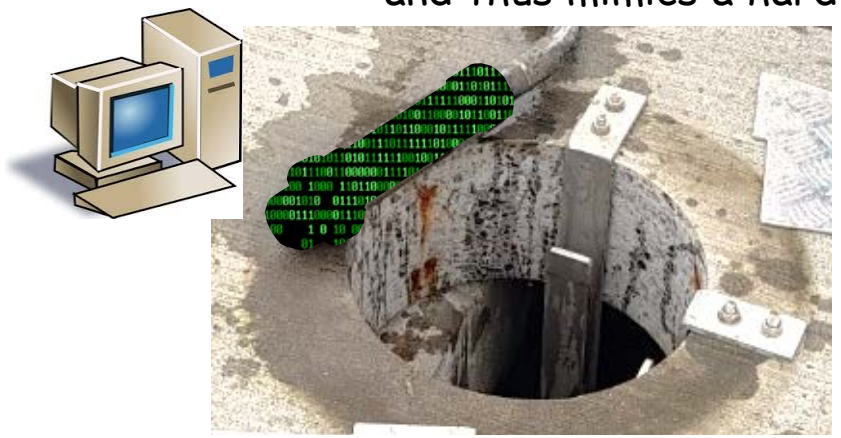
Getting high-quality sensor data can be difficult!



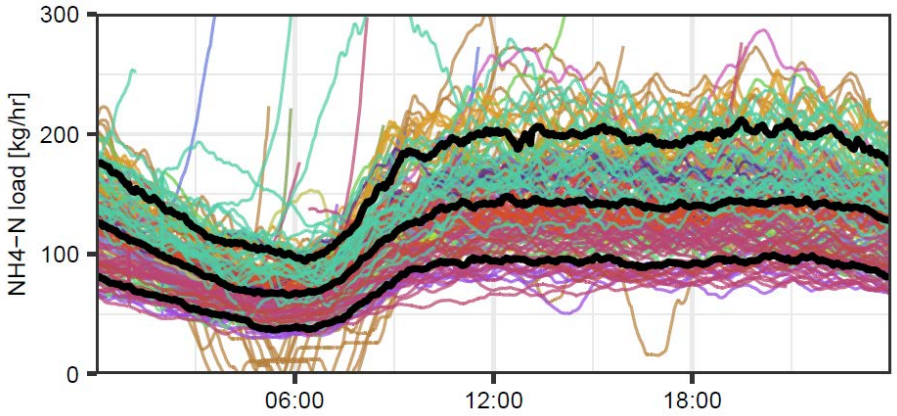
What is a software sensor?

Hardware sensor = physical component measures a variable in the system

Software sensor = model that indirectly "measures" a variable and thus mimics a hardware sensor



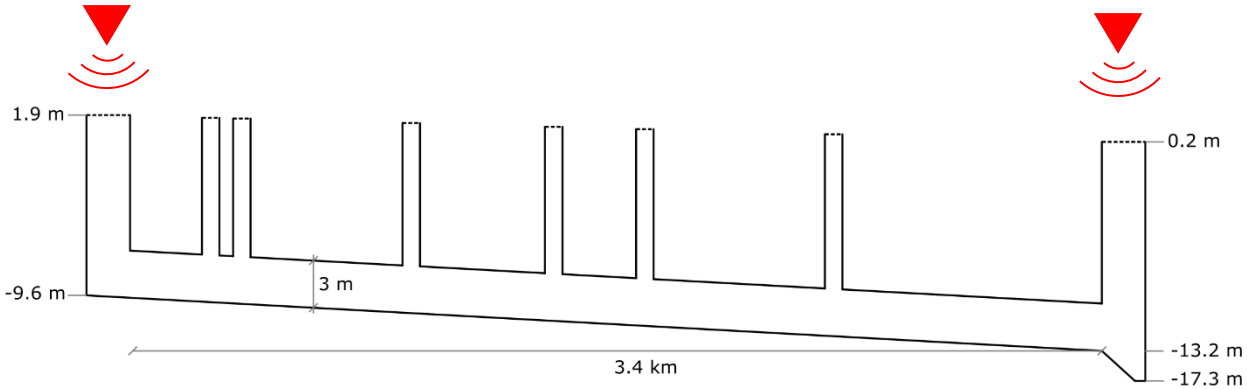
Three software sensor examples



"Monitor" NH_4^+ loads [kg/hr] at WWTP inlet

Input data: Flow

Method: Conceptual model



"Monitor"/validate water levels at upstream location

Input data: Downstream water level

Method: Data assimilation into MU model

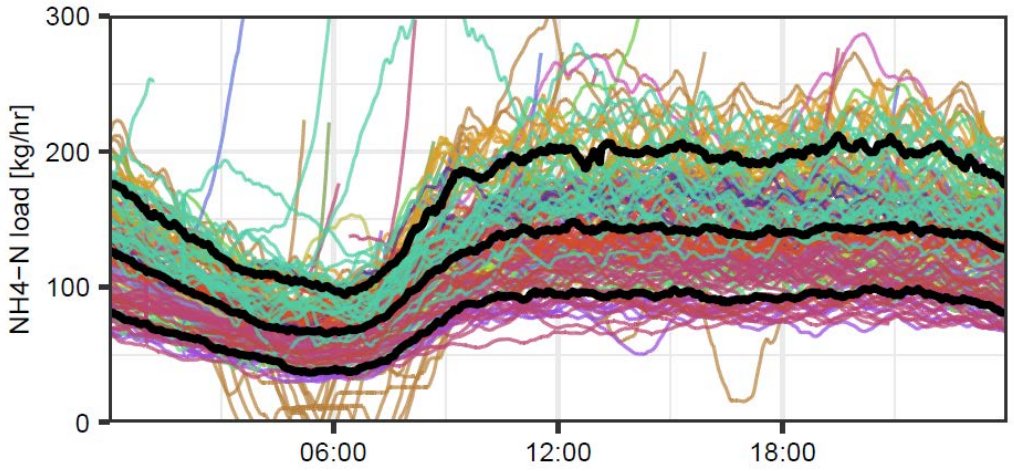
"Monitor"/predict water levels when sensor is unavailable

Input data: Antecedent water level, ToD, rain

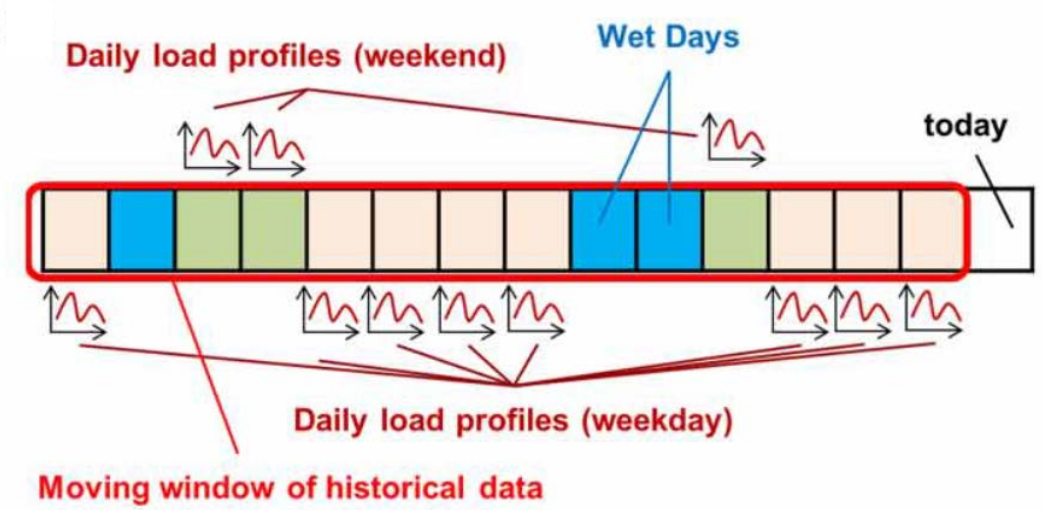
Method: LSTM neural networks

Use flow sensor to "monitor" NH_4^+ concentration

Measured NH4+ load for every day in a year

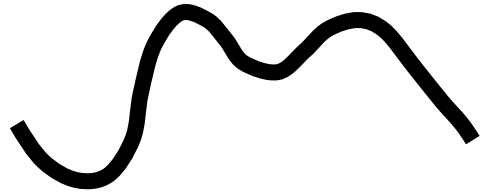


Train software sensor on all dry weekdays



Model parameters

$$F_{NH_4^+}(t) = \boldsymbol{\mu} + \sum_{k=1}^{2} (\boldsymbol{\alpha_k} \sin(2\pi kt) + \boldsymbol{\beta_2} \cos(2\pi kt))$$



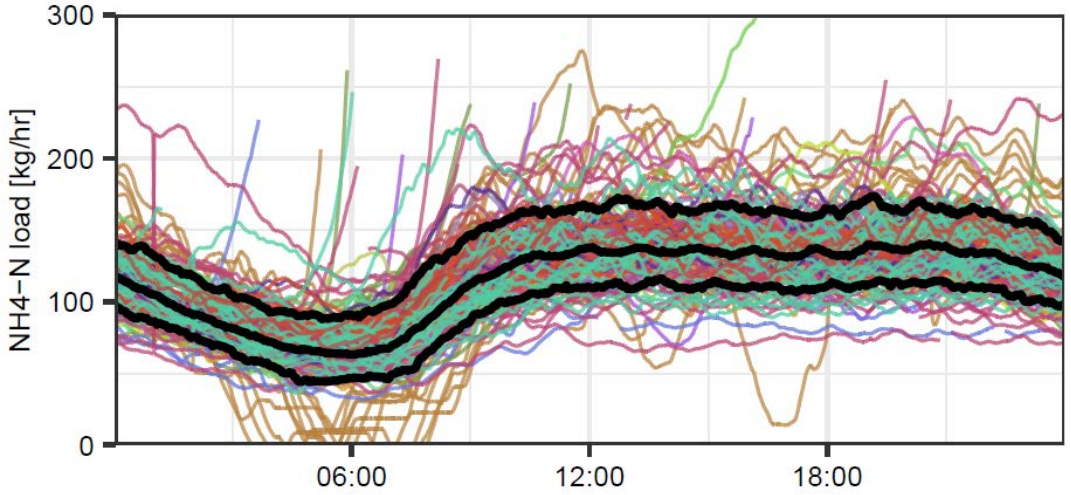
Trained relationship for load

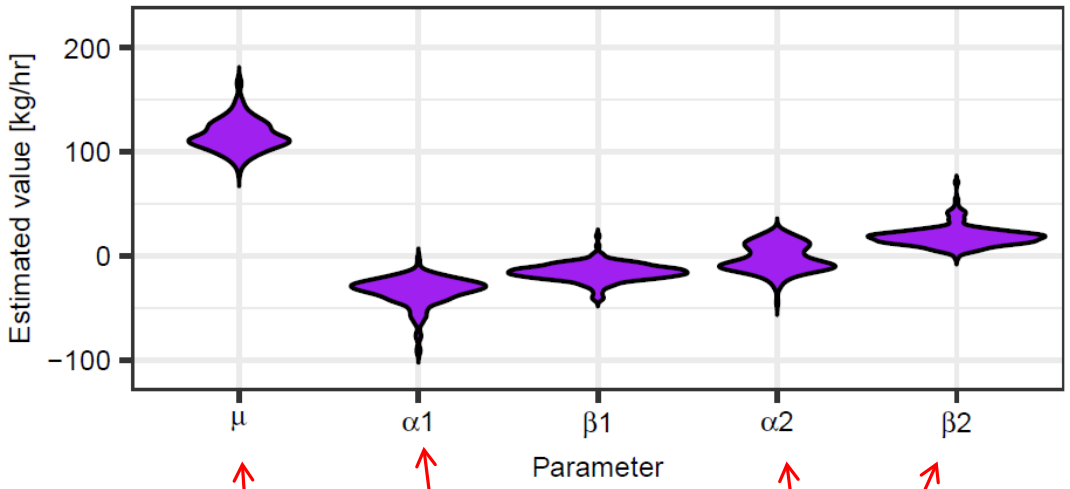
Real-time "monitored" concentration

$$S_{NH_4^+}(t) = \frac{F_{NH_4^+}(t)}{Q(t)}$$

Real-time flow observation

Get distributions of parameters for different days





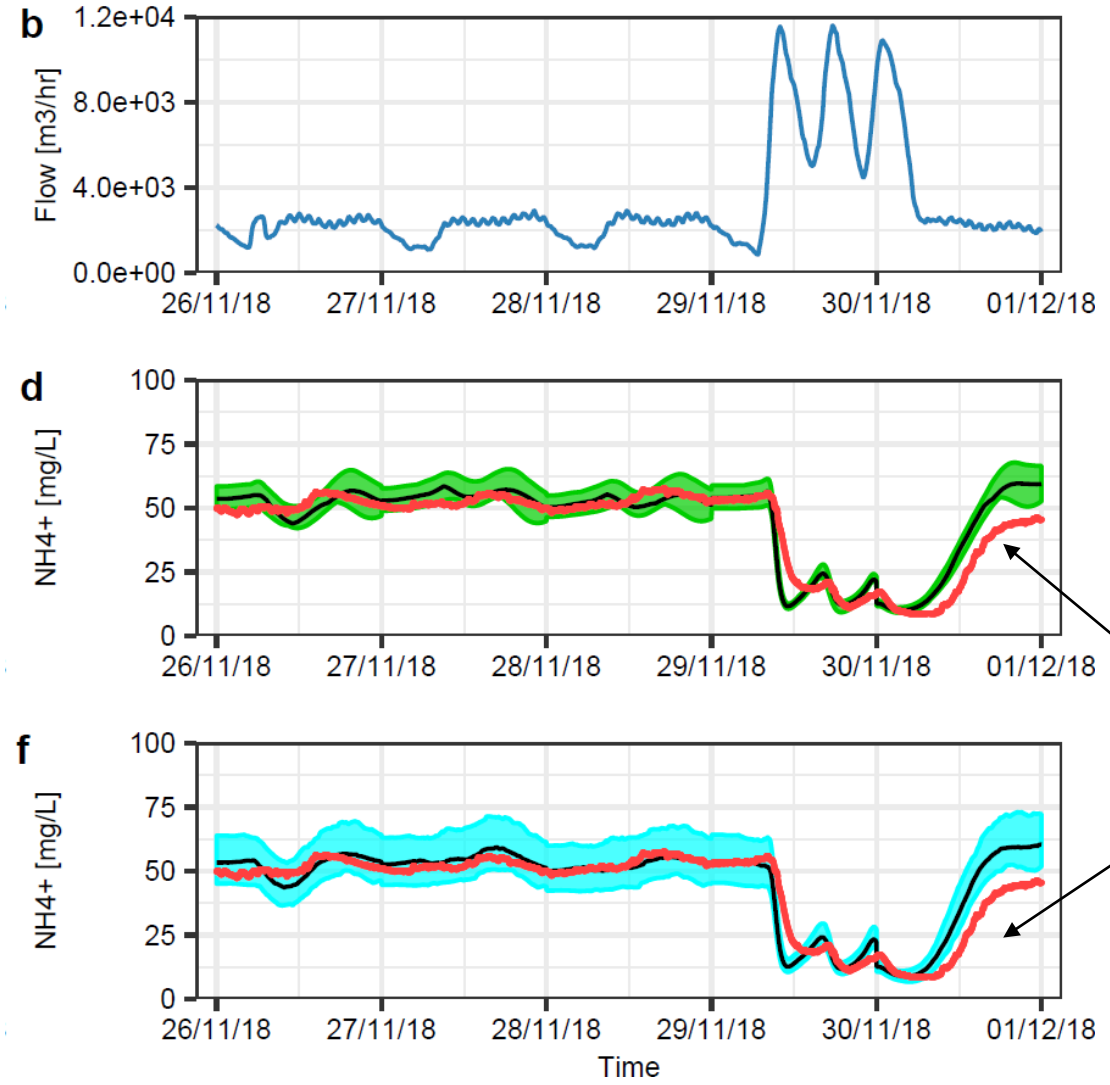
$$F_{NH_4^+}(t) = \boldsymbol{\mu} + \sum_{k=1}^{2} (\boldsymbol{\alpha_k} \sin(2\pi kt) + \boldsymbol{\beta_2} \cos(2\pi kt))$$

Example of software sensor with uncertainty estimate

Flow measurements:

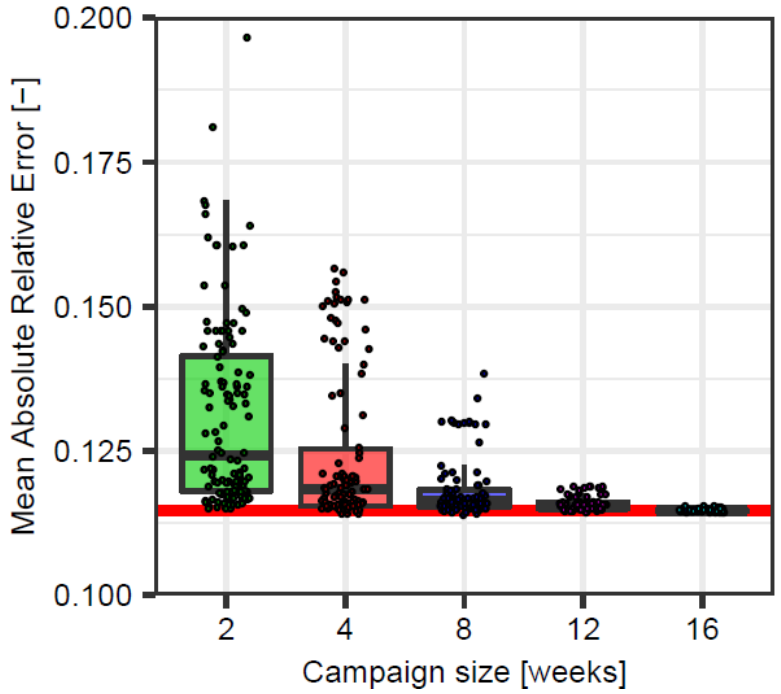
Trained on 2 weeks of data:

Trained on 16 weeks of data:

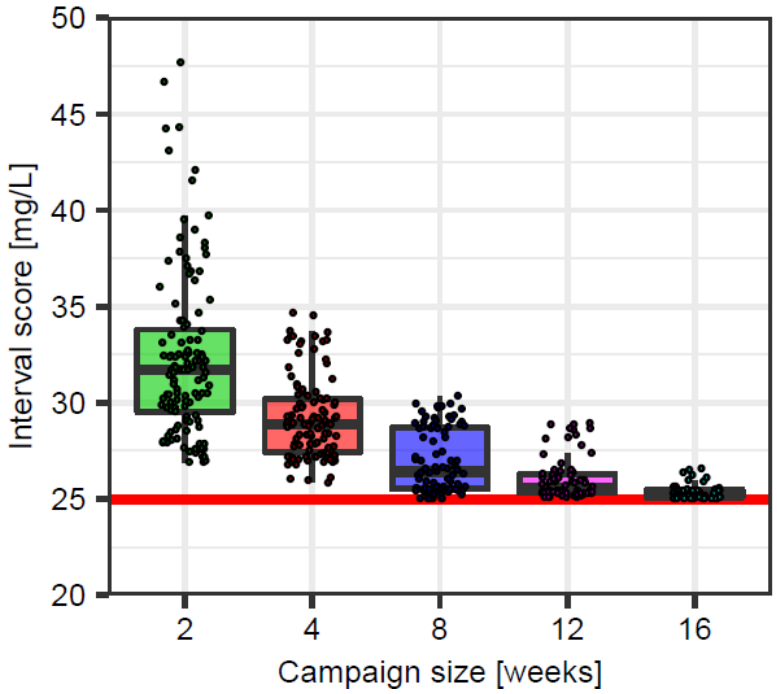


Long-term results

~8 weeks of training data = good median estimate



~12-16 weeks of training data = good uncertainty estimate



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Reconstruction of corrupted datasets from ammonium-ISE sensors at WRRFs through merging with daily composite samples

Jonas Wied Pedersen[a,*], Laura Holm Larsen[a], Carsten Thirsing[b], Luca Vezzaro[a,c]

[a] DTU Environment, Technical University of Denmark, Bygningstorvet, Building 115, 2800 Kgs, Lyngby, Denmark
[b] BIOFOS A/S, Refshalevej 250, 1432 København K, Denmark
[c] Krüger A/S, Veolia Water Technologies, Gladsaxevej 363, 2860 Søborg, Denmark

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ABSTRACT

Long-term, continuous datasets of high quality are important for instrumentation, control, and automation efforts of wastewater resources recovery facility (WRRFs). This study presents a methodology to increase the reliability of measurements from ammonium ion-selective electrodes (ISEs). This is done by correcting corrupted ISE data with a data source that often is available at WRRFs (volume-proportional composite samples). A yearlong measurement campaign showed that the existing standard protocols for sensor maintenance might still create corrupted dataset, with poor sensor recalibrations responsible for abrupt and unrealistic jumps in the measurements. The proposed automatic correction methodology removes both recalibration jumps and signal drift by using information from composite samples that already are taken for reporting to legal authorities. Results showed that the developed methodology provided a continuous, high-quality time series without the major data quality issues of the original signal. In fact, the signal was improved for 87% of days when a reference sample was available. The effect of correcting the data before use in a data-driven software sensor was also investigated. The corrected dataset

Evaluating the performance of a simple phenomenological model for online forecasting of ammonium concentrations at WWTP inlets

Luca Vezzaro IWA, Jonas Wied Pedersen, Laura Holm Larsen, Carsten Thirsing IWA, Lene Bassø Duus and Peter Steen Mikkelsen IWA

ABSTRACT

A simple model for online forecasting of ammonium (NH_4^+) concentrations in sewer systems is proposed. The forecast model utilizes a simple representation of daily NH_4^+ profiles and the dilution approach combined with information from online NH_4^+ and flow sensors. The method utilizes an ensemble approach based on past observations to create model prediction bounds. The forecast model was tested against observations collected at the inlet of two wastewater treatment plants (WWTPs) over an 11-month period. NH_4^+ data were collected with ion-selective sensors. The model performance evaluation focused on applications in relation to online control strategies. The results of the monitoring campaigns highlighted a high variability in daily NH_4^+ profiles, stressing the importance of an uncertainty-based modelling approach. The maintenance of the NH_4^+ sensors resulted in important variations of the

Luca Vezzaro IWA (corresponding author)
Krüger A/S, Veolia Water Technologies,
Gladsaxevej 363, 2860 Søborg,
Denmark
E-mail: *luve@env.dtu.dk*

Luca Vezzaro
Jonas Wied Pedersen
Laura Holm Larsen
Peter Steen Mikkelsen IWA
Department of Environmental Engineering (DTU Environment),
Technical University of Denmark,
Building 115, 2800 Kongens Lyngby,
Denmark

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