Design Project – SIE 2024

Initial steps towards fully automated Urine Nitrification

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Company:
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Project partner

VunaNexus has been operating a urine nitrification reactor with data accumulating since 2020. Until this project started, the data has never been analyzed in its entirety. With their operations expanding, there is an increasing need for full automation to decrease reliance on experienced employees to operate their systems.

Urine Nitrification

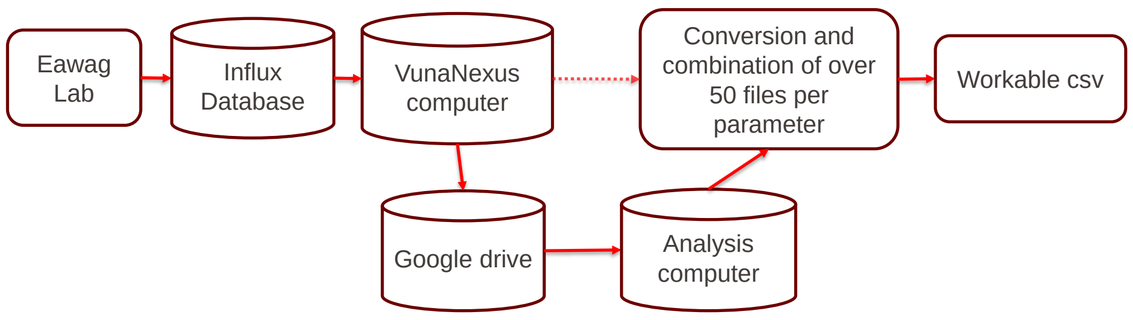
Steady urine nitrification occurs when the biological activities of ammonia-oxidizing bacteria (AOB) and nitrate-oxidizing bacteria (NOB) are balanced. Increase in nitrite concentrations indicate an imbalance and should be predicted to avoid complications.

Goals

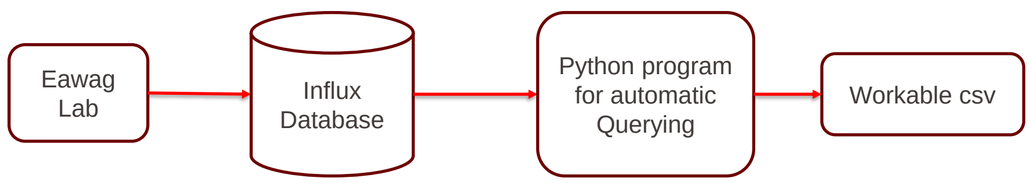
The goals of this design project include the assessment and analysis of the available data to characterize the mechanisms and feedback loops of the urine nitrification with machine learning in mind. Additionally, possible improvements to move towards fully automated process control were to be identified.

Data access

The data access pipeline at the beginning of the project was inefficient



After having difficulties, it has been enhanced and serves as a basis for future work



Improvements:

- No adjustments of script for converting data into workable csv when data is updated
- Consistent format of the queried data
- No intermediate storage
- Less Steps in the process which makes it work more consistently
- -Possibility to directly work with the csv file for analysis/plotting using excel.

Initial examination of the data:

- The density of datapoints from manual nitrite measurements is low (Fig. 2)
- Experiment documentation not designed to enable integration into automated data analysis pipelines, making it impossible to filter for relevant experiments and corresponding data
- Few changes of measurement values under known experimental circumstances

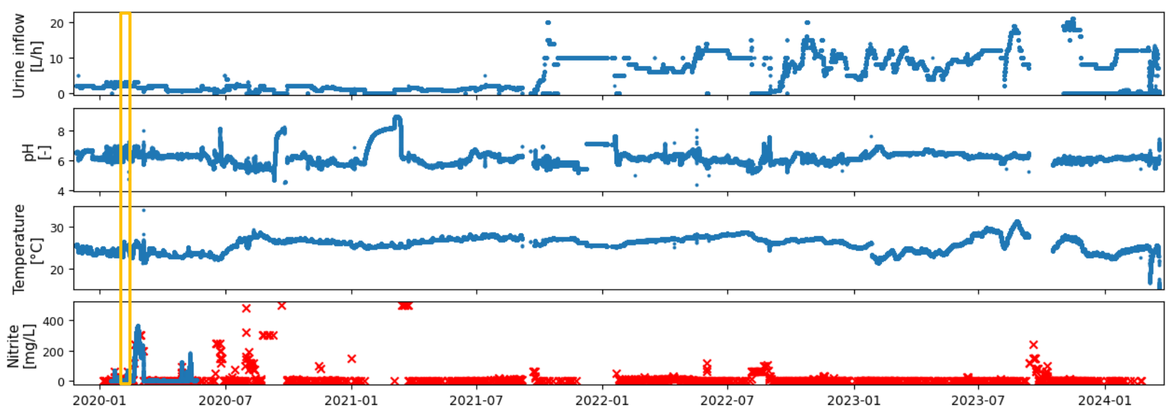


Fig. 1: The entire available dataset for nitrite, pH, temperature, and urine inflow

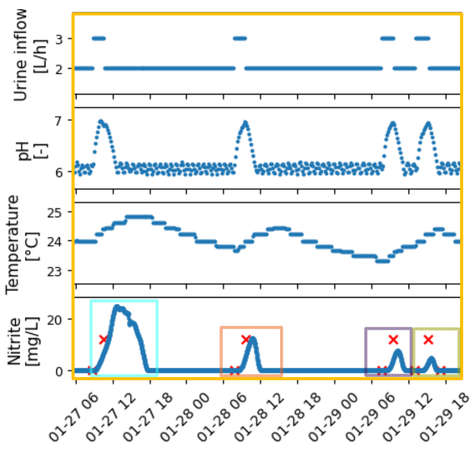


Fig. 2: Zoom of fig. 1, the data around the peaks in this plot was used to produce fig 3.

Digging deeper

Correlation analysis of the entire dataset after preprocessing did not yield conclusive results. For the subset of data containing continuous nitrite data, splitting into subsets showed that correlations between parameters are lower when they are unchanging compared to time periods when the are increasing/decreasing.

Isolating the data of **nitrite peaks** in fig. 3 shows that concentrations increase after pH increased and temperature stays high even after Nitrite returned to normal levels.

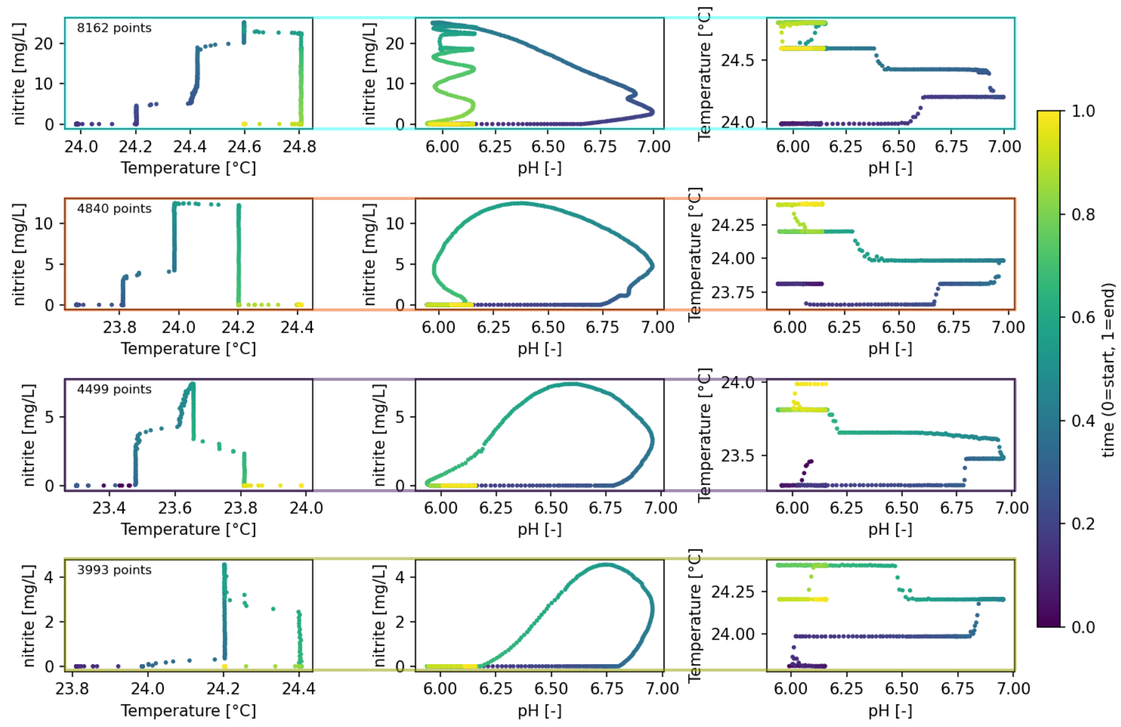


Fig. 3: Scatterplots of the data around the peaks of fig. 2

Conclusions and Outlook

The direct **outcomes** of this project include an improved **data accessing pipeline**, facilitating future data analysis. The data collected up until this point has been analyzed and its quality evaluated. Insight into the **evolution of nitrite, pH and temperature** during nitrite accumulation has been gained.

Based on the data evaluation, **recommendations** directing future work towards machine learning and automation were formulated. The key points are changing the experiment documentation to facilitate data analysis and shifting the focus from achieving stable nitrification to varying parameters during experiments, generating enough high-quality data suitable for modelling.