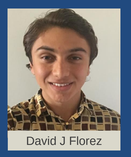
The coupled aerobic anoxic nitrous decomposition operation (CANDO) automated circuit of data collection (ACDC) system for nitritation reactor (RRS5)

Energy and resource recovery

Re-Inventing the Nation's Urban Water Infrastructure (ReNUWIt)



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Background

Wastewater ammonia may be released to the environment and end up in bodies of water. This nitrogen can lead to eutrophication, hurting photosynthetic algae and fish supply for human consumption. Nitrogen can also be toxic for marine life. And the growing population of cities only increases the wastewater and its potential harm. If nitrogen were to be well managed or retrieved from the wastewater, its derived compounds could be prevented from hurting aquatic ecosystems. **CANDO is a biological process that converts waste nitrogen into useful nitrous oxide**—which can be used to burn methane and produce electricity. Looking to selectively remove ammonia from wastewater, **this project is looking into the first reactor in a CANDO system that converts ammonia into nitrite.**

This is a lab-scale project for which a pilot scale exists in Delta Diablo, Antioch, California. With optimizations at the laboratory level that can be scaled up to the pilot reactor, hopefully a municipal reactor can be approved to start **Re**novating the **N**ation's **U**rban **W**ater **I**nfrastructure
The goals of the project are as follows:

- **Increase ammonia removal.**
- **Maximize the production of nitrite over nitrate (both are oxidized forms of ammonia).**
- **Minimize pH inhibition of nitrite-producing bacteria while manipulating pH to select against nitrate-producing bacteria.**

The automated circuit data collector was named **Joey**.

Approach

This individual approach will construct an Arduino system to monitor the dissolved oxygen, pH, temperature and oxidation-reduction potential of the tank where the nitritation reaction happens.

This will hasten the optimization component of research, since the computerized system can provide instantaneous readings and overall several orders of magnitude more data than manual measurements.

- Binh Nguyen's "How to Make a Data Logger for the Temperature, PH, and Dissolved Oxygen" on instructables.com, inspired and was the basis for Joey.
- The reactor runs on an automated 24 hour schedule with repetitive aeration and buffer addition at about 16.5 hours in. It holds about 3 L of fluid, has a solid retention time of 60 days and a hydraulic retention time of 2 days.
- Before a cycle with the Joey datalogger, the pH sensor had to be calibrated with 7, 4.01 and 10.01 pH standard solutions. The DO sensor was calibrated at air saturated water and 0 DO (sodium sulfite in cobalt nitrate standard solution).
- Data processing was done with excel and Python.

Image 1: Nitritation Reactor

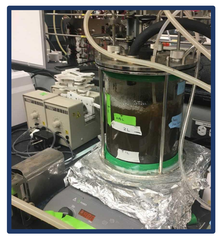
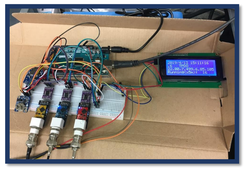


Image 2: ACDC Joey Data-logger



Results

The Arduino setup, named Joey Data-logger, collects four types of data, saves it with a timestamp to a micro- SD card and displays the immediate measurements on the LCD screen

Image 3: ACDC Joey Data-logger Design

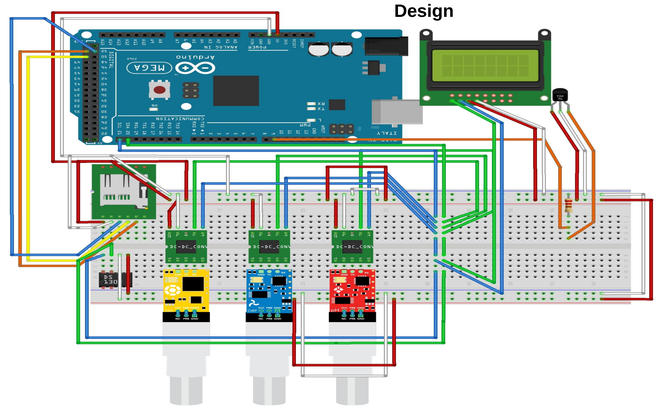
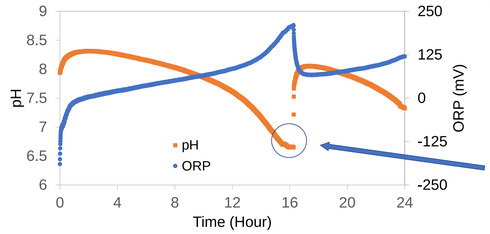


Fig. 1: pH and ORP for Nitritation Reactor



Optimization Opportunity

- Ammonia oxidation lowers the pH.
- Low pH hurt bacteria activity.
- Buffer addition must be well timed, and was late in this cycle.

New Information from the Data

The magnitude of data available allowed for precise insight.

- Positive slopes in DO demonstrate the aeration cycles.
- Negative slopes in DO represent the rates of bacteria nitritation.
- The overall slope from the DO pattern indicates decreasing bacteria activity and is correlated to lower pH levels.

As seen in the charts to the right., DO increases overall in the process, and the momentary slopes of DO change as well responding to the decreasing bacteria activity.

Fig. 2: DO Between 4.75 and 4.96 Hours

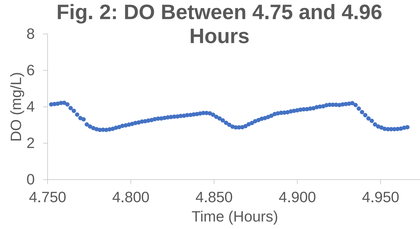


Fig. 3: DO Between 23.5 and 23.71 Hours

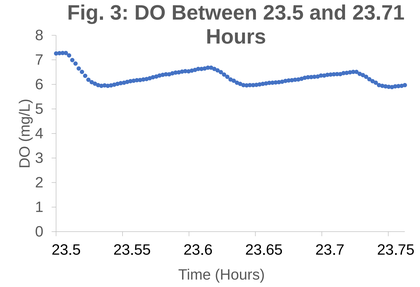
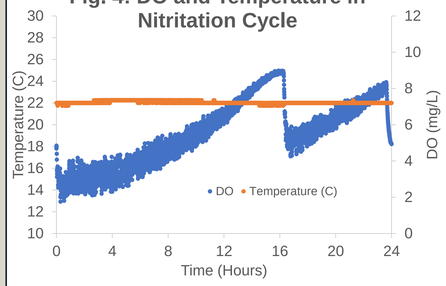


Fig. 4: DO and Temperature in Nitritation Cycle



More Ways to Optimize Reactor

The new data shows the smaller patterns in DO variation as well as it's overall increasing trend. These could later inspire experimentation with the aeration periods or the overall beginning and ending DO levels.

This could allow **bacteria to produce more nitrite or select for bacteria that can do so more efficiently with less DO.**

Conclusions

Introducing the Automated Circuit of Data Collection, Joey Datalogger, did provide more information on all aspects of the nitritation reactor that concerned its probes. Joey also provided insight into methods of measuring bacterial activity. Additionally, the time saved from not having to retrieve the collected data by hand allows for work in other aspects of the reactor, or on the other reactor to progress.

The largest barrier to greater results in this project was the expertise required to get Joey fully functioning, which speaks to the benefit of interdisciplinary collaboration. Not all projects could benefit equally from a similar component, but the advantage of bigger data could help speed up the research component of research and development in many cases.

Next Steps

Other aspects of the reactor and separate reactors can benefit from the feedback of the magnitude of data that automation provides. Moreover, the ammonia concentrations at the end of the cycle have been higher than desired.

- Other probes could increase the data available in the tank environment.
- Pumps hooked up to the basic buffer can also be added to the circuit so that pH may be regulated as well as monitored.
- The second reactor in the CANDO process could also be paired with an automated data collector like Joey. Between local maximums and their following minimums, the average slope can be used to derive bacterial oxygen consumption through a python program.
- Aiming to select for more rapidly growing bacteria, the solid retention time will be cut to 20 days.

Acknowledgements

My mentor, Phillip Zhiyue Wang and the entire CANDO team made this possible with their extensive field knowledge and guidance. Marion Lepert from lab 64 in Stanford's Packard building must also be recognized as absolutely essential to getting Joey to work.

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