Real-time, Low-cost Nitrate Detection in Wastewater

Introduction:

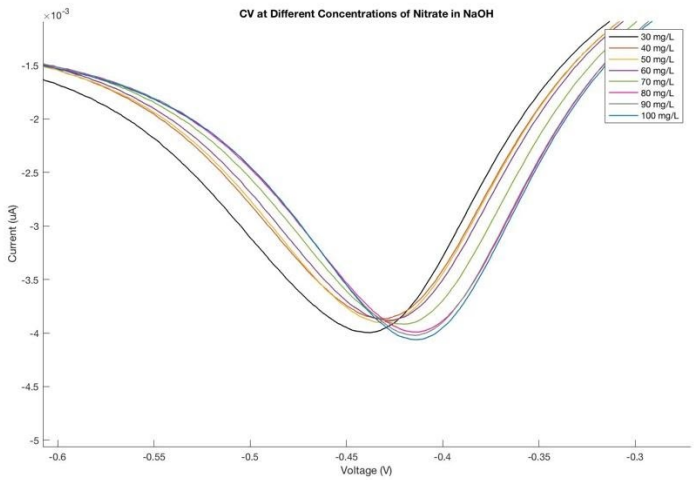
Nitrogen is an essential nutrient for plant development and is, thus, commonly found in fertilizers. However, direct ingestion of nitrogen due to agricultural runoff in water supplies can be harmful to the human body, particularly for babies. For example, “Blue Baby Syndrome” is a condition caused by the consumption of nitrogen that restricts the transportation of oxygen in the body. In addition to negative health effects, nitrogen runoff can have negative environmental impacts, such as polluting and destroying life in lakes and reservoirs (eutrophication).

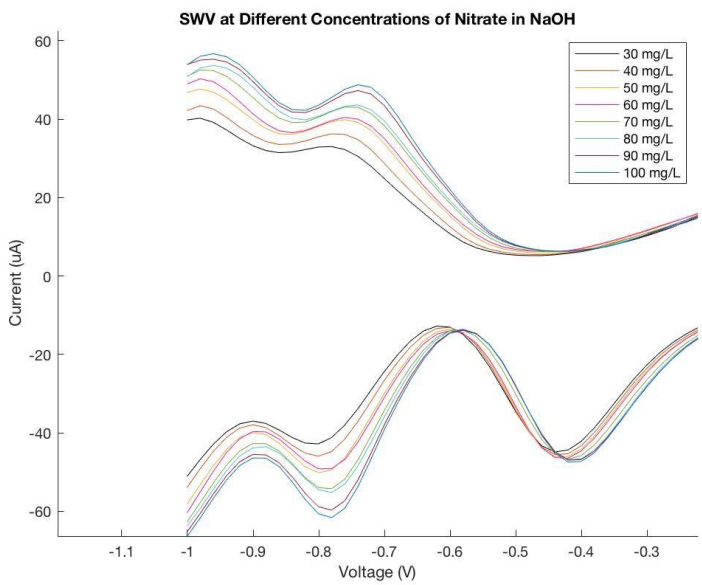
Electrochemical techniques are an effective way of measuring ionic content in a solution. Given that ions have an electrical charge, we can measure the magnitude of current that flows through a solution and thereby determine the concentration of the analyte. However, while it is simple to measure the conductivity of a solution, it is difficult to measure the conductivity of a specific ion. In order to detect the presence of a specific ion, we have to differentiate the ion of interest from other substances such as chloride, sulphate, phosphate, and sodium by understanding specific reaction kinetics.

My research is focused on developing a simple, inexpensive electrochemical sensor for the detection of nitrates in water through the use of voltammetry. The sensor will measure the ionic content of the water, and interface with the internet to send information about contamination to consumers. By monitoring their water, consumers can prevent consumption of polluted water, as well as determine their need for a more complex purification system.

Research Progress:

This semester, I tested and compared various voltammetric methods, looking for the most sensitive and feasible method. Below are a few results showing the sensitivity of cyclic voltammetry versus square wave voltammetry.





Both techniques provide a simple, linear relationship between concentration and current. By looking at the differences in the current peaks at different concentrations, it is clear that square wave voltammetry far outperforms cyclic voltammetry in its ability to sense changes in nitrate

concentration. I am still experimenting with the exact experiment parameters to maximize sensitivity.

Future Directions:

In addition to testing out different voltammetric options, I began working with Marios Sophocleous, an expert in sensors at the University of Cyprus. Marios has previously worked on ion-selective sensors for potassium and sodium ions.[1] He and I have worked on a sensor design involving a screen printed electrode and an ionophore membrane for sensing nitrates. Over the course of the upcoming semester, I hope to be able to build this sensor with him in Cyprus.

[1] M. Sophocleous, L. Contat-Rodrigo, E. García-Breijo and J. Georgiou, "Towards solid-state, thick-film K+ and Na+ ion sensors for soil quality assessment," *2020 IEEE SENSORS*, Rotterdam, Netherlands, 2020, pp. 1-4, doi: 10.1109/SENSORS47125.2020.9278872.