Electrochemical Sensor for Detection of Phosphorus in Stormwater

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Abstract

Phosphorus is one of the main elements behind the process of eutrophication, which hurts the aquatic life in any body of water. Unfortunately the current methods we have of detecting phosphorus in storm water requires expensive machines and much more time. The main purpose behind this research is to provide a way of measuring phosphorus levels in stormwater. This is achieved by using a electrochemical phosphate sensor that was made out of cobalt oxide nanoparticles by drop-casting[1] method that was previously used to test for phosphorus in drinking water.

Introduction

Eutrophication occurs when there is an excessive amount of nutrients in a lake or any body of water, that usually comes from land runoff, which causes the plants to grow at an exponential rate. With the large amount of plant growth that is occurring in the water the aquatic life dies off due to lack of oxygen. This nutrient pollution has become a problem not only for the habitats it has destroyed but for humans as well. The water not only becomes uninhabitable for the aquatic life, but it also becomes a danger to humans because the water could become toxic if left untreated. So, eutrophication is high on the list of priorities especially for freshwater lakes because states like Wisconsin often use the lake water for drinking. The main problem we are faced with as of right now is how can we tell how much phosphate is in the runoff produced by farms. As of right now the only effective method is to take a sample from the farm to a lab and analyze it using a UV Spectrometer. While that is an effective way of measuring phosphorus in a given sample it takes a while to do and UV spectrometers are not cheap. That is what this phosphate sensor tries to duplicate, a way of measuring phosphorus in stormwater without all of the extra steps and machinery. The sensor has been used before to test phosphorus levels in drinking water, but for this research project the goals is to see if this sensor can also be used in stormwater runoff.

Test the sensor to see if it has an affinity for detection of Phosphorus under the given conditions. Questions to be answered while conducting test:

➢ Does the sensor show any difference in measuring different concentrations of P Stock Solution?

➢ Does the sensor show any readings with a stormwater sample with an unknown concentration of phosphorus?

➢ Did the sensor accurately predict the concentration of phosphorus from the stormwater sample?

➢ How many times can one sensor be used to conduct this test?
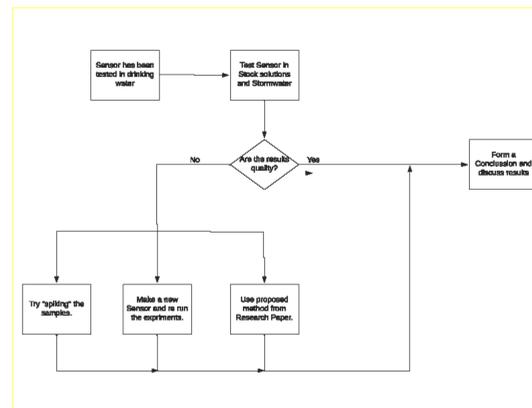
Methodology

*Figure 1: Flowchart for process of testing sensor.*

Method of getting a known concentration of Phosphorus:

• The first step in making the known concentration of Phosphorous solution is to make a stock solution of 100mg/L. We first take the compound KH_2PO_4 as source of phosphorous.

• Next we measure out the appropriate amount of KH_2PO_4 to achieve the 100mg/L concentration. Then transfer the weighted Phosphorus to a 1L volumetric flask. Next pour 1L of E-pure water into the flask and invert several time to make sure it is a homogenous mixture.

• The stock solution should not be used for the test but instead dilute solutions should be made from the stock solutions. The preparation for the dilution are: make sure the volumetric flask is cleaned with DI water, use 5 100ml volumetric flask to dilute the stock solution to a working standard.

• Next using a 100-1000μL pipette with the epT.I.P.S 50-1000μL tip, cleaned with a kimwipe and ethanol, extract exactly 0.005 ml of solution from the stock solution and transfer this solution to the 100ml volumetric flask. Pour E-pure water to just below meniscus line then use a bulb pipette to fill flask to the meniscus line, making sure the bottom the Semi-sphere should coincide the meniscus line. For the remaining 4 flasks repeat the same steps except change the amount of stock solution to .1, 0.5, 0.01, 0.05 mg P/L for each flask respectively.

Electrochemical Detection:

1. The first thing we have to do when testing the sensor is dip in in DI water for about 2-3 minutes and dry it off without touching the center
2. Open Circuit Voltammetry, Run time: 400 s, Sample interval: 0.1 s
3. Prepare cuvettes with concentrations of the P solution from low to high concentration.

Three-electrode Detection
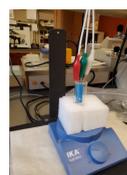
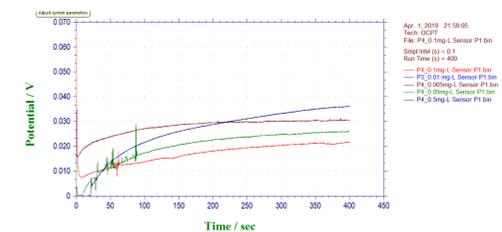Electrical potential reading

Preliminary Results

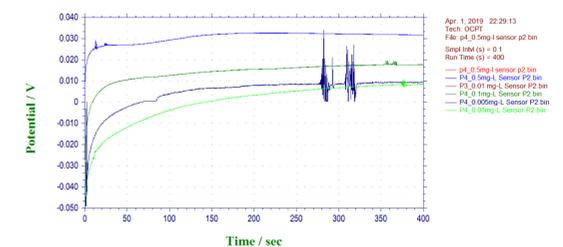Figure 2: Readings from Sensor P1 plotted at Potential Voltage over Time

Figure 3: Readings from sensor P3 plotted at Potential Voltage over Time

Discussion

• From our initial results we can see that each concentration of P solution gives a different reading.
• The sensors were not calibrated so that is why there are some concentration are higher than others.

Conclusion

From these initial test we can answer two of our previous questions and predict the outcome for future tests. The sensor was able to differentiate between different concertation of P solution and gave a different reading for each. Also this was the second set of results we achieved because we ran the experiment twice with the same concentrations and the same sensors. The next step in our experiments is to test the sensor with a stormwater sample of a known concentration and see if the sensor can achieve around the same value per concentration.

Literature cited

[1] L. Zhu, X. Zhou, H. Shi, Front. Environ. Sci. Eng. 2014, 8(6), 945-951.

Acknowledgments

For further information

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