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 stormwater requires expensive equipment and is time consuming. The main purpose of this research is to evaluate the performance of an electrochemical sensor for detection of phosphorus in stormwater.

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 algae to grow at an exponential rate.[2] With the large amount of algae 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.[3] The main problem our state is faced with as of right now is how can they 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.[2][3] While that is an effective way of measuring phosphorus in each 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 the extra steps and machinery. This research project the goals is to see if this sensor can also be used in stormwater runoff.

The research questions that need to be addressed are:

- How conductive is zeolite and how does it compare to other highly conductive materials?
- Is the zeolite more conductive with different materials incorporated into it ?
- Will a high level of conductivity in the zeolite result in better absorption for the sensor?

Methodology

EPA Method 5.1 for determination of 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, the appropriate amount of KH_2PO_4 is measured out to achieve the 100mg/L concentration. Then transfer the weighted Phosphorus to a 1L volumetric flask. Next, 1L of E-pure water is poured 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 as follows: make sure the volumetric flask is cleaned with DI water, use five 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.

Measuring the Conductivity:

A Semiconductor was used to measure the conductivity of various objects then compared to zeolite.

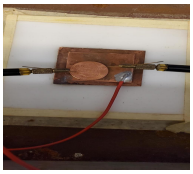

Figure 1: Testing conductivity of copper penny.

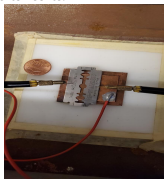

Figure 2: Testing the conductivity of a stainless-steel blade.

Preliminary Results

The Semiconductor used doesn't test specifically for conductivity instead it finds the resistance of an object. Conductivity is just the reciprocal of resistance so when the resistance is low, we know there is a high conductivity and vice versa.

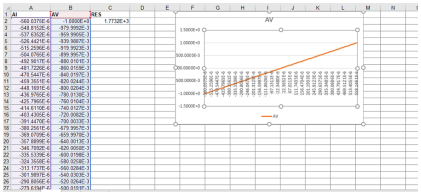

Figure 3: Results compiled from the semiconductor.

Discussion

From these initial tests we can see that zeolite has a high conductivity when compared to other materials. When looking at the anatomy of the zeolite used it makes sense because of it's high surface area. So, from the test results we see that zeolite would be good to coat the sensor in to have a high absorption capacity and be more accurate in detecting the levels of phosphorus in stormwater runoff.

Conclusion

- Initial results indicate zeolite has a high conductivity than most natural materials.
- Zeolite is a great candidate for using in sensor to detect phosphurs.

Literature cited

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[2]"Sources and Solutions: Stormwater." EPA, Environmental Protection Agency, 15 Apr. 2019, www.epa.gov/nutrientpollution/sources-and-solutions-stormwater.

[3]"Causes, Effects and Solutions to Eutrophication." Conserve Energy Future, 15 Jan. 2017, www.conserve-energy-future.com/causes-effects-and-solutions-to-eutrophication.php#:~:text=.

[4]Yang, J., Kwak, T.-J., Zhang, X., McClain, R., Chang, W.-J., & Gunasekaran, S. (2016, November 22)

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For further information

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