Woodchip Bioreactors

The Search for Fewer Nitrates

**TEACHER NOTES & ACTIVITY PREP INSTRUCTIONS**

**Iowa State University scientist background:**

In 2008, Dr. Michelle Soupir joined the Agriculture and Biosystems Engineering department at Iowa State University. The goal of Dr. Soupir’s research program is to conduct basic research to move us toward more sustainable water systems. Dr. Soupir uses lab- and field-based research projects to monitor the occurrence, fate and movement of nutrients and microorganisms in surface and drainage water.

Photo credit: Iowa State University

In 2013, Dr. Soupir’s lab began a project on which these curriculum modules are based. Experimental woodchip bioreactors were designed and installed at the Agricultural Engineering Research Farm near Ames, Iowa. These pilot-scale woodchip bioreactors are used to evaluate the nutrient removal from agricultural drainage water. Dr. Soupir’s students manipulate a variety of variables including hydraulic retention times, bioreactor fill materials, and influent nutrient conditions to determine the effectiveness and efficiency of the bioreactors and investigate ways to make bioreactors work better.

**Research background:**

Many parts of the Upper Midwestern United States have wet soils that require drainage in order for them to be used for agriculture. Draining of subsurface water (tiling) in farm fields is a practice that farmers have used for more than 100 years because doing so results in a significant increase in crop yield. Concerns have grown, however, about the effect this practice has on the movement of pollutants (i.e., nitrates and phosphates) through fields and into waters. systems. Nitrate (NO3-1), which can be present in high amounts in drainage water, makes its way into streams, rivers and lakes where it unbalances ecosystems and can result in hypoxic conditions, as we have seen develop in the Gulf of Mexico, also known as the Gulf Dead Zone.

Woodchip bioreactors have proven to be a simple, yet highly effective way to remove nitrate pollution without impacting current land management practices. Field runoff water is collected via tiling and diverted into the bioreactor, which is essentially a buried trench filled with woodchips. Denitrification occurs when microbes living on the surface of woodchips (or other suitable material) use the wood as a carbon source to convert nitrate to nitrogen gas (N2). The result is cleaner water which can be discharged into existing streams and rivers.

**Students’ use of the Science and Engineering Practices:**

* Students will collect data to serve as the basis for evidence to answer scientific questions or test design solutions. SEP-INV-M4/H2
* Students will analyze and interpret data to determine similarities and differences in findings and/or optimize a process. SEP-DATA-M7/H6
* Students will construct a written argument supported by evidence and scientific reasoning to support or refute an explanation. SEP-ARG-M3/H4

**Overview:**

In this activity, students use various forms of data to determine the relative effectiveness of several woodchip bioreactors. The results from gel electrophoresis (DNA fingerprinting), water quality sampling, and general information about the bioreactor are used to do this. Students visit four different stations (bioreactors) where they collect relevant information about the bioreactor’s activity and effectiveness in removing nitrates from flow-through water. A discussion can be had upon conclusion of the activity using these questions or similar:

* What evidence seemed most/least useful in determining the effectiveness of a bioreactor?
* Was any ONE of the bioreactors more effective than the others? What evidence did you use to make this determination?
* If you were a researcher at Iowa State University, what might be your next steps in this project? What else do you want to know/learn?

**Activity Preparation:**

1. Remove the supplies from the bag provided by the BOEC.
2. Remove the bioreactor data sheets and accompanying electrophoresis gel from the bags. Place the gel in the empty square on the data sheet. Scatter these around the classroom, creating four stations for students to visit.
3. Make copies of the student pages (front/back, flip on short side) and fold them in half, if desired. Students may work alone or in pairs/small groups.
4. Provide students time to visit all four stations, collecting necessary information from each one.
5. Use the discussion questions above to help students process and make sense of their findings.

**Take-aways:**

* Data collected from the bioreactors is not “clean”. Some data may contradict other findings, making it more difficult to determine a “winning” bioreactor.
* Research scientists use a variety of data when trying to discern the effectiveness of a project/system. This serves as the basis for evidence to answer scientific questions.
* Data sets vary in size/scale. Sometimes they are messy and require analysis from many perspectives.

**Want to know more?**

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