How Do Agricultural Residue Media Perform in Denitrifying Bioreactors at Low Temperatures?

Denitrifying bioreactors can be effective for removing nitrate from agricultural tile drainage; however, questions about cold springtime performance persist. The objective of a study published in the May–June 2016 issue of the Journal of Environmental Quality was to improve the nitrate removal rate of denitrifying bioreactors using corn cobs (CC), corn stover (CS), barley straw (BS), and CC followed by a compartment of wood chips (CC+WC) rather than WC. Tests were run in laboratory columns at 60 and 35°F.

Nitrate removal rates were highest for CC and lowest for WC at 60°F, 0.059 and 0.002 lb N yard⁻³ bed day⁻¹, respectively. At 35°F, CC (0.012) and CC+WC (0.011) were highest. However, the ag residues released more carbon into the outflow water than WC. The microbial populations were measured and found to be higher for the ag residues than WC at 60°F, and CS and BS were higher than WC at 35°F. Nitrous oxide, a greenhouse gas, was measured and found to be a higher percentage of nitrate removed at 35°F (7.5%) than at 60°F (1.9%).

Overall, the combination of CC followed by WC has the potential to increase nitrate removal at cold and warm temperatures and to keep greenhouse gas production to a minimum. This idea awaits field trial.


Reduced growth of corn near the crop–buffer interface.
Tightening Nitrogen and Carbon Cycling Using Clays

Nitrogen (N) and carbon (C) dynamics in agricultural settings are central to the global issues of food production and environmental pollution. Low-impact technologies are being sought to limit the gaseous release of these elements, which contribute to climate change and poor nutrient-use efficiency. Most technologies trialed to date have involved the application of chemical inhibitors to retard N mineralization processes. While some of these approaches have been effective in certain contexts, there is concern regarding the environmental persistence of these chemicals and their effects on agricultural ecosystems as well as human health.

In the March–April 2016 issue of the Journal of Environmental Quality, researchers report on a process-based investigation into the potential for clays to decrease gaseous N and C losses from soil-applied organic fertilizers. The team found that the clays could decrease ammonia (NH₃) emissions by 2× and nitrous oxide (N₂O) emissions by 3× and improve C retention by up to 10× compared with untreated fertilizer applications. This novel approach presents a promising opportunity to develop a technology to improve nutrient cycling in agricultural settings, particularly given that clays are ubiquitously distributed and environmentally benign. The team is testing the technology at the field scale.


Moving Denitrifying Bioreactors Beyond Proof of Concept

Denitrifying bioreactors are organic carbon-filled excavations designed to enhance the natural process of denitrification for the simple, passive treatment of nitrate nitrogen. Research on and installation of these bioreactors has accelerated within the past 10 years, particularly in watersheds concerned about high nonpoint-source nitrate loads and also for tertiary wastewater treatment.

A special section in the May–June 2016 issue of the Journal of Environmental Quality aims to firmly establish that denitrifying bioreactors for treatment of nitrate in drainage waters, groundwater, and some wastewaters have moved beyond the proof of concept. This collection of 14 papers expands the peer-reviewed literature of denitrifying bioreactors into new locations, applications, and environmental conditions. There is momentum behind the pairing of wood-based bioreactors with other media (biochar, corn cobs) and in novel designs (e.g., use within treatment trains or use of baffles) to broaden applicability into new kinds of waters and pollutants and to improve performance under challenging field conditions such as cool early season agricultural drainage. Concerns about negative bioreactor by-products (nitrous oxide and hydrogen sulfide emissions, start-up nutrient flushing) are ongoing, but this translates into a significant research opportunity to develop more advanced designs and to fine tune management strategies. Future research must think more broadly to address bioreactor impacts on holistic watershed health and greenhouse gas balances and to facilitate collaborations that allow investigation of mechanisms within the bioreactor “black box.”

The special section should be online by mid-May at http://bit.ly/1TLFykv. Until then, view articles from this special section on the “Just Published” pages at http://bit.ly/1U5yldx.

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Nitrogen and carbon cycling improvements achieved through clay additions to organic fertilizer applications to soil. Data are upper and lower standard errors about the mean.
Remediating Brine-contaminated Soils From the Surface

In the oil and gas industry, drilling and fracturing operations produce saline-sodic wastewaters (i.e., brines) as a byproduct. These brines commonly contain salts at concentrations similar to or well above that found in seawater. When a brine is released into the environment, soil remediation is necessary, and most methods involve either leaching the salts below the root zone, a time-consuming process, or the complete excavation of the contaminated soil.

A recent article in Agricultural & Environmental Letters reports on a new method for removing salts from brine-contaminated soils. Unlike other brine remediation techniques, this new in situ method removes salts from the soil surface and may expedite the remediation process.

Researchers found that a crystallization inhibitor (ferric hexacyanoferrate) prevented salts from crystallizing as a cemented crust at the surface of soil columns contaminated with a NaCl brine. Instead, the salt effloresced above the surface as dendritic formations that were easily harvestable without mechanically disturbing the soil. The researchers harvested 29 to 57% of the brine salts from the soil surface within seven days after efflorescence began after a single application of the crystallization inhibitor.

Given the need for quick and effective remediation options, the use of crystallization inhibitors shows great potential and could be useful for brine spill first responders as well as coupled with other remediation methods to expedite the full remediation of brine-contaminated soils.


Probing Impacts of Fertilization on Soil Organic Matter with Light

Soil organic matter (SOM) is a primary determinant of soil quality, regulating many important characteristics and processes. It is exceedingly diverse and inextricably related to the myriad life forms in healthy soil. Studies of SOM typically employ a series of chemical extractions to remove operationally defined categories of SOM and then determine their properties by various means.

A study in the April issue of Vadose Zone Journal examined the potential for a sophisticated optical technique to characterize SOM in bulk mineral soil and extracts to probe long-term changes related to different fertilization practices. Specifically, Fourier transform infrared spectroscopy (FTIR) was used to assess long-term changes in SOM in soils that had been systematically subjected to different fertilization schemes. FTIR provides a sensitive and non-destructive way to investigate SOM by measuring the selective absorption of specific wavelengths by distinct functional groups: common molecular appendages on organic molecules that tend to behave similarly in chemical reactions. The investigators complemented the FTIR results with measurements of cation exchange capacity (CEC).

Building on studies designed to investigate the effects of different fertilizer treatments on crop nutrition and yield, the investigators extracted SOM from four distinct experimental plot areas in three regions of Germany. These areas had been subject to 31 to 95 years of different, continuous fertilizer treatments: no fertilizer, manure only, manure plus mineral nitrogen, and mineral nitrogen only.

Results indicated that all types of fertilization increased CEC in bulk soil; however, manure and mineral nitrogen had opposite effects on the closely bound SOM extract. Specifically, long-term manure application increased CEC by as much as 40% (relative to unfertilized controls) while long-term mineral nitrogen application decreased CEC by as much as 15% (relative to controls). Corresponding changes in functional groups were identified with FTIR.

This study indicates that long-term fertilization practices have the potential to change the amount and composition of SOM across the full range of organic compounds in soils. Combining differential extractions with FTIR and CEC analyses in long-term studies can provide valuable insights into the role of agricultural practices on soil carbon.


Dendrite formation following the infiltration of the crystallization-inhibitor ferric hexacyanoferrate in a brine-contaminated soil column.
Development of a Portable Field Phenotyping Platform

Accurately selecting superior plants is the key to plant breeding, but many traits like yield are controlled by many genes and are also impacted by the environment. While plant breeders have traditionally relied on time-consuming methods for measuring plant traits, termed phenotyping, new technology offers opportunities to both increase the speed at which these measurements are collected as well as the accuracy of measurements.

In the May–June 2016 issue of Crop Science, researchers report development and evaluation of a low-cost, high-throughput phenotyping platform call the “Phenocart.” The platform measures spectral reflectance and canopy temperature while simultaneously recording precise GPS position information. Using the platform, researchers could take more than 70,000 data points per hour while reducing the processing time of data collection. The platform performs as well as existing methods while dramatically reducing the time and increasing the information available to plant breeders.

Applying advances in technology, like the Phenocart, will allow plant breeders to make faster progress. Additionally, the dense phenotypic data will allow for improved genomic selection models as well as information for genetic mapping and helping geneticists understand which genes are controlling important traits.

Cotton Pollen Sensitivity to Low Humidity Can Limit Natural Outcrossing

Adventitious presence is defined as the unintended presence of unwanted biotechnology traits in a seed lot. With the majority of U.S. commercial cotton cultivars containing proprietary technologies, today’s cotton breeders must be careful to ensure that the company technologies do not find their way into public cultivars under development.

In the May–June 2016 issue of Crop Science, researchers evaluated the genetic diversity in the ability of mature cotton pollen to move to neighboring cotton plants. Six cotton cultivars were studied because of their identified differences in pollen humidity sensitivity. Differences in outcrossing of 5 to 15% were observed under both irrigated and dryland production systems. Year-to-year variability was larger than genetic differences within a year. The lowest levels of outcrossing were observed for cotton cultivars having pollen with the greatest sensitivity to low humidity.

The results suggest that the pollen desiccation in response to low humidity could be used to reduce the amount of cotton outcrossing in the natural environment. Additionally, cultivars with pollen resistant to drying out under low humidity could be used to enhance outcrossing in the development of hybrid cotton.

Adapted from Burke, J.J. 2016. Genetic diversity of natural crossing in six cotton cultivars. Crop Sci. 56(3). View the full article online at http://dx.doi.org/doi:10.2135/cropsci2015.09.0572

Adapted from Crain, J.L., Y. Wei, J. Barker, S.M. Thompson, P.D. Alderman, M. Reynolds, N. Zhang, and J. Polan. 2016. Development and deployment of a portable field phenotyping platform. Crop Sci. 56(3). View the full article online at http://dx.doi.org/doi:10.2135/cropsci2015.05.0290

Top: Integrated hardware components of the Phenocart. Bottom: Phenocart to carry instruments in the field with arrows showing adjustable areas.

A honey bee covered in cotton pollen.
Soybean Cultivar and Input Use Decisions

Increased soybean commodity prices in recent years have growers interested in switching to an aggressive input-based approach instead of utilizing a traditional active management system based on integrated pest management principles. Many of these high-input systems are being adopted in attempt to increase yield despite limited validation. Furthermore, little is known about how these high-input systems interact with other agronomic management decisions, including cultivar selection.

In the March–April 2016 issue of *Crop Science*, researchers report on a three-year study from 19 locations across nine states in the Midwest and Mid-South where many soybean cultivars were grown under three different input systems to determine their effect on soybean yield.

The researchers found that cultivar selection rarely interacted with the different input systems to affect yield. The high-input systems did increase yield on average, but the yield increase was not significant enough to cover the cost of the inputs.

For soybean growers interested in developing high-input-based systems, cultivar selection and input choices can remain as independent management decisions. However, these results also further support the active use of scouting and making input decisions based on sound integrated pest management principles instead of prophylactic applications.


Field trial located at East Troy, WI in June 2014 depicting six soybean cultivars grown under three different input systems.

Application of Biochar for Soil Physical Improvement

The quality of a soil is inherently determined by its composition and properties. A healthy soil always possesses desirable physical, chemical, and biological properties and demonstrates great soil tilth, moderate drainage, adequate supply of nutrients, high populations of beneficial organisms, and strong resistance to erosion and degradation. The common quality constraints of crop-land soil are identified as compaction, poor aggregation, poor drainage, low water and nutrient retention, low organic matter content, and high population of soil-borne pathogens. Many of these constraints can be minimized by ameliorating soil physical properties in structure, porosity, aeration, and hydraulic conductivity.

Biochar amendment boosts the overall quality of a soil by improving its physical, chemical, and biological properties. In particular, biochar amendment at appropriate rates (e.g., >2 w% soil) can significantly alter soil physical properties including color, bulk density, porosity, specific surface area, aggregate stability, water-holding capacity, water infiltration, and permeability. The alterations, however, are biochar and soil dependent and may change with the application rate and the elapsing time.

This chapter in the book *Agricultural and Environmental Applications of Biochar: Advances and Barriers* reviews the recent research findings on the effect of biochar amendment on soil physical properties. It introduces the common management practices for sustaining soil physical quality, summarizes the physical properties of various biochar products, and provides an overview of the effects of biochar incorporation on soil physical properties. It concludes that biochar amendment generally improves soil physical quality, but the extent of improvement varies with the biochar, the soil, and the application rate. Long-term (e.g., >5 yr) field trials are needed to design best biochar amendment practices for maximizing physical quality improvement of specific soils.


Evident physical changes of a loamy soil with 3 w% wood biochar addition.