
Applying Molecular Scale Research to Water Quality Problems: Improving Our Understanding of Phosphorus Chemistry in Manured Soils

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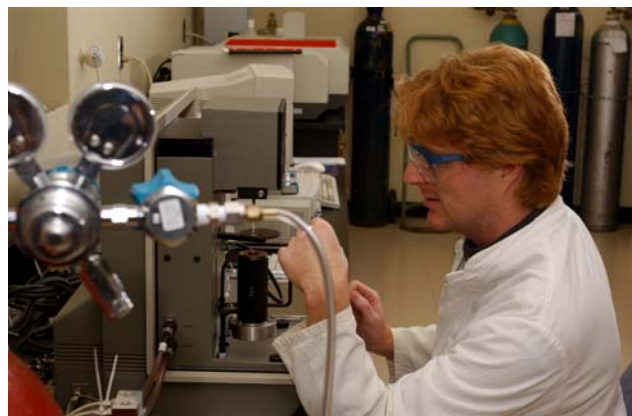
Photo by Jonathan Cox

Delaware's 1999 Nutrient Management Act required the Delaware Nutrient Management Commission (*DNMC*) to develop a statewide program for managing nutrients to protect water quality. The ***DWRC*** is providing scientific support to the *DNMC*'s ongoing efforts to improve nutrient management in Delaware by funding three graduate fellowships. Our spring issue described ***DWRC*** fellow Jennifer Jennings' study of the role of land use and land cover in the delivery of nutrients to Delaware's Inland Bays. This issue highlights the research of ***DWRC*** fellow Stefan Hunger on the "*Mechanisms of Phosphorus Stabilization in the Soil Environment: A Molecular Scale Evaluation*".

One of the key features of the Delaware act was a requirement that improved phosphorus (P) management be required for "high P" soils, those that have received long-term over-applications of manure P and fertilizer P. Research world-wide has shown that areas with highly concentrated animal agriculture, such as poultry production on the Delmarva peninsula, have some of the greatest concerns with nonpoint P pollution of surface waters. A major cause of this is the fact that animal manure applications often provide more P than is removed in crop harvest, resulting in the buildup of P in soils. In recent years the effects of manure application on soil P and water quality have been studied extensively, with the goal of developing improved P management practices for manure use. One "best management practice" (BMP) that has been proposed for poultry manure is the addition of alum (aluminum sulfate) to the manure to stabilize P in a form that is less soluble and thus less likely to be lost by runoff and leaching. While this BMP has been shown to be effective in field studies, the exact chemical mechanisms involved are unknown.

Stefan Hunger's ***DWRC***-funded research has focused on improving our understanding of the basic chemistry of P in alum-amended manures and soils. His research is unique in that it applies modern chemical methods, such as nuclear magnetic resonance (NMR) and x-ray absorption near edge (XANES) spectroscopy to determine the exact forms of P present in manures and soils. "Using samples taken at different times during my experiments," Hunger explains, "I can observe changes in the exact

chemical species of P present in manures and soils." Hunger is also exploring, at the molecular level, the interactions of P with other minerals and acids over time and with changing pH conditions. He concludes: "My primary goal is to understand if and how P interacts with aluminum, calcium or organic acids and how they influence its adsorption and potential availability to plants and losses in runoff and leaching. However, the longer I research these reactions and the more I read others' findings, the more I think that the application to soils of P in fertilizers and poultry litter, even litter amended with alum, has to be closely monitored in order to supply only as much P as can be used by the crops in order to avoid an accumulation of P. It has been shown very clearly by many researchers that the more P is in soils, the higher the likelihood that P will be lost to streams and lakes, with known detrimental effects. The sensible thing would be to avoid over-application of P in the first place."



Stefan Hunger in UD campus WorriLOW Lab

Results of Hunger's research are expected to improve predictions regarding P stability and mobility toward the goal of protected aquatic ecosystems and water quality. Says Hunger: "I appreciate the chance Dr. Sparks gave me to integrate my own ideas into this project, making it more intriguing. I believe I can contribute to the effort towards a more sustainable agriculture. After graduating next summer, I hope to continue working with spectroscopic techniques in the field of environmental chemistry, especially to learn how contaminants are retained and degraded in natural media, and how their mobility and bioavailability is influenced by environmental factors." As for his experience with the ***DWRC*** fellowship, Hunger says, "My advisor, Dr. Sparks, suggested I apply since the efforts supported by the ***DWRC*** fit nicely with my research. I have enjoyed living in the U.S. due to the wonderful people I have met and the research possibilities that I would not have had in my native Germany."

For more information on this project, contact Stefan Hunger at hunger@udel.edu, or Donald Sparks at dlsparks@udel.edu.