CONSERVATION INNOVATION GRANTS
Final Progress report

Grantee Name: Cornell University
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All of the monitoring and sampling of the three VFA field sites has now been completed for this project, and the monitoring apparatus has been removed from one of the sites. The laboratory experiments to explore factors contributing to the P retention of soils in the VFA were completed and the results were analyzed, summarized, and submitted for publication to Soil Science (Zhang, W., J.W. Faulkner, S.K. Giri, L.D. Geohring, and T.S. Steenhuis**,** *Evaluation of Two Langmuir Models for Phosphorus Sorption of New York Soils*) and to the Soil Science Society of America Journal (Zhang, W., J.W. Faulkner, S.K. Giri, L.D. Geohring, and T.S. Steenhuis, *Effect of Soil Reduction on Phosphorus Sorption of an Organic-rich Silt Loam***)**. In summary, the results suggest that the reduced soil conditions occurring in the VFA (resulting from the hydraulic loading of highly enriched BOD effluent) increased P sorption maxima and decreased zero-sorption concentration, implying the potential for a higher P retention. The organic based, high P concentration wastewater loadings simultaneously increased soil organic matter and Morgan extractable calcium, which via competitive adsorption, reductive dissolution of Fe(III), and complexation, also increased the maximum amount of P that the soil could take up and store in a labile pool form. However, this sink of labile P can also lead to a greater P loss potential when the VFA is exposed to water with low P concentration (i.e., natural rainwater). In other words, the increased labile P pool may be temporary in nature, unlike when inorganic based P is adsorbed and permanently affixed to aluminum, iron, and manganese oxide minerals. There has been some evidence of vivianite (iron phosphate hydrate) formation based on a one-time X-ray diffraction analysis of soil from the VFA, but more research would be needed to better characterize this phenomena. Nevertheless, these desorption experiments demonstrated that more P was released from wet soils than dry soils, suggesting that maintaining a drier soil condition improves P retention in VFA's. This conclusion is significant because it suggests that the wastewater needs to be adequately distributed across the VFA to minimize hydraulic loading and reduce the opportunity for concentrated (preferential) flow pathways to develop. These results were summarized and presented at the annual meeting of the Northeast Region Certified Crop Advisors conference, and were also used to suggest revisions to the NY-NRCS Code of Practice Standard 635, whereby VFA's should be periodically sampled and analyzed for their P status to assure that they remain effective in removing P during their use.

The results of the chloride and nitrate-N tracer experiment were also analyzed, summarized, and submitted for publication in the Journal of Soil and Water Conservation (Faulkner, J.W., W. Zhang, L.D. Geohring, and T.S. Steenhuis, *Tracer Movement through Paired Vegetative Treatment Areas Receiving Silage Bunker Runoff*). Another paper titled *Nutrient Transport within Three Vegetative Treatment Areas Receiving Silage Bunker Runoff* is in final review stage for submittal to a referred journal. In summary, the results indicate that subsoil hydraulic properties greatly influence the extent of leaching below VFA's. Generally, nitrate-N concentrations leaching below the VFA are below the drinking water threshold of 10 mg/L, likely because denitrification processes as opposed to nitrification processes are favored in these VFA environments. Nevertheless, these results indicate that siting criteria for the VFA and preliminary and on-going soil nutrient sampling are also important to assure the proper functioning and nutrient retention of the VFA. Based on this work, recommendations for revisions to the NY-NRCS Code of Practice Standard 635 include evaluating VFA sites using the NY Nitrate Leaching Index and determining the appropriate size of the VFA based on various wastewater (i.e., barnyard, milkhouse, silage leachate) N inputs.

We presented a water budget model for VFA's to various NRCS personnel and worked with NYS NRCS personnel in revising the draft language in the 635 practice standard. Since subsoil hydraulic properties greatly influence temporal and spatial soil moisture conditions within the VFA, and the subsequent nutrient fate and transport processes, the initial siting criteria is a critical aspect for VFA success. As per EPA-CAFO rule, VFA's treating agricultural process wastewaters are not supposed to have a surface discharge. On the other hand, groundwater may be at risk of wastewater contamination if soils are too permeable. Consequently, discussions regarding the policy implications and the practical use and operation of VFA's have also been done with NYS DEC. The practical, scientific, and policy implications are best addressed by rigorous siting criteria and allowing custom built engineering modifications to address the less than ideal site conditions. Based on our observations, maintenance practices and modifications for the proper operation and functioning of the VFA by the landowner is also critically important. A significant impact of this project has been the gathering of actual on-site performance monitoring data for three different VFA sites across different regions of NYS, and from which recommendations can be made to further improve the application and implementation of VFA's via an improved 635 practice standard.

Publications Produced

Faulkner, J.W., W. Zhang, L.D. Geohring, and T.S. Steenhuis. 2011. Tracer movement through paired vegetative treatment areas receiving silage bunker runoff. *Journal Soil and Water Conservation* 66(1):18-28. [http://www.jswconline.org/content/66/1/18.full.pdf+html]

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Faulkner, J.W., Z.M. Easton, W. Zhang, L.D. Geohring, and T.S. Steenhuis. 2010. Design and risk assessment tool for vegetative treatment areas receiving agricultural wastewater: Preliminary results. *Journal of Environmental Management* 91(8):1794-1801.

Zhang, Wei, J.W. Faulkner, S.K. Giri, L.D. Geohring, and T.S. Steenhuis. 2010. Effect of soil reduction on phosphorus sorption of an organic-rich silt loam. *Soil Sci. Soc. Am. J.* 74:240-249.

Zhang, Wei, J.W. Faulkner, S.K. Giri, L.D. Geohring, and T.S. Steenhuis. 2009. Evaluation of two Langmuir models for phosphorus sorption of P-enriched soils in New York for environmental applications. *Soil Sci.* 174(10):523-530.

Wright, P.E. and L.D. Geohring. 2009. Conservation Practice Standard Code 635 – Vegetated Treatment Area. USDA-NRCS, Syracuse, NY. [ftp://ftp-fc.sc.egov.usda.gov/NY/eFOTG/Section_4/Practice_Standards/nyps635.pdf]

Zhang, Wei, J.W. Faulkner, L.D. Geohring, and T.S. Steenhuis. 2009. Phosphorus Sorption and Desorption Properties of Surface and Subsurface Horizons at Three Vegetative Treatment Areas in New York. ASABE Paper # 09-7002. ASABE, St. Joseph, MI. 19 pp.

Faulkner, J.W., W. Zhang, L.D. Geohring, and T.S. Steenhuis. 2008. Investigating event nitrate dynamics in paired vegetative treatment areas receiving silage bunker runoff using a simple mixing approach. ASABE Paper # 08-3915, ASABE, St. Joseph, MI. 25 pp.

Zhang, W., J.W. Faulkner, L.D. Geohring, and T.S. Steenhuis. 2008. Evaluation of two Langmuir models for phosphorus sorption on various soils under various conditions. ASABE Paper # 08-4181, ASABE, St. Joseph, MI. 14 pp.

Kim. Y.J., L.D. Geohring, J.H. Jeon, A.S. Collick, S.K. Giri, and T.S. Steenhuis. 2006. Evaluation of the effectiveness of vegetative filter strips for phosphorus removal with the use of a tracer. *Journal of Soil and Water Conservation* 61(5):293-302. [http://www.jswconline.org/content/61/5/293.full.pdf+html]