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Roadside Ditches: Source or Filter of Greenhouse Gases?

Improving roadside ditch management
to reduce greenhouse gas emissions associated with agricultural runoff

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Abstract

This project investigated the transport and transformation of dissolved nitrogen (N) moving through a roadside ditch from an adjacent farm field in Tompkins Co, NYS. Dissolved nitrate concentrations and discharge were measured at input and output locations on 21 dates from June through October 2014. Nitrous oxide (N_2O) fluxes were measured on six dates, and estimates were made of the amount of N stored in plant and soil reservoirs. Results indicate that the roadside ditch can be a major conduit of dissolved N. During the study, 0.5 m of rain fell and water was flowing through the ditch on 80 days. Nitrogen loading to the adjacent stream ranged as high as 40 kg day^{-1}. Nitrous oxide flux was measured during both wet and dry conditions; rates ranged from 0 – 252 µg N m^{-2} hr^{-1} with an average of 59 ± 15. Given the high N loads, neither denitrification processes nor immobilization in plant and soil reservoirs removed significant quantities of nitrogen. The potential for roadside ditches to filter N depends on several factors, including flow rates, N inputs, weather, and sediment conditions. Future work will investigate the potential for enhancing denitrification transformations, as both N_2O and N_2, and nitrogen removal.

Three Summary Points of Interest

- The results of monitoring a roadside ditch adjoining a <10 ha, manure-spread farm field from June through October 2014 indicated that this roadside ditch is a major conduit of dissolved nitrogen moving directly from the field to an adjacent stream, with average flow concentrations of 24 mg N L^{-1} and daily outflowing loads of up to 40 kg N day^{-1}.
- Ditch substrates are generation sites of the greenhouse gas nitrous oxide under both flowing and non-flowing conditions, with production rates ranging from 0 to 252 µg N m^{-2} hr^{-1} and a seasonal average of 59 ± 15 µg N m^{-2} hr^{-1}.
- Given the high loads of nitrogen moving through this ditch, neither denitrification processes nor storage in plant and soil reservoirs were removing significant quantities of nitrogen, however the potential for other ditches to filter nitrogen will depend on a combination of factors, including flow rates, nitrogen loading from the source field, weather conditions, vegetation, and sediment type.

Keywords: Roadside ditches, nitrogen, pollution, nitrous oxide, greenhouse gas, farm management

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Introduction

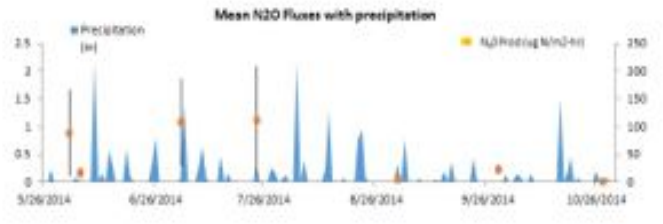
Nitrogen from agricultural activities is a critical pollutant, both as dissolved nitrate in streams and when converted to the potent greenhouse gas, N_2O. A decade of research on roadside ditches indicates they perform critical roles in watersheds: intercepting runoff and shunting it rapidly to streams, contributing to elevated peak stream flows, and transporting sediments, microbes and other contaminants[1]. This project investigated the role of a 369 m long ditch to act as a conduit or filter of dissolved nitrogen from <10 ha manure-spread farm field to an adjacent stream.

Results & Discussion

Results indicated that the roadside ditch functions as a critical conduit of dissolved nitrogen, with concentrations averaging 24 mg N L^{-1} over the study period (peak growing season, June – October). A total of 0.52 m of rainfall fell, and water was flowing through the ditch on 80 days. Daily loads of nitrogen ranged as high as 40 kg N day^{-1} at the outflowing culvert, and discharged directly into the stream 10 m away. Nitrous oxide production from bottom substrates was occurring on all six sampling dates, including both wet and dry conditions. Rates of N_2O production ranged from 0 – 252 µg m^{-2} hr^{-1} with an overall average of 59 ± 15 µg m^{-2} hr^{-1}. Given the high loads of nitrogen moving through this ditch, neither denitrification processes nor storage in plant and soil reservoir were removing significant quantities of nitrogen. The results of this research indicate that roadside ditches play a key role as conduits of nitrogen, linking agricultural activities and downstream aquatic systems. Ditches also play a role in the production of a potent greenhouse gas, N_2O. However, the potential for other types of roadside ditches to filter nitrogen will depend on a combination of factors, including flow rates, nitrogen loading from the source field, weather conditions, vegetation, and sediment conditions. Some of these parameters can be optimized for N filtering by appropriate management strategies. Future research will explore this, with regard to denitrification and other N removal processes.

References

[1] Buchanan, B.P., Falbo, K. Schneider, R.L., Easton, Z.M., and Walter, M.T. 2012. Hydrologic impact of roadside ditches in an agricultural watershed in c. NYS: implications for non-point source pollutant transport. Hydro. Proc. 27 (17): 2422- 2437.



Policy Implications

Identification of the critical roles of roadside ditches in both the transport and transformation of nitrogen, including as a source of a potent greenhouse gas, further heightens the immediacy of focusing on improving roadside ditch management. EPA Phase II Stormwater Regulations have generally overlooked this critical component of watershed hydrology, or "plumbing", and current policies and management strategies concerning ditches are confusing, conflicting or non-existent within and among northeastern states.

Methods

An in-depth study of nitrogen dynamics was conducted in a single 369 m long roadside ditch receiving runoff and tile drainage from a <10 ha, manure-spread farm field. Dissolved nitrogen concentrations (nitrate+nitrite) and discharge rates were measured at input and output locations on 21 dates when the ditch contained flowing water, from June through October 2014. Nitrous oxide (N_2O) production rates as well as CO_2 and CH_4 fluxes were measured using four replicate static chambers on six dates, and estimates were made of the amount of nitrogen stored in plant and soil reservoirs.

Outreach Comments

Although preliminary, the results of this project have very significant implications for water resource management, and particularly for downstream estuarine ecosystems dealing with nitrogen pollution. The results were briefly presented at a conference, "Re-plumbing the Chesapeake Watershed: Improving Roadside Ditch Management to Meet TMDL Goals (Oct. 2014, Easton, MD) sponsored by the Chesapeake Bay Program Science and Technical Advisory Committee.

Student Training

One undergraduate was engaged in the field data collection portion of this project.

This report was prepared for the New York State Water Resources Institute (WRI) and the Hudson River Estuary program of the New York State Department of Environmental Conservation, with support from the NYS Environmental Protection Fund.