EVALUATING NITROGEN LOSS IN SUFFOLK COUNTY GROUNDWATER:

DENITRIFICATION IN NORTHPORT PUBLIC SUPPLY WELLS

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Suffolk County is designated a Sole Source aquifer area by the Environmental Protection Agency, indicating it provides at least 50% of drinking water to the overlying communities. Nitrate pollution is widespread in the Suffolk County aquifer due to two primary factors: artificial fertilizers and septic system/cesspools. Few municipalities provide centralized sewage treatment; therefore each home has its own septic tank and cesspool system to dispose of waste. Artificial fertilizers are commonly used in residential lawn care throughout Suffolk County. Nitrates are introduced into groundwater via both these mechanisms, with septic systems providing the bulk of contamination (Munster, 2004). Mass balance studies of nitrogen inputs/outputs estimate a 50% loss of nitrogen in the system. The amount of nitrogen introduced at the surface cannot be accounted for in the amount of nitrate measured in the aquifer and discharge to surface bodies (Valiela, 2004). The purpose of this study is to determine if denitrification is occurring in the Suffolk County aquifer and, if so, how much nitrogen loss is attributable to denitrification. Our study finds that denitrification in Northport public supply wells does not account for 50% loss of nitrogen in the system; we find that denitrification can account for, at most, 15% of the nitrogen loss in Northport.

The community of Northport was chosen for this study because of its high nitrate levels. Northport was an agricultural community until the 1950s when population levels began increasing; presently the land use is primarily residential with each home having its own septic tank/cesspool system. Nitrate pollution from agriculture fertilizers combined with nitrates from newer sewage inputs put this community at risk for nitrate pollution in drinking water. Presently, nitrate levels in a number of SCWA's Northport supply wells consistently test above the federal limit of 10 ppm $N\text{-}NO_3^-$. Increased demand on the local water supplier, Suffolk County Water Authority (SCWA), to provide potable water for the growing community necessitated the installation of a denitrification plant in 2005 to remove nitrate from supply wells. This study tested for denitrification in seventeen deep supply wells, depths ranging from 412 to 617 feet, with nitrate levels of 10 ppm $N\text{-}NO_3^-$ or higher within the last year.

Denitrification is a biologically mediated process that converts nitrate (NO_3^-) to nitrogen gas (N_2) under hypoxic conditions (Seitzinger, 2006). To determine if conditions in the SCWA wells are hypoxic, dissolved oxygen data was collected using a YSI handheld multiprobe in the field. Samples were also tested for nitrate as nitrogen($N\text{-}NO_3^-$), cations (Ca^{2+},Mg^{2+},Na^+, K^+, Fe^{2+}, Mn^{2+}), and dissolved organic carbon. This study tested for denitrification directly via dissolved gas analysis. Briefly, this analysis relies on the principle that dissolved gases in rainwater are in equilibrium with the atmosphere at the time of aquifer recharge. Excess nitrogen, the byproduct of denitrification, is added to the dissolved gases in the water while argon from atmospheric equilibration remains the same. Water samples were analyzed for their nitrogen to argon ratio using Membrane Inlet Mass Spectrometry (Kana, 1994), which has an error of less than 1 ppm $N\text{-}NO_3^-$. After correcting for excess air, any nitrogen gas above the atmospheric equilibrium was determined to be a result of denitrification.

Data results from the Northport field site indicate limited amounts of denitrification in the groundwater. Total excess nitrogen gas (N_2) ranges from 0-50µm/l, equivalent to 0-1.5ppm $N\text{-}NO_3^-$. The percent of total nitrate denitrified ranges from 0% to 14.5%. Dissolved oxygen amounts range from 6 mg/l to 11mg/l with a number of samples at 100% saturation. Dissolved organic carbon (DOC) amounts range from 29 µm/l to 41 µm/l. Free iron (Fe^{2+}) amounts range from below detection limit to 0.05ppm; free manganese (Mn^{2+}) levels are below detection limit in all samples.

Our data present a picture that indicates denitrification is not the primary mechanism for nitrogen loss in the Northport system. High dissolved oxygen amounts would not necessitate bacteria to use nitrate as a terminal electron acceptor, so large amounts of denitrification would not occur in these wells. Minimal amounts of electron donors, either organic (DOC) or inorganic (Fe^{2+} or Mn^{2+}) would not provide sufficient 'food' for bacteria to perform the stepwise reduction of nitrate to nitrogen gas. Finally, only a small amount of excess dissolved nitrogen gas is present in samples from Northport. This indicates only a small percentage of all nitrate in the system was denitrified.

Our study concludes that nitrogen loss in the Northport community cannot be attributed to denitrification. One possible reason that denitrification is not occurring is a thick vadose zone in Northport that allows for continued interaction of soil-water with the atmosphere. This interaction keeps dissolved oxygen levels high and allows bacteria to use up DOC in the upper portion of the soil profile so it is not transferred to the aquifer during recharge. Other possible mechanisms for the 50% nitrogen loss in the system are ammonification (Bleifuss et al, 1998) or ammonium sorption onto soil particles at the septic tank/cesspool site Hanson and Schoonen, 1999.

References

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