Nitrogen 101

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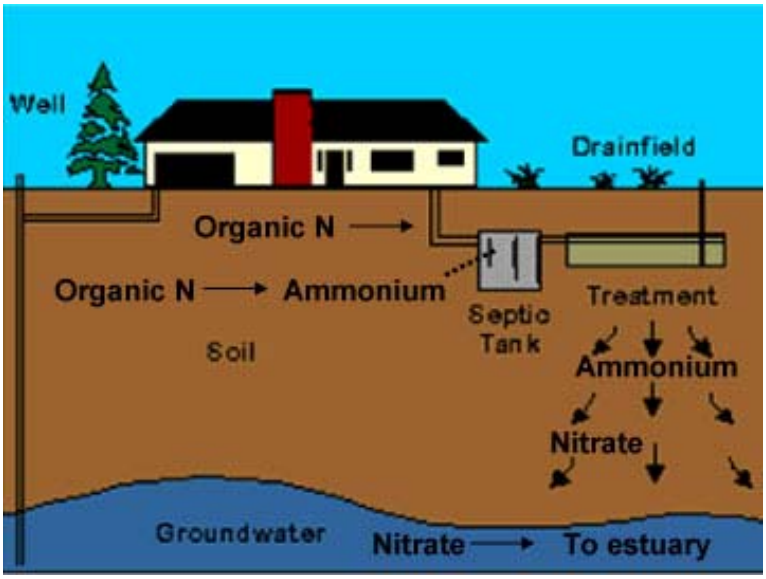
Nitrogen that leaches from septic systems, into groundwater and through watersheds to estuaries causes a cascading chain of events that degrades the water quality and marine life in Falmouth's coastal bays and ponds.

The chain starts when higher nitrogen concentrations in coastal waters cause the growth of algae to increase. These well-nourished algae shade eelgrass and cause a build-up of organic matter that both directly eliminates habitat for fish and shellfish and reduces levels of oxygen in the water.

But all nitrogen is not created equal. To understand how nitrogen does its dirty work, it helps to understand different forms of nitrogen, how they are produced and how nitrogen in the water that reaches estuaries might be lessened.

If you are like 96 percent of Falmouth residents, the nitrogen contained in the human waste works its way through the plumbing in your house and into your backyard septic system. Microbes then attack this "organic" nitrogen. The first step in this decomposition produces ammonium, or NH_4^+. As this ammonium makes its way from the septic tank and into the leaching field, another set of microbes, known as "nitrfiers," convert it to nitrate, or NO_3^-.

This transition has important consequences. While ammonium doesn't typically travel very far because it typically sticks firmly to soils, nitrate generally goes with the flow and moves quickly into groundwater. Oxygen is key to this conversion—indeed Title V leaching fields are designed to provide oxygen to remove any pathogens that make it past the septic tank.



How nitrogen moves from homes to estuaries. Organic nitrogen is collected in a septic tank, where organic N is decomposed to ammonium. Ammonium moves to leaching fields where it is converted to nitrate. This nitrate then moves easily to groundwater and within aroundwater to estuaries.

The net result, however, is production of large amounts of nitrate in well-functioning septic fields. Once in groundwater, nitrate typically moves to groundwater and on to coastal waters where it is easily assimilated by algae. There is, however, one critically important exception to this rule. That occurs when nitrate in groundwater enters "anoxic" locations where oxygen is absent. These are typically places at the edges of marshes, layers of buried peat, or other sites with lots of decaying organic material that uses up oxygen.

Under these conditions another set of microbes—whoever says microbes run the world is telling the truth—is capable of using up the nitrate in a process called "denitrification."

Denitrification is a critical, and for our bays, beneficial process. While we and other animals breathe oxygen, these microbes use nitrate like we use oxygen. We burn sugars in food and breathe out carbon dioxide and water vapor. Denitrifying microbes burn sugars in organic material (food) and make nitrogen gas.
Because nitrogen gas makes up 78 percent of the atmosphere, converting nitrate to nitrogen gas has no effect on the global atmosphere—but encouraging denitrification is part of the solution to Falmouth's coastal water quality problems.

Falmouth's new "denitrifying" wastewater treatment plant in West Falmouth promotes denitrification by subjecting water to oxygen (to encourage formation of nitrate just like a Title V septic system). But it follows this with a second step, a period of anoxic conditions that encourages denitrification and the conversion of that nitrate to nitrogen gas.

Denitrification can be encouraged in central wastewater plants, or in on-site septic systems that add this critical anoxic second step. It can also be encouraged by construction of permeable "barriers" of wood chips or other material to intercept groundwater and route it into an artificial zone that promotes denitrification.

None of these methods are perfect and all cost money—but there's no doubt that the restored health of Falmouth's coastal waters will depend on our resolve to encourage, promote, mandate, and otherwise dramatically increase the amount of denitrification that happens after the "organic" nitrogen we all contribute starts its series of chemical and biological transformations that lead it toward the coast.

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Important Points

1. Ammonium (NH_4^+), nitrate (NO_3^-) and dissolved organic nitrogen (DON) are all forms of dissolved nitrogen. Ammonium and nitrate combined are called dissolved "inorganic" nitrogen.

2. Septic waste coming from leaching fields is already in the form of nitrate. It is injected below the zone of plant uptake.

3. Nitrate (NO_3^-) and dissolved organic N (DON) move rapidly through soils while ammonium (NH_4^+) does not.

4. In pristine Cape Cod forests, about 90% of dissolved nitrogen is DON. Very little nitrate is lost.

5. In developed watersheds, the large majority of dissolved nitrogen is nitrate.

6. Nitrate can be kept out of estuaries by two processes.
   a) uptake by contact with plants along shorelines in wetlands
   b) denitrification, or conversion of NO_3^- to nitrogen gas (N_2).

7. Denitrification requires anoxic sediments, or even better, zones that fluctuate between oxygenated and anoxic (this is how the new sewage treatment plant works).