Occurrence of Dissolved Organic Nitrogen (DON) in Low-relief Streams on the Eastern Shore of Virginia, USA

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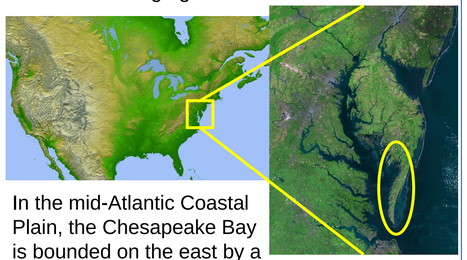
Introduction and Study Context

Coastal waters of the United States are degraded by terrestrial nutrients discharged by streams draining agricultural watersheds.



In the mid-Atlantic Coastal Plain, the Chesapeake Bay is bounded on the east by a peninsula, the Eastern Shore of Virginia USA.

The Eastern Shore of Virginia comprises many small, low-relief watersheds where 50% of land use is agricultural, mostly row crops treated with nitrogenous fertilizer.

Coastal ecosystems are susceptible to the consequences of nitrogen enrichment, including eutrophication and harmful algal blooms.

Quantifying nitrogen loading to coastal aquatic ecosystems has predominantly focused on nitrate (NO_3^-), a reactive inorganic form that is biologically available to primary producers.

Previous measurements of stream discharge and nitrate concentration were used to determine nitrate load. Normalized to watershed area, results were scaled up to estimate total export to seaside lagoons.

Load to the seaside lagoons = 2.4 x 10^5 kg N a^{-1}

The contribution of dissolved organic nitrogen (DON) to the total nitrogen loading to coastal waters had not been evaluated.

Research Objective and Approach

We quantified concentrations of DON, NO_3^-, and total dissolved nitrogen (TDN) under baseflow conditions in 15 streams varying in watershed size and cropland use across a one-year period.

DON is a mixture of nitrogen-containing organic compounds such as urea, amino and nucleic acids, proteins, and humic-like substances, and its bioavailability varies by compound.

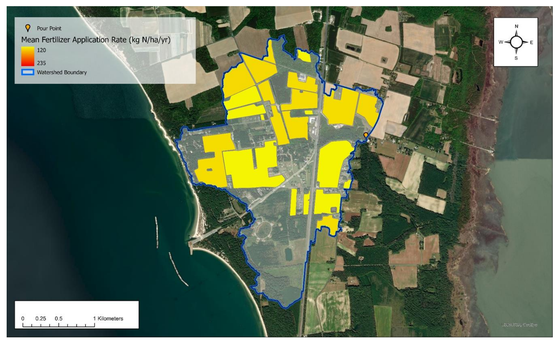
Five campaigns to collect surface water were accomplished in May, June, August, and November 2019 and February 2020. Samples were filtered (0.45 µm) and refrigerated.

Chemical analyses
- NO_3^- and NO_2^- - Dionex ion chromatograph
- NH_4^+ - Lachet QuikChem autoanalyzer (colorimetric)
- TDN - persulfate oxidation using autoclave digestion, autoanalyzer

$$DON = TDN - (NO_3^- + NO_2^- + NH_4^+)$$

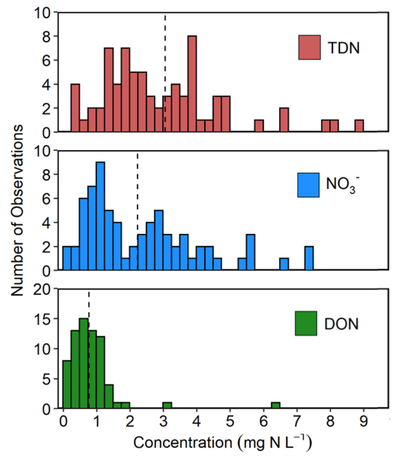
The relationship between DON concentration and spatio-temporal variability, land use, and fertilizer application was examined to gain insights into sources of DON in streams.

Land-use parameters – total watershed area, total cropland area, cropland area as a percentage of the total watershed area, and annual fertilizer application rate – were determined via spatial analysis using ArcGIS. The point from which the contributing watershed area was delineated was the point at which each stream was sampled.



Watershed sizes ranged from 30 – 630 ha.

The most frequently detected nitrogen species in the TDN pool were NO_3^- and DON. NH_4^+ and NO_2^- were rarely detected and only at low concentrations.

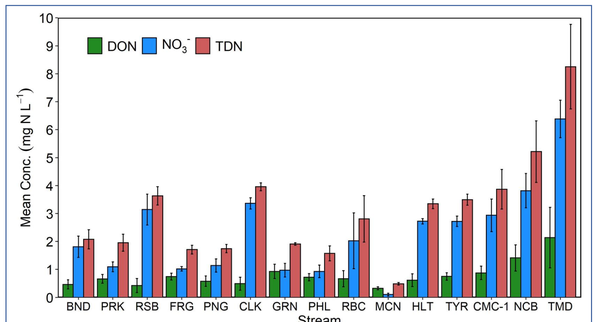


Number of observations of the N species and their concentrations (bin widths = 0.25 mg N L^{-1}) in water collected from 5 sampling campaigns to 15 streams. Dotted lines represent the overall mean of all measured concentrations. NO_2^- and NH_4^+ not shown.

NO_3^- concentrations ranged from 0 – 7.40 mg N L^{-1} (overall mean 2.23 mg N L^{-1})

DON concentrations ranged from 0 – 6.45 mg N L^{-1} (overall mean 0.787 mg N L^{-1})

DON in streams represented 12 to 70% of the TDN pool.

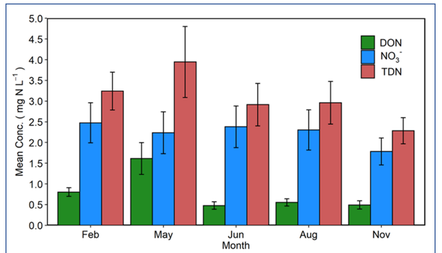


Mean ± SE of DON, NO_3^-, and TDN concentrations in individual streams ordered by geographic location (N to S from left to right).

Results

DON varied seasonally with highest DON concentrations observed in spring.

NO_3^- concentrations did not vary significantly across seasons.

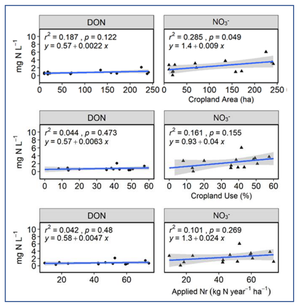


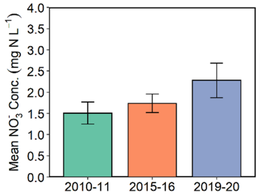
Mean ± SE of DON, NO_3^-, and TDN concentrations in all streams aggregated by sample date and ordered by calendar year .

The relationships of DON and NO_3^- concentrations to watershed characteristics were examined using linear regression analysis.

Concentrations of DON were weakly correlated with
- cropland area
- watershed area (not shown)
- percent cropland use
- applied reactive nitrogen.

Concentrations of NO_3^- were more strongly correlated with these factors.





A slight trend of increasing mean NO_3^- concentrations over time in these streams may be due to increased use of fertilizer in these watersheds

While DON does not represent the dominant nitrogen species in most streams, DON nonetheless represents a significant constituent of the TDN pool. With the potential that a portion of the nitrogen in the DON pool is accessible to phytoplankton, the bioavailable nitrogen loads to coastal waters may be underestimated if calculated from NO_3^- concentrations alone.