Surface water nitrogen attenuation from the Accomack County, VA southern landfill groundwater discharge.

Richard A Snyder and Paige G Ross

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VIMS ESL
PO Box 350
40 Atlantic Avenue
Wachapraeague, VA 23480

757-787-5834
rsnyder@vims.edu
http://www.vims.edu/esl/

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The Issue. Previous sampling of the stream crossing Bobtown Road (Rt 178) near the intersection of Hollies Church Road (Rt. 620), had indicated high levels of nitrogen in the stream flow (Snyder and Ross, 2019a). The proximity of the retired Accomack County Landfill upstream of the site triggered a higher resolution sampling of the stream in an attempt to isolate a source of the nitrogen loading (Snyder and Ross, 2019b). Accomack County has requested repeated sampling of this stream segment to monitor nutrient attenuation trends from the site, and stations were established for that purpose. This is the first report of that sampling plan for samples taken 10 Dec 2019.

Methodology. Sampling was conducted 10 Dec 2019, with sample points designed to pick up and exponential decrease in nitrogen concentrations with distance downstream from the Landfill to tidal water (Figure 1). These stations were established with PVC pipe markers and the locations recorded by a Garmin handheld GPS meter (~12 ft accuracy). Distance downstream was determined with a measuring tool on an ESRI ARCmap GIS software plot of the stations, following the stream channel course with a Bayside NHDFlowline layer. An additional sample was taken of the ponds at the landfill site, midway down the berm separating the two basins (Figure 1 and LFP station in Table 1). Surveying and sampling personnel included Richard Snyder, VIMS ESL and John Lauer, Accomack County.

Standard water quality sampling procedures were followed. The field technician used latex gloves to prevent contamination of samples. For each sampling event, a 125 ml polypropylene bottle was filled and rinsed three times with site water before final filling, capping, and placing on ice for transport to the laboratory. This sample was analyzed for Total Nitrogen and Total Phosphorous (methods for analysis are included in Appendix I). A 60cc polypropylene syringe was rinsed three times with site water and then used to pass water through a Whatman 25 mm GF/F glass fiber filter held in a Millipore stainless steel swinnex into a 60 ml polypropylene bottle. This sample was analyzed for Dissolved ammonia and dissolved $NO_2 + NO_3$ (NO_x; methods for analysis are included in Appendix I). Rainfall data was obtained from https://weatherspark.com/h/m/147126/2019/12/Historical-Weather-in-December-2019-at-Melfa-Accomack-Airport-Virginia-United-States, indicating a 0.2" rainfall in the previous 24 hrs and a light drizzle with minimum accumulation the day of sampling.

A field data sheet recorded the number of the sample, station number, date and time of collection. Temperature, salinity, pH, and dissolved oxygen of the water were recorded from a handheld YSI meter. Flow rates at two culverts were estimated by timing the transit of a visual marker in the culvert as insufficient depth was available to use a SonTek Flowtracker. Field collection data were transferred to a MS Excel spreadsheet and is presented as Table 1. Water samples were frozen at -20 deg C at VIMS ESL until transport to VIMS Gloucester Point Analytical Services for analysis of nutrients. Samples were delivered still frozen during custody transfer. The analytical data were made available 2 February 2020 and were combined with the field data in a MS Excel spreadsheet, presented as Table 1. Data were plotted using ESRI Arcmap GIS mapping software and Kaleidagraph software.

Results and Discussion

Ammonia and NOx concentrations decreased with distance downstream of the landfill groundwater discharge site (Table 1; Figure 1) previously identified (Snyder and Ross 2019b). NOx represented only a very small fraction of the total nitrogen load (Figure 1), so little difference was noted between ammonia and total nitrogen values (Figure 1). Total phosphorous concentrations also decreased with distance, but all values were relatively low (Table 1; Figure 1). The persistence of ammonia and the low concentrations of NOx may be a consequence of cool water temperatures (Table 1) inhibiting ammonia oxidizing activity.

The attenuation of ammonia (as the bulk of the nitrogen load) fit to an exponential loss curve with distance into the swamp between Bobtown Road and County Club Road (Figure 2). The extinction coefficient was 0.0030 ln mg NH_3/m, which will be used for comparison to future sampling events. However an additional source of nitrogen apparently enters the stream in this swamp, as shown by the break in the data and a slower extinction coefficient (0.0016 ln mg NH_3/m from Country Club Road to where the stream reaches tidal water (Figure 2).

There are several stream branches from the south joining with the stream from the landfill that are not in the NHDFlowline database layer, and numerous seepage areas into the swamp between Bobtown Road and Country Club Road, contributing a significant volume of water to the system. An increase in water flow noted in the estimated flows at Bobtown Road and Country Club Road culverts, with the flow on the downstream side of this swamp segment recorded as 2.64 L/sec (Table 2), about 10x the flow coming from the landfill stream as it passes under Bobtown Road (0.24 L/Sec; Table 2). Apparently the increase in flow is due to ground water discharge into this wooded swamp area.

Despite the increase in flow, the concentration of ammonium increased, indicating added ammonium with the flow addition and not dilution. Estimated ammonium load coming off the landfill site (concentration x flow volume) was 7.57 x 10^{-3} kg/day compared to a load of 9.63 x 10^{-2} kg/day running under Country Club Road (Table 2). These estimates however are relatively crude based on the nature of the flow measurement, although the culverts themselves provided an accurate cross sectional area for calculating volume of flow.

The source of the additional nitrogen loading is not known, although a residence along Country Club Road borders the stream passing through the swamp. To the south are an abandoned nursery operation and woodlands. Regional ground water values run >10 mg/L nitrate, although the presence of minimal nitrate in the stream flow suggests this may not be a source. Overall the data show attenuation of the nitrogen coming off the landfill site to a level that merges with a regional background from other nitrogen sources.

References

Snyder, RA and PG Ross. 2019a. Water quality in southern Accomack County watersheds. VIMS ESL technical report #2. 21 pp. https://doi.org/10.25773/cmm4-m650

Snyder, RA and PG Ross. 2019b. Water quality in an unnamed branch of Pungoteague Creek, Bobtown road and Hollies Church Road, VA. VIMS ESL technical report #3. 9 pp. https://doi.org/10.25773/bhz7-8h64

Table 1. Field and analytical data for the stream samples taken 11 March 2019.

Station	Lat	Long	Dist. m	Date	Time EST	Temp deg C	DO mg/L	Salinity ppt	pH	NH_3 Units: mg/L MDL: 0.0062	NO_x Units: mg/L MDL: 0.0055	TN Units: mg/L MDL: 0.0285	TP Units: mg/L MDL: 0.0095
LFA1	37.6488	75.7909	0.0	10-Dec-19	9:20	13.5	0.97	0.64	6.68	45.3600	0.0297	54.0300	0.0360
LFA2	37.6488	75.7912	24.7	10-Dec-19	9:27	13	0.73	0.47	6.89	30.5400	0.01	40.3200	0.1118
LFA3	37.6489	75.7915	53.9	10-Dec-19	9:33	14.4	0.8	0.33	6.92	22.9600	0.01	25.0100	0.0930
LFA4	37.6491	75.7921	110.8	10-Dec-19	9:42	12.3	0.68	0.34	7.04	19.0650	0.01	22.6950	0.2005
LFA5	37.6493	75.7924	147.6	10-Dec-19	9:50	13.4	1.62	0.38	7.06	20.1850	0.0706	21.8650	0.0830
LFA6	37.6493	75.7930	199.7	10-Dec-19	9:57	13.6	0.71	0.4	7.11	19.3250	0.0448	19.9150	0.0601
LFA7	37.6494	75.7936	235.6	10-Dec-19	10:04	13.6	1.19	0.38	7.27	14.7150	0.02	18.4450	0.0470
LFA8	37.6498	75.7944	347.0	10-Dec-19	10:21	14.2	2.28	0.36	7.06	10.9500	0.01	13.1000	0.0451
LFA9	37.6502	75.7950	415.4	10-Dec-19	10:40	14	2.08	0.34	7.46	9.4650	0.0630	11.6950	0.0325
LFA10	37.6512	75.7975	664.5	10-Dec-19	11:03	14.5	4.61	0.36	7.25	12.6650	0.0255	15.4850	0.01
LFA11	37.6526	75.7990	885.9	10-Dec-19	11:22	14.5	5.05	0.28	7.24	9.5100	0.0459	10.9300	0.02
LFA12	37.6531	75.8005	1061.8	10-Dec-19	11:32	14.6	5.92	0.24	7.22	6.1900	0.7060	8.3600	0.03
LFP	37.6478	75.7432		10-Dec-19	15:50	13.1	9.13	0.41	7.79	18.1500	0.6024	24.9550	0.01

Table 2. Estimated flow rates and calculated nutrient loading rates at two stations with road culverts confining the stream flow.

Culvert sampled	Station	Lat	Long	Flow rate Liters/sec	NH_3 kg/day	NO_x kg/day	TN kg/day	TP kg/day
Bobtown Road	LFA8	37.6498	75.7944	0.24	7.57E-03	2.42E-07	9.13E-09	1.19E-12
Country Club Road	LFA10	37.6512	75.7975	2.64	9.63E-02	7.07E-06	3.15E-07	1.14E-11

Figure 1. Surface water sample locations downstream of the Accomack Southern Landfill site.

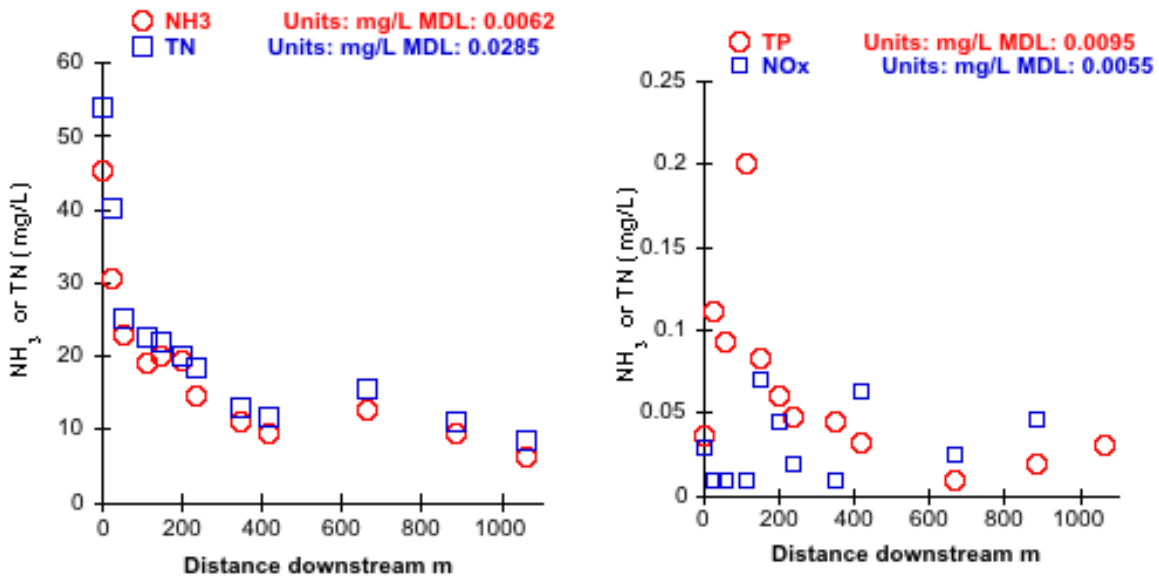

Figure 2. Ammonia (NH_3) and Total Nitrogen (TN) content of steam waters downstream of the landfill (left) and (right) Total Phosphorous (TP) and NO_2 + NO_3 (NO_x).

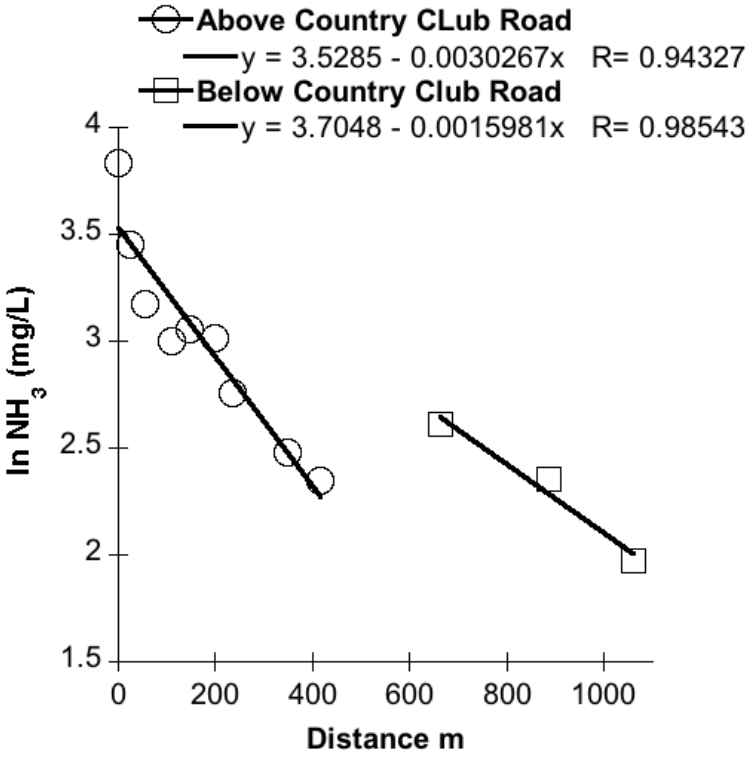

Figure 2. Ammonia concentrations downstream of the landfill plotted as natural logrithyms and fitted to lines for estimating attenuation rates.

Appendix I. Analytical methods for nutrient analyses.

Determination of Ammonia by Skalar Auto Analyzer
ASC METHOD: 3000
Document Control Number: 00072

1.0 SCOPE AND APPLICATION:

1.1 This method is for the determination of Ammonia by Skalar Autoanalyzer. The applicable range is 0.005-2.0 mg/l.

2.0 SUMMARY OF METHOD:

2.1 Automated Continuous flow, segmented stream, no bubble gating.

2.2 Dual wavelength detection and matrix correction.

2.3 Alkaline phenol and hypochlorite react with ammonia to form indophenol blue that is proportional to the ammonia concentration. The blue color formed is intensified with sodium nitroprusside. Reaction is heat catalyzed at 37^{o}C.

Determination of Total Dissolved Nitrogen and Total Dissolved Phosphorous by Skalar Auto Analyzer
ASC METHOD: 3005
Document Control Number: 00076

1.0 SCOPE AND APPLICATION:

1.1 This method describes the digestion procedure for total dissolved nitrogen (TDN) and total dissolved phosphorus (TDP) in fresh and estuarine surface waters by the alkaline persulfate oxidation technique. The dissolved fraction are aliquots of sample which have passed through a filter to remove particulates. The method is suitable for the determination of total nitrogen (TN) and total phosphorus (TP) with necessary precautions to ensure that particulates are fully digested. The applicable range for TDN and TN is 0.09-0.90 mg/L. The applicable range TDP and TP is 0.01-0.40 mg/L.

2.0 SUMMARY OF METHOD:

2.1 The persulfate oxidation technique for nitrogen in water is performed under heated alkaline conditions, where all organic and inorganic forms of nitrogen are oxidized to nitrate. As the reaction proceeds, NaOH is consumed and the pH drops to < 2.2, which allows the oxidation of all phosphorus compounds to orthophosphate.

2.2 An aliquot of digested sample is analyzed for nitrate and orthophosphate using automated colorimetric methods (Method 3001 and Method 3003, respectively) to produce total nitrogen and total phosphorus concentrations.