Citizen Science Fact Sheet W-4

Nitrogen

WATER

W-4 Nitrogen

Purpose

Nitrogen (N) and phosphorous (P) are the most important nutrients limiting plant growth in terrestrial and aquatic ecosystems. While moderate to high levels of available nitrogen and phosphorus in soil are desirable for crop and pasture production, high levels of soluble N and P in aquatic ecosystems often lead to excessive growth of algae and other plants, which can reduce oxygen levels and kill fish as plants die and decompose. The process by which bodies of water gradually increase in plant life due to excess nutrient loading is called eutrophication. This is the leading problem in Kansas lakes and ponds

Water tests for nitrogen can only detect the inorganic forms readily available to plants such as nitrate, nitrite and ammonium. As shown in Figure 4-1, water can also contain significant amounts of nitrogen as dissolved or suspended organic matter, or in living organisms. In fact, high plant growth caused by excess nutrients can result in low, even non-detectable levels of inorganic nitrogen in water, making it difficult to use inorganic nitrogen alone as a measure of eutrophication. However, inorganic nitrogen tests can locate areas of a farm that contribute significant amounts of inorganic nitrogen in runoff or base flow. The inorganic nitrogen is soluble, and the content of the stream increases where and when those inputs occur. For a more complete measurement of the nitrogen status of water, obtain a total nitrogen (organic plus inorganic) analysis from a commercial laboratory. This would include nitrogen present in suspended microorganisms or organic matter.

The three forms of nitrogen that can be measured with field test kits include nitrate, nitrite and ammonia. One water sample gives a snapshot of a particular time. Storm runoff water is often higher than standing water because plants, including algae, have taken up the soluble forms of nitrogen.

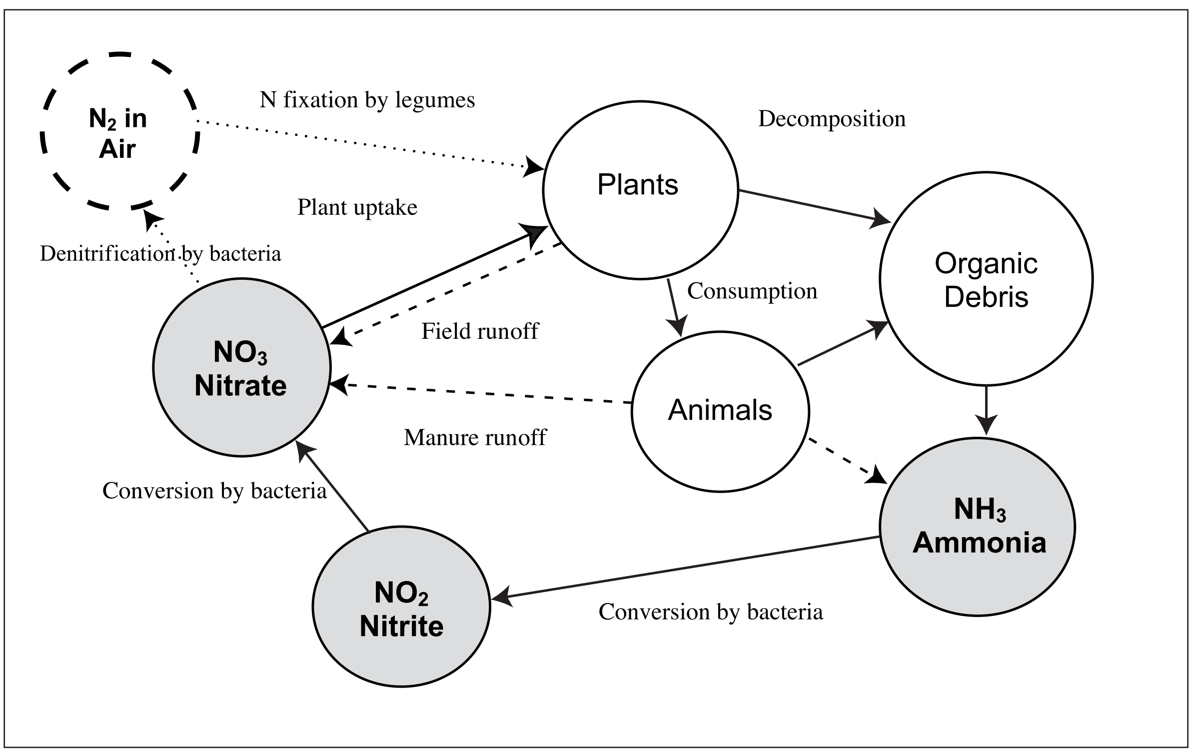

Figure 4-1. Nitrogen cycle in water (Test kit samples nitrate, nitrite, and ammonia.)

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Nitrate nitrogen (NO_3-N) and Nitrite nitrogen (NO_2-N)

Tools

Test strips are recommended for this field test kit. These are convenient, inexpensive and relatively accurate compared to commercial laboratory analysis. These can be purchased from stores selling aquarium supplies and science supply catalogs or from the address at the end of this fact sheet. The brand tested for this kit is manufactured by Hach, and tests nitrate (range 1 to 50 ppm) and nitrite (range 0.15 to 3.0) on the same test strip. This is adequate for most field samples.

Interpretation

Nitrate Nitrogen (NO_3 -N)

Anything higher than zero in streams or ponds may be a concern. However, 10 ppm is the maximum contaminant level in drinking water. Because of ambient levels in many groundwater sources, many municipal water systems test at about 2 ppm. There are no national or state standards related to nitrate and aquatic life in surface water, but if nitrate is detected, it could lead to increased plant growth in the water, which causes decreased oxygen, which then can stress or kill fish and other aquatic life that requires oxygen.

Procedure

Two tests are on two separate pads on the same test strip. Remove the number of test strips needed for your samples, place on a clean, dry surface and replace the cap. Label the test strips with the sample number or place on a numbered paper towel or sheet of paper. Store the rest of the test strips at room temperature with the lid tightly closed. The expiration date is on the bottom of the bottle.

Directions

1. Dip a strip into your sample for 1 second. Do not leave it in the water to soak, and do not shake excess water from the strip.
2. Hold the strip level or place tab up on clean, flat paper towel for 30 seconds. Note the color of the lower test pad compared to the second set of color comparisons. This is the nitrite test. On the bottle label there is a drawing of a test strip with two pads. Use this as a guide for which color chart goes with each test pad.
3. After 60 seconds, compare the color of the top pad to the upper chart on the bottle. This is the nitrate test, which measures nitrate plus nitrite.
4. Leave the strip undisturbed for another couple of minutes. Read both color pads again, at maximum color intensity. Note when the color starts to fade.
5. Record the maximum intensity numbers from Step 4 for nitrate and nitrite on your data sheet. This reading will take about two to five minutes. If there was nitrite in the sample, subtract that number from the nitrate test, and write down the nitrate level. The units are nitrate-N and nitrite-N, in ppm (mg/L).

Note: We compared reading the strips at 30 and 60 seconds (for nitrite and nitrate respectively), with the maximum method, and found that reading the nitrate at 30 and 60 seconds consistently resulted in a low reading compared to results from K-State water test lab. The maximum color reading correlated most accurately. So, even though the bottle says to read the color at 30 and 60 seconds, we recommend the revised version of this test.

Figure 4-2. Nitrate and nitrite test strips are easy to use. Simply dip in the water and then record the color change after about two minutes.

In our sampling of pilot-test farms, most stream, pond and field runoff samples had either no detectable or very low levels of nitrate N (below 1 ppm). We occasionally found high nitrogen levels in water when sampling next to recently fertilized corn fields. These samples were 50+ ppm nitrate nitrogen.

Record the actual nitrate nitrogen value on the data sheet, and circle the rating.

Nitrate is not directly toxic to plants or animals, but it can become toxic to a variety of animals if it is converted to nitrite (NO_2-N) during digestion. Nitrite can bind with hemoglobin in the bloodstream and prevent blood from carrying oxygen. Adult humans possess enzymes that reverse this process, but drinking water with more than 10 ppm nitrate nitrogen is not safe for consumption by infants and pregnant women. A similar disorder, called brown blood disease, can occur in fish, but it is relatively rare in the wild because it is associated with high levels of nitrite rather than nitrate.

Nitrite nitrogen (NO_2-N)

The maximum contaminant level in human drinking water is 1 ppm nitrite nitrogen (NO_2-N). While there is no formal aquatic life criterion in Kansas, there is evidence that nitrites can cause brown blood disease in some species of fish at concentrations as low as 0.1 ppm depending on other water quality criteria. Other species are considerably less sensitive. We rarely detected nitrite under base flow conditions in our preliminary study, but occasionally found small, but detectable amounts in runoff.

Nitrite is potentially toxic to a variety of organisms. Fortunately nitrite rarely accumulates in the environment because it is rapidly converted to other nitrogen species such as nitrate, nitrous oxide or nitrogen gas by oxidizing (nitrification) or reducing (denitrification) reactions. High levels of nitrite in water samples are unusual and highly undesirable.

Nitrate Rating			
4 – Best	3 – Good	2 – Fair	1 – Poor
No detectable nitrate nitrogen.	Nitrate nitrogen detectable, but less than 1 ppm.	Nitrate nitrogen between 1 and 10 ppm.	Nitrate nitrogen higher than 10 ppm.

Nitrite Rating			
4 – Best	3 – Good	2 – Fair	1 – Poor
No nitrite nitrogen detected.	Nitrite nitrogen detectable, but less than 1 ppm.	Nitrite nitrogen between 1 and 2 ppm.	Nitrite nitrogen higher than 2 ppm.

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Ammonia nitrogen (NH_4 and NH_3)

The directions that follow use the ammonia nitrogen test from Hach. A bottle of 25 test strips come with three clear plastic vials for mixing. To order, see the address at the end of this fact sheet. These test strips are sensitive to levels between 0.25 and 6.0 ppm NH_4^+.

Interpretation

Ammonia has acute and chronic toxic affects on aquatic life. To calculate whether the level in the water is toxic at the acute or chronic level, you must also know the temperature and pH of the water.

Procedure

Rinse the three water sample tubes that come with the test strip kit in distilled water and drain. Take out the same number of test strips as you have samples of water and place them on a clean, dry paper towel. Write the water sample numbers on the strips or on clean pieces of paper or paper towel used while running tests. After dipping the strips, lay them next to their respective sample numbers on the second towel. Store the remainder of the test strips at room temperature with the lid tightly closed. The expiration date for the strips is on the bottom of the bottle.

Directions

1. Fill the sample vial to the top line with the water sample.
2. Dip the strip into the water sample. Vigorously move the strip up and down in the water sample for 30 seconds, making sure both pads are always submerged. (*Figure 4-3*)
3. Remove the test strip and shake off excess water.
4. Hold the test strip horizontally with the pad side up for 30 seconds.
5. To read the strip, turn the test strip over so that both pads are down, and hold it so that the pads are facing away from you. It helps to have good lighting while doing this reading.
6. Compare the color of the small pad to the color chart on the bottle. Read the result through the clear plastic of the test strip.

   Note: these samples also change after 30 seconds, but in our experience, they become less accurate if you wait. Read these at the time intervals stated on the bottle, after 30 seconds in the water, plus 30 seconds out of the water, for a total of one minute.
7. Rinse the sample vial with distilled water after each use and drain.

   Note: For this test, we recommend also running a side-by-side sample with distilled water. For some reason, we often get a low level ammonia reading (0.25 or lower) with this test, even in distilled water. If this is the case when you run your test, subtract the level obtained with distilled water from the level obtained from your sample water. At high pH and high temperature, even a small amount of ammonia nitrogen can be toxic, so it is important to be accurate even at low concentrations.

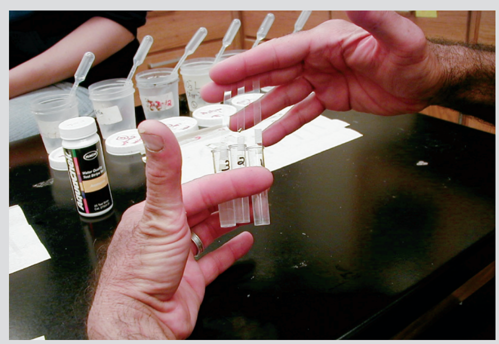

Figure 4-3. The ammonia test strips have a compound on the test strip that reacts with ammonia to cause the color change. Strips react within a vial of sample water for 30 seconds and can be read after another 30 seconds

Most of the ammonia nitrogen in water exists in the form of ammonium ion (NH_4^+), but a small fraction exists as free ammonia (NH_3), which is highly toxic to fish and other aquatic organisms. Because the relative proportion of free ammonia increases rapidly as pH and temperature increase, the best way to estimate ammonia toxicity is to use separate measurements of pH, temperature and total ammonia (NH_4 and NH_3). Tables 4-1 and 4-2 on page 6 provide an estimate of ammonia toxicity based on these three measurements.

Refer back to the data sheets where the pH and temperature have been recorded. Using Table 4-1, find the pH of the sample on the left-hand column. Now look for the water temperature reading (in Celsius) across the top. Follow the column down until the temperature and pH column and row intersect. That is the level of ammonia that would cause long-term problems for aquatic life at the temperature and pH of the water sampled.

On the line following the ammonia nitrogen level on the data sheet (W-11), record the chronic concentration level. Repeat this exercise with Table 4-2 to find the acute concentration level. On the next line of the data sheet, record the acute toxicity level (from Table 4-2) Refer to these two numbers when using the interpretation chart.

Where is the nitrogen coming from?

Some nitrogen could come from natural deposits of soil or rock, but most comes from human sources such as wastewater treatment plants, leaking septic systems, farm runoff from livestock areas and from fields fertilized with nitrogen fertilizer or manures. Gardens and lawns fertilized with nitrogen and leaky compost piles can be a source in urban and suburban areas. Storm runoff from dog kennels or cat litter box dumping and wildlife feces contribute a small amount of nitrogen in the environment. Large farms are generally required to have lagoons to hold the manure and keep field records of land application. This prevents too much from being applied to the land, which would then be vulnerable to runoff. Best management practices for manures and fertilizers include split application (put on small amounts several times rather than a large amount all at once), incorporation of the N source (till after application or inject), and avoiding winter application when plants are not present or active in taking up the applied nitrogen. To avoid livestock manure running off fields into surface water, leave a buffer of unmown grass near streams to act as a filter and fence sensitive areas such as where cattle stand in the water, or create pathways for erosion and runoff.

Where to order test kits:

Hach Company
P.O. Box 389
Loveland, CO 80539-0389
1-800-227-4224
www.hach.com
E-mail: *orders@hach.com*

Nitrate/nitrite test strips: order #27454

Ammonia test strips: order #27553

Cost: About $0.60 per test

Ammonia Rating			
4 – Best	3 – Good	2 – Fair	1 – Poor
Total ammonia nitrogen level is zero or non-detectable.	Total ammonia level is detectable, but below the level that would cause chronic toxicity to aquatic life (Table 1).	Total ammonia level is high enough that it is within the chronic toxicity range, but not acute (higher than Table 4-1, but lower than the value in Table 4-2).	Total ammonia nitrogen level would cause acute toxicity to aquatic life (exceeds value in Table 4-2).

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Table 4-1.

Chronic Concentration Criterion (Total Ammonia as mg/L or ppm N)

	Temperature (Degrees Celsius)						
pH	**0**	**5**	**10**	**15**	**20**	**25**	**30**
6.50	2.20	2.06	1.95	1.90	1.81	1.79	1.27
6.75	2.58	2.41	2.31	2.20	2.13	2.12	1.50
7.00	3.12	2.96	2.77	2.71	2.63	2.59	1.84
7.25	4.27	3.99	3.80	3.62	3.55	3.50	2.48
7.50	3.18	3.00	2.87	2.75	2.69	2.71	1.93
7.75	2.23	2.11	2.01	1.93	1.86	1.90	1.36
8.00	1.46	1.37	1.31	1.27	1.26	1.27	0.92
8.25	0.83	0.78	0.75	0.73	0.73	0.74	0.54
8.50	0.47	0.45	0.43	0.43	0.43	0.45	0.34
8.75	0.27	0.26	0.25	0.25	0.26	0.28	0.22
9.00	0.16	0.15	0.15	0.16	0.17	0.19	0.15

Table 4-2.

Acute Concentration Criterion (Total Ammonia as mg/L or ppm N)

	Temperature (Degrees Celsius)						
pH	**0**	**5**	**10**	**15**	**20**	**25**	**30**
6.50	42	39	37	36	34	34	24
6.75	38	36	34	33	32	32	22
7.00	33	32	30	29	28	28	20
7.25	28	26	25	24	23	23	16
7.50	21	19	19	18	18	18	13
7.75	15	14	13	13	12	12	9
8.00	10	9	9	8	8	8	6
8.25	5	5	5	5	5	5	4
8.50	3	3	3	3	3	3	2
8.75	2	2	2	2	2	2	1
9.00	1	1	1	1	1	1	1

***To convert degrees Celsius (°C) to Fahrenheit (°F), use the equation** $(\frac{9}{5} \times °C) + 32 = °F$*

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Kansas State University Agricultural Experiment Station and Cooperative Extension Service

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