Measuring the Quality of Tile Drainage Water

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1.0 Introduction

There is a growing interest among farmers in analysing the quality of tile drainage water. There are two main reasons why farmers are interested in this sampling: a) to monitor concentrations of nutrients over a period of time and use variations to give feedback on the effectiveness of nutrient management planning; and b) to sample tile water at manure spreading time to ensure no manure has entered the tile system. Studies have been done over the years to establish that macropore flow of manure can happen, and that there are steps that may be taken to reduce or eliminate the risks. It is now expected that farmers will check tile drain outlets during and after manure spreading to ensure no manure has entered the water. In addition, studies have shown typical concentrations of nutrients in tile water under a variety of farm management systems in Ontario.

As nutrient management plans become the norm for farmers, and as neighbour scrutiny at manure spreading times increases, the interest in tile water sampling will only increase. Some farmers will be interested in simple, cost-effective tests that can be done on site, where results are quick and fairly accurate. Even if they intend to submit samples to a lab, farmers (or crop consultants) need to know the proper way to collect samples (whether for nutrient of microbiological analysis), the proper time to collect samples, how to store and ship the samples, and what to include in the tests. At present, there is no good guidance on these issues.

2.0 Background

2.1 Factors Influencing Tile Water Quality

Many factors can influence the quality of tile drainage water. The relative impact of these varies from field to field. Following is a brief discussion of the main factors:

Soil type - The texture of a soil affects its infiltration rate, which has an impact on the speed that potential contaminants can reach tile drains. Patni et al (1984) showed that fine-textured soils can have 25 to 50% more tile flow than coarse-textured soils. The quality of drain water was similar, but since there was more water from the fine-textured soil, the total quantity of contaminants was also higher.

Tillage type - Contaminants can find their way down to the drainage system by travelling through macropores in the soil. Tilling a field helps breaks up these flow paths. In a study by Patni et al (1996), nitrate-N concentrations of water samples from “conventionally-tilled” plots were consistently lower than samples from no-till plots over a 40- month period in southwestern Ontario. Fleming et al (1998) found slightly different results. Tile water nitrate levels were significantly higher for fields that were chisel plowed than for all other tillage methods - cultivation, moldboard plow, ridge tillage, and no-till.

Nutrients added - A crop only requires a finite amount of nutrients. There is a general acceptance that applications of nutrients beyond the agronomic optimum will result in little additional crop response and also that it is these nutrients that are most likely to be lost from the field in water percolating through the soil or in surface runoff (Lanyon, 1995).

Precipitation - Water serves as a method of transport for potential contaminants. The water may pick up these contaminants as it percolates down into the ground, and carry them into the tile drain. Alternatively, it may carry contaminants from the field into a surface water system as runoff.

2.2 Water Quality Standards

Many standards have been created to assist in the regulation of water quality. The most applicable to Ontario are the Canadian Water Quality Guidelines and Ontario's Provincial Water Quality Objectives. Following is a brief description of these standards. Note that the quality of tile drain water is not covered by some of the standards.

Canadian Water Quality Guidelines

This consists of four major parts. They are as follows:

1. Protection of Aquatic Life (PAL) - This guideline is designed to protect all plants and animals that live in our lakes, rivers and oceans by establishing acceptable levels for substances or conditions that affect water quality. (Environment Canada, 2002)

2. Protection of Agricultural Water Uses (PAWU) - This guideline is designed to protect sensitive crop species that may be exposed to toxic substances in irrigation water and to protect livestock from substances in their drinking water that may cause harm or accumulate in the animals' bodies. (Environment Canada, 2002)

3. Drinking Water Quality (DWQ) - This guideline is designed to protect the health of Canadians by establishing maximum acceptable concentrations for substances found in water used for drinking. (Environment Canada, 2002)

4. Recreational Water Quality (RWQ) - This guideline is designed to protect the health of Canadians using water for recreational activities like swimming, boating, fishing, etc. The guideline deals mainly with the infectious capabilities and the aesthetic qualities of water. (Environment Canada, 2002)

Ontario's Provincial Water Quality Objectives (OPWQO)

Ontario's objectives are designed to ensure that the surface waters of the province are of a quality which is satisfactory for both aquatic life and recreation. The effluent requirements of the province are established on a case-by-case basis. In establishing these requirements, the province considers the characteristics of the receiving body of water. (Ontario Ministry of the Environment, 1984)

2.3 Tile Water Quality Indicators

Following is a discussion of the main indicators used to determine if tile water quality has been affected by farming practices. There are three general types of indicators: Physical, Chemical and Biological.

Physical Indicators

1. Turbidity

Turbidity is an optical quality of water. Turbidity is caused by suspended matter such as clay, silt, finely divided organic and inorganic matter, soluble coloured organic compounds, plankton and other microscopic organisms. High turbidity has been linked with bad odour and taste in water. It promotes bacterial growth and causes the entrapment of bacteria, viruses and other harmful substances. High turbidity levels can even protect bacteria and viruses from disinfection.

There are no turbidity standards for the protection of aquatic life, though there is a recreational water guideline of 50 NTU (Environment Canada 2002).

In past studies of tile water quality, turbidity has not been measured so there are no background levels to report.

Chemical Indicators

1. Ammonia

Ammonia is produced naturally by the biological degradation of nitrogenous matter present in organic materials or soils. Ammonia is very soluble in water. This can result in a high mobility in soil. Typically, more than half the nitrogen in liquid manure is in the ammonia form.

A standard exists for levels of ammonia in surface water - for the protection of aquatic life. The OPWQO states that concentrations of un-ionized ammonia should not exceed 0.02 mg/L (total ammonia levels are related to this by taking into account temperature and pH of the water) (Ontario Ministry of the Environment, 1984).

Ammonia levels have been measured in various tile water studies. For example, Patni and Hore (1978) measured average concentrations of ammonia-N between 0.08 and 0.10 mg/L in several hundred samples. For water at 15 degrees and a pH of 7.0, the un-ionized ammonia concentration would be 0.003 mg/L. Based on 748 tile water samples in a study by Fleming et al (1998), the average ammonia-N concentration was 2.3 mg/L (equivalent to 0.008 mg/L un-ionized ammonia using the above assumptions).

2. Conductivity

Conductivity is a measure of the ability of electrical current to flow through a solution, and is the reciprocal of electrical resistance. Due to the fact that conductivity increases nearly linearly with increasing ion concentration, we can use conductivity measurements to estimate ion concentrations (i.e. dissolved salts) in solutions. The results of conductivity measurements are often reported as Total Dissolved Solids.

Since the conductivity of water causes no quality concerns on its own, there are no standards. However, because the test is relatively easy to do, it can be useful in detecting the presence of other, more serious water quality impacts. Typical values for tile water are in the range 230 to 760 (μS/cm) (Patni and Hore 1978; Patni et al 1996).

3. Nitrate/Nitrite

Nitrogen is essential to all life, and most crops require large quantities to sustain high yields. Plants use nitrate from the soil to satisfy nutrient requirements. Sometimes rain or irrigation water can leach the highly soluble nitrate into the subsurface drainage system. If humans or animals ingest water high in nitrate, it may cause methemoglobinemia or blue baby syndrome, a condition affecting infants under six months of age. Healthy adults can consume fairly large amounts of nitrate with few known health effects.

Currently, there are no nitrate standards for surface water quality. The drinking water standard is 10 mg/L nitrate-N (which is equivalent to 45 mg/L total nitrate) (Environment Canada 2002).

Ontario studies of tile water quality have yielded a range of nitrate concentrations. Patni and Hore (1978) found average values in the range 3.6 to 52.2 mg/L nitrate-N. Fleming (1990) found an average of 10.6 mg/L nitrate-N, based on 1110 samples. Fleming et al (1998) found an average of 17 mg/L, based on 1295 samples (in a different region of southern Ontario). Patni et al (1996) found averages of 21 to 25 mg/L nitrate-N.

4. pH

pH is a measure of the acidic or basic nature of a substance. If the pH of water changes, the water may no longer be able to support the life that it previously could. Many living things are very sensitive to even the slightest pH changes, which is why it is very important that this parameter is not altered significantly.

A standard exists for the pH in surface water - for the protection of aquatic life. The OPWQO states that pH should be maintained within the range 6.5 to 8.5 (Ministry of the Environment, 1984).

The average pH values reported in the tile water studies carried out by Patni and Hore (1978), Fleming et al (1998) and Patni et al (1996) were in the range 7.0 to 7.6.

5. Phosphorus

Phosphorus occurs in natural waters almost solely in the form of phosphate (composed of phosphorus and oxygen). Phosphate, like nitrate, is an essential plant nutrient. It can promote algae growth if present in too high a concentration in surface water. The low solubility of phosphate means that it is less of a threat to groundwater quality than to surface water.

Ontario has a guideline for phosphorus in surface water. For rivers and streams, excessive plant growth can be prevented if the total P level is held below 0.03 mg/L (Ontario Ministry of the Environment, 1984).

Patni and Hore (1978) found average P concentrations in the range 0.05 to 0.08 mg/L. Fleming (1990) found an average of 1.3 mg/L, based on 1109 samples. Fleming et al (1998) found an average of 0.48, based on 749 samples.

Biological Indicators

1. Bacteria

Bacteria are microscopic organisms that are present throughout the natural environment. Bacteria can be harmful or helpful to humans. Organisms that can lead to sickness in humans are called pathogens. Coliform bacteria are generally used as indicators of bacterial contamination of water. Coliform bacteria originate in the intestinal tract of warm-blooded mammals, and are excreted in large numbers with digestive wastes. When they are present in a water sample, it can be assumed that the water has been contaminated by fecal matter (e.g. humans or livestock). Most coliform bacteria are not pathogenic, but they indicate the potential for other, more harmful, fecal organisms to be present.

There is currently no standard for bacteria levels in surface water - for the protection of aquatic life. There is a standard for bathing water (recreational use). In Ontario, the maximum fecal coliform density in bathing water is 100/100 mL. For total coliform bacteria, the maximum is 1000/100 mL (Ontario Ministry of the Environment, 1984). There are, of course, drinking water standards.

Tile water studies have shown a range of concentrations of bacteria. Based on 1123 samples, Fleming (1990) found a geometric mean density of fecal coliform bacteria of 78 per 100 mL. Studies by Patni and Hore (1978) and Patni et al (1984) found between three and 12 fecal coliform organisms per 100 mL. These two studies also found between 15 and 220 total coliform organisms per 100 mL.

2. Organic Matter

When organic matter such as dead plants, leaves, grass clippings, manure, sewage, or even food waste is present in water, bacteria begin the process of breaking down this material. As this happens, much of the available dissolved oxygen is consumed by aerobic bacteria, robbing other aquatic organisms of the oxygen they need to live. Biological Oxygen Demand (BOD) is a measure of the oxygen used by microorganisms to decompose this waste. When BOD levels are high, dissolved oxygen (DO) levels decrease because the oxygen that is available in the water is being consumed by the bacteria. This can be fatal to fish and other aquatic organisms.

BOD is more often associated with wastewater than it is with tile drainage water or other surface water or groundwater. No standards exist for BOD levels in surface water and it is very difficult to find any tile water studies where levels of BOD have been measured.

3.0 Objectives

A study was started at Ridgetown College - University of Guelph in the summer of 2002 with the following objectives:

1. Determine the most appropriate and useful tests that land-owners should carry out to assess the quality of tile drainage water.
2. Evaluate simple test procedures that may be used on-site to establish tile water quality.
3. Develop a tile water testing protocol for land owners who want to take tile water samples for chemical or microbiological analysis.

4.0 Project Setup

Step 1 The first step in the project involved a review of accepted sampling practices used to collect environmental water samples. This step also included a review of typical test procedures.

Step 2 Based on the review included in the Background section of this report, a series of test parameters was chosen.

Step 3 A group of readily available test kits was investigated and purchased. These had to be appropriate for use by the land-owner - e.g. bacteria presence/absence test kits, kits for nitrate or other nutrients, conductivity pen, etc.

Step 4 Surface water samples were collected from a variety of sources. The original intent was to use tile water samples but no tile drains were running during the summer of 2002 due to the dry conditions, so other surface water samples were collected. This change in plan was not deemed to have any impact on the final results of testing.

Step 5 Each water sample was tested using each of the test kits and a sample was sent to a recognized lab for analysis - Laboratory Services Division, University of Guelph. This latter test was considered to represent the “official” levels.

Step 6 The various test results were compared.

5.0 Observations and Discussion

Collecting Water Samples

General information on recognized procedures for collecting surface water samples is included in Appendix 1. For this evaluation, eight water samples were tested. Samples were collected in new one litre glass bottles. The original intent was to collect tile water samples, but as no tiles were running (due to the dry summer), surface water samples were used. These came from streams and ponds/lakes in the area. The expectation was that nitrate and phosphorus levels would be less than typical tile drain water and that bacteria levels would be higher. One of the eight samples was tap water. The samples were refrigerated overnight until testing. A smaller sample bottle was used to hold the sample that was delivered to the Guelph testing lab. The testing of the kits was carried out inside a lab at Ridgetown College, though they could just have easily been done on-site when the sample was collected.

Test Kits

A survey of lab-supply catalogues was carried out to gather information on the types of test kits available, the test range possible and the costs. The goal was to test for some of the parameters listed above and to find tests that cost less than $200. Of the water quality indicators discussed earlier: turbidity, ammonia, conductivity, nitrate, pH, phosphorus, bacteria and BOD, not all were deemed to be suitable for on-site testing. For example, most people would be able to get a feel for changes in turbidity by simply collecting a sample in a glass jar and doing a visual assessment. It is unlikely that pH values in water samples would change appreciably with the entry of contaminants, so it would not be as useful a test. Finding low cost tests in the correct concentration ranges for BOD or ammonia may be possible, but they do not seem to be readily available. The following list represents the test kits that were evaluated.

TDSTestr 4 (from Fisher Scientific) - This test kit measures electrical conductivity, which is related to Total Dissolved Solids. It is fast (instant readings) and extremely easy to use. The conductivity meter needs only to be turned on and dipped into the sample. The range of this particular unit is 0 to 19.90 mS/cm. A lower range model is available as well though. The meter can be used to take readings in all manner of liquid samples, including raw manure. The approximate cost of this unit is $110, and the number of tests is based on the battery life.

ECTestr (from Cole-Parmer) - This tester also measures electrical conductivity. It is fast, but not as quick as the previous tester. This model can take up to 30 seconds to finally settle on a value. The method of testing is the same as for the previous meter - merely dip and read. The range of this meter is 0 to 19.99 mS/cm and a lower range model is also available. The approximate cost of this unit is $145.

Kool Kount Assayer (from Cole-Parmer) - This test kit measures bacterial presence - not just E. coli, but a broad range of bacteria that may be present. The test is more time-consuming and difficult to carry out. There are no quick and easy bacteria tests that give instant results. Even lab analysis relies on culturing and growing the living organisms. The Kool Kount Assayer requires up to 12.5 hours of incubation time in 35 degree C (e.g. a shirt pocket). A great deal of care must be taken when handling the sample and carrying out the test to avoid contamination. Although results can be obtained within one half hour of sampling, this is only if bacterial presence is extremely high. The kit provides a chart for determining ranges of bacterial concentrations (in Colony Forming Units per 100 mL (cfu/mL)). Because this test relies on colour changes, samples that are not clear at the beginning of the test may cause problems. The approximate cost of this unit is $86 for 8 tests.

AquaCheck Test Strips (from Fisher Scientific) - This test kit measures nitrate-N and nitrite-N concentrations, but strips that measure other parameters can be just as easily obtained. This kit provides an estimated concentration within 30 seconds for nitrate and 1 minute for nitrite. The test involves dipping a small test strip into the sample, and after the appropriate time, noting the colour of the strip. A colour chart is used to interpret the results. The chart provides a range (in 7 steps) from 0 to 50 ppm for nitrate-N and 0 to 3 ppm for nitrite-N. Estimations are needed if the colours do not exactly match up to the colours on the chart. Also, the test may require a relatively clear sample so as not to block the colour of the strip. The approximate cost of this unit is $25 for 25 test strips.

EM Quant Test Strips (from Fisher Scientific) - This test kit is virtually identical to the previous with the following exceptions: These test strips give values in ppm nitrite and ppm nitrate as opposed to ppm nitrite-N and ppm nitrate-N. Nitrite is not given a numerical quantity, instead its measured range is divided into (-) (+) and (++). Nitrate is measured over the range of 0 to 500 ppm. The approximate cost of this unit is $65 for 100 test strips.

CHEMets Kit (from Fisher Scientific) - This test kit measures phosphate concentrations (i.e. PO_4). For proper interpretation of results, the user must be aware of the differences between total P, dissolved P and phosphate (1.0 mg/L of dissolved P is equivalent to 3.07 mg/L of phospate). The test is quite simple to perform and only takes about two minutes to complete. Like the test strips, this kit requires that a comparison between the sample and a colour chart be made in order to determine the concentration of phosphate in the sample. The test kit comes with both a high range and a low range colour comparison chart. The range of the test kit is 0.1 to 10 ppm phosphate. Again, because colour comparisons are necessary, clear water is needed for this test to perform well. The approximate cost of this unit is $75 for 30 tests.

Contact information for the suppliers of test kits in this project:

1. Cole-Parmer
   www.coleparmer.com
   Labcor Technical sales
   55 Administration Road, Unit 10,
   Concord, Ontario, L4K 4G9
   1-800-363-5900
   1-905-761-7788
   fax 1-905-761-7644
   www.labcor.com

2. Fisher Scientific
   1-800-234-7437
   fax 1-800-463-2996
   www.fishersci.ca
   Located in Vancouver, Edmonton, Winnipeg, Toronto, Ottawa, Montreal, Quebec City, Halifax

Test Results

The lab results are reported in Table 1. Sample #5 was the tap water sample, and as expected, it had low numbers for all parameters tested. Unfortunately (for the purposes of this test) most of the parameters had fairly low concentrations, so we were not able to test for the entire range of typical results for tile water quality.

Table 1 - "Official" results from the water testing lab for the eight water samples

Water Sample	Total P (mg/kg)	Dissolved P (mg/L)	Elec. Cond (mS/cm)	Tot. Colif (cfu/100 mL)	E coli (cfu/100 mL)	Nitrate-N (mg/L)	Nitrite-N (mg/L)
1	0.282	0.161	2.7	130000	15000	0	0
2	<0.05	<0.05	0.33	300	2	0.03	0.05
3	<0.05	<0.05	0.41	2000	16	0.04	0.06
4	<0.05	<0.05	0.625	10000	100	5.2	0.13
5	<0.05	<0.05	0.335	32	< 1	0	0
6	<0.05	<0.05	0.25	2000	90	0.18	0.08
7	<0.05	<0.05	0.7	12000	<1	21.38	0.08
8	<0.05	<0.05	0.65	20000	40	0.36	0.11

The results for electrical conductivity were the most impressive of the various test kits. Figure 1 shows the results obtained from the lab test and the two testers used on site. Both of the quick tests gave results that agreed well with the lab results, in the range of values tested. Note also that the electrical conductivity was highest for sample #1, which had the highest P and bacteria contents.

There was good agreement on the bacteria testing. The Kool Kount Assayer detected the presence of bacteria in all of the surface water samples. The only sample that showed up as a negative was the sample of tap water. Unfortunately, getting an idea of the numbers of organisms present in the surface water samples was not as easy as had been hoped. It requires careful timing and the use of the colour chart, and it is hard to guarantee the accuracy of the incubation temperature.

The concentrations of total P and dissolved P were below the detection limit used in the lab analysis in all but one sample. Similarly, the results for the CHEMets Kit showed that the concentrations were all below the detection limit of 0.1 mg/L phosphate (approx. equivalent to 0.03 dissolved P). While this may be viewed as being in agreement, it is hard to draw conclusions about the performance of the test kit for higher concentrations that may be encountered in tile drain water.

The nitrate kits performed reasonably well. Concentrations for six of the eight samples were less than 0.5 mg/L. The two test kits gave correspondingly low values, even though the numbers were

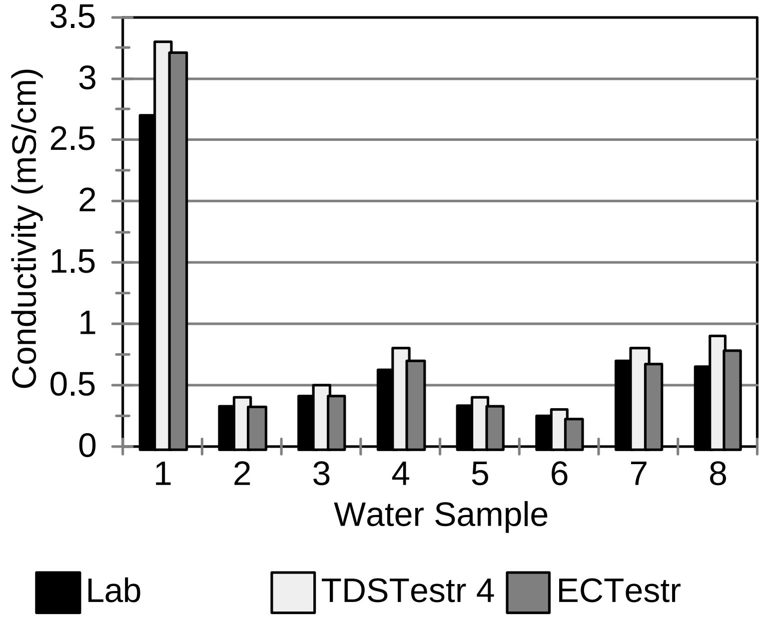

Figure 1 Electrical conductivity results for the 8 water samples

not execatly the same. However, sample #4 had a concentration of 5.2 mg/L. The AquaChek Test Strips gave a result of 5 mg/L and the EM Quant Test Strips gave a result of 2.3 mg/L. Sample #7 had a concentration of 21.4 mg/L. The AquaChek Test Strips gave a result of 20 mg/L and the EM Quant Test Strips gave a result of 23 mg/L. These easy-to-use strips should be considered for quick on-site testing, where "ball-park" accuracy is all that is needed.

6.0 Summary

To measure the quality of water from tile drains, a number of standards tests may be performed, including measuring one or more of: turbidity, ammonia, conductivity, nitrate, pH, phosphorus, bacteria and BOD. Some of these may be measured relatively quickly and at a fairly low cost on-site using one of the rapid tests evaluated in this study.

As part of a nutrient management program to monitor nitrate-N and P, the tests used in this study would be suitable. They should be used only to give a general idea of the range of concentrations. If the tester needs to know whether the concentration is closer to 1.0 or 10, these tests are appropriate. For more precision, more expensive tests are available, but the lab analysis is likely more feasible.

Tests are available that give an indication of the presence or absence of bacteria in a water sample. They cost around $10 per sample and the answer is not immediate - it generally takes a few hours to accurately determine the presence of bacteria. Some of the test kits available will analyse for specific organisms. Often, it is the low numbers of bacteria that are occasionally present in tile water at manure spreading time that are of greatest concern. In these cases, an accurate analysis is needed immediately, but this is not feasible, unfortunately. A presence/absence test may not be appropriate, since there are often low levels of background bacteria in water samples.

Tests for turbidity, ammonia, pH and BOD were not evaluated in this study. For turbidity, to progress beyond a visual assessment becomes expensive (e.g. purchase of a turbidimeter). For ammonia, tests are available but none that fit the criteria were found for this test project. The value of a pH test to detect changes in water quality is not clear, though rapid test kits are available. BOD test kits are beyond the cost goals of this project.

The electrical conductivity of water, by itself, poses no quality concern. However, it is often possible to detect changes in water quality by measuring conductivity. The tester is relatively inexpensive (typical $100 to $150 for the accuracy needed) and is very fast and easy to use.

The test kits evaluated in this study certainly would not replace the accuracy of a laboratory test though the conductivity meters are close). However, for specific concerns and as part of a sampling program, it is hard to beat the speed and convenience of some of these tests. Their strength is likely as a screening tool - in alerting the landowner to changes in water quality, so that more accurate testing may be carried out.

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Appendix I - Water Quality Sampling Procedures and Modes of Testing

The following information is a guide intended for persons interested in testing their own tile water. It is only a guide, and should not be considered the only way to perform a sampling operation.

Choosing When to Take Samples

To best ensure that drainage water is of acceptable quality, a regular sampling schedule should be undertaken - such as biweekly, or monthly, depending on the level of commitment of the sampler and when the tile drains are running. However, if such frequent sampling is not feasible, at the least samples should be collected yearly or twice-yearly. Also, it is important to check the quality of tile effluent soon after nutrient application or heavy rainfalls. This will ensure that any significant changes in the tile water due to the application of the nutrients will be noticed, and appropriate protective measures can still be taken.

Preparations to Make Before Sampling

If the sample is for Chemical Properties:

- For any nutrient samples, plastic or glass containers with screw lids should be used.
- If the sample bottle is not new, wash it with detergent that is free of phosphate and ammonia, then rinse it under tap water until suds are no longer present.
- The lab that you are working with may have specific requirements for containers, and they may supply the containers.

If the sample is for Physical Properties:

- For any samples tested for physical properties, plastic or glass containers with screw lids should be used.
- If the sample bottle is not new, wash it with detergent that is free of phosphate and ammonia, then rinse it under tap water until suds are no longer present.

If Sample is for Biological Properties:

- For any bacteria samples, plastic or glass containers should be used.
- These containers need to be completely sterilized before use. The lab may specify that a preservative be used in the bottle, to help prolong the life of any bacteria in the water sample.

Labeling and Documenting

This is a critical step in the sample process. Before taking any samples, a proper method of labeling and documenting must be set up in order to keep track of the samples and the results of the tests. Records items such as: locations of sample sites, nutrient applications, recent rainfalls, date and time of sampling and current crop cover. This will help in understanding the sample test results. Any anomalies in the data collected over time can be better explained. Any information that may influence the quality of the water should be documented.

To assist in the documentation, all samples should be well labeled and logged. The label should contain information concerning the location of the site where the sample was taken and the date and time of sampling. It may seem like overkill at the time, but it will save a lot of confusion later.

Collecting and Storing Samples

Chemical and Physical Samples:

- Collect the sample directly into the sample container.
- The sample container should be rinsed once or twice with water from the site being sampled.
- Fill the container to within 1 cm of the top.

Biological Samples:

- Keep the sample container sealed right up until the sample is actually taken.
- When taking the sample, do not make contact with the underside of the lid or the neck of the container and protect the container from any contamination.
- Fill the container *without* rinsing it and quickly secure the lid.
- Be sure to leave airspace in the container - about 2 cm.

The following table is a guide to storage of samples and timing of analysis:

Parameter	Container Volume	Preservative	Holding Time
Conductivity	100 mL	keep at 4°C	28 days
pH	25 mL	none required	little as possible
Turbidity	100 mL	keep at 4°C	48 hours
Ammonia	400 mL	keep at 4°C	28 days
Nitrate	100 mL	keep at 4°C	48 hours
Phosphorus	50 mL	keep at 4°C	28 days
Bacteria	100 mL	0.008% Na_2SO_4	6 hours

Laboratories or purchased test kits may have their own sample requirements, perhaps differing from the above. Laboratory employees and test kit instruction manuals should be considered the correct source for the above information. The preservative that is often used for bacteria tests in water may be supplied with the test bottles or may not be needed - check with the lab.

Sample Analysis

Once the sample has been properly collected, it must be analyzed. Generally, the sooner the testing takes place, the more accurate the results will be, no matter what the parameter.

Laboratory Testing:

- Results might not be received until a week or two after the delivery date. If the results are needed quickly, this mode of analysis is not appropriate.
- Results will be the most reliable.
- Costs are initially low for most common tests. If testing is performed frequently, ask about volume discounts.

In-field Testing:

- Results can usually be obtained within seconds or minutes of sampling (excluding bacterial tests).
- Results are not as reliable as would be from a laboratory.
- Portable testing devices can cost as low as $20 or can reach costs in excess of $5000.