

Total Dissolved Solids

INTRODUCTION

Solids are found in streams in two forms, *suspended* and *dissolved*. Suspended solids include silt, stirred-up bottom sediment, decaying plant matter, or sewage-treatment effluent. Suspended solids will not pass through a filter, whereas dissolved solids will. Dissolved solids in freshwater samples include soluble salts that yield ions such as sodium (Na^+), calcium (Ca^{2+}), magnesium (Mg^{2+}), bicarbonate (HCO_3^-), sulfate (SO_4^{2-}), or chloride (Cl^-). Total dissolved solids, or *TDS*, can be determined by evaporating a pre-filtered sample to dryness, and then finding the mass of the dry residue per liter of sample. A second method uses a Vernier Conductivity Probe to determine the ability of the dissolved salts and their resulting ions in an unfiltered sample to conduct an electrical current. The conductivity is then converted to TDS. Either of these methods yields a TDS value in units of mg/L.

The TDS concentration in a body of water is affected by many different factors. A high concentration of dissolved ions is not, by itself, an indication that a stream is polluted or unhealthy. It is normal for streams to dissolve and accumulate fairly high concentrations of ions from the minerals in the rocks and soils over which they flow. If these deposits contain salts (sodium chloride or potassium chloride) or limestone (calcium carbonate), then significant concentrations of Na^+ , K^+ , Cl^- will result, as well as hard-water ions, such as Ca^{2+} and HCO_3^- from limestone.

TDS is sometimes used as a “watchdog” environmental test. Any change in the ionic composition between testing sites in a stream can quickly be detected using a Conductivity Probe. TDS values will change when ions are introduced to water from salts, acids, bases, hard-water minerals, or soluble gases that ionize in solution. However, the tests described here will not tell you the *specific* ion responsible for the increase or decrease in TDS. They simply give a general indication of the level of dissolved solids in the stream or lake. Further tests described in this book can then help to determine the specific ion or ions that contributed to changes in the initial TDS reading.

There are many possible manmade sources of ions that may contribute to elevated TDS readings. Fertilizers from fields and lawns can add a variety of ions to a stream. Increases in TDS can also result from runoff from roads that have been salted in the winter. Organic matter from wastewater treatment plants may contribute higher levels of nitrate or phosphate ions. Treated wastewater may also have higher TDS readings than surrounding streams if urban drinking water has been highly chlorinated. Irrigation water that is returned to a stream will often have higher concentrations of sodium or chloride ions. Acidic rainwater, with dissolved gases like CO_2 , NO_2 , or SO_2 , often yields elevated H^+ ion concentrations.

Sources of Total Dissolved Solids

- Hard-Water Ions
 - Ca^{2+}
 - Mg^{2+}
 - HCO_3^-
- Fertilizer in agricultural runoff
 - NH_4^+
 - NO_3^-
 - PO_4^{3-}
 - SO_4^{2-}
- Urban runoff
 - Na^+
 - Cl^-
- Salinity from tidal mixing, minerals, or returned irrigation water
 - Na^+
 - K^+
 - Cl^-
- Acidic rainfall
 - H^+
 - NO_3^-
 - SO_3^{2-} , SO_4^{2-}

If TDS levels are high, especially due to dissolved salts, many forms of aquatic life are affected. The salts act to dehydrate the skin of animals. High concentrations of dissolved solids can add a laxative effect to water or cause the water to have an unpleasant mineral taste. It is also possible for dissolved ions to affect the pH of a body of water, which in turn may influence the health of aquatic species. If high TDS readings are due to hard-water ions, then soaps may be less effective, or significant boiler plating may occur in heating pipes.

Expected Levels

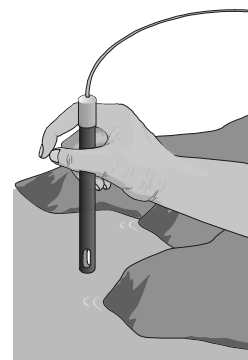
TDS values in lakes and streams are typically found to be in the range of 50 to 250 mg/L. In areas of especially hard water or high salinity, TDS values may be as high as 500 mg/L. Drinking water will tend to be 25 to 500 mg/L TDS. United States Drinking Water Standards¹ include a recommendation that TDS in drinking water should not exceed 500 mg/L TDS. Fresh distilled water, by comparison, will usually have a conductivity of 0.5 to 1.5 mg/L TDS.

Site	Season	TDS (mg/L)	Season	TDS (mg/L)
Rio Grande River, El Paso, TX	Spring	510	Fall	610
Mississippi River, Memphis, TN	Spring	133	Fall	220
Sacramento River, Keswick, CA	Spring	71	Fall	60
Ohio River, Benwood, WV	Spring	300	Fall	143
Hudson River, Poughkeepsie, NY	Spring	90	Fall	119

Summary of Methods

Method 1: TDS Using a Conductivity Probe

A Vernier Conductivity Probe is used on site, or placed into samples collected at sites, to measure TDS concentration of the solution. It offers the advantage that it can be performed without filtration, providing instantaneous feedback about total dissolved solids concentration in a stream.



Method 2: TDS By Evaporation

Using this method, samples are first filtered to remove suspended solids. A precise amount of sample is added to a carefully cleaned, dried, and weighed beaker. The water is then evaporated in a drying oven. The difference in mass between the two weighings is the mass of the total dissolved solids. Calculations are then performed to convert the change in mass to mg/L of TDS. This procedure does not require a sensor, but does require an analytical balance (0.001 or 0.0001 g resolution).

¹ Established by 1986 Amendments to the Safe Drinking Water Act

Method 1: TDS USING A CONDUCTIVITY PROBE**Materials Checklist**

- | | |
|------------------------------------|--|
| ___ computer | ___ wash bottle with distilled water |
| ___ Vernier computer interface | ___ tissues or paper towels |
| ___ Logger <i>Pro</i> | ___ small paper or plastic cup (optional) |
| ___ Vernier Conductivity Probe | ___ 50 mg/L TDS standard solution (optional) |
| ___ 500 mg/L TDS standard solution | |

Collection and Storage of Samples

1. This test can be conducted on site or in the lab. A 100 mL water sample is required.
2. It is important to obtain the water sample from below the surface of the water as far away from shore as is safe. If suitable areas of the stream appear to be unreachable, samplers consisting of a rod and container can be constructed for collection. Refer to page Intro-4 of the Introduction of this book for more details.
3. If the testing cannot be conducted within a few hours, place the samples in an ice chest or a refrigerator.

Testing Procedure

1. Position the computer safely away from the water. Keep water away from the computer at all times.
2. Prepare the Conductivity Probe for data collection.
 - a. Plug the Conductivity Probe into Channel 1 of the Vernier interface.
 - b. Set the switch on the probe box to the 0-2000 $\mu\text{S}/\text{cm}$ range (2000 $\mu\text{S}/\text{cm}$ = 1000 mg/L TDS).
3. Prepare the computer for data collection by opening the file “12 Tot Dissolved Solid” from the *Water Quality with Vernier* folder of *LoggerPro*.
4. You are now ready to calibrate the Conductivity Probe.
 - If your instructor directs you to use the calibration stored in the experiment file, then proceed to Step 5.
 - If your instructor directs you to perform a new calibration for the Conductivity Probe, follow this procedure:

**First Calibration Point**

- a. Choose Calibrate ► CH1: Conductivity (mg/L) from the Experiment menu and then click .

- b. Perform the first calibration point with the probe in the air (e.g., out of any solution).
- c. Type **0** in the edit box.
- d. When the displayed voltage reading for Reading 1 stabilizes, click .

Second Calibration Point

- e. Place the Conductivity Probe into the 500 mg/L TDS standard solution. The hole near the tip of the probe should be covered completely.
- f. Type **500** (the concentration in mg/L TDS) in the edit box.
- g. When the displayed voltage reading for Reading 2 stabilizes, click , then click .

5. You are now ready to collect TDS concentration data.
 - a. Rinse the probe tip with distilled water.
 - b. Place the tip of the probe into the stream, or into a cup with sample water from the stream. The hole near the tip of the probe should be completely covered.
 - a. Click to begin data collection.
 - c. Click to begin a 10 s sampling run. **Important:** Leave the probe tip submerged for the 10 seconds that data is being collected.
 - d. When the sampling run is complete, stop data collection and record the mean TDS value on the Data & Calculations sheet.
6. Return to Step 5 to obtain a second reading.



DATA & CALCULATIONS

Method 1: TDS Using a Conductivity Probe

Stream or lake: _____ Time of day: _____

Site name: _____ Student name: _____

Site number: _____ Student name: _____

Date: _____ Student name: _____

Column	A
Reading	TDS (mg/L)
1	
2	
Average	

Column Procedure:

- A. Record the TDS value (in mg/L) from the computer.

Field Observations (e.g., weather, geography, vegetation along stream) _____

Test Completed: _____ Date: _____

Method 2: TDS BY EVAPORATION

Materials Checklist

- | | |
|--|---------------------------------|
| ___ sampling bottles | ___ drying oven |
| ___ one 600 mL beaker for filtration container | ___ 100 mL graduated cylinder |
| ___ large funnel (>10 cm diameter) | ___ two 250 mL beakers |
| ___ filter paper to fit large funnel | ___ milligram balance (0.001 g) |
| ___ tongs or gloves to hold beaker | |

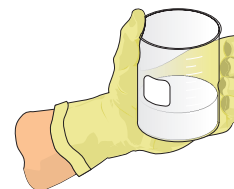
Collection and Storage of Samples

1. This test can be conducted on site or in the lab. Collect a 500 mL water sample per site so that you can run two 200 mL trials. **Note:** If your stream or lake could have low levels of TDS, then collect a larger sample volume (see Step 6 of the Testing Procedure).
2. It is important to obtain the water sample from below the surface of the water as far away from shore as is safe. If suitable areas of the stream appear to be unreachable, samplers consisting of a rod and container can be constructed for collection. Refer to page Intro-4 of the Introduction of this book for more details.
3. If samples cannot be tested immediately upon returning to the lab, they should be refrigerated until the time of analysis to avoid microbiological decomposition of solids. Samples should not be tested after seven days.

Testing Procedure

Day 1

1. Filter any solid particles or suspended solids from your sample.
 - a. Set up a funnel and funnel support on a ring stand. Place a 600 mL beaker or other large container below the funnel.
 - b. Place a folded piece of filter paper in the funnel and moisten it with distilled water so that it adheres to the funnel sides.
 - c. Slowly add your 500 mL sample to the funnel, being sure not to let the level of liquid in the funnel go above the top of the filter paper. Continue adding your sample to the funnel until you have more than 400 mL of filtrate in the beaker below the funnel.
2. Prepare two 250 mL beakers for drying and sample evaporation.
 - a. Carefully clean two 250 mL beakers and place them in a 100/105°C drying oven for one hour to dry.
 - b. Remove the beakers from the oven. Allow them to cool.
 - c. Using a pencil, number your beakers “1” and “2”. Do not use tape.
 - d. From this point on, always handle the beakers with tongs or gloves to prevent the oils on your hands from affecting their mass. Weigh each beaker on a milligram balance to the nearest 0.001 g. Record the data on the Data & Calculations sheet.
 - e. If you complete Step 2 before collecting samples, leave the beakers in a clean, dry, dust-free space until you return to the lab.

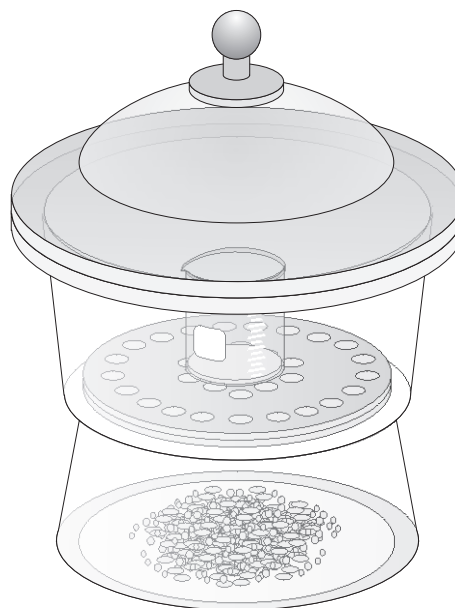


Total Dissolved Solids

3. Transfer the samples to the beakers.
 - a. Using a 100 mL graduated cylinder, carefully measure 200.0 mL of filtered sample water into each beaker.
 - b. Place the remaining sample water into a refrigerator for possible future use.
4. Using tongs or gloves, place the beakers into the oven and allow the water to evaporate overnight at 104°C.

Day 2

5. Measure the mass of the beakers and solids.
 - a. Using tongs or gloves, remove the beakers from the oven and place them in a *dessicator*, if available, to cool. A *dessicator* will keep the samples from absorbing any water from the air that would increase their mass. If no *dessicator* is available, the beakers can be cooled on a table top. Proceed to the next step as soon as possible to minimize any absorption of water.
 - b. Use an analytical balance to measure the mass of each beaker with the solids now left behind. Record the values on the Data & Calculations sheet (round to the nearest 0.001 g).
 - c. Obtain the mass of the solids by subtracting the mass of the empty beaker from the mass of the beaker with the solids. If the mass of the solids is at least 0.025 g, proceed to Step 7. If the mass of the solids is less than 0.025 g, proceed to Step 6.
6. If the mass of the solids is less than 0.025 g, add another 200.0 mL of sample to each beaker and repeat Steps 4 and 5. Make a note on the Data & Calculations sheet that your total volume is now 400.0 mL instead of 200.0 mL.
7. Record the mass of each beaker plus the solids on the Data & Calculations sheet.
8. Soak the beakers in hot soapy water.



*Cool sample in a
dessicator, if available.*

DATA & CALCULATIONS

Method 2: TDS by Evaporation

Stream or lake: _____ Time of day: _____

Site name: _____ Student name: _____

Site number: _____ Student name: _____

Date: _____ Student name: _____

Column	A	B	C	D	E	F
Beaker Number	Mass of empty beaker (g)	Mass of beaker plus solids (g)	Mass of solids (g)	Mass of solids (mg)	Total volume (L)	TDS (mg/L)
Example	95.245 g	95.277 g	0.032 g	32 mg	0.200 L	160 mg/L
1						
2						

Average TDS (mg/L)	
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Column Procedure:

- A. Mass of empty beaker
- B. Mass of beaker with dried solids
- C. Mass of solids (g) = B – A
- D. Mass of solids (mg) = C × 1000
- E. Total volume (L) = mL water / 1000
- F. TDS = D / E

Field Observations (e.g., weather, geography, vegetation along stream) _____

Test Completed: _____ Date: _____

Vernier Lab Safety Instructions Disclaimer

THIS IS AN EVALUATION COPY OF THE VERNIER STUDENT LAB.

This copy does not include:

- **Safety information**
- **Essential instructor background information**
- **Directions for preparing solutions**
- **Important tips for successfully doing these labs**

The complete *Water Quality with Vernier* lab manual includes 16 water quality tests and essential teacher information. The full lab book is available for purchase at:

<http://www.vernier.com/cmat/wqv.html>



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