CONDUCTIVITY

Fresh water is not highly conductive of electricity unless it has certain types of soluble minerals in it. Seawater is much more conductive than fresh water because of its high concentration of dissolved salt. Conductivity greatly affects the types of creatures that can survive in water. In this activity students will measure conductivity of water samples from a stream.

Although the pre and post discussions are necessary to provide important information about each topic, it is the activity that is most vital to this unit. Be sure to allow plenty of time to complete the activity.

Pre-Activity Discussion (Answers can be found in the Background Information section below)

Before beginning the activity, ask students:
1) What is conductivity?
2) What causes water to be conductive of electricity?
3) Why is ocean water more conductive than fresh water?
4) Why is the level of conductivity of water important? How does it affect living things?
5) What human activities affect the level of conductivity of water?

The Activity

Equipment needed

--Small table (convenient but not essential)
--Conductivity meter
--Sampling container (a small glass or plastic jar is fine)
--Boots or waders (not usually necessary)
--Data form and clipboard
--Display board

Procedure

1. Select a site along the stream where the water has not been stirred up so that clear water samples can be easily obtained. If sampling from the bank, pick a spot that is not obstructed by brush and watch out for poison ivy, stinging nettle, and thorny plants.

2. Collect a clear water sample. Rinse the sampling container 3 times before taking your sample. If you are collecting the sample while actually in the stream, take your sample upstream from where you are standing.

3. Turn the conductivity meter on.

4. Rinse out the sample cell in the meter three times with stream water from the sample container, then fill it with sample water. (If the instrument uses a probe on an electrical lead, simply put the probe in the stream or, after rinsing it in stream water, in the water sample in the container.

5. Read the conductivity on the panel on the front of the instrument and record the result on the data sheet.

6. Repeat the measurement three more times to be sure you have obtained an accurate reading and to give everyone a chance to participate.

7. Compare results to the chart in the next section.

6. Turn the meter off if it is not to be used shortly

How the Meter Works

The instrument applies a known voltage across two electrodes, one on either side of the cell containing the water sample (or on the body of the probe if the instrument uses a probe). The instrument then measures how much electric current is flowing between the electrodes; the more current, the higher the conductivity of the water sample. Current is measured in microsiemens. (See definition under Background Information.)

Conductivity Chart (in microsiemens per centimeter- µs/cm)

Pure (distilled) water	0.5 to 3 µs/cm
Most fresh drinking water	100 µs/cm or less
Range found in lake and river water in the U.S.	50 to 1500 µs/cm.
Lake and stream water with healthy fish populations	150 to 800 µs/cm
Industrial wastewater/ Water softener backwash	10,000 µs/cm or more
Sea water	~ 50,000 µs/cm
Great Salt Lake in Utah	158,000 µs/cm

Post-activity discussion questions:

1) On the basis of the average conductivity reading, what can you conclude about the water in the stream? Does the conductivity level suggest the presence of pollutants?
2) Salt is a common cause of higher than normal conductivity. What are some ways that salt gets into our watershed? How can people keep the conductivity of the stream in a healthy range?

Background Information

Conductivity is a measure of the ability of the water sample to conduct an electric current. Pure water itself has almost no ability to carry an electric current. The presence of dissolved atomic-sized particles (ions) in the water allows it to carry a current. These positively charged ions (cations) and negatively charged ions (anions) are the actual current carriers.

These charged ions come from dissolved minerals such as gypsum, limestone, clay soils, and weathering rock. Other sources include: common salt (sodium chloride) and calcium chloride put on roads for de-icing; salt (sodium chloride) or potassium chloride present in the backwash from water softeners; industrial wastewaters; and treated and untreated domestic sewage. The conductivity of a water sample gives a fairly good measure of the overall concentration of ionic substances (salts, acids, alkalis) in the water.

The unit for measuring conductivity in water is the microsiemen per centimeter (μs/cm). A siemen is a unit of conductivity. A microsiemen is a millionth of a siemen. A siemen is the reciprocal of an ohm, a unit of resistance.

The chart above gives a range of measurements of conductivity for various types of samples of water. The concentrations given above for some industrial wastewaters and home water softener backwash are very toxic to a number of species of fish and other aquatic life. The Great Salt Lake is so salty that most types of aquatic life would die almost instantly in it, although there is a brine shrimp that thrives in it.

All living organisms, including us, can survive only if the parameters of their environment are in the right ranges. Conductivity of water is an important parameter. Seawater, which has a very high conductivity because of the salt it contains, is poisonous to us; humans can die of thirst in the middle of the ocean. High conductivity in water indicates generally that the concentration of salts is high. The most common salt is ordinary table salt, $NaCl$. Water that contains strong acids or strong alkalis (bases) also has high conductivity.

Often when we see an increase in conductivity this is a warning sign of pollution so it alerts us to look for the problem by doing additional testing and surveying. By monitoring our lakes and streams and taking measures to prevent or mitigate against high conductivity levels, we can protect the creatures that live there.

Three ways to keep salt from reaching streams and lakes: 1) Encourage local highway departments to use sand on their roads whenever possible rather than salt, and, where salt is necessary, to use as little as possible to do the job. 2) Discharge water softener backwash into a drywell or other outdoor container rather than into a sewage system; 3) Use potassium chloride (KCl) in water softeners rather than sodium chloride ($NaCl$). However, both of these products cause other problems. (See below.)

Excessive chloride is a real problem, particularly if the water is to be used subsequently for crop irrigation, lawn watering, etc. It also has a damaging effect on aquatic life. These problems are independent of whether one is using cheap $NaCl$ or expensive KCl. Several areas in Southern California have made home water softeners illegal unless the backwash brine is disposed of in such a way that it doesn't contaminate streams or groundwater. Ocean disposal may be the most common method. Unfortunately, drywell disposal generally contaminates groundwater.

The bottom line is that if salinity is a problem in your watershed you should either (1) not soften your water, or (2) if softening is essential, use a technology that does not result in the discharge of large amounts of chloride ion. Unfortunately, this technology is quite expensive and high-tech.

For this and all other units, advanced level information is available if desired. Contact the HRWC and request an electronic version of the unabridged manual.

Stream Electrical Conductivity Data Sheet

Conductivity tests the amount of ions in the water. It tells us if there might be salt in the stream. If there is too much salt, it hurts the organisms that live in the water.

1st reading: ______________ **2nd reading: ______________** **3rd reading: ______________** **4th reading: ______________** **Average = ______________** **(Sum of readings divided by 4, or number of readings)**	The unit for measuring conductivity in water is the microsiemen per centimeter (µs/cm). The conductivity of pure water is in the range 0.5 to 3 µs/cm. Lake and river water in the U.S. is much higher, generally ranging from 50 to 1500 µs/cm. Streams that support good populations of freshwater fish have conductivities in the range 150 to 800 µs/cm. Conductivities outside this range tend to be unsuitable for some species of fish and aquatic macro-invertebrates.

1. **Does the conductivity suggest the presence of pollution?**
   (Recall that a conductivity in the range 150 to 800 µs/cm is OK for most critters.

2. **On the basis of your average conductivity reading, is high salt concentration a problem in this stream?**

3. **How can people keep the conductivity of the stream in a healthy range?**

Key to Student Worksheet Questions

1. Does the conductivity suggest the presence of pollution?
   (Recall that a conductivity in the range 150 to 800 **µs/cm** is OK for most critters.

   Answers will vary

2. On the basis of your average conductivity reading, is high salt concentration a problem in this stream?

   Answers will vary

3. How can people keep the conductivity of the stream in a healthy range?

   A. Limit the use of salt on roads and sidewalks
   B. Avoid disposal of water softener waste into streams, rivers or the ground.
   C.

Conductivity Lesson Narrative (High School)

Introduction, 5 minutes. The mission is make these points:
The most common pollutant that causes an increase in conductivity is salt, although some other pollutants can also contribute to high readings.
Three ways to keep salt from reaching streams and lakes: 1) Encourage local highway departments to use sand on their roads whenever possible rather than salt, and, where salt is necessary, to use as little as possible to do the job. 2) Minimize the use of salt on your sidewalk and driveway; use sand instead, if possible. 3) Don't soften your water unless there is serious need to do so.

Common human sources: common salt (sodium chloride) and calcium chloride put on roads for de-icing; salt (sodium chloride) or potassium chloride present in the backwash from water softeners; acid rain (sulfuric acid from coal combustion), runoff from mining operations, industrial wastewaters; and treated and untreated domestic sewage.

1. My name is ______ and I'm a volunteer with the Conductivity station. Please tell me your names. (Go around.)
2. We put salt on our roads in the winter to help melt the ice. Where does the salt go after it has done its job? (Solicit 2-3 answers. Explain that it gets dissolved in water and runs off to the nearest stream, and then to the river.)
3. One way we can test is to use the conductivity meter. Pure water won't carry a current, so the conductivity meter won't register. But tiny particles of salt in the water can register on the meter. When salt is present, the meter will show it. Some other pollutants can also increase the readings, but the main issue for the Huron River is salt from de-icing.
4. Here are some examples of readings;

Pure (distilled) water	0.5 to 3 ms/cm
Most fresh drinking water	100 ms/cm or less
Range found in lake and river water in the U.S.	50 to 1500 ms/cm
Lake and stream water with healthy fish populations	150 to 800 ms/cm
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Sea water	~ 50,000 ms/cm
Great Salt Lake in Utah	158,000 ms/cm

5. What kind of numbers do you think we will find in the river today? (accept some guesses).

The Activity. 15 min

Ahead of time select a site along the stream where the water has not been stirred up so that clear water samples can be easily obtained. If sampling from the bank, warn students about poison ivy, nettles, thorny plants, etc.

6. Collect a clear water sample. Rinse the sampling container 3 times before taking your sample. If you are collecting the sample while actually in the stream, take your sample upstream from where you are standing.
7. Turn the conductivity meter on.
8. Rinse out the sample cell in the meter three times with stream water from the sample container, then fill it with sample water. (If the instrument uses a probe on an electrical lead, simply put the probe in the stream or, after rinsing it in stream water, in the water sample in the container.
9. Read the conductivity on the panel on the front of the instrument and record the result on the data sheet.

10. Repeat and record the measurement three more times to be sure you have obtained an accurate reading and to give everyone a chance to participate. Average the results.
11. Compare the results to the chart above.
12. Turn the meter off if it is not to be used shortly

Wrap Up. 5 min.

13. On the basis of the average conductivity reading, what can you conclude about the water in the stream? (Look at the conductivity chart.)
    Does the conductivity level suggest the presence of pollutants? (We worry if it is significantly greater than 800 ms/cm.)
14. Salt is a common cause of higher than normal conductivity. What are some ways that salt gets into our watershed? (Road salting, sidewalk and driveway salting, water softening, sewage and septic tank leakage)
    How can people keep the conductivity of the stream in a healthy range? (Minimize the above!)