A VERY SIMPLE CONDUCTIVITY METER

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Grade Lever: 6th to 8th Grade

Discipline: Physical Science

Goals:1. Introduce students to the ionic or non-ionic nature of water.
2. Review water quality and usefulness for various manufacturing purposes.
3. Introduce students to the concept of open and closed circuits.

Specific Objectives:
1. Students will construct a simple conductivity meter.
2. Students will observe that when dipped in certain samples of water the LED on the conductivity meter will light while it will not light when placed in other samples that appear identical.
3. Students will observer that the LED is brighter in some samples that in others that look the same.
4. Students will conclude that the water samples may look similar but have different proprieties.
5. Students will discuss the properities and usefullness of water and water purification.
6. Students will conduct a semi-quantitative test of their own homes' tap water to obtain a rough idea of its ionic content.

Background:

I learned about this conductivity meter during a three week long workshop called OPERATION CHEMISTRY which was held at Widner University in the summer of 1992. Since that time write ups of the device have appeared various education journals. Despite variations in configuration, I have found that this device serves best in a very basic form, The meter is a rough and reasonably accurate device which at 1.60 per copy is cheap and easy to construct. Hard to break, construction takes about five minutes. It is extremely safe for children, provided they are careful with the 9 volt batteries.

The device is basically an open circuit with two exposed leads. When the leads are touched or come into contact with any material that will conduct electricity the LED will light. The brightness of the bulb will depend on the conductance of the material being tested.

Pure water is a very poor conductor of electricity. Yet ordinary household tap water will conduct electricity reasonably well. If dilutions of tap water are made, using pure or de-ionized water, and then tested with the conductivity meter, the brightness of the bulb will decrease in marked degrees with each diluton. What then is the difference between pure, de-ionized water and ordinary tap water?

A clue to the answer is found in the name given to pure or di-ionized water. Scientists know that when materials like sodium, calcium, and magnesium, are dissolved in water they dissociate. Dissociation means that particles with electric charges are found in water that had no charged particles prior to exposure to materials that were electrically neutral before being placed in the water. These dissociated atoms now an carry electric charge and are called ions. When salt, sodium chloride (NaCl), is dissolved in water the sodium atoms, which have lost one electron apiece and represented by the symbol Na+, separate or dissociate from the chlorine atoms. The chlorine atoms each gain one electron in the process and are represented by the symbol Cl-. These atoms exist in equal numbers

When solid sodium, magnesium, and calcium are dropped in water their solid structure is broken up and charged ions float all through the water molecules in the solution. When electric current is introduced to the solution via the conductivity meter the movement of the ions allows the current to flow through the solution causing the LED to light. The number of ions per liter of solution will affect the flow of current through the now closed circuit. Conductivity is dependent therefore on the presence of ions as well as the concentration of ions per quantity of water.

Tips: It should be noted here that many of the same elements which contributed to water hardness also make it possible for water to conduct electric current. This is not however an exclusive statement. Salt dissolved in hard water continues to allow the water to conduct electricity, but lowers the total hardness. A stock solution of hard water made from conductive elements, along with suitable dilutions, might provide a convenient tie in with problems faced by certain manufacturing and power companies. The problems associated with hard water should be familiar to children who have completed the previous activity. It seems reasonable to connect hardness with conductivity in experimenting with a mystery sample, as long as the rough and inconclusive

nature of the activity is explained. Students should understand that this test can not be used to determine the exact hardness or make up of a mystery sample but can only be used as a sort of guide. Conductivity of a water sample, in a laboratory would lead to further testing to determine the exact nature of the ionic material..

Students should be arranged in teams of 4 students. Each team should provide one sample of tap, rain, or pond water. Be sure to wash off the bare ends of the meter between samples to avoid contamination. The conductivity meter once constructed can be used for a wide range of additional activities.

Materials:

TO CONSTRUCT THE METER - (part numbers from the 1991 Radio Shack catalogue)

LED assorted	276-1655
resistor 330ohm	271-1321
9v batteries	
Alligator clips (no soider type)	270-374
18 gauge wire	278-1602
black electrical tape	
craft sticks or tong depressors (one per meter)	

TESTING SOLUTIONS

1.4 grams (1/4 tbs) Calcium or Calcium Chloride ice melt material
3 grams (1/2tbs) of Magnesium Chloride or Epsom Salts
4 empty two liter soda bottles
1 empty one liter soda bottles
100ml graduated cylinder
several empty baby food jars - 4 per team
samples of students' tap water from home
de-ionized water- obtain from high school or purchase from food
NOTE: DE-IONIZED WATER IS DIFFERENT FROM DISTILLED WATER

Advanced Preparation:

A. construction OF CONDUCTIVITY METER

1. The LED and the resistor are pigtailed together and placed flat on stick, near the middle of the stick
2. Wrap tape around the pigtailed joint attaching it to the craft stick.
3. Strip both ends from 2 pieces of wire leaving about 1/4 inch of exposed copper at each end.
4. Pigtail an end of one wire to one end of the resistor/LED combination so that the bare end extends over the end of the stick about 1/2 inch.
5. The battery with cap and alligators can be attached to the end of stick, opposite the bare wire, with a rubber band.

** CAUTION - TO AVOID DISCHARGE OF THE BATTERY DO NOT HOOK BOTH ENDS OF THE BATTERY CAP UNTIL THE LAST CONNECTION HAS BEEN MADE.

6. Clip one of the alligators to the unattached end of the LED/resistor.

7. Take the second piece of wire and attach one end to the second alligator clip, allowing the bare end of the wire to extend next, but not touching the first wire.

8. Tape all exposed joints securely to the stick with electricians tape.

9. Connect the battery cap and touch the bare ends of the wire together. The LED should light brightly, if not check all connections.

**NOTE ** Since the LED only conducts electricity in one direction try reversing the alligator connections

B. TO MAKE A STOCK HARD WATER SOLUTIONS AND DILUTIONS OF KNOWN CONCENTRATION.

**NOTE-- ONLY DE-IONIZED WATER CAN BE USED.

1. Mass out 1.4 grams of calcium chloride or 3 grams of magnesium chloride.

2. Add to two liters of water, a soda bottle will work well. Just make a mark on the outside to indicate when the bottle is full.
label this bottle A.

3. Take 100ml or one 4oz baby food jar of A and place in a second two liter bottle.

4. Fill this with one liter (1000ml) of de-inozed water and label it B. This is a 0.1 dilution of the stock. For a 0.2 dilution use 200ml of A.

5. Take 100 ml of B and add to 1 liter (1000ml) of de-inozed water and label this C. This is a 0.01 dilution of the stock.

Procedure:

1. 4 baby food jars per team, labeled A.B.C.and D.
2. Add 25ml of the appropriate solution to each jar.
3. Place 25ml of de-ionized water in D and use as a control.
4. Students should test each sample with their conductivity meter, being careful wash off the exposed leads with de-ionized water between each sample to avoid contamination.
5. Students should compare the intensity of the LED as the meter is placed in each sample.
6. Each group should agree on the intensity of the LED and arrange the samples in order from least to greatest.
7. Test a sample of tap water from one of the students. Find which test comes closest to the unknown in the intensity of the LED.
8. Refer to the hardness chart. How hard is the sample of unknown water?

Suggested Questions:

1. Did all water samples look the same?
2. How did the conductivity meter react when placed in each solution?
3. Did the LED indicate the same intensity for each solution?
4. Did The LED not light in any of the solutions?
5. What was different about each solution and the control that caused the conductivity meter to respond differently.
6. Describe how the meter functioned in the unknown sample?
7. Which of the dilutions came closest to the unknown in intensity of the LED?
8. What might be implied about the unknown and the sample that made the meter behave in a similar fashion?

Extensions:

Materials other than water can be tested for conductivity. 1k, 2k or .5k resistors could be obtain and used in place of the 330 ohm resistor. The results could be compared with the 330ohm version