KELWAY® TECHNICAL BULLETIN "S" (SALINITY)

The KELWAY Salinity Tester makes soluble salts testing easy. The purpose of this bulletin is to explain this technical subject in terms which have meaning to the professional grower.

The terms **soluble salts** and **salinity** mean the same thing and are defined as the total of all dissolvable (soluble) mineral residues contained in the soil. We are therefore not talking about "table salt" or "ocean salt water" but instead this means everything that exists in your soil which can and will dissolve when water is added. Examples of minerals which may be present are such chemicals as sodium, magnessium, potassium or calcium. These combined with chlorine, sulfur, nitrogen or carbon form such "salts" as sulfates, chlorides, nitrates, carbonates, bicarbonates and many others.

Some of these salts will help your crop (plant, flower, tree, vegetable, fruit, turf etc.) grow. You may have added them in the form of fertilizer or they may have been introduced by nature. It is important to realize that every crop has its individual needs in terms of the right amount of salts needed for best growth. We could call these salts chemicals, minerals or fertilizers but we would mean the same thing regardless of terminology. It is also true that not one specific salt or chemical is needed but rather a balance, such as the right proportion of nitrate and phosphate. Obviously the right chemicals and the proper blends are chosen based upon the specific crop involved and after the grower has made a chemical analysis of his soil. He can then add fertilizer to accomplish his goals. Sometimes he adds fertilizer without full knowledge of the soil's chemical make-up. Often he runs tests for specific minerals being present but does not know how much of that mineral is present.

The object of salinity testing is to allow the grower to control the **amount** of total available salts (chemicals, fertilizers, minerals). Salinity testing will not reveal what minerals are present. Analysis does this. Analysis does not help you keep the **total amount** of soluble salts under control. Salinity testing does this.

Why is control of soluble salts important? The reason is that too low a total can cause the crop to receive insufficient nourishment, leading to smaller growth, no growth, lesser yields, slower growth etc. The reason is also that too high a total can cause the same result (but from a different mechanism).

To explain the problem of poor growth due to excessive salts we must recognize the way plants receive nutrition. This involves absorption of water (in which the salts are dissolved) by the root system. Absorption involves a process called "osmosis" which involves the flow of liquid through a membrane. Liquids with different amounts of salts dissolved in them have different osmotic pressures. Think of the plant's root network as the membrane through which the liquid must flow. Water having high soluble salts content has a different osmotic pressure than water which has a low soluble salts content. What occurs is that the flow goes the wrong way. The high salts content liquid takes the water **out of the plant root** system instead of passing into the plant. The osmotic pressures having been incorrect caused the flow to be reversed. In effect by adding too much fertilizer and watering it in poorly you can cause your crop to become dehydrated and starved!

We mentioned earlier that salts can either exist naturally or have been introduced by the grower. Let's look at this a bit further.

Salts can exist from long term build-up. As an example it is common for small amounts of natural minerals to be "leached" out slowly by small quantities of rainfall in dry regions. Due to the scarcity of water in these regions the salts are only carried short distances where they are deposited and build up. Obviously with more rainfall they can be carried longer distances and where rainfall is more plentiful these naturally leached salts wind up in local streams, rivers and eventually in oceans. If the salts are carried far enough they do not build up and do not cause local salinity problems.

Growers introduce salts when they add fertilizers. If fertilizing is excessive or too frequent and if not enough water is added to dissolve all of the added fertilizer (and to wash it into the soil) then salts build up. In some cases the right amount of water is added but soil drainage is poor. This can also lead to a salts build-up. In other cases the grower uses water which has its own high salts content (local streams, for example) and in the worst situation this can be combined with land that has poor drainage. Instead of reducing problems, extra watering in this latter combination of circumstances builds higher salinity. All of the above discussion can just as easily translate into conditions in the field, in the greenhouse, in the nursery or even in individual pots.

How do you solve a low salinity problem? That's easy. Add the proper combination of chemicals in the form of the right balance of fertilizer for the chosen crop. Make sure the pH is proper. Water the fertilizer in well so that these added nutrients can be absorbed. Now set up a program of peridoic salinity testing in order to maintain a correct level of balanced salts.

How do you solve a high salinity problem? This may be a little harder to do but there are many approaches and they may be very specific for your crop and soil. One or more of the actions we list will probably help.

a.) Leach the soil. Remove the excess soluble salts by watering heavily and being sure of good drainage.
b.) Plow the soil to replace subsoil with surface soil.
c.) Add rapid decomposing organic material like corn cob, compost or straw and mix well into soil.
d.) Keep the soil constantly moist.
e.) Plant fertilizer absorbing crops, such as corn or kale.
f.) Improve drainage, if needed.
g.) Stop using high salts content irrigation water, if applicable.
h.) Use applicable chemical amendments.
i.) Shift to a more salt tolerant crop if you cannot solve the actual problem. Examples are cotton, barley or sugar beets.

Obviously this bulletin cannot attempt to address to each specific problem but it is intended only to make you aware of the overall scope of the situation so that you can approach your own specific problem with the assurance that there are solutions available.

FUNCTIONALITY OF SALINITY TESTER

How does a salinity tester function? It is basically an instrument designed to test how much electrical current can flow through a water solution. This is termed "Conductivity". The electrical current is very small and is far below the levels that we can feel.

Water that has no salts dissolved in it does not conduct electricity. Distilled or deionized water are examples of this because they do not have electrolytes present. An electrolyte is any substance which can be "chemically active" in water (the correct technical term is "ionized"). The salts we are concerned with do become ionized in water and the more salts that are present, the more electrical current can flow through the solution (and therefore the higher the conductivity is).

To measure conductivity the salinity tester uses a cell (sometimes called a probe) which does the actual measuring of electrical flow between its contact points. This is translated into a reading on a meter which can then be compared versus a chart which defines soil conditions that correspond to that reading. Actually to make the reading you will have first prepared a solution of soil in water (distilled or deionized) generally at a ratio of 1 part of soil to 2 parts of water. With a KELWAY salinity tester making the solution is really simplified because a premarked jar is provided which permits making several different solutions (see the instruction sheet accompanying your tester). You can also measure the salinity of your tap or irrigation water by following the regular test procedure (without adding soil).

SALINITY OR CONDUCTIVITY TERMINOLOGY

The term most commonly used is the **mho** or a fraction of it, namely the millimho (1 millimho is 1/1000th of 1 mho). The word mho is the unit of conductance which is the opposite of the ohm, the unit of resistance. Mho is actually the word ohm spelled backwards. When the term ohm was devised it referred to the resistance of a substance of a given size. In the same "technical fashion" the mho also refers to matter of a specific size, which is why you sometimes see a reference to mhos per centimeter or mhos per square centimeter (also shown as mhos/cm^2). These all refer to the same thing so don't let them confuse you. There is also the term micromho. A micromho is 1/1000th of a millimho or 1/1000, 000th of a mho. There are symbols generally used for these and we list them for your reference.

MHO .... ℧

MILLIMHO .... ℧m

MICROMHO .... ℧mm

The numbers on a KELWAY salinity tester are "millimhos" and you can forget the rest of the details. On the other hand if you ever run into these other terms you will be able to make the conversion to millimhos. On later model SSTs a second scale appears showing PPM for measuring water or nutrient solutions (parts per million).

FURTHER DISCUSSION OF 1:2, 1:5 and 1:10 SOLUTIONS AND "SPECIAL CASE"

The chart provided with your instructions is based on the use of a test solution of 1 part soil to 2 parts water. This is discussed in the instructions as is the use of the other solutions.

We have advised use of a 1 to 2 soil to water test solution whenever practical. If you decided to use a 1 to 5 solution you would expect to get a lower reading from the test because you would expect the lower concentration of dissolved salts in the more dilute solution to provide less Conductivity. Normally this would be true — which is why we advise multiplying such a result by 2½ to refer back to the chart. Sometimes you do not actually get a lower reading with the 1 to 5 solution. This is caused by the presence of salts which are not very soluble — and which only dissolve when extra water is present, such as in the 1 to 5 or even the 1 to 10 solutions. If you try a 1 to 5 test solution and you find that your reading is not lower than with a 1 to 2 test solution you can suspect the soil has salts like sulfates or carbonates present. If this is the case, then — for this special situation — use the reading that you get from the 1 to 5 or 1 to 10 test solution — without multiplying to convert it back for the chart provided. If you have a serious concern as to this situation we suggest you consult with your local Agricultural Extension Service or other suitable reference point.

CONVERSION FROM MILLIMHOS TO PARTS PER MILLION

Occasionally one sees a reference to salts in terms of "PPM" (parts per million). You can convert from millimhos to **approximate** parts per million by multiplying the readings from a **1 to 2 solution** in millimhos by 1500.

Example: a 1 to 2 solution gives a reading of 0.5 millimhos.
0.5 times 1500 = 750 parts per million of salts.

To convert from millimhos to PPM **using water** (not a soil in water solution), such as tap or irrigation water, multiply the reading in millimhos by 640. This is useful for Hydroponic Nutrient Solutions.

Examples: a water sample reads 1.0 millimhos on the meter.
1.0 times 640 = 640 PPM (approx.)
a water sample reads 2.0 millimhos on the meter.
2.0 times 640 = 1280 PPM (approx.)

SUGGESTED REFERENCES ON THE SUBJECT OF SALINITY

1.) "SOIL", The 1957 Yearbook of Agriculture. U.S.D.A.

2.) "Diagnosis and Improvement of Saline and Alkali Soils". U.S.D.A. Ag. Handbook No. 60.

3.) "Bulletin #1S: Interpretation of Conductivity Readings on Soils"
"Bulletin No. 2S: Use of Brackish Waster for Irrigation in New Jersey"
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CONVERSION CHART*

Millimhos	Parts Per Million (PPM)
0.5	320
1.0	640
1.5	960
2.0	1280
2.5	1600
3.0	1920
3.5	2240
4.0	2560
4.5	2880
5.0	3200
5.5	3520
6.0	3840

*For use in testing water or Hydroponic nutrient solutions and other liquids.

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"KELWAY® PRODUCTS"

KELWAY® SST: OPERATING INSTRUCTIONS

For determining salinity (soluble salts content) by measuring electrical conductivity.

READ THESE INSTRUCTIONS THOROUGHLY PRIOR TO USE

I. **Description.**

The Kelway SST is an electrical conductivity tester which measures soluble salts content. It provides the ability to make "in the lab" or "in the field" tests for salinity of water, of hydroponic nutrient solutions or of solutions of soil (or other media) in water. Soluble salts are determined by measuring electrical conductivity. This tester gives an accurate reading of conductivity in "millimhos per centimeter" (m ℧ /cm.). Use this to measure soil salinity. There is also a scale in parts per million (PPM) for measuring hydroponic nutrient solutions or water.

Included with the SST are a built in electrode (cell), a thermometer, a calibrated test jar, a syringe, a 9 volt battery and a carrying case. To operate the tester, prepare a test solution, fill the electrode (cell) "pit" and make a reading. Then consult the chart provided.

II. **Brief Theory.**

Soluble salts content means the total of all soluble minerals present which can dissolve in water. The accumulation of soluble salts by soils, impairs their "productivity" by reducing the rate at which plants absorb water, consequently retarding growth. Insufficient soluble salts means lack of fertilizer which can be equally harmful. In either case, testing leads to proper remedial practises.

We suggest you read the KELWAY TECHNICAL BULLETIN "S"(enclosed) for a more detailed understanding of salinity.

III. **Preparation of Sample.**

Make a 1 to 2 soil to water solution. Do this by filling the calibrated test jar with deionized or distilled water to the "C" mark. Add soil (or other media to be tested) until the solution level reaches the "A" mark. Close the test jar, shake vigorously for about 30 seconds and then allow it to settle for about 1 minute. While doing so measure the temperature of the solution with the thermometer provided. Adjust to 25°C (77°F.).

NOTES: 1.) Do not use tap water to make the test solution. Tap waters vary and almost all contain soluble salts in varying amounts. You can measure your tap water by testing it without adding soil. Testing deionized or distilled water should yield zero or near zero readings.

2.) To make a 1 to 5 soil to water solution - fill the test jar with deionized or distilled water to the "B" mark. Add soil until the solution level reaches the "A" mark. Then proceed as in the case of the 1 to 2 solution. The use of a 1 to 5 solution is discussed later in this set of instructions.

IV. **Making the Test.**

Place the Kelway SST tester horizontally on your work surface. Using the syringe, transfer some of the upper portion of the test solution to the "electrode pit" (hopefully this is now a fairly clear "supernatant" liquid) — but if it is not fully clear don't let this deter you — just be prepared to do a better clean out job in the "electrode pit" after the test. For the test, the "pit" should be filled approximately to the level of the inner edge, below the top ridge. In other words fill the "pit" without overflowing it.

Press the white button which is on the upper left of the face of the tester and **while holding this button down** slowly turn the black dial button from zero in a clockwise direction. When you first depressed the white button the red light on the upper right will have flashed on and then off. Now, keep turning the black dial button very slowly to the right (clockwise) until the red light again flashes on. If you turn the black button slightly further the red light will go out. The reading you want is taken at the point where the red light stays on. If you fail to get a reading — you probably forgot to keep the white button depressed:

After getting your reading pour the solution out of the "pit" and rinse the "pit" with some deionized or distilled water. Wipe it clean and dry with a suitable paper tissue or clean soft cloth. If soil had settled in the "pit" you may have to repeat the clean-out procedure. The objective is to clean the "pit" thoroughly but carefully (without harming the two electrode contact points which are visible in the "pit" and without spilling water on the tester's surface). The tester is carefully constructed but water seepage is hard to prevent and obviously this can be harmful to the electronic circuits within. Simple care is all that is needed. **Never put solvents into the "pit"** and it would be wise to avoid use of solvents on the plastic housing (case) of the tester.

V. **Interpretation of Readings.** A) For soil in water solutions using the millimhos/cm scale.

The reading(s) you have obtained is **conductivity** expressed in millimhos per centimeter (m℧/cm.). It is common to refer to these units simply as millimhos. An explanation of the units is contained in the KELWAY TECHNICAL BULLETIN "S" which accompanies this tester. Now refer to the chart which "translates" the numerical reading into words describing salinity level and most important — into plant condition.

NOTE: DO NOT USE THE "PPM" SCALE TO READ SOIL IN WATER SOLUTIONS!

Relative Salt Level	1 to 2 Solution		Plant Condition
	Inorganic Soil	Organic Soil	
Low	0-0.2	0-0.5	Too Low. Plants may be starved.
Medium	0.2-0.5	0.5-1.0	OK range most plants.
High	0.5-0.8	1.0-1.5	Slightly higher than desirable. Germinating seeds or seedlings may be injured.
Excessive	Above 1.5	Above 2.0	Plants usually dwarfed and crop often fails.

B) For hydroponic nutrient solutions use the "PPM" scale.

VI. **Discussion of 1 to 2, 1 to 5 or 1 to 10 soil to water solutions.**

Most times with most soils a 1 to 2 soil to water solution will give you the correct test results. Sometimes a problem can occur. If your soil is very high in organic matter (peat, for example) you may not be able to dissolve it in the amount of distilled water available in the 1 to 2 solution. You may need more distilled water. In this case you should make a 1 to 5 soil to water solution. If the amount of water is still not adequate, make a 1 to 10 soil to water solution. This is done by filling the test jar with distilled water to a point halfway between the "A" and the "B" mark. Then add soil to bring the level to the "A" mark. Shake solution, settle, adjust temperature as when using the 1 to 2 solution and make the test reading. **HOWEVER**, when you get the reading in millimhos per centimeter you must make a conversion in order to interpret the readings from the chart (the chart was established for use with 1 to 2 solutions).

To use the chart with a 1 to 5 soil to water solution:
Multiply your reading by 2½ and then use the chart.

To use the chart with a 1 to 10 soil to water solution:
Multiply your reading by 5 and then use the chart.

VII. **SPECIAL CASE:** For soils known to contain excessive sulfates and-or excessive carbonates: We suggest that you refer to KELWAY TECHNICAL BULLETIN "S" enclosed.

VIII. **After the testing.**

Once you know the salinity of your soil you can take steps to increase it, decrease it or maintain it at its current level. If you combine salinity testing with a chemical analysis of your soil so that you know its make-up, you can create the desired chemical balance for the crop (or plants) you desire to grow and then maintain the proper amount of fertilizer content by testing the salinity level on a regular basis. Some general ideas on how to proceed are contained in the KELWAY TECHNICAL BULLETIN "S". These ideas may help you to pursue more specific solutions to your own soil problems through use of available literature, consulting with the local Agricultural Extension Service, etc.

We recommend removal of the battery from the Kelway SST if you do not plan to use it regularly.

When the battery becomes weak the red light tends to stay lit through a wider swing of the black dial button — and eventually the red light will not light. Replace with a 9 volt battery.

GUARANTEE

The Kelway SST is guaranteed against defective workmanship or materials. If such defect does arise during the period of 90 days from date of purchase, and if in the opinion of Kel Instruments Co., Inc. the defect is due to the aforenamed factors, the product will be repaired or replaced free of charge, provided that the tester be returned to Kel Instruments Co., Inc. accompanied by "Proof of Purchase" including date of purchase. This guarantee does not apply to any damage or defect caused by abuse or accident.