HAWTHORNE™

5 Steps to a Well-Rounded Nutrient Monitoring System
It's about more than just measuring electrical conductivity in your plants

Growers have been using Electrical Conductivity (EC) to determine the strength of a given fertilizer or nutrient solution for decades—and for good reason. EC can provide a quick snapshot into whether a fertilizer has been properly diluted, making it more readily accessible to plants.

But relying too heavily on EC measurements doesn't always give you the full picture, and can limit your potential for ensuring your plants are getting the nutrients they need. Read on for 5 steps to using EC measurements paired with lab analysis as part of a holistic approach to monitoring your nutritional regimen.

STEP 1: UNDERSTANDING EC

By the time you've been growing a while, you likely have a good idea of what EC is and how monitoring it is helpful in the cultivation process. Simply put, EC tells you the concentration of mineral fertilizers dissolved in water, a measurement that helps inform which, and how much, of a particular nutrient you feed your plants.

EC is determined by measuring a solution's ability to conduct an electrical current. Mineral fertilizers are composed of fertilizer salts. When these salts are dissolved in water they form positively and negatively charged ions—cations and anions, respectively—which we call electrolytes. Water that does not have electrolytes, such as distilled water or "RO water," has a very low ability to conduct electricity—an EC of practically zero. Adding electrolytes increases the electrical conductivity of water. Generally speaking, as you add fertilizer to water, EC increases in a direct and linear relationship.

STEP 2: ACCURATELY MEASURING EC

Units and Conversions
When EC is measured, it is measured in conductivity units. Historically, these units were called milliMhos per cm (mMhos/cm) or micro mhos per cm (uMhos/cm). The term milliMhos and microMhos have given way to the International System of Units (SI) called millisiemens or microsiemens. The prefix milli relates to one thousandth and micro relates to one millionth. Therefore, it follows that to convert from one to another you need to multiply or divide by a factor of 1,000. See below for specifics.

Electrical Conductivity Units and Conversions

Common EC units	**Abbreviation**	**Conversion Factor**
Millisiemens per centimeter	mS/cm	mS/cm→ µS/cm multiply EC value by 1000
Microsiemens per centimeter	µS/cm	mS/cm→ µS/cm divide EC value by 1000
Ex: 0.5 mS/cm = 500 µS/cm Ex: 2000 µS/cm = 2.0 mS/cm		

TDS Meters and Parts Per Million (PPM)
Parts per million is a term used to describe the ***concentration*** of something. PPM is technically one part ***by weight*** of something in a million parts by weight of something, while Total Dissolved Solids (TDS) is a way to measure the amount of very minute inorganic and organic material in water. TDS is typically measured by evaporating water and measuring the residue and is expressed in units of milligrams per liter (mg/L).

Chemists often also express PPM as mg/L, since these terms are essentially equivalent. This has led to the use of EC meters to measure TDS, which is expressed as PPM. So, if you are to use a TDS meter or a "PPM meter" you are **really using an EC meter**. The only difference is in which units that EC measurement is expressed.

Modern PPM measuring devices actually measure EC and then **convert** that measurement to PPM. There are two common PPM scales depending on what country you are in. The 500 NaCl scale is common in both the USA and Canada. The 700 KCl scale is common in Europe.

How to Convert from EC to PPM

EC➔ PPM (500 NaCl scale)	Multiply EC value (ms/cm) by 500
EC➔ PPM (700 KCl scale)	Multiply EC value (ms/cm) by 700
Example: EC 0.5 (mS/cm) = 250 ppm 500 NaCl scale Example: EC 0.5 (mS/cm) = 350 ppm 700 KCl scale	

Bear in mind that this conversion is based on a specific salt. When using a mixture of salts or salts other than NaCl or KCl, the correlation between PPM and EC differs. This means that the actual PPM is not exact but general.

STEP 3: KNOWING WHAT EC *CAN* TELL YOU

Measuring EC is useful for determining the following:

General concentration or salinity of a nutrient solution
Nutrient solutions made up of various fertilizer sources or nutrient products are often fairly complex. The more inputs used, the easier it is to make a mistake. Often, you can estimate the EC from adding the EC from each fertilizer input. When finished, the EC can tell you if you generally hit the target zone. If the EC is too high, it may potentially damage the crop. Unfortunately, EC cannot tell you which input was incorrect.

Concentration of a nutrient solution based on a known fertilizer product
When you are using one nutrient source or product in solution, there is a direct linear relationship between the concentration of a nutrient derived from the source and EC. You will often find charts showing the concentration of nitrogen (N) to the EC of a solution when using many water soluble fertilizers (WSFs).

General nutrient status or salinity of the root zone
Finding the EC of your plants' root zone can be done a multitude of ways.

1. Measuring the EC of a "classic" hydroponic solution. This technique has been practiced for years when growing crops using the "classic" hydroponic approach. The key to remember is that the EC measurement will indicate if the general salinity of a solution is acceptable or unacceptable. It cannot tell you exact nutrient concentrations or ratios of nutrients.

2. Measuring the EC of leachate coming from the bottom of the container containing some type of growing medium or substrate. This is a common practice among greenhouse growers. This is because measuring leachate is easy to do and “sacrificing” or sampling growing media is not necessary. Often, this is done by monitoring the EC of the solution being fed to the crop as well as the EC of the solution that drains out of a container in the crop, known as leachate. The difference in EC can be monitored to indirectly determine how much fertilizer is being taken up by the crop (and held by the growing medium) and whether or not the feed levels need to be changed. However, it is critical to use a consistent, standard operating procedure when measuring EC of leachate. Starting nutrient solution, the moisture in the container, the amount of nutrient solution applied and the amount of leaching all have a bearing on the EC that is calculated. If these factors vary, your data will vary, which leads to inconsistent data. Remember: the only thing worse than no data, is bad data.

3. Measuring the EC of an extract from a growing medium. Methods used to measure the EC of extract from growing media are standardized tests and tend to be more accurate than other methods of EC testing. Each involves creating a solution from the medium, which is then tested to produce an EC value. These methods vary significantly in their results when compared to each other, but are useful when compared against historical data using the same method.

3 Ways to Measure EC in Media Extract

Pour-Thru Extraction. Growing containers are brought up to container capacity using distilled water just before the point of leaching. After the containers are hydrated, they are allowed to set for a short period of time, after which a set volume of water is poured over the top of the growing media surface to form a “head” of water. The volume of water applied is standardized against the volume of the pot. This water causes leaching to occur, which is collected before the pH and EC are measured. Growers may choose to collect the leachate and send that off for analysis of specific nutrients as well.

1:2 Extraction. Samples of growing media are collected from pots and air-dried. The growing medium is then mixed at a ratio of 2 parts volume of distilled water to 1 part volume of growing medium. The slurry is allowed to set for a time and then is filtered. EC is measured on the filtrate. There are a number of variations to this procedure which can affect the results of the test.

Saturated Medium Extract. Some call this method the “Saturated Paste Method.” This method takes a certain volume of growing medium, where an amount of distilled water is added to allow the surface of the growing medium to start to “glisten.” The growing medium is commonly considered to be at 100% saturation when this occurs. While this is subjective, it is a way to compensate for the starting moisture content of the growing medium. After hydration, the growing medium is allowed to set for a period of time and then filtered. The EC of the filtrate is measured. Some may measure the pH of the slurry before filtering and some may measure the pH of the filtrate.

No matter which method for measuring your media extract you choose, it’s critical to pick one and stick with it. By standardizing your EC testing procedure, you’ll help cut down on variable factors, allowing you to compare results over time and identify patterns and trends.

STEP 4: KNOWING WHAT EC CAN'T ALWAYS TELL YOU

EC is not a helpful measurement when comparing two different fertilizer programs.
The composition of the fertilizers are different and EC only measures the total charge of the fertilizers in solution.

This means that two different fertilizers can have the same EC, but perform completely differently. To illustrate this point, we compare two dry water soluble fertilizers below:

Fertilizer	Dilution Rate	EC (mS/cm)
Formula A	1.9 grams/L	2.0 (mS/cm)
Formula B	1.9 grams/L	2.0 (mS/cm)

Once the fertilizer is incorporated in water, the nutrients (NPK) delivered to the crop are:

Nutrients Delivered	Formula A (1.9 grams/L)	Formula B (1.9 grams/L)
Sum of nitrogen	90 ppm	180 ppm
Sum of phosphorous	120 ppm	40 ppm
Sum of potassium	220 ppm	220 ppm

You will notice that Formula A delivers half of the nitrogen and three times the phosphorus of Formula B. These two fertilizers have the same EC at the same dilution rate, but deliver very different levels of specific nutrients. We would expect crops to respond very differently to these two fertilizer formulas.

With this example, it's easy to see why comparing two different fertilizers based only on EC can lead to misleading conclusions.

EC measurements do not guarantee correct fertilizer mixes
The problem only compounds when growers start using multi-part fertilizer programs. EC measurements have no way of distinguishing if the grower is mixing or diluting the fertilizers in the right proportion. For example, in the table below, both fertilizer mixes yield the same EC, yet Recipe 1 delivers balanced and appropriate nutrients (NPK) for vegetative growth, while Recipe 2 is highly deficient in both the phosphorus and potassium needed at this stage.

Recipe 1 (Mixed correctly)	Recipe 2 (Mixed incorrectly)
EC: 1.7 mS/cm	EC: 1.7 mS/cm
Micro Formula 2 ml/L	Micro Formula 3.5 ml/L
Grow Formula 2 ml/L	Grow Formula 0 ml/L
Bloom Formula 1 ml/Lv	Bloom Formula 0 ml/L
Nutrients Delivered upon Dilution with Water	
Sum of nitrogen 170 ppm	Sum of nitrogen 220 ppm
Sum of phosphorous 40 ppm	Sum of phosphorous 0 ppm
Sum of potassium 170 ppm	Sum of potassium 37 ppm

EC does not provide information about the individual nutrient levels within a medium, and includes non-nutrient ions such as sodium or chlorides in the measurement. This is extremely important when operating a recirculating system, where elements such as sodium can build up within the nutrient solution to toxic levels despite the EC values being on target for the crop.

STEP 5: ADDING LABORATORY FERTILIZER ANALYSIS TO YOUR MONITORING PROCEDURE

As every grower knows, providing the right level of nutrients—tailored to your crop, growing style and environment—is critical to achieving high-quality, consistent yields. But the truth is, EC alone doesn't always tell the whole story.

Working with plant biology experts to conduct thorough lab analysis on everything from media to fertilizer can lead to a more holistic approach to nutrition. Fertilizer solution analysis reveals the exact nutrient composition of your feed, which EC is not able to provide, for true peace of mind.

Having access to this level of information can help you better understand why your crop may be responding a certain way—and how you might adjust your fertilizer program to best suit the needs of your crop.

FERTILIZER SOLUTION ANALYSIS		
The analysis is for samples of dilute liquid fertilizer solutions used to fertilize crops. This analytical package is for those who want to know/verify the nutrient content of the fertilizer solutions in their feed program. Concentrated fertilizer solutions will require dilution at the lab for further analysis.		
pH	P	B
EC	K	Cu
Alkalinity	Ca	Mo
Carbonate	Mg	Si
Bicarbonate	Sulfate-S	Na
SAR	Fe	Cl
Ammonium-N	Mn	Al
Nitrate-N	Zn	Summation of Cations and Anions

Contact Hawthorne Technical Services today and learn more about how lab analysis can change how your approach to fertilization, crop health and monitoring.

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