

The following is evidence which substantiates a paradigm shift in determining the sterilization capabilities of a water. The shift is from pH values as the determining factor to positive ORP. pH has long been the value used by Enagic.

Data sourcing by Ron Chaves

Oxidation-Reduction Potential (ORP) for Water Disinfection Monitoring, Control, and Documentation...Trevor V. Suslow – Extension Research Specialist, Department of Vegetable Crops, University of California, Davis...UC Peer Reviewed Study Publication 8149

“Many packers of raw produce, as well as many processors of fresh cut products, now use sensors to determine the oxidation-reduction potential(ORP) status of their water systems. ORP, measured in millivolts (mV) has increasingly become a primary approach to standardizing water disinfection parameters. Rather than exclusively monitoring dose (for instance, in parts per million, or ppm), postharvest handlers now monitor activity, since ORP reflects the antimicrobial potential of the water, irrespective of the water quality.”

“In simple terms, from a microbial perspective, an oxidizing chemical pulls electrons away from the cell membrane, causing it to become destabilized and leaky. Destroying the integrity of the cell membrane leads to rapid death.”

“Research has shown that at an ORP value of 650 to 700 mV, free-floating decay and spoilage bacteria as well as pathogenic bacteria such as *E. coli* O157:H7 or *Salmonella*

Species are killed within 30 seconds. Spoilage yeast and the more-sensitive types of spore-forming fungi are also killed at this level after a contact time of a few minutes or less.”

Table 1. Summary of results from various lab simulation and commercial hydrocooler survey studies

Pathogen/Indicator	Survival in seconds (s) or hours (h) at ORP (mV)		
	< 485	550 < × < 620	> 665
<i>E. coli</i> O157:H7	> 300 s	< 60 s	< 10 s
<i>Salmonella</i> spp.	> 300 s	> 300 s	< 20 s
<i>Listeria monocytogenes</i>	> 300 s	> 300 s	< 30 s
thermotolerant coliform	> 48 h	> 48 h	< 30 s

(NOTE: The above example shows an ORP of >665, Living Water consistently creates waters with >885 and an average of >1000 mV)

“Recent research in commercial and model postharvest water systems has shown that, if necessary, ORP criteria can be relied on to determine microbial kill potential across a broad range of water quality. In other words, an ORP of 700 mV at pH 6.5 has the same “killing” potential as an ORP value of 700 mV at pH 8.5.” (NOTE: this shows that

ORP value trumps pH in disinfection)

Free Chlorine and ORP ...Pulse Instruments –Van Nuys, CA

“...the term "oxidation" now refers to any chemical action in which electrons are transferred between atoms. The atom that loses an electron is said to be "oxidized". The atom that gains an electron is said to be "reduced," because in picking up that extra electron, it loses the electrical energy that makes it "hungry" for more electrons.”

Sanitizing Effect of Oxidizers:

“Chemicals like chlorine, bromine and ozone are all strong oxidizers. It is their ability to oxidize or to steal electrons from other substances that makes them good sanitizers. Oxidizers literally burn off germs, bacteria and other organic material in water leaving as a by-product a few harmless chemicals.”

“ An ORP role is really a millivoltmeter, measuring the voltage across a circuit formed by a measuring electrode (the positive pole of the circuit), and a reference electrode (the negative pole), with the water in between. The measuring electrode (+) of the probe, is usually made of platinum, although other noble metals (which do not oxidize easily), such as gold, could be used. When this platinum electrode is placed in water in the presence of oxidizing agents, electrons are constantly transferred back-and-forth on its surface, generating a tiny voltage. The reference electrode (-), usually made of silver is surrounded by a saline (electrolyte) solution that produces another tiny voltage. The voltage is the reference against which the voltage generated by the platinum and the oxidizers in the water is compared. The difference in voltage between the two electrodes is what is actually measured by the meter. As an oxidizer is added to the water, it "steals" electrons from the surface of the platinum measuring electrode, causing the electrode to become more and more positively charged. As you continue to add oxidizer to the water, the electrode generates a higher and higher positive voltage. When used with a chlorine-based sanitation system, an ORP measuring device will not specifically indicate the chlorine concentration in parts per million. It will however, indicate the effectiveness of the chlorine as an oxidizer. Also, ORP readings will vary as pH fluctuates. As the pH goes up, the millivolt reading on an ORP meter will go down, indicating that the sanitizer is not as effective. Bringing the pH down or adding more sanitizers raise the millivolt reading. That is why most ORP instruments also incorporate an electronic pH meter. With water, the meter measures the difference in electrical potential between the water sample and a sample of known pH that is contained in the meter in a small glass bulb.”

“The kill time is just a fraction of a second at a Redox level of 650 mV, but increases rapidly to several hours at lower ORP values. In 1971, the World Health Organization adopted an ORP standard for drinking water disinfection of 650 millivolts. That is, the WHO stated that when Oxidation-Reduction Potential (ORP) in a body of water measures 650/1000 (about 2/3) of a volt, the sanitizer in the water is active enough to destroy harmful organisms almost instantaneously. In Germany, which has about the strictest water-quality standards in the world, an ORP level of 750 millivolts was

established by the Deutsche Institut fur Normung (DIN) Standard 19643, “***Oxidation Reduction Potential (ORP): A New Tool for Evaluating Water Sanitation...Hybrid A Hendrix Genetics Company, Ontario Canada***”

“...evaluating the quality of water has advanced from pH and free chlorine measurements to include Oxidation Reduction Potential (ORP).”

“...Chemicals like chlorine, bromine, hydrogen peroxide, peroxyacetic acid and ozone are all oxidizers. It is their ability to oxidize or “steal” electrons from other substances that makes them good water sanitizers – because in altering the chemical makeup of unwanted bacteria, algae and organic material, they kill them.”

“Research has shown that at a level of 650 mV of ORP, bacteria such as E. coli are killed on contact or within a few seconds. Tougher organisms such as listeria, salmonella, yeasts and molds may require 750 mV or higher in-order-to be killed.”

“Measurement of ORP allows you to evaluate the effectiveness of the water sanitation, regardless of the type of oxidizer or combination of sanitizer, and regardless of other varying water conditions. It tells you if your sanitation process is really doing what you think it is.”

Introduction to ORP as the Standard of Postharvest Water Disinfection Monitoring ...Pulse Instruments –Van Nuys, CA

“Accurate monitoring and recording of disinfection procedures is an important component of a sound postharvest quality and safety program. Oxidation-Reduction Potential (ORP), measured in millivolts (mV), has recently been introduced to fresh produce packers and shippers as an easily standardized approach to water disinfection for harvest and postharvest handling. Operationally much like a digital thermometer or pH probe, ORP sensors allow the easy monitoring, tracking, and automated maintenance of critical disinfectant levels in water systems”

“Research has shown that at an ORP value of 650 to 700 mV, spoilage bacteria and bacteria such as E. coli and Salmonella are **killed within a few seconds.** Spoilage yeast's and the more sensitive type of spore-forming fungi are also killed at this level after a contact time of a few minutes or less. Expanded studies of ORP:Contact Time for a range of postharvest pathogens are in progress.”

“An ORP value of 650mV measured at pH 6.5 or 8.5 provides the same killing potential...”

“ORP meters measure the very small voltages generated when the measuring probe is placed in water in the presence of an oxidizing agent. The electrode is made of platinum or gold, which reversibly loses its electrons to the oxidizer. A voltage is generated which is compared to a silver electrode in a silver salt solution, similar to a pH probe. The more oxidizer available, the greater the comparative voltage generated between the two probes. “

Sterilizing effect and mechanism of electrolyzed water...Department of Chemical and Environmental Engineering, Wuhan Polytechnic University, Wuhan 430023, China

“When the oxidizing-reductive potential (ORP) and pH values of EOW were 1138 mV and 2.24 respectively, the killing rate for *Bacillus subtilis* var. *niger* was 99.99%. When the ORP and pH values of EOW were 883 mV and 5.43 respectively, the killing rate of *Bacillus subtilis* var. *niger* was 99.73%.” (this shows that the killing rate is reduced when the ORP is lowered)

PPM or ORP: Which Should Be Used?...Jacques M. Steininger – Swimming Pool Age & Spa Merchandiser

“Water treatment experts are becoming increasingly aware that water disinfection is dependent upon ORP and not the free residual chlorine ratio.”