



# FOOD TECHNOLOGY FACT SHEET

## Adding Value to OKLAHOMA

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# Water Use in the Food Industry

## Tim Bowser

FAPC Food Process Engineer

Water is important to the food processing industry because it is present in all foods. It is extensively used in most food plants as a processing aid and for cleaning operations. When water is used as a food ingredient, its quality (e.g. impurities) can affect the properties of the food, including texture, shelf stability, appearance, aroma and flavor. As a processing aid, water may be used for conveying, heating, cooling, rinsing, dissolving, dispersing, blanketing, diluting, separating, steam generation and other activities. In each case, purity of the water will affect its performance. For example, hardness (minerals in water) may deposit on equipment surfaces in an evaporative cooler or reduce water's ability to dissolve and disperse food ingredients. Cleaning activities in the food industry involve the use of water as a carrying agent, dispersant, solvent and diluent. Most individuals have firsthand experience with "hard water" (water with >120 ppm of hardness) that reduces foaming of soaps and rinsing effectiveness.

The purpose of this fact sheet is to highlight the importance of water to the food processing industry, describe its sources and quality, and discuss appropriate treatment and handling procedures.

## Water Sources

The two primary sources of fresh water are surface and ground water. Food processors generally obtain water from municipal sources or owned wells. Knowledge of the water source and how it was obtained will help to indicate any required in-house treatment(s). Surface waters are from rivers, lakes and reservoirs, and may have higher levels of suspended materials, turbidity, temperature fluctuations and mineral content. Ground

water from springs and wells tends to be high in dissolved minerals, with a relatively constant temperature over time.

## Water Quality

What attributes contribute to the quality of water and what should their limits be for food processors? This section focuses on these questions. Impurity of water is identified and measured in three basic categories (Osmonics, 1997): qualitative, general quantitative and specific. Qualitative identification, includes turbidity, taste, color and odor, and describes obvious conditions of water. Most qualitative measures do not describe the concentration of the contamination and do not identify the source. It should be noted, however, that taste, color and odor evaluations may be very accurate qualitative measurements that can be rapidly completed. The human nose, for example, can detect odors in concentrations down to the parts-per-billion level. General quantitative water analysis has higher precision compared to qualitative analysis. Table 1 lists the main quantitative tests for water (Osmonics, 1997).



**Table 1. Tests used for general quantitative analysis of water (incomplete list in no particular order).**

Quantitative water analysis	Purpose	Scale	Normal value
pH	Relative acidic or basic level of the solution. [hydrogen ion concentration]	0 to 14 with a pH of 7 as neutral; 0 more acidic; and 14 more basic. The scale is logarithmic, meaning that a pH of 9 is 10 times more basic than a pH of 8.	Surface water: 6.5 to 8.5  Groundwater: 6 to 8.5
Total Solids (TS)	Sum of total dissolved solids (TDS) and suspended solids (TSS) in water.	Measured in weight per volume of water; e.g. mg/l	up to 500 mg/l (WHO, 2003)
Conductivity (Ionic Contamination)	Measurement of total dissolved solids (TDS)	Conductivity meter, which measures electrical conductivity of water in Seimens/m	Drinking water: 0.005 to 0.5 S/m (www.lenntech.com)
Resistance (Ionic Contamination)	Measurement of ionic contamination	Resistivity meter, which measured electrical resistivity of water in ohms·cm (resistance is the inverse of conductivity)	1.8 to 200 $\Omega$ /m
Total Bacterial Count	Measure of total viable (can proliferate) organisms in water	Colony forming units (CFU) of organisms per volume of water	100 CFU/ ml
Pyrogens	Amount of substances that can produce a fever in mammals (normally produced by bacteria)	Endotoxins units (EU) per volume of water	Water for injection: 0.25 EU/ml (USP, 1995)
Total Organic Carbon (TOC)	A measurement of the organic material contamination present in water	Measured weight per volume of water (e.g. mg/l)	0.05 mg/l (USEPA, 1991)
Biochemical Oxygen Demand (BOD)	Amount of dissolved oxygen needed to meet the demand of aerobic microorganisms in water	Measured in weight of dissolved oxygen per volume of water (e.g. mg/l)	1 mg/l
Chemical Oxygen Demand (COD)	Amount of dissolved oxygen required to cause chemical oxidation of the organic material in water	Measured in weight of dissolved oxygen per volume of water (e.g. mg/l)	10 mg/l (hannainst.com)

## Water Treatment

Water treatment is any process that is used to alter water supplies to meet required needs and/or regulations. The steps in identifying water treatment techniques required for a particular application are:

1. Identify the water source and define characteristics such as impurities, and seasonal and periodic variations.
2. Define the intended use(s) of the water.

Common treatment techniques are summarized in table 2 (EHEDG, 2007). Combinations of treatment techniques are often required to achieve required results. Primary types of pretreatments for water include multimedia filtration, activated carbon, water softening, chemical injection and ultraviolet units for disinfection, and chemical injection for pH adjustment.

**Table 2. Common water treatment techniques and their purpose.**

Treatment	Condition								
	Algae	Bacteria	Chemical	Odor/ flavor	pH	Protozoa	Salts and hardness	Solids	Virus
Activated Carbon	X		X	X					
Chlorination or ozonation		X				X			X
Filtration			X					X	
Deaeration			X	X					
Ion exchange			X				X		
Membrane filtration (e.g. reverse osmosis)	X	X	X			X	X	X	X
Neutralization					X				
Settling								X	
UV radiation		X				X			X

*"When the well is dry, we know the worth of water."  
-Benjamin Franklin (1706-1790)*

Intended uses for water in food production systems include (but are not limited to) the following cases:

1. Food ingredient
2. Bottled water
3. Washing and rinsing
4. Culinary steam (boiler feed water)

Filtration is recommended in all cases for all potable water use in Oklahoma food processing plants for solids removal to about 5 microns. Rainfall events, seasonal weather patterns, distribution system issues and other factors can result in variable solids content and loading. The following cases describe common treatment techniques for the four intended water uses listed above.

### Case 1 Food Ingredient

When water is used as an ingredient in food, it must be free from undesirable taste, odor, color and impurities that could be harmful to consumers and product quality. In general, ordinary tap water (meeting the safe drinking water standard) may not achieve these qualifications. Off odor and taste may be removed with an activated carbon filter. Activated carbon has a massive surface area that is available to adsorb substances like chlorine, yeast, odor, taste, and non-polar materials such as mineral oil and poly aromatic hydrocarbons. The activated carbon filter also removes materials that might foul subsequent treatment steps, like ion exchange and reverse osmosis (Collentro, 2010).

Hardness (calcium and magnesium ions) in water may deposit in pipes, valves and process equipment surfaces. Some food products may not dissolve well in hard water. In addition, hardness may affect flavor, mouth-feel and aroma of foods. A water softener is a specific type of ion exchanger that is used to remove hardness. If bacteria are suspected, then a disinfection step should be included such as ozone, chlorine or ultra-violet systems (Osmonics, 1997). Figure 1 shows a flow diagram of a system used to treat water for ingredient addition to foods. The ozonator is used to prevent bacterial growth in the storage tank.

### Case 2 Bottled Water

Case 2 is more stringent than case 1 because bottled water should be bacteria-free. Many bottled water processors use ozonation to disinfect the water, since it has little effect on taste. Ultra-violet treatment may also be used and is frequently included as a backup measure. Reverse osmosis (RO) removes 99.9 percent of all viruses, bacteria and pyrogens and is more energy efficient compared to distillation processes. Drawbacks of RO include removal of “good” minerals, low speed and wasting of two to three parts of water for every part purified (Everpure, 2012). Figure 2 gives a flow diagram of a water treatment system for bottled water. It is important to place the carbon filter ahead of the RO unit to reduce fouling (by removing naturally occurring organic material) and to remove the disinfecting agent, which can chemically react with the membrane (Collentro, 2010).

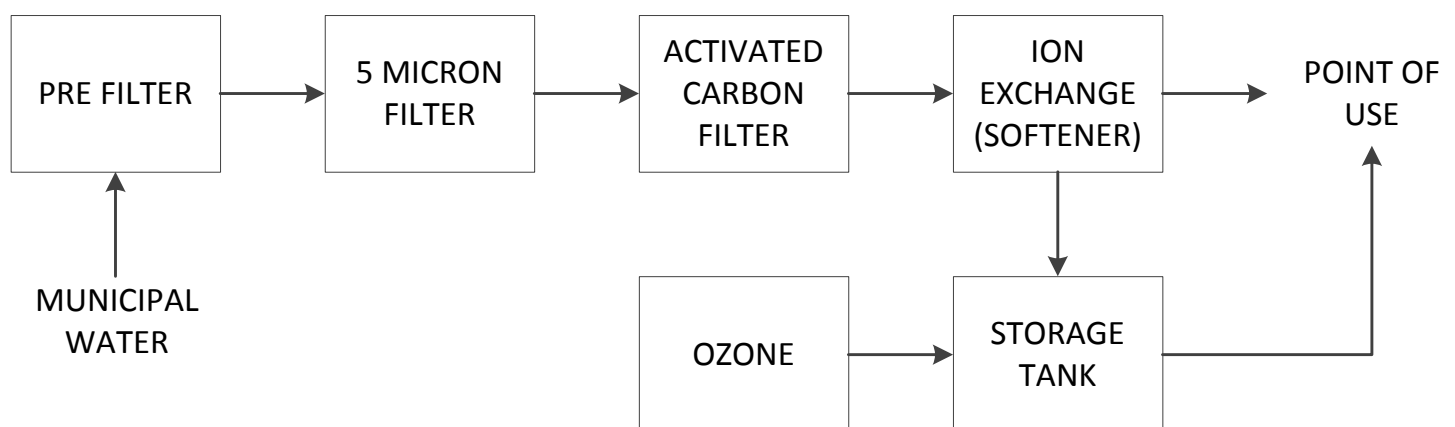


Figure 1. Flow diagram of a treatment system for water as a food ingredient.

### Case 3 Washing and Rinsing

Washing and rinsing requires clean, soft water. Mild taste and odor issues are probably not as important as they are for cases 1 and 2. Mineral content that could affect additive performance should be removed. Soaps, cleaners and sanitizers will perform much better in softened water. Processors often see a dramatic reduction in

chemical usage that pays for the water treatment system in a short time. A flow diagram of a minimal water treatment system for wash and rinse water is given in figure 3. Case 3 treatment systems may morph into case 1 system when the softener benefits from the fouling protection of an activated carbon filter and water storage is required.

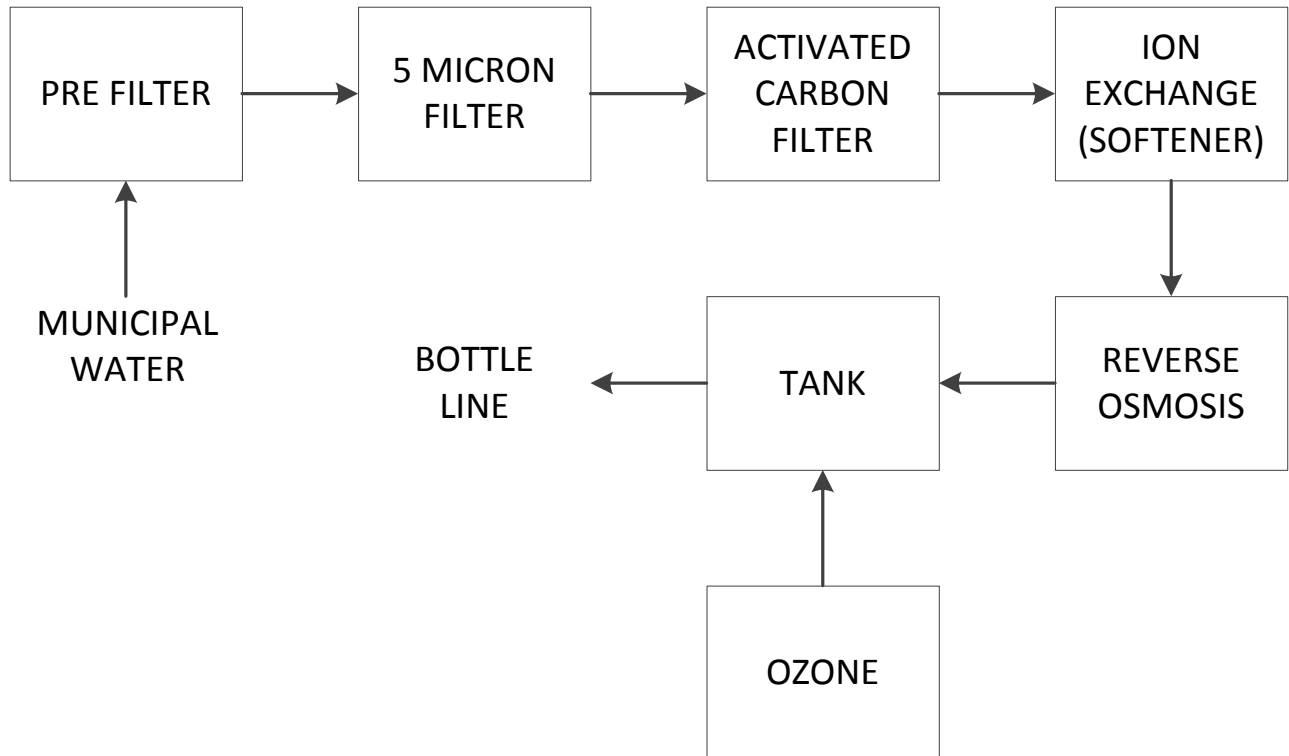


Figure 2. Flow diagram of a treatment system for bottled water.

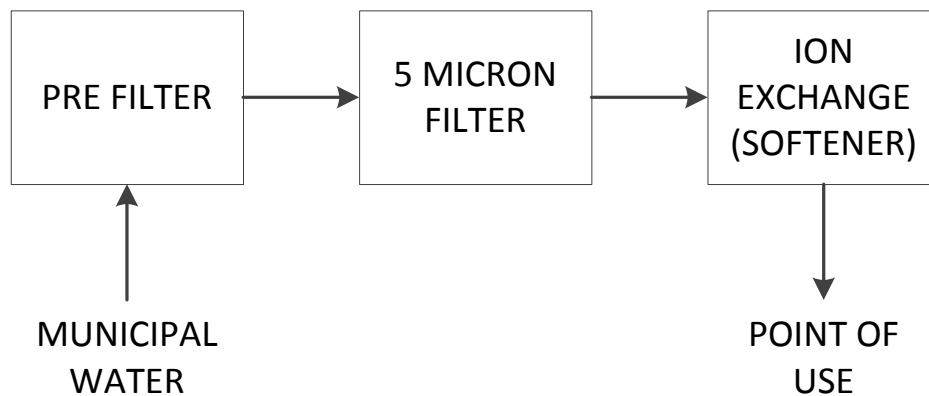


Figure 3. Flow diagram of a treatment system for wash and rinse water.

## Case 4 Culinary Steam

Culinary (or sanitary) steam is safe for direct injection into a product or for product contact. Water for culinary steam may be one of the most difficult treatment cases in the food industry. Boiler feed water should be thoroughly treated to prevent problems in boilers and associated piping, valves and processing equipment. Corrosive components, like oxygen and carbon dioxide, may be removed by deaeration. Figure 4 shows a flow diagram of a water treatment system for a culinary steam boiler. A step not shown in figure 4 is pH adjustment. Boiler water pH should be maintained at about 8.5 (Cleanboiler.org, 2012) and may require the addition of chemicals. Options and issues regarding pH measurement are discussed by Rosemont Analytical (2010).

## Conclusion

Water is a critical resource to the food industry that has many uses. Water quality and its impact on products and operations are often underestimated in food production systems. Underestimation of water quality impact may lead to mismanagement of water, equipment operation and maintenance issues, loss of income, food safety and product quality issues.

This fact sheet outlines proactive steps for water treatment in the food industry. If you would like guidance in the development of your water treatment and management strategy, please call the Robert M. Kerr Food & Agricultural Products Center at 405-744-6071 or e-mail [fapc@okstate.edu](mailto:fapc@okstate.edu) to request assistance.

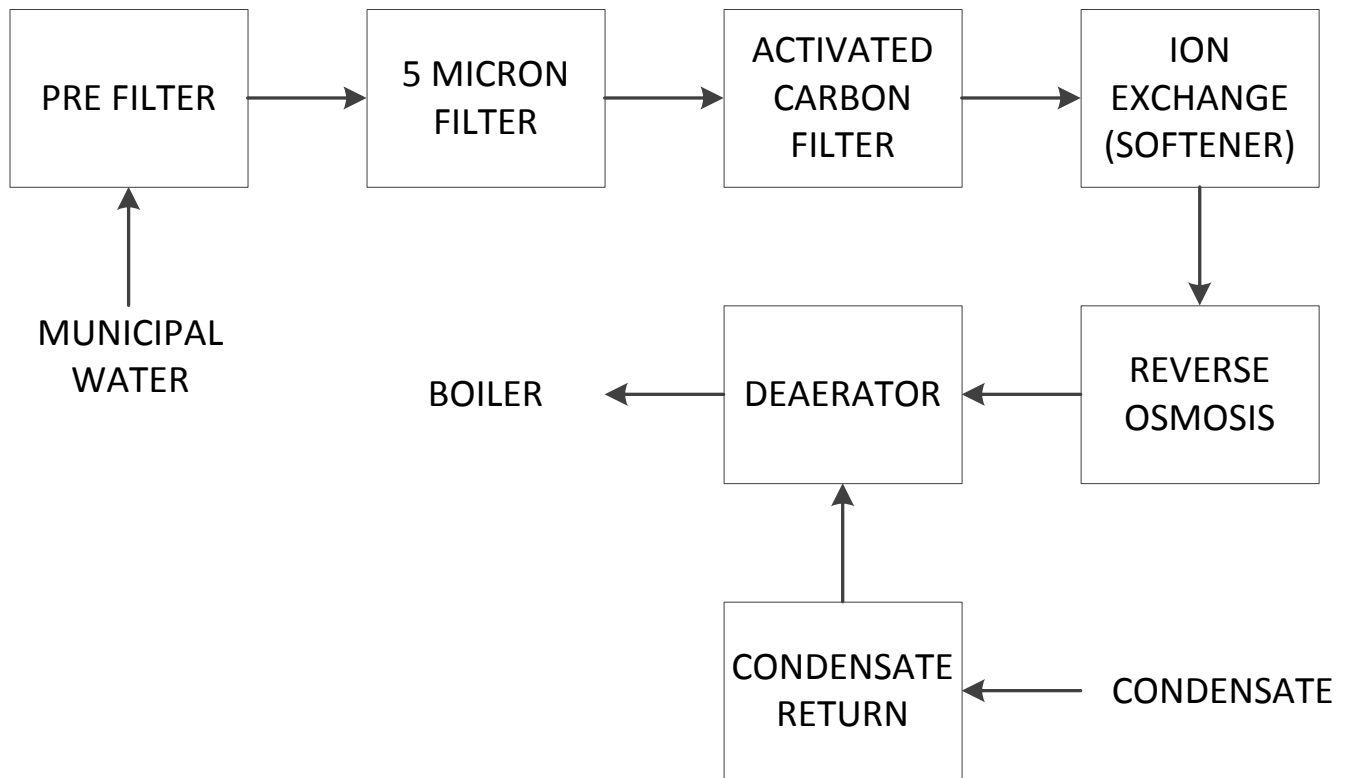


Figure 4. Flow diagram of a water treatment system for a culinary steam boiler.

## References

Cleanboiler.org. 2012. pH treatment. Available at: [http://www.cleanboiler.org/Eff\\_Improve/Operations/pH\\_Treatment.asp](http://www.cleanboiler.org/Eff_Improve/Operations/pH_Treatment.asp). Accessed on June 12, 2012.

Collentro, W.V. 2010. Pretreatment unit operations. *Journal of validation technology*. 16(2): 37-48.

EHEDG. 2007. Safe and hygienic water treatment in food factories. *Trends in Food Science & Technology*. Elsevier Ltd. 18 S95.

Everpure. 2012. Understanding reverse osmosis systems. Available at: [www.everpure.com](http://www.everpure.com). Accessed on June 26, 2012.

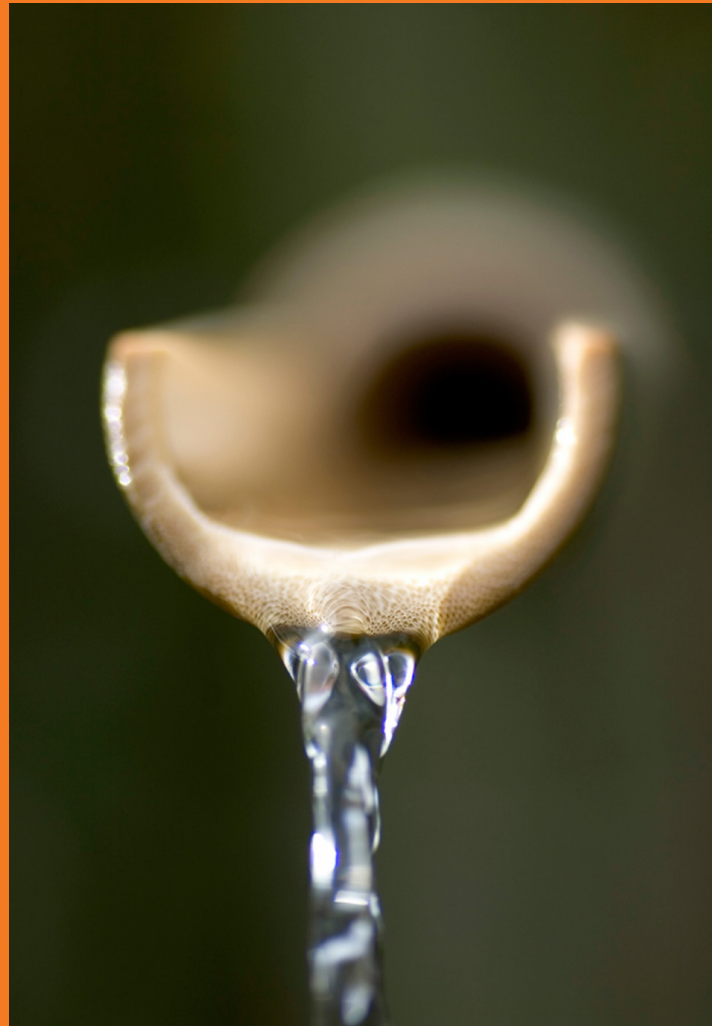
Osmonics. 1997. Pure water handbook. Osmonics Inc., Minnetonka, MN. Available at <http://dwb4.unl.edu/Chem/CHEM869A/CHEM869AMats/PureWater/pwh-s.pdf>, Accessed on June 12, 2012.

Rosemount Analytical. 2010. pH control of boiler water. Application data sheet ADS 4900-85/ref.E. Irvine, CA. [www.raihome.com](http://www.raihome.com).

USEPA. 1991. National Primary Drinking Water Standards, Office of Water, Fact Sheet. EPA 570/9-91-012FS.

USP, 1995. National Formulary, NF18, Vol 2. United States Pharmacopeia, USP 23.

WHO. 2003. Total dissolved solids in drinking-water. WHO/SDE/WHS/03.04/16. World Health Organization, Geneva





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Some characteristics of Cooperative Extension are:

- The federal, state, and local governments cooperatively share in its financial support and program direction.
- It is administered by the land-grant university as designated by the state legislature through an Extension director.
- Extension programs are nonpolitical, objective, and based on factual information.
- It provides practical, problem-oriented education for people of all ages. It is designated to take the knowledge of the university to those persons who do not or cannot participate in the formal classroom instruction of the university.
- It utilizes research from university, government, and other sources to help people make their own decisions.
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- It dispenses no funds to the public.
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