Consistent and precise quality

The importance of water treatment in beverage manufacture as a means of ensuring consistent product quality cannot be underestimated. Tom Wingfield* explains why membrane filtration systems offer a wide range of benefits

Clear, colourless, odourless, and tasteless, water is the common thread that runs through the production of any beverage. And whether you're producing alcoholic beverages or soft drinks, it's also one of the most critical raw materials in producing what every marketer wants: a unique product signature.

This product signature carries significant weight as companies work to have their brand stand out among the proliferation of fruit, energy, health, and specialty beverages that are marketed today.

Apart from the obvious health concerns, water quality is critical to the taste and appearance of any beverage. Product integrity is dependent on high water quality, a must regardless of the beverage you're producing.

The pur e facts: quality in, quality out

In the beverage world, a unique product signature results from a precise combination of liquid ingredients including flavours, additives, sweeteners, enhancers, and water. For nearly every type of beverage, water quality has a direct impact on taste, which is affected by its constituents mixing with other ingredients.

Apart from maintaining precise control of ingredients, their mixing and separation, the most variable ingredient from place to place is water. Fluctuations in water quality and content affect taste, appearance, and even safety. It can also affect the efficient operation of any bottling or production facility.

Feed water content and quality can vary according to raw water source and pretreatment, as shown in Figure 1.

For manufacturers, achieving measurable and repeatable water quality is essential to protecting the integrity of their brand. Precise treatment of raw water provides the foundation for creating and protecting the brand.

Since incoming water may come from several sources including municipal water supplies, surface water, ground water, and springs, it presents many different challenges.

Waterborne cysts, oocysts, bacteria and viruses can contaminate source water and have serious health implications while metals and salts can affect taste, colour, and uniformity.

The challenge is to remove the variability regardless of the source, as well as provide low-SDI (silt density index) feed water for downstream processes.

There are two methods by which manufacturers can purify their water: conventional treatment, which involves physical and chemical processes, and membrane separation.

Conventional water tr eatment

In conventional treatment, feed water is sent through a multi-stage physical/chemical process that may include ion exchange or demineralisation, ozonation, granular activated carbon (GAC) treatment, ultra-violet purification, and oxidisers before being of high-enough quality for beverage production.

After the addition of chemical coagulants, flocculants, and oxidants to the feedwater to precipitate organic and inorganic material, clarifiers and sand filters are used to remove particles. Sand filters remove most particles, but produce a water quality of 2NTU or less. However, conventional systems do not remove all particles and have proven to be ▶

Figure 1: Common water constituents and their potential effects

	Bottled Water	Juice	Tea	Soft Drinks	Beer
Hardness	Moderate hardness impacts taste	Can cause post precipitation and hazing	Affects taste	Can cause precipitates	pH affects bitterness
Iron	'tin' taste, affects plant fixtures and appearance	Affects taste and may cause clouding	Can be chelated by tea and or hazing precipitation	Affects plant fixtures and product taste later	Inhibits yeast, may cause gray discoloration and haze
Manganese	Affects product appearance and plant fixtures	Creates a 'speckled' effect	Can cause precipitation	Affects plant fixtures and product taste	Inhibits yeast, may cause gray discoloration and haze
Copper	Toxic at higher concentrations	May accelerate oxidation	Can be chelated by tea	- - - -	Oxidation catalyst and yeast inhibitor
Zinc	-	-	-	-	Oxidation catalyst and yeast inhibitor
Calcium	Calcium hardness has positive taste effects	Undesirable in clear juices	Negatively impacts taste	Can cause precipitation	Must be balanced to avoid precipitation bitterness
Magnesium	Toxic at higher concentrations	Can cause post bottling effects	Negatively impacts taste	Can cause precipitation	Causes bitter taste
Nitrate	Water is likely polluted, negative impact on taste and appearance	Negatively impacts taste, health concerns	Negatively impacts taste, health concerns	Negatively impacts taste, health concerns	Health concerns

Figure 2: Membrane filtration processes

- Microfiltration (MF) has a molecular weight cut-off (MWCO) between 300,000 and 1,000,000. This process separates compounds with a size less than 0.2 µm.
- Ultrafiltration (UF) uses a membrane with a MWCO between 500 and 300,000. This process separates compounds in the range of 0.0001 to 0.1 µm.
- Nanofiltration (NF) offers separation qualities between ultrafiltration and reverse osmosis. They require a lower working pressure and give higher flux than RO membranes, but have a lower salt separation capability
- Reverse osmosis (RO) uses the most impermeable membrane. These membranes have a MWCO of less than 500 and require high pressure.

Membrane Filtration Processes

Type	Separation/Removal capabilities	Typical Pressure
Microfiltration (MF)	>0 .1 - 0.4 µm	20 - 350 kPa
Ultrafiltration (UF)	0.005 - 0.09 µm	105 - 1000 kPa
Nanofiltration (NF)	5 - 10Å	700 - 950 kPa
Reverse Osmosis (RO)	<5Å	1,380 - 10,350 kPa

Figure 3: Benefits of membrane technology

- Lower overall production costs
- Precise separation forms absolute barriers to unsafe and undesired components
- Automated operation translates to low maintenance
- Increased uptime
- Capable of handling a high degree of variability in both the quality and quantity of feed water
- Modular design offers the most cost-effective capital expansion
- Compact, modular designs maximize available space
- Biological control
- Extremely high rejection rates of dissolved organics and inorganics
- High recovery rates

System	Conventional	Membrane
Capital	Same	Same
Maintenance	Higher	40-60 percent lower
Running cost	Higher	20-25 percent lower
Quality of water	Variable	Constant
Upgrades	No	Yes
Technology	Conservative	Latest
Transportable	No	Yes
Modular	No	Yes
Predictability	Nominal	Absolute

inadequate to the task of protecting against pathogens and bacteria.

Particles and bacteria pass through most conventional treatment systems causing complications in downstream treatment processes. For example, those exiting a sand filter to enter a GAC column may cause bacterial growth and a reduction in its effectiveness.

Ozonation, another chemical water treatment process that inactivates bacteria and other micro-organisms through an infusion of ozone, may be deployed to help accomplish this, as can UV disinfection. After ozonation, the water is sent for GAC, a physicochemical process that removes a wide variety of contaminants by adsorbing them from the water stream. The treatment is most commonly used to remove chlorine and organic contaminants from water.

Following GAC, the water is UV purified, which further removes contaminants before going through cartridge filters for final filtration. Then the water is of a high enough quality to be used in beverage production.

Membrane water treatment

In contrast, the use of membranes for water treatment is simple, reducing highly-variable feed water to an ingredient of consistent quality and precise content. Membranes are capable of precisely separating contaminants and substances from purified water when pressure is applied across them.

Benefits include product consistency, process and plant efficiency, and maximising throughput per floor area. Advancements in membrane process technology have led to its increasing acceptance, mostly due to reduced maintenance and less reliance on chemistry in the separation process. In comparison to conventional systems, membrane systems produce more water more reliably while reducing chemical costs by up to 90 percent and staff costs by almost half.

Other advantages of membrane filtration include lower overall production costs, fewer processing steps, higher yield, a higher degree of selectivity, and greater flexibility in handling feed liquids with different specifications and in which viscosity fluctuates. A membrane filtration system, due to its modular design, is easy to expand step-by-step, so that capacity always fits actual needs. Also, the ability to integrate systems make membranes a much more flexible part of any water filtration design.

Membrane filtration provides a higher clean water yield in fewer processing steps than conventional treatment. Its modular design allows for treatment expansions that closely match production demands. Membrane systems also provide a degree of precision and flexibility not attained in physical chemical processes. These benefits add up to lower overall production costs.

Conclusion

Consuming a drink is a unique combination of aroma, flavour, sweetness, and tartness. ▶

Water quality changes the beverage signature in any of these areas. More than just equipment, manufacturers need separation expertise that is applicable across the process from ingredients to production to packaging.

Expertise of this type integrates solutions to enable companies to reduce total cost of ownership, enable new processes or products, and meet regulatory requirements. An end-to-end process management initiative must also include extensive local support systems and a wide range of troubleshooting, consulting, and co-development services. The separation technologies applied must provide verifiable effluent and the services rendered must provide demonstrable value.

Total Fluid Management is a concept that enables the relocation manufacturing processes anywhere while maintaining standards of product consistency, process efficiency, and business growth. Process control, validated performance, and value-added service from raw ingredients to finished product is a capability that is critical in today's global marketplace.

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