

# The Water Purification Process

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## Water purity is extremely important to pharmaceutical and biotech industries.

Suspended or dissolved particles, organic compounds, impurities and other contaminants prohibit the usage of tap water in laboratory applications and scientific research. Parameters such as resistivity, conductivity, size of particulate matter and concentration of microorganisms are used to categorize water quality and, therefore, specify intended uses for water. Some applications can tolerate the presence of specific impurities in the water, but others, such as High Performance Liquid Chromatography (HPLC) require removal of the majority of contaminants.

## Contaminants

Water is an excellent solvent and can be sourced from almost anywhere on Earth. This property makes it prone to all kinds of contamination.

- **Particulates:** Silt and debris which can be removed by passing water through a 10 to 20 micron filter (or less if necessary).
- **Microorganisms:** Bacterial agents constitute a real challenge for water purification systems. Their growth rate, size and robustness require an efficient design (detection, removal from water inlet, inhibition of growth, etc.). Bacteria are measured in colony forming units per milliliter and can be killed with disinfectants. As a result, their secretions and cellular fragments must also be removed to avoid contamination.
- **Endotoxins, pyrogens, DNA and RNA:** Cellular fragments and bacterial by-products. Harmful to tissue cultures. Can be detected with a Limulus Amoebocyte Lysate (LAL) test.
- **Dissolved inorganic elements:** Include phosphates, nitrates, calcium and magnesium, carbon dioxide, silicates, iron, chloride, fluoride, and any other natural or man-made chemicals resulting from exposure to the environment. Electrical conductivity ( $\mu\text{Siemens/cm}$ ) is used to monitor high concentration of ions, while resistivity ( $\text{M}\Omega\text{cm}$ ) is used to identify ions if present in small concentrations. These contaminants affect water hardness and alkalinity/acidity.
- **Dissolved organic elements:** Pesticides, plant and animal remains or fragments. Total Organic Carbon (TOC) analyzers are used to measure  $\text{CO}_2$  emitted by organics subjected to
- **oxidization.** Organic-free water is mainly used in applications where analysis of organic substances is carried out (e.g. HPLC, chromatography and mass spectrometry).

Scientific applications require elimination of certain types of contaminants. On the other hand, pharmaceutical productions require, in most cases, near-total removal of impurities /criteria dictated by specific standards or local/international regulatory bodies).

# Purification Process

There are a number of methods commonly used to purify water. Their effectiveness is linked to the type of contaminant being treated and the type of application the water will be used for.

- Filtration: This process can take the form of any of the following:
  - Coarse filtration: Also called particle filtration, it can utilize anything from a 1 mm sand filter, to a 1 micron cartridge filter.
  - Micro filtration: Uses 1 to 0.1 micron devices to filter out bacteria. A typical implementation of this technique can be found in the brewing process.
  - Ultra filtration: Removes pyrogens, endotoxins, DNA and RNA fragments.
  - Reverse osmosis: Often referred to as RO, reverse osmosis is the most refined degree of liquid filtration. Instead of a filter, it uses a porous material acting as a unidirectional sieve that can separate molecular-sized particles.
- Distillation: Oldest method of purification. Inexpensive but cannot be used for an on-demand process. Water must be distilled and then stored for a later use, making it again prone to contamination if not stored properly.
- Activated carbon adsorption: Operates like a magnet on chlorine and organic compounds.
- Ultraviolet radiation: At a certain wavelength, this might cause bacteria to be sterilized and other micro organisms to be broken down.
- Deionization: Also known as ion exchange, it is used for producing purified water on-demand, by passing water through resin beds. Negatively charged (anionic) resin removes positive ions, while positively charged one (cationic) removes negative ions. Continuous monitoring and maintenance of the cartridges can produce the purest water.

## Hot Water Sanitization

Sanitization of water purification equipment with hot water is achieved via an appropriate combination of exposure time and temperature. A primary use for this process is to deactivate viable microbes. It is worth mentioning that Endotoxin reduction is not achieved as a direct result of the hot water sanitization process.

Based on the feed water source, system operating conditions and the end-user's operating and maintenance procedures, traditional chemical cleaning processes may still be required.

Sanitization using hot water involves incorporating heat exchangers into the traditional clean in place (CIP) system to gradually heat and cool water circulating through the reverse osmosis membrane system. Membrane manufacturers commonly stipulate a controlled heating and cooling rate to protect

against irreversible damage to the membrane and ensure the system's long-term performance.

A typical hot water sanitization sequence would consist of the following phases:

- Initialization (conditions checking)
- Heating
- Holding
- Cooling

A control system must therefore provide flexibility in the way in which accurate and repeatable control of the sterilization is achieved and will include the following features:

- Precise loop control with setpoint profile programming
- Sequential control for sanitization/sterilization
- Onscreen operator messaging
- Duty standby pump control
- Secure collection of on-line data from the purified water system for analysis and evidence
- Local operator display with clear graphics and controlled access to parameters.

The Eycon™ Visual Supervisor is an ideal solution for this application.

