AQUA TECH

WATER TREATMENT

OUR ESSENTIAL GUIDE TO WATER TREATMENT TECHNOLOGY

What is water treatment?

Water treatment and water treatment technologies are an essential line of defence to remove contaminants and bacteria before the delivery of clean, potable water supplies for consumption. Water sources can be subject to contamination and therefore require appropriate treatment to remove disease-causing agents.

Public drinking water systems use a variety of methods to provide safe drinking water for their communities. Depending on the continent, country and region, different water treatment systems may be in operation depending on regional regulations and raw water input. The following article provides an overview of the basic principles of water treatment and the processes and technologies involved.

Maintaining water treatment to ensure a clean supply to meet growing global populations has been an ongoing challenge throughout human history.

Thanks to significant technological developments in water treatment, including monitoring and assessment, high-quality drinking water can be supplied and enjoyed around the world. Replicating the earth's hydrological cycle in which water is continuously recycled, treatment enables the same water to be cleansed through several natural processes.

Most water sources require treatment to eliminate health risks before consumption, focusing on removing microbiological contamination and physical impurities like suspended solids (turbidity). Following this, a final disinfection stage deactivates any remaining microorganisms. Persistent disinfectants such as chlorine can also prevent biological regrowth during storage or distribution in larger systems.

Water treatment consists of multiple stages, starting with pre-treatment via settling or coarse media, followed by filtration and chlorination, following the multiple barrier principle. Each stage prepares the water for downstream processes, such as filtration priming it for UV disinfection.

Depending on the quality and type of the water entering a water plant, treatment may vary. For example, groundwater treatment works abstract water from below ground sources such as aquifers and springs. These sources tend to be relatively clean in comparison to surface water, with fewer water treatment steps required.

Surface water treatment facilities draw from rivers, lakes, and reservoirs, prone to environmental contamination. Employing multiple treatment steps, they remove contaminants to ensure clean, disinfected water for distribution.

Certain water supplies may contain disinfection by-products, inorganic and organic chemicals, and radionuclides, necessitating specialized treatment methods to control their formation and removal.

Additionally, renewed regulations may enforce stricter limits on endocrine-disrupting chemicals as well as lead limits being halved.

How does the water treatment process work?

Coagulation, flocculation, and sedimentation are essential processes employed to eliminate colour, turbidity, algae, and various microorganisms from surface water sources, ensuring clarity and safety for consumption and other uses.

Chemical coagulants can be added to the water for the formation of a precipitate, or floc to entrap these impurities. After sedimentation and/or filtration, the floc is separated from the treated water.

Aluminium sulphate and ferric sulphate are among the most frequently utilized coagulants, although alternatives exist. The dosage rate of coagulants in solution is determined by the raw water quality near the inlet of a mixing tank or flocculator.

By adding coagulant at a point of high turbulence, it is rapidly and thoroughly dispersed on dosing. The next stage is the sedimentation tank. Here aggregation of the flocs takes, which settle out to form sludge that will need to be removed.

One of the advantages of coagulation ais that it reduces the time required to settle out suspended solids. Furthermore, it can be very effective in removing fine particles that are otherwise very difficult to remove.

The cost and the requirement for accurate dosing, thorough mixing and frequent monitoring, are often cited as the principal disadvantages of using coagulants for treatment of small supplies. Bench scale coagulation tests can be used to determine which coagulant to use for specific raw water.

As a result, to remove colour and turbidity, coagulation and flocculation are considered the most effective treatment techniques. However, for small water supplies they may not be suitable. This is due to the level of control required and volumes of sludge generated.

Six essential Water treatment technologies

A variety of water treatment technologies are needed to work together, in sequence, in order to purify raw water before it can be distributed. Here is a list of basic technologies often used in water treatment works.

1. Screens

Screens are used on many surface water intakes to remove particulate material and debris from raw water. Coarse screens handle weeds and large debris, while band screens and microstrainers capture smaller particles, including fish. Microstrainers reduce solids loading before coagulation or filtration.

2. Gravel filters

Gravel filters are effective in removing turbidity and algae. They feature a rectangular channel or tank filled with graded gravel (4 to 30mm). Raw water enters through an inlet chamber and flows horizontally, encountering coarse gravel first, then finer gravel. Filtered water is collected in an outlet chamber, while solids accumulate on the filter floor.

3. Slow sand filters

Slow sand filters effectively remove turbidity, algae, and microorganisms. This reliable process is suitable for small supplies if enough land is available. Typically, these filters comprise tanks filled with sharp sand (0.15-0.30mm) to a depth of 0.5 to 1.5m.

4. Activated carbon

Using physical adsorption, contaminants can be removed using activated carbon. This will be affected by the amount and type of the carbon, the nature and concentration of the contaminant, retention time of water in the unit and general water quality (temperature, pH, etc.).

One of the mocst common mediums is granular activated carbon (GAC), although powdered activated carbon (PAC) and block carbon are also sometimes used. Filter media is contained in replaceable cartridges and a particulate filter at the outlet of the cartridge is used to remove carbon fines from the treated water.

5. Aeration

Aeration is designed to transfer oxygen into water and remove gases and volatile compounds by air stripping. A common method is packed tower aerators as a result of their compact design and high energy efficiency. To achieve air stripping various techniques can be used including counter current cascade aeration in packed towers, diffused aeration in basins and spray aeration.

6. Membrane processes

Reverse osmosis (RO), ultrafiltration (UF), microfiltration (MF), and nanofiltration (NF) are common membrane technologies used in water treatment. Initially used for industrial and pharmaceutical purposes, membranes are now applied to drinking water treatment. They effectively remove pathogenic bacteria, Cryptosporidium, Giardia, and potentially human viruses and bacteriophages. Notably, Dutch and Danish companies are integrating enzymes into membrane technology to remove pesticides and pharmaceutical residues from drinking water.

UV water treatment: shining a light on disinfection

UV light, invisible to the naked eye, effectively disinfects microorganisms in water treatment. Operating within wavelengths of 200 to 300 nanometres, UV radiation, primarily emitted at 254 nm by low-pressure mercury vapour lamps, optimally disinfects and destroys ozone. Categorized as germicidal, UV light can inactivate bacteria, viruses, and protozoa. Notably, UV lamps remain external to the water, either within UV transparent Teflon tubes or housed in quartz glass sleeves inside water chambers.

How does it work? The wavelength of UV light render bacteria, viruses and protozoa incapable of reproducing and infecting.

UV disinfection can be used for the primary disinfection technology of potable drinking water. Furthermore, the process can also be used as a secondary form of disinfection. For example, against microorganisms, such as Cryptosporidium and Giardia, which can be chlorine-resistant.

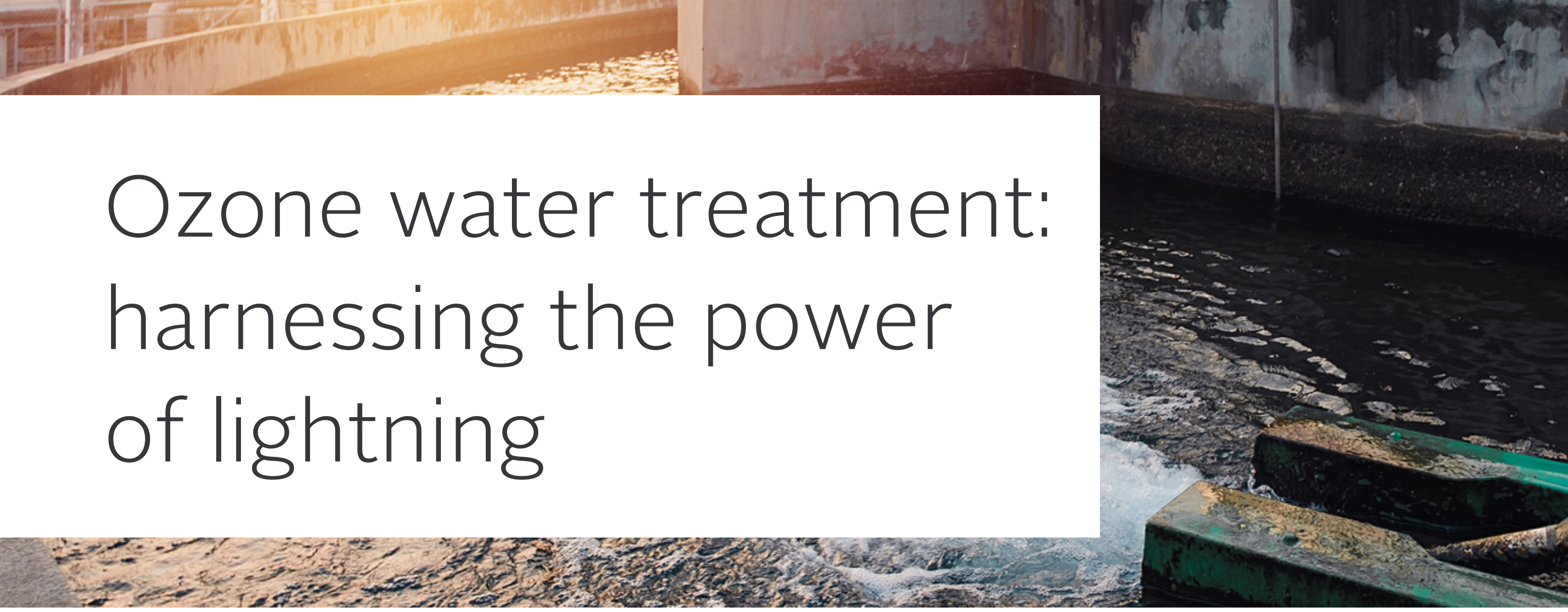
In addition, UV light (either alone or in conjunction with hydrogen peroxide) can destroy chemical contaminants such as pesticides, industrial solvents, and pharmaceuticals through a process called UV-oxidation.

Under ideal conditions, a UV unit can provide greater than 99% reduction of all bacteria. However, even with this performance, ultraviolet disinfection has two potential limitations: “point” disinfection and also cells not being removed.

“Point” Disinfection can occur if the UV units only kill bacteria at one point in a watering system and do not provide any residual germicidal effect downstream. If just one bacterium passes through unharmed (100% destruction of bacteria cannot be guaranteed), there is nothing to prevent it from attaching to downstream piping surfaces and proliferating.

Secondly, a second limitation can be if bacteria cells are not removed in a UV unit but are converted into pyrogens. The killed microorganisms and any other contaminants in the water are a food source for any bacteria that do survive downstream of the UV unit.

One notable development to UV systems is the scaling up of light-emitting diode technology, known as UV-LED, with 2018 witnessing a tipping point on power density and purchasing price.



Ozone water treatment: harnessing the power of lightning

Like a lightning storm, ozone is created when oxygen is exposed to the discharge of a powerful electric current through air. While widely used in Europe for many years to treat municipal drinking water, it has not had a similar acceptance in the US.

Ozone's exceptional disinfection and oxidation properties make it valuable in various stages of water treatment. It's commonly employed for pre-oxidation before sand or activated carbon filtration, where these filters effectively remove residual organic matter, crucial for final disinfection.

Ozonation is carried out by an electric discharge field as in the CD-type ozone generators, or by ultraviolet radiation (UV-type ozone generators). Ozone can also be achieved through electrolytic and chemical reactions, in addition to commercial methods.

Typically, an ozonation system involves passing dry, clean air through a high voltage electric discharge, such as corona discharge, generating ozone at about 1% concentration or 10,000 mg/L.

UV ozonation is prevalent for treating small waste amounts, whereas larger systems employ corona discharge or other bulk ozone-producing techniques.

Raw water is then passed through a venturi throat which creates a vacuum and pulls the ozone gas into the water or the air is then bubbled up through the water being treated. Since the ozone will react with metals to create insoluble metal oxides, post filtration is required.

Ozone is highly reactive, with a short half-life once dissolved in water. Typically, it returns to its oxygen form within 10–20 minutes at 20 °C.

Advantages to ozone water treatment include the minimisation of inorganic, organic and microbiological problems and taste and odour problems. Furthermore, no additional chemicals are added to the water.

Meanwhile, disadvantages include a lack of germicidal or disinfection residual to inhibit or prevent growth. Furthermore, the system may require pre-treatment for hardness reduction.

Types of water treatment chemicals & why they are used

Chemical disinfection of drinking water involves chlorine-based technologies like chlorine dioxide, ozone, and other oxidants, along with some strong acids and bases. Except for ozone, maintaining a residual concentration of chemical disinfectants in water aims to offer protection against post-treatment contamination during storage.

Household drinking water in developing countries is mainly disinfected using free chlorine, available as hypochlorous acid (in commercial bleach or diluted sodium hypochlorite solutions between 0.5% and 1% hypochlorite) or in dry forms like calcium hypochlorite or sodium dichloroisocyanurate. These chlorine options are favoured for their convenience, safety, affordability, and ease of dosing.

Chlorine is most widely used for primary disinfection and residual disinfection in distribution systems. Monitoring its levels upon water entry is crucial to ensure disinfection. However, residual chlorine concentrations exceeding 0.6 mg/l may lead to taste concerns for certain consumers.

Chlorine dioxide decomposes into chlorite and chlorate, which can be managed by regulating the chlorine dioxide dosage in water treatment. Chlorite can also be present in aged hypochlorite solutions.

Proper dosing of chlorine for household water treatment is critical in order to provide enough free chlorine to maintain a residual during storage and use. Recommendations are to dose with free chlorine at about 2 mg/l to clear water (< 10 nephelometric turbidity units [NTU]) and twice that (4 mg/l) to turbid water (> 10 NTU).

Monochloramine, a residual disinfectant in distribution systems, is typically created by combining chlorine with ammonia. It's crucial to carefully manage monochloramine formation in water treatment to prevent the development of di- and trichloramines, which can lead to undesirable tastes and odours.

A number of other chemicals may be added in treatment. These include substances such as sodium hydroxide for adjusting pH and, in certain circumstances, chemicals for fluoridation of drinking-water.

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