**Raw water**

**Raw water** is water found in the environment that has not been [treated](https://en.wikipedia.org/wiki/Water_treatment) and does not have any of its minerals, ions, particles, bacteria, or parasites removed. Raw water includes infiltration wells, and water from bodies like [lakes](https://en.wikipedia.org/wiki/Lake) and [rivers](https://en.wikipedia.org/wiki/River). Raw water is generally unsafe for human consumption due to the presence of contaminants. A major health problem in some [developing countries](https://en.wikipedia.org/wiki/Developing_country) is use of raw water for drinking and cooking.

Without treatment, raw water can be used for [farming](https://en.wikipedia.org/wiki/Farming), [construction](https://en.wikipedia.org/wiki/Construction) or cleaning purposes.Farmers use it for watering their [crops](https://en.wikipedia.org/wiki/Crop) or give to [livestock](https://en.wikipedia.org/wiki/Livestock) to drink, storing it in man-made lakes or reservoirs for long periods of time. Construction industries can use raw water for making [cement](https://en.wikipedia.org/wiki/Cement) or for damping down unsealed roads to prevent dust rising. Raw water can also be used for flushing toilets and washing cars, as well as any other purposes that do not require it to be consumed by humans. Water in this form is considered raw, as opposed to water which has been [treated](https://en.wikipedia.org/wiki/Water_treatment) before consumption, such as [drinking water](https://en.wikipedia.org/wiki/Drinking_water) or water which has been used in an industrial process, such as [waste water](https://en.wikipedia.org/wiki/Waste_water).

# MUNICIPAL WATER

A public water supply system or water supply network including water treatment facilities, water storage facilities (reservoirs, water tanks and water towers) and a pipe network for distributing the treated water to customers including residential, industrial, commercial or institutional establishments

**TYPES OF WATER - MUNICIPAL WATER**

**Municipal Water (Tap Water)**

In most developed countries, water is supplied to households and industries using underground pipes. That water is processed and treated to meet drinking water standards, even though only a very small proportion is consumed or used in food preparation. In the United States, less than 1% of municipal water is used for human consumption. The rest is used for things like bathing, watering gardens, cleaning, and cooking. The quality and reliability of municipally supplied tap water can vary from community to community.

In most cities and towns, municipal water comes from large wells, lakes, rivers, or reservoirs. Most cities and towns process the water at treatment plants before the water is tested for EPA compliance and is then piped to residential homes and industries

Some municipal drinking water is obtained from streams, rivers, and lakes. This water is called surface water. Surface water must be treated before it can be used for drinking, because there is a greater chance that harmful chemicals or microorganisms could have washed into surface water. Municipalities that rely on surface water will pump the water from the river or lake to a water treatment plant.

The amount and type of treatment applied by a public water system varies with the source type and quality. Some groundwater systems can satisfy all federal requirements without applying any treatment, while others need to add chlorine or additional treatments. Because surface water systems are exposed to and fed by direct land runoff and exposed to the atmosphere, they are more easily subjected to contamination. Federal and state regulations require that those systems treat this type of water to meet health-based standards.

# Municipal Water Use

Many people live in municipalities (cities, towns, and villages with services such as water treatment, police, and fire departments). One benefit of living in a municipality is that potable water (water safe to drink) is usually available at any time by turning on the tap. Part of the responsibility of citizens and municipal officials however, is to manage and protect the local [water supply](https://www.encyclopedia.com/science-and-technology/biology-and-genetics/environmental-studies/water-supply).

If municipal water becomes contaminated, the result can be far-reaching and rapid. Bacteria and viruses in water can spread throughout the underground reservoir of water (the aquifer) or throughout the miles of pipelines that carries water to houses in towns and cities. As well, non-living pollutants such as oil, gasoline and sediment can spread contaminate water.

The results of such contamination can be disastrous. In the summer of 2000, the municipal [water supply](https://www.encyclopedia.com/science-and-technology/biology-and-genetics/environmental-studies/water-supply) of Walkerton, a town in the Canadian province of Ontario, became contaminated with a certain type of bacteria called [Escherichia coli](https://www.encyclopedia.com/plants-and-animals/microbes-algae-and-fungi/moneran-and-protistan/escherichia-coli) (or E. coli for short). This type of E. coli caused a serious illness in over a thousand people who drank the town water, and killed seven people.

In addition to protecting water for human use, water management also benefits the environment. Polluted water is bad for the many creatures that live in the water and depend on the watercourse in their lives.

## Protecting municipal drinking water

People who live in a municipality usually have to pay money to the [local government](https://www.encyclopedia.com/social-sciences-and-law/political-science-and-government/political-science-terms-and-concepts/local) for their water. Municipal drinking water may come from wells, which pump water that is located underneath the ground (groundwater) into an underground reservoir. Groundwater is often free of contaminating chemicals and microorganisms because the contaminants are filtered out of the water as it moves downward into the ground, yet the water still must be tested to ensure the absence of contaminants. Once tested, the water is pumped through pipes that run underneath the streets of the municipality. The pipes lead to houses, fire stations, other offices, swimming pools, and the many other places where water is used.

## Other uses of municipal water

Many municipalities provide golf courses, swimming pools, sports fields, gardens and parks for their residents. All of these places require water. Fire fighters need easy access to water, which is provided by a system of pipes that lead to fire hydrants positioned throughout the municipality. The fire fighters hook their hoses up to the high-pressure hydrants to fight fires with water. Many municipalities have cleaning programs, where roads and other surfaces are cleared of dirt and other material that piles up during the winter or a dusty, dry summer. Water is sprayed from vehicles that move slowly along the road, to wash away the accumulated grime.

## Safeguarding municipal water

Many municipalities have laws that restrict people from throwing garbage into streams, rivers, and lakes, and to stop the dumping of liquids such as oil and gasoline into the water. Preserving undeveloped areas of riverbanks or lakes also encourages growth of natural vegetation that benefits the water supply. By leaving grass, trees, and other vegetation alongside a stream or river, it makes it more difficult for toxic (poisonous) material to wash into the water. Along with this benefit, the natural stream or river bank often becomes an attractive spot to walk, bike ride, and picnic.

**Treatment of Municipal water**

Municipal water suppliers use a variety of treatment processes to remove contaminants from drinking water. Tap water regularly makes headlines when communities are put on a boil alert notice. Such an alert occurs when the water source, a treatment system failure, or broken pipes cause the municipal water to become contaminated and unfit for consumption. Contamination can include toxic metals (lead and arsenic), excessive toxic chemicals, medical pharmaceutical drugs, chemicals used to sanitize water (chlorine, aluminum, copper, and fluoride), and bromine.

Normally there are three principal stages in water purification:-

**Primary treatment**- Collecting and screening including if required pumping from rivers and initial storage

**Secondary treatment**- removal of fine solids and the majority of contaminants using filters, coagulation, flocculation and membranes

**Tertiary treatment**- polishing, pH adjustment, carbon treatment to remove taste and smells, disinfection, and temporary storage to allow the disinfecting agent to work. Here disinfection is most important.

Primary Treatment

**Pumping and containment**– If required water is to be pumped from its source or directed into pipes or holding tanks. To avoid adding contaminants to the water, this physical infrastructure must be made from appropriate materials and constructed so that accidental contamination does not occur.

**Screening**- The first step in purifying surface water is to remove large debris such as sticks, leaves, trash and other large particles which may interfere with subsequent purification steps.

**Storage**- Water from rivers may also be stored in [bank side reservoirs](http://en.wikipedia.org/wiki/Bankside_reservoirs) for periods between a few days and many months to allow natural biological purification to take place. This is especially important if treatment is by [slow sand filters](http://en.wikipedia.org/wiki/Slow_sand_filter). Storage reservoirs also provide a buffer against short periods of [drought](http://en.wikipedia.org/wiki/Drought) or to allow water supply to be maintained during transitory [pollution](http://en.wikipedia.org/wiki/Water_pollution) incidents in the source river.

**Pre-conditioning**- Waters rich in hardness salts are treated with soda-ash ([Sodium carbonate](http://en.wikipedia.org/wiki/Sodium_carbonate)) to precipitate [calcium carbonate](http://en.wikipedia.org/wiki/Calcium_carbonate) out utilizing the [common ion effect](http://en.wikipedia.org/wiki/Common_ion_effect).

**Pre-chlorination**- In many plants the incoming water was chlorinated to minimize the growth of fouling organisms on the pipe-work and tanks.

Secondary Treatment

There are a wide range of techniques that can be used to remove the fine solids, micro-organisms and some dissolved inorganic and organic materials. The choice of method will depend on the quality of the water being treated, the cost of the treatment process and the quality standards expected of the processed water.

1.**pH adjustment** – If the water is acidic, lime or soda ash is added to raise the pH. Lime is the more common of the two additives because it is cheaper, but it also adds to the resulting water hardness. Making the water slightly alkaline ensures that coagulation and flocculation processes work effectively and also helps to minimize the risk of lead being dissolved from lead pipes and lead solder in pipe fittings.

2.**Coagulation** – Together, coagulation and flocculation are purification methods that work by using chemicals which effectively “glue” small suspended particles together, so that they settle out of the water or stick to sand or other granules in a granular media filter. The coagulation chemicals are added in a tank (often called a rapid mix tank or flash mixer), which typically has rotating paddles. In most treatment plants, the mixture remains in the tank for 10 to 30 seconds to ensure full mixing. The amount of coagulant that is added to the water varies widely due to the different source water quality.

One of the more common coagulants used is aluminum sulfate, sometimes called filter alum. Aluminum sulfate reacts with water to form flocs of aluminium hydroxide. Iron (II) sulfate or iron (III) chloride is other common coagulants. Iron (III) coagulants work over a larger pH range than aluminum sulfate but are not effective with many source waters. Other benefits of iron (III) are lower costs and in some cases slightly better removal of natural organic contaminants from some waters. Coagulation with iron compounds typically leaves a residue of iron in the finished water. This may impart a slight taste to the water, and may cause brownish stains on porcelain fixtures. The trace levels of iron are not harmful to humans, and indeed provide a needed trace mineral. Because the taste and stains may lead to customer complaints, aluminium tends to be favoured over iron for coagulation.

Now a days inorganic polymer of Aluminium chloride is widely used as a coagulant to control high turbidity in monsoon season. Oftenly called as Poly Aluminium Chloride. Cationic and other polymers can also be used. They are often called coagulant aids used in conjunction with other inorganic coagulants. The main advantages of polymer coagulants and aids are that they do not need the water to be alkaline to work and that they produce less settled waste than other coagulants, which can reduce operating costs. The drawbacks of polymers are that they are expensive, can blind sand filters and that they often have a very narrow range of effective doses.

**3 Flocculation**- The joining of the particles so that they will form larger settable particles is called flocculation. The larger formed particles are called [floc](http://en.wikipedia.org/wiki/Floc). In flocculation coagulants are used but the resultant floc is settled out rather than filtered through sand filters. The chosen coagulant and the raw water are slowly mixed or water which previously coagulated is directly taken in a large tank called a flocculation basin (Chamber). Unlike a rapid mix tank, the flocculation paddles turn very slowly to minimize turbulence. The principle involved is to allow as many particles to contact other particles as possible generating large and robust floc particles. Generally, the retention time of a flocculation basin is at least 30 minutes with speeds between 0.5 feet and 1.5 feet per minute (15 to 45 cm / minute).

**4 Sedimentation/Clarification/Settling**-Water exiting the flocculation basin (chamber) enters the [sedimentation basin](http://en.wikipedia.org/wiki/Settling_basin), also called a clarification or settling basin (chamber). It is a large tank with slow flow, allowing floc to settle to the bottom. The sedimentation basin is best located close to the flocculation basin so the transit between does not permit settlement or floc break up. Sedimentation basins can be in the shape of a rectangle, where water flows from end to end, or circular where flow is from the center outward. Sedimentation basin outflow is typically over a [weir](http://en.wikipedia.org/wiki/Weir) so only a thin top layer-furthest from the sediment-exits. **The amount of floc that settles out of the water is dependent on the time the water spends in the basin and the depth of the basin. The retention time of the water must therefore be balanced against the cost of a larger basin.** The minimum clarifier retention time should be normally 4 hours. A deep basin will allow more floc to settle out than a shallow basin. This is because large particles settle faster than smaller ones, so large particles bump into and integrate smaller particles as they settle. In effect, large particles sweep vertically though the basin and clean out smaller particles on their way to the bottom. As particles settle to the bottom of the basin a layer of sludge is formed on the floor of the tank. This layer of sludge must be removed and treated. The amount of sludge that is generated is significant, often 3%-5% of the total volume of water that is treated. The tank may be equipped with mechanical cleaning devices (called as bridge units in conventional clarifiers) that continually clean the bottom of the tank or incase of sedimentation tanks, without such cleaning devices, the tank can be taken out of service when the bottom needs to be cleaned.

Recently a new type of settlers called *Tube Settlers* have been used. Tube settlers offer an inexpensive method of upgrading existing water treatment plant clarifiers and sedimentation basins to improve performance. They can also reduce the tankage/footprint required in new installations or improve the performance of existing settling basins by reducing the solids loading on downstream filters. Made of lightweight PVC, tube settlers can be easily supported with minimal structures that often incorporate the effluent trough supports. They are available in a variety of module sizes and tube lengths to fit any tank geometry, with custom design and engineering offered by the manufacturer.

5.**Filtration** – After separating most floc, the water is filtered as the final step to remove remaining suspended particles and unsettled floc. The most common type of filter is a rapid sand filter. Water moves vertically through sand which often has layers of sand. If charcoal is used as topmost layer of a filter media then, it removes organic compounds including taste and odor. The space between sand particles is larger than the smallest suspended particles, so simple filtration is not enough. Most particles pass through surface layers but are trapped in pore spaces or adhere to sand particles. Effective filtration extends into the depth of the filter. This property of the filter is key to its operation: if the top layer of sand were to block all the particles, the filter would quickly clog. To clean the filter, water is passed quickly upward through the filter, opposite the normal direction (called back flushing or backwashing) to remove embedded particles. Prior to this, compressed air may be blown up through the bottom of the filter to break up the compacted filter media to aid the backwashing process; this is known as air blowing. This contaminated water can be disposed of, along with the sludge from the sedimentation (clarifiers) basin, or it can be recycled by mixing with the raw water entering the plant. Some water treatment plants may employ pressure filters. These work on the same principle as rapid gravity filters differing in that the filter medium is enclosed in a steel vessel and the water is forced through it under pressure.

Tertiary treatment

Disinfection is normally the last step in purifying drinking water. Water is disinfected to destroy any pathogens which pass through the filters. Possible pathogens include viruses, bacteria, including Escherichia coli, Campylobacter and Shigella, and protozoans, including G. lamblia and other Cryptosporidia. Mostly public water supplies are required to maintain a residual disinfecting agent throughout the distribution system, in which water may remain for days or hours before reaching the consumer. Following the introduction of any chemical disinfecting agent, the water is usually held in temporary storage – often called a contact tank or clear well to allow the disinfecting action to complete.

1.**Chlorine**- The most common disinfection method is some form of chlorine or its compounds such as chloramines or chlorine dioxide. Chlorine is a strong oxidant that kills many micro-organisms. Because chlorine is a toxic gas, there is a danger of a release associated with its use. This problem is avoided by the use of sodium hypochlorite, which is a relatively inexpensive liquid that releases free chlorine when dissolved in water. We can also use TCP/ Bleaching powder. Handling the solid, however, requires greater routine human contact through opening bags and pouring than the use of gas cylinders which are more easily automated. These disinfectants are widely used despite their respective drawbacks. A major drawback to using chlorine gas or sodium hypochlorite is that they react with organic compounds in the water to form potentially harmful levels of the chemical by-products trihalomethanes (THMs) and halo acetic acids, both of which are carcinogenic and regulated by the U.S. Environmental Protection Agency (EPA). The formation of THMs and haloacetic acids is minimized by effective removal of as many organics from the water as possible before disinfection. Although chlorine is effective in killing bacteria, it has limited effectiveness against protozoans that form cysts in water. (Giardia lamblia and Cryptosporidium, both of which are pathogenic). Hence water purification plants must have a very good filtration system.

2.Chlorine dioxide is another fast-acting disinfectant. It is, however, rarely used, because it may create excessive amounts of chlorate and chlorite, both of which are regulated to low allowable levels. Chlorine dioxide also poses extreme risks in handling: not only is the gas toxic, but it may spontaneously detonate upon release to the atmosphere in an accident.

3.Chloramines are another chlorine-based disinfectant. Although chloramines are not as effective as disinfectants, compared to chlorine gas or sodium hypochlorite, they are less prone to form THMs or haloacetic acids. It is possible to convert chlorine to chloramine by adding ammonia to the water along with the chlorine: The chlorine and ammonia react to form chloramines. Water distribution systems disinfected with chloramines may experience nitrification, wherein ammonia is used a nitrogen source for bacterial growth, with nitrates being generated as a byproduct.

4.**Ozone (O3)** is a relatively unstable molecule of oxygen which readily gives up one atom of oxygen providing a powerful oxidizing agent which is toxic to most water borne organisms. It is a very strong, broad spectrum disinfectant that is widely used in Europe. It is an effective method to inactivate harmful protozoans that form cysts. It also works well against almost all other pathogens. Ozone is made by passing oxygen through ultraviolet light or a “cold” electrical discharge. To use ozone as a disinfectant, it must be created on site and added to the water by bubble contact. Some of the advantages of ozone include the production of relatively fewer dangerous by-products (in comparison to chlorination) and the lack of taste and odor produced by ozonation. Although fewer by-products are formed by ozonation, it has been discovered that the use of ozone produces a small amount of the suspected carcinogen Bromate. Another one of the main disadvantages of ozone is that it leaves no disinfectant residual in the water. Ozone has been used in drinking water plants since 1906 where the first industrial ozonation plant was built in Nice, France.

5.**UV radiation** is very effective at inactivating cysts, as long as the water has a low level of colour so the UV can pass through without being absorbed. The main drawback to the use of UV radiation is that, like ozone treatment, it leaves no residual disinfectant in the water. Because neither ozone nor UV radiation leaves a residual disinfectant in the water, it is sometimes necessary to add a residual disinfectant after they are used. This is often done through the addition of chloramines, discussed above as a primary disinfectant. When used in this manner, chloramines provide an effective residual disinfectant with very little of the negative aspects of chlorination.

Storage – Once the disinfection process is complete, the water is stored. Storage usually takes place in an underground storage tank called a “clear well”, and also in elevated storage tanks that are visible around town. There must always be an ample supply of water available in the event of emergencies. These can include power outages, fires, floods, etc. Distribution – So how does the water come out of your kitchen tap? The stored water is pushed through underground pipelines all over town in what is called a “distribution system”. The distribution system consists of large water pumps at the treatment plant, overhead water storage tanks, large pipelines, smaller pipelines, fire hydrants, valves, and water meters in your front yard.



