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Direct Lighting

(Term of lighting design)

Lighting provided from a source without reflection from other surfaces. In daylighting, this means that the light has travelled on a straight path from the sky (or the sun) to the point of interest. In electrical lighting it usually describes an installation of ceiling mounted or suspended luminaires with mostly downward light distribution characteristics.

Advantages:

* Very energy effective lighting.
* Plastic display of three dimensional objects, eg. sculptures.
* Well suited for zonal or accent lighting.
* Can create a vivid environment with attractive light and shadow patterns eg. on wall surfaces.

Disadvantages:

* The ceiling is relatively dark, which can cause a "cave like" environment.
* Luminaires with wide opening angle that are badly positioned can cause reflected glare on computer screens, dark "executive style" desk surfaces or glossy paper.
* Harsh shadows can be unflattering when cast on human faces.

Indirect Lighting

(Term of lighting design)

Lighting provided by reflection usually from wall or celiling surfaces. In daylighting, this means that the light coming from the sky or the sun is reflected on a surface of high reflectivity like a wall, a window sill or a special redirecting device. In electrical lighting the luminaires are suspended from the ceiling or wall mounted and distribute light mainly upwards so it gets reflected off the ceiling or the walls.

Advantages:

* Creates a soft, undisturbing environment suitable for concentrated work or viewing paintings or drawings.
* Reflective glare on computer monitors can be controlled more easily.
* Displays human faces advantageously for social gatherings.
* Can be installed without disturbing the ceiling surface (eg. in historical buildings or a painted ceiling).

Disadvantages:

* It can be disturbing if the ceiling is the brightest surface in a room.
* Makes it difficult to recognise details on three dimensional objects.
* There is very little contrast in the room which can be boring.
* Not very energy effective.

# Water purification

From Wikipedia, the free encyclopedia

Jump to: [navigation](http://en.wikipedia.org/wiki/Water_purification#mw-head), [search](http://en.wikipedia.org/wiki/Water_purification#p-search)

This article is about large scale, municipal water purification. For portable/emergency water purification, see [portable water purification](http://en.wikipedia.org/wiki/Portable_water_purification). For industrial water purification, see [deionized water](http://en.wikipedia.org/wiki/Deionized_water). For distilled water, see [distilled water](http://en.wikipedia.org/wiki/Distilled_water).

Water purification is the process of removing undesirable chemicals, materials, and biological contaminants from contaminated water. The goal is to produce water fit for a specific purpose. Most water is purified for human consumption ([drinking water](http://en.wikipedia.org/wiki/Drinking_water)) but water purification may also be designed for a variety of other purposes, including meeting the requirements of medical, pharmacology, chemical and industrial applications. In general the methods used include physical processes such as [filtration](http://en.wikipedia.org/wiki/Filtration) and [sedimentation](http://en.wikipedia.org/wiki/Sedimentation), biological processes such as [slow sand filters](http://en.wikipedia.org/wiki/Slow_sand_filters) or [activated sludge](http://en.wikipedia.org/wiki/Activated_sludge), chemical processes such as [flocculation](http://en.wikipedia.org/wiki/Flocculation) and [chlorination](http://en.wikipedia.org/wiki/Chlorination) and the use of electromagnetic radiation such as [ultraviolet light](http://en.wikipedia.org/wiki/Ultraviolet_germicidal_irradiation).

The purification process of water may reduce the concentration of particulate matter including [suspended](http://en.wikipedia.org/wiki/Suspension_%28chemistry%29) [particles](http://en.wikipedia.org/wiki/Particle_%28ecology%29), [parasites](http://en.wikipedia.org/wiki/Parasite), [bacteria](http://en.wikipedia.org/wiki/Bacteria), [algae](http://en.wikipedia.org/wiki/Algae), [viruses](http://en.wikipedia.org/wiki/Virus), [fungi](http://en.wikipedia.org/wiki/Fungi); and a range of dissolved and particulate material derived from the surfaces that water may have made contact with after falling as [rain](http://en.wikipedia.org/wiki/Rain).

The standards for drinking [water quality](http://en.wikipedia.org/wiki/Water_quality) are typically set by governments or by international standards. These standards will typically set minimum and maximum concentrations of contaminants for the use that is to be made of the water.

It is not possible to tell whether water is of an appropriate quality by visual examination. Simple procedures such as [boiling](http://en.wikipedia.org/wiki/Boiling) or the use of a household [activated carbon](http://en.wikipedia.org/wiki/Activated_carbon) filter are not sufficient for treating all the possible contaminants that may be present in water from an unknown source. Even natural [spring water](http://en.wikipedia.org/wiki/Spring_%28hydrosphere%29) – considered safe for all practical purposes in the 19th century – must now be tested before determining what kind of treatment, if any, is needed. Chemical analysis, while expensive, is the only way to obtain the information necessary for deciding on the appropriate method of purification.

According to a 2007 [World Health Organization](http://en.wikipedia.org/wiki/World_Health_Organization) report, 1.1 [billion](http://en.wikipedia.org/wiki/1%2C000%2C000%2C000_%28number%29) people lack access to an improved [drinking water](http://en.wikipedia.org/wiki/Drinking_water) supply, 88% of the 4 billion annual cases of [diarrheal disease](http://en.wikipedia.org/wiki/Diarrhea) are attributed to unsafe water and inadequate [sanitation](http://en.wikipedia.org/wiki/Sanitation) and hygiene, and 1.8 million people die from diarrheal diseases each year. The WHO estimates that 94% of these diarrheal cases are preventable through modifications to the environment, including access to safe water.[[1]](http://en.wikipedia.org/wiki/Water_purification#cite_note-0) Simple techniques for treating water at home, such as chlorination, filters, and solar disinfection, and storing it in safe containers could save a huge number of lives each year.[[2]](http://en.wikipedia.org/wiki/Water_purification#cite_note-1) Reducing deaths from [waterborne diseases](http://en.wikipedia.org/wiki/Waterborne_diseases) is a major [public health](http://en.wikipedia.org/wiki/Public_health) goal in developing countries.

## Treatment

The processes below are the ones commonly used in water purification plants. Some or most may not be used depending on the scale of the plant and quality of the water.

###  Pre-treatment

1. Pumping and containment – The majority of water must 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.
2. Screening (see also [screen filter](http://en.wikipedia.org/wiki/Screen_filter)) – 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. Most deep [groundwater](http://en.wikipedia.org/wiki/Groundwater) does not need screening before other purification steps.
3. Storage – Water from rivers may also be stored in [bankside 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 or to allow water supply to be maintained during transitory [pollution](http://en.wikipedia.org/wiki/Water_pollution) incidents in the source river.
4. Pre-conditioning – Water rich in hardness salts is 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).
5. Pre-chlorination – In many plants the incoming water was chlorinated to minimize the growth of fouling organisms on the pipe-work and tanks. Because of the potential adverse quality effects (see chlorine below), this has largely been discontinued.[[citation needed](http://en.wikipedia.org/wiki/Wikipedia%3ACitation_needed)]

Widely varied techniques are available 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.

####  pH adjustment

Distilled water has a [pH](http://en.wikipedia.org/wiki/PH) of 7 (neither alkaline nor acidic) and sea water has an average pH of 8.3 (slightly alkaline). If the water is acidic (lower than 7), [lime](http://en.wikipedia.org/wiki/Lime_%28mineral%29), [soda ash](http://en.wikipedia.org/wiki/Soda_ash), or [sodium hydroxide](http://en.wikipedia.org/wiki/Sodium_hydroxide) is added to raise the pH. For somewhat acidic waters (lower than 6.5)[[citation needed](http://en.wikipedia.org/wiki/Wikipedia%3ACitation_needed)], forced draft degasifiers are the cheapest way to raise the pH, as the process raises the pH by stripping dissolved carbon dioxide (carbonic acid) from the water. Lime is commonly used for pH adjustment for municipal water, or at the start of a treatment plant for process water, as it is cheap, but it also increases the ionic load by raising the water hardness. Making the water slightly alkaline ensures that [coagulation](http://en.wikipedia.org/wiki/Coagulation) and [flocculation](http://en.wikipedia.org/wiki/Flocculation) processes work effectively and also helps to minimize the risk of [lead](http://en.wikipedia.org/wiki/Lead) being dissolved from lead pipes and lead [solder](http://en.wikipedia.org/wiki/Solder) in pipe fittings. Acid (HCl or H2SO4) may be added to alkaline waters in some circumstances to lower the pH. Having alkaline water does not necessarily mean that lead or copper from the plumbing system will not be dissolved into the water but as a generality, water with a pH above 7 is much less likely to dissolve [heavy metals](http://en.wikipedia.org/wiki/Heavy_metal_%28chemistry%29) than water with a pH below 7.





[floc](http://en.wikipedia.org/wiki/Flocculation) floating at the surface of a basin





Mechanical system to push floc out of the water basin

### Flocculation

See also: [Alum#Industrial](http://en.wikipedia.org/wiki/Alum#Industrial).

[Flocculation](http://en.wikipedia.org/wiki/Flocculation) is a process which clarifies the water. Clarifying means removing any [turbidity](http://en.wikipedia.org/wiki/Turbidity) or colour so that the water is clear and colourless. Clarification is done by causing a precipitate to form in the water which can be removed using simple physical methods. Initially the precipitate forms as very small particles but as the water is gently stirred, these particles stick together to form bigger particles. Many of the small particles that were originally present in the raw water adsorb onto the surface of these small precipitate particles and so get incorporated into the larger particles that coagulation produces. In this way the coagulated precipitate takes most of the suspended matter out of the water and is then filtered off, generally by passing the mixture through a coarse sand filter or sometimes through a mixture of sand and granulated [anthracite](http://en.wikipedia.org/wiki/Anthracite) (high carbon and low [volatiles](http://en.wikipedia.org/wiki/Volatiles) coal). Coagulants / [flocculating agents](http://en.wikipedia.org/wiki/Flocculants) that may be used include:

1. [Iron (III) hydroxide](http://en.wikipedia.org/wiki/Iron_%28III%29_hydroxide). This is formed by adding a solution of an iron (III) compound such as [iron(III) chloride](http://en.wikipedia.org/wiki/Iron%28III%29_chloride) to pre-treated water with a pH of 7 or greater. Iron (III) hydroxide is extremely insoluble and forms even at a pH as low as 7. Commercial formulations of iron salts were traditionally marketed in the UK under the name Cuprus.
2. [Aluminium hydroxide](http://en.wikipedia.org/wiki/Aluminium_hydroxide) is also widely used as the flocculating precipitate although there have been concerns about possible health impacts and mis-handling led to a [severe poisoning incident](http://en.wikipedia.org/wiki/Camelford_water_pollution_incident) in 1988 at [Camelford](http://en.wikipedia.org/wiki/Camelford) in south-west UK when the coagulant was introduced directly into the holding reservoir of final treated water.
3. [PolyDADMAC](http://en.wikipedia.org/wiki/PolyDADMAC) is an artificially produced [polymer](http://en.wikipedia.org/wiki/Polymer) and is one of a class of synthetic polymers that are now widely used. These polymers have a high molecular weight and form very stable and readily removed [flocs](http://en.wikipedia.org/wiki/Flocs), but tend to be more expensive in use compared to [inorganic](http://en.wikipedia.org/wiki/Inorganic) materials. The materials can also be biodegradable.

###  Sedimentation

Waters exiting the flocculation basin may enter the [sedimentation basin](http://en.wikipedia.org/wiki/Settling_basin), also called a clarifier or settling basin. 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 may be rectangular, where water flows from end to end, or circular where flow is from the centre outward. Sedimentation basin outflow is typically over a [weir](http://en.wikipedia.org/wiki/Weir) so only a thin top layer—that furthest from the sediment—exits. The amount of floc that settles out of the water is dependent on basin retention time and on basin depth. The retention time of the water must therefore be balanced against the cost of a larger basin. The minimum clarifier retention time is 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 collide with and integrate smaller particles as they settle. In effect, large particles sweep vertically through 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 to 5 percent of the total volume of water that is treated. The cost of treating and disposing of the sludge can be a significant part of the operating cost of a water treatment plant. The tank may be equipped with mechanical cleaning devices that continually clean the bottom of the tank or the tank can be taken out of service when the bottom needs to be cleaned.

###  Filtration

After separating most floc, the water is filtered as the final step to remove remaining suspended particles and unsettled floc.

####  Rapid sand filters





Cutaway view of a typical rapid sand filter

The most common type of filter is a [rapid sand filter](http://en.wikipedia.org/wiki/Rapid_sand_filter). Water moves vertically through sand which often has a layer of [activated carbon](http://en.wikipedia.org/wiki/Activated_carbon) or [anthracite coal](http://en.wikipedia.org/wiki/Anthracite_coal) above the sand. The top layer removes organic compounds, which contribute to taste and odour. 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 backflushing or [backwashing](http://en.wikipedia.org/wiki/Backwashing_%28water_treatment%29)) 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 scouring. This contaminated water can be disposed of, along with the sludge from the sedimentation basin, or it can be recycled by mixing with the raw water entering the plant although this is often considered poor practice since it re-introduces an elevated concentration of bacteria into the raw water

Some water treatment plants 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.

Advantages:

* Filters out much smaller particles than paper and sand filters can.
* Filters out virtually all particles larger than their specified pore sizes.
* They are quite thin and so liquids flow through them fairly rapidly.
* They are reasonably strong and so can withstand pressure differences across them of typically 2–5 atmospheres.
* They can be cleaned (back flushed) and reused.

###  Membrane filtration

Membrane filters are widely used for filtering both drinking water and [sewage](http://en.wikipedia.org/wiki/Sewage). For drinking water, membrane filters can remove virtually all particles larger than 0.2 um—including [giardia](http://en.wikipedia.org/wiki/Giardia) and [cryptosporidium](http://en.wikipedia.org/wiki/Cryptosporidium). Membrane filters are an effective form of tertiary treatment when it is desired to reuse the water for industry, for limited domestic purposes, or before discharging the water into a river that is used by towns further downstream. They are widely used in industry, particularly for beverage preparation (including bottled water). However no filtration can remove substances that are actually dissolved in the water such as phosphorus, nitrates and heavy metal ions.

####  Slow sand filters





Slow "artificial" filtration (a variation of [bank filtration](http://en.wikipedia.org/wiki/Bank_filtration)) to the ground, Water purification plant Káraný, Czech Republic

[Slow sand filters](http://en.wikipedia.org/wiki/Slow_sand_filter) may be used where there is sufficient land and space as the water must be passed very slowly through the filters. These filters rely on biological treatment processes for their action rather than physical filtration. The filters are carefully constructed using graded layers of sand with the coarsest sand, along with some gravel, at the bottom and finest sand at the top. Drains at the base convey treated water away for disinfection. Filtration depends on the development of a thin biological layer, called the zoogleal layer or [Schmutzdecke](http://en.wikipedia.org/wiki/Schmutzdecke), on the surface of the filter. An effective slow sand filter may remain in service for many weeks or even months if the pre-treatment is well designed and produces water with a very low available nutrient level which physical methods of treatment rarely achieve. Very low nutrient levels allow water to be safely sent through distribution system with very low disinfectant levels thereby reducing consumer irritation over offensive levels of chlorine and chlorine by-products. Slow sand filters are not backwashed; they are maintained by having the top layer of sand scraped off when flow is eventually obstructed by biological growth.[[citation needed](http://en.wikipedia.org/wiki/Wikipedia%3ACitation_needed)]

A specific 'large-scale' form of slow sand filter is the process of [bank filtration](http://en.wikipedia.org/wiki/Bank_filtration), in which natural sediments in a riverbank are used to provide a first stage of contaminant filtration. While typically not clean enough to be used directly for drinking water, the water gained from the associated extraction wells is much less problematic than river water taken directly from the major streams where bank filtration is often used.

####  Removal of ions and other dissolved substances

[Ultrafiltration](http://en.wikipedia.org/wiki/Ultrafiltration) [membranes](http://en.wikipedia.org/wiki/Artificial_membrane) use polymer membranes with chemically formed microscopic pores that can be used to filter out dissolved substances avoiding the use of coagulants. The type of membrane media determines how much pressure is needed to drive the water through and what sizes of micro-organisms can be filtered out.

[Ion exchange](http://en.wikipedia.org/wiki/Ion_exchange):[[3]](http://en.wikipedia.org/wiki/Water_purification#cite_note-Helfferich-2)[[4]](http://en.wikipedia.org/wiki/Water_purification#cite_note-3)[[5]](http://en.wikipedia.org/wiki/Water_purification#cite_note-4)[[6]](http://en.wikipedia.org/wiki/Water_purification#cite_note-5)[[7]](http://en.wikipedia.org/wiki/Water_purification#cite_note-Zagorodni-6) Ion exchange systems use [ion exchange resin](http://en.wikipedia.org/wiki/Ion_exchange_resin)- or [zeolite](http://en.wikipedia.org/wiki/Zeolite)-packed columns to replace unwanted ions. The most common case is [water softening](http://en.wikipedia.org/wiki/Water_softening) consisting of removal of [Ca2+](http://en.wikipedia.org/wiki/Calcium) and [Mg2+](http://en.wikipedia.org/wiki/Magnesium) [ions](http://en.wikipedia.org/wiki/Ion) replacing them with benign (soap friendly) [Na+](http://en.wikipedia.org/wiki/Sodium) or [K+](http://en.wikipedia.org/wiki/Potassium) ions. Ion exchange resins are also used to remove toxic ions such as [nitrate](http://en.wikipedia.org/wiki/Nitrate), [nitrite](http://en.wikipedia.org/wiki/Nitrite), [lead](http://en.wikipedia.org/wiki/Lead), [mercury](http://en.wikipedia.org/wiki/Mercury_%28element%29), [arsenic](http://en.wikipedia.org/wiki/Arsenic) and many others.

[Electrodeionization](http://en.wikipedia.org/wiki/Electrodeionization):[[7]](http://en.wikipedia.org/wiki/Water_purification#cite_note-Zagorodni-6)[[3]](http://en.wikipedia.org/wiki/Water_purification#cite_note-Helfferich-2) Water is passed between a positive [electrode](http://en.wikipedia.org/wiki/Electrode) and a negative electrode. Ion exchange [membranes](http://en.wikipedia.org/wiki/Membrane_%28selective_barrier%29) allow only positive ions to migrate from the treated water toward the negative electrode and only negative ions toward the positive electrode. High purity deionized water is produced with a little worse degree of purification in comparison with ion exchange treatment. Complete removal of ions from water is regarded as [electrodialysis](http://en.wikipedia.org/wiki/Electrodialysis). The water is often pre-treated with a [reverse osmosis](http://en.wikipedia.org/wiki/Reverse_osmosis) unit to remove non-ionic [organic contaminants](http://en.wikipedia.org/w/index.php?title=Organic_contaminants&action=edit&redlink=1).

####  Other mechanical and biological techniques

See also: [Greywater](http://en.wikipedia.org/wiki/Greywater) and [Ecological sanitation](http://en.wikipedia.org/wiki/Ecological_sanitation).

In addition to the many techniques used in large-scale water treatment, several small-scale, [less (or non)-polluting techniques](http://en.wikipedia.org/wiki/Biofilter) are also being used to treat polluted water. These techniques include those based on mechanical and biological processes. An overview:

* mechanical systems: [sand filtration](http://en.wikipedia.org/wiki/Sand_filter), lava filter systems and systems based on [UV](http://en.wikipedia.org/wiki/UV)-radiation)
* biological systems:
	+ [plant systems](http://en.wikipedia.org/wiki/Biofilter) as [constructed wetlands](http://en.wikipedia.org/wiki/Constructed_wetlands) and [treatment ponds](http://en.wikipedia.org/wiki/Treatment_pond) (sometimes incorrectly called reedbeds and [living walls](http://en.wikipedia.org/wiki/Living_wall)) and
	+ compact systems as [activated sludge systems](http://en.wikipedia.org/wiki/Activated_sludge), [biorotors](http://en.wikipedia.org/wiki/Biorotor), [aerobic biofilters](http://en.wikipedia.org/wiki/Biofilter) and [anaerobic biofilters](http://en.wikipedia.org/wiki/Biofilter), [submerged aerated filters](http://en.wikipedia.org/w/index.php?title=Submerged_aerated_filter&action=edit&redlink=1), and [biorolls](http://en.wikipedia.org/w/index.php?title=Bioroll&action=edit&redlink=1) [[8]](http://en.wikipedia.org/wiki/Water_purification#cite_note-7)

In order to purify the water adequately, several of these systems are usually combined to work as a whole. Combination of the systems is done in two to three stages, namely [primary](http://en.wikipedia.org/w/index.php?title=Primary_water_purification&action=edit&redlink=1) and [secondary purification](http://en.wikipedia.org/w/index.php?title=Secondary_water_purification&action=edit&redlink=1). Sometimes tertiary purification is also added.

###  Disinfection

Disinfection is accomplished both by filtering out harmful microbes and also by adding disinfectant chemicals in the last step in purifying drinking water. Water is disinfected to kill any [pathogens](http://en.wikipedia.org/wiki/Pathogens) which pass through the filters. Possible pathogens include [viruses](http://en.wikipedia.org/wiki/Viruses), [bacteria](http://en.wikipedia.org/wiki/Bacteria), including [Escherichia coli](http://en.wikipedia.org/wiki/Escherichia_coli), [Campylobacter](http://en.wikipedia.org/wiki/Campylobacter) and [Shigella](http://en.wikipedia.org/wiki/Shigella), and [protozoa](http://en.wikipedia.org/wiki/Protozoa), including [Giardia lamblia](http://en.wikipedia.org/wiki/Giardia_lamblia) and other [cryptosporidia](http://en.wikipedia.org/wiki/Cryptosporidia). In most developed countries, public water supplies are required to maintain a residual disinfecting agent throughout the distribution system, in which water may remain for days 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.

####  Chlorine disinfection

Main article: [Chlorination](http://en.wikipedia.org/wiki/Chlorination)

The most common disinfection method involves some form of [chlorine](http://en.wikipedia.org/wiki/Chlorine) or its compounds such as [chloramine](http://en.wikipedia.org/wiki/Chloramine) or [chlorine dioxide](http://en.wikipedia.org/wiki/Chlorine_dioxide). Chlorine is a strong [oxidant](http://en.wikipedia.org/wiki/Oxidizer) that rapidly kills many harmful 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](http://en.wikipedia.org/wiki/Sodium_hypochlorite), which is a relatively inexpensive solution that releases free chlorine when dissolved in water. Chlorine solutions can be generated on site by electrolyzing common salt solutions. A solid form, [calcium hypochlorite](http://en.wikipedia.org/wiki/Calcium_hypochlorite) exists that releases chlorine on contact with water. Handling the solid, however, requires greater routine human contact through opening bags and pouring than the use of gas cylinders or bleach which are more easily automated. The generation of liquid sodium hypochlorite is both inexpensive and safer than the use of gas or solid chlorine. All forms of chlorine are widely used despite their respective drawbacks. One drawback is that chlorine from any source reacts with natural organic compounds in the water to form potentially harmful chemical by-products [trihalomethanes](http://en.wikipedia.org/wiki/Trihalomethane) (THMs) and [haloacetic acids](http://en.wikipedia.org/wiki/Haloacetic_acid) (HAAs), both of which are [carcinogenic](http://en.wikipedia.org/wiki/Carcinogenic) in large quantities and regulated by the [United States Environmental Protection Agency](http://en.wikipedia.org/wiki/United_States_Environmental_Protection_Agency) (EPA) and the [Drinking Water Inspectorate](http://en.wikipedia.org/wiki/Drinking_Water_Inspectorate) in the UK. The formation of THMs and haloacetic acids may be minimized by effective removal of as many organics from the water as possible prior to chlorine addition. Although chlorine is effective in killing bacteria, it has limited effectiveness against protozoa that form cysts in water ([Giardia lamblia](http://en.wikipedia.org/wiki/Giardia_lamblia) and [Cryptosporidium](http://en.wikipedia.org/wiki/Cryptosporidium), both of which are pathogenic).

###  Chlorine dioxide disinfection

[Chlorine dioxide](http://en.wikipedia.org/wiki/Chlorine_dioxide) is a faster-acting disinfectant than elemental chlorine, however it is relatively rarely used, because in some circumstances it may create excessive amounts of chlorite, which is a by-product regulated to low allowable levels in the United States. Chlorine dioxide is supplied as an aqueous solution and added to water to avoid gas handling problems; chlorine dioxide gas accumulations may spontaneously detonate.

###  Chloramine disinfection

The use of chloramine is becoming more common as a disinfectant. Although chloramine is not as strong an oxidant, it does provide a longer-lasting residual than free chlorine and it won't form THMs or haloacetic acids. It is possible to convert chlorine to chloramine by adding ammonia to the water after addition of chlorine. The chlorine and ammonia react to form chloramine. Water distribution systems disinfected with chloramines may experience [nitrification](http://en.wikipedia.org/wiki/Nitrification), as ammonia is a nutrient for bacterial growth, with nitrates being generated as a by-product.

####  Ozone disinfection

[O3](http://en.wikipedia.org/wiki/Ozone) is an unstable molecule which readily gives up one atom of oxygen providing a powerful oxidizing agent which is toxic to most waterborne organisms. It is a very strong, broad spectrum disinfectant that is widely used in Europe. It is an effective method to inactivate harmful protozoa 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 fewer dangerous by-products (in comparison to [chlorination](http://en.wikipedia.org/wiki/Chlorination)) and the lack of taste and odour produced by [ozonisation](http://en.wikipedia.org/w/index.php?title=Ozonisation&action=edit&redlink=1). 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](http://en.wikipedia.org/wiki/Bromate), although little [bromine](http://en.wikipedia.org/wiki/Bromine) should be present in treated water. Another 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](http://en.wikipedia.org/wiki/Nice), France. The U.S. Food and Drug Administration has accepted ozone as being safe; and it is applied as an anti-microbiological agent for the treatment, storage, and processing of foods.

####  Ultraviolet disinfection

[Ultraviolet light](http://en.wikipedia.org/wiki/Ultraviolet_germicidal_irradiation) is very effective at inactivating cysts, in low turbidity water. UV light's disinfection effectiveness decreases as turbidity increases, a result of the [absorption](http://en.wikipedia.org/wiki/Absorption_%28electromagnetic_radiation%29), [scattering](http://en.wikipedia.org/wiki/Scattering), and shadowing caused by the suspended solids. The main disadvantage to the use of UV radiation is that, like ozone treatment, it leaves no residual disinfectant in the water; therefore, it is sometimes necessary to add a residual disinfectant after the primary disinfection process. 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 few of the negative aspects of chlorination.

####  Hydrogen peroxide disinfection

Works in a similar way to ozone. Activators such as [formic acid](http://en.wikipedia.org/wiki/Formic_acid) are often added to increase the efficacy of disinfection. It has the disadvantages that it is slow-working, [phytotoxic](http://en.wikipedia.org/wiki/Phytotoxic) in high dosage, and decreases the pH of the water it purifies.

####  Various portable methods of disinfection

Available for disinfection in emergencies or in remote locations. Disinfection is the primary goal, since aesthetic considerations such as taste, odor, appearance, and trace chemical contamination do not affect the short-term safety of drinking water.

####  Solar water disinfection

One low-cost method of disinfecting water that can often be implemented with locally available materials is [solar disinfection](http://en.wikipedia.org/wiki/Solar_disinfection) (SODIS).[[9]](http://en.wikipedia.org/wiki/Water_purification#cite_note-8)[[10]](http://en.wikipedia.org/wiki/Water_purification#cite_note-9)[[11]](http://en.wikipedia.org/wiki/Water_purification#cite_note-10)[[12]](http://en.wikipedia.org/wiki/Water_purification#cite_note-11) Unlike methods that rely on [firewood](http://en.wikipedia.org/wiki/Firewood), it has low impact on the environment.

One recent study has found that the wild Salmonella which would reproduce quickly during subsequent dark storage of solar-disinfected water could be controlled by the addition of just 10 parts per million of [hydrogen peroxide](http://en.wikipedia.org/wiki/Hydrogen_peroxide).[[13](http://en.wikipedia.org/wiki/Water_purification#cite_note-12)

## Other water purification techniques

Other popular methods for purifying water, especially for local private supplies are listed below. In some countries some of these methods are also used for large scale municipal supplies. Particularly important are distillation (de-salination of seawater) and reverse osmosis.

1. [Boiling](http://en.wikipedia.org/wiki/Boiling): Water is heated hot enough and long enough to inactivate or kill [micro-organisms](http://en.wikipedia.org/wiki/Micro-organism) that normally live in water at room temperature. Near sea level, a vigorous rolling boil for at least one minute is sufficient. At high altitudes (greater than two kilometres or 5000 feet) three minutes is recommended.[[17]](http://en.wikipedia.org/wiki/Water_purification#cite_note-16) In areas where the water is "hard" (that is, containing significant dissolved calcium salts), boiling decomposes the [bicarbonate](http://en.wikipedia.org/wiki/Bicarbonate) ions, resulting in partial precipitation as [calcium carbonate](http://en.wikipedia.org/wiki/Calcium_carbonate). This is the "fur" that builds up on kettle elements, etc., in hard water areas. With the exception of calcium, boiling does not remove solutes of higher boiling point than water and in fact increases their concentration (due to some water being lost as vapour). Boiling does not leave a residual disinfectant in the water. Therefore, water that has been boiled and then stored for any length of time may have acquired new pathogens.
2. Granular Activated Carbon filtering: a form of [activated carbon](http://en.wikipedia.org/wiki/Activated_carbon) with a high surface area, adsorbs many compounds including many toxic compounds. Water passing through [activated carbon](http://en.wikipedia.org/wiki/Activated_carbon) is commonly used in municipal regions with organic contamination, taste or odors. Many household water filters and fish tanks use activated carbon filters to further purify the water. Household filters for drinking water sometimes contain [silver](http://en.wikipedia.org/wiki/Silver) as metallic silver nanoparticle. If water is held in the carbon block for longer period, microorganisms can grow inside which results in fouling and contamination. Silver nanoparticles are excellent anti-bacterial material and they can decompose toxic halo-organic compounds such as pesticides into non-toxic organic products.[[18]](http://en.wikipedia.org/wiki/Water_purification#cite_note-17)
3. [Distillation](http://en.wikipedia.org/wiki/Distillation) involves boiling the water to produce water [vapour](http://en.wikipedia.org/wiki/Vapour). The vapour contacts a cool surface where it condenses as a liquid. Because the solutes are not normally vaporised, they remain in the boiling solution. Even distillation does not completely purify water, because of contaminants with similar boiling points and droplets of unvapourised liquid carried with the steam. However, 99.9% pure water can be obtained by distillation.
4. [Reverse osmosis](http://en.wikipedia.org/wiki/Reverse_osmosis): Mechanical pressure is applied to an impure solution to force pure water through a [semi-permeable membrane](http://en.wikipedia.org/wiki/Semi-permeable_membrane). Reverse osmosis is theoretically the most thorough method of large scale water purification available, although perfect semi-permeable membranes are difficult to create. Unless membranes are well-maintained, [algae](http://en.wikipedia.org/wiki/Algae) and other life forms can colonize the membranes.
5. The use of iron in removing arsenic from water. See [Arsenic contamination of groundwater](http://en.wikipedia.org/wiki/Arsenic_contamination_of_groundwater).
6. Direct contact membrane distillation (DCMD). Applicable to desalination. Heated seawater is passed along the surface of a [hydrophobic](http://en.wikipedia.org/wiki/Hydrophobic) [polymer](http://en.wikipedia.org/wiki/Polymer) membrane. Evaporated water passes from the hot side through pores in the membrane into a stream of cold pure water on the other side. The difference in vapour pressure between the hot and cold side helps to push water molecules through.
7. Gas hydrate crystals centrifuge method. If carbon dioxide gas is mixed with contaminated water at high pressure and low temperature, gas hydrate crystals will contain only clean water. This is because the water molecules bind to the gas molecules at molecular level. The contaminated water is in liquid form. A centrifuge may be used to separate the crystals and the concentrated contaminated water.
8. [In Situ Chemical Oxidation](http://en.wikipedia.org/wiki/In_situ_oxidation) , a form of advanced oxidation processes and advanced oxidation technology, is an environmental remediation technique used for soil and/or groundwater remediation to reduce the concentrations of targeted environmental contaminants to acceptable levels. ISCO is accomplished by injecting or otherwise introducing strong chemical oxidizers directly into the contaminated medium (soil or groundwater) to destroy chemical contaminants in place. It can be used to remediate a variety of organic compounds, including some that are resistant to natural degradation.

# Water softening

From Wikipedia, the free encyclopedia

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Water softening is the reduction of the concentration of [calcium](http://en.wikipedia.org/wiki/Calcium), [magnesium](http://en.wikipedia.org/wiki/Magnesium), and other [ions](http://en.wikipedia.org/wiki/Ion) in [hard water](http://en.wikipedia.org/wiki/Hard_water). These "hardness ions" can cause a variety of undesired effects including interfering with the action of [soaps](http://en.wikipedia.org/wiki/Soap), the build up of [limescale](http://en.wikipedia.org/wiki/Limescale), which can foul [plumbing](http://en.wikipedia.org/wiki/Plumbing), and [galvanic corrosion](http://en.wikipedia.org/wiki/Galvanic_corrosion).[[1]](http://en.wikipedia.org/wiki/Water_softening#cite_note-0) Conventional water-softening appliances intended for household use depend on an [ion-exchange resin](http://en.wikipedia.org/wiki/Ion-exchange_resin) in which hardness ions are exchanged for [sodium](http://en.wikipedia.org/wiki/Sodium) ions. [Water](http://en.wikipedia.org/wiki/Water) softening may be desirable where the source of water is hard.[[2]](http://en.wikipedia.org/wiki/Water_softening#cite_note-CMHC-1) However, hard water also conveys some benefits to health by providing dietary calcium and magnesium and reducing the solubility of potentially toxic metal ions such as [lead](http://en.wikipedia.org/wiki/Lead) and [copper](http://en.wikipedia.org/wiki/Copper)[[3]](http://en.wikipedia.org/wiki/Water_softening#cite_note-2).

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##  Methods for water softening

Water softening methods mainly rely on the removal of Ca2+ and Mg2+ from a solution or the sequestration of these ions, i.e. binding them to a molecule that removes their ability to form scale or interfere with detergents. Removal is achieved by ion exchange and by precipitation methods. Sequestration entails the addition of chemical compounds called sequestration (or chelating) agents.

Since Ca2+ and Mg2+ exist as nonvolatile salts, they can be removed by distilling the water, but [distillation](http://en.wikipedia.org/wiki/Distillation) is too expensive in most cases (rainwater is soft because it is, in effect, distilled).

###  Ion-exchange resin devices

Ion-exchange materials contain sodium ions (Na+) that are electrostatically bound and that readily are replaced by hardness ions such as Ca2+ and Mg2+. Ion exchange resins are [organic polymers](http://en.wikipedia.org/wiki/Organic_polymer) containing [anionic](http://en.wikipedia.org/wiki/Anionic) functional groups to which the Na+ is bound. Minerals called [zeolites](http://en.wikipedia.org/wiki/Zeolites) also exhibit ion-exchange properties; these minerals are widely used in [laundry detergents](http://en.wikipedia.org/wiki/Laundry_detergent).

####  How it works

 [Ion chromatography](http://en.wikipedia.org/wiki/Ion_chromatography)

The water to be treated passes through a bed of the resin. Negatively-charged resins absorb and bind metal ions, which are positively charged. The resins initially contain [univalent](http://en.wikipedia.org/wiki/Univalent) (1+) ions, most commonly [sodium](http://en.wikipedia.org/wiki/Sodium), but sometimes also [hydrogen](http://en.wikipedia.org/wiki/Hydrogen) (H+) or [potassium](http://en.wikipedia.org/wiki/Potassium) (K+). [Divalent](http://en.wikipedia.org/wiki/Divalent) calcium and magnesium ions in the water replace these univalent ions, which are released into the water. The "harder" the water, the more hydrogen, sodium or potassium ions are released from the resin and into the water.

Resins are also available to remove carbonate, bi-carbonate and sulphate ions which are absorbed and hydroxyl ions released from the resin. Both types of resin may be provided in a single water softener.

###  Regeneration

The resin's capacity is gradually exhausted and eventually it contains only divalent ions, Mg2+ and Ca2+ for cation exchange resins, and SO42- for anion exchange resins. At this stage, the resin must be regenerated. If a cationic resin is used (to remove calcium and magnesium ions) then regeneration is usually effected by passing a concentrated brine, usually of [sodium chloride](http://en.wikipedia.org/wiki/Sodium_chloride) or [potassium chloride](http://en.wikipedia.org/wiki/Potassium_chloride), or hydrochloric acid solution through them. For anionic resins, regeneration typically uses a solution of sodium hydroxide ([lye](http://en.wikipedia.org/wiki/Lye)) or potassium hydroxide. The salts used for regeneration are released into the soil or sewer.

In industrial scale water softening plants, the effluent flow from re-generation process can precipitate scale that can interfere with sewerage systems.

Chelators are used in [chemical analysis](http://en.wikipedia.org/wiki/Chemical_analysis), as water softeners, and are ingredients in many commercial products such as [shampoos](http://en.wikipedia.org/wiki/Shampoos) and food [preservatives](http://en.wikipedia.org/wiki/Preservative). [Citric acid](http://en.wikipedia.org/wiki/Citric_acid) is used to [soften water](http://en.wikipedia.org/wiki/Citric_acid#Water_softening) in soaps and [laundry detergents](http://en.wikipedia.org/wiki/Laundry_detergent). A commonly used synthetic chelator is [EDTA](http://en.wikipedia.org/wiki/EDTA).

# Water Softeners

Water is often called the universal solvent, though people with hard water problems would hardly agree. Too bad water doesn’t come with instructions.

When it hits the ground, rain interacts with vegetation, top soil, and bedrock, dissolving whatever is soluble and finally ends up in our lakes, rivers, streams and ground water. Of the soluble minerals that end up suspended in the water calcium, magnesium and iron are three that can make our water “hard.”



Hard water causes soaps and detergents to lose some effectiveness. The mineral salts react with soap to form an insoluble mix that can lead to coagulated curd and a film or scum. Soap in suspension does nothing to clean your clothing but just gives you something more to clean including bathtub rings, spots on dishes, etc.

Fear not homeowners, there is zeolite to the rescue! Zeolites are minerals that are microporous cage-like molecules. Theses cages are interconnected forming a framework with many cavities and channels. The zeolite pictured here is the main ingredient in a water softener and is also called resin. A typical water softener is a mechanical device that is plumbed into your home's water supply system. All water softeners use the same operating principle, trading minerals in a process called “ion exchange.” The zeolite/resin carries a negative charge and the offending minerals carry a positive charge. The positive charged mineral ions exchange places with the weaker positively charged sodium ions and are held fast in the zeolite until they themselves are knocked off during the recharge cycle. After recharging, the zeolite is cleaned of the bad minerals and reunited with its slightly positive friend the sodium ion and ready to attract more minerals in the water stream.

The essential part of a water softener is the mineral tank that holds the negatively charged resin/zeolite beads. Calcium, magnesium and sodium (the minerals that make your water hard) carry positive charges with sodium holding the weaker charge of the three.



Zeolite

As the water moves through the tank, the minerals will displace the weaker charged sodium ions and become entrapped in the zeolite. If all is working correctly, after the zeolite bed is completely saturated, the unit will recharge itself with a strong brine (salt) solution. The force and strength of the solution knocks the minerals off the beads and reseats the sodium ions back into the zeolite beads.

The recharging of the mineral tank is dependent on the type of softener you have and will activate on either a preset amount of time or amount of flow

# Plumbing fixture

A **plumbing fixture** is a device which is part of a [system](http://en.wikipedia.org/wiki/System) to deliver and drain away water, but which is also configured to enable a particular use.

The most common plumbing fixtures are:

* [Bathtubs](http://en.wikipedia.org/wiki/Bathtub)
* [Bidets](http://en.wikipedia.org/wiki/Bidet)
* [Channel Drains](http://en.wikipedia.org/wiki/Trench_drain) (also called trench drains)
* [Drinking fountains](http://en.wikipedia.org/wiki/Drinking_fountain)
* [Hose bibbs](http://en.wikipedia.org/w/index.php?title=Hose_bibbs&action=edit&redlink=1) (connections for water [hoses](http://en.wikipedia.org/wiki/Hose_%28tubing%29))
* [Kitchen sinks](http://en.wikipedia.org/wiki/Kitchen_sink)
* Lavatories (also called bathroom sinks)
* [Showers](http://en.wikipedia.org/wiki/Shower)
* Tapware - an industry term for that sub-category of plumbing fixtures consisting of [tap valves](http://en.wikipedia.org/wiki/Tap_%28valve%29), also called water taps (British English) or [faucets](http://en.wikipedia.org/wiki/Faucet) (American English), and their accessories, such as water spouts and [shower](http://en.wikipedia.org/wiki/Shower) heads.
* Terminal [valves](http://en.wikipedia.org/wiki/Valve) for dishwashers, ice makers, humidifiers, etc.
* [Urinals](http://en.wikipedia.org/wiki/Urinal_%28restroom%29)
* Utility sinks
* Water closets ([WC](http://en.wikipedia.org/wiki/WC)) (known as [toilets](http://en.wikipedia.org/wiki/Toilet) in the USA, loos, [flush toilets](http://en.wikipedia.org/wiki/Flush_toilet) or lavatories in Britain)

A **bath** is a large container for holding water in which a person may [bathe](http://en.wikipedia.org/wiki/Bathing) (take a bath). Most modern bathtubs are made of [acrylic](http://en.wikipedia.org/wiki/Acrylic_glass) or [fiberglass](http://en.wikipedia.org/wiki/Fiberglass), but alternatives are available in [enamel](http://en.wikipedia.org/wiki/Vitreous_enamel) over [steel](http://en.wikipedia.org/wiki/Steel) or [cast iron](http://en.wikipedia.org/wiki/Cast_iron), and occasionally waterproof finished wood. A bathtub is usually placed in a [bathroom](http://en.wikipedia.org/wiki/Bathroom) either as a stand-alone fixture or in conjunction with a [shower](http://en.wikipedia.org/wiki/Shower).

Modern bathtubs have overflow and waste drains and may have [taps](http://en.wikipedia.org/wiki/Tap_%28valve%29) mounted on them. They may be built-in or free standing or sometimes sunken. Until recently, most bathtubs were roughly rectangular in shape but with the advent of acrylic [thermoformed](http://en.wikipedia.org/wiki/Thermoforming) baths, more shapes are becoming available. Bathtubs are commonly white in colour although many other colours can be found. The process for enamelling cast iron bathtubs was invented by the Scottish-born American [David Dunbar Buick](http://en.wikipedia.org/wiki/David_Dunbar_Buick).

Two main styles of bathtub are common:

* Western-style bathtubs in which the bather lies down. These baths are typically shallow and long.
* Eastern style bathtubs in which the bather stands up. These are known as [ofuro](http://en.wikipedia.org/wiki/Ofuro) in Japan and are typically short and deep
* Bidets are primarily used to [wash and clean](http://en.wikipedia.org/wiki/Hygiene) the genitalia, [perineum](http://en.wikipedia.org/wiki/Perineum), inner buttocks, and anus. They may also be used to clean any other part of the [body](http://en.wikipedia.org/wiki/Human_body); they are very convenient for cleaning shaven heads, for example. Despite appearing similar to a [toilet](http://en.wikipedia.org/wiki/Toilet), it would be more accurate to compare it to the [washbasin](http://en.wikipedia.org/wiki/Washbasin) or [bathtub](http://en.wikipedia.org/wiki/Bathtub).

A **trench drain** (also **channel drain**, **line drain** , **slot drain** , **linear drain** or **strip drain**) is a specific type of [floor drain](http://en.wikipedia.org/wiki/Floor_drain) containing a dominant through- or channel-shaped body. It is used for the rapid evacuation of surface water or for the containment of utility lines or chemical spills.

## Splash fountains





International Fountain in [Seattle](http://en.wikipedia.org/wiki/Seattle), United States was designed specifically as a bathing fountain and includes a large nonslip play area, with speakers for music.

A [splash fountain](http://en.wikipedia.org/wiki/Splash_pad) or [bathing](http://en.wikipedia.org/wiki/Bathing) fountain is intended for people to come in and cool off on hot summer days. These fountains are designed to allow easy access, and feature nonslip surfaces, and have no standing water, to eliminate possible drowning hazards, so that no lifeguards or supervision is required.

## Drinking fountains





A sensor based automated drinking fountain

A water fountain or drinking fountain is designed to provide drinking water and has a basin arrangement with either continuously running water or a [tap](http://en.wikipedia.org/wiki/Tap_%28valve%29). The drinker bends down to the stream of water and swallows water directly from the stream



A **hose** is a hollow [tube](http://en.wikipedia.org/wiki/Tubing_%28material%29) designed to carry [fluids](http://en.wikipedia.org/wiki/Fluid) from one location to another. Hoses are also sometimes called [pipes](http://en.wikipedia.org/wiki/Pipe_%28material%29) (the word pipe usually refers to a rigid tube, whereas a hose is usually a flexible one), or more generally [tubing](http://en.wikipedia.org/wiki/Tubing_%28material%29). The shape of a hose is usually [cylindrical](http://en.wikipedia.org/wiki/Cylinder_%28geometry%29) (having a [circular](http://en.wikipedia.org/wiki/Circle) [cross section](http://en.wikipedia.org/wiki/Cross_section_%28geometry%29)).

Hose design is based on a combination of application and performance. Common factors are Size, Pressure Rating, Weight, Length, Straight hose or Coilhose and Chemical Compatabiltiy.



In [plumbing](http://en.wikipedia.org/wiki/Plumbing), a **sink** or **basin** is a bowl-shaped [fixture](http://en.wikipedia.org/wiki/Plumbing_fixture) that is used for washing [hands](http://en.wikipedia.org/wiki/Hands) or small objects.

Sinks generally have [taps](http://en.wikipedia.org/wiki/Tap_%28valve%29) (faucets) that supply hot and cold water and may include a spray feature to be used for faster rinsing. They also include a drain to remove used water; this drain may itself include a strainer and/or shut-off device and an overflow-prevention device. Sinks may also have an integrated [soap](http://en.wikipedia.org/wiki/Soap) dispenser.

When a sink becomes stopped-up or clogged, a person will often resort to use a chemical [drain cleaner](http://en.wikipedia.org/wiki/Drain_cleaner) or a [plunger](http://en.wikipedia.org/wiki/Plunger), though most professional plumbers will attack the clog with a drain auger (often called a "[plumber's snake](http://en.wikipedia.org/wiki/Plumber%27s_snake)").

 Types of showers

* [Air shower](http://en.wikipedia.org/wiki/Air_shower_%28room%29), a type of bathing where high pressure air is used to blow off excess dust particles from cleanroom personnel.
* [Electric shower](http://en.wikipedia.org/wiki/Electric_shower), a shower stall device to locally heat shower water with electrical power.
* [Field shower](http://en.wikipedia.org/wiki/Field_shower)
* [Navy shower](http://en.wikipedia.org/wiki/Navy_shower), a method of showering that allows for significant conservation of water and energy.
* Power shower, a shower stall device to locally increase the water pressure available to the shower head by means of an electric pump.
* [Steam shower](http://en.wikipedia.org/wiki/Steam_shower), a type of bathing where a humidifying steam generator produces steam that is dispersed around a person's body.
* [Vichy shower](http://en.wikipedia.org/wiki/Vichy_shower), a shower where large quantities of warm water are poured over a spa patron while the user lies within a shallow (wet) bed, similar to a massage table, but with drainage for the water.
* [Roman shower](http://en.wikipedia.org/wiki/Roman_shower) an architecturally designed type of shower that does not require a door or curtain.
* Emergency showers are installed in [laboratories](http://en.wikipedia.org/wiki/Laboratories) and other facilities that use hazardous chemicals, and are required by law in the United States.[[10]](http://en.wikipedia.org/wiki/Shower#cite_note-9) Emergency showers are designed to deluge continuously at around 30-60 [gallons per minute](http://en.wikipedia.org/wiki/Gallons_per_minute)[[11]](http://en.wikipedia.org/wiki/Shower#cite_note-FOOTNOTEMayer1995155-10) for at least 15 minutes,[[12]](http://en.wikipedia.org/wiki/Shower#cite_note-FOOTNOTEVincoli2000343-11) and should be located at most 10 seconds away from potential users



* A **tap** (also called **spigot** and **faucet** in the [U.S.](http://en.wikipedia.org/wiki/United_States)) is a [valve](http://en.wikipedia.org/wiki/Valve) controlling release of [liquids](http://en.wikipedia.org/wiki/Liquid) or [gas](http://en.wikipedia.org/wiki/Gas). In the [British Isles](http://en.wikipedia.org/wiki/British_Isles) and most of the [Commonwealth](http://en.wikipedia.org/wiki/Commonwealth), the word is used for any everyday type of valve, particularly the fittings that control water supply to [bathtubs](http://en.wikipedia.org/wiki/Bathtub) and [sinks](http://en.wikipedia.org/wiki/Sink). In the U.S., the term "tap" is more often used for [beer taps](http://en.wikipedia.org/wiki/Beer_tap), cut-in connections, or [wiretapping](http://en.wikipedia.org/wiki/Wiretapping). "Spigot" or "faucet" are more often used to refer to water valves, although this sense of "tap" is not uncommon, and the term "[tap water](http://en.wikipedia.org/wiki/Tap_water)" is the standard name for water from the faucet.



A **valve** is a device that regulates, directs or controls the [flow](http://en.wikipedia.org/wiki/Fluid_dynamics) of a [fluid](http://en.wikipedia.org/wiki/Fluid) ([gases](http://en.wikipedia.org/wiki/Gas), [liquids](http://en.wikipedia.org/wiki/Liquid), [fluidized](http://en.wikipedia.org/wiki/Fluidize) [solids](http://en.wikipedia.org/wiki/Solid), or [slurries](http://en.wikipedia.org/wiki/Slurries)) by opening, closing, or partially obstructing various passageways. Valves are technically [pipe](http://en.wikipedia.org/wiki/Piping) [fittings](http://en.wikipedia.org/wiki/Piping_and_plumbing_fittings), but are usually discussed as a separate category. In an open valve, fluid flows in a direction from higher pressure to lower pressure.



A **urinal** is a specialized [toilet](http://en.wikipedia.org/wiki/Toilet) for [urinating](http://en.wikipedia.org/wiki/Urination) into. It has the form of a container or simply a wall, with drainage and automatic or manual flushing.

Whilst generally intended for use by males, it is also possible for females to use urinals. The different types of male urinal, for single or multiple users in trough style designs, are intended to be utilised from a standing position. Female urinal design have adopted various approaches - some intending the user to "hover" over the unit, facing away from it, others intending the user to face the urinal, with or without a [female urination device](http://en.wikipedia.org/wiki/Female_urination_device). Whilst uncommon due to restroom designations, it is possible for females to use male urinals[[1]](http://en.wikipedia.org/wiki/Urinal_%28restroom%29#cite_note-restroomsdotorg-0) (and vice versa).

Flush toilet



A **flush toilet** is a [toilet](http://en.wikipedia.org/wiki/Toilet) that disposes of human waste by using water to flush it through a drainpipe to another location. Flushing mechanisms are found more often on western toilets (used in the sitting position), but many [squat toilets](http://en.wikipedia.org/wiki/Squat_toilets) also are made for automated flushing.[[1]](http://en.wikipedia.org/wiki/Flush_toilet#cite_note-0) Modern toilets incorporate an 'S','U', 'J', or 'P' shaped bend that causes the water in the toilet bowl to collect and act as a seal against sewer gases. Since flush toilets are typically not designed to handle waste on site, their drain pipes must be connected to waste conveyance and [waste treatment](http://en.wikipedia.org/wiki/Waste_treatment) systems. Flush toilets were once called water closets in the 18th, 19th and 20th centuries.

## Outlets and drains





A bathtub drain.

Each of these plumbing fixtures has one or more [water](http://en.wikipedia.org/wiki/Water) outlets and a [drain](http://en.wikipedia.org/wiki/Drain_%28plumbing%29). In some cases, the drain has a device that can be manipulated to block the drain to fill the basin of the fixture. Each fixture also has a flood rim, or level at which water will begin to overflow. Most fixtures also have an overflow, which is a conduit for water to drain away, when the regular drain is plugged, before the water actually overflows at the flood rim level. However, water closets and showers (that are not in bathtubs) usually lack this feature because their drains normally cannot be stopped

### Traps and vents





This drain cover has a container underneath (which can be taken out for cleaning and revealing another container below) acting as a trap. Water inside the container forms a seal when the cover is in place. Positive air pressure will push the cover up, acting as an early warning device. The underside of the cover (centre image) is kept moist by condensation occurring and insects that go back up the drain pipe get stuck to the walls of the cover.

All plumbing fixtures have [traps](http://en.wikipedia.org/wiki/Trap_%28plumbing%29) in their drains; these traps are either internal or external to the fixtures. Traps are pipes which curve down then back up; they 'trap' a small amount of water to create a [water seal](http://en.wikipedia.org/wiki/Water_seal_%28plumbing%29) between the ambient air space and the inside of the [drain system](http://en.wikipedia.org/wiki/Plumbing_drainage_venting). This prevents [sewer gas](http://en.wikipedia.org/wiki/Sewer_gas) from entering buildings.

Most water closets, bidets, and many urinals have the trap integral with the fixture itself. The visible water surface in a toilet is the top of the trap's water seal.

## Electronic plumbing





Sensor operated plumbing fixtures have fewer moving parts, and therefore outlast traditional manual flush fixtures. Additionally, they reduce water consumption by way of intelligent flushing schedules (fuzzy logic) that determines the quantity of each flush based on how many people are standing in line to use the fixture.





One of several wall-mounted sensors installed in a shower room, to control the shower nozzle above it.

In public facilities, the trend is toward sensor-operated fixtures that improve hygiene and save money. For example, sensor operated automatic-flush urinals have fewer moving parts, reduce wear, and tend to last longer than manual-flush valves. Also they ensure fixtures are flushed only once per use. Some contain intelligence that flushes them at different amounts of water flow depending on traffic patterns: e.g., the fixture can detect a lineup of users and only give a full flush after the last person has used the urinal.

Automatic flush compensates for users who do not bother to flush. Also, since the fixtures are always flushed, there is no need for a [urinal cake](http://en.wikipedia.org/wiki/Urinal_cake), or other odor reduction. Sensor-operated toilets also have automatic flush. Sensor-operated faucets and showers save water. For example, while a user is lathering up with soap, the fixture shuts off and then resumes when the user needs it to. Sensor-operated soap and shampoo dispensers reduce waste and spills that

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| Traps - Types and Uses |   |
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| A trap is a device which is used to prevent sewer gases from entering the buildings. The traps are located below or within a plumbing fixture and retains small amount of water. The retaining water creates a water seal which stops foul gases going back to the building from drain pipes. Therefore all plumbing fixtures such as sinks, washbasins, bathtubs and toilets etc. are equipped with traps. This article tells you the features of traps, various types of traps and water seal.    A trap has following features. * It may be manufactured as an integral trap with the appliance as in some models of European WC, or it may be a separate fitting called an attached trap, which is connected to waste or foul water outlet of appliances.
* The traps should be of a self-cleansing pattern.
* Traps for use in domestic waste should be convenient for cleaning.
* A good trap should maintain an efficient water seal under all conditions of flow.

****Various Types of Traps****

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| 1. Gully Trap:These traps are constructed outside the building to carry waste water discharge from washbasin, sinks, bathroom etc. and are connected to the nearest building drain/sewer so that foul gases from sewer do not come to the house. These are deep seal traps, the depth of water seal should be 50 mm minimum. It also prevents the entry of cockroach and other insects from sewer line to waste pipes carrying waste water. Plumbing trap**(Gully Trap)** | 2. P. Trap:This trap is used with Indian water closet (ORISSA Pattern). The traps are made from cast iron or UPV sheet. This trap also has water seal and prevents entry of foul gases to the house.   Drain traps**(P Trap)** |
| 3. S. Trap:This trap is similar to P. trap and is used for fixing water closets in toilets. The only difference between P trap and S trap is that P. trap is used for outlet through the wall whereas S. trap is used for outlet through the floor. plumbing trap |  Drainage trap**(S Trap)**4. Floor Trap or Nahini Trap:This trap is provided in the floor to collect waste water from washbasin, shower, sink and bathroom etc. These are available in cast iron or UPVC material and have removable grating (JALI) on the top of the trap. The minimum depth of water seal should be 50 mm.  |

5. Intercepting Trap:this trap is provided at the last main hole of building sewerage to prevent entry of foul gases from public sewer to building sewer. It has a deep-water seal of 100 mm. 6. Grease Trap:this trap is a device to collect the grease contents of waste and can be cleaned from the surface. This is generally used in food processing unit. Drainage traps(This picture is contributed by"S.Krishnan")7. Bottle Trap:This trap is used below washbasin and sinks to prevent entry of foul gases. plumbing bottle trap(This picture is contributed by "S.Krishnan")8. Q Trap:This trap is used in toilet under water closet. It is almost similar to S trap and is used in upper storey other than ground floor. Water SealWater seal in a trap is the depth of water which should be removed from a fully charge trap before gases at atmospheric pressure may pass from the waste pipe through trap into a building. The tape is useless unless they retain their seals at all times. The seal may be broken due to air compressor, momentum and evaporation. The trap in fittings in range is liable to siphonic action and each trap should be ventilated.    water seal in trap(This Picture is contributed by "S.Krishnan")The depth of water seal in various sanitary appliances is given below.• Water closet 50 mm• Floor trap 50 mm Other fixtures are directly connected to the stack through branch waste pipe of diameter = 75 mm and 40 mm• Hand-pour flushed type 20 mm |

## Flushing mechanism

The flushing mechanism provides a large flow of water into the bowl (which is described later in this article). The mechanism usually incorporates one or more parts of the following designs:

###  Tank fill valve





The Ballcock or Float Valve is often used to regulate the filling of a tank or cistern. When the fluid level drops, the float descends, levering the valve opening and allowing more fluid to enter. Once the float reached the 'full' position, the arm presses the valve shut again.

Tank fill [valves](http://en.wikipedia.org/wiki/Valves) are found in all tank-style toilets. The valves are of two main designs: the side-float design and the concentric-float design. The side-float design has existed for over a hundred years. The concentric-design has only existed since 1957, but is gradually becoming more popular than the side-float design, and Fluidmaster, founded in the United States by inventor [Adolf Schoepe](http://en.wikipedia.org/wiki/Adolf_Schoepe), makes them.

The side-float design incorporates a float, usually ball-shaped, which is located to one side of the main valve tower at the end of a rod or arm. As the side-float rises, so does the side-float-arm. The arm is connected to a linkage which blocks the water flow into the toilet tank, and thus maintains a constant level in the tank.





One type of Concentric Float Valve. The Concentric Float valve opens when the fluid level is low, allowing more fluid to enter (Figure 1). When the fluid level returns to the full level, the valve is shut (Figure 2).

The newer concentric-float fill valve consists of a tower which is encircled by a plastic float assembly. Operation is otherwise the same as a side-float fill valve, even though the float position is somewhat different. By virtue of its more compact layout, interference between the float and other obstacles (tank insulation, flush valve, and so on) is greatly reduced, thus increasing reliability. The concentric-float fill valve is also designed to signal to users automatically when there is a leak in the tank, by making much more noise when a leak is present than the older style side-float fill valve, which tends to be nearly silent when a slow leak is present.

### Tank style with flapper-flush-valve





A traditional gravity toilet tank concluding the flush cycle. As the water level in the tank drops, the flush valve flapper falls back to the bottom, stopping the main flow to the flush tube. Because the tank water level has yet to reach the fill line, water continues to flow from the tank and bowl fill tubes. When the water again reaches the fill line, the float will release the fill valve shaft and water flow will stop.
1. float, 2. fill valve, 3. lift arm, 4. tank fill tube, 5. bowl fill tube, 6. flush valve flapper, 7. overflow tube, 8. flush handle, 9. chain, 10. fill line, 11. fill valve shaft, 12. flush tube

In a tank-based system, the storage tank (or cistern) collects between 6 and 17 liters of water over a period of time. This system is suitable for locations plumbed with 1/2" (15 mm) or 3/8" (10 mm) water pipes. The storage tank is kept full by a tank fill-valve. The storage tank is usually mounted directly upon the bowl, although some tanks are mounted on the wall a few feet above the bowl in an attempt to increase the flush water pressure as it enters the bowl. Tanks near the ceiling are flushed by means of a dangling pull chain, often with a large ornate handle, connected to a flush lever on the cistern itself. "Pulling the chain" remains a British euphemism for flushing the toilet, although this type of tank or cistern is becoming rare. A similar [German](http://en.wikipedia.org/wiki/German_language) expression is *Wasser ziehen* ("to pull water").

In tanks using a flapper-flush-valve, the outlet at the bottom of the tank is covered by a buoyant plastic cover or flapper, which is held in place against a fitting (the *flush valve seat*) by water pressure. To flush the toilet, the user pushes a lever, which lifts the flush valve from the valve seat. The valve then floats clear of the seat, allowing the tank to empty quickly into the bowl. As the water level drops, the floating flush valve descends back to the bottom of the tank and covers the outlet pipe again. This system is common in homes in the [USA](http://en.wikipedia.org/wiki/United_States) and in continental Europe. Recently this flush system has also become available in the UK due to a change in regulations.

###  Tank style with siphon-flush-valve

This system, invented by Albert Giblin and common in the [UK](http://en.wikipedia.org/wiki/United_Kingdom), uses a storage tank similar to that used in the flapper-flush-valve system above. This flush valve system is sometimes referred to as a *valveless* system, since no traditional type of valve is required. Some would argue, however, that any system of regulating the flow of a fluid is still technically a *valve*. In the siphon-flush-valve system, the user pushes a lever or button, forcing the water up into the tank siphon passageway which then empties the water in the tank into the bowl. The advantage of a siphon over the flush valve is that it has no sealing [washers](http://en.wikipedia.org/wiki/Washer_%28mechanical%29) that can wear out and cause leaks, so it is favoured in places where there is a need to conserve water. Until recently, the use of siphon-type cisterns was mandatory in the UK to avoid the potential waste of water by millions of leaking toilets with flapper valves but due to EU harmonisation the regulations have changed. These valves can sometimes be more difficult to operate than a "flapper"-based flush valve because the lever requires more torque than a flapper-flush-valve system. This additional torque required at the tank lever is due to the fact that a user must forcefully lift a certain amount of water up into the siphon passageway in order to initiate the siphon action in the tank.

Older installations, known as "high suite combinations", used a high-level cistern (tank), fitted above head height, that was operated by pulling a chain hanging down from a lever attached to the cistern. When more modern close-coupled cistern and bowl combinations were first introduced, these were first referred to as "low suite combinations". Modern versions have a neater-looking low-level cistern with a lever that the user can reach directly, or a close-coupled cistern that is even lower down and integrated with the bowl. In recent decades the close coupled tank/bowl combination has become the most popular residential system, as it has been found by ceramic engineers that improved waterway design is a more effective way to enhance the bowl's flushing action than high tank mounting.

###  Tank style with high-pressure or pressure-assist valve

This system utilizes mains water pressure to pre-pressurize a plastic tank located inside of what otherwise appears to be the more typical ceramic flush tank. A flush cycle begins each time a user flushes the bowl. After a user flushes and the water in the pre-pressurized tank has finished emptying into the bowl, the outlet valve in the plastic tank shuts. Then the high pressure water from the city main refills the plastic tank. Inside the tank is an air-filled balloon-like rubber diaphragm. As the higher-pressure mains water enters the tank, the rubber diaphragm is also pressurized and shrinks accordingly. During flushing, the compressed air inside the diaphragm pushes the water into the bowl at a flow rate which is significantly higher than a tank style gravity-flow toilet. This system requires slightly less water than a gravity-flow toilet. Pressure-assist toilets are sometimes found in both private (single, multiple and lodging) bathrooms as well as light commercial installations (such as offices). They seldom clog, but the pressurized tanks require replacement about once every 10 years. They also tend to be noisier - a concern for residential settings. The inner bowl stays cleaner (in appearance) than gravity counterparts because of the larger water surface area and the toilet's forceful flush. Newer toilets from several companies such as Kohler that are pressure-assisted use 1.4 US gallons (5.3 l) to 1.1 US gallons (4.2 l) per flush.

###  Tankless style with high-pressure (flushometer) valve

In 1906, [William Sloan](http://en.wikipedia.org/wiki/William_Elvis_Sloan) first made his "flushometer" style toilet flush valve, incorporating his patented design,available to the public. The design proved to be very popular and efficient, and remains so to this day. Flushometer toilet flush valves are still often installed in commercial restrooms, and are frequently used for both toilets and urinals. Since they have no tank, they have zero recharge time, and can be used immediately by the next user of the toilet. They can be easily identified by their distinctive chrome pipe-work, and by the absence of a toilet tank or cistern, wherever they are employed.

Some flushometer models require the user to either depress a lever or press a button, which in turn opens a flush [valve](http://en.wikipedia.org/wiki/Valve) allowing mains-pressure water to flow directly into the toilet bowl or urinal. Other flushometer models are electronically triggered, using an infrared sensor to initiate the flushing process. Typically, on electronically triggered models, an override button is provided in case the user wishes to manually trigger flushing earlier. Some electronically triggered models also incorporate a true mechanical manual override which can be used in the event of the failure of the electronic system. In retrofit installations, a self-contained battery-powered or hard-wired unit can be added to an existing manual flushometer to flush automatically when a user departs.

Once a flushometer valve has been flushed, and after a preset interval, the flushometer mechanism closes the valve and stops the flow. The flushometer system requires no storage tank, but requires a high volume of water in a very short time. Thus a 3/4 inch (19 mm) pipe at minimum, or preferably a 1 inch (25 mm) pipe, must be used, but as the high volume is used only for a short duration, very little water is used for the amount of flushing efficacy delivered. Water main pressures must be above 30 pounds per square inch (2.1 bar). While the higher water pressure employed by a flushometer valve does scour the bowl more efficiently than a gravity-driven system, and while fewer blockages typically occur as a result of this higher water pressure, flushometer systems still require approximately the same amount of water as a gravity system to operate (1.6 gpf).

# WC - Different Types

 **Types and Designs**
There are two main types of WC:
-  Washdown
-  Syphonic

 **Washdown**
The pan is cleared by careful distribution of the force and volume of the flush water. This type is by far the most common type of WC installed in the UK. Washdown pans have a 50 mm water seal and a convenient bowl shaped to provide efficient cleaning and minimise fouling. WC’s are normally 400mm high but varying heights and shapes are available to suit individual choice.
 **Syphonic**

The flushing operation creates suction to assist the clearance of the pan. A double trap syphonic WC is very quiet and efficient in operation, it has an unrestricted fullbore trap arrangement that reduces the risk of blockage. However, they are now rarely sold in the U.K. due to reductions in flushing volume.
 **Traps and fittings**

Traditionally WC’s were manufactured with “P” traps or ‘S’ traps formed as an integral part of the casting. From a cost and logistics viewpoint this was expensive so today nearly all WC’s have a simple horizontal outlet and the connection to the drains is made by plastic connectors available in  number on configurations which replicate the ‘P’ and ‘S’ configurations.

Note: Recent changes in legislation now allow a low-level WC suite with close-coupled pan to be fitted with a bottom outlet without having to move the soil pipe.

A comprehensive range of WC designs are available which include:
-  Close coupled
-  Low level
-  High level
-  Back to wall/Concealed
-  Wall hung
-  Squatting
 **Close coupled**

This type of WC is typically floor mounted with the cistern resting on an extended platform at the back of the WC pan. The cistern is fixed directly to the WC using a washer to provide a water tight seal.

 **Low Level**
The WC pan is floor mounted with the cistern mounted separately on the wall. A short flush pipe connects the cistern to the WC.
 **High Level**

Similar to the low level arrangement but the cistern is mounted high on the wall with a longer flush pipe.

Note: High and low level cistern installation - It is important that the manufacturers’ recommended dimensions are followed when determining the fixing height. If flush pipes are shortened the flush will be weakened and the pan contents may not be cleared effectively.

For a low level installation the top of the cistern is usually set at 1000mm above the floor. High level installations usually have the underside of the cistern set at about 2000mm from the floor but in both cases, follow the manufacturers recommendations.

 **Back to Wall/Concealed**
The cistern is concealed behind a false wall with just the flushing mechanism showing. The WC is
fitted "back to the wall", commonly used in commercial applications (public toilets etc.) for easy cleaning but also used for neatness in domestic rooms.

 **Wall Hung**
The WC pan is mounted on brackets adjacent to the wall giving completely free floor space beneath. Ideal for easy floor cleaning in non domestic application but also used in domestic bathrooms to give a feeling of ‘added’ space.
 **Squatting**

The WC pan is mounted at floor level where the user "straddles" the unit. The design is more commonly associated with particular cultures worldwide.
 **Fixing WC pans**

WC pans must be fixed to the floor by screws using the holes provided, this applies whether on wooden or concrete floors. The joint between the pan and floor can be ‘pointed’ with a cement mortar but WC pans must never be set onto a solid bed of concrete or the foot might split. Brass screws should be used to prevent rusting, care should be taken to align them with the angle of the fixing holes. Plastic connectors should be used to connect the horizontal outlet to the soilpipe. Many different designs are available to suit the majority of installations.

 **Toilet Seats**
Toilet seats are generally available in two main styles – round and elongated. It is important to make sure that the style of seat chosen is compatible with the WC pan as they are not always interchangeable and need to be suitable for the proposed application. It is essential that toilet seats are fitted correctly and in accordance with the manufacturer’s instructions. All of the fittings provided with a seat (fixing bolts, nuts, washers etc) should also be used in order to reduce movement of the seat once it has been installed. This improves safety and helps reduce the risk of breakage - helping to extend the life of the seat. The wrap - over seat, as the name implies has a cover which wraps over the seat to give a neat and clean looking appearance. Some seats are available with a mechanism hidden in the seat hinges, which slows down the movement of the seat as it closes. The seat will not close with a thud but will gently fall into place unaided

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