BASIC

DRINKING WATER TREATMENT GUIDE

WATER RESEARCH COMMISSION

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Printed in the Republic of South Africa

This booklet is based on the report, CF Schutte, Quality of domestic water supplies Volume 4: Treatment guide (**WRC report no. TT 181/02**)

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INTRODUCTION

Water must meet certain basic requirements to make it fit for domestic use. The most important requirement is that it must be safe to drink.

Many water sources contain harmful microorganisms or other substances in concentrations that make the water unsafe to drink or in other ways unfit for domestic use. These organisms and substances must therefore be removed from the water by means of treatment processes to make the water fit for domestic use.

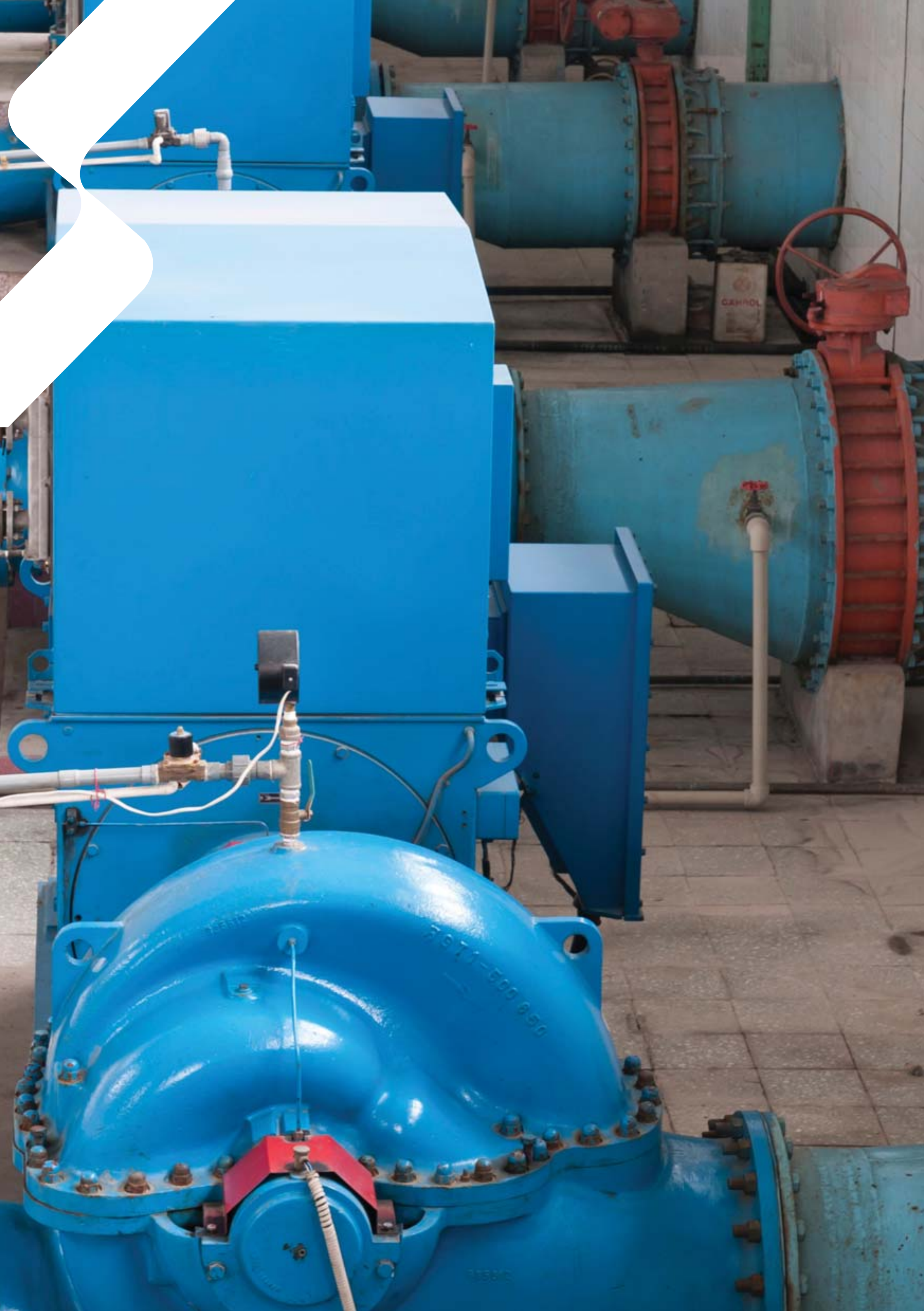
Water treatment is an essential element in any water supply system to make the water fit for domestic use. In a conventional treatment system raw water is abstracted from the source (for example, a river, dam or groundwater source), whereafter the raw water is conveyed to the treatment plant where it is treated in different treatment processes. After treatment the water is stored and then distributed to individual users.

This booklet is focused on explaining the principles of sound water treatment and the processes by which a safe potable water supply is produced. The focus is placed solely on conventional treatment processes. For desalination, point-of-use and emergency processes please refer to the full guide.

The main objective of the booklet is to empower readers to make more informed decisions about the management of conventional treatment plants under their control and to ensure sustainability of their water supplies. For readers requiring more technical details a list of additional resource is provided at the back of the booklet.

The following people may find this guide useful:

- Water treatment plant operators and managers
- Members of water committees or local authorities responsible for water supply
- Environmental health officers who have to assess water quality for domestic use
- Water supply agencies
- Educators and student



SUBSTANCES OF CONCERN THAT MUST BE REMOVED DURING WATER TREATMENT

The types of contaminants or substances of concern that may occur in water source vary over a wide spectrum. The following general categories are normally taken into account when a water treatment plant is designed. When water has to be treated, it is normally not possible to consider each substance of concern individually. There are exceptions, however, for example the removal of a toxic substance.

Consuming water without treatment is a dangerous practice that may result in the user contracting diseases such as cholera or dysentery if the water source is contaminated by pathogens (disease causing organisms)

Suspended particles occur generally in surface water and give water a turbid or murky appearance. Suspended material varies widely in nature and includes clay particles, algae, microorganisms, decaying plant material and other organic and inorganic substances. Larger suspended particles can be easily removed from water simply by means of settling (i.e. by allowing the water to stand for a short period and then decanting the clean water). Very small particles (called colloidal particles) are difficult to remove from water. These particles have to be destabilised chemically before the particles can be removed.

Microorganisms including bacteria, viruses and other organisms may also be present in water as colloidal particles. Most microorganisms in water are harmless, but disease-causing organisms, but disease-causing organisms (called pathogens) may enter water sources as a result of pollution by human and animal wastes and by untreated or poorly treated wastewaters discharged into the water source. These organisms may cause disease such as cholera and dysentery if they are present in water that is consumed without treatment. The water therefore has to be disinfected (i.e. the microorganisms have to be removed or destroyed to make the water fit for domestic purpose).

Examples of disease causing organisms

Name or organism	Major disease	Sources
Bacteria		
Salmonella typhi	Typhoid fever	Human faeces
Shigella	Bacillary dysentery	Human faeces
Vibrio cholera	Cholera	Human faeces
E. Coli	Gastroenteritis	Human faeces
Legionella pneumophila	Legionellosis	Thermally enriched water
Mycobacterium tuberculosis	Tuberculosis	Human respiratory exudates
Enteric viruses		
Polioviruses	Poliomyelitis	Human faeces
Coxsackie viruses A & B	Aseptic meningitis	Human faeces
Echoviruses	Aseptic meningitis	Human faeces
Reoviruses	Upper respiratory and gastrointestinal illness	Human faeces
Rotaviruses	Gastroenteritis	Human faeces
Hepatitis A virus	Infectious hepatitis	Human faeces
Protozoans		
Giardia lamblia	Giardiasis (dysentery)	Human and animal faeces
Cryptosporidium	Cryptosporidiosis	Human and animal faeces
Entamoeba hystolytica	Amoebic dysentery	Human faeces
Balantidium coli	Balantidosis (dysentery)	Human faeces
Algae (blue-green)		
Anabaena flos-aqua	Gastroenteritis, skin rash	Nutrient enriched water
Microcystis aeruginosa	Gastroenteritis	Nutrient enriched water

Dissolved inorganic substances normally do not affect the appearance of the water but may cause the water to have a brackish or salty taste. Some dissolved substances may also cause the water to be toxic at very low concentrations, for example, arsenic and mercury. Most of the naturally occurring substances such as sodium chloride (NaCl, table salt), and calcium sulphate ($CaSO_4$, gypsum) are harmless in water for domestic use at the concentrations at which they normally occur. Other dissolved inorganic substances may be harmful if they are present at concentrations exceeding certain limits, e.g. fluoride. The presence of other inorganic substances may have different effects, e.g. high concentrations of calcium and magnesium cause excessive hardness in the water. Iron and manganese on the other hand, may cause the water to be corrosive or to form layers of scale in pipes.

Dissolved organic substances are generally present in most surface waters. Most dissolved organic substances are harmless, for example, dissolved substances (called humic acids) from decaying plant matter. However, there may also be harmful organic substances in water such as pesticides and herbicides that find their way into water sources. Another category of dissolved organic substances is the so-called disinfection byproducts. These are chlorinated organic compounds that form during disinfection of water with chlorine. These chlorinated compounds are called trihalomethanes or THMs. Chloroform is one of the compounds in this group.
Different treatment processes are used to remove the different types of contaminants. Water treatment technology is highly developed and there are processes available to produce drinking water from just about any source of water no matter how polluted it is. Examples include water reclamation processes that produce drinking water from sewage, and desalination processes that produce drinking water from seawater.

The more polluted a water source, the more sophisticated the treatment required to produce high-quality drinking water from it and the higher the treatment cost would be.

GENERAL METHODS OF WATER TREATMENT

There are many different water treatment methods or processes that can be used, each on its own or in combination with others, to treat water for domestic use.

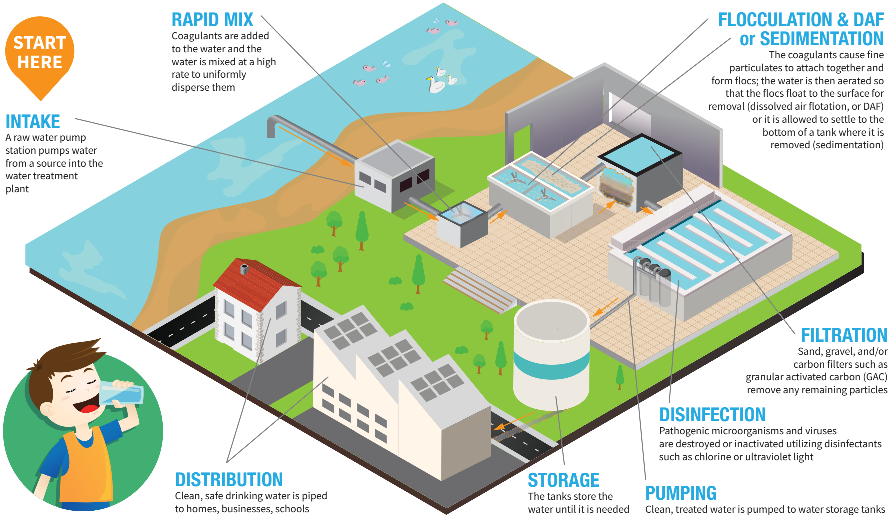
In general, water treatment processes can be classified into the following categories:

- **Clarification processes** that are used to remove suspended material from water. These processes include coagulation, flocculation, sedimentation, flotation, and filtration.
- **Disinfection processes** including chemical treatment with chlorine and chlorine compounds and advanced processes such as the use of ozone as well as physical processes such as ultraviolet irradiation.
- **Advanced / specialised processes** for the removal of dissolved inorganic substances including reverse osmosis, ion exchange and electrodialysis.
- Relatively simple processes that can be used for home treatment or during emergency situations.

These processes can be selectively combined in process trains to produce water of the required quality. They can be applied on a large or small scale. Most treatment plants in South Africa employ what is known as a series of conventional treatment processes

The most important consideration in the design of treatment processes is that the water must be safe for human consumption after treatment.

WATER TREATMENT

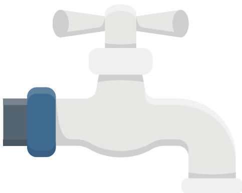


A typical water treatment plant. (Source Tata & Howard)

The main aspects to take into account when considering different treatment options

- The raw water quality and its variability
- The quality of the treated water to be produced
- The volume of water to be treated (capacity requirements of the plant)
- The cost limitations
- The level of sophistication that is acceptable (what level of expertise is available to control and operate the plant)
- The support services available to assist with plant optimisation, troubleshooting and maintenance and repair problems

PROCESS SELECTION



Step 1 entails a detailed evaluation of the raw water quality. This includes evaluation of all the constituents and groups of constituents that must be removed from the water and the alternative processes and combinations that can be used for their removal.

Step 2 involves a conceptual process design in which alternative processes and combinations are evaluated to determine the performance of each combination in terms of efficiencies and product water quality as well as possible problems. At this point laboratory and bench-scale testing is done to determine the best coagulants and other chemicals to be used and their dosages. It problems are evident at this point further tests and pilot-scale studies may be necessary.

In **step 3** a preliminary design is made which allows estimates of the treatment costs for the different options to be made. The projected treatment costs of the different options and process efficiencies are evaluated in selecting combinations for inclusion in the final design.

OVERVIEW OF CONVENTIONAL WATER TREATMENT PROCESSES

Conventional water treatment involves a number of treatment steps aimed at achieving the following:

- **Removal of suspended and colloidal water** to an acceptable level by means of coagulation, flocculation, sedimentation and sand filtration
- **Disinfection** to produce water that is safe to drink
- **Chemical stabilisation** of the water to prevent corrosion of pipelines or the formation of chemical scale in distribution systems and fixtures

The processes employed for the removal of suspended and colloidal matter include the following:

- A process to change the nature of the colloidal material in the water to facilitate its removal (coagulation)
- A process to form larger groups of particles or flocs (flocculation)
- A process to remove the flocs from the water (sedimentation or alternatively flotation); and
- A process for final cleanup of the water (sand filtration)

Disinfection involves the addition of disinfection chemicals to the water. On large-scale plants chlorine gas is normally used (but ozone or chlorine dioxide can also be used), while on small plants chlorine granules, $Ca(OCl)_2$ (commercially known as HTH) are often used for disinfection.

Chemical stabilisation is achieved by addition of different chemicals such as lime and /or carbon dioxide to the water.

Each of these processes discussed in more detail on the next page.

WHY IS IT IMPORTANT TO REMOVE SUSPENDED AND COLLOIDAL MATERIAL FROM WATER?

Suspended material in water causes it to look dirty and therefore not acceptable to drink. Furthermore, suspended material may 'shield' microorganisms against the action of disinfectants such as chlorine. A third factor is that suspended material may settle in reservoirs and distribution systems, thereby creating conditions in which microorganisms may grow and recontaminate the water.

Types of suspended and colloidal material

A variety of different types of suspended and colloidal material can be present in water. This includes:

- Inorganic salt and clay particles that occur mainly in surface water sources
- Algae that grow in surface waters enriched with plant nutrients
- Bacteria and other microorganisms that are present in water as a result of pollution
- Decaying plant material as well as a variety of other types of particles

The most common type of colloidal particles in surface water is minute clay or silt particles that are washed into surface waters by runoff after rainstorms. Erosion is a major factor that contributes to the amount of silt that is washed into streams and end up in most surface waters in South Africa. The amount of silt that has to be removed adds substantially to the cost and complexity of treatment of surface water.

The Vaal River is a typical surface water source containing lots of suspended and colloidal material that needs to be removed during treatment for drinking purposes.

Algae are another general type of colloidal particle that occur in many surface waters. There are many different types of algae, but the most important algae type that cause problems in water treatment are very small single-cell algae which float freely in the water. Because algae are so small, they are not effectively removed by sand filtration unless they are killed by pre-chlorination and / or coagulated. Other algae types include filamentous algae.

Other types of suspended material include microorganisms, decaying organic material which can also cause colour in the water, as well as a variety of industrial pollutants.

The main characteristics of suspended and colloidal material

The nature and characteristics of suspended and colloidal material in water are important in determining the type of treatment process required for removal. The suspended material can be inorganic in nature, e.g. sand or clay particles or organic in nature, such as algae or humic material from decaying plant material. The size of the particles is another important characteristic because size determines (to a large extent) the type of treatment process that can be used to treat the water.

The nature of suspended material in water can vary from relatively coarse particles that can be removed simply by allowing the particles to settle and decanting the clean water. At the other end of the spectrum are very fine particles, called colloidal particles, which do not settle at all even if left for a long period of time and which have to be treated chemically to remove them from the water.

Colloidal particles are very small (smaller than 0,1 micron), and since they are electrically charged they have very specific characteristics. The most important characteristic is that they form a stable colloidal suspension that do not settle readily, but remain in suspension (even for periods of days or weeks). In order for such particles to settle, they must be chemically destabilised, or coagulated to neutralise the charge on them and to form larger flocs that can settle, thereby facilitating their removal from water.

The size of particles in water

The standard (SI) unit for size or length is the metre (m). However, the particles that occur in water are extremely small and their dimensions are normally given in micro-metre (µm) or nano-metre (nm).

1 m = 1 000 mm (millimetre) • 1 mm = 1 000 µm (micrometre)
1 µm = 1 000 nm (nanometre)

This means that 1 m = 1 00 000 µm = 1 000 000 000 nm.

PROCESSES USED IN CONVENTIONAL WATER TREATMENT FOR REMOVAL OF SUSPENDED AND COLLOIDAL MATERIAL

The conventional treatment methods for removal of suspended and colloidal material from water include chemical coagulation of small colloidal particles, flocculation of the small particles to form larger flocs, followed by sedimentation and sand filtration. When the water contains a large amount of suspended material, larger suspended particles such as sand particles can be removed by means of settling without coagulation and flocculation.

Other methods that can be used include slow sand filtration, flotation, microfiltration and ultrafiltration.

The selection of the best combination of processes to treat a particular water depends on a number of factors, including:

- The amount of suspended solids
- The turbidity of the water
- The nature of the suspended material
- The chemical properties of the water (alkalinity and pH)
- The volume of water to be treated, and the availability of facilities, trained operators and supervisors.

The settling of water

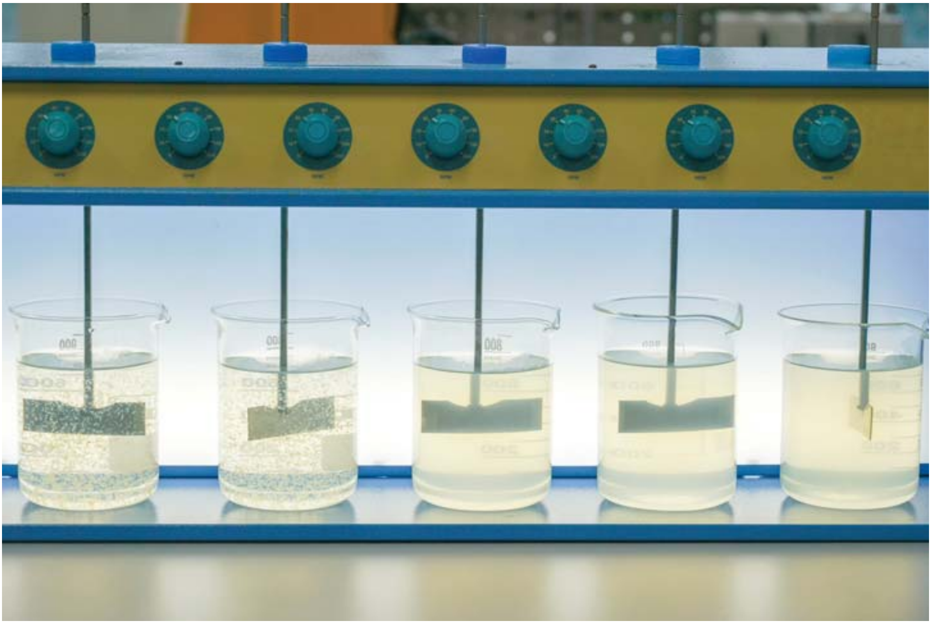
Simple settling is often used as a pre-treatment step to remove larger suspended particles from wate without coagulation-flocculation. Settling requires that the water remans stagnant for a period of time to allow the larger particles to settle to the bottom of a tank or holding reservoir. After settling of the particles clear water can be decanted from the container.

COAGULATION-FLOCCULATION

Coagulation is the process by means of which the colloidal particles in water are destabilised (i.e. the nature of the colloidal particles is changed) so that they form flocs through the process of flocculation that can be readily separated from the water. Destablisation is achieved through the addition of chemicals (called coagulants) to the water.

Different chemicals can be used as coagulants. The most common coagulants are aluminium sulphate, ferric chloride, lime and polyelectrolytes. There are a number of important factors that must be taken into account to ensure successful coagulation, including the type of raw waterencountered (including pH and alkalinity), the storage of the coagulant, and the preparation of the solution, among others.

The best way of determining which chemical to use for coagulation and at what dosage (optimum amount to be used) and the optimum chemical conditions e.g. pH is by performing so-called jar or beaker tests. A jar test is a standardised way of determining the optimum conditions for clarification of water. It is performed on a beaker test unit. They consist essentially of a variable drive with normally six stirrers which can be used to stir the contents of a set of beakers to which different coagulants and dosages are added, mixed and allowed to settle.

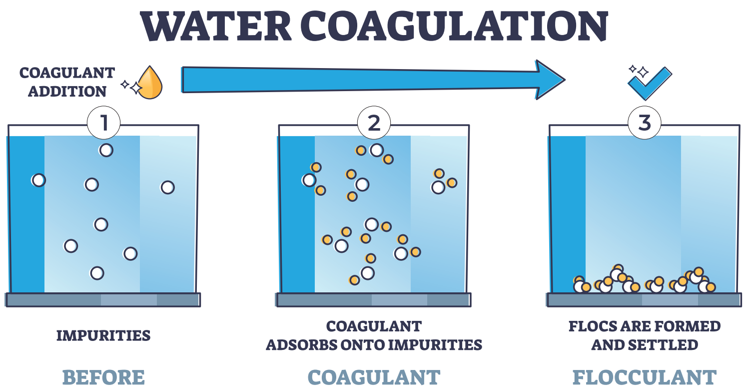


A coagulation jar test.

The objective of the flocculation step is to cause the individual destabilised colloidal particles to collide with one another and with the precipitate formed by the coagulant in order to form larger floc particles. Flocculation involves the stirring of water to which a coagulant has been added at a slow rate, causing the individual particles to 'collide' with each other and with the flocs formed by the coagulant. In this way, the destabilised individual colloidal particles are agglomerated and incorporated into the larger floc particles.

Flocculation can take place in different types of equipment. A simple mechanical stirrer can be used for flocculation or a specially designed channel with baffles to create the desired flow conditions can also be used to flocculate the particles in water. The basis of the design of a flocculation channel is that the flow velocity of the water has to be reduced from a high initial value to a much lower value to enable large, strong flocs to grow. If the flow velocity is too high the flocs may break up again, causing settling of the broken flocs to be incomplete.

Flocculation is controlled through the introduction of energy into the water (through paddles or by means of baffles in the flocculation channel) to produce the right conditions (required velocity gradient) for flocs to grow to the optimum size and strength. The velocity gradient for (or G-value) is an extremely important factor that determines the probability of particles to collide and form flocs. If G-values are too low, the probability of collision is low and poor floc formation results. If it is too high, shear forces become large and this may result in floc break-up. Flocs are removed from water by means of separation processes, i.e. sedimentation and sand filtration, or flotation and sand filtration.



Coagulant chemicals are added water to neutralise the negative charges on the colloidal particles to prevent those particles from repelling each other (1). Once the particles' charges have been neutralised, it causes them to form micro-flocs (2). When enough coagulant is added, there is a defined difference between the clumped micro-flocs and the clear water surrounding them. After coagulation, the flocculation process is used to increase the sizes of the suspended particles and further promote clumping, making them easy to remove from water.

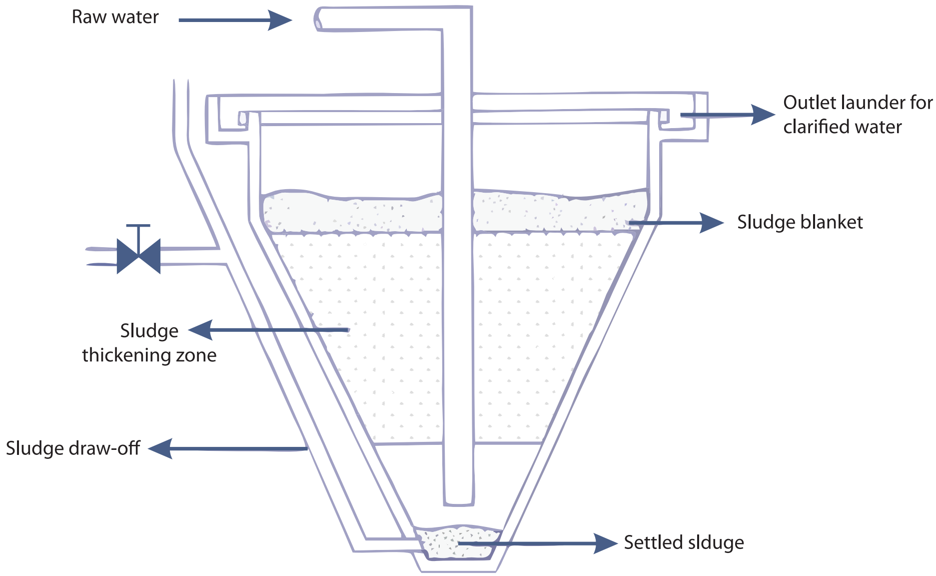
Acceptable G-values are:
Coagulation: 400 to 1 000 s^{-1}
Flocculation: in the order of 100 s^{-1}

Sedimentation

Sedimentation is the process in which the flocs that have been formed during coagulation and flocculation are allowed to settle from the water. The flocs collect as sludge at the bottom of the sedimentation tank from where it must be removed on a regular basis. The clean water leaves the sedimentation tank through collection troughs located at the top of the tank.

There are a variety of designs for sedimentation tanks. These include large rectangular tanks in which the water enters one side and leaves at the other end. This type is normally used at large conventional treatment works. Flocculated water enters the tank at a central distribution section and clarified water leaves the tank at collection troughs at the circumference of the tank. The design and flow conditions in a sedimentation tank must be such that the minimum amount of floc leaves with the clarified water.

Typical sedimentation tanks.



Layout of a sedimentation unit.

Disposal of water treatment plant sludge

Sludge from a sedimentation tank has a large pollution potential because it contains all the suspended material removed from the water together with the chemicals used for coagulation. It must therefore be disposed of in a proper manner to prevent contamination of water sources.

The sludge is withdrawn from the sedimentation tank in a diluted form and is sometimes thickened (excess water removed before disposal). At smaller treatment works sludge is disposed of in sludge lagoons. The lagoons are large holding dams in which the sludge compacts and clear water accumulates on tope of the sludge. The clear water may be recycled to the inlet of the plant.

Flotation

Flotation is an effective process for removal of relatively light types of flocs. Flotation involves the formation of small air bubbles in water that has to be flocculated. The bubbles attach to the flocs causing them to rise to the surface where they are collected as a froth that is removed from the top of the flotation unit.

Air is dissolved under pressure in a small amount of water in a device called a saturator. This water that is saturated with dissolved air is added to the main stream of water that is to be treated. When the pressured is released after the saturated water is mixed with the water to be treated, the dissolved air comes out of solution in the form of very fine bubbles.

Sedimentation and flotation are two processes that perform the same function. Sedimentation is normally used when the raw water contains mainly silt or clay particles, while flotation is normally used when the raw water contains algae or other types of organic material.

SAND FILTRATION

A typical rapid gravity sand filtration tank.

Sand filtration is a simple process in which the water is allowed to filter through a layer of sand in a specially constructed container. In the filtration process the small remaining floc particles are removed by the sand grains and are retained in the bed of sand, while clean water flows out from the bottom of the sand bed.

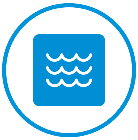
There are two types of sand filtration processes:

- **Rapid gravity sand filtration** – normally follows flotation or sedimentation as the final 'polishing' step in conventional water treatment. Filtration takes place at a relatively high rate, and the filter has to be back-washed at intervals of a few hours.
- **Slow sand filtration** – has a slow rate of filtration and is a process that can be employed as a stand-along treatment process. The filter media is not back-washed at all but the filter is cleaned by removal of the top layer of sand at long intervals (e.g. weeks)

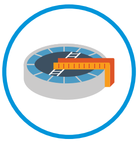
CONVENTIONAL WATER DISINFECTION PROCESSES

A large fraction of bacteria and larger microorganisms are removed during clarification processes, especially by sand filtration. However, many bacteria and viruses still remain in clarified water even at low turbidity levels. It is therefore essential to disinfect water to prevent the possibility that waterborne diseases are spread by pathogens.

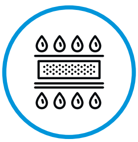
The provision of microbiologically safe drinking water must include a series of barriers aimed at preventing pathogens from infecting the consumer.



The **first barrier** is aimed at preventing pathogens from entering water sources. This is achieved by protection of the water source from pollution by human or animal wastes or other wastes that may be carriers of pathogens.



The **second barrier** comprises clarification processes to remove the maximum number of microorganisms from the water. Only the final step in this multi-barrier approach is disinfection of the water.



The **third** step – disinfection of water – entails the addition of the required amount of a chemical agent (disinfectant) to the wate rand allowing contact between the water and disinfectant for a pre-determined period of time under specified conditions of pH and temperature.

The most commonly used disinfectant is chlorine gas, Cl, that is dissolved in the water at a certain concentration for a certain minimum contact time. Other disinfectants include ozone, chlorine dioxide and other chlorine compounds such as calcium hypochlorite (HTH), sodium hypochlorite (bleach) and monochloramine.

Chlorine gas is the most commonly used disinfectant on large scale as it is very effective, is more cost-effective and its application can be accurately controlled.

HOW CAN ONE TELL IF WATER IS PROPERLY DISINFECTED?

There are two main ways in which the safety of water can be determined:

- To do a microbiological assessment of the water by determining the presence or absence of certain organisms in the particular water
- To determine the amount of residual chlorine in the water. If there is residual chlorine present in water with a low turbidity, it can normally be accepted that the water is safe to drink.

DISINFECTION BY MEANS OF CHLORINE

Chlorine is a strong oxidising agent and it reacts and oxidises some of the essential systems of microorganisms, thereby inactivating or destroying them. The different forms in which chlorine is used for disinfection have different oxidising powers. This must be taken into account to ensure effective disinfection.

Chlorine can be added to water in different forms. On large-scale plants the most common form in which chlorine is used is chlorine gas. Calcium hypochlorite and sodium hypochlorite are two other chlorine compounds that can be used for disinfection of water.

Chlorine gas, Cl, is delivered to the plant in gas cylinders and the chlorine is introduced into the water by means of special dosing devices (chlorinators). Calcium hypochlorite, ($Ca(OCl)_2$, commonly known as HTH), is available in granular or solid (tablet) form and is therefore a very convenient form in which to apply chlorine, especially for smaller or rural plants. It contains between 65% and 70% available chlorine, it is relatively stable and can be stored for long periods (months) in a cool dry environment.

Monichloramine (so-called combined available chlorine) is also used for water disinfection. It is formed when HOCl is added to water that contains a small amount of ammonia. The ammonia reacts with HOCl (the same order of effectiveness as chlorine ion). However, it has the advantage of being much more stable in water than free available chlorine. For this reason it is often used to provide residual protection in larger distribution systems.

HOW DISINFECTION BY MEANS OF CHLORINE IS CONTROLLED

The two most important factors that determine the effectiveness of disinfection by means of chlorine are the chlorine concentration and the chlorine contact time. The pH of the water also plays an important role as well as the turbidity of the water, exposure to sunlight and the water temperature.

Concentration
The chlorine concentration is the most important control factor to ensure effective disinfection. However, since chlorine can exist in different forms in water with different degrees of effectiveness, the concentration of the actual chlorine species used for disinfection must be taken into account. It is normally accepted that sufficient chlorine must be added to water to give a free chlorine residual of not less than 0,2 mg/L after 20 minutes contact time.

It is important to note that free available chlorine species are formed only after the breakpoint in the chlorination process. This means that sufficient chlorine must be added to react with any ammonia that may be present in the water and to oxidise the chloramines that are formed.

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Contact time
The second important control factor for disinfection is the contact time. This refers to the time of contact between the dissolved chlorine and each unit or 'pocket' of water. To ensure effective contact between chlorine and water, a contact chamber or basin must be provided with a so-called plug-flow pattern. This is to ensure that no short-circuiting takes place, because this may result in some parts of the water not being in contact with chlorine for the prescribed contact time. (an example of a plug flow system is a hosepipe where no back mixing or short-circuiting is possible. This is in contrast to a completely mixed system such as rinsing in a washing machine).

The following table gives the recommended chlorine concentration after 10 minutes contact time at different pH levels for free available chlorine and after 60 minutes for combined available chlorine.

pH value	Minimum free available chlorine after 10 min. contact time (mg/L)	Minimum combined available chlorine after 60 min. contact time (mg/L)
6	0,2	1,0
7	0,2	1,5
8	0,4	1,8
9	0,8	> 3
10	0,8	> 3

Turbidity
A further important factor that affects disinfection is the turbidity of the water to be disinfected. The reason is that when water contains colloidal particles, they may 'shield' the microorganisms from the action of the disinfectant, or alternatively, react with the chlorine and in this way prevent effective disinfectant. It is therefore important to optimise the clarification processes to produce water for disinfection with as low as possible turbidity levels (< 1, but preferably < 0,5 NTU).

Sunlight
Chlorine in water is rapidly broken down (reduced) by sunlight to the inactive chlorine ion, Cl^- that has no disinfecting power. This means that chlorine contact tanks should always be covered. Furthermore, chlorine compounds such as bleach should always be stored in dark containers out of sunlight.

DISINFECTION BY MEANS OF ULTRAVIOLET (UV) IRRADIATION

UV radiation kills or inactivates microorganisms provided each organism receives a minimum amount of irradiation. UV irradiation functions on the principle that each unit of water must be exposed to the irradiation for a minimum amount of time at a minimum dosage intensity.

Commercial UV units are used to disinfect water in many small- and large-scale water treatment plants. UV disinfection units have been used for many years and the process is accepted as an effective disinfection method.

It is important that the water to be disinfected is properly pretreated to ensure a low turbidity, preferably lower than 0,5 NTU. If the water contains high turbidity levels the colloids either absorb some of the radiation or shield the microorganisms against radiation which reduces the effectiveness of the process.

A further important aspect is that the UV tubes is prone to the formation of layers of scale or other fouling material. This also reduces the effectiveness of radiation. It is therefore important that the tubes are regularly inspected and cleaned to prevent formation of scale or accumulation of other material on them.

STABILISATION OF WATER FOR DOMESTIC USE

Stabilisation of water refers to the chemical stability of water specifically with respect to the tendency of the water to be corrosive or to form chemical scale in pipes and fixtures. Stabilisation of water involves the addition of chemicals to the water to adjust its chemical properties in order to prevent corrosion or scale formation.

The chemical stability status of water is determined by means of a chemical analysis of water and calculating certain indices or properties of the water. The index that has been most commonly used in the past to assess the stability of water is the Langelier Saturation Index, ISI. This index gives a qualitative indication of the stability of water. A more useful measure of chemical stability of water is to calculate the calcium carbonate precipitation potential or CCTP.

Water that is not chemically stable may be:

- Corrosive towards metal pipes and fittings, causing leaks in distribution systems with substantial cost implications
- Scale-forming, causing a layer of chemical scale to form in pipes and on heating elements. This also has substantial cost implications because the capacity of pipes is reduced and the heat transfer in kettles and geysers is reduced. From a cost point of view, it is very important to ensure that water for domestic use is chemically stable.

What does stabilisation of water involve?

Stabilisation of water involves the addition of chemicals to the water to produce water with a calcium carbonate precipitation potential (CCPP) of about 4 mg/L. This means that the water should be slightly supersaturated with calcium carbonate. The effect of this is that a very thin layer of calcium carbonate will form on surfaces protecting it against corrosion. At the low supersaturation value excessive scale formation is avoided.

The two chemicals most commonly used to stabilise water are slaked lime, $Ca(OH)_2$, and carbon dioxide (CO_2). Lime is used to stabilise soft water (low calcium content) and water with a low pH. Carbon dioxide is used to stabilise water with a high pH and to add alkalinity to the water. Other chemicals that could also be used include sodium carbonate (Na_2CO_3, also known as soda ash) and sodium hydroxide, NaOH (also known as caustic soda).

FURTHER READING

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Quality of domestic water supplies Volume 2: Sampling guide (**WRC report no. TT 117/99)**

Quality of domestic water supplies Volume 3: Analysis guide (**WRC report no. TT 129/00**)

Quality of domestic water supplies Volume 4: Treatment guide (**WRC report no. TT 181/02)**

Quality of domestic water supplies Volume 5: Management guide (**WRC report no. TT 162/02**)

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