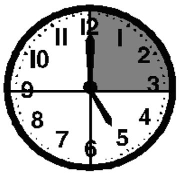
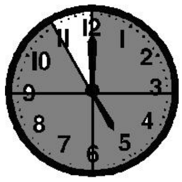
-WATER TREATMENT PLANT-

PREPARATION TIME:



LESSON TIME:



OBJECTIVES:

- Learn where our drinking water comes from and how it gets to our household tap.
- What makes water unclean and what harmful contaminants it can contain?
- Understand the extreme complexity of providing water to society.
- Discover the water cycle.
- Recognise the need to conserve and protect our environment and water sources.
- Discover how water quality is tested and the guidelines that exist in controlling the quality of water. Australian Drinking Water Guidelines (ADWG).
- ADWG 2002 (Australian Drinking Water Guidelines) what it is and how to test for it?
- To explore and identify the different types of processes in a Water Treatment Plant (WTP).
- Appreciate the important aspects of a WTP and complete an activity that shows some processes of a WTP.
- Understand the role of technology in a WTP and its impact on society and the environment.

SAFETY NOTES:

Supervision is recommended as the activity uses:

- Aluminium Sulfate Solution
- Use only in ventilated areas
- Do not drink any samples

WORDS TO KNOW:

- Aluminium Sulfate, $Al_2(SO_4)_3$
- Coagulation
- Flocculation
- Filtration
- Clarifier
- Sedimentary Tank
- Disinfection
- Sludge Thickening
- Reservoir
- Scour
- Flash Mixing
- Jar Testing
- Turbidity

RAINWATER TO TAP WATER- THE PROCESS

The process from rainwater to tap water is more complex than you might imagine. The water that comes out of your tap has been through various processes that clean and change its original properties, physically and chemically.

Do you know what the processes are? The aim of this Engineering Kit is to introduce you to a number of Water Treatment Plant (WTP) processes that are commonly used in getting clean potable water to your household.

Civil Engineers design, monitor and maintain water treatment plants and water supplies. Civil engineers are vital in the treatment and delivery of water to your household.

Water supply is the water that comes into your property from the water mains via a service pipe and through the water meter into your home.

Water is a limited resource. Less than one per cent of the earth's water is fresh and can be utilised for human consumption. The amount of this water will never increase as the water cycle is a closed system.

Australia is the driest inhabited continent on earth. This seems hard to imagine when we have always been able to turn on a tap and out comes as much water as we need.

Have you ever thought what would happen if you turned on the tap and no water was available or the water was unfit to drink? What would you do? How would you survive? Where would you get water from?

DRINKING WATER

Drinking water is water that is safe for humans to drink and to use for domestic purposes, such as cooking, washing up, bathing and showering.

The Australian Drinking Water Guidelines (ADWG) provides the Australian community and the water supply industry with guidance on what constitutes good quality drinking water, it is concerned with the safety of water from a health point of view and with its aesthetic quality. According to the Australian Drinking Water Guidelines:
Ideally, drinking water should be clear, colourless, and well aerated, with no unpalatable taste or odour, and it should contain no suspended matter, harmful chemical substances, or pathogenic microorganisms.

Drinking water must not contain chemicals, organic substances or organisms that may be harmful to human health. Drinking water should also be at a reasonable temperature and be free of unappealing odours, tastes and colour.

The ADWG also define drinking water as water
'…which, on the current state of knowledge, is safe to drink over a lifetime: that is, it constitutes no significant risk to health'.

When most Australians turn on the tap, they expect a continuous supply of drinking water that meets these guidelines – water that is safe and pleasant to drink.

Do you think that water from the tap is safe to drink? Do you observe your tap water's aesthetic quality – that is, its taste, colour and odour or do you just drink it regardless?

STEPS FOR THE WTP ACTIVITY:

PART ONE:

MATERIALS:

- 4 Students Booklets
- 1 Master Booklet
- Activity Worksheet Part One
- Bottles (Samples 1-3) of water

RAIN TO YOUR TAP....

1. There are 3 bottles of water to assess; the object of this task is to use one of the physical properties of water, colour, to determine which one is suitable to drink.
2. Using the sheet provided mark selections.
3. Identify the waters and reasons why you chose them?

PART TWO:

1. Divide the class into 4 groups and allocate them materials.

MATERIALS:

Group 1-4 Coagulation and Flocculation and Filtration

- Activity Instruction Booklet
- Activity Worksheet Part Two

Part A- Coagulation and Flocculation

- 4 500ml Plastic Beakers
- 4 Plastic stirring paddles
- 4 120ml Plastic Beaker
- 3 25ml plastic beakers
- 3 1ml Pipettes
- 2L Jug
- Timer- stop watch
- White Paper
- Alum Solution 10mg/L
- pH Strip
- Water 2L
- Soil 1gram

Part B- Filtration

- 1 120ml Plastic Beaker
- Plastic Funnel
- Wet Sand Media
- Special Coal
- Small Gravel
- Stand & Holder for Funnel
- Tweezers
- Filter Paper
- Pump
- Laboratory Filter
- White Paper

2. Each group will now start the coagulation and flocculation process as outlined in the instruction sheets.
3. Part A involves a Jar Test and sedimentation of the suspended solids.
4. Part B involves investigating filtration systems in the water treatment process.

WATER TREATMENT PROCESS

A Water Treatment Plant aims to ensure that water is:

- Safe for human consumption
- Pleasant to consumers
- Provided at a reasonable cost

Water Treatment Plants have many processes and steps before a household turns on their tap and receives water. From the dam to the tap there is a vigorous process with many steps that are all essential in assuring high quality water for drinking.

This activity looks at two of these processes; it will help you understand the processes of coagulation, flocculation and filtration which are all steps in water treatment.

COAGULATION AND FLOCCULATION

When particles are slow to settle or are non-settling, chemicals (coagulants), such as alum (Aluminium Sulfate), are added to the water. These react with the unwanted suspended particles to form larger particles, called floc. The larger size and weight of the flocs then causes them to settle rapidly.

Jar testing determines how much alum to add to the water in a treatment plant to economically settle out the particles. Jar testing is widely used in industry.

FILTRATION

Filtration is also another important element of the treatment process. This process involves the water passing through a bed of fine particles, usually sand. This process is called sand filtration. Other materials are also used in the filtration process. Generally they are layered.

Originally filtration was a slow process, however because the sand filtration processes become less effective at removing fine suspended particles at higher water flow rates. The water must be pretreated – coagulated and flocculated – before passing through the filter bed. Such high rate direct filtration processes are widely applied to raw water with low levels of suspended matter.

The diagram below shows the complete water treatment plant processes. Note: where coagulation, flocculation and filtration occur in the design.

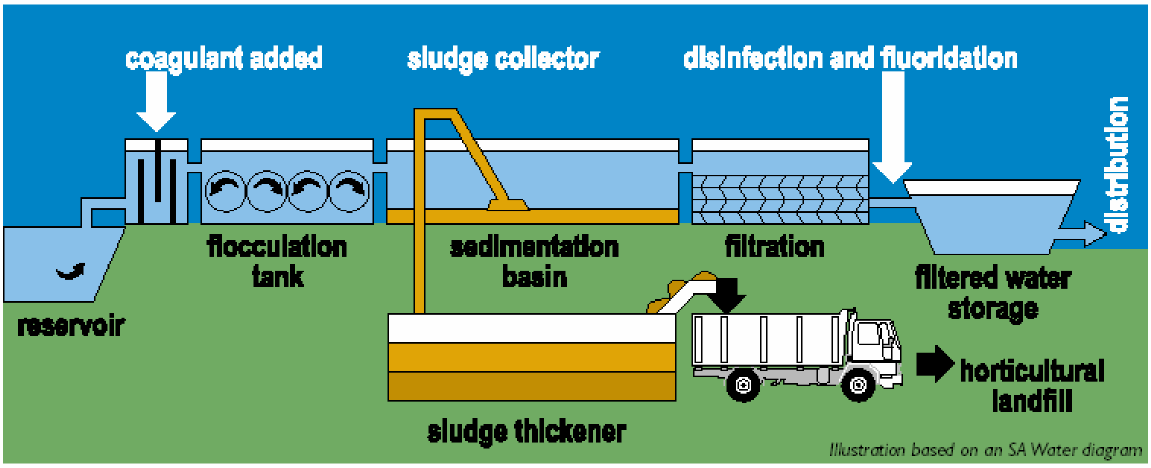


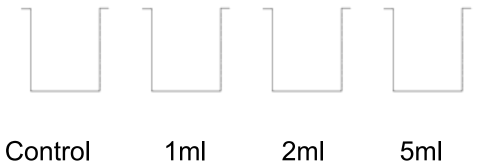
Figure 1 WATER TREATMENT PROCESS

The Cooperative Research Centre for Water Quality and Treatment, 8 July 2004. http://www.waterquality.crc.org.au/aboutdw_dwfacts.htm

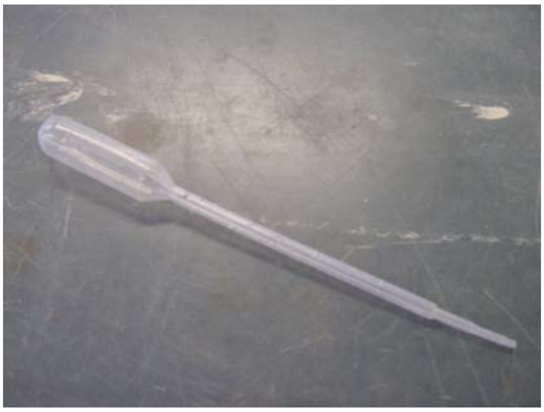
Part A: Coagulation and Flocculation

1. Fill the plastic jug with 2L of tap water.
2. Add the 1gram of soil to 2L of tap water.
3. Using the large stirring paddle mix and stir it well into a homogenous solution for ~1min. This represents the soil that can be eroded and washed into dams from catchment areas before the water is treated.

4. Using the 2L jug pour 500ml of the dirty solution into 4 separate containers, being careful you don't spill the water. Make sure they're as close to 500ml as possible.
5. Place the four containers in order, next to each other as shown below.



6. Leaving one of the 500ml containers as a control in this experiment, measure 1ml, 2ml, and 5ml with the mini plastic pipet from the Alum container supplied. Place the measured alum into the 25ml plastic beakers provided.



7. Place the corresponding 25ml plastic beakers next to the corresponding 500ml beaker. Repeat this for each of the quantities of alum.

8. Designate 1 person for each beaker to stir the mixtures and start each one at the same time.
9. Start the timer, from the moment you add the Alum solution to all mixtures. **Continue timing the entire activity.**
10. Add each alum solution (1ml, 2ml and 5ml) to the corresponding 500ml container and start to mix the solution with the paddles provided quickly for 1min. This is **flash mixing** so you need to do it fast and quickly (careful not to spill the dirty water). Make sure you stir the control too.

11. 

12. After ~1min start to stir slowly (continue the timer) continue to stir the solution for another 5min intermediately.

13. After a total of 6min stop stirring and remove the stirring wands. Let the solutions settle. Continue timing the activity.

14. Complete the Part Two questions, remembering to check the timer to obtain your results.

15. After 10min using the four corresponding 120ml plastic beakers, carefully pour the top layer of water from the 500ml plastic beakers into these, one by one, including the control water.

16. Place a sheet of white paper in front of the plastic 500ml beakers, line up the 120ml beakers on the white paper. Compare and contrast the appearance of the 4 samples. Continue to answer the questions in Part Two.

17. What do you observe? Does more alum take less time or more time to settle out? Is there an effect of increasing the alum? Is it economic to add more chemical?

18. After completing the **jar test** using alum, think about the following questions.

- What step in the Water Treatment Process is coagulation and flocculation?

Coagulation and Flocculation is the 1st steps in the WTP process. This is where coagulant is added (in this case, alum) and the mixture is stirred rapidly and then slowly. Then the particles settle out ready for the sedimentation process.

- What do you think you will observe in the water when you test your process?

The particles are settled out and the water becomes clearer.

- How do you think this process contributes to the overall water treatment process?

It allows water to be cleaned more quickly as the larger particles are removed at the beginning of the process.

- Did you even consider that treated water that comes out of your tap goes through many different processes?

The processes are vital to maintaining clean potable water to society.

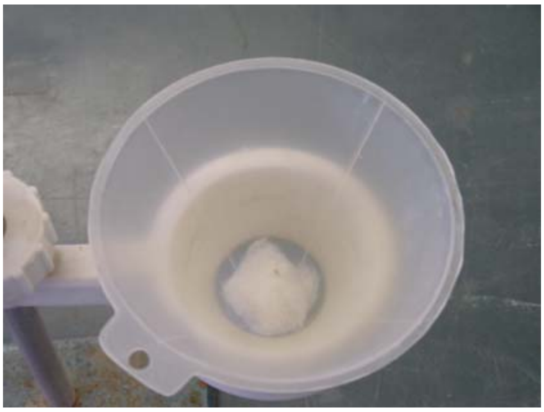
Part B: Filtration

1. Place the plastic funnel on the stand.

2. Using the plastic funnel, follow the steps to produce an individual filter for each group.

3. Place another marked 120ml beaker under the funnel, ready to collect the filtered water.

4. Place cotton wool at the bottom of the funnel.



5. Place the washed gravel into the funnel above the cotton wool.

6. Drain the water from the white sand and place the wet white sand above the gravel. Why does the sand have to be wet? What would happen if it's not wet?

The sand needs to be wet so the water solution can be absorbed more easily. If it was not wet there is a possibility that the water would catch dry sand particles and pull them through into the clean water.

7. Start to add the special coal on top of the sand layers (media layer).

8. You have made your filter.

9. Make sure you don't **scour** the top of the filter when you are pouring the water in as it lessens the effect of the filter.

10. It is now time to test the filter you have made. Flush clean tap water through the filter to dislodge loose media. Use the given "filtered control" container and then tip the water out and continue the activity.

11. Pick up the settled water from the coagulation and flocculation process and slowly start to pour this water sample into the filter and allow it to soak through, notice the clean water running through the tube into a new container.

12. Continue to pour the water through the filter until half is filtered ~60ml. Make sure there is always about 30mm from the top so that the water doesn't overflow.

13. Place the original 120ml beaker next to the filtered 120ml sample respectively and compare the results.

14. Discuss and comment on the clean water that has been produced by the filter. (Do not drink this water- it is not clean as the process is only to help you understand the WTP process.)

15. Why can't the WTP stop after this step of filtration? What follows Filtration? The water is clean however it needs to progress through the rest of the processes to become safe to drink.

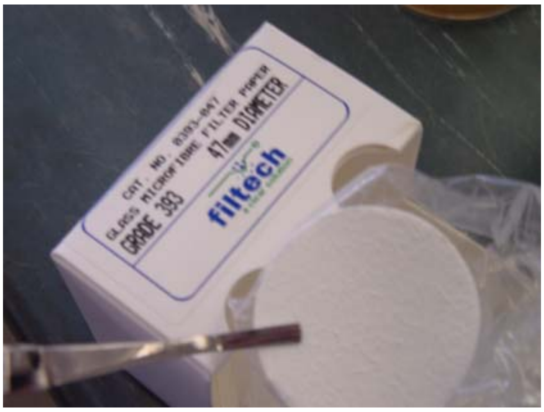
    After the filtration process the water needs to be disinfected and in some case fluoridised. It then goes into the distribution system where it gets stored in reservoirs ready for transport through pipes to your tap.

16. Fill out the filtration activity sheet.

17. Now its time to test the filter you have just constructed, using the laboratory filter provided.

18. Now unscrew the top of the laboratory filter off.

19. Using the tweezers, place a filter paper on the top of the plastic container.



20. Place the round lid on top and then screw the top section of the filter on, this should secure the filter paper.

21. Using the control water **only**, run through the unfiltered control water into the filter. Then using the pump draw the water through the filter into the container below.

22. Then release the pump by releasing the plastic nob on the side then take the pump off.

23. Screw off the top of the filter and remove the filter paper with the tweezers.

24. Place the filter onto another piece of white paper.

25. Repeat these steps with the filtered control water.

26. Note the difference between the filtered and the unfiltered filter paper. See below the samples and what you should observe.

Unfiltered Control Water Sample

Filtered Control Water Sample

27. After testing your filter, think about the following questions.

- Did the media filter work?
- What step in the Water Treatment Process is filtration?

Filtration is the 5th process. It is one of the last processes at the WTP before disinfection and the distribution system.

- What do you think you will observe in the water when you test your process?

After the filtration process you will hopefully see cleaner water.

- How do you think this process contributes to the overall water treatment process?

It is an important step that filters dirty water into clean, drinkable water. It is one of the only processes some WTP use and in that way a very important process.

DISCUSSION

1. Why do you think it is necessary to treat water for drinking?

Treating water is an important process in maintaining a healthy society. The treatment of water removes germs and viruses from the water that can cause disease and sickness in humans.

2. Can you identify which processes are the most important in treating drinking water?

All processes in the WTP are important however filtration is one of the most important processes as it cleans the water in an affective way.

3. Do you know where your water comes from (which WTP)?

Look on the Maps provided to see the closest WTP to your home.

- Mt Crosby Water Treatment
- North Pine Water

In Brisbane there are 3 treatment plants. Mt. Crosby water supplies Brisbane to area south of a line that roughly runs from Enoggera across to Nundah. We also supply Logan city, Ipswich City and when required Logan on- sell to Gold Coast City (last summer up to 50 ML/day). North Pine supply north of the same line and also to Redcliffe and supplement the Pine Shire and Caboolture's water. Please note that in winter, North Pine can be turned off for up to three months for economic &/or maintenance purposes and Mt. Crosby's two plants will supply all areas.

Part A – Coagulation and Flocculation:

1. What do you think would happen if you put more alum solution in the dirty water?

There is a threshold for the amount of alum what will affect different solutions that are what a jar test is actually for, to determine the amount of alum for each individual situation out on site, at the WTP.

2. How does the flash mixing assist the jar testing?

The flash mixing assists the jar test by allowing all the alum to be absorbed into the mixture. The flash mixing will allow the flocculation to be completed efficiently.

Part B – Filtration:

1. What do you think will happen if the water is dirtier (the river is polluted in real life?)

The jar testing will have a new threshold and you may need more alum to produce the correct sedimentation.

The filter will get dirtier quickly and this can produce an inefficient filter that does not clean the water properly. This is important in real life due to the fact that the filter needs to be backwashed more than regular to clean the media.

The media can get clogged up and produce unclean water.

2. If you had time you could add more dirt to the water and try the process again. What do you observe? Write down your observations?

If the water is dirtier the water will be cleaned but not as capably as if it was cleaner as the media gets clogged with the sediment through the water.

3. How have these minor modifications changed the way the treatment process is operating?

The minor change of dirtier water changes the flocculation and coagulation and then also changes the filters ability to produce clean water.
A stronger dose of alum may be needed and also the filter media may need to be altered to clean the water more thoroughly.

4. In real life how do Engineers rectify this situation?

Engineers in real life change the process by adding more alum or changing the filter material to capture the sediment as it passes through the filter.
In a laboratory, chemical engineers test the samples of untreated water to find the amount of alum that is required.

Discussion challenge:

- Discuss the advantages and disadvantages of treating water, cost, health, and environment?

The advantages of treating water are plentiful. The cost of treating water far out ways the cost of the health issues that arises from unclean water.
The health benefits from treating water can be seen in Australia compared to 3rd world countries that have increasingly more waterborne deceases.
The environment benefits for WTP's due to the fact that unclean water is purified and cleaned. The environmental aspect really plays apart with WWTP, as they clean the water before it renters the rivers and streams. So then the system continues and the water is re cleaned in the WTP.

- How does the distribution pipeline network change in real life and how does the demand of community change the quality of a WTP?

Depending on the distribution pipelines and whether it is a branched system or a linear system, will have a change ion the level f disinfection that the WTP needs to provide, so that there si always residue in the system.
Also the demand will affect the quality of the WTP as if there is a higher demand the water may not be as clean, over loading treatment plant or if there is not enough water can go stagnant in the tanks.

- What materials might Engineer use to design real WTP, concrete, steel?

The WTP are made on concrete tanks that are deep into the ground, they have steel and concrete pipes. All WTP are different. Take a look at some pictures of real WTP's in the South East Queensland region.

BACKGROUND INFORMATION:

When most Australians turn on a tap, clean, clear water runs out. But how does the local water supplier make sure the water is safe and pleasant to drink? The answer is likely to include some form of water treatment.

Most urban communities collect water from a natural water body in the catchment, whether a stream, river, or underground aquifer. The water collected may then be stored in a reservoir for some time.

Unless it is already of very high quality, it then undergoes various water treatment processes that remove any chemicals, organic substances or organisms that could be harmful to human health. The water is then delivered to the community through a network of mains and pipes called a distribution system.

Why learn about water:

- Water issues affect everyone.
- Understanding how water is supplied and managed assists in a better appreciation of this precious resource.

THE WATER CYCLE (HYDROLOGICAL CYCLE):

The movement of water above, on and below the earth's surface has no beginning or end.

Figure 2 WATER CYCLE

Securing Our Water Future. A State Water Strategy for Western Australia. 9 July 2004 www.watercorporation.com.au/Docs/State_Water_Strategy_complete.pdf

Surface Water- used to describe water on the earth's surface.

- Lakes and Reservoirs
- Rivers and Streams

Groundwater- all water that is beneath the earth's surface.

When we turn on the tap, start the washing machine or take a shower, we don't necessarily think of the sun and the rain, but that is where the water comes from. The process known as the water cycle begins with energy from the sun reaching water in oceans, seas, rivers and lakes. Water evaporates and becomes water vapour. As the water vapour rises, it cools and condenses into billions of droplets to form clouds.

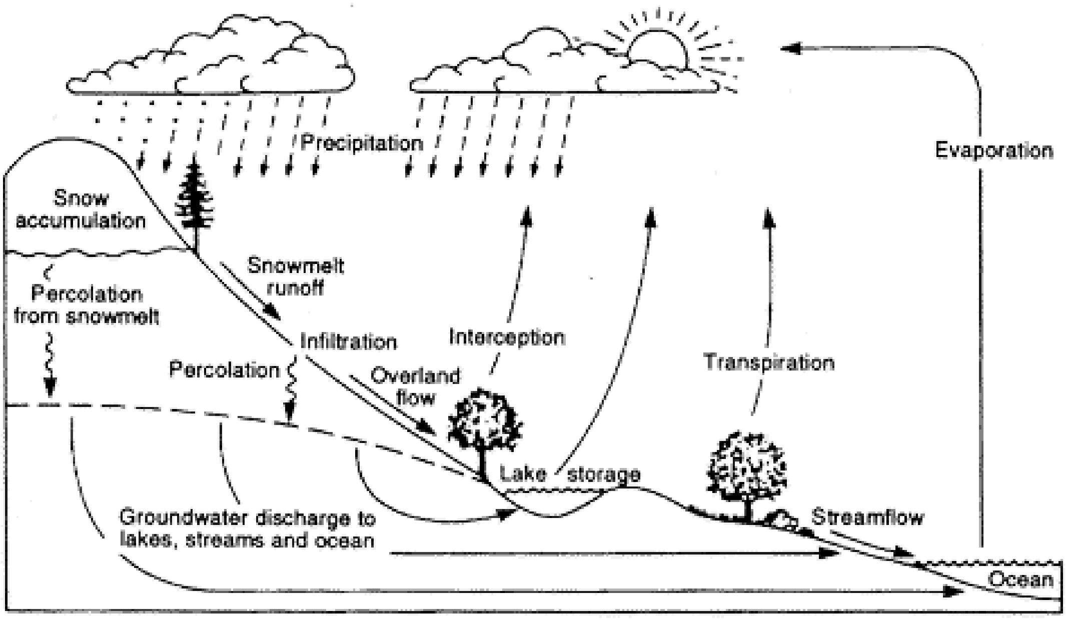
Vegetation is another source of water vapour. The roots of plants pump water out of the ground and pass it into the atmosphere in a process known as transpiration.

Clouds hold rainwater as long as they stay warm. If the air cools, the droplets merge until they are so heavy that they fall back to Earth as rain, hail or snow. The atmosphere is capable of holding about 10 days' supply of rain – enough to drop about 25 millimetres of freshwater over the entire surface of the planet.

Rain and snow falling within catchments can take several routes. Some evaporates, some seeps into the ground to become groundwater and some stays on or near the surface to form streams, and ultimately rivers.

The water cycle is also referred to as the hydrological cycle. Both terms describe the solar-powered system that provides freshwater to the land-based ecosystems upon which we depend.

The physical processes related to the movement and storage of water within the environment are seen in the diagram below:



Source: ANZECC & AWRC

Figure 3 WATER CYCLE

NSW EPA, What is Water Quality? 12 July 2004. http://www.epa.nsw.gov.au/envirom/waterqual.htm

HISTORY OF WATER TREATMENT - WHY TREAT WATER:

The importance of good drinking water in maintaining human health was recognised early in history. However, it took centuries before people understood that their senses alone were not adequate judges of water quality. The earliest water treatments were based on filtering and driven by the desire to remove the taste and appearance of particles in water. Filtration was established as an effective means of removing particles from water and widely adopted in Europe during the eighteenth century.

Exactly why a clean and reliable water supply was needed was not known until the second half of the nineteenth century, when the nature of infectious disease was first recognised and the ability of water supplies to transmit diseases such as cholera and typhoid was first demonstrated. After this, concerns about the quality of drinking water focused on disease-causing micro organisms (pathogens) in public water supplies.

Scientists discovered that visible cloudiness, or turbidity, not only made the water look unappealing; it could also indicate a health risk. The turbidity was caused by particles in water that could harbour pathogens.

As a result, drinking water treatment systems were designed to reduce turbidity, thereby removing pathogens that were causing typhoid, dysentery and cholera.

By the early twentieth century, better protection of water supplies from sewage pollution and simple but effective methods of water treatment (chlorination, sand filtration) had greatly reduced rates of waterborne disease in developed nations.

The water treatment processes developed in the 19th century and refined during the 20th century are simple in nature. However, engineers have since developed ways of making these processes happen faster, in a smaller area and in a more controlled way at lower cost.

As you will see in the coagulation and flocculation test (jar test), different amounts of alum in the process change the time the process takes to produce a result.

DIFFERENT TYPES OF PROCESSES:

- Collection of water from the dam or reservoir
- Coagulant (Alum and Lime added)
- Flocculation Tank
- Sedimentation Basin or Tank
- Sludge Collection
- Sludge Thickening
- Storage of sludge, reuse and disposal
- Filtration
- Disinfection and Fluoridation
- Water Storage
- Water Distribution

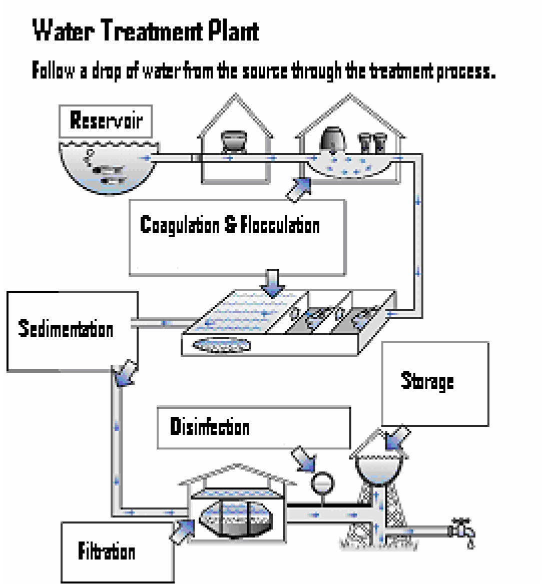


Figure 4 Water Treatment Process

Where does my drinking water come from and how is it treated?
9 September 2004
http://www.pueblo.gsa.gov/cic_text/health/watertap/ch3.pdf

COLLECTION OF WATER FROM DAMS:

The water is collected from the dams and reservoirs via a pump to the Water Treatment Plant.

The entire area from which a stream or river receives its water is called a catchment. A catchment is a natural drainage area, bounded by sloping ground, hills or mountains, from which water flows to a low point.

Virtually everybody lives in a catchment, which may include hundreds of sub-catchments. What happens in each of the smaller catchments will affect the main catchment.

The water that comes out of a tap once flowed across a catchment and that is why catchments are a crucial part of urban water systems.

The quality of the catchment determines the quality of the water harvested from it. Few communities have pristine water sources and the quality of water from most sources is at risk from activities occurring in the catchment.

Water resources can be classified as surface water or groundwater resources. In both cases the quality of the catchment determines the quality of the water harvested.

Groundwater is a significant source of supply in many parts of rural Australia. It is also a significant ongoing source for several major urban centres. In parts of inland Australia, water from the Great Artesian Basin is used for urban, agricultural and mining purposes.

COAGULATION AND FLOCCULATION:

Coagulation and Flocculation is a process where by adding aluminium sulfate to the raw water, settlement can be achieved in a considerably shorter time.

In traditional water treatment, certain chemicals are added to raw water to remove impurities. While some particles will spontaneously settle out from water on standing (a process called sedimentation), others will not. To cause particles that are slow to settle or are non-settling to settle out more readily, a soluble chemical or mixture of chemicals is added to the water. Such a chemical is called a coagulant and the process is called coagulation.

Coagulation/flocculation processes generally use aluminium sulphate (alum) or ferric chloride as the coagulant.

The process is controlled so that the coagulant chemicals are removed along with the contaminants.

A combination of coagulation/ flocculation/ sedimentation and filtration is the most widely applied water treatment technology around the world, used routinely for water treatment since the early part of the 20th century.

SEDIMENTATION BASINS AND TANKS:

Some particles will spontaneously settle out from standing water (a process called sedimentation).

Sedimentation is used to remove the majority of settleable solids from coagulated/flocculated raw water. The solids are removed before the water passes to the filter hence reducing the solids load on the filter and increasing the efficiency of the treatment plant.

SLUDGE COLLECTION AND THICKENING:

Sludge produced in water treatment processes is both a waste product and a resource. Normally, the sludge is contaminated by heavy metals and sometimes by organic micro pollutants. This makes it necessary to treat the sludge before the valuable products can be recovered.

The filter press is another process option available for dewatering sludge for final land disposal.

Figure 5 BELT FILTER PRESS

Dintrade EKOSEP, Effective Belt Filter Press. 12 September 2004
www.ekotuotanto.fi/

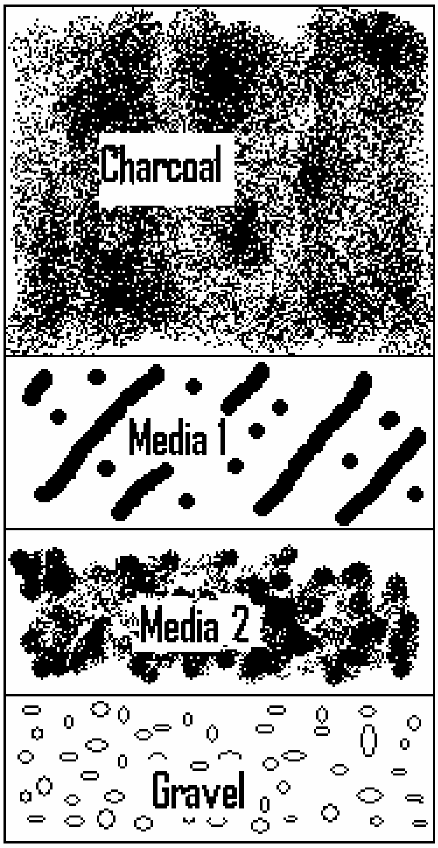
The sludge which gathers at the base of the mixing tanks is released into a valve and gravity fed through pipes to thickening tanks. At the thickening tanks the sludge is further processed and polyelectrolyte is added to help the settling process.

The sludge is dewatered on a belt press and then squeezed into a dry cake are produced. The conveyer belt collects the dry cake and it is transported into a storage tank.

FILTRATION:

One of the oldest and simplest processes used to treat water is to pass it through a bed of fine particles, usually sand. This process is called sand filtration. In its simplest form, the water is simply passed through the filter with no other pre-treatment, such as the addition of a coagulant. Usually this type of filter will remove fine suspended solids and also some other particles such as larger microorganisms.

Sand filtration is even more efficient when the water being treated passes through the sand filter very slowly. Over time the sand particles become covered with a thin surface layer of microorganisms. Some might refer to this layer as a slime but water scientists call it a biofilm. Even very small particles stick to this biofilm and are held, while water of greatly improved quality passes out through the filter.



Water Passes through charcol, sand and gravel layers

Figure 6 FILTER

Where does my drinking water come from and how is it treated?
9 September 2004
http://www.pueblo.gsa.gov/cic_text/health/watertap/ch3.pdf

First operating in London in the 19th century, slow sand filters are still widely used throughout the world today. Although very effective, they require a large area of land to achieve the sort of flows required by a large modern city. Additional processes may also be needed to achieve adequate water quality.

In the early 20th century, engineers developed rapid sand filters, which use high rates of water flow and sophisticated backwashing of the filter bed to remove trapped contaminants.

The sand filtration processes become less effective at removing fine suspended particles at higher water flow rates, the water must be pretreated – coagulated and flocculated – before passing through the filter bed. Such high rate direct filtration processes are widely applied to raw water with low levels of suspended matter.

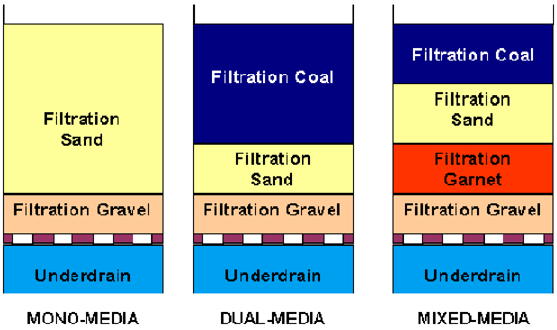


Figure 7 Types of Media Filters

River Sands, Product Range. 12 September 2004
http://www.riversands.com.au/Filtermedia/FProducts/FilterProductRange.htm

DISINFECTION:

Disinfection is carried out to kill harmful microorganisms that may be present in the water supply and to prevent microorganisms regrowing in the distribution systems.

Good public health owes a lot to the disinfection of water supplies. Without disinfection, waterborne disease becomes a problem, causing high infant mortality rates and low life expectancy. This remains the situation in some parts of the world.

Key factors considered by a water authority in selecting a disinfection system are:

- Effectiveness in killing a range of microorganisms.
- Potential to form possibly harmful disinfection byproducts.
- Ability of the disinfecting agent to remain effective in the water throughout the distribution system.
- Safety and ease of handling chemicals and equipment.
- Cost effectiveness.

A summary of each of the main disinfection processes is given below.

Chlorination

Chlorination is the most widely used disinfectant for drinking water in Australia. Its introduction a century ago removed the threat of cholera and typhoid from Australian cities.

It is cheap, easy to use, effective at low dose levels against a wide range of infectious microorganisms, and has a long history of safe use around the world.

Chloramination

Chloramines are produced when ammonia and chlorine are added to water together. They are less effective than chlorine in killing microorganisms because they are not as chemically active. However, chloramines maintain their disinfecting capability longer than chlorine and are ideal for very long distribution systems or for water supplies with long holding times in service reservoirs.

Ozone

Ozone (O_3) is the most powerful disinfectant used in water treatment. It is even effective against the difficult to treat protozoan parasites, Cryptosporidium and Giardia.

Ozone, which only recently began to be used in Australia, destroys soluble contaminants such as algal toxins, taste and odour compounds and trace levels of insecticides.

Ultraviolet irradiation
Ultraviolet radiation (UV) is a component of sunlight. Sunlight achieves disinfection by ultraviolet irradiation naturally. In water treatment, an appropriate level of UV irradiation, produced by mercury lamps, can kill bacteria and viruses. However, there is some uncertainty surrounding the effectiveness of UV irradiation against Cryptosporidium and Giardia.

UV irradiation adds no chemicals to water and uses equipment that is relatively simple to operate and maintain.

WATER STORAGE AND WATER DISTRIBUTION:

After treatment, drinking water is distributed via large trunk mains to water storage reservoirs. From these reservoirs water is reticulated to each household through a network of smaller water mains.

In some urban water systems, the water supply is obtained directly from a river or another body of freshwater. In others, rivers are dammed and the water supply is distributed from artificial storages, such as reservoirs.

Dams are built across rivers and streams to create reservoirs to collect water from catchments to ensure sufficient supply will be available when needed. Dams also have been built for a range of purposes besides water supply, such as agriculture and hydro-electricity generation.

Water may also be released from a reservoir as an "environmental flow" to maintain the health of the ecosystem downstream of the reservoir.

It is estimated that the significant reservoirs built around the world store five billion megalitres of water.

The water mains and pipes beneath the streets of a community are described as the water supply distribution system or reticulation system. As part of this system, strategically located service reservoirs store and supply enough water to meet local peak demand at sufficient pressure. These service reservoirs are often large covered tanks in an elevated position.

Pumps and valves also form an important part of the distribution system. The end points of the system are the consumers' taps.

After water has been treated to protect public health, improve aesthetics by removing colour and taste and odour as required, it is ready to be delivered to consumers. The system of mains and pipes used to deliver the water is known as the distribution, or reticulation, system.

Treated water may be held at a treatment plant or immediately discharged into the system of mains and pipes that will transport it to consumers' taps. On the way it may be held in short-term storages, usually known as service reservoirs, which are located as close as possible to where the water will be used.

Sufficient water is required in a local area to supply periods of high demand, as on a hot summer day.

From a design perspective, the needs of fire services usually determines the capacity of the system.

An important characteristic of a drinking water distribution system is that it is closed, to prevent contamination by birds, animals or people. In contrast, irrigation water is usually delivered in open channels or aqueducts.

A significant part of the water supply system lies buried underground. Out of the public eye, such infrastructure can be overlooked. It is easy to forget how valuable and essential water distribution systems are to the community. In terms of money spent on supplying water in Australia, most of it has been invested in the mains and pipes buried under the streets of towns and suburbs across the country.

Most distribution systems have developed and expanded as urban areas have grown. A map of a water distribution system would show a complex mixture of tree-like and looped pipe networks, together with valves and pumps.

Distribution systems require regular cleaning (flushing and scouring), maintenance and a program to replace pipes and other equipment as they near the end of their useful lives. Water mains can be expected to have a useful life of 40 to 100 years. Many of the pipes under the older parts of our cities may be towards the upper end of this range.

ALTERNATIVES TO TAP WATER:

What are the alternatives to tap water?

Boiled water: boiling water for one minute kills most harmful microbes but does not remove chemical contaminants. In fact, if water is boiled for longer than one minute, it can actually concentrate some chemicals.

Bottled water: while bottled water is generally of good quality, some brands are simply glorified tap water with basic filtering and a good marketing campaign.

Water filters: water filters can be installed either at the tap without a plumber, under the kitchen sink with a plumber, or at point of entry (i.e., installed on the main water supply). The most effective filter is generally thought to be a reverse-osmosis system, which filters out lead and other toxic metals and other contaminants. This type of filter can be expensive and the cartridges have to be replaced every year at an additional cost.

WATER QUALITY:

Water is essential to human life and to the health of the environment. As a valuable natural resource, it comprises marine, estuarine, freshwater (river and lakes) and groundwater environments, across coastal and inland areas. Water has two dimensions that are closely linked - quantity and quality.

Water quality is commonly defined by its physical, chemical, biological and aesthetic (appearance and smell) characteristics. A healthy environment is one in which the water quality supports a rich and varied community of organisms and protects public health.

Water quality in a body of water influences the way in which communities use the water for activities such as drinking, swimming or commercial purposes.

Why is water quality important?
Water resources are of major environmental, social and economic value to Australia, and if water quality becomes degraded this resource will lose its value. Water quality is important not only to protect public health - water provides ecosystem habitats, is used for farming, fishing and mining, and contributes to recreation and tourism.

If water quality is not maintained, it is not just the environment that will suffer - the commercial and recreational value of our water resources will also diminish.

How is water quality measured?
The presence of contaminants and the characteristics of water are used to indicate the quality of water. These water quality indicators can be categorised as:
Biological: bacteria, algae
Physical: temperature, turbidity and clarity, colour, salinity, suspended solids, dissolved solids
Chemical: pH, dissolved oxygen, biological oxygen demand, nutrients (including nitrogen and phosphorus), organic and inorganic compounds (including toxicants)
Aesthetic: odours, taints, colour, floating matter
Radioactive: alpha, beta and gamma radiation emitters

GLOSSARY:

Australian Drinking Water Guidelines – The key Australian reference to drinking water quality published by the National Health and Medical Research Council (NHMRC) and the Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ).

Backwashing – In water treatment, the process of reversing the flow of water back through the filter media to remove the entrapped solids.

Chloramines – Compounds formed by the reaction of hypochlorous acid (or aqueous chlorine) with ammonia. Used to disinfect water supplies.

Chlorination – The application of chlorine to water, generally for the purpose of disinfection.

Chlorinator – A mechanical device which is used to add chlorine to water.

Coagulation – The clumping together of very fine particles into larger particles caused by the use of chemicals (coagulants). The chemicals neutralise the electrical charges of the fine particles and destabilise the particles. This clumping together makes it easier to separate the solids from the water by settling, skimming, draining, or filtering.

Coliform – A group of bacteria found in the intestines of animals (including humans) and also in soil, vegetation and water.

Colloids – Very small, finely divided solids (particles that do not dissolve) that remain dispersed in a liquid for a long time due to their small size and electrical charge. When most of the particles in water have a negative electrical charge, they tend to repel each other. This repulsion prevents the particles from clumping together, becoming heavier, and settling out.

Condensation – The process of water vapour in the air turning into liquid water. Condensation is the opposite of evaporation.

Contaminant – Any physical, chemical, biological, or radiological substance or matter that has an adverse effect.

Disinfection – The process designed to kill most microorganisms in water, including essentially all pathogens.

Distribution system – A network of pipes leading from a water treatment plant to customers·plumbing systems.

Drinking water supplier – An organisation, agency or company that has responsibility and authority for treating and/or supplying drinking water.

Drinking water supply system / water supply system – All aspects from the point of collection of water to the consumer. It can include catchments, ground-water systems, source waters, storage reservoirs and intakes, treatment systems, service reservoirs and distribution systems, and consumers plumbing.

Evaporation: The process by which water or another liquid becomes a gas. Water from land areas, bodies of water, and all other moist surfaces is absorbed into the atmosphere as a vapour.

Filtration – A process for removing particles from water by passage through porous media.

Flocculation – The gathering together of fine particles in water by gentle mixing after the addition of coagulant chemicals to form larger particles.

Fluoridation – The addition of a chemical to increase the concentration of fluoride ions in drinking water to a predetermined optimum limit to reduce the incidence of tooth decay in children.

Giardia lamblia – a protozoan pathogen that can cause gastroenteritis (called giardiasis) if ingested. The infective form , known as a cyst, is shed in the faeces of people and animals.

Great Artesian Basin – Largest artesian ground-water basin in the world. It underlies approximately one-fifth of Australia and extends beneath the arid and semi-arid parts of Queensland, New South Wales, South Australia and the Northern Territory, stretching from the Great Dividing Range to the Lake Eyre depression. The Basin covers a total area of more than 1.7 million square kilometres and has an estimated water storage of 8,700 million megalitres.

Hydrology – The study of the occurrence, distribution and circulation of the natural waters of the earth.

Inorganic – Material such as sand, salt, iron, calcium salts and other mineral materials. Inorganic substances are of mineral origin. Also see organic.

Ion – An atom or group of atoms which has gained or lost electrons and carries an electric charge

Nutrient – Any substance that is assimilated (taken in) by organisms and promotes growth.

Organic – Substances that come from animal or plant sources. Organic substances always contain carbon.

Ozonation – The application of ozone to water for disinfection or for taste and odour control.

pH – A measure of the basic (alkaline) or acidic condition of a solution. A pH of less than 7 is acidic, of 7 is neutral and of more than 7 is alkaline. Natural waters usually have a pH between 6.5 and 8.5.

Potable water – Water that is safe and satisfactory for drinking and cooking.

Protozoa – Single-celled microscopic animal. Plural protozoa.

Quality – The totality of characteristics of an entity that bear on its ability to satisfy stated and implied needs.

Reservoir – Any natural or artificial holding area used to store, regulate, or control water.

Sand filter – Device to remove suspended solids from water by passage through a bed of sand.

Scouring – Interrupting the first layer of the filter so it is unusable.

Sediment – Usually applied to material suspended in water or recently deposited from suspension. In the plural the word is applied to all kinds of deposits from the waters of streams, lakes, or seas.

Sedimentation – A water treatment process in which solid particles settle out of the water being treated in a large clarifier or sedimentation basin.

Service pipe – A pipeline extending from the water main to the building served or to the consumers system.

Service reservoir/tank – A storage for drinking water generally within the distribution system used to meet fluctuating demands, accommodate emergency requirements and/or equalise operating pressures.

Surface water – All water naturally open to the atmosphere (rivers, lakes, reservoirs, streams, impoundments, seas, estuaries, etc.).

Total dissolved solids (TDS) – The concentration of dissolved solids in water. TDS is measured on a sample of water that has passed through a very fine mesh filter to remove suspended solids. The water passing through the filter is evaporated and the residue represents the dissolved solids.

Turbidity – The cloudy appearance of water caused by the presence of suspended and colloidal matter. The water quality parameter indicating the clarity of water. Turbidity is measured by the amount of light that is reflected off particles in the water. It is measured by a nephelometer in nephelometric turbidity units (NTU).

Virus – A large group of infectious agents, much smaller than bacteria, that are able to be viewed only through an electron microscope.

They are not cells, but biologically active particles that vary in size from 0.01 to 0.1 microns.

Water cycle – The circulation of water on Earth as it evaporates from the sea and lakes, condenses into clouds and falls again as precipitation (rain, hail, sleet, snow).

Water quality – A description of the chemical, physical and biological characteristics of water for a particular purpose.

Water supplier – The owner or operator of a public water system.

Water supply system – The collection, treatment, storage, and distribution of potable water from source to consumer.

Water table – The level of ground-water in an unconfined aquifer. This level can be very near the surface of the ground or far below it.

REFERENCES:

http://www.zesthealthclubs.com.au/pages.asp?page=nutrition&pubid=7&issid=48&artid=334&pgid=372[Accessed on 9/7/04]

http://www.vic.waterwatch.org.au/fortheteacher/manual/sect5a.htm [Accessed on 9/7/04]

http://www.actewagl.com.au/education/water/thehome.cfm [Accessed on 12/7/04]

http://www.waterquality.crc.org.au/DWFacts/DWFact_All_About_Water.pdf [Accessed on 9/7/04]

http://www.ourwater.vic.gov.au/ourwater/education/whylearnaboutwater.htm [Accessed on 12/7/04]

http://www.waterquality.crc.org.au/consumers/Consumersp4.htm#T1 [Accessed on 9/7/04]

http://www.waterquality.crc.org.au/consumers/Consumersp5.htm#T4 [Accessed on 9/7/04]

http://www.waterquality.crc.org.au/consumers/Consumersp8.htm [Accessed on 9/7/04]

http://www.waterquality.crc.org.au/consumers/Consumersp9.htm [Accessed on 9/7/04]

http://www.waterquality.crc.org.au/consumers/Consumersp11.htm#T2 [Accessed on 9/7/04]

http://www.waterquality.crc.org.au/consumers/Consumersp17.htm#T1[Accessed on 9/7/04]

http://www.kemira.com/water_treatment/english/Applications/Sludge+treatment/ [Accessed on 9/7/04]

http://www.epa.nsw.gov.au/envirom/waterqual.htm [Accessed on 12/7/04]

http://www.riversands.com.au/Filtermedia/FProducts/FilterProductRange.htm [Accessed on 12/9/04]

http://water.prsc.qld.gov.au/htm/waterTreatmentSupply/default.htm [Accessed on 12/9/04]

www.ekotuotanto.fi/ [Accessed on 12/9/04]

http://www.pueblo.gsa.gov/cic_text/health/watertap/ch3.pdf [Accessed on 9/9/04]

www.watercorporation.com.au/Docs/State_Water_Strategy_complete.pdf [Accessed on 9/7/04]

ACKNOWLEDGEMENTS

Created by Laura Winkle in the School of Civil Engineering, 2004