Water Quality Star Rating

From waste-d-water to pure water

Jenifer Simpson

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There were many who kindly helped me to gather material for this booklet — thanks to you all.

I would particularly like to acknowledge those who reviewed the book and provided some useful comments.

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I can no other answer make, but, thanks, and thanks - Shakespeare

About the author, Jenifer Simpson

Jenifer became interested in water management issues in 1992 and was struck by the profound lack of understanding in the community of this basic, essential and precious part of our lives. She has travelled widely to find out how water is managed in various parts of the world and visited over eighty water and wastewater treatment plants.

She has served on the Australian Water Association's Queensland Branch Committee where her role has been to help forge links between AWA and the broader community and raise awareness of water management issues.

In a voluntary capacity she was the principal author of the AWA's water education kit, *We All Use Water*. As Project Officer for Water Management Issues for the Sunshine Coast Environment Council, she is involved in water management issues in her local community.

Jenifer recognises that the lack of knowledge of water quality at all levels in the community is a barrier to sustainable water management

Foreword

The Hon Greg Hunt MP
Parliamentary Secretary to the Minister for the Environment and Heritage.
June 2006

Australia is in the midst of a water crisis, largely due to the failure of the states to invest in water infrastructure reform.

The major consequence of this failure is that the Australian states continue to dump almost 1800 billion litres of wastewater off our coasts each year while at the same time it is predicted that Australia will face a water shortage of around 1200 billion litres by 2030.

This use of coastal zones for raw and partially treated sewage discharge is a 19th century practice that is simply unacceptable in the 21st century. The states must embrace water recycling for industry and agriculture as the first step to addressing our nation's future water needs and ensuring the sustainability of our cities into the next century and beyond.

I commend any research and insight into water usage, and publications such as this help to encourage the public and all levels of government to recognise the importance of conserving our most valuable resource — water.

INTRODUCTION

We are dependent on water for our health and prosperity yet we know surprisingly little about it. We take for granted that good quality, safe water will come out of the tap when we turn it on and our used water will go 'away' when we pull the plug.

This book is concerned with the water that we use inside our home and its adventures after it leaves us. We will explore what we put into water and how it is taken out again.

Importantly we will address the issue of how we can be sure that it has been taken out. Sophisticated and efficient new technologies are now available and we need to take advantage of them, understand them and learn to trust them, in order that we may make the most of the water that is currently available to us.

The Star Rating System describes the quality of water as it becomes progressively cleaner. It is a community education tool, designed to enable lay people to take an unprejudiced and informed view of this important aspect of our health and well-being — it does not quantify water quality or conflict with water quality regulations or standards.

We take for granted that good quailty, safe water will come out of the tap when we turn it on and our used water will go 'away' when we pull the plug.

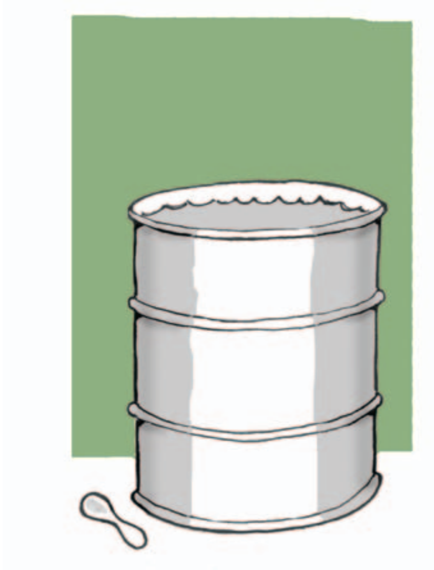
What do we put into water?

 All will come out in the washing - Miguel de Cervantes Saavedra

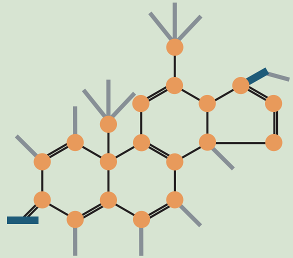
About half of the water that comes into our homes, that which we use inside the house, ends up at the sewage treatment plant.

We use it to wash our food, our dishes, our clothes and ourselves, and to flush away our personal waste. We use considerable amounts of it to carry away only a small quantity of dirt, so wastewater is mostly water — a 200-litre drum of it contains only about one tablespoon of dirt.

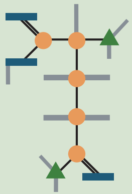
The dirt consists of organic molecules that contain carbon, inorganic molecules that do not contain carbon (except for carbonates), microorganisms and fine particles that are suspended in the water rather than dissolved.



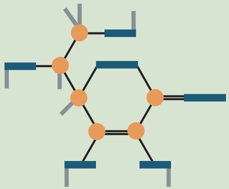
A 200 litre drum of wastewater contains only about one tablespoon of dirt.



Hormone:
testosterone



Amino acid:
glutamine



Vitamin C:
ascorbic acid

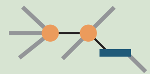
ORGANIC MATTER — THE STUFF OF LIFE

Carbon is very reactive so there are millions of organic compounds. Each atom has four bonds — it can attach itself to four other atoms at the same time. It has a particular affinity with hydrogen, oxygen, nitrogen and phosphorus and readily joins on to other carbon atoms.

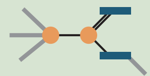
Some organic compounds are simple, such as ethanol or acetic acid (vinegar), but others are highly complex — carbon can form rings and long chains that may branch.

There are natural organic chemicals that living matter is made of — we are made of them and so is our food. They include compounds such as amino acids (the building blocks of proteins), sugars, fats, hormones and vitamins.

Some natural organic compounds are toxic, such as snake or spider venom, and others can cause allergic reactions.



Ethanol



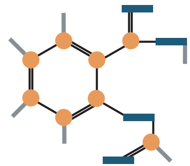
Acetic acid

SPECIALTY CHEMICALS

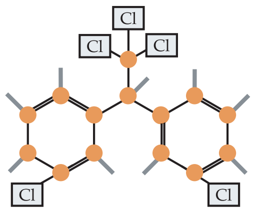
Synthetic, designer organic chemicals have been developed because they exhibit some quality or activity that is valuable to us.

Specialty chemicals include herbicides, insecticides, pharmaceuticals, food colouring and flavours, personal-care products, dyes and paints, adhesives, detergents, polymers and plastics — they are found just about everywhere in our modern lives.

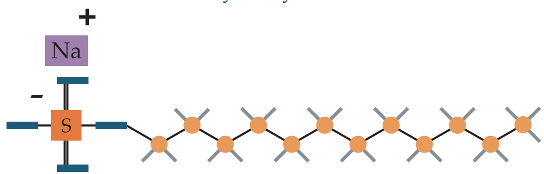
Some organic chemicals are easy to break down (they are biodegradable) but others do not degrade so easily.



Aspirin:
acetylsalicylic acid



DDT:
dichloro-diphenyl-trichloroethane



Surfactant:
sodium dodecyl sulphate

Chlorine Sodium Sulphur

INORGANIC MATTER

Most minerals are not a cause for concern in water — indeed we frequently go out of our way to buy water that contains minerals. Our water contains many natural minerals from the rocks the water has come into contact with on its journey to the water treatment plant. Some of these, such as iron and manganese, can be nuisances as they stain clothes and appliances, so they are treated before the water is supplied to us.

Inorganic compounds that need attention include heavy metals and nutrients.

Heavy metals

These can accumulate in our bodies and be detrimental to our health. They are usually found in trade waste and are effectively limited by efficient trade waste controls. They are easily removed by wastewater treatment and are not found in the effluent leaving the plant, but are accumulated in the biosolids.

Most minerals are not a cause for concern in water.

What do we put into water?

Nutrients: nitrogen and phosphorus

Nitrogen in the form of urea is a breakdown product of the proteins in plant and animal matter. We excrete urea in our urine but by the time it reaches the Sewage Treatment Plant (STP) most of it has reacted with water to form ammonia compounds.

Phosphorus also comes from plant and animal matter but at least half of the phosphorus found in sewage comes from the detergents we use.

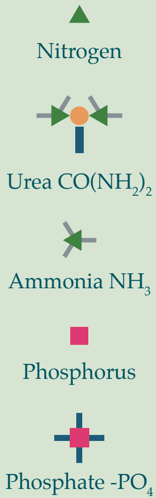


Photo: courtesy Mick Smith

Coughs and sneezes spread diseases

MICROORGANISMS

Microorganisms include bacteria, viruses and single celled organisms — protozoa. Those that cause infectious diseases are called pathogens.

Person to person is the most usual way a disease is transmitted. We can catch infections from coughs and sneezes, sexual activity, swimming pools, food, cuts and skin lesions and mosquitoes.

Bacteria

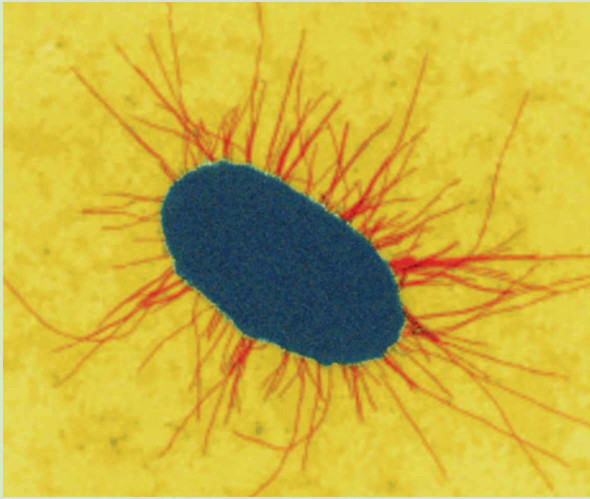
Bacteria are everywhere. They are relatively simple and the most abundant of all organisms. There are many thousands of different species and they are always around us — they are our constant companions. It is true to say that their presence in the right place and in the right quantity is essential to life. It is only when bacteria get into the wrong place, from a human point of view, that problems arise.

Only a few diseases are transmitted by water – person to person is the most usual way an infection is transmitted.

Bacteria can perform a large number of chemical transformations. For example, they are responsible for:

- fermentation — we use bacteria to produce wine, bread and cheese
- fixing nitrogen from the atmosphere so that plants can use it
- decay — including treating our wastewater.

Our lives depend on many of them. Faecal coliforms, such as *Escherichia coli (E. coli)* are found in the gut of humans and warm-blooded animals — without *E. coli* we would not be able to digest our food. Although few of them are themselves pathogens, they are used as indicator organisms to alert us to potential human contamination.



Escherichia coli

A few pathogenic bacteria can be transmitted by water. The main ones are:

- *Vibrio* (cholera)
- *Salmonella* (typhoid)
- *Mycobacterium* (tuberculosis)
- *Shigella* (bacterial dysentery)
- *Yersina* (plague) and
- *Camphylobacter* (gastroenteritis).

Water-transmitted diseases such as cholera and typhoid that ravaged communities in the past have been brought under control by good water management and vaccination.

Our immune systems keep pathogens at bay. Immunity is developed by exposure to the pathogens or by vaccination. Lack of exposure can put an individual at risk.

Water-transmitted diseases that ravaged communities in the past have been brought under control by good water management and vaccination.

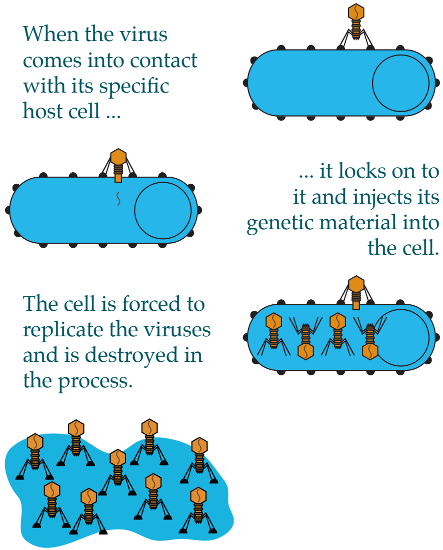
Viruses

Viruses are very small — an electron microscope is needed to see them. They are not typical living organisms for they don't take in food, get rid of waste or reproduce normally. A virus is just a package of genetic material.

Viruses are highly specialized and can only infect specific host cells so, for example, a virus that infects the liver cells of a rabbit cannot infect any other cells in the rabbit or the liver cells of any other animal. Very few viruses can cross species, rabies being one that can.

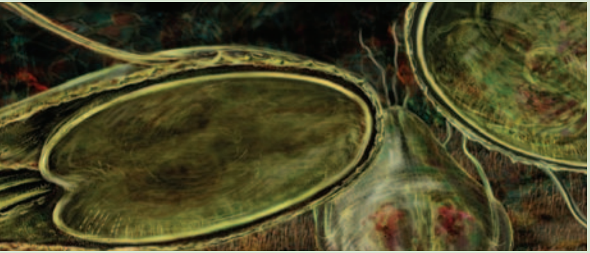
Viral infection does not always cause a disease — some hosts can have an infection without showing any symptoms whereas others can become very ill indeed.

Viruses found in water include *poliovirus, hepatitis A & E* and Norwalk Agent.



Viruses are just a package of genetic material. They are parasitic and destroy their host's cells when they replicate.

Cryptosporidium parvum



Giardia lamblia

Cryptosporidium and Giardia

These single celled organisms — protozoa — are parasitic and cause diarrhoea. They have relatively recently been identified so there are things we don't know about them, such as how many need to be ingested to cause an infection.

Although they are most often transmitted by direct contact, water, particularly in swimming pools, is commonly implicated. It is likely that these parasites have always been with us and generally our immune systems cope well.

They cannot multiply in water but can survive for long periods. Ingestion of their oocysts (eggs) can cause infection but these are relatively large and easy to filter.

SUSPENDED PARTICLES

Wastewater also contains some particles that are suspended in the water rather than dissolved in it. They include fine particles of silt, paper fibres and other insoluble matter. They cause the water to appear cloudy and coloured.

Our immune systems generally cope well with cryptosporidium and giardia.

THE SEWAGE TREATMENT PLANT

After the used water leaves our homes it goes through the sewerage system to the Sewage Treatment Plant (STP). Here Mother Nature's biological processes are used but they are speeded up.

Natural bacteria are given optimum conditions to enable them to carry out their chemical transformations quickly and efficiently.

In more advanced plants several types of bacteria requiring varying conditions are used to reduce the amounts of the pollutants. The wastewater therefore passes through several zones where the different conditions are provided.

Plants vary in size and complexity and so does the quality of their products — effluent (the liquid part) and biosolids (the solid part).

Photo: courtesy Maroochy Water Services

Sewage treatment plants vary in size and complexity and so does the quality of their products - effluent and biosolids.

The Visitors' Centre at Singapore's NEWater reclamation plant.

WHY DO WE TREAT SEWAGE?

The main reason that we developed the sewerage system was to protect human health. We did this by ensuring that our sewage and water supply were kept apart.

Originally wastewater was collected into sewers and discharged into the nearest waterway. This improved our health but it caused environmental problems. Our rivers were suffering because natural processes were too slow to keep up with the impact of our waste.

Various methods were introduced to clean the sewage before disposing of it. The technology available to do this has become more efficient and effective over the years and new methods are still being found today.

Modern technology allows us to recycle water - NEWater in Singapore is used for microchip production and to replenish reservoirs.

A TIME FOR CHANGE

Traditionally we have tried to keep our drinking water supply and wastewater separate — as far apart as possible — both physically and mentally. As a consequence, we think about the urban water 'cycle' as a straight line from dam to disposal. There are problems at both ends of the pipeline — a shortage at one end and pollution and waste at the other.

The separation is an illusion. In most parts of the western world water has been recycled for many decades when a town upstream discharges its effluent to become the water supply for the next town downstream.

Increasing population and climate change have put pressure on our water supplies and we are facing shortages. We need to change the way we think about urban water management, acknowledge that recycling is already happening and do it more and better.

New technology allows us to reclaim water so that it can be recycled. We can no longer afford to use water once and throw it away.

How do we take it out again?

QUALITY — NOT DEGREE OF TREATMENT

Effluent quality is currently described in terms of the degree of treatment it has received — primary, secondary, advanced secondary and tertiary. The terms are not well defined and are meaningless to the layperson who wants to know what the water can safely be used for, so we use the Star Rating System to describe water quality. This takes us from 0-star waste-d-water to 6-star water that is as pure as modern technology can make it.

WATER QUALITY STAR RATING

No-Star Wastewater

Domestic sewage and trade waste.

Should not be discharged or used without treatment.

★

One-Star Effluent

Screened to remove large particles.

Should not be discharged or used without further treatment.

★★

Two-Star Effluent

Biodegradable organic material reduced. Usually disinfected.

May be discharged into some waterways or applied to land in controlled conditions.

★★★

Three-Star Effluent

Nearly all biodegradable organic material removed and nutrient content reduced (either nitrogen or both nitrogen and phosphorus). Usually disinfected.

May be discharged to sensitive waterways or land with approval of the regulating authority.

Four-Star Reclaimed Water

Has received treatment so that its quality is fit-for-purpose.

Treatment and monitoring have been carefully considered so that its quality is suitable and safe for its application.

May be used for industrial processes, irrigation of public areas and crops for consumption, environmental flows or dual reticulation.

Five-Star Drinking Water

Treated sufficiently for human consumption and conforms to Australian Drinking Water Guidelines.

Risk management and monitoring must conform to specified quality assurance procedures.

Six-Star Purer than Drinking Water

Has had modern advanced treatments and is as pure as it is possible for water to be.

May be used for kidney dialysis and industrial processes such as pharmaceutical manufacturing, boiler-feed water, carbon chip washing. May be blended with other water supplies.

... to six-star highly purified water.

ZERO-STAR WASTEWATER

Zero-star wastewater is made up of domestic sewage and trade waste.

Most water authorities have an effective trade waste policy and require pre-treatment for wastes not fully treatable at their plants. Some wastes should not be put down the drain at all — these include heavy metals, fats and oils and products that affect the bacteria in the reactor tanks.

Organic matter and nutrients are the most important pollutants to control if effluent is discharged to a waterway.

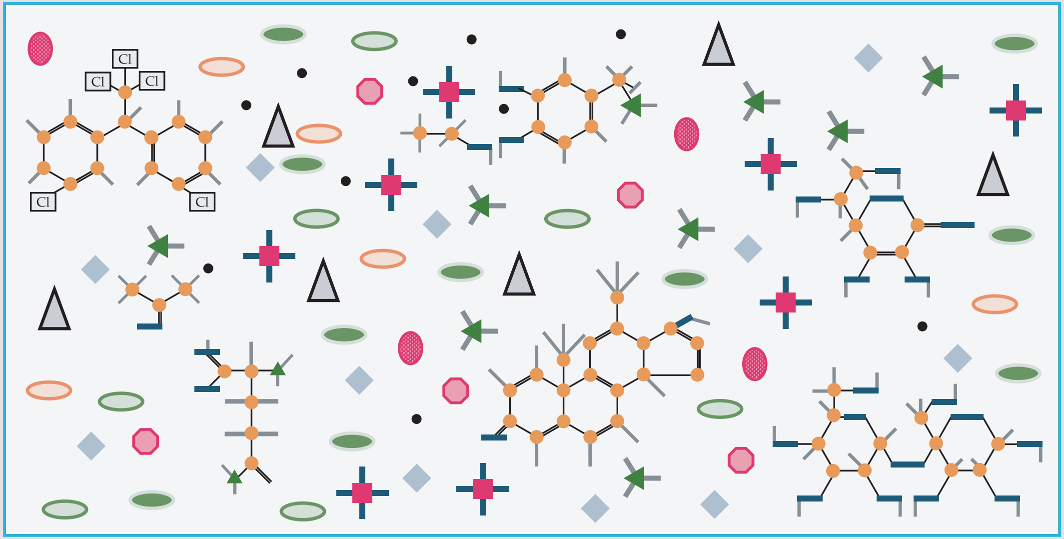
Wastewater also contains ‘rags’ and ‘sticks’ — euphemisms for the assortment of larger objects, such as sanitary items, cotton wool buds, sandshoes, money, dolls — it’s amazing what finds its way to the STP!

ONE-STAR EFFLUENT

A screen removes the larger particles from the wastewater so as to protect downstream units.

The effluent is not of good quality and should not be discharged or used without further treatment — but it has had some treatment so it is awarded a star.

A screen removes the larger particles from the wastewater so as to protect downstream units.



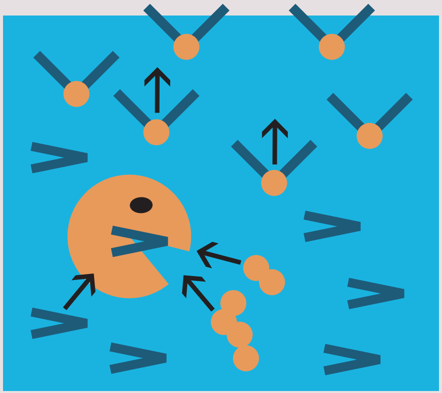
★

ONE-STAR EFFLUENT

- Carbon
- Hydrogen
- Oxygen
- Suspended solids
- Inorganics
- Nitrogen
- Phosphorus
- Giardia
- Cryptosporidium
- Virus

Bacteria

- Coliforms
- Pathogens
- Other



Carbon-eating bacteria take in carbon and oxygen and give out carbon dioxide.

$$C + O_2 \rightarrow CO_2$$

TWO-STAR EFFLUENT

The organic matter in the wastewater is digested by carbon-eating microorganisms whose activities are speeded up by the introduction of plenty of air.

As soon as food becomes available the bacteria feed, grow and divide repeatedly to produce millions more of their kind and they continue to do so until the food is used up or the conditions change.

Much of the organic matter is broken down and converted to carbon dioxide and water but the less biodegradable compounds remain. Disinfection is less efficient than with a clearer effluent.

Two-star effluent may be discharged into waterways that have adequate flow to dilute the pollutants, or applied to land in controlled conditions.

Carbon-eating microorganisms convert organic compounds into carbon dioxide, that escapes into the air, and water.

CARBON REDUCTION

A trickling filter plant is an example of technology that reduces the amount of carbon molecules so as to produce two-star effluent. The wastewater is sprayed from a rotating arm over rocks that grow slime on their surface in which live many bacteria and larger organisms. There are spaces between the rocks so the bacteria have access to plenty of air.

The rotating arms are hydraulically driven — the water passing through them causes them to rotate so they can reliably and cheaply produce a two-star, carbon-reduced effluent.

After the effluent has passed through the trickling filter it is clarified when the heavier particles are allowed to settle out and the clearer top layer of water is separated from the sludge.

Trickling filter plants reliably and cheaply produce a 2-star, carbon-reduced effluent.

★★

TWO-STAR EFFLUENT

Carbon
Hydrogen
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Suspended solids
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Phosphorus
Giardia
Cryptosporidium
Virus
Bacteria
Coliforms
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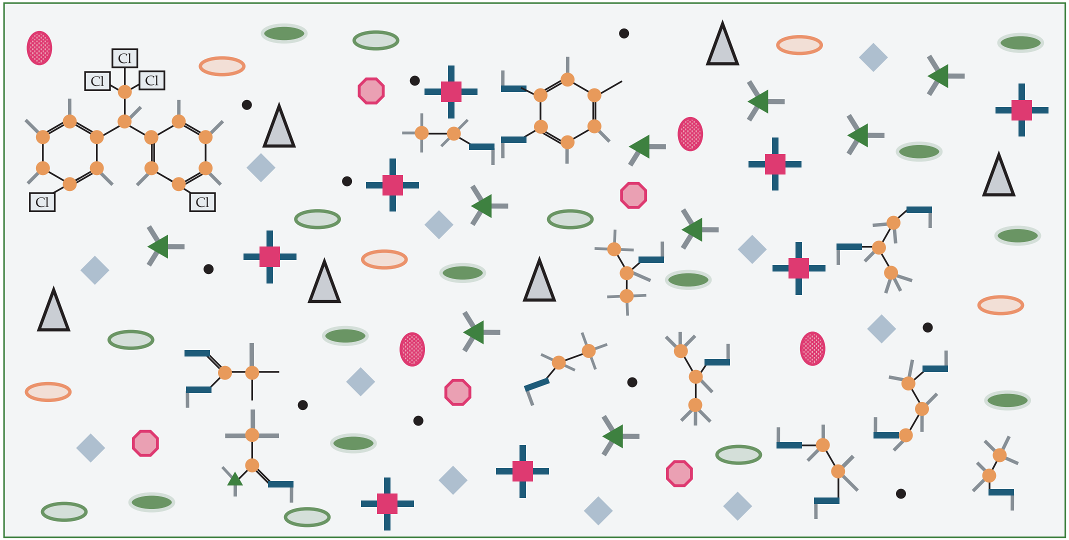
Other



THREE-STAR EFFLUENT

Three-star effluent has had nearly all of the biodegradable organic material removed and the nutrient content reduced — in some plants just nitrogen and, in others, both nitrogen and phosphorus. It is usually disinfected before it is discharged.

The nutrients are reduced by allowing the effluent to flow through different zones in the plant where conditions are made ideal to enable the various bacteria to perform their work. The conditions are varied by controlling the amount of oxygen that is available, either dissolved in the water or combined with other molecules.

The reactor tanks of activated sludge plants have two zones, aerobic and anoxic and can achieve nitrogen reduction, but in modern biological nutrient reduction (BNR) plants a third zone, the anaerobic zone, is added to allow the amount of phosphorus to be reduced.

Aerobic zone - plenty of oxygen both dissolved and attached to other molecules

Anoxic zone - no dissolved oxygen but present attached to other molecules

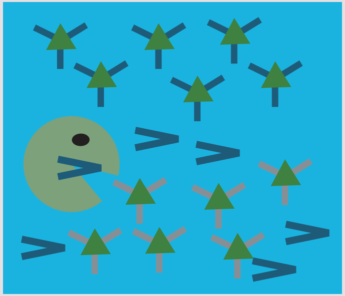
Anaerobic sone - no oxygen either dissolved or attached to other molecules

The different conditions in the zones of the reactor tank promote the activities of the various species of bacteria.

ACTIVATED SLUDGE — NITROGEN REDUCTION

The sludge that settles at the bottom of the reactor tank contains billions of actively growing bacteria. A portion of this 'activated sludge' is returned to the beginning of the reactor tank to re-seed the new sewage entering the tank.

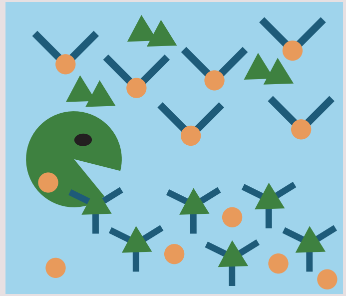
The different zones in the tank are achieved either by alternating periods when the tanks are aerated and when they are not, or by moving the effluent into different areas that provide the varying conditions.



Nitrification

In the aerobic zone, where there is plenty of oxygen, ammonia is oxidised to form nitrate.

$$NH_3 + O_2 \rightarrow -NO_3 + H_2O$$



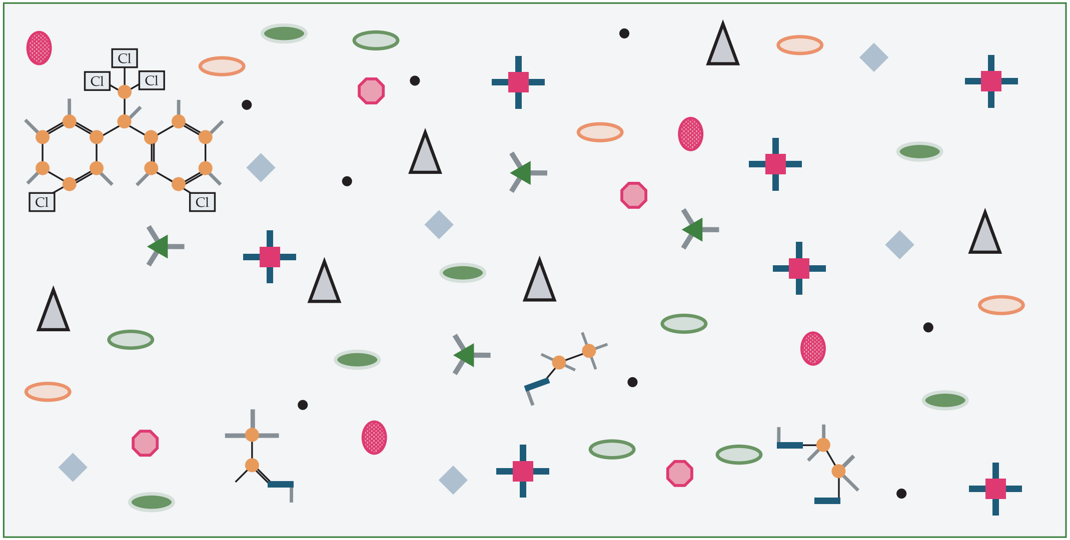
Denitrification

In the anoxic zone, other bacteria use more carbon and the oxygen in the nitrate make nitrogen gas and carbon dioxide.

$$-NO_3 + C \rightarrow N_2 + CO_2$$

The ammonia is firstly oxidised to nitrate and then reduced to nitrogen gas.

How do we take it out again?



★★★

THREE-STAR EFFLUENT

NITROGEN REDUCED

- Carbon
- Hydrogen
- Oxygen
- Suspended solids
- Inorganics
- Nitrogen
- Phosphorus
- Giardia
- Cryptosporidium
- Virus

Bacteria

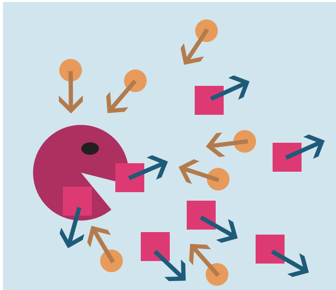
- Coliforms
- Pathogens
- Other

BIOLOGICAL NUTRIENT REDUCTION

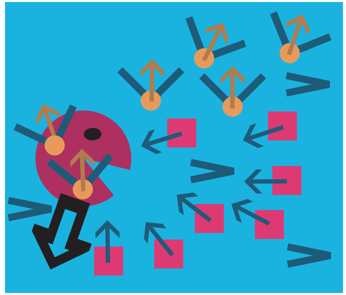
Nitrogen and Phosphorus Reduction

Modern Biological Nutrient Reduction (BNR) plants reduce phosphorus as well as nitrogen and carbon and can produce a very high quality effluent.

- Carbon
- Carbon dioxide
- Oxygen
- Phosphorus



In the anaerobic zone the phosphorus-seeking bacteria, in the absence of oxygen, are stressed. They spit out any phosphates they have absorbed and take up small carbon compounds instead.



When oxygen becomes plentiful in the aerobic zone, they use up their stored carbon and take up phosphates. They become heavy and sink into the sludge.

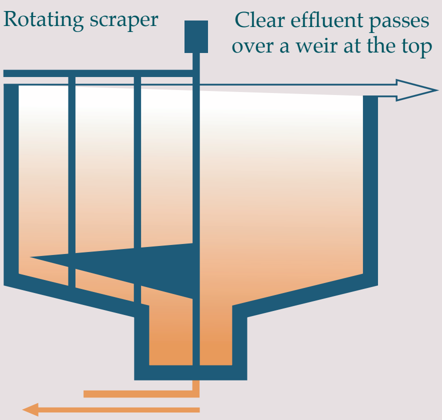
The effluent passes through a clarifier to separate the clear water from the sludge. Some of the sludge is re-circulated to ensure there is a high population of bacteria in the reactor tank.

Activated sludge treatment is very effective for removing hormonal activity from effluent.

The quality of three-star effluent is variable but it is generally suitable for discharge to land or to sensitive waterways that cannot tolerate high nutrient levels. It may be filtered through sand and is usually disinfected with chlorine or UV radiation before discharge.

Modern BNR plants can produce a very high quality clear effluent, in which the nitrogen content is less than 5 mg per litre and the phosphorus less than 1 mg per litre. Its good, clear quality enables disinfection to be efficient.

CLARIFIER



The clear effluent is separated from the sludge in a clarifier.

★★★

THREE-STAR EFFLUENT

N & P REDUCED & DISINFECTED

Carbon
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Suspended solids
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Nitrogen
Phosphorus
Giardia
Cryptosporidium
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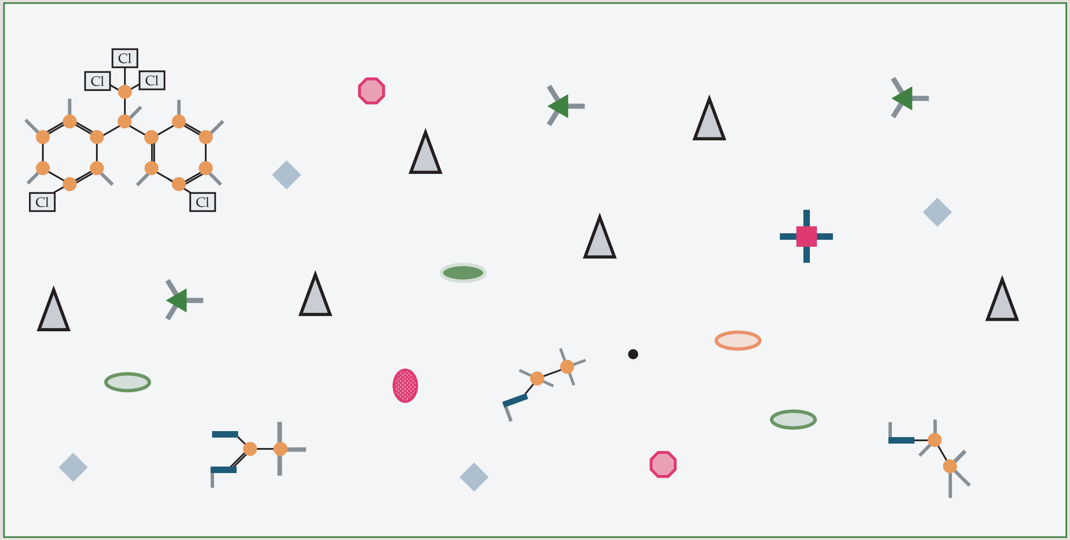
Other



FOUR-STAR RECLAIMED WATER

The quality of four-star reclaimed water is variable; it has received its fourth star because its quality is 'fit-for-purpose' for its intended use. It could be that three-star effluent will need no further treatment to attain the quality needed for some recycling opportunities but, for others, additional advanced treatments may be required.

The fourth star is awarded because the treatment the water has received and its monitoring have been carefully considered. Its quality is suitable for its application but it has not been unnecessarily and expensively over-purified. The assessment is made with reference to the relevant State or National Guidelines.

It may be used for industrial processes — large users of water include power stations, mines, pulp mills and refineries. Four-star reclaimed water may also be used for irrigation of public areas or crops for consumption, for dual reticulation and for environmental flows.

Four-star reclaimed water has received its fourth star because its quality has been carefully considered and it is 'fit-for-purpose' for its intended use.

ADVANCED TREATMENTS

Advanced treatments to improve water quality include:

- constructed wetlands
- ultra-violet light
- ozone and activated carbon
- conventional filtration
- membrane filtration.

Existing technologies are becoming more efficient, less energy consumptive and cheaper. New technologies are constantly being developed.

Constructed wetlands

Specially constructed wetlands may be used to polish the effluent from a conventional treatment plant. Nitrogen and phosphorus accumulate in the biomass and soils. They reduce the nutrients and take up heavy metals. They should be harvested regularly so that their ability to absorb pollutants is maintained.

Ultra-violet light

UV radiation occurs naturally in sunlight and can also be generated

As well as having the ability to reduce pollutants, wetlands are pleasant recreational areas.

by mercury lamps. It is a potent disinfectant and helps to breakdown organic molecules.

Ozone

Ozone is an activated form of oxygen with three atoms per molecule instead of the usual two. This extra oxygen atom makes ozone a highly energetic oxidiser and an efficient natural purifying agent. It is usually generated onsite by passing an electric current through air or oxygen just like lightning does in a thunderstorm. It breaks down resistant organic molecules and is an effective disinfectant. It may lead to the formation of by-products so it is usually followed by activated carbon filtration.

Activated carbon

Activated carbon (charcoal) is made heating carbonaceous material such as coconut shells, coal or wood, in the absence of air. Pores are formed on the surface of the carbon and organic molecules lodge in them.

Ozone generators

Photo: courtesy Aquagen

Ozone is very efficient at breaking down resistant organic molecules and as a disinfectant.

MEMCOR® Memjet™ Rack Assembly

Conventional filtration

Water may be filtered by allowing it to seep through a thick bed of sand. Other media of varying particle size and density are available — some filters involve the use of beds of mixed media. Moving-bed filters of various designs are also available.

Filters need to be backwashed regularly in order to remove the build up of contaminants they collect so that they maintain their efficiency.

Membrane filtration

Membrane filtration can be used to produce high quality water and to desalinate seawater. The membranes are made out of plastic or ceramic and are classified into four types depending on their pore sizes.

The smaller the pore and the greater quantity of pollutants, the more energy needed.

The waste stream has to be carefully managed.

Membrane filtration can be used to produce high quality water and to desalinate seawater.

MEMBRANE FILTRATION

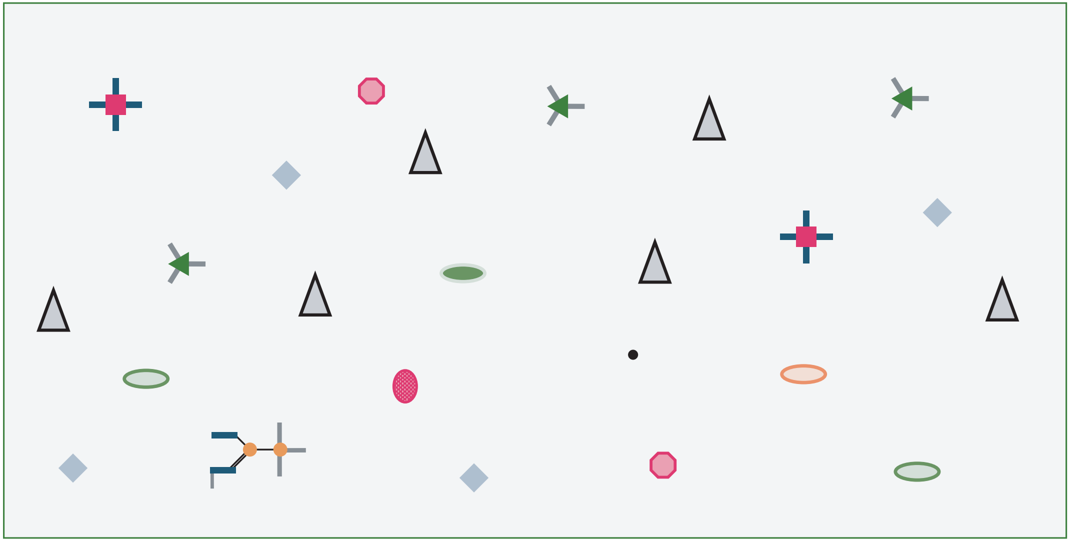
Sand filter 10 microns	most silt and fine sand, hair, yeast, micro-organisms attached to particles
Microfiltration 0.1 micron	pollen, most silt and all fine sand, all colloids, all bacteria, large viruses, all protozoa cysts
Ultrafiltration 0.01 micron	most silt, colloids, bacteria, viruses and protozoa cysts, large organic molecules, some pesticides
Nanofiltration 0.001 micron	most organic molecules, dissolved metals and salts except for some small ions (sodium and chloride)
Reverse osmosis 0.0001 micron	most organic molecules, dissolved metals and salts including sodium and chloride

FOUR-STAR RECLAIMED WATER

Carbon
Hydrogen
Oxygen
Suspended solids
Inorganics
Nitrogen
Phosphorus
Giardia
Cryptosporidium
Virus

Bacteria

Coliforms
Pathogens
Other



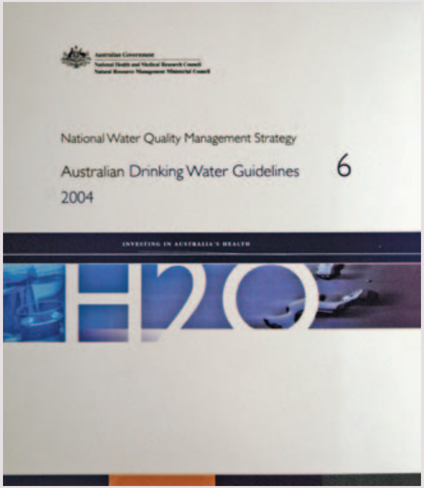
FIVE-STAR DRINKING WATER

Five-star drinking water has been treated sufficiently for human consumption and it conforms to the Australian Drinking Water Guidelines.

Several barriers to each pollutant are used to ensure that if the first and second treatment processes do not reduce them to undetectable or acceptable levels then the subsequent treatment processes will.

Hazard Analysis and Critical Control Point (HACCP)

HACCP was initially developed to ensure that food for astronauts was safe. Traditionally, industry and regulators have depended on spot-checks of manufacturing conditions and random sampling of final products to ensure safe food; in contrast, HACCP focuses on identifying and preventing hazards and managing risk.



Reproduced with permission from NHMRC

The water reclamation plant in Windhoek, Namibia

Photo: courtesy Dr. Gunter Lempert

HACCP is now established as the food safety standard throughout the USA and it is being adopted in Australia for both food and water.

The HACCP based approach for water recommends a multi-barrier system based on sound science. The system is equally applicable to water that has been recycled.

In Windhoek, Namibia, they have been proudly recycling water directly into their drinking supplies for nearly 40 years.


FIVE-STAR DRINKING WATER
Carbon
Hydrogen
Oxygen
Suspended solids
Inorganics
Nitrogen
Phosphorus
Giardia
Cryptosporidium
Virus
Bacteria
Coliforms
Pathogens
Other

The pollutants in 6-star water are undetectable – they are at less than one part per trillion.

1 min in 2 million yrs.

A person drinking 2 litres of 6-star water daily would need 138,000 years to consume 100 mg of a pharmaceutical product.

SIX-STAR — PURER THAN DRINKING WATER

Six-star water is as pure as it is possible for water to be and has had the most advanced treatments available.

The treatment train comprises of several barriers to each pollutant so that if the first barrier does not remove it, several others will follow. Two-stage membrane filtration, which includes reverse osmosis, is used to produce six-star water and this is complemented by advanced oxidation and disinfection. Online monitoring is important in order to ensure the plant is working efficiently.

Water of such high quality is required for kidney dialysis and industrial processes such as pharmaceutical manufacturing, boiler-feed water and carbon chip washing, or for best-practice recycling to replenish drinking water supplies.

As six-star water lacks any minerals, these should be added if it is to be used as a regular water supply.

We drink 2 litres of water daily so a person drinking only six-star water would need 138,000 year to consume the equivalent of one 100 mg tablet of a pharmaceutical product.

★★★★★★

SIX-STAR PURER THAN DRINKING WATER

- Carbon
- Hydrogen
- Oxygen
- Suspended solids
- Inorganics
- Nitrogen
- Phosphorus
- Giardia
- Cryptosporidium
- Virus

Bacteria

- Coliforms
- Pathogens
- Other

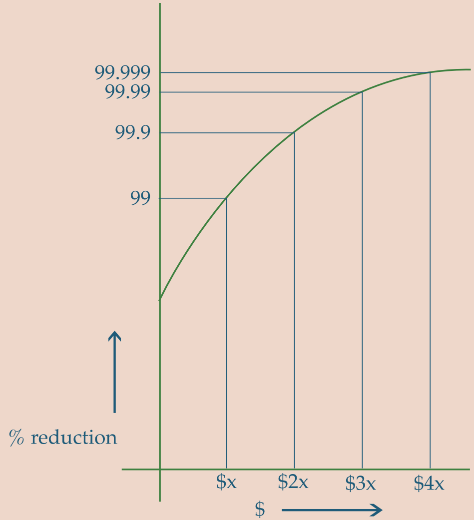
How do we know that it has been taken out?

Doubt is not a pleasant condition but certainty is absurd - Voltaire

CAN WE BE SURE?

There is no such thing as zero risk — it is a risk to get out of bed in the morning but probably a greater risk not to. We can, however, reduce risk to an acceptable level.

It is relatively easy and inexpensive to remove 99% of pathogens or pollutants from water but it costs a lot more to remove 99.9% of them and much more again to remove 99.99%. As we continue to purify the water it costs an ever-increasing amount of money to remove ever-decreasing amounts of pollutants. Eventually there is so little left that we cannot detect it — the stage is reached where the risk is reduced to a point where it is insignificant and further expense is not justified.



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REAL RISK V. PERCEIVED RISK

We are, at times, irrational and react to our perception of the risk rather than the risk itself.

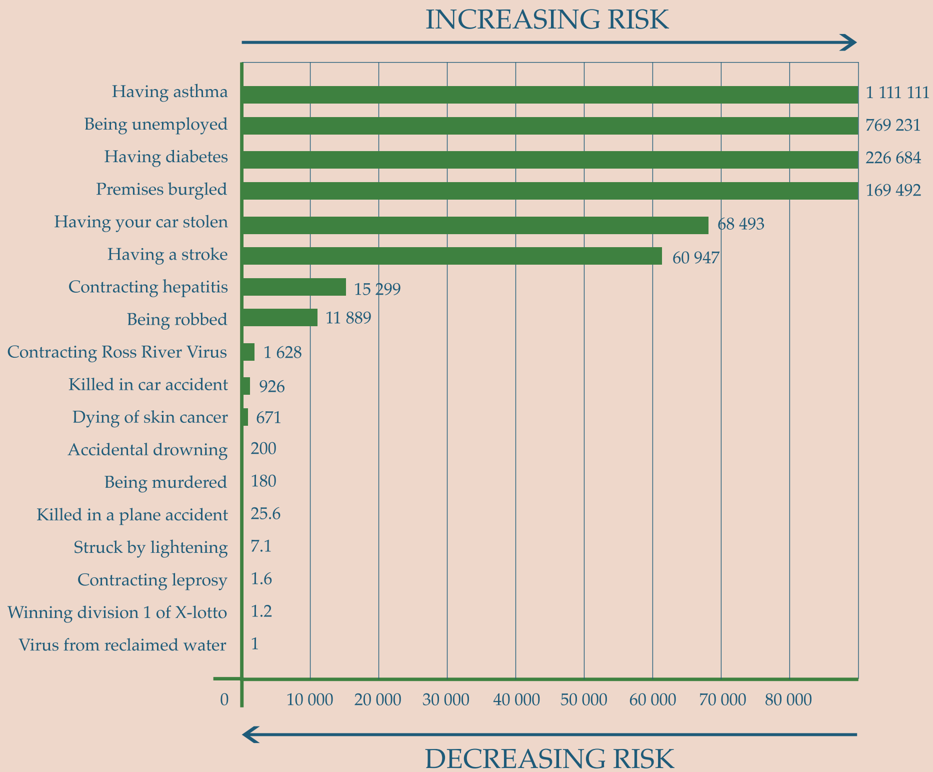
We are generally more accepting of risks that:

- we voluntarily expose ourselves to, as opposed to those over which we have no control
- are natural, as opposed to human made
- are familiar, as opposed to unfamiliar
- we have a good understanding of, as opposed to 'fear of the unknown'.

WE CAN MEASURE RISK

It is possible to quantify a risk and compare it to other risks. Risk depends on exposure and effect. How likely are we to come into contact with the hazard and how much of it is required to cause harm? How much harm will it do?

How do we know that it has been taken out?



Chance in 10, 000, 000 million Australians (adapted from ABS 1997; Kelly & Stevens, 2001)

The risk of being killed in a car accident is a thousand times more likely than catching a treatable viral infection from recycled water.

IT'S UP TO US

We could spend a great deal of money removing from our water the last molecule of a chemical that might cause us harm, only to find that we regularly consume significant quantities of it in our food.

Perhaps the money would be better spent on reducing risk in other areas of our lives — how do the risks from recycled water compare with those caused by food, alcohol, smoking or driving?

It is up to the community to decide where our money is best spent.

When we are considering how we should be managing our water in the future it is important that we have accurate knowledge and a realistic perspective.

It's pointless to spend all our money plastering up a pin-prick hole in one side of a bucket with million dollar notes if there is a gaping hole on the other side.

WATER QUALITY STAR RATING — FROM WASTE-D-WATER TO PURE WATER

Jenifer Simpson takes the premise that ‘we can no longer afford to use our water once and throw it away’ and builds a case for rethinking our attitudes to waste-d-water.

In this highly readable guide, we discover what we put into water, how we take it out again and how we can be sure that it has been taken out.

She understands that the community is not interested in where the water has been or how much treatment it has had — we want to know what it can safely be used for. Moving away from the largely misunderstood ‘primary, secondary, tertiary’ descriptions of effluent quality, she introduces a stunningly logical concept — she awards stars. The more stars, the more opportunities to reuse this precious resource — simple and straightforward — just like the booklet itself.

The technical content is easy to follow — and the conclusions that she arrives at are not only common sense — but urgent.