

## Ecology of Disease

Weekly theme: **WATER**  
Lecture: **Recycled water**



Prof Peter O'Donoghue

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## Drinking water

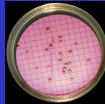
Government regulations governing potable waters

- free of pathogenic microbes (esp. coliforms)
- free of dangerous chemicals (esp. toxins, carcinogens, teratogens)
- suitable taste, colour, odour

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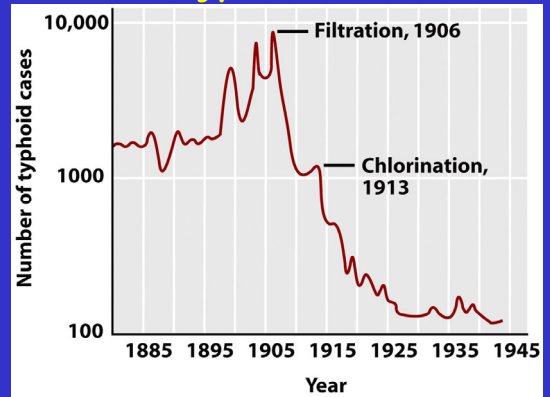
## Public Health and Water Quality

- Most water purification limited to filtration to reduce turbidity
- Coliform-counting procedures developed 1905
- Chlorine introduced as disinfectant in 1910
- Filtration + Chlorination significantly decrease microbial load
- Water purification of drinking water most important public health measure ever devised



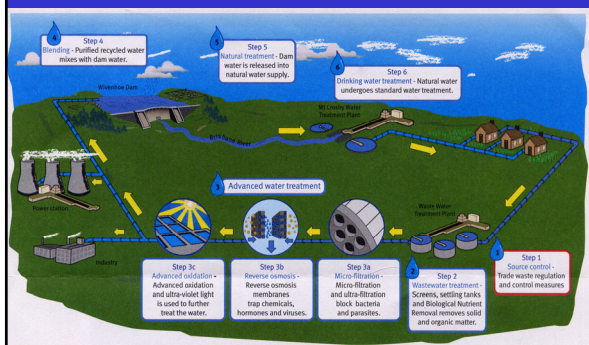
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## US typhoid cases



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## Purified recycled water (6 step plan for Brisbane)



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## Purified recycled water

URBAN USE

WASTEWATER SOURCE CONTROL

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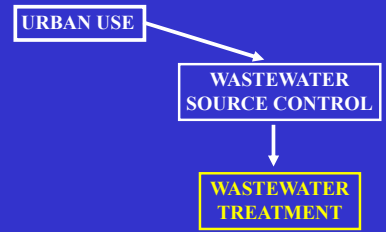
## Wastewater Source Control

- prevent ingress of harmful substances
- regulate domestic discharges
  - sewage, grey water, stormwater
- regulate non-domestic discharges
  - business, industry
    - (primary - agriculture, ...)
    - (secondary - manufacturing, ...)
    - (tertiary - processing, ...)
  - biological (clinical, hospital, dental, ...)
  - chemical (organic, inorganic, pharmaceutical, ...)



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## Purified recycled water



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## Wastewater Treatment

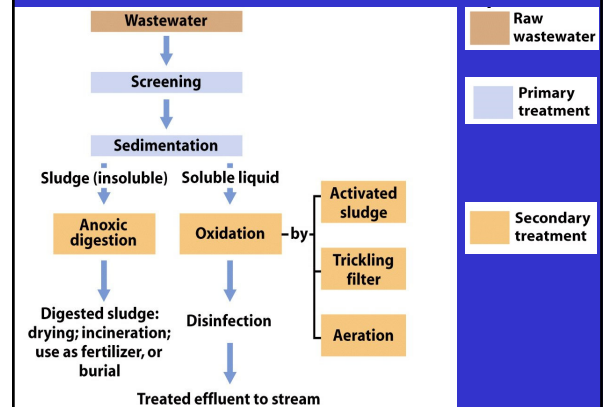
biological reactor destroys and removes most:

- solids, organic matter
- regulated chemicals
- some micro-organisms
- screening, settling and BNR (biological nutrient removal) which reduces nutrients (nitrogen, some phosphorus)
- quality suitable for outdoor irrigation (e.g. golf courses)



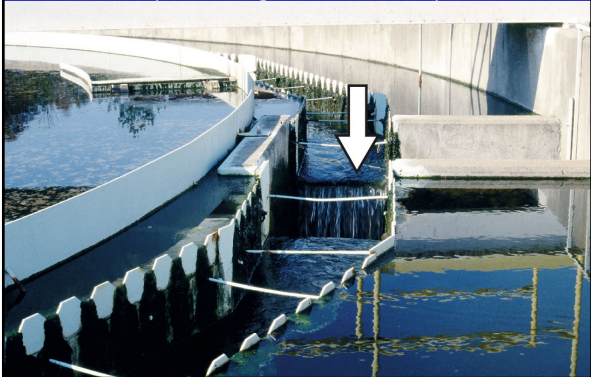
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## Wastewater Treatment



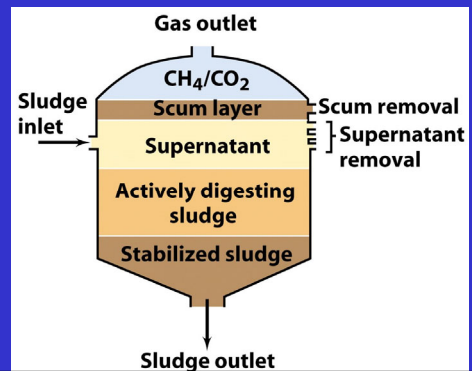
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## Primary Wastewater Treatment (screening/sedimentation)



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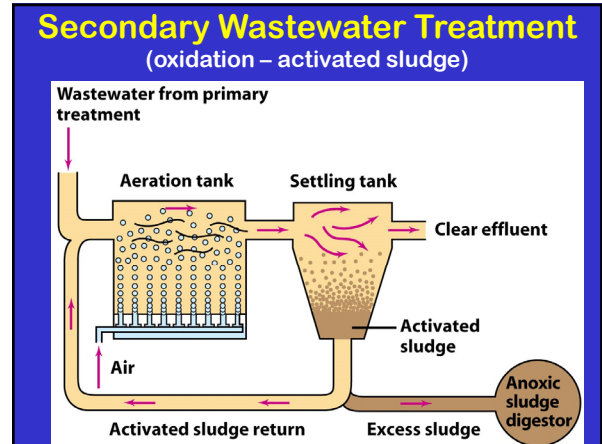
## Secondary Wastewater Treatment (anoxic digestion)



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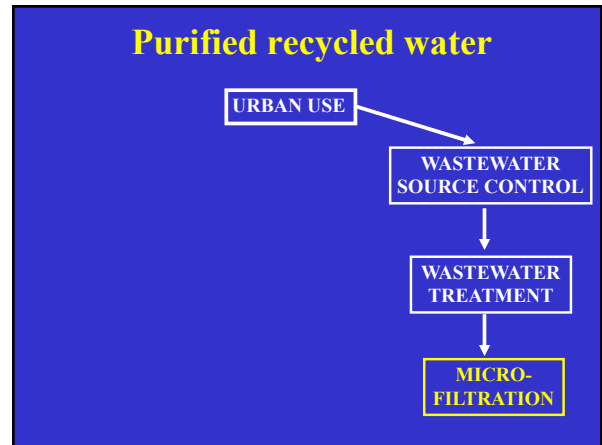
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### Microfiltration

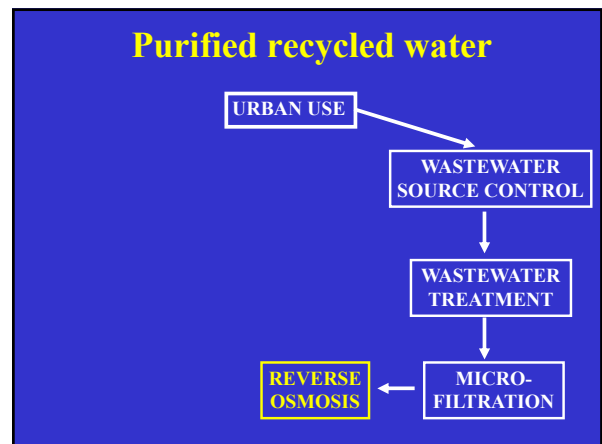
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low pressure membrane filtration that removes:

- small suspended particles
- bacteria
- parasites

• similar technology used to make everyday products (food, beer, fruit juice, soft drinks, medicines)

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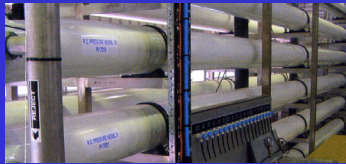


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## Reverse Osmosis

high pressure membrane filtration that removes:

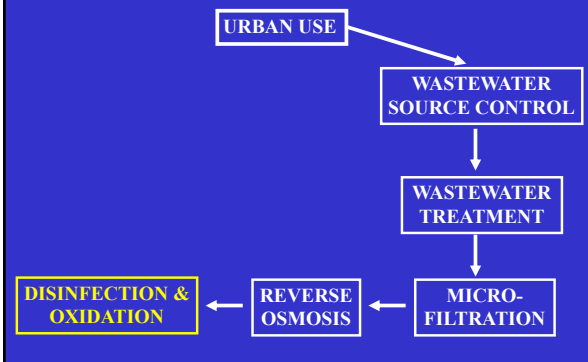
- inorganic molecules (minerals, salts, ...)
- organic molecules (pesticides, herbicides, ...)
- microbes (bacteria, viruses)



- same technology used for desalination, bottled water, home water filtration units, renal dialysis

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## Purified recycled water



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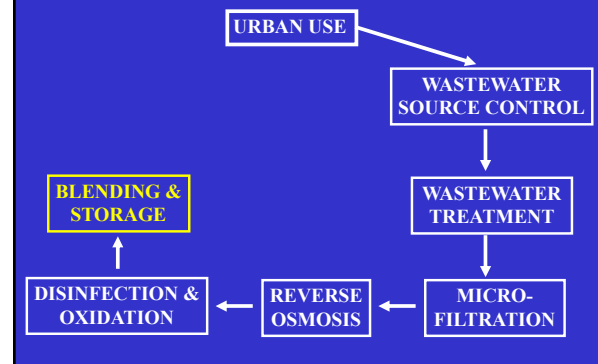
## Disinfection & Oxidation

- exposed to ultraviolet light (kills microbes)
- similar to process used in medical/dental surgeries
- then exposed to hydrogen peroxide and light (creates advanced oxidation reaction that eliminates any remaining organic compounds) (generates ultra-pure water)



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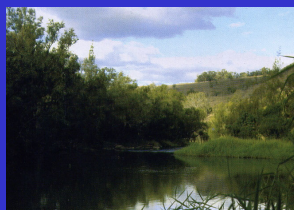
## Purified recycled water



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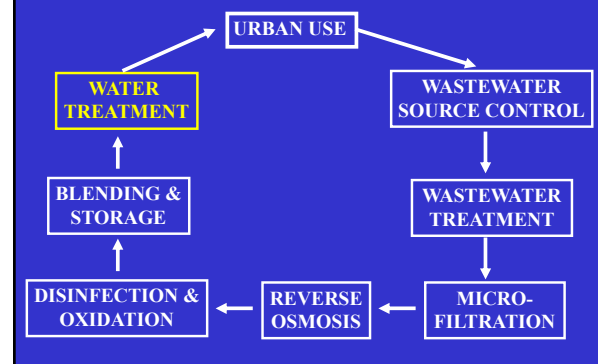
## Blending & Storage

- cleansed water blended with natural water (stream, dam)
- mixed and exposed to natural sunlight and other natural processes (polishing, finishing) (dilution effect) (ultra-pure water needs natural salts, etc)



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## Purified recycled water



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## Drinking Water Treatment

to remove/kill contaminants and improve colour/taste/smell by:

- sedimentation
- coagulation
- filtration
- chlorination

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## Sedimentation

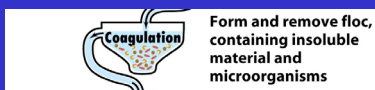
- raw water pumped to sedimentation basin
- large particles settle out
- anionic polymers, alum (aluminum sulfate) and chlorine added
- particles mix, interact, flocculate (form large aggregated masses)



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## Coagulation

- sediment-free water pumped to large holding tank (clarifier)
- coagulated floc removed



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## Filtration

sand filters further remove:

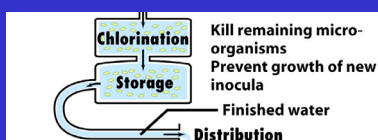
- particulate material
- bacteria
- algae
- other microbes



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## Chlorination

- chlorine added as disinfectant
- to maintain residual chlorine levels, most municipal water treatment plants introduce ammonia gas with chlorine to form stable, nonvolatile chloramine

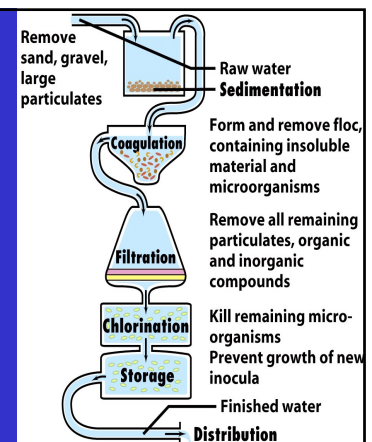


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## Drinking Water Treatment

in accordance with drinking water standards

- national (Aust DW Guidelines)
- international (WHO)



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## Waterborne Microbial Diseases

- Numerous sources of waterborne pathogens in drinking water and recreational water
- Worldwide, lack of clean water and inadequate treatment contribute significantly to spread of infectious diseases
- In developed countries, number of disease outbreaks small in relation to large number of exposures to water

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**Table 28.1 Infectious disease outbreaks associated with drinking water in the United States<sup>a</sup>**

Disease	Agent	Outbreaks	Cases
Salmonellosis	<i>Salmonella</i> species	2	208
Giardiasis	<i>Giardia intestinalis</i>	6	52
Cryptosporidiosis	<i>Cryptosporidium parvum</i>	1	5
Acute gastro-intestinal illness	<i>Escherichia coli</i> O157:H7	4	60
	<i>Campylobacter jejuni</i>	2	117
	<i>E. coli</i> O157:H7 and <i>C. jejuni</i>	1	781
	Small round virus	1	70
	Norwalk-like viruses	3	356
	Unknown	17	416

<sup>a</sup> Compiled from data provided by the Centers for Disease Control and Prevention for 1999–2000. There were a total of 37 outbreaks and 2065 cases of infectious disease due to drinking water contamination by infectious agents. Regulated community-owned water systems were responsible for 237 cases (11.5%). Noncommunity water systems such as those in some factories, schools, and on cruise ships accounted for 1425 cases (69%). Individual water supply systems such as wells, springs, and streams accounted for 403 cases (19.5%).

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**Table 28.2 Infectious disease outbreaks associated with recreational water in the United States<sup>a</sup>**

Disease	Number of outbreaks	Percent
Gastroenteritis <sup>b</sup>	74	46.8
Dermatitis/keratitis <sup>c</sup>	50	31.6
Meningoencephalitis <sup>d</sup>	22	13.9
Other <sup>e</sup>	12	7.6

<sup>a</sup> Compiled from data provided by the Centers for Disease Control and Prevention for 1989–2000. There were 158 outbreaks of recreational waterborne disease, or about 13 outbreaks per year.

<sup>b</sup> Most cases of gastroenteritis were due to *Cryptosporidium parvum* (Section 28.6), *Escherichia coli* O157:H7 (Section 29.8), or a Norwalk-like virus (Section 28.8).

<sup>c</sup> Most cases of dermatitis were caused by *Pseudomonas aeruginosa*.

<sup>d</sup> Meningoencephalitis was caused by the amoeba *Naegleria fowleri* (Section 28.8).

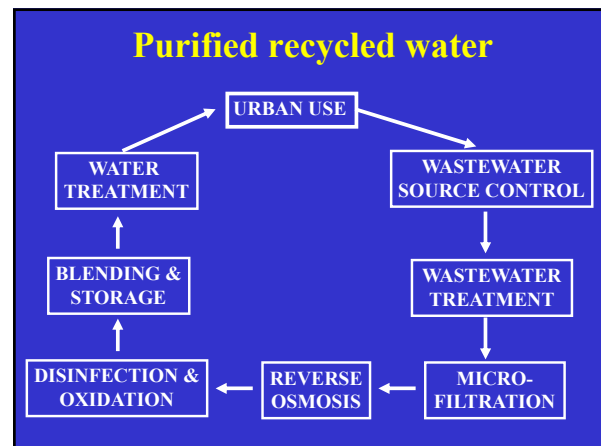
<sup>e</sup> Other diseases include leptospirosis caused by *Leptospira interrogans*, Pontiac fever due to infection by *Legionella* (Section 28.7), and acute respiratory infections of unknown cause.

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## Cholera

- caused by *Vibrio cholerae*
- acute diarrheal disease
- results in severe dehydration
- occurs in pandemics
- endemic foci in Americas, India, Asia, Africa
- avoid contaminated water
- treatment by oral rehydration (with electrolytes) is effective (reducing mortality to ~1%)

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