CIV4288 – Water Treatment

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1. Introduction

1.1 Unit Overview

Lecture Topics	
Topic	**Modules**
1. Water Supply & Demand	• Potable water source types and conveyance overview • Water use by sector • Melbourne water use, conveyance, and sources
2. Drinking Water Treatment	• Basic chemistry of natural water (alkalinity and hardness) • Pollutants and drinking water quality • Unit operations in drinking water treatment • Advanced water treatment processes
3. Conventional wastewater treatment	• Wastewater system components and flows • Wastewater constituents • Wastewater unit operations • Sludge treatment disposal
4. Passive wastewater treatment	• Ecological engineering principles • Constructed wetlands • Waste stabilisation ponds • Decentralised treatment systems
5. Resource recovery	• Wastewater as a resource: carbon, nutrients, and water

- Unit Objectives
  - Perform simple calculations to estimate water flows;
  - Conceptually design and estimate flows of a minor water supply network;
  - Determine inflows into treatment plants;
  - Make initial designs and calculations of treatment processes;
  - Recommend tertiary treatment processes;
  - Estimate the design effluent and waste production of a treatment plant;
  - Assess water quality and recommend treatment options.

1.2 Water & Sanitation History

Of earths water, only 3% is freshwater & .57% of earths water supply is readily accessible for direct human use. Water in our taps/faucets mainly come from reservoirs filled by precipitation i.e protected catchment areas which prevent people developing in these areas preventing pollution, agriculture etc. to secure clean water. In AUS water is mainly used for Agriculture (70%), Industry (22%) & Household (8%)

Shifting from the modern urban water cycle to water sensitive cities:

- Water we use comes from easily accessible, but resource-intensive and, sometimes, non-renewable water resources (Imported water and Groundwater)
- In a water sensitive city, the following changes (green) reduce both demand and the resource-intensive use of Imported water.

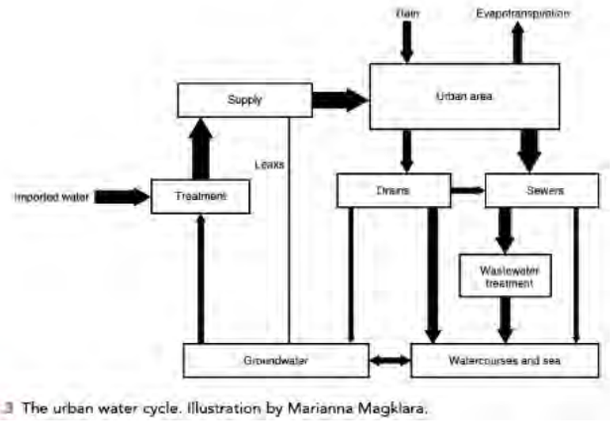


Figure 1.3 The urban water cycle. Illustration by Marianna Magklara.

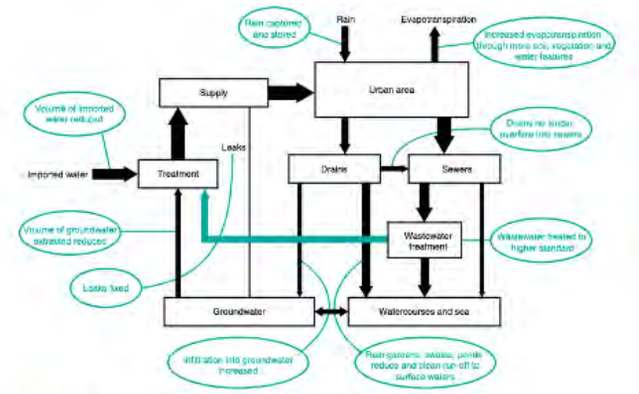
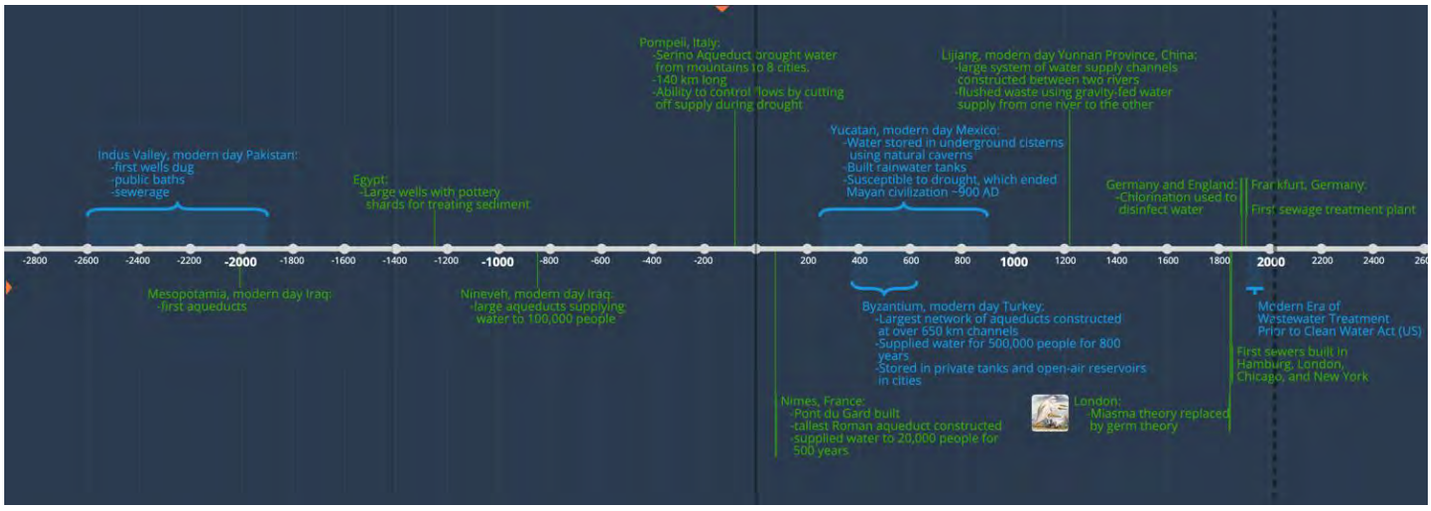


Figure 1.4 The sustainable urban water cycle. Illustration by Marianna Magklara.

- Milestones in WASH History
  - John Snow supported germ theory (disease was spread through water by a germ cell)
  - William Farr supported miasma theory
  - Robert Koch discovered *Vibrio cholerae*, the bacterium that causes cholera



  - Aqueducts and sewers: Romans move water

    Romans used lead pipes to carry drinking water, but lead levels were not elevated enough to cause harmful health effects. What does contribute to lead leaching from pipes in water?

    1. Standing water (no or low flow)
    2. Acidic water
    3. Presence of trihalomethanes

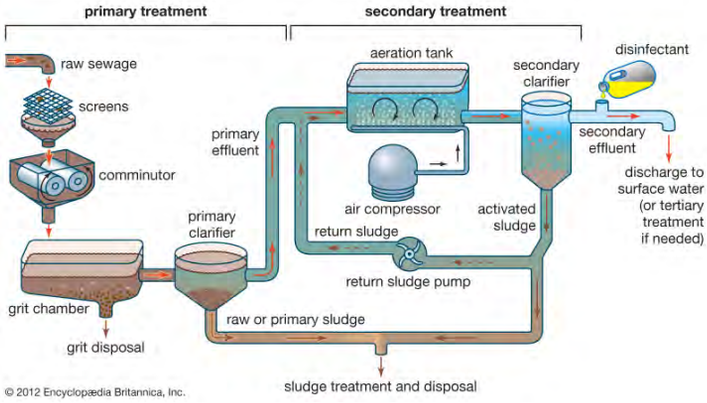
- Modern Sewers

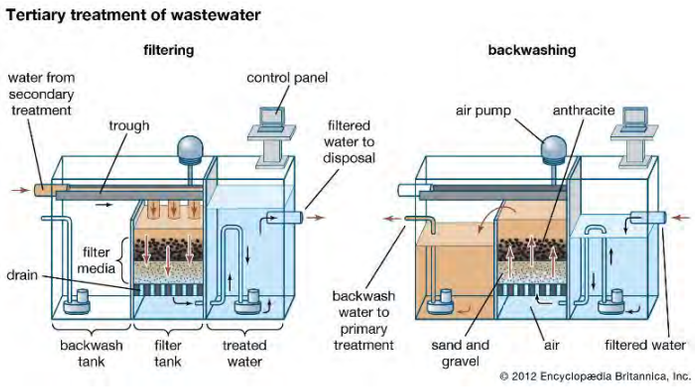
  We often have combined & separated sewers. Australia has separate sewers: 1) Sewerage i.e wastewater & 2) stormwater drain i.e runoff.

- <u>Modern Wastewater Treatment</u>

  In most industrialized areas, secondary treatment is minimum standard w/ primary & secondary treatment & tertiary becoming the norm:

  1) Primary = physical process removing coarse particles/rubbish & suspended solids (sand, dirt etc.) via screens & sedimentation
  2) Secondary = biological process removing organic matter & is subject to degradation i.e microorganisms/bugs like bacteria, viruses and algae breakdown the sludge consuming organic matter
  3) Tertiary = disinfects water removing remaining microorganisms & killing bacteria





- **Note:** Wastewater carries with it:
  - Carbon: organic matter (#2)
  - Nutrients: urea and organic matter (#1 and #2)
  - Contaminated water
- This can be used for fertilizing, energy production & water reuse. I.e wastewater carries a lot of organic matter which can be used to recover energy w/ methane gas combusted to generate electricity through anerobic digestors

- Recent approaches to wastewater treatment include:

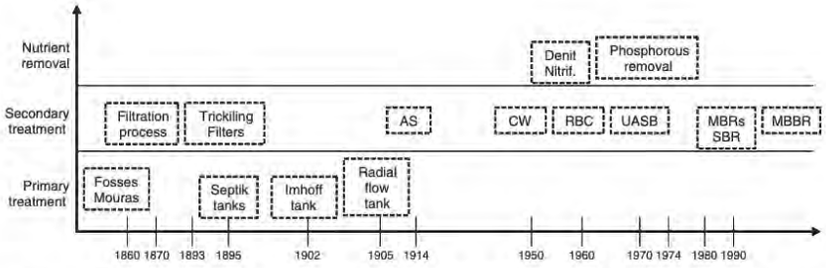
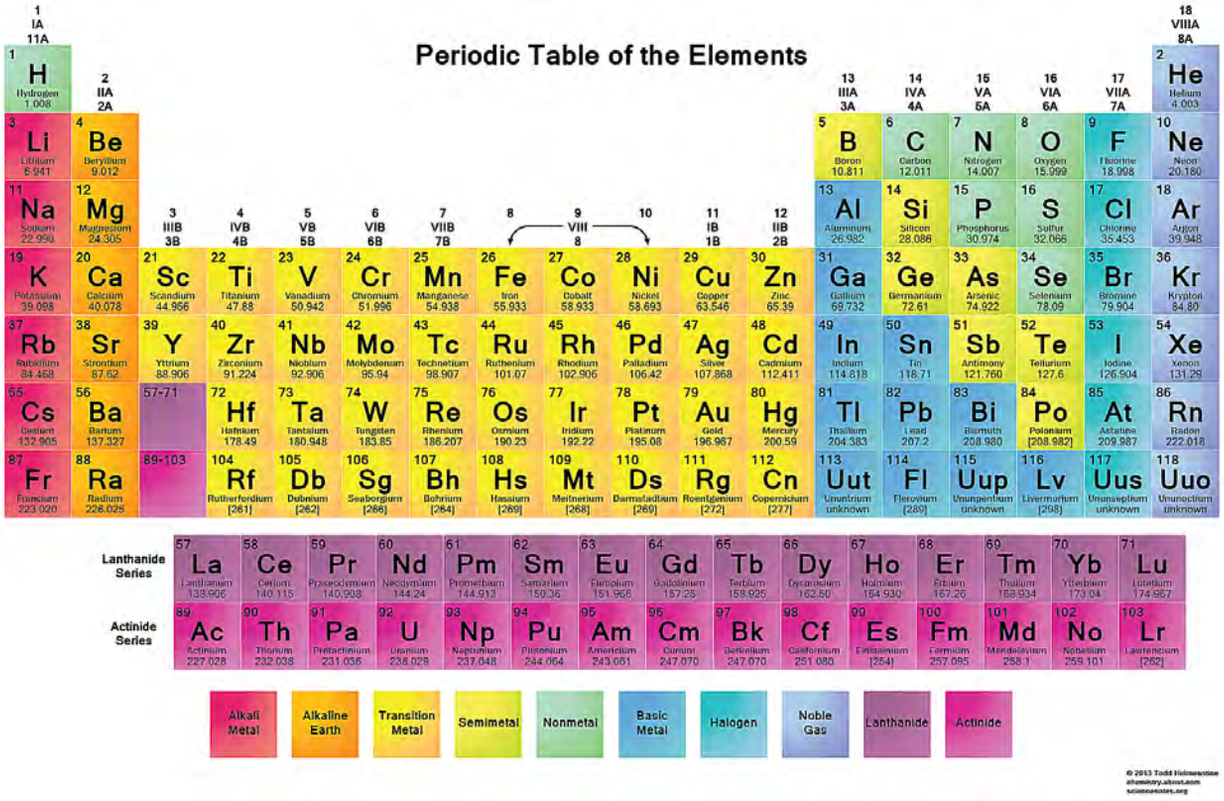


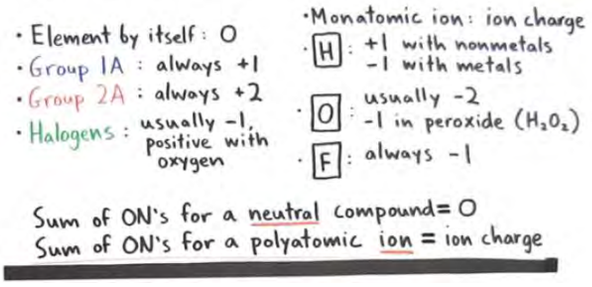
Fig. 8. Evolution of wastewater treatment. AS - Activated sludge; CW - constructed wetlands; RBC - Rotating biological reactors; UASB - Upward-flow anaerobic sludge blanket; MBRs - Membrane biological reactors, SBR - Sequencing Batch Reactors; MBBR - Moving Bed Biofilm Reactors.

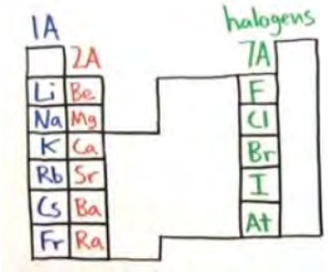
1.3 Week 1 Prac Summary

- Stoichiometry



- Redox Reactions





- Water Chemistry

$$Molarity, M = \frac{moles\ of\ solute}{L\ of\ solution}$$

$$Moles = \frac{grams\ (g)}{atomic\ mass\ units\ (amu)} = \frac{grams\ (g)}{molar\ weight\ (mw)}$$

2. Water Supply

2.1 Sources of Water

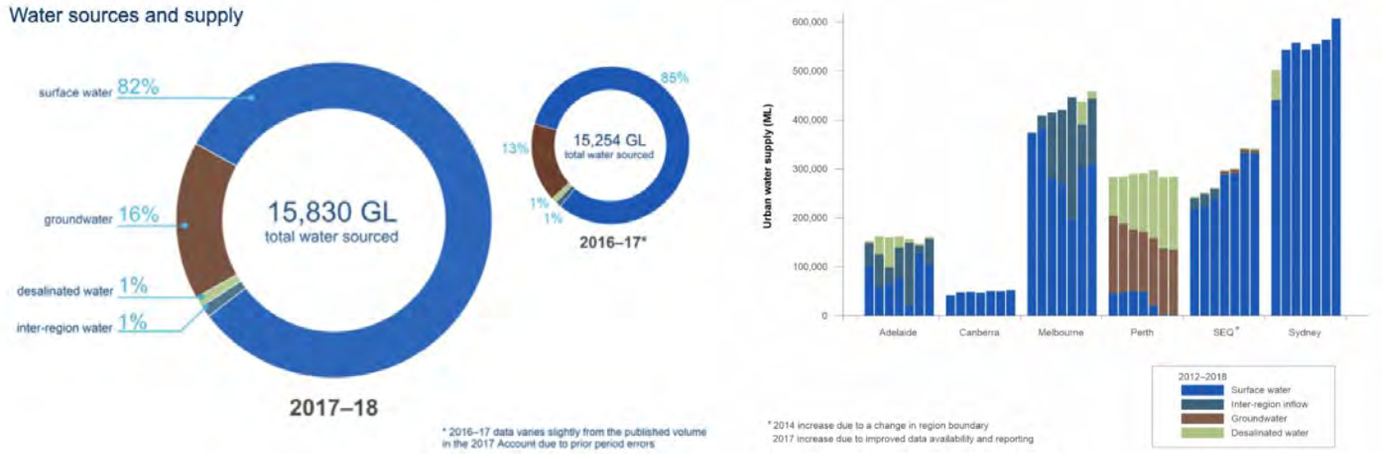
- Most of the world's water is not available to our water supply network.
- Sources of freshwater suitable for drinking comprise a small fraction of water on Earth.
- Of earths water, 97% is saltwater, <3% is freshwater & <1% of earths water supply is readily accessible for direct human use. Water in our taps/faucets mainly come from reservoirs filled by precipitation i.e protected catchment areas which prevent people developing in these areas preventing pollution, agriculture etc. to secure clean water. In AUS water is mainly used for Agriculture (70%), Industry (22%) & Household (8%)

- Types of Water Sources

  Drinking water sources are generally split into the following categories:
  - Sub-surface (Springs, Wells & Infiltration wells
  - Surface (Lakes, Rivers & Reservoirs)
  - Re-use (Treated wastewater)
  - Rainwater
  - Ocean (By Desalination)

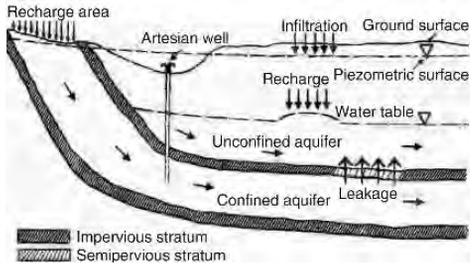
Australian Water Resources

- In Australia, most water extracted comes from surface water. Most of the rest is extracted from groundwater. Typically, <10% of water comes from desalination plants and even less from rainwater harvesting and water re-use. Regionally, water resources depend on availability!



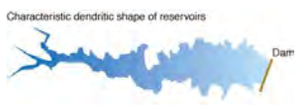
- Australian Water Resources

1. Groundwater



- Groundwater recharged from rainfall
- Pressure heads vary i.e confined aquifer (Artesian) has advantage
- Aquifer may flow away from recharge area
- Recharge vs extraction should be balanced
  If recharge rate << extraction rate we can't consider GW renewable
  i.e Very slow or no recharge limits sustainability of extraction rates
- Fossil water formed millions of years ago
  Fossil water = GW w/ very low recharge rate
- Recharge rate depends on rainfall and geology

2. Reservoirs & Lakes



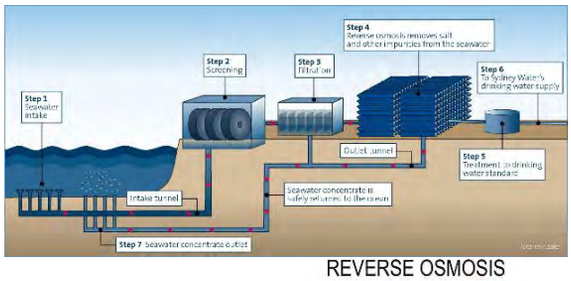
- Reservoirs are artificial water bodies created by damming waterways
- Lakes are naturally formed water bodies but can be dammed to control water level (Rounded shape = due to natural weathering processes)
- Dams built to control water level and use as storage to manage water demand for cities

3. Rivers

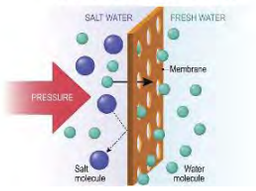
- Extraction from rivers often supplies irrigation in adjacent areas, but drinking water can be piped from large river systems.
- River water quality can be an issue (e.g., Flint, Michigan due to land use & climate conditions causing poorer water quality)

4. Desalination

- Saltwater is extracted (typically from oceans/seas)
- Saltwater passes through membrane to remove dissolved salts
- High purity water produced, along with brine.
- Brine is the highly saline waste by-produce of desalination
- Because of differences in density, waste brine can flow to deep ocean environments, potentially disrupting vulnerable ecosystems.



REVERSE OSMOSIS

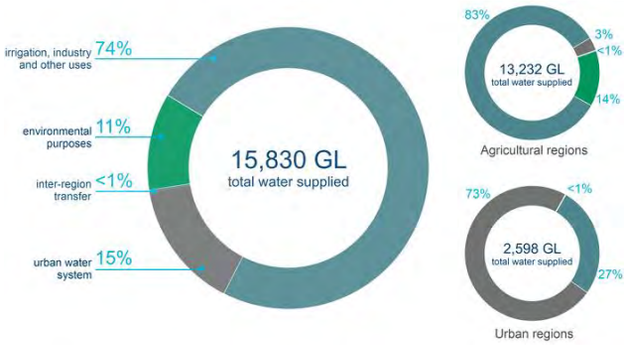


2.2 Water Consumption

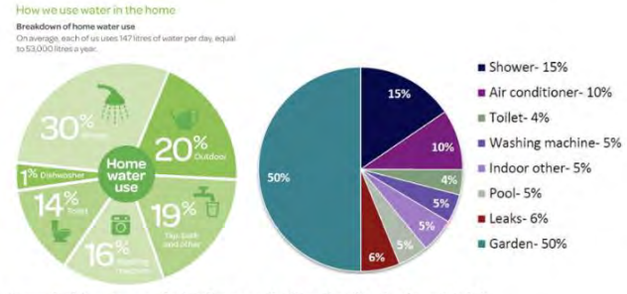
- Globally, per capita water consumption is related to water availability, level of industrialisation, population, irrigation demand, and access to secure water resources. Water consumption includes water used by industry, including electricity generation, agricultural use, mining, and manufacturing use, public services, and household use.
- **Note:** In AUS environmental water is supplied to maintain river baseflows and replenish groundwater. Globally, this is unique

- <u>Average Water Consumption</u>
  - The Water we physically drink is a small portion of what we use (Typically, 2.5 – 3 L/day required under normal conditions & 6 L/day under extreme heat or strenuous activity)
  - Water consumption (water used) at the household level in AUS ≈ 70 m3/capita/yr
  - Around 135 L/day w/ the target being 155L/pp/day based on reservoirs storage and rainfall in Melbourne
  - Dispersity in water use between areas depends on many factors:
    - Metering = If we see how much water we use, we are inclined to want to use less
    - Quality
    - Pressure
    - Rates
    - Income
    - City Size
    - Industries
    - Weather conditions (Extreme conditions being very hot or cold affects consumption)

- <u>Australian Water Use</u>
  - Water consumed in urban regions is allocated to household, public, commercial, industrial use, fire protection, & losses through supply network



  - Domestic water is used in gardens, showers, for drinking, for cleaning, and to flush the toilet.
  - Domestic water use varies in these percentages by location depending on climate and cultural norms (i.e Melb. vs. Alice springs)



Household water use in Melbourne (left) and Alice Springs (right).