On-site Wastewater Management Training Course

Wastewater Characterisation

What is Wastewater?

Wastewater – the water arising from domestic activities in dwellings, institutions or commercial facilities consisting of all wastewater

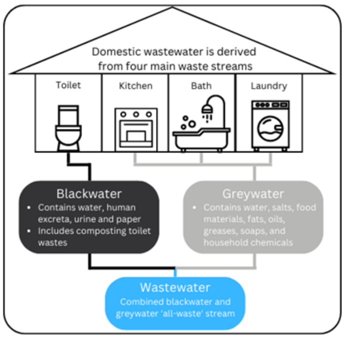
- **Domestic wastewater** - derived from household waste streams: kitchen; bathroom (basin, bath and shower); laundry and toilet
- **Industrial and Commercial wastewater** - varies widely in character - often requires specialised treatment processes as it may contain substances that are harmful to the biological processes utilised for treatment processes

Wastewater Terms

Domestic wastewater is commonly described as any of three forms:

- Wastewater – “discharge from any sanitary fixtures of appliances” e.g. toilet water, may include composting toilet solids
- Greywater – “water that is contaminated by but does not contain human excreta” e.g. kitchen, bathroom and laundry water. Also referred to as ‘sullage’
- All-waste – “a combination of both black and grey water”

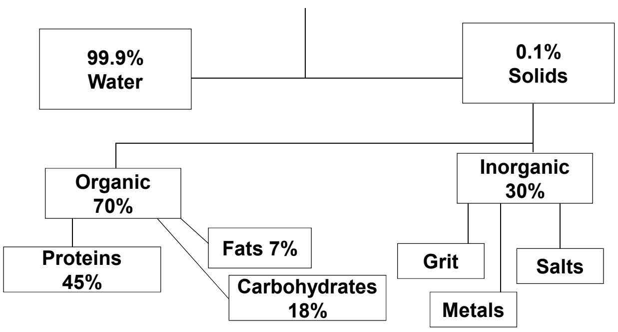
Domestic Wastewater Stream



Sewage

- Contains faecal and urinous matter, sullage (washing water), grit, bacteria, viruses, plus a variety of other liquids and solids
- Consists of approximately 99.9% water and 0.1% solids (every 1,000 kg or 1,000 litres of wastewater contains about 1 kg of solids)
- About 70% of solids are made up of organic compounds either suspended or dissolved in wastewater (proteins, carbohydrates and fats)
- Organic solids are readily broken down into more stable inorganic compounds by bacteria and other micro organisms

Sewage Composition



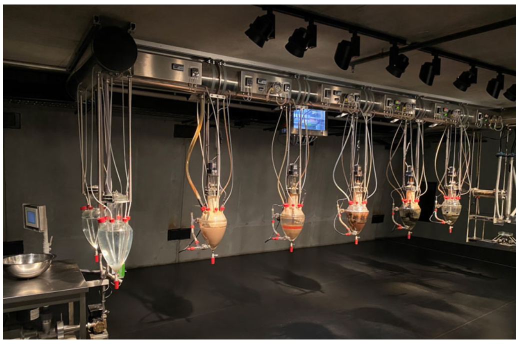
Treatment Processes

- Domestic wastewater begins to change immediately after generation (both physically and chemically), due to the action of bacteria and other organisms

Treatment may involve:

- Physical Processes - the separation of the suspended solids from the liquids - use of screens, sedimentation tanks, filters
- Biological Processes - various processes involving the oxidation of organic matter, carried out by micro-organisms
- Advanced Processes - disinfection/nutrient removal

Cloaca



Typical Domestic Wastewater Quality

Parameter (mg/L)	Raw Effluent	Septic Tank	AWT Effluent	Sand Mound Effluent
BOD_5	300-340	120-150	5-80	1-10
SS	260-300	40-190	5-100	5-20
TN NO_3–N (% of TN)	50-60 (0%)	40-50 (0%)	25-50 (80%)	30-50 (85%)
TP PO4 – P (% of TP)	10-15 (45%)	10-15 (90%)	7-12 (85%)	5-10 (90%)
Faecal coliforms org/100ml	10^5-10^7	10^5-10^7	10-10^3	10-10^3

BOD_5 - Biochemical Oxygen Demand; TN - Total Nitrogen
SS - Suspended Solids; TP - Total Phosphorus

Organic Matter

- Organic matter (OM) consists of chemical compounds based on carbon skeletons (proteins, carbohydrates and fats)
- Usually present in domestic wastewater in dissolved, suspended or colloidal form
- Measured by a standardised lab test referred to as 5-day Biochemical Oxygen Demand (BOD_5) - results typically expressed as mg/L
- BOD_5 refers to the amount of oxygen used as the biodegradable wastewater fraction is decomposed by bacteria and other microbes (oxygen demand)

Biochemical Oxygen Demand

- Oxygen demand measured by determining the amount of oxygen consumed by microorganisms during organic matter degradation
- Organic content of waste obtained by measuring amount of oxygen required for its stabilisation i.e. 5 day test

SOURCE	BOD mg L^{-1}
Natural Waters	1 - 5
Sewage	250 - 300
Septic systems	150 - 200
Stormwater	200 - 600
Industrial Water	500 - 5000
Landfill Leachate	10 000 - 35 000

Total Suspended Solids

- Proportion of particulate material retained after passing through a glass fibre filter
- Material size ranging from coarse solids to colloidal particles
- Suspended solids may be organic or inorganic in origin
- Typically measured by a standardised laboratory test and referred to as either Total Suspended Solids (TSS) or Non-filterable Residue (NFR)
- Results typically expressed as milligrams per litre (mg/L)
- TSS ≠ Turbidity

Oil and Grease

Describes the fats, oils, waxes and other related constituents of wastewater - builds up as a layer in septic tank (commonly FOG)

- Can cause problems in downstream wastewater treatment processes if not managed correctly (carryover etc.)
- Oil and grease content in domestic wastewater is determined using an analytical extraction method
- Results typically expressed as mg/L or as a thickness (mm) on the surface of a water sample
- Can be determined qualitatively by inspection

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Nutrients

Nutrients, along with trace quantities of other elements are essential for biological growth
Phosphorus (P) and Nitrogen (N) are the principal nutrients of concern with regard to on-site wastewater management systems

- In excess, they may encourage nuisance growth of algae and aquatic plants in sensitive surface water systems and in some cases (nitrate) may pose a threat to human health
- Both N and P are found in a variety of forms in domestic wastewater

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Nitrogen

Nitrogen in wastewater is typically found in one of four forms: ammonia (NH_3) / ammonium (NH_4^+) (dependent on pH); nitrite (NO_2^-); nitrate (NO_3^-) and organic nitrogen

- In untreated wastewater the ammonia/ammonium and organic nitrogen forms dominate
- Typically measured using a range of standardised lab tests including colorimetric and physico-chemical methods and expressed in mg/L or g/m^3
- Nitrate (N) is highly mobile in the soil/water environment = potential public health risks

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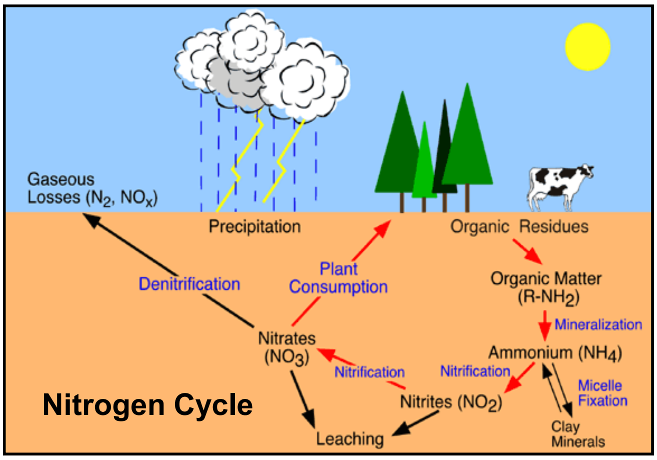

Nitrogen Source

Most common sources of N present in domestic wastewater (~50-60mg/L) include:

- Urine
  - Urea (46% N) or ~8.6g N/EP/day
- Faeces
  - ~0.1g N per kg bodyweight per day
  - 65kg woman (6.5g) 90kg male (9.0g)
- Hygiene
  - Body exudates (hair, sweat, skin etc.)
  - Personal care (shampoo) and cleaning
- Laundry products contain little N

Source: Patterson 2003

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Nitrogen Source

Our diet (consumption and preparation) is a major N contributor:

- Red meat - ~45g per kg consumed
- Cheese - ~42g per kg consumed
- Eggs and bread - ~1.9g per 100g consumed
- Leafy greens can contain up to 1g per kg consumed
- Large portion of organic N derived from vegetable scraps (including washing) during preparation
- Drinks (water, milk, sports drink etc.) also contain varying amounts of N

Source: Patterson 2003

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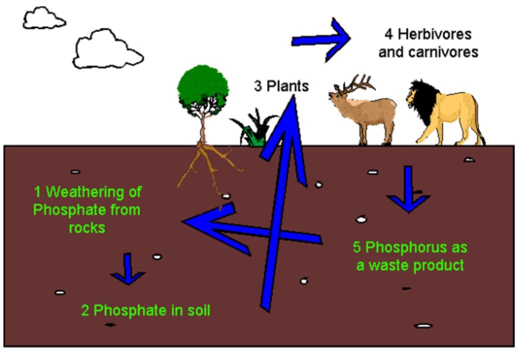
Phosphorus

- Typically found in one of three forms in domestic wastewater: orthophosphate complexes (e.g. PO_4^{-3}, HPO_4^{-2}, $H_2PO_4^{-}$); polyphosphate (e.g. P_2O^{-4}) and organic phosphate
- Orthophosphates - readily available for biological metabolism, while poly and organic phosphates must first undergo some form of conversion
- Measured using a range of standardised laboratory tests - analytical results typically express the combined values for all forms of P as total P - results are expressed as mg/L or µg/L in natural waters

Phosphorus Cycle



Phosphorus Source

Most common sources of P present in domestic wastewater (~10-15mg/L) include:

- Blackwater
  - ~5-10mg/L or up to 1g/EP/day
- Greywater
  - ~10-15mg/L or up to 1.5g/EP/day
- Depending on diet food can contribute a large proportion of the household P load (cheese, soft drinks etc.)
- Laundry products are the other major contributor, containing as much as 7.8g P per wash cycle

Source: DLG 1998 and Minnis (undated)

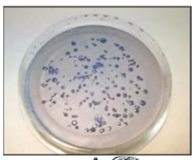
Microorganisms

The principal groups of organisms found in natural waters and wastewater include: bacteria; fungi; protozoa; parasites; rotifers; algae and viruses

- Not all pose potential human and public health risks
- Organisms with the potential to pose health risks to humans are known as "pathogenic"

DISEASE	H_2O RELATIONSHIP
Cholera Hepatitis Paratyphoid Typhoid Amoebic Dysentery Bacillary Dysentery Gastroenteritis	Waterborne
Conjunctivitis Leprosy Scabies Tinea Trachoma	Water-washed
Malaria Sleeping Sickness Yellow Fever	Water-related insect

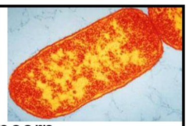
Bacteria



Wastewaters contain a wide variety and concentration of pathogenic and non-pathogenic bacteria

- Many infectious diseases are waterborne e.g. typhoid, cholera and infectious doses can lead to illness in some people
- Testing for pathogens difficult and expensive; therefore, common bacteria used e.g. coliform bacteria such as Escherichia coli used as an indicator of potential faecal contamination in water

Parasites



Two dominant protozoan parasites of concern in the treatment of wastewater:

1. *Cryptosporidium*, and
2. *Giardia*

- Resistant to standard disinfection methods
- Considerable risk to susceptible members of the community (children, elderly and immuno – compromised)
- Helminths or Intestinal worms are also commonly found in wastewater e.g. tapeworms, roundworm
- Release millions of environmentally resilient eggs throughout their lifespan

Viruses

- Contamination by virus may lead to major outbreaks
- *Hepatitis* A is the dominant water borne virus, referred to as infectious hepatitis
- Causes widespread illness in epidemic patterns
- Exposure to faecally contaminated water can transmit the diseases caused by waterborne virus
- Polio Virus is also transmitted in wastewater
- Virus are more common and diverse than bacteria in the aquatic environment

Pathogen Survival in Different Environmental Media

Pathogen	Survival in Freshwater (days)	Survival in Saltwater (days)	Survival in Soil (days)
Viruses	11-304	11-871	6-180
Bacteria-Salmonellae	<10	<10	15-100
Bacteria-Cholera	30	+285	<20
Bacteria-Faecal coliforms	<10	<6	<100
Protozoan cysts	176	365	>75

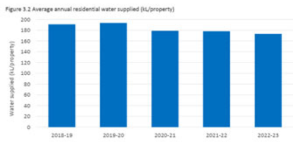
Quantifying Wastewater Volumes (Hydraulic Load)

- Liquid flow required to be managed by a wastewater system over time period
- The volume discharged from a dwelling or building during a 24-hour period i.e. "daily hydraulic load"
- Key consideration for designing and sizing an onsite wastewater management system (L/day or m^3/day)

- OWMS need to be adequately sized and offer sufficient treatment / storage capacity for a number of days prior to effluent application

Household Water Use

- Average residential water usage of 173kL per year (474L/day) across TasWater in 2022/23

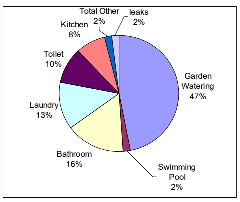


- Sewer charges typically calculated at ~80% of water usage (70%-90% seasonal)
- Calculate = 380L/day household wastewater generation (equivalent ~2.5EP @ 150L/day)

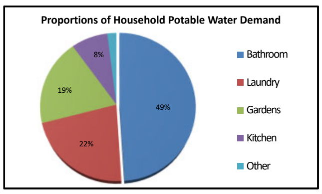
Water Use for Individual Fixtures

Waste	Calculation Allowance
S (Sludge Allowance)	1550 L
WC (Water Closet)	50 DF Litres/person/day
HB (Handbasin)	10 DF Litres/person/day
K (Kitchen)	10 DF Litres/person/day
B + SHR (Bath and Shower)	50 DF Litres/person/day
L (Laundry)	30 DF Litres/person/day
All wastes (WC + HB + K + B + SHR + L)	150 DF Litres/person/day

Source: NSW Health, 2016



Source: NSW Basix and WELS rating scheme



Source: DSE 2012

Calculating Hydraulic Load

Firstly, important to define '**design occupancy**'

- TAS OWMS Guideline (2017) specifies 1 bedroom (2 EP), 2-3 bedroom (beds plus 2EP), >3 bedroom (5 EP + 1 EP for each additional bedroom)
- AS/NZS 1547:2012 suggests No. of bedrooms (+2)
- Other methods may include – No. of bedrooms x (design) occupancy factor (i.e. 1.6) based on known population characteristics

Design Flow Allowances
(L/person/day) - Domestic Use

- AS/NZS 1547:2012 (Table H) provides ‘typical’ domestic flow allowances for all-waste OWMS design
- Assumes ‘basic’ water reduction fixtures are standard (WELS 3-star or better)
- Water supply concessions can be applied
- Split-system (e.g. greywater) design values (Table H2)

TABLE H1
TYPICAL DOMESTIC WASTEWATER DESIGN FLOW ALLOWANCES – AUSTRALIA

Source	Typical wastewater design flows (L/person/day)	
Residential premises	On-site roof water tank supply	Reticulated water supply
	120	150
Source: Australian Bureau of Statistics. Water Account 2004/2005. Chapter 7 Figure 7.3		

Commercial (non-residential) Loading

- TAS OWMS Guideline (2017) provides minimum flow allowances and organic loadings for ‘non-residential’ buildings
- Conservative based on industry information and reliable international data or research
- Organic loading values particularly relevant for food and alcohol-based enterprises
- Data for processing wastes (e.g. brewery) should be sourced from reliable industry data

Table 4 Minimum daily wastewater allowance for non–residential buildings

Source	Design hydraulic loading Litres/person/day	Design organic loading grams/person/day
Motel – per bar attendant	1000	120
Motel – meals per diner	10	10
Motel – per resident guest and staff (in house laundry)	150	80
Motel – resident guest and staff (out sourced laundry)	100	80
Restaurant per seat	40	50
Tea rooms and café per seat	10	10
Take-away food per customer	10	40
Conference /function centre	30	35
Public toilet	6	3
Public hall, theatre, gallery (no kitchen)	3	2
Public hall, theatre, gallery (with kitchen)	10	5
Public building with showers and toilets (sports club, gym, pool)	50	10
Hospital (per bed)	350	150
Childcare centre per child and staff	20	20
Factory, office, medical centre per person	20	15
Campgrounds (fully serviced)	150	60
Camp Grounds (with showers and toilets)	100	40

Design Hydraulic Load - example

No. of Bedrooms	2	3	4	5
Occupancy (Bedrooms + 2) (EP)	4	5	6	7
Reticulated (Town) supply				
TAS OWMS Guideline (2017) (150L/EP/day)	**600**	**750**	**900**	**1,050**
VIC GOWM (2024) (150L/EP/day)	450	600	750	900
NSW SCA (300L/bedroom/day)	600	900	1,200	1,500
Rainwater (Tank) supply				
TAS OWMS Guideline (2017) (120L/EP/day)	**480**	**600**	**720**	**840**
VIC GOWM (2024) (120L/EP/day)	360	480	600	720
NSW SCA (200L/bedroom/day)	480	600	720	840

Organic Matter Loading

- As water usage decreases (e.g. water saving devices or education programs), organic concentration increases
- Also elevated in commercial (food premises, function centres) or non-domestic developments (e.g. schools)
- Possible to size OWMS on the basis of organic loading, commonly describing wastewater ‘strength’
- Residential (domestic strength) organic loading rate = 60-70g BOD_5/person/day

Organic Loading considerations

- Medium – High strength wastewaters often associated with ‘non-residential’ activities
- Frequent examples in OWMS applications:
  - Boutique brewery = <1,500mg/L BOD and <3,000mg/L COD
  - Small-batch distillery = 10,000-30,000mg/L BOD
  - Wineries = <10,000mg/L (vintage) and <3,000mg/L non-vintage
  - Bar Service (unconsumed alcohol) =
    - Vodka 360,000mg/L BOD and 845,000mg/L COD
  - Dairy food production (cheese) = 2,000-3,000mg/L BOD
  - Meat processing = 2,200-7,200mg/L BOD

Wastewater Calculations

Question 1.

The load of a material, solute or pollutant is the mass transported over a given time period. It can be carried by a watercourse or conveyed to the point of discharge along a pipe. The load is calculated by multiplying the concentration of the pollutant by the volume of flow, while taking into account the time over which the discharge or flow occurred. It can be simply calculated using the following relationship:

$$L = c \times Q \times t$$

where;

L = load or mass of pollutant
c = concentration of pollutant
Q = stream discharge or volume of pipe flow
t = time base of calculation

Note: Units must be consistent between variables to undertake calculations. When undertaking calculations, it is important to show all workings and conversions clearly.

Example

Calculate the daily pollutant load to a receiving water body (in kilograms per day) given that average concentration in effluent is 20 mg/L and the discharge volume per day is 20 ML (a Megalitre is a million litres).

c = 20 mg/L, Q = 20 x 10^6 litres per day
In 1 ML there are 20 x 10^6 milligrams of pollutant per day
In 20 ML there are 400 x 10^6 milligrams of pollutant per day
As there are 10^6 milligrams in 1 kilogram, the daily load of pollutant is **400 kg**.

(i) Calculate the annual pollutant loads of Suspended Solids, Total Nitrogen and Total Phosphorus reaching a septic tank where the concentrations of Suspended Solids, Total Nitrogen and Total Phosphorus are, 250 mg/L, 55 mg/L and 15 mg/L respectively and the daily hydraulic load (flow) is 1000 L. Express results for each pollutant in kilograms.

Wastewater Calculations

ANSWERS

Question 1.

Suspended Solids

L = 250 mg/L x 1,000 L x 1 day

L = 250 x 1,000 x 365 mg/year

L = 91,250,000 mg/year

L = 91.25 kg/year

Total Nitrogen

L = 55 mg/L x 1,000 L x 1 day

L = 55 x 1,000 x 365 mg/year

L = 20,075,000 mg/year

L = 20.08 kg/year

Total Phosphorus

L = 15 mg/L x 1,000 L x 1 day

L = 15 x 1,000 x 365 mg/year

L = 5,475,000 mg/year

L = 5.48 kg/year