

On-site Wastewater Management Training Course

Wastewater Characterisation

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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

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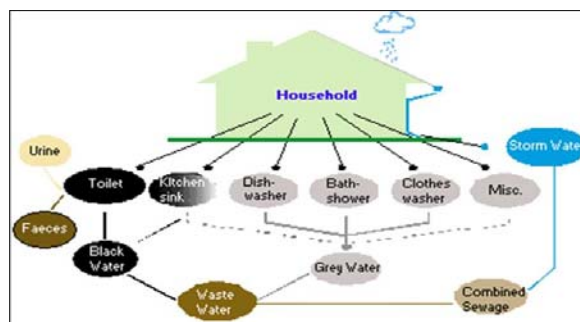
Wastewater Terms

Domestic wastewater is commonly described as any of three forms:

- **Blackwater** – “water grossly contaminated with human excreta” e.g. toilet water, composting toilet solids
- **Greywater** – “water that is contaminated by but does not contain human excreta” e.g. kitchen, bath and laundry water. Also referred to as ‘sullage’
- **Combined** – “a combination of both black and grey water”

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Domestic Wastewater Streams



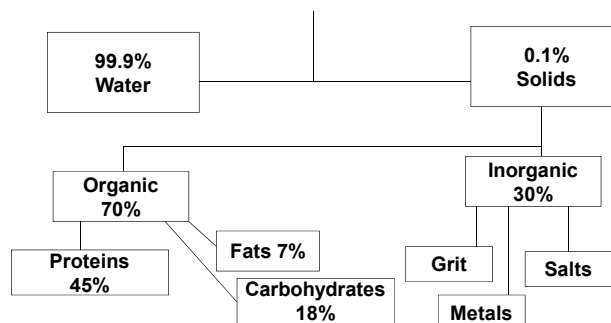
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Sewage

- 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

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Sewage Composition



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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

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	50-60	40-50	25-50	30-50
NO ₂ -N (% of TN)	(0%)	(0%)	(80%)	(85%)
TP	10-15	10-15	7-12	5-10
PO ₄ -P (% of TP)	(45%)	(90%)	(85%)	(90%)
Faecal coliforms org/100ml	10 ⁵ -10 ⁷	10 ⁵ -10 ⁷	10-10 ³	10-10 ³

BOD₅ - Biochemical Oxygen Demand; TN - Total Nitrogen
SS - Suspended Solids; TP - Total Phosphorus

Organic Material

- Organic material consists of chemical compounds based on carbon skeletons (proteins, carbohydrates and fats)
- Typically measured by a standardised laboratory test referred to as 5-day Biochemical Oxygen Demand (BOD₅) - results typically expressed as mg/L
- Usually present in domestic wastewater in dissolved, suspended or colloidal form
- BOD₅ 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

TSS comprise the proportion of particulate material retained after passing through a glass fibre filter

- May comprise material 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)

Oil and Grease

- Used to describe the fats, oils, waxes and other related constituents of wastewater - builds up as a layer in septic tank
- 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

Nutrients



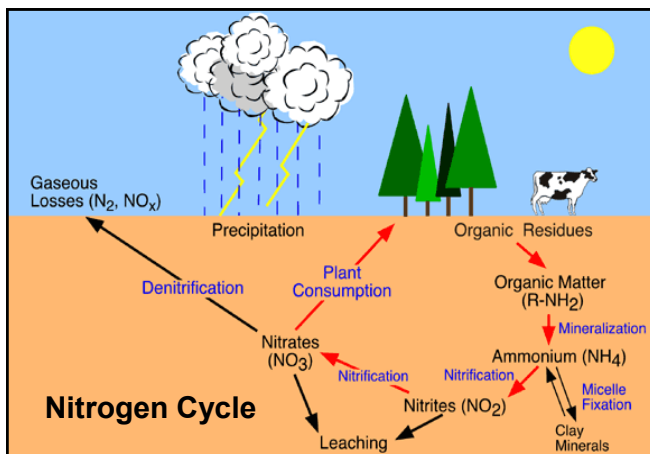
Nutrients, along with trace quantities of other elements are essential for biological growth. Phosphorus (P) and Nitrogen (N) are the principal nutrients of concern with regard to on-site wastewater management systems

- 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

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 domestic wastewater the ammonia/ammonium and organic nitrogen forms dominate
- Typically measured using a range of standardised laboratory tests including colorimetric and physico-chemical methods and expressed in mg/L or g/m³
- Nitrate nitrogen is highly mobile in the soil/water environment and can potential public health risks



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

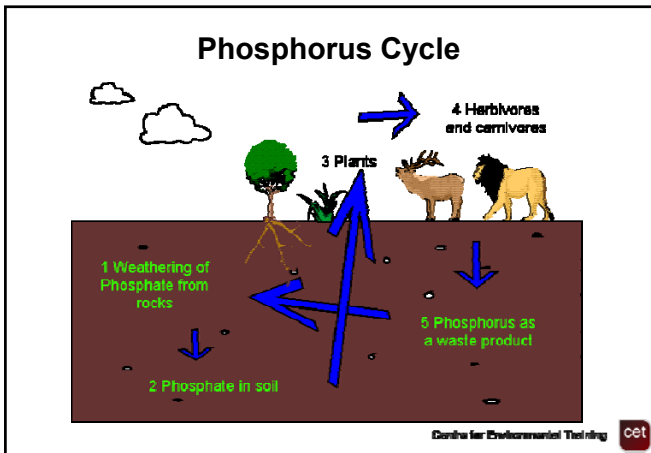
Nitrogen Source

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

Phosphorus

- Typically found in one of three forms in domestic wastewater: orthophosphate complexes (e.g. PO_4^{-3} , HPO_4^{-2} , $\text{H}_2\text{PO}_4^{-}$); 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 $\mu\text{g/L}$ in natural waters



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)
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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 ₂ O 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

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Bacteria

Domestic 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

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Parasites

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

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

- Resistant to standard disinfection methods
- Pose 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
- They release millions of environmentally resilient eggs throughout their lifespan

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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

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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

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Quantifying Wastewater Volumes (Hydraulic Load)

- The liquid flow required to be managed by the wastewater treatment system over time period
- The volume discharged from a household during a 24-hour period i.e. "daily hydraulic load"
- Key consideration when designing and sizing an on-site wastewater management system (L/day or m³/day)
- Systems need to be adequately sized and offer sufficient treatment/storage capacity for a number of days prior to discharge or additional treatment steps

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Household Water Use

- Average residential water usage of 179KL per year (490L/day) across TasWater in 2020/21

Figure 3.2 Average annual residential water supplied (kilometres)



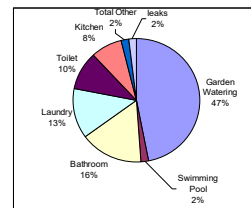
- Sewer charges typically calculated at ~80% of water usage (70%-90% seasonal)
- Calculate = 390L/day household wastewater generation (equivalent ~2.6EP @ 150L/day)

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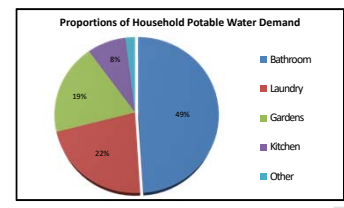
Water Use for Individual Fixtures

Fixture	Daily flow (DF) L.p/d
Basin	7
Bath/shower	32
Laundry trough/washing machine	31
Dishwashing machine/kitchen sink	30
Toilet	50
Total	150

Source: SA Health



Source: WELS rating scheme



Source: DSE 2012

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Design Occupancy - Dwellings

- AS/NZS 1547:2012 suggests 1-3 bedroom (5 EP), 4-bedroom (6-7 EP), 5-bedroom (8 EP) and 6 bedroom house (9-10 EP)
- TAS OWMS Guideline (2016) specifies 1 bedroom (2 EP), 2-3 bedroom (4-5 EP), 4+ bedroom (5 EP + 1 EP for each additional bedroom)
- SCA (CRP) – designates design flows (300L/d) based on number of 'potential' bedrooms
- Other methods: No. of bedrooms x (design) occupancy factor (i.e. 1.6) based on known population characteristics

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Typical Flow Allowances (L/unit/day) - Domestic Use only

- AS/NZS 1547:2012 (Table H1) provide (min) daily wastewater flow allowances based on source of water supply – e.g. town or tank
- Other Codes (e.g. VIC EPA 891.4) may allow further reductions for 'water saving' measures

No. of Bedrooms	2	3	4	5
TAS OWMS Guideline (2016)	4	5	5	6
AS/NZS 1547 (2012)	5	5	6	8
Reticulated (Town) supply				
TAS OWMS Guideline (2016) (150L/EP/d)	600	750	750	900
AS/NZS 1547 (150L/EP/d)	750	750	900	1,200
Rainwater (Tank) supply				
TAS OWMS Guideline (2016) (120L/EP/d)	480	600	600	720
AS/NZS 1547 (120L/EP/d)	600	600	720	960

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Commercial (non-residential) Loading

- TAS OWMS Guideline (2016) 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 allowances for non-residential buildings

Source	Design hydraulic loading Litres/person/day	Design organic loading grams/person/day
Hotel - per full attendance	1000	130
Hotel - meals per diner	10	10
Hotel - per resident guest and staff (in house laundry)	150	80
Hotel - resident guest and staff (not in-house laundry)	100	80
Restaurant per seat	40	50
Tea rooms and cafe per seat	10	10
Take-away food per customer	10	40
Conference function venue	30	30
Public toilet	5	3
Public toilet (theatre, gallery (no kitchen))	3	3
Public toilet (theatre, gallery (with kitchen))	10	5
Public building with showers and toilets (sports club, gym, school)	50	10
Hospital (per bed)	150	150
Childcare centre per child and staff	20	20
Factory office, medical centre per person	20	15
Compostworks (full services)	150	80
Camp Grounds (with showers and toilets)	100	40

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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

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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 10⁶ litres per day

In 1 ML there are 20 x 10⁶ milligrams of pollutant per day

In 20 ML there are 400 x 10⁶ milligrams of pollutant per day

As there are 10⁶ 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

$$L = 250 \text{ mg/L} \times 1,000 \text{ L} \times 1 \text{ day}$$

$$L = 250 \times 1,000 \times 365 \text{ mg/year}$$

$$L = 91,250,000 \text{ mg/year}$$

$$L = 91.25 \text{ kg/year}$$

Total Nitrogen

$$L = 55 \text{ mg/L} \times 1,000 \text{ L} \times 1 \text{ day}$$

$$L = 55 \times 1,000 \times 365 \text{ mg/year}$$

$$L = 20,075,000 \text{ mg/year}$$

$$L = 20.08 \text{ kg/year}$$

Total Phosphorus

$$L = 15 \text{ mg/L} \times 1,000 \text{ L} \times 1 \text{ day}$$

$$L = 15 \times 1,000 \times 365 \text{ mg/year}$$

$$L = 5,475,000 \text{ mg/year}$$

$$L = 5.48 \text{ kg/year}$$