On-site Wastewater Management Training Course

Secondary Treatment

Aerated Wastewater Treatment Systems (AWTS)

Aerated Wastewater Treatment Systems (AWTS)

- Mechanical secondary treatment option incorporating aeration
- Replicates treatment processes of larger municipal wastewater treatment plants in small tank(s) suited to domestic setting
- Up to 2,000L/day capacity (AS/NZS1546.3:2008)
- 1,200 – 5,000L/day capacity (AS1546:2017)

Testing

AS/NZS1546.3:2008

OSET Testing – Rotorua (2007-2018)

https://www.waternz.org.nz/OSET

Australian Standard AS1546.3:2017 *On-site domestic wastewater treatment units, Part 3: Secondary treatment systems* (Standards Australia 2017)

Testing at Jimboomba (QLD) and Hahndorf (SA)

Australian Standard AS1546.3:2017

Covers:

- Performance criteria / design requirements
- Minimum marking requirements
- Information to be provided with the system
- Product conformity evaluation for type testing

Attempted to also cover non-AWTS Secondary treatment systems e.g. sand filters, reed beds etc., but is poorly suited to passive and scalable systems. This has now been recognised by Standards Australia

Variety of Systems

Wide range of designs and configurations:

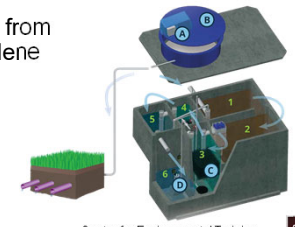
- AWTS (AS/NZS 1546.3 2008) and OSET (2007-2018)
- STS (AS 1546.3 2017) and (~100 models on AUS market)
- Large number of New Zealand, Australian and overseas manufacturers
- New brands and models entering market
- Many discontinued models still in operation
- Older systems often modified

Variety of Systems

- Wide variety of configurations and processes
- Some key similarities due to compliance with the Standards
- Differences between systems accredited under 2008, OSET and 2017 Standards
- Understanding of basic processes is important
- Performance commonly variable
- Many AWTS prove challenging to operate well
- See list of OSET tested systems

AWTS/STS Configurations

- Most systems comprise 1 or 2 tanks, with between 3 and 6 separate chambers
- The tanks are constructed from either concrete, polypropylene or fibreglass



Design Load

- OSET testing for various loads
- AS/NZS 1546.3: 2017 stipulates the following design load characteristics:
  - Minimum daily flow of 150 litres per person
  - Average daily BOD_5 – 70 grams per person
  - Average daily TSS – 70 grams per person
  - Average daily total nitrogen – 15 grams per person
  - Average daily total phosphorus – 2.5 grams per person

The Aims of Secondary Treatment

- Improve effluent quality:
  - To reduce impact on receiving environment
  - To reduce land area required for safe disposal by applying at higher loading rates than Primary treated effluent
- Reduce impact on surface / ground waters
  - By removing pathogens and possibly some nutrients
- Provide reuse water for garden irrigation

Treatment Stages

Typically four treatment stages:

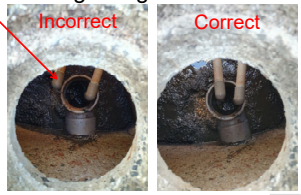
- Anaerobic digestion (Primary treatment)
- Aerobic digestion (Secondary treatment)
- Clarification (settling)
- Disinfection

Anaerobic Digestion / Primary Treatment

- Can be in a separate septic tank, or the first one or two chambers in a multi-chambered tank
- Minimum of 24 hours detention required to maximise settling and moderate peak flows
- STS Primary chambers ~2,300L - ~3,500L
- Physical, chemical and biological processes:
  - Sedimentation of solids (sludge layer)
  - Flotation (scum layer)
  - Clarification (partial)
  - Anaerobic degradation of organic material (BOD_5)

Anaerobic Digestion

- Crust important to maintain anaerobic conditions and prevent the escape of gases and odours
- Avoid damaging crust by directing sludge return to inlet tee

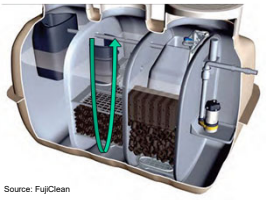


Sludge Accumulation and Removal

- Sludge accumulates at base of tank
- Progressively reduces the effective capacity of system and will require periodic removal

Anaerobic Upflow Filter

- Accelerates anaerobic breakdown and methane generation, improves solids stabilisation (e.g. Hynds FujiClean ACENZ)



Source: FujiClean

Sludge Return

- Sludge may be returned from the aeration and/or clarification chamber to the Primary chamber
- Return to inlet tee to avoid disturbing crust
- Adds to sludge accumulation in Primary
- May assist with de-nitrification

Aerobic Digestion / Secondary Treatment

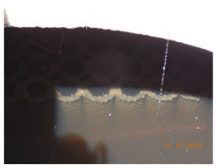
- Oxygen supply by air pump (blower) through air diffuser at bottom of chamber
- Promotes oxidation and microbiological consumption of the organic matter

Aerobic Processes

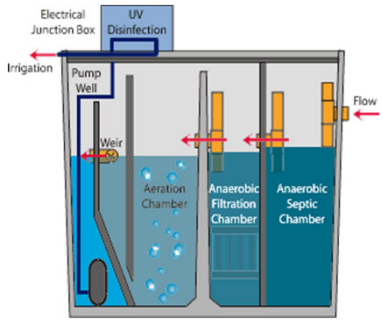
- Require oxygen
- Facilitate bacterial metabolism
- Convert suspended and dissolved organic matter to energy, biomass and wastes
- Assist with the removal of:
  - Carbonaceous organic matter (BOD and TOC)
  - Nutrients (N and P)
- Assist with:
  - Waste (sludge) stabilisation

Aerobic Processes

- Can be by way of:
  - Attached Growth Processes
  - Suspended Growth Processes
- Both can achieve a high level of BOD removal



Aeration



Source: AWTS Maintenance Services

Aeration

- Rising bubbles transfer oxygen to the biomass and mix the wastewater to allow maximum contact with treatment surfaces
- Factors impacting aerobic treatment are:
  - Volume of oxygen supplied (need to consider additional non-process requirements such as airlifts)
  - Rate/timing of oxygen supply (variable demand)
- Oxygen transfer efficiency is highly dependent upon diffuser type and bubble size (total bubble surface area)
  - Larger bubbles transfer minimal oxygen to the water
  - Fine bubbles transfer up to 80% of the available oxygen to the water column

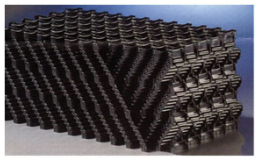
Attached Growth Processes

- Fixed or Floating Media (FM) systems
- Trickling Filter (TF) systems
- Rotating Biological Contactor (RBC) systems

- Typically require Primary sedimentation to remove coarse solids and avoid clogging
- Typically utilise a high surface area media (mineral or synthetic), or discs or drums, to support the growth of a biological film (biofilm)

Attached Growth Fixed Media

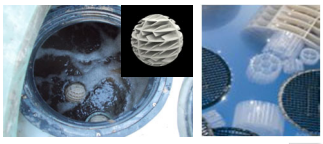
100-300 m^2/m^3



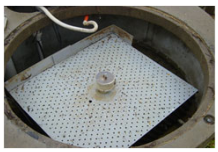
125-240 m^2/m^3

Attached Growth Floating Media

- Predominantly attached growth, but typically a hybrid of suspended / attached growth processes
- Chamber may have fixed-submerged or free floating media
- Fixed media most common



Trickling Filter



Trickling Filter





Rotating Biological Contactor



Source: Kingspan

Microbial Biofilm Growth

- Microorganisms attached to inert media
- Plastic tubes, plastic sheets, mesh with large surface area / volume ratio
- Attached or 'fixed-film' processes remove fine or dissolved organic matter from wastewater



Attached Growth

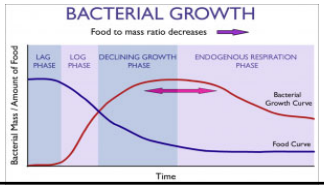
- Wastewater contacts with the biofilm
- Food is brought to microbes
- Microorganisms consume or convert organic material as part of their metabolic processes
- Oxygen is provided to the system either passively (TF and RBC) or mechanically by use of a air pump/blower
- Aerobic process requires a dissolved oxygen concentration (DO) >2mg/L

Attached Growth

- Biofilm consists of aerobic and facultative bacteria, fungi, algae and protozoans
- Worms, larvae and snails may also be present in non-submerged systems
- Media are self cleansing – excess biological film sloughs off and is transferred to the clarification chamber where it and settles and accumulates

Aerobic Treatment

- Aeration chambers are sized to ensure endogenous respiration occurs
- Over time dead cell mass and residuals will accumulate in the chamber and will eventually need to be removed



Aerobic Treatment

- Most systems rely on continuous flows and have limited ability to buffer flows
- Systems require careful consideration of hydraulic and organic loading rates
- Treated effluent requires clarification to remove sloughed biofilms and residual solids
- Sludge may be proportionally returned to the treatment reactor in submerged and hybrid systems

Aerobic Treatment

- Aerobic treatment can be impacted by variation of hydraulic or organic loads
- Factors impacting aerobic treatment are:
  - Volume/rate/timing of oxygen supply
  - Food/microorganism ratio (F/M)
  - Temperature and pH
  - Sludge return ratios and wasting (sludge age)
- AWTS experience constant variations in the above factors and can rarely be left as installed

Design/Process Controls

- The air supply and sludge return systems require regular monitoring and adjustment to ensure optimal system performance
- Airlift transfer at controlled rates is a more common feature of STS, but requires larger air supply
- Higher rate sludge return may be used to “dilute” influent

(Aerobic) Suspended Growth

- **Activated Sludge** is the principal aerobic suspended growth process in AWTS
- Blends raw or Primary treated wastewater with a retained population of microbes in suspension in an aerobic reactor (Mixed Liquor)
- Microbes consume or convert organic material as part of their metabolic processes
- Process requires a dissolved oxygen (DO) concentration >2mg/L

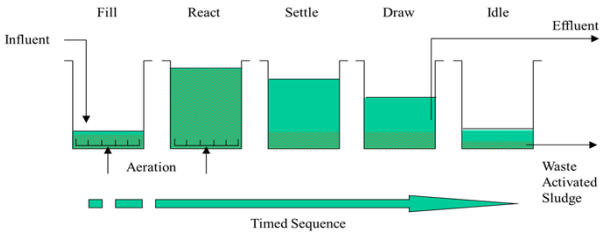
(Aerobic) Suspended Growth

- Treated mixture requires clarification, when air is switched off, to remove flocculent microorganisms from the waste stream
- A proportion is returned to the aerobic reactor (Return Activated Sludge)
- Various adaptations to the basic process address issues such as:
  - Nutrient removal
  - Small flows
  - Intermittent or low-strength flows
  - Operational simplicity

(Aerobic) Suspended Growth

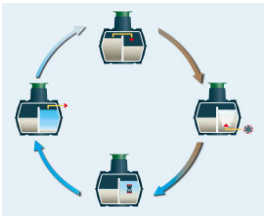
- Process performance can be limited by various environmental and chemical factors:
  - Temperature – cold (slow), warm (fast) metabolism
  - pH – 6.0-9.0, prefer limited variation (6.5-7.5)
  - Available oxygen (DO) – 2mg/L to 3mg/L + mixing
  - Alkalinity – for nitrification (min 50-100mg/L as $CaCO_3$)
  - Essential nutrients – CNP ratio (100:10:1)
  - Inhibiting substances
- Above are rarely managed in domestic AWTS

Sequencing Batch Reactor



- In a Sequencing Batch Reactor (SBR) a proportion of activated sludge is retained in the tank after decanting

Graf E-Clean 20 SBR



Aerobic Treatment

- Aerobic processes also convert organic nitrogen and ammonia to nitrate (nitrification)
- Some AWTS are designed to provide denitrification of this nitrate to nitrogen gas
- Denitrification requires high organic content (BOD_5) and anaerobic conditions
- For this to occur the aeration pump must be shut off for extended periods, which can adversely impact on BOD reduction

Nutrient Reduction

- Two baffled aeration chambers allow managed oxygen control for nitrification and denitrification
- Few AWTS have defined nutrient reduction levels
- May be expressed as percentage reduction, e.g. FujiClean ACE NZ: TN 79.05% reduction, TP 14.50% reduction
- But nutrient removal depends on influent strength
- Generally P only reduced by sedimentation
- AS1546.3 2017 nutrient reduction endorsement requires TN<15mg/L, TP<2mg/L

Clarification

- Provides settling of aerobically treated effluent
- Facilitates solids settling by providing quiescent conditions
- May utilise a funnel (Imhoff) design to concentrate settled sludge and minimise re-suspension
- In smaller systems, WAS is typically directed to the Primary chamber by sludge return (return to inlet tee)
- Skimmer may remove floatable flocs and debris (sometimes to the aeration chamber)

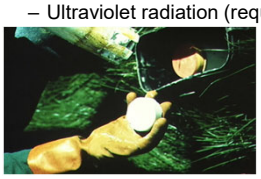
Clarification

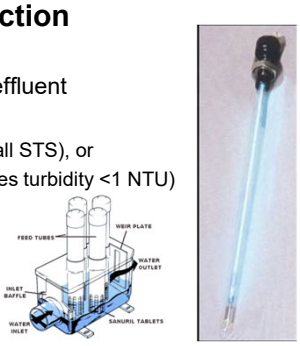
Clarification

- Eventually some sludge will need to be removed from the aeration chamber
- High F/M ratio - more food than microbes - will result in poorer BOD reduction and poorer final effluent quality
- However, some additional food (sludge return) is needed in the aeration chamber to assist with denitrification

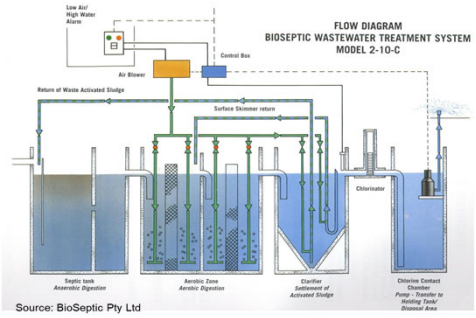
Disinfection

- Requires highly clarified effluent
- Disinfection by either:
  - Chlorination (now used in all STS), or
  - Ultraviolet radiation (requires turbidity <1 NTU)





AWTS System Configuration



Source: BioSeptic Pty Ltd

Source: Bioseptic Pty Ltd

AWTS Treatment Summary

- Treatment efficiency is highly dependent on even and constant hydraulic and organic loads
- Domestic wastewater is highly variable in quantity and quality (short and long term)
- AWTS are sensitive to biocides (e.g. bleaches, disinfectants, antibiotics)
- AWTS can remove up to 90% BOD_5 and TSS, but are less effective at removal of thermotolerant coliforms
- AWTS do not significantly reduce N or P without careful management and design modifications

Performance Objectives

(90th percentile)

- Biochemical oxygen demand (BOD_5) ≤20mg/L
- Total suspended solids (TSS) ≤30mg/L
- Chlorination (if applied)
  - Thermotolerant bacteria - median ≤10 cfu/100 mL
  - Total chlorine 0.5 – 2.0mg/L

References

- OSET test results: https://www.waternz.org.nz/OSET
- Standards Australia/Standards New Zealand (2008) AS1546.3:2008 On-site domestic wastewater treatment units. Part 3: Aerated wastewater treatment systems
- Standards Australia (2017) AS1546.3:2017 On-site domestic wastewater treatment units. Part 3: Secondary treatment systems

New Zealand AWTS Brands and Models

AWTS tested in OSET Rotorua trails

Brand	Model	Trial	Description
Bor Plastika	BO Eurotreat SBR	13	SBR
Environment Technology	AES 38R	13	AES
Hydrozone	Pureflow	13	PBR
Reflexion	Textile 5000	13	RTF
Wormsmart	Wormsmart Plus	13	VER
Austin	Bluewater AB2K	12	Submerged aerated filter
Advanced Wastewater Systems	AWWS 3200P	12	Submerged aerated filter
Biolytix	Multipod	12	VER & TF
Graf Plastics	EClean 20	12	SBR
Tech Treat	TXT	12	Submerged aerated filter & RTF
Environment Technology	AES 38	12	AES
Biocycle	8200	11	Submerged aerated filter
Hynds	Lifestyle 2	11	Submerged aerated filter
Hynds	COM1	10	Submerged aerated filter
Wright	Protech 10000	10	Submerged aerated filter
Oasis	Series 2000L	10	Submerged aerated filter
Ecocycle	Fusion	10	RPB Biofilter
Devan	Integra S-15	9	Submerged aerated filter
Biolytix	Biopod	9	VER & TF
CleanStream	TXR-1	9	RTF
AquaNova	10EP	8	Submerged aerated filter
AquaNova	NR	8	Submerged aerated filter
Ecosewerage	Ecosewerage	8	VER & TF & SSF wetland
Super-Treat	NZ12	8	Submerged aerated filter
Tech Treat	SS10	8	Submerged aerated filter
BioRock	S	8	Gravity Flow fixed film bioreactor
Findlater	PA 5X5	8	Submerged aerated filter
Allflow	Klaro 9000 10PE	7	SBR
BOPRC	AWTS NI	6	Submerged growth aerated filter & Bark filter
Quantum	Eco System	6	Submerged biological contact media
Devan	Green	5	Floating growth fixed film media
Innoflow	AX20 Mode 3 and Mode 3B	5	RTF
RX Plastics	Airtech 7000	5	Submerged fixed growth media
Humes	FR1	4	Submerged fixed film media
WaterGurus	NovaClear	4	MBR
Hynds	Advanced Lifestyle	4	Submerged fixed film media
Waipapa Tanks	Econo-Treat VBB C-2200-2	4	Submerged fixed film media
Innoflow	Advantex AX20 Mode 3	3	Textile PBR
Oasis	Clearwater S2000	3	Submerged fixed film media
Waipapa Tanks	Maxi-Treat MVC-3000	3	Submerged fixed film media
Biocycle	6300	3	Submerged fixed film media