Package Treatment Plant Operation and Management

Technologies and Performance: Part 2

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Introduction

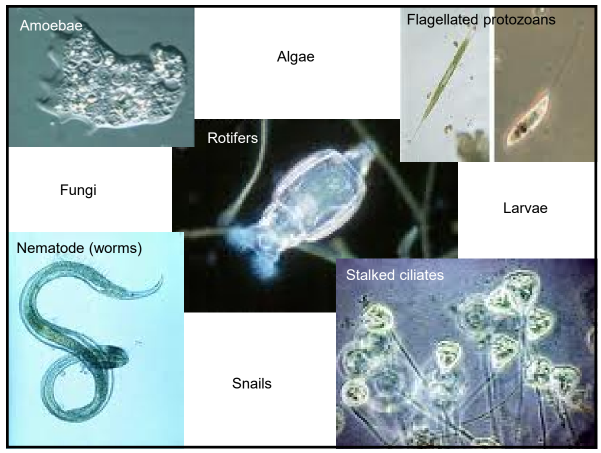
In this session we will cover:

Common Attached Growth and Hybrid Technologies

- Description
- Typical Configuration and Unit Processes
- Applicability
- Performance
- Examples

Biological Filter Plants

- A biological (trickling) filter is a non-submerged attached growth aerobic reactor using both physical filtration and biological processes
- Rock, plastic or other material is used as a supportive substrate for the development of a microbial biomass
- Biomass (or biofilm) consists of aerobic and facultative bacteria, fungi, algae and protozoans. Worms, larvae and snails may also be present
- Capable of receiving raw or primary wastewater



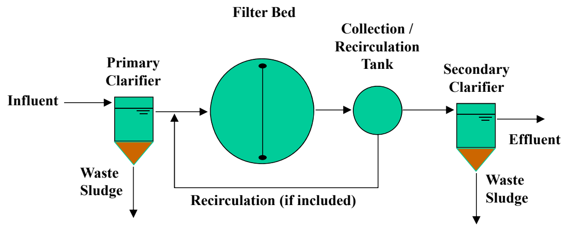
Biological Filter Plants

- Wastewater is distributed over the filter bed surface continuously or intermittently (dosed) using spray heads or rotating sprinklers
- Treatment occurs as organic material and other dissolved wastewater constituents come into contact with the microbial biomass
- Organic material is adsorbed onto the microbial biomass and degraded by aerobic microorganisms on the surface of the films and anaerobic or facultative microorganisms deeper within the biomass layer

Biological Filter Plants

- Aeration of the filter bed is typically provided passively as the wastewater percolates through and air fills the voids
- Some systems may use assisted aeration
- Treated wastewater is collected within an under drain system and transferred to either a secondary clarifier or a recirculation tank depending upon system design
- If required, disinfection takes place after this treatment process

Biological Filter Plants (Typical Configuration)



Biological Filter Plants (Applicability)

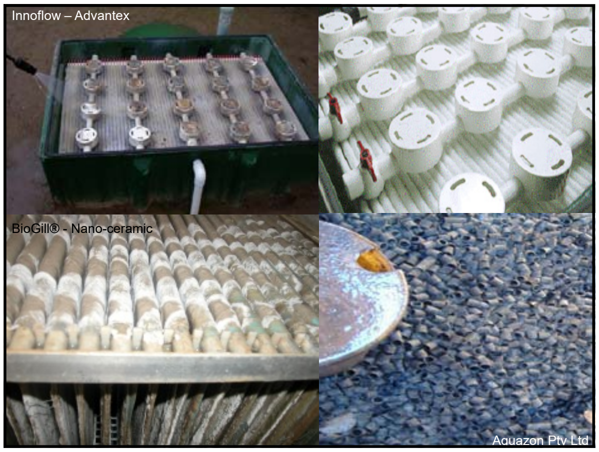
- Typically lower maintenance and management requirements compared to AS systems
- Lower energy requirements
- Arguably more resilient to shock load events
- Advanced filter designs require higher levels of pre-treatment
- Effluent quality highly variable dependent upon system selection:
  - Rock (Roughing) filters – single pass – low quality
  - Fabric/Media filters – recirculating – very high quality

Biological Filter Plants (Performance)

- Potential for high BOD (80 – 90%) removal and nitrification (> 75%) in correctly designed systems utilising recirculation
- Denitrification possible in recirculating systems where filtered effluent is returned to the Primary treatment system (carbon source)
- Susceptible to problems associated with higher than design hydraulic loading – biofilm shear/sloughing and subsequent solids carry over
- Pathogen reduction moderate (2-3 log) without disinfection

Biological Filter Plants (Performance)

- Excess loading typically results in biofilm bridging of the media void spaces, reducing down flow rate and minimising effluent contact
- Appropriate media selection can reduce the risks of high organic load related problems occurring (low rate, high rate and roughing filters)
- Significant predator (snails) and insect (flies) problems can occur with trickling filters if not managed, particularly exposed media beds
- Temperature sensitive (exposed systems)



Submerged or Floating Media Treatment Plants

- These treatment systems use submerged attached growth processes to treat wastewater
- Typically synthetic media are either fixed (banks) or floating (loose) in the treatment reactor
- Wastewater is pumped or flows into the reactor vessel and comes into contact with the microbial biomass supported on the media surfaces
- Organic material is adsorbed onto the microbial biomass and degraded by aerobic and anaerobic microorganisms

Submerged or Floating Media Treatment Plants

- Oxygen is typically supplied to the biofilm via a blower or air diffuser assembly fixed to the bottom of the reactor vessel
- Rising bubbles serve the a dual purpose of transferring oxygen to the biomass and mixing of the wastewater to allow for maximum contact with the treatment surfaces
- Various types of fixed and floating media are available, most are synthetic and contain large surface area/volume ratios

Submerged or Floating Media Treatment Plants

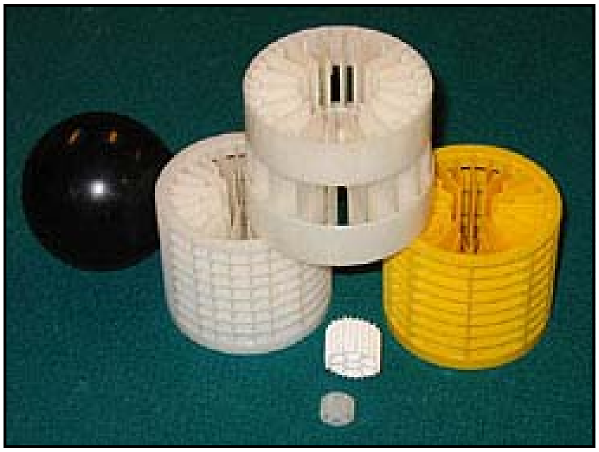
- Fixed media systems typically require Primary sedimentation to avoid solids overloading the reactor vessel
- Systems may be configured compartmentally with baffles to allow managed oxygen reactions (nitrification/de-nitrification) to occur
- Technology commonly incorporated into Biological Nutrient Removal (BNR) plants
- Sludge is retained within the system and will require regular wasting

Submerged or Floating Media Plants (Applicability)

- Minimal land area requirement for construction (typically compact designs)
- Costs can be lower as the majority of treatment takes place in the one reactor
- Floating media systems suitable for receiving high strength or raw wastewaters
- May be referred to as Moving Bed Biofilm Reactors (MBBR)
- Also adequate for intermittent flow conditions when used in conjunction with recirculation

Submerged or Floating Media Plants (Performance)

- Potential for high BOD and COD (85 – 95%) removal and nitrification (> 75%) in compartmental or staged treatment systems
- Better process control and air management during staged treatment allows for significant denitrification
- Phosphorus removal difficult without chemicals
- Potential for biofilm bridging and clogging in heavily loaded fixed media systems. Can be rectified with Primary sedimentation and backwashing



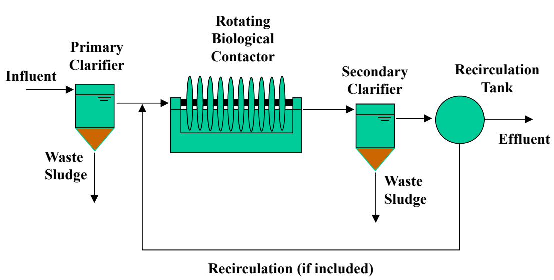
Rotating Biological Contactors

- An RBC is a partially submerged attached growth aerobic reactor
- Consists of a series of slowly rotating circular disks or suitable plastic media of various shapes attached to a central horizontal shaft
- The media and shaft together are commonly referred to as the ‘drum’
- In typical designs approximately 40-80% of the drum depth is submerged into a tank into which settled wastewater is fed

Rotating Biological Contactors

- The drum is slowly rotated and a microbial biomass (biofilm) develops on the media surfaces
- Aeration of the filter media and biomass is provided passively as the drum rotates through the water and air fills the disk/media/biofilm voids
- Many system reactors are baffled to improve mixing and sludge management
- Some systems also use assisted aeration
- Requires Primary sedimentation and clarification to manage influent and residual solids

Rotating Biological Contactors (Typical Configuration)



Rotating Biological Contactors (Applicability)

- RBCs are suitable for similar applications to Activated Sludge (AS) systems
- Relatively small footprint makes them suitable for constrained sites
- Moderate energy demand for system operation
- Some systems also act like a pump and are capable of achieving lift within the system

Rotating Biological Contactors (Performance)

- High BOD removal (>90%) is achievable in well designed RBC systems
- Considerable nitrification is also possible if adequate BOD reduction has occurred
- Some systems include recirculation to include denitrification process
- As with AS, advanced P reduction difficult without chemicals
- Require Primary clarification to operate effectively
- Can be susceptible to temperature problems

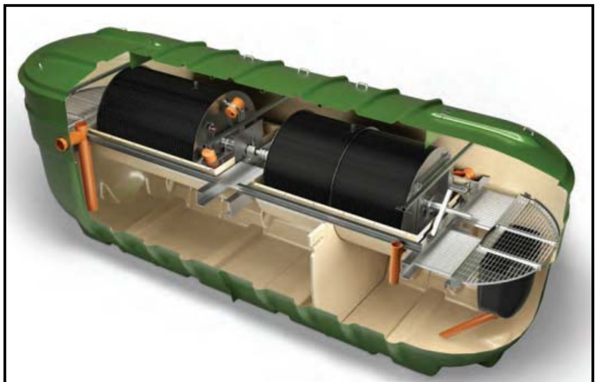
Rotating Biological Contactors (Performance)

- Performance problems may be encountered in high organic loading situations where the BOD or COD may be greater than the oxygen transfer rate to the biofilm
- Development of anaerobic conditions can result in odours and excessive biofilm sloughing
- Under normal operating conditions biofilm bridging is limited by sloughing excess biofilm using the shear forces exerted by the rotating drum
- System performance is highly energy dependent

AIM Water – AlphaDisc © RBC


Kelair-Blivet ™ RBC


Kelair-Blivet ™ RBC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Biological Nutrient Removal

- BNR systems or processes may include, or be incorporated with, any of the suspended or attached growth aerobic treatment processes
- The most important elements of BNR systems are oxygen management and electron acceptor availability (carbon sourcing)
- The BNR treatment system configuration can be used to manage these parameters for targeted nutrient removal
- Additionally, external augmentation can increase nutrient removal performance

Nitrification

- Biological nitrification (conversion of primarily ammonia to nitrate) is a microbially facilitated two-step process
- While the process is highly sensitive and complex it can be narrowed down to 4 basic variables:
  - Adequate BOD/COD control (priority process)
  - Available DO (high demand)
  - pH (6.5-8.0) and Alkalinity ($CaCO_3$ availability)
  - Temperature
- Well managed (aerobic) treatment systems can often achieve >90% nitrification

Denitrification

- Biological denitrification (conversion of oxidised nitrogen to gaseous nitrogen) is also microbially facilitated, but often far more elusive
- Denitrifying bacteria use the conversion as an energy source, but require an available carbon source for cell synthesis and electron donation
- The process is controlled by the same variables as nitrification with the exception that the concentration of carbon and nitrate are also important (along with pH, temp, DO etc.)

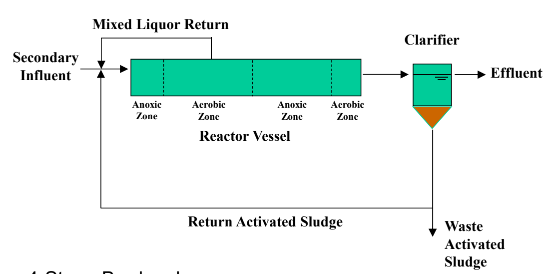
Denitrification

- Simply, **in a depleted oxygen (anoxic) environment, facultative heterotrophic bacteria use O and H from nitrate and a carbon source to release C for metabolism and in the process create bicarbonate, water and nitrogen gas (N_2)**
- A number of treatment processes exist to facilitate denitrification. Generally they comprise:
  - One or multiple anoxic zones, effluent recycling and carbon source management
- Carbon inputs may be passive (wastewater) or active (methanol etc. addition)

Biological Phosphorus Removal

- The major process for P removal in wastewater treatment systems is through the capture of solids to which organic P is attached
- Biological removal of primarily dissolved P can be achieved using many of the same processes as denitrification
- Although the removal efficiency is generally much less for wholly biological methods
- Because of this practicality, many systems are designed for combined (N + P) removal

Biological Nutrient Removal (Typical Configuration)



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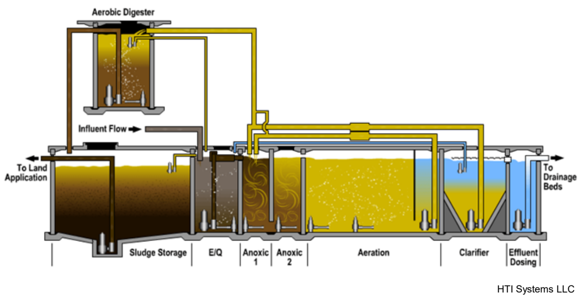


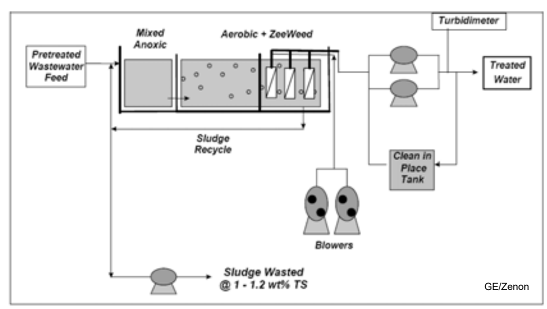
Biological Nutrient Removal (Performance)

- BNR treatment plants are capable of very high levels of nutrient control
- Total N concentrations of less than 3 mg/L are readily achievable
- Total P concentrations less than 10 mg/L are common and less than 5 mg/L is achievable in well managed systems
- P stripping below these values will typically require chemical assistance

Membrane Bioreactor Plants

- MBRs have become increasingly available and popular in the past decade
- In most early examples they comprised the addition of a MF or UF membrane as a Tertiary treatment process following a conventional Secondary treatment process (e.g. bioreactor)
- More recently, the membrane is incorporated directly into the Secondary treatment reactor, negating the need for a clarifier
- Advantage of combining reliable and efficient Secondary treatment process with extremely efficient filter technology (including pathogens?)

Membrane Bioreactor Plants (Typical Configuration)



Membrane Bioreactor Plants (Applicability)

- MBRs typically have a much smaller footprint than conventional system because of lower sludge retention time (SRT) and decreased clarification demand
- Reliable production of high quality effluent makes them most suitable for sensitive sites (N, P and pathogen reduction)
- They are also often required for reuse applications where primary contact is a concern
- Often only used in larger installations but becoming more common for smaller applications

Membrane Bioreactor Plants (Performance)

- Performance from many systems installed indicate the delivery of reliable high quality effluent
- Reported monitoring indicates that the following results are achievable with UV disinfection:
  - BOD/TSS - ~2 mg/L
  - Nitrate - <3 mg/L
  - Total P - <1 mg/L
  - Turbidity - <2 NTU
  - Fecal Coliforms - ~5 MPN/100mL

Membrane Bioreactor Plants (Performance)

- Performance issues with MBR plants are usually associated with membrane fouling, cleaning and replacement
- Careful pre-treatment is required to avoid membrane damage
- Cleaning can require the storage and use of caustic and acid agents
- Well-maintained membrane units have a reported life of up to 10 years
- MBR's also have higher sludge production rates