Package Sewage Treatment Plants

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Sewage Treatment Theory

- Sewage treatment is the use of physical, chemical and biological equipment/processes to remove/recover pollutants from sanitary waste water (mix of Black, Yellow and Grey Water) to make it environmentally and hygienecally safe for reuse (drinking, swimming, flushing, irrigation or industrial use) or discharge to receiving bodies (land or water).

Pollutants in Sewage: Physical, Chemical & Biological

- Bulk solids/plastics/ Grit/Hair
- BOD5 (Biological Oxygen Demand): Organic waste from food digestion, biochemical catabolism
- COD (Chemical Oxygen Demand)
  - Surfactants (mostly from soap, shampoo and laundry)
  - Pharmaceuticals (from human excretion)
  - Cleaning products
- SS (Suspended Solids)
- Fat, Oil and Grease (FOG)
- Scum (Soap + Hardness)
- NaCl (urine has cond. = 20000 µS/cm)

Pollutants in Sewage cont'd

- N and P: N mostly from urine, P from detergents, can cause eutrophication (Depletion of DO and Algal blooms) in receiving waters. Nitrites can be toxic.
- Bacteria, viruses and other pathogens (ex. cysts)
- Odours: H2S, Putrescine, Cadaverine, Indole, Skatole, Mercaptans (R-S-H))
- Endocrine Disrupting Chemicals (Pharmaceuticals, contraceptives, hormones, pollutants, industrial chemicals and PCP's)
- Heavy metals (more in industrial waste water or storm runoff)
- VOC's (more in industrial waste water) or Gases
- Radionuclides? (more in industrial waste water)

Typical Pollutant Concentrations in Raw Sewage

Type	Unit	Concentration
pH		6-9
TSS	mg/l	120-400
COD	mg/l	250-800
BOD5	mg/l	110-350
Total N	mg/l	20-70
Total P	mg/l	4-12
Oil and Grease	mg/l	50-100
Total coliforms	MPN/100	70,000,000

Pollutants Concentrations in Effluent

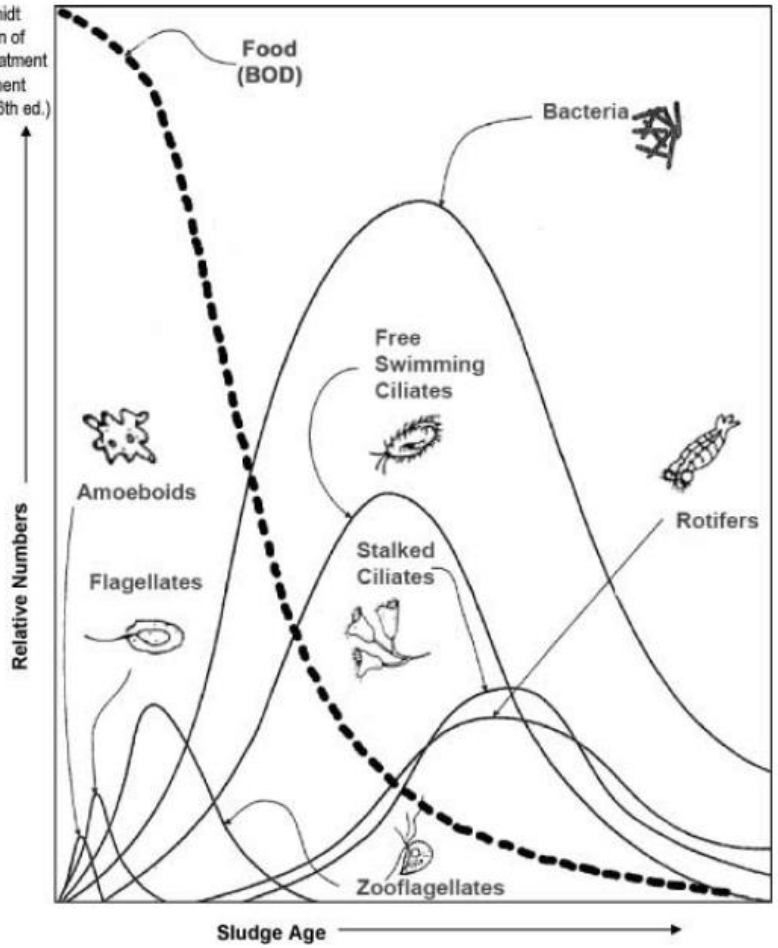
Type	Unit	Concentration
pH		6-9
TSS	mg/l	10 (96% reduction)
COD	mg/l	100 (81% reduction)
BOD5	mg/l	10 (96% reduction)
Total N	mg/l	10 (78% reduction)
Total P	mg/l	2 (75% reduction)
Oil and Grease	mg/l	< 10 (87% reduction)
Total coliforms	MPN/100	400 (99.999% reduction)

Micro-organisms In Waste Water Treatment

The principal role of rotifers in wastewater is the removal of bacteria and the development of floc. Rotifers contribute to the removal of effluent turbidity by removing non-flocculated bacteria.

Figure 1.2.2.2

Courtesy of Amy Schmidt (WIDNR) and Operation of Municipal Wastewater Treatment Plants, Water Environment Federation (WEF) (Vol. II, 6th ed.)



The growth of microorganisms over time (sludge age) due to the presence of food (BOD) in the aeration basin.

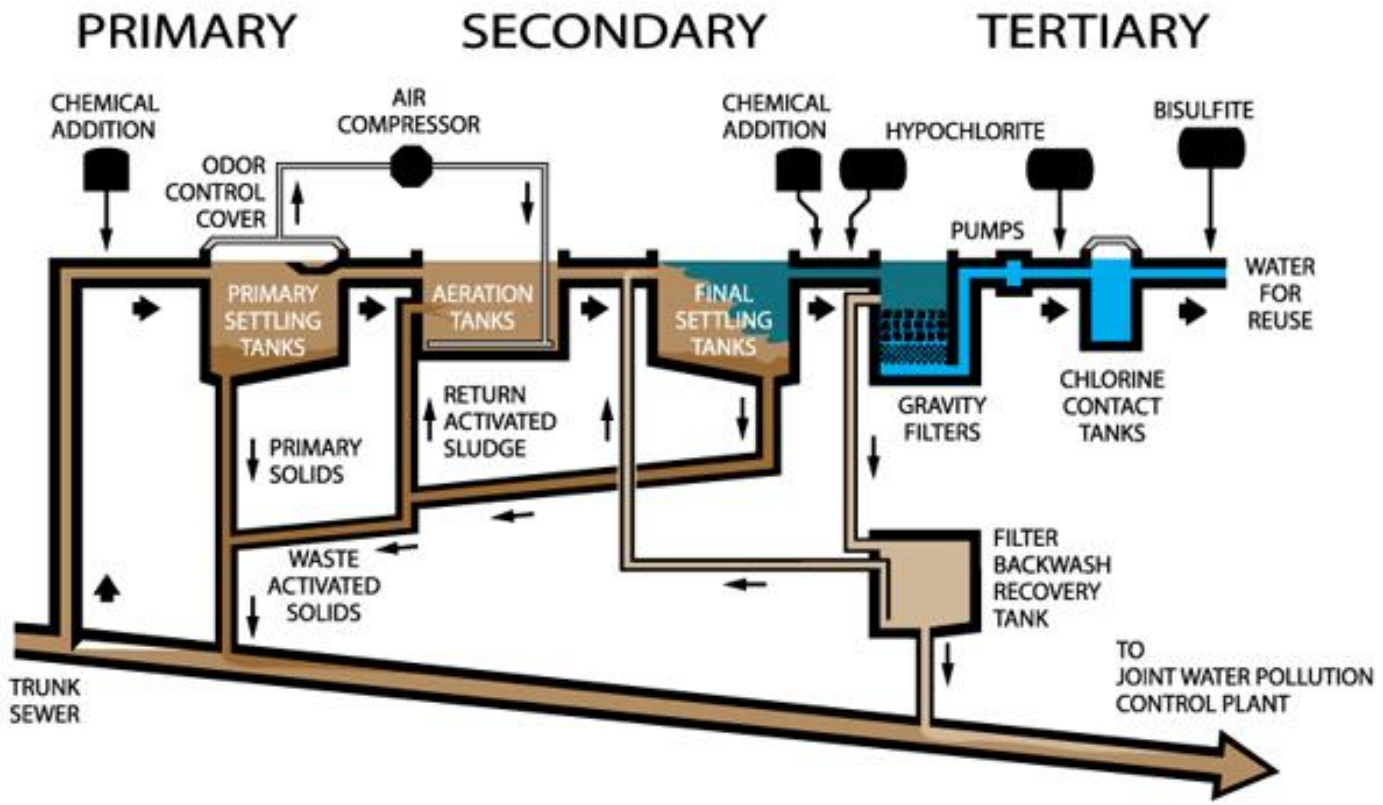
Treatment Processes: Physical, Chemical & Biological

- Need grinding/screening to remove bulk waste and protect pumps (1'ry treatment)
- Need skimming to remove floating scum, FOG (1'ry treatment)
- Need 1'ry settling to separate non-biodegradable solids from the water
- Some plants use pH adjustment + Air stripping/acidic scrubber to remove ammonia
- Need aeration for bacteria which break down the organics to CO2 and H2O + build cell tissue (2'ry treatment) and convert Ammonia to nitrates (nitrification). C:N:P ratio should be ~ 100:10:1, typical 100:20:5. Anaerobic biodegradation is too slow (but requires less energy). Used in sludge digestion and Biological Nutrient Removal (produces useable Methane). Biological treatment is either Suspended Growth (floc or granules) or Attached Growth type or hybrid.
- Need anoxic zone (0 DO, high NOx) for denitrification: Nitrates are converted to N2 gas (2'ry treatment)
- Need disinfection: UV, Chlorine, Ozone, ClO2 (3'ry chemical treatment) or MBR

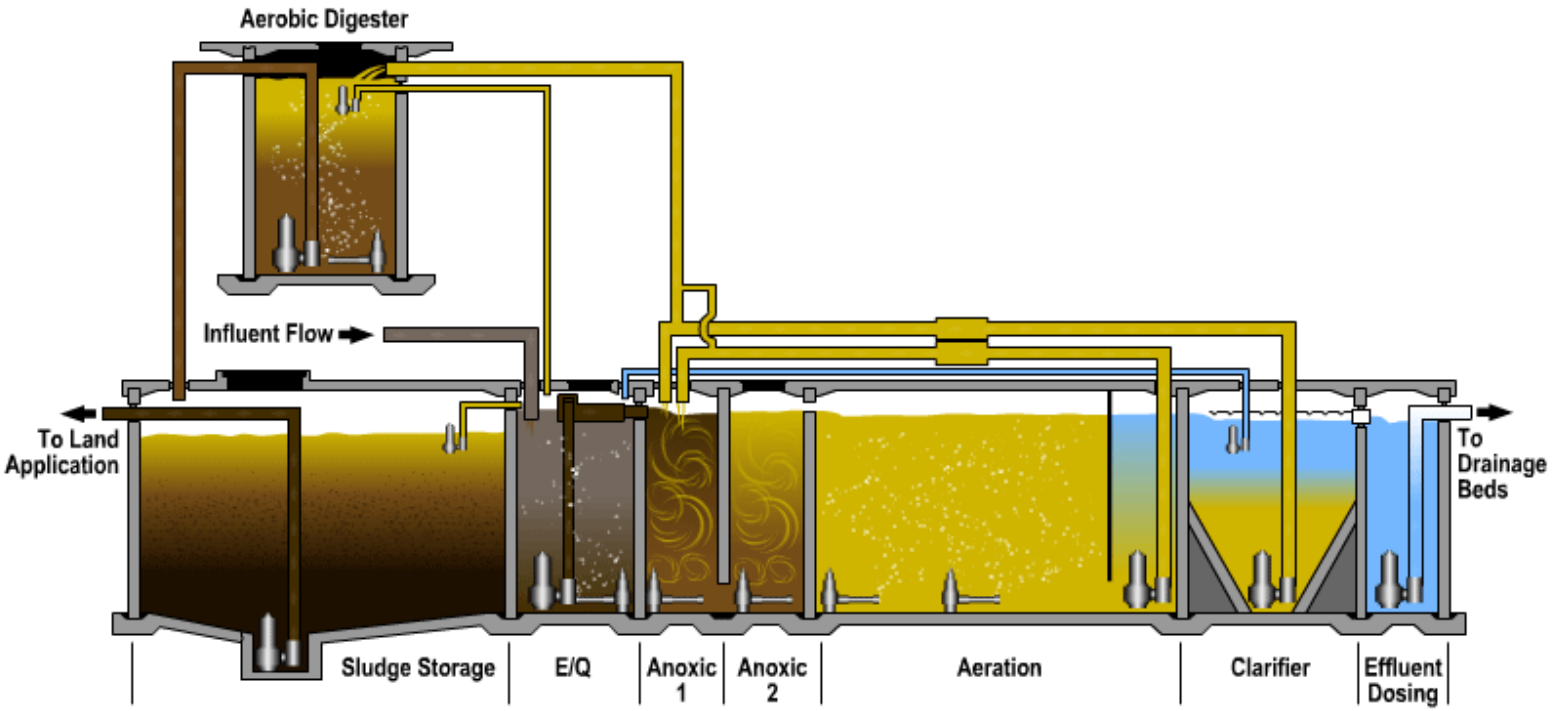
Treatment Processes: Physical, Chemical & Biological

- Need chemical dosing (ex. $FeCl_3$ or Alum) for P removal or adsorption filter (3'ry chemical treatment) or $MgCl_2$ dosing for removal of Ammonia from separated Urine (as struvite).
- Lime treatment to remove heavy metals
- Need filtration to remove SS not removed by gravity settling (3'ry physical treatment)
- Need advanced oxidation processes or GAC (for removal of non biodegradable organics)
- Some plants use RO to produce potable water from effluent (Ex. Newater ™ in Singapore, NASA space station)
- Need sludge digestion/dewatering/disposal
- Need odor removal technologies: ex. AC, Biofilters or Air Oxidation
- Some sewage treatment plants aim to recover heat from raw sewage through heat exchanegrs

Treatment Processes: 1’ry, 2’ry and 3’ry



Schematic for Package STP ASP with Anoxic Zone



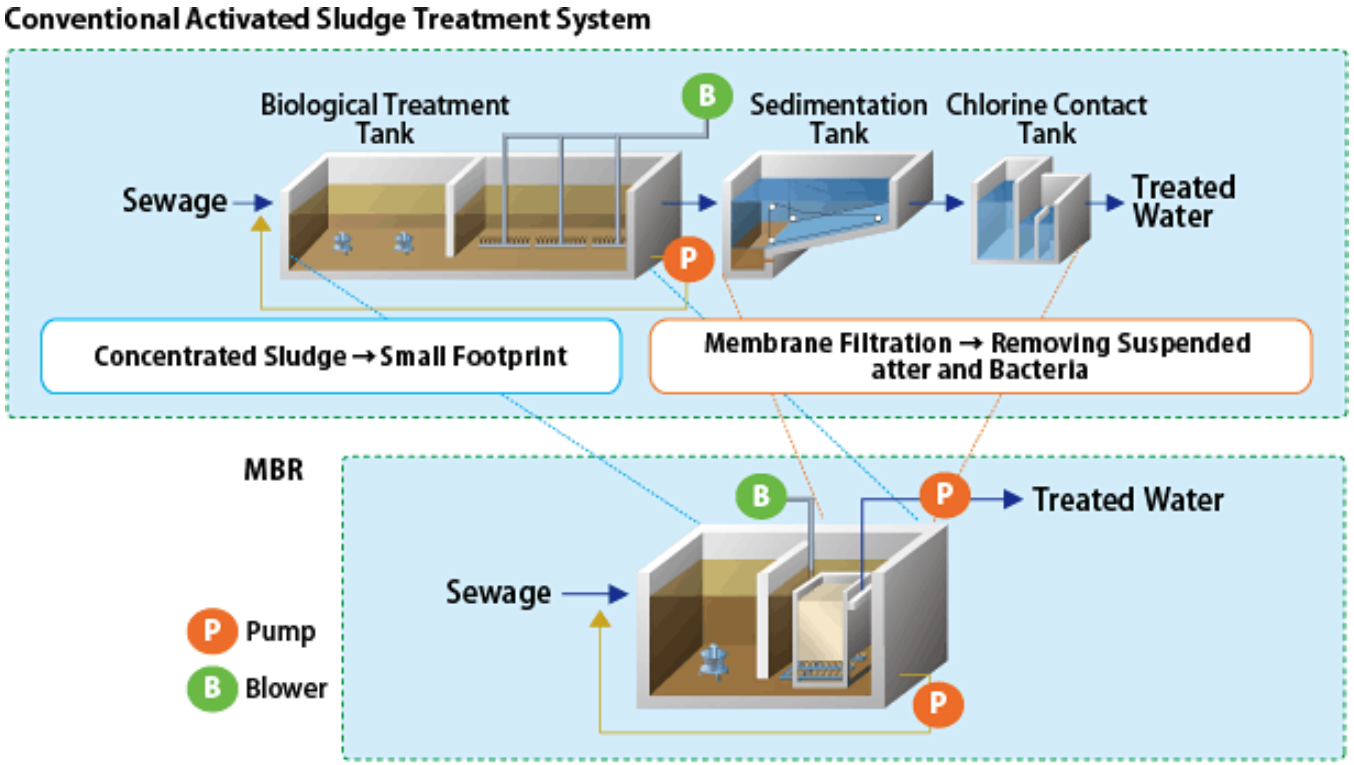
Types of Package STPs

- **Septic tank**: collects raw sewage + slow anaerobic degradation of BOD+ drain field
- **Sequence Batch Reactor** (aeration and settling in same tank)
- **Activated Sludge Process** (aeration + settling) – Suspended Growth
- **Fixed Film Processes** (moving substrate ex RBCs, MBBR)
- **Trickling Biological Filter** (stationary substrate)
- **Membrane Bio Reactor** (MBR – uses MF or UF to separate solids from water)
- **Oxidation Ditches** (aerobic/anaerobic bacteria) ex Carrousel ™
- **Algae Based** (symbiosis between bacteria and algae) – Oilgae (oilgae.com)
- **Reed Beds** (plants uptake lots of N and P from the soil)
- **Soil treatment**
- **Energy free** packages (Biorock, Clearfox Nature, Epur Flo)

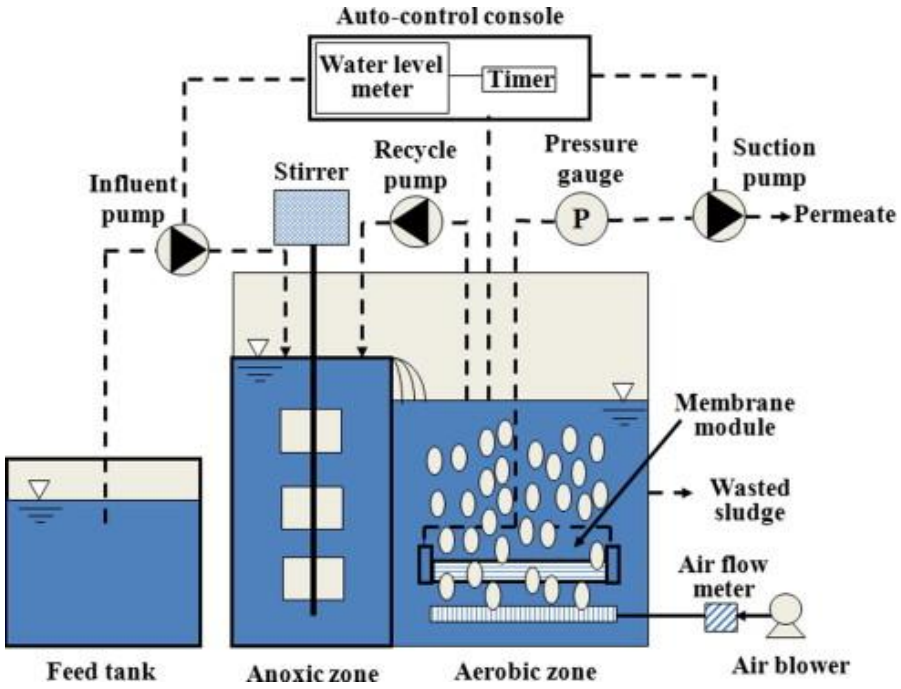
Classes of Package STP's

- Class C: Removes BOD Carbon
- Class N: Nitrification – Removes Organic N (TKN)
- Class D: Denitrification – Removes Total N (organic + nitrates)
- Class + H: Disinfects
- Class + P: Reduces Total P
- Class + RO: Removes salinity (TDS)

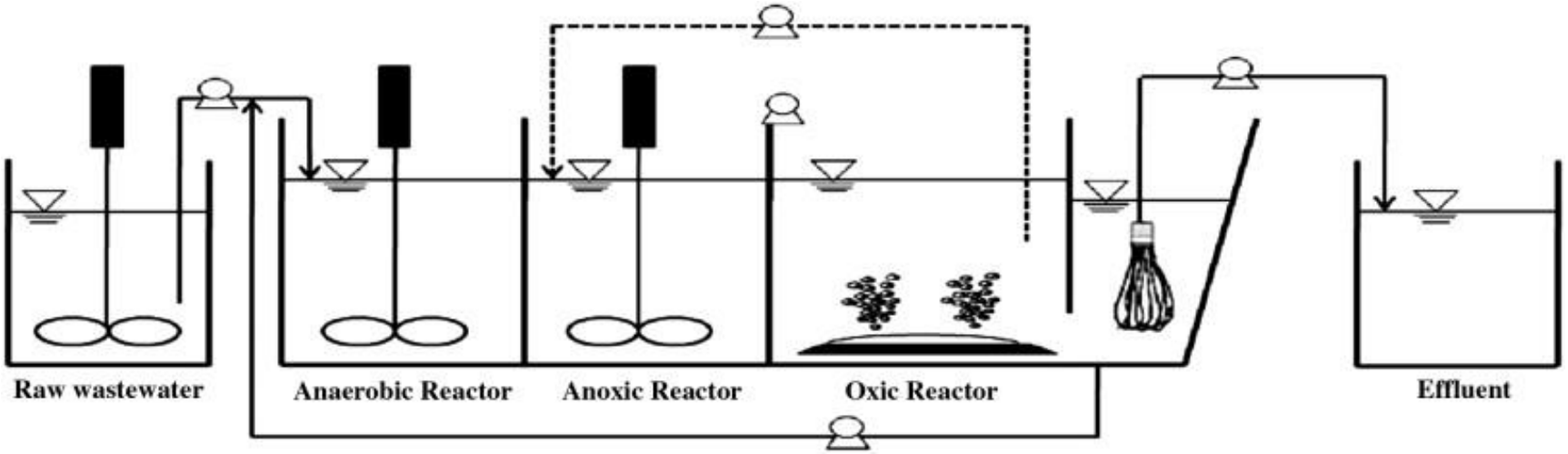
Comparison of Classical ASP with MBR



MBR Process Schematic

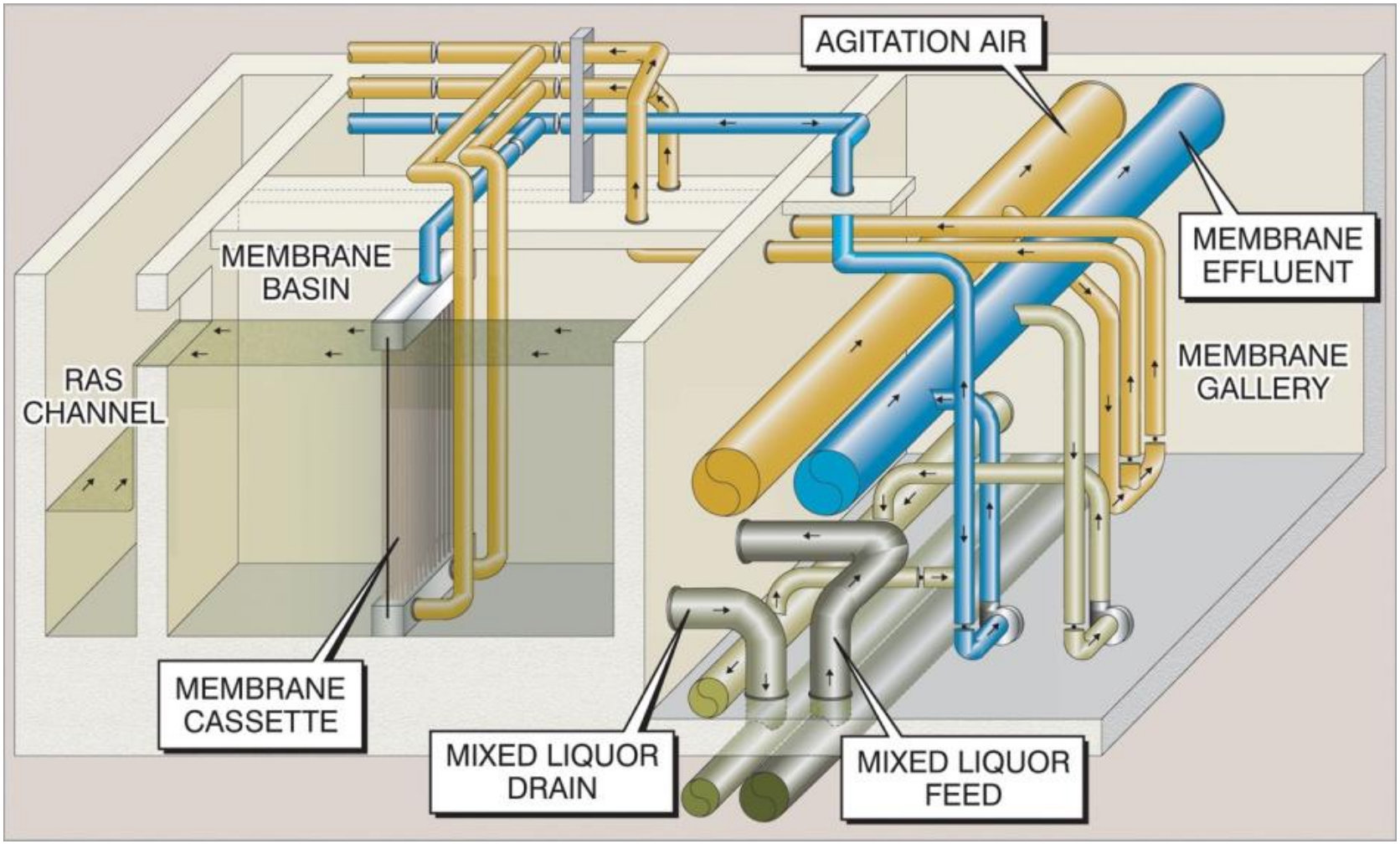


MBR Process Schematic w/ Anaerobic Zone

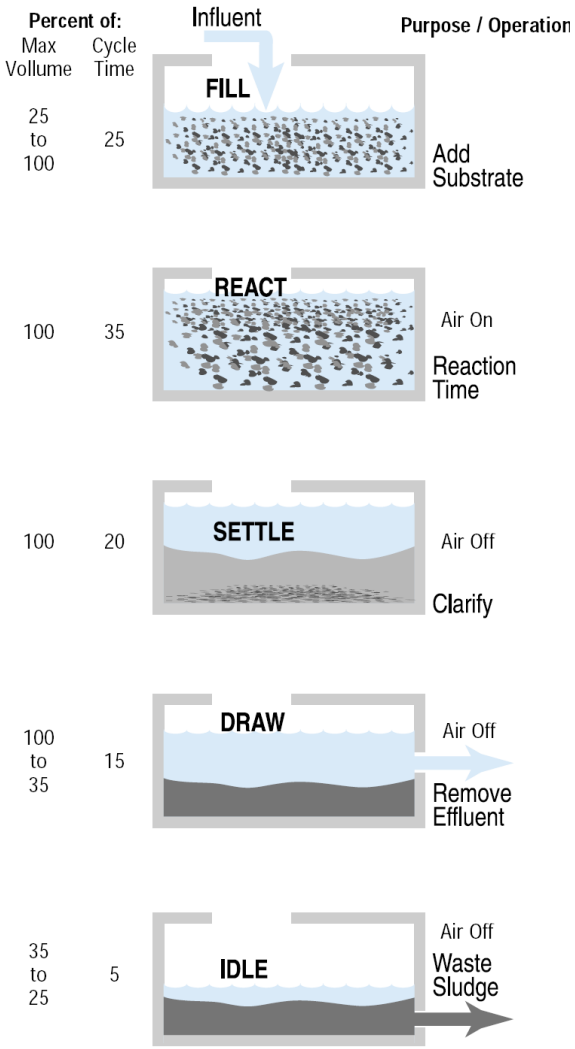


- Anaerobic zone helps with BNR

MBR Isometic View



SBR Process Cycle



Advantages

- Low foot print/capital cost
- Easy to operate
- Good contaminant removal
- No RAS

Disadvantages

- Limited to smaller flows

Legislation

- Country/region specific
- Controls effluent parameters such as:
  - BOD/COD
  - SS
  - Tot N and P
  - Bacteria
  - Sludge disposal (For example, sludge cannot be used in fields as fertilizer in CH)
  - Flow
- World Bank, IPPC (EU), WHO, FAO, EPA
- The future is heading towards higher energy efficiency/sustainable energy sources, further pollutant and GHG (CO2 and N2O) emission reduction, nutrient recovery and ZLD.

Design Considerations

- Influent/Effluent quality
- Population Equivalent (175 l/person)
- Sludge treatment/dewatering?
- Process Selection
- Sizing: tanks, pumps, blowers
- Automation concept
- Capital, operational and maintenance costs
- Pre-assembled minimizes erection costs
- Expandable? Upgradeable?
- Operational Plant Life
- Flushing water quality (alkalinty is important)
- Hydraulic and nutrient shock resistance
- Available area for process equipment
- Ambient temperature

Advanced Process Monitoring

- pH/alkalinity/Salinity
- DO (2 mg/l is ideal for ASP)
- SVI: sludge volume index (volume of settleable sludge)
- SRT = Sludge Retention Time
- MLSS: Mixed Liquor Suspended Solids (WAS and RAS)
- MCRT = Mean Cell Residence Time (Sludge Age) and SRT
- Microbiology (to determine health of sludge)
- TKN, Nitrates, Nitrites
- TP

Advanced Process Monitoring

- SS (suspended solids)
- BOD and COD
- Visual (Sludge Judge) and Smell
- Bacterial Counts (Coliforms, Faecal Coliforms)
- F/M = Food/Micro organism ratio
- Hormones, EDC's
- Micronutrients

Operational Problems

- Pin floc (bacteria are starved - extracellular polymeric substances eaten away) -> carryover of Turbidity
- Bulking due to filamentous bacteria predominance (foam/floating sludge)
- Death of biomass due to lack of organic/nutrient load (Black sludge)
- Septicity due to lack of aeration -> Odour problems
- Straggler floc (during start up, not enough time for bacteria to form flocs) -> carryover of Turbidity
- Floating sludge in clarifier (Denitrification – N2 production)

Operational Problems

- Formation of Struvite scale ($NH_4MgPO_4 \cdot 6H_2O$) in Sludge Digester piping
- Chemical toxicity to Biomass (toxic heavy metals, biocides)

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Suppliers

- PPU Umwelttechnik - Germany
- JS Umwelttechnik – CH (qualified)
- Graf – Germany
- Klargester - UK
- Klartechnik - Germany
- Martin Membrane Systems - Germany
- Busse IS Gmbh - Germany
- GES - Israel
- ISEA – Italy (qualified)
- Artas - Turkey

Klargester Biodisc (Fixed biofilm process)

Klargester
Treatment Systems

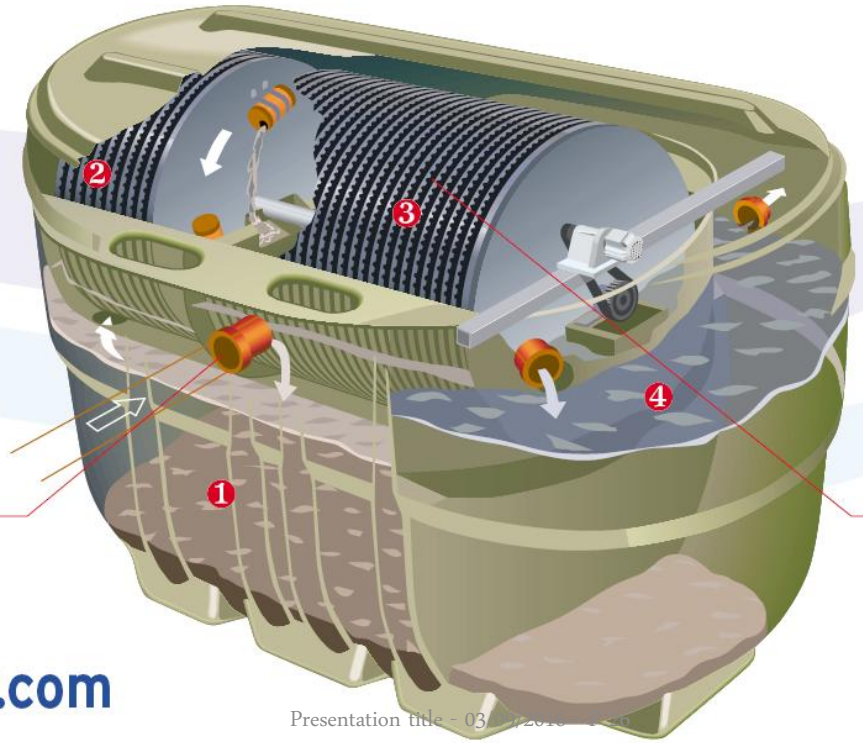
BioDisc® - Specialised High Perfomance Treatment Plants for Residential and Commercial Applications

Assured Performance

The nature of waste water has changed over the last few decades. In recognition of this Klargester's unique patented Managed Flow System has been specifically designed to maintain optimum performance despite shock organic loadings and hydraulic surges. The detrimental effects of modern disinfectants and cleaning materials are minimised by the managed flow system.

How BioDisc® Works

Central to the operation of each BioDisc® is the Rotating Biological Contactor (RBC), which supports a biologically active film or biomass. This consists of aerobic micro-organisms, naturally occurring in sewage which break down the pollutants in the waste water flow.



The Treatment Process

- Waste water flows into the primary settlement zone ❶ where solids are settled out and retained. Accumulated sludge should be drawn out periodically.
- Partially clarified liquor flows into the managed flow section of the biozone ❷.
- Here it is buffered both organically and hydraulically before being fed at a controlled rate to the second stage of the biozone ❸ for further biological treatment.
- Humus solids are settled out in the final settlement tank ❹.
- The quality of the resultant effluent allows discharge into or close to a water course, subject to discharge consents.

Deep Drain Invert

This provides the flexibility to connect with most incoming drainage systems without the need for greater excavation depth.

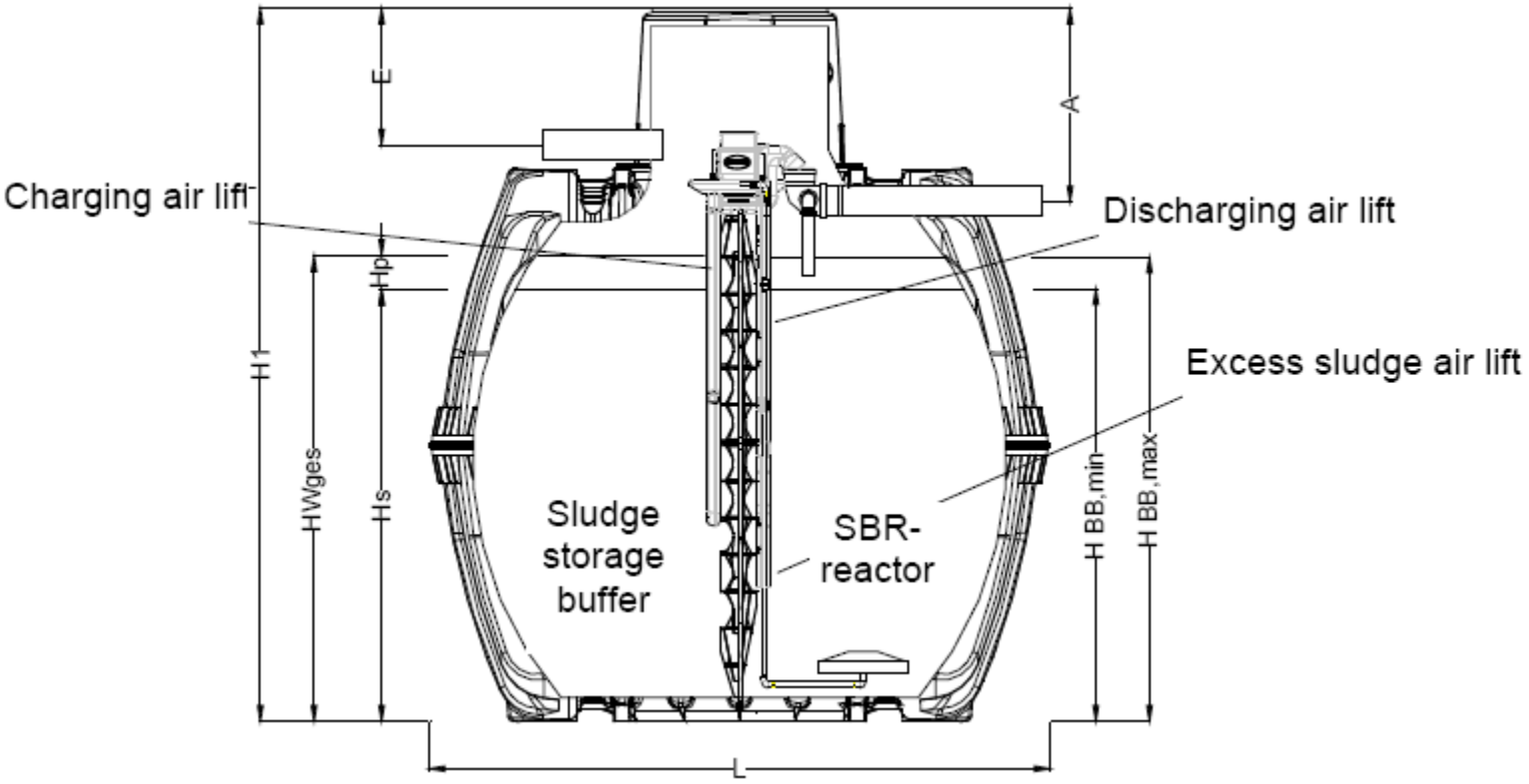
Rotating Biological Contactor (RBC)

The RBC comprises banks of vacuum formed polypropylene media supported by a steel shaft. This is slowly rotated by a low energy consumption electric motor and drive assembly.

www.klargester.com

GRAF Klaro SBR Unit (ASP)

Schematic


Charging air lift
Discharging air lift
Excess sludge air lift
E
A
Hp
H1
HWges
Hs
H BB,min
H BB,max
Sludge storage buffer
SBR-reactor
L

KEC Experience

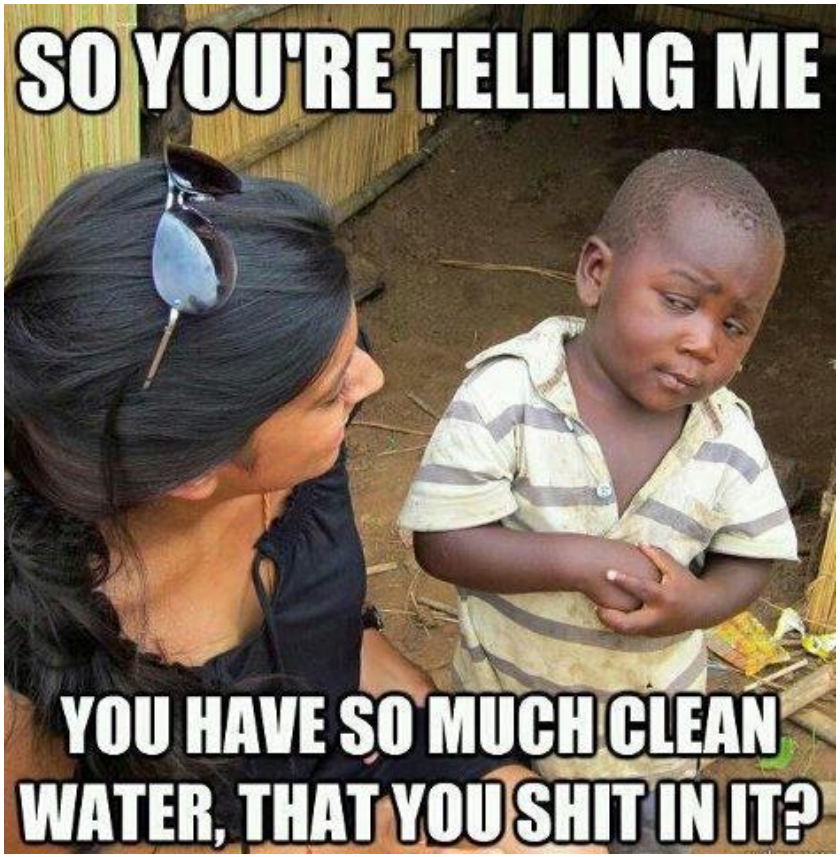
- **Maritza** Case: could not meet TN requirement during construction
- **Pembroke** case:
  - IPPC requirements provided by EA too late
  - system designed too small
  - system did not achieve environmental agency requirements
  - Result was offsite disposal ($$$$$) during construction
- **Malaga:** *Minitroll* Station from JS Umweltechnik (BOD, SS 40 mg/l)
- **Terga**: ISEA underground Containerzed ASP Plant

R&D

- **Sharon**: **S**ingle reactor system for **H**igh activity **A**mmonium **R**emoval **O**ver **N**itrite: $NH_4^+ + O2 \rightarrow NO_2^-$ (saves Energy)
- **Anammox** = **AN**aerobic **AMM**onia **Ox**idation ($NH_4^+ + NO_2^- \rightarrow N_2 + 2H_2O$) (auto-trophic, no need for C-source, Less O_2, Less CO_2)
- **BABE**: **B**io-**A**ugmentation **B**atch **E**nhanced
- **BNR**: **B**iological **N**utrient **R**emoval
- **NEREDA ™ :** aerobic granular biomass
- **MBR:** Best SS,BOD, Bacteria parameters
- **Flush free toilets/waste separation**
- **Nanotechnology** and Water Treatment (nanoH2O, Graphene)

Nereda®
The natural way of treating wastewater

Food for Thought: Eliminate Blackwater !



"The flush toilets we use in the wealthy world are irrelevant, impractical and impossible for 40 percent of the global population, because they often don't have access to water, sewers, electricity, and sewage treatment systems.“ Bill Gates

Quality/Design Standards

- PIA = Prüf Institut fur Abwasser
- NSF (National Sanitation Foundation - USA)
- ISO 9001
- ISO 14001
- Specifications (ETD), ITPL, Quality Control Plan
- Supplier Qualification
- AWWA (American Water Works Association) and European Water Association
- WQA (Water Quality Association)

Environment, Health and Safety

- Bacteria/pathogens/EDC's
- Aeration basin – drowning hazard
- Methanogenesis (CH_4 is an explosive gas)
- Chemicals: NaOCl, Lime, $FeCl_3$, Alum
- Confined Space
- Electrical control panel
- Risk of toxic gases: H_2S formation in sewer network

Acronyms

- MBR = Membrane Bio Reactor
- ASP = Activated Sludge Process
- EDC = Endocrine Disrupting Chemical
- FOG = Fat, Oil and Grease
- BNR = Biological Nutrient Removal
- PCP's = Personal Care Products
- BOD = Biological Oxygen Demand
- COD = Chemical Oxygen Demand
- SS = Suspended Solids
- SBR = Sequence Batch Reactor
- TKN = Total Kjeldahl Nitrogen (Organic N)
- GAC = Granular Activated Carbon
- DO = Dissolved Oxygen
- PAC = Poly Aluminium Chloride or Powdered Activated Carbon
- ETD = Equipment Technical Dossier
- IPPC = Integrated Pollution Prevention and Control
- MBBR = Moving Bed Biofilm Reactor
- ZLD = Zero Liquid Discharge
- GHG = Green House Gas

Questions?
Remarks?

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