Alternative Treatment Technologies and Clusters

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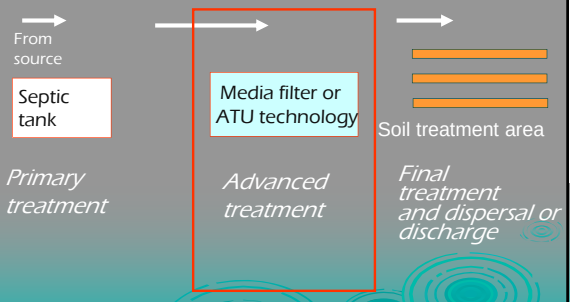
Presentation Overview

- Why use alternative treatment
- Options for alternative treatment
  - Media filters
  - Aerobic treatment units
  - Cluster systems
  - Mounds
  - Drip distribution

Alternative Treatment



Why Use Alternative Systems?

- New idea
- Sizing
- Additional Pretreatment
- Separation
- Siting Problems
  - Soil
  - Environment

Why Not?

- Increased cost
- Increased maintenance
- More regulatory oversight required

Criteria for Selection of Pretreatment/Treatment Unit

- What level of pretreatment/treatment is desired?
  - Septic tank effluent level
  - Aerobically treated effluent level
- Site conditions and homeowner preference should dictate degree of treatment prior to effluent entering soil.
- Does unit receive effluent daily or seasonally?
  - Some units respond better to seasonal situations than others.

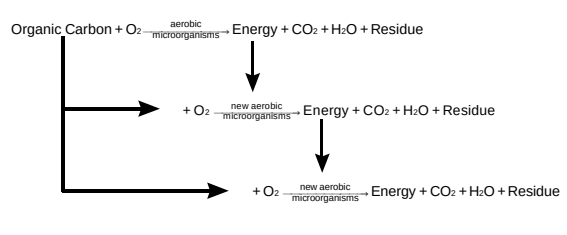
Criteria for Selection of Pretreatment/Treatment Unit

- Is BOD and TSS removal important?
  - Most aeration units have BOD/TSS < 25 mg/L
- Is nitrogen reduction important?
  - Not all units give same nitrogen removal
    - Some designed for denitrification, others are not.

Organics, Microbes & Oxygen

- Bioavailable organic compounds provide food and energy to microbes
  - naturally-occurring microorganisms consume food, and create more microorganisms
  - the more microorganisms, the more food consumed
  - the more food consumed, more dissolved oxygen is required

Basic Equation - Carbon



Microbes as Workhorses

- Microorganisms are used
  - aerobic process is 10 - 20 times faster than anaerobic
  - to convert colloidal and dissolved carbonaceous organic matter into various gases and into cell tissue
    - gases evolve (CO2, N2, and others)
    - new cells can be settled – thus carbon is removed
  - break other nutrients out of organic compounds
    - nitrogenous compounds
    - phosphorous species

Criteria for Selection of Pretreatment/Treatment Unit

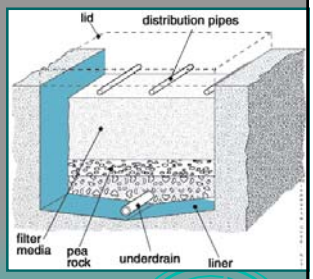
- Is fecal coliform removal important?
  - Not all units are equal in removing bacteria
- What is the level of maintenance?
  - Some have higher requirements than others
- What are the costs?
  - Consider initial costs, operational costs, and maintenance cost over a 20-yr period

What is a Media Filter?

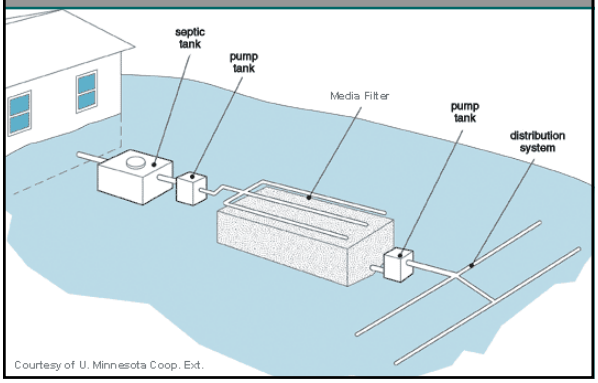
- Designed to follow septic tank
- Fixed film treatment system
- Passive aerobic system

What Is a Media Filter?

- A container or lined excavation with a specific media through which wastewater flows
- An aerobic, fixed-film bioreactor
- Treatment occurs in an unsaturated flow



Media Filter Location



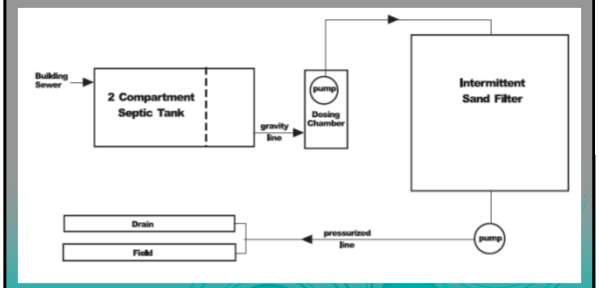
When to Use a Media Filter?

- Need higher quality effluent:
  - Environmentally sensitive areas
  - Soils that are not acceptable for septic tank effluent
    - Hydraulically slow
    - Inadequate vertical separation
  - When land area is small
- Systems with large flows
  - Lessen impact of dispersal
  - Higher application rate
  - Spray irrigation used

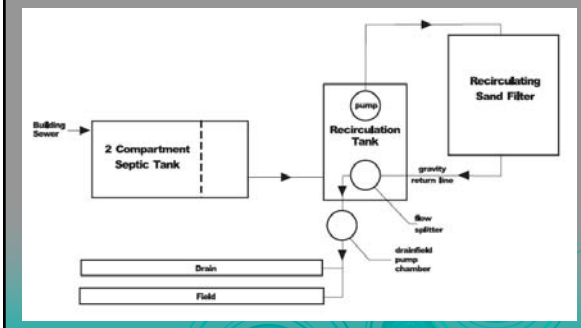
Categories of Media Filters

- Single Pass
  - Effluent pass through MF once
- Recirculating
  - Effluent passes through MF, some diverted and passes through again.

Intermittent (Single-pass) Media Filter



Recirculating Media Filter



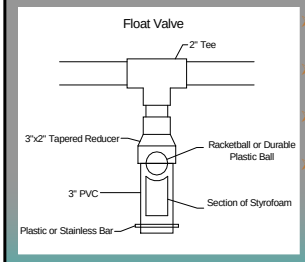
Media Filter

- Recirculating systems have increased nitrogen removal
- Why?
  - Ammonia converted to nitrate in media filter (aerobic)
  - Effluent goes to recirculating tank
    - Nitrate converted to nitrogen gas via denitrification

Benefits of Recirculation

- Filter receives diluted effluent
  - Can apply effluent at a greater loading rate
  - Less odor
- Smaller filter surface area needed for given flow
- Can withstand somewhat higher strength incoming wastewater
- Can cope with flow variations, including peak flows
- Can adjust for variations in flow and strength through varying recirculation ratios

Flow Splitter Simple Float Valve



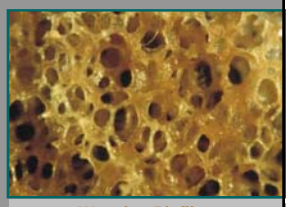
- Valve mounted in recirc. tank on filter drain return line
- When valve is closed
  - All flow goes to final dispersal
- When valve is open
  - All flow drops into tank
- Set timer for correct total daily flow to filter for proper recirculation ratio.

Modular Units

- "Filter in a box"
- Proprietary technologies
- Make 2 wet connections
- Make an electrical connection
- Quality control (QC) done by manufacturer
- Less QC attention needed by installer
- Installer is still responsible

Types of Media

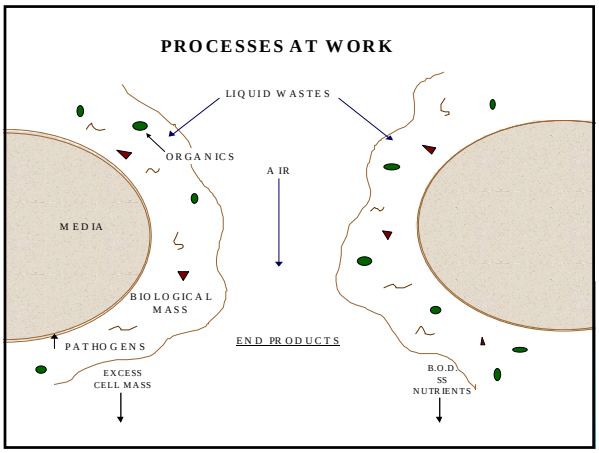
- Washed, graded sand
- Gravel
- Foam chips and cubes
- Peat
- Synthetic textile materials
- Crushed glass
- Other



Waterloo Biofilter

Treatment Process

- Wastewater applied in small doses
- Percolates over media in thin film
- Organisms on media contact wastewater
- Air is maintained in media pores
- Oxygen is transferred into the thin film and to organisms
- Aeration may be active or passive



How Does a Media Filter Work?

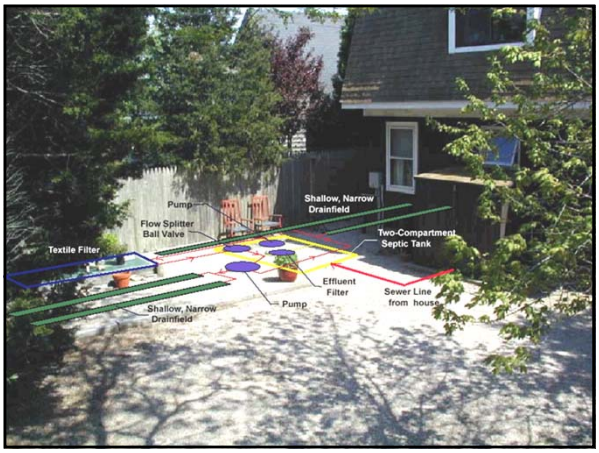
- Slow, **unsaturated** flow through media
  - Must be sufficient retention time
  - Time between doses must allow sufficient re-aeration
  - Most are time dosed
    - ATUs are normally not time dosed

Types of Treatment

- Physical:
  - Filtration and trapping
- Chemical:
  - Adsorption
- Biological
  - Biological decomposition
  - Biochemical transformation

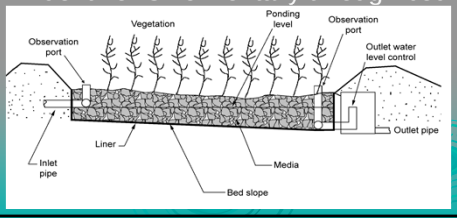
Comparisons of Domestic WW Effluent (Varies with type of MF)

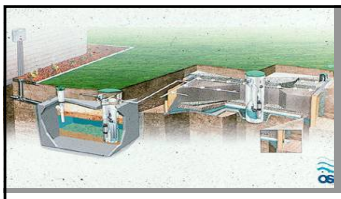
Constituent	Septic tank	Media Filter
BOD mg/L	140-220	5-25
TSS mg/L	50-100	5-30
Total N mgN/L	40-100	25-60
Total P mgP/L	5-15	4-10
Fecal col/100ml	1,000,000 - 100,000,000	100 – 10,000



Constructed Wetland

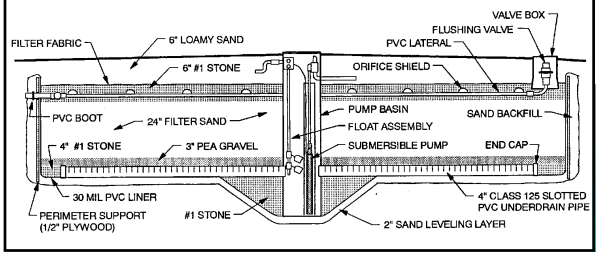
- Basin/cell containing microorganisms, media, and plants that treat effluent
- Effluent flows horizontally through bed





Orenco Single Pass Sand Filter with internal pump Chamber. Some may not have internal pump chamber.

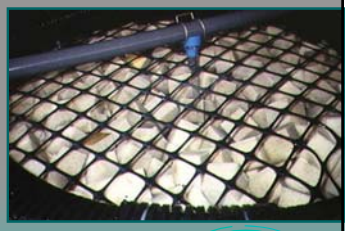
There are other designs



Open Cell Foam Filters

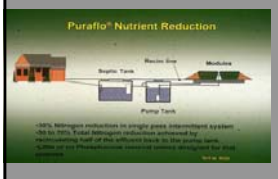
- Developed for use in Ontario
  - "Waterloo Biofilter®"
- Polyurethane foam
  - 2-inch cubes
  - Large surface area, large void volume percentage
  - Not decomposed by organisms in wastewater
  - Lightweight for easy shipping and handling
- Wastewater is sprayed over top
- Long retention time on filter = good treatment
- Sometimes requires forced aeration

Foam Filters

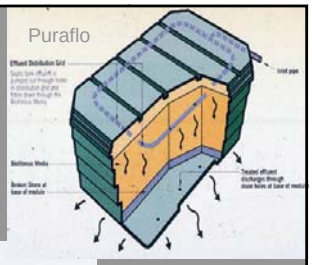


Textile Filter

Peat Filters



Puraflo



Holes in bottom can be plugged to divert effluent to a pc or distant dispersal area.

Ecoflo Biofilter

Peat Filters

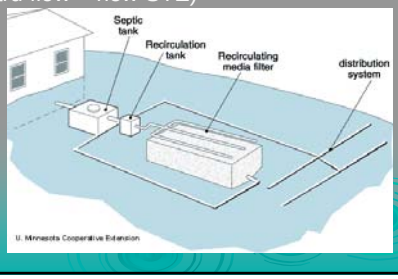
Peat Filter Performance

- Good, long term performance
  - Media must be replaced
- Effluent quality similar to sand filters, but has a light brown color
- Takes less space than sand filter
  - about 1/6 as much space
- Advantage
  - Material is pre-selected and prepackaged

Other Media

Typical Loading Rates

- Single-pass: 1 – 2 gal / ft^2 / day
- Multiple-pass filters: up to 5 gal / ft^2 / day (forward flow – new STE)



Dosing Frequency:

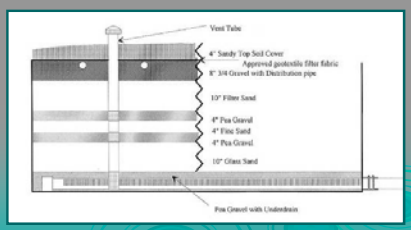
- Timer-controlled dosing being used more
  - Single-pass filters:
    - Historically: 4 times/day
    - Current recommendation: 12 - 24 times/day
  - Multiple-pass: 12 – 72 or more times/day

Media Filters

- May be buried or free-access
- Free-access often use
  - Gravel
  - Foam
  - Textile material
  - Peat
- Free-access filters may have covers
  - Protect from elements
- Filters may be totally below ground or in containment vessel above ground

Media Filters

- Research on other types of media, filters
  - Varied layers of different size media (stratified filters)



Media Filters

- Multiple-pass *gravel* filters are primarily used for reliability and O/M simplicity
- Initial cost ranges from $4,000 - $5,000

Effluent Quality

- Systems have been evaluated at various locations throughout US
  - National Demo Projects
  - Individual sites
  - Research centers

BOD_5 Performance - 2004

Unit	No. Sites	BOD_5 Geo. Mean mg/L	BOD_5 Media mg/L	BOD_5 Mean mg/L
Multi-flo	24	7	8	10
Norweco	10	32	34	42
BioMicrobics (Homes)	27	14	13	21
D. Whitewater	3	12	12	15
Nibbler Jr.	5	28	29	36
Orenco SPSF	51	3	4	5
Comm. RSF	6	11	11	19
Orenco RSF Home	6	3	3	4
Conc. Box RSF	4	13	15	23
Septic Tank	51	161	167	173

Management/Maintenance Is Essential

- On a regular basis 6 – 12 mo.
- By a professional
- County/state may have tracking system to ensure systems are maintained
- Owner pays for maintenance service
- Without maintenance – *Poor Effluent Quality*
- Consistent maintenance
  - Biggest challenge facing onsite industry today.

Access to Components Is Critical

- Risers to grade
- Easy-to-reach quick disconnects for pump removal
- Floats on separate mount that is easy to remove
- Control boxes within sight of pump chamber riser
- Convenient sampling locations

Media Filter O&M Often Includes

- Raking filter media as needed
  - Exposed bed
- Checking for settling, damage, depressions
- Replacing (sand) to maintain design depth

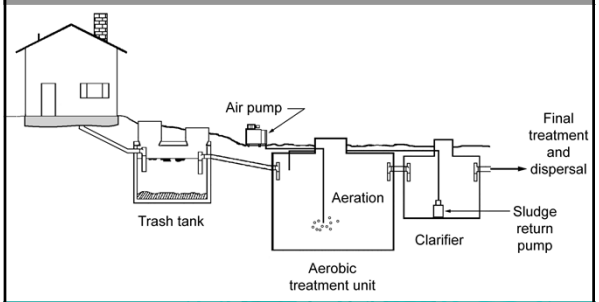
Aerobic Treatment Units

- System treatment train
- Performance
- Loading rates
- Sizing example
- Management plan

ATUs versus Media Filters

- ATUs are saturated
  - Water and solids
  - Minimal air-water interface
  - Mechanical aeration
- Media Filters are non-saturated
  - Water-air-solids
  - Maximum air-water interface
  - Passive aeration

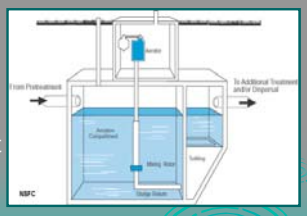
Aerobic treatment unit system



Fixed Activated Sludge System

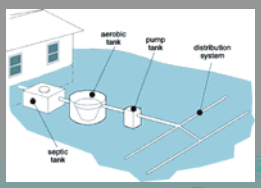
How do they work

- Saturated environment
- Aeration
  - Dissolved oxygen (DO)
- Aerobic Bacteria
- Eat BOD & Settle out
- Return to be reused
- Removed when tired



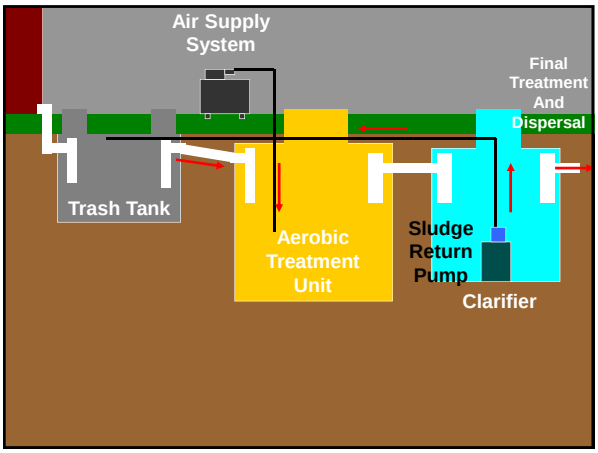
Septic Tank – Trash Trap

- Typically smaller than code minimums
- Removes non degradable materials from the waste stream
- Provide some flow equalization
- Provides some anaerobic treatment
- Can be used as a component of a denitrification process



Flow Equalization

- Variations in flow seriously complicate treatment process
  - need stable flow and stable substrate supply to maintain stable microbial population
    - single family home can have extreme variations from vacations (no flow) to laundry (high flow)
  - Equalization tanks (before ATU) can buffer flow
    - dose the ATU during low flows
    - store excess wastewater during high flows



Primary Goal of an ATU

- Use aerobic microorganisms to provide secondary treatment to domestic wastewater
  - secondary treatment focuses on the removal of biodegradable organics and suspended solids
  - usually accomplished with biological reactors

Environmental Effects

- Microbes need more
  - temperature must be life-sustaining
  - need steady supply of food to maintain stable microbial population
  - pH needs to be controlled
  - Be careful with biocides (acid drain cleaner, antibiotics, etc
- Dead Microbes
  - Stink
  - Are Black
  - Don't move

Packaging

- The Unique Features of ATUs include
  - packaging for easy installation
  - ease of maintenance

Three Tank System

Pump Tank

Aeration Chamber and Clarifier

Trash Tank

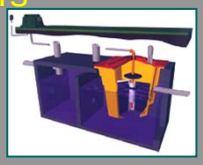
Primary Function is to Provide Secondary Treatment

- Removal of Oxygen Demand
  - bioavailable organic compounds converted to cell mass and into CO_2
  - Organically-bound nitrogen is oxidized to ammonium and then to nitrate
- Removal of Suspended Solids
  - colloidal organics are enzymatically degraded
  - biomass is slightly more dense than water and will settle

Configurations

- Generally Speaking, ATU's are:
  - Intermittent flow
    - not a constant flow from wastewater source
  - Complete mix
    - aeration provides complete mix of D.O., microbes and food
  - Constant volume
    - flow in is approximately equal to flow out
    - flow equalization is usually provided in the primary tank

ATU's versus Packed-Bed Media Filters



- ATU's are Saturated
  - water and solids
  - minimal air-water interface
  - mechanical aeration
- Pack-Bed Media Filters are Non-Saturated
  - water-air-solids
  - maximum air-water interface
  - passive aeration

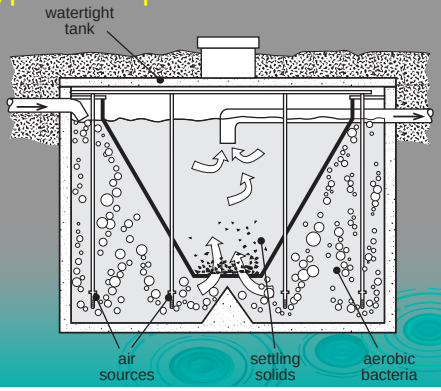
Common Types of ATUs

- Suspended growth reactor – open chamber
- Submerged attached growth/fixed film media reactor – media in aeration
- Combination suspended/attached growth reactor – both media and open area
- Membrane bioreactors
- Sequencing batch reactor – all-in-one with panel to control pumps
- Adaptive mechanical aerator – aerator in septic tank with/without bioaugmentation

Suspended Growth Reactors

- Suspended Growth
  - activated sludge process
  - biomass is thoroughly mixed with nutrients and biodegradable compounds
  - organisms flocculate and form active mass of microbes - biological floc
  - food mixed with bugs

Typical Suspended Growth Reactor

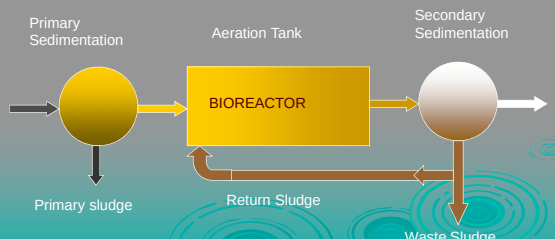


Membrane BioReactor (MBR)

- MBRs are a combination of two basic processes:
  - Biological degradation through the activated sludge (AS) treatment process and
  - Membrane separation
- Into:
  - A single process where suspended solids and microorganisms responsible for degradation are separated from the treated water by membrane filtration units which pull the effluent through the membrane

What is a Bioreactor?

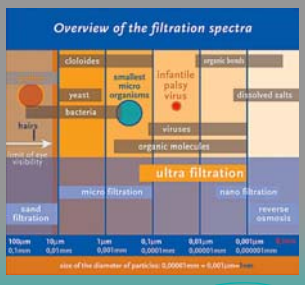
Consider Activated Sludge Treatment

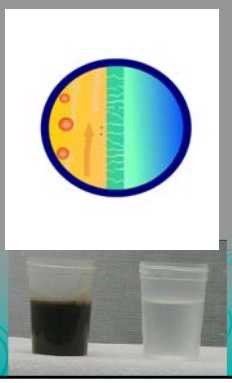


What is a Membrane?

- Separation device like a clarifier to separate suspended solids from the water
- Physical barrier: suspended solids bigger than pore size remain in process tank
- Typically a polymer - polypropylene, cellulose acetate, aromatic polyamides or thin-film composite
- Microfiltration and ultrafiltration membranes are normally used
- Pore size is < 0.5 microns (one millionth of a meter)
- Bacteria cannot pass through the membrane
- Membranes come in flat sheets and in hollow fiber form

Membrane Ultra-Filtration





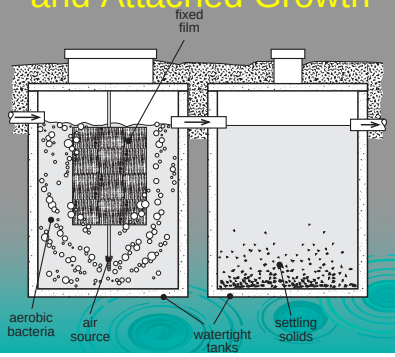
MBR Process

- Typically MBR is immersed in a tank and a slight suction is applied to pull the treated effluent through the membrane
- Flux rate - The rate of effluent passing through a unit area of membrane per unit time and is defined
- The membranes are kept clean by various strategies including:
  - low flux operation,
  - air scouring by bubbling,
  - intermittent operation and
  - backwashing

Attached Growth Reactors

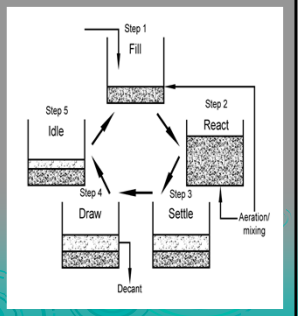
- Attached Growth
  - fixed-film process
  - inert medium provided for microbial attachment
  - wastewater flows through media
  - colloidal and dissolved organics compounds absorbed by biological film
  - food brought to bugs

Combination Suspended Growth and Attached Growth



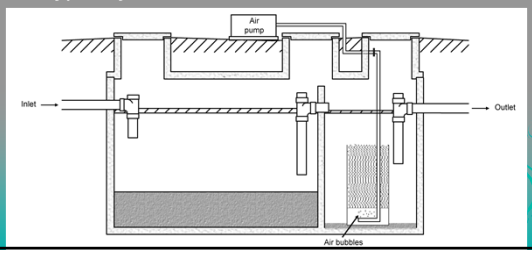
Sequencing Batch Reactor (SBR)

- Suspended growth treatment process
- Use a *single chamber* for aeration, clarification & anoxic conditions
- Flow equalization chamber for dosing effluent into the treatment chamber



Adaptive Mechanical Aerator

- Introduces air mechanically into a treatment component
- Typically used for remediation

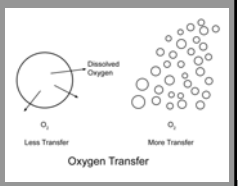


Aeration and Mixing

- Aeration system is generally used to provide mixing
  - displacement of water as air is injected causes turbulence

Oxygen (O_2) transfer

- Air is about 21% oxygen
- O_2 in air bubbles must transfer to water.
- O_2 diffuses through the air in the bubble, then across the bubble surface and into the water.
- Balance efficiency of O_2 transfer and volume of air moved through the unit.



Oxygen Transfer into Solution

- Increasing the potential for oxygen to go into solution
  - bubble create air-water surfaces
- Air injection should be near bottom of tank
  - more time for oxygen to go into solution
  - more hydrostatic pressure on bubble

Diffused Aeration

- Small diameter bubbles are best
  - more surface area per unit volume
  - oxygen transfer takes place across interface between air and water
- Spargers
  - small interconnected passageways inside a ceramic matrix

Air Delivery method

- Blower
  - More air
  - Less Electric
  - Less pressure
- Compressor
  - More pressure
    - Deeper
    - Diffusers
  - More parts

Mechanical

- Spinning blades
- Aspirator

Venting

- All systems need to vent
- If the ATU is separated the unit may need a separate vent

Venting Odors

- Air scrubbing
- Charcoal filters
- Bio filters

Design

- Location
  - Setbacks
- Water – Hydraulic
  - Flow volume
  - Flow rate
- Food – Organic
  - BOD
    - Concentration, mg/l
    - Mass, Pounds per day
      - Flow-Q (GPD) X Estimated BOD (mg/L) X 8.35 E-6
- Food to Microorganism Ratio

DO Testing

- Meter
- Kit

What About N & P

- Most applications do not incorporate nitrogen removal
  - ATUs convert ammonium to nitrate
  - minimal nitrogen is removed in biomass
- Not used for phosphorus removal
  - phosphate will be released from organic form
  - minima phosphorus is removed in biomass
- Additional unit processes must be added onto ATU's for effective N & P removal

Insulation

- Do you need insulation?
- Components to insulate
  - Tank
  - Riser
  - Lid

Flotation Prevention

- Fill tanks with water once set
  - Tanks will float if water enters excavation
- Rainfall
  - Limit water running into an open excavation
- Bouyancy calcs needed?

Considerations for Blowers or Compressors

- In cold climates, may be housed in an insulated container, crawl space or heated structure (in accordance to manufacturer specifications)
- Elevated above potential flood level
- Potential noise should be considered in locating the blower or compressor

Start Up

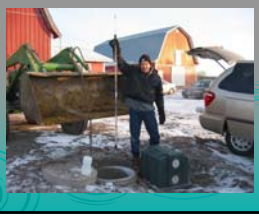
- Establishment of microbial population
  - Recommended method is add a few gallons of mixed liquor from operational ATU or activated sludge plant
  - Could add a few shovels-full of an organic soil
- Poor treatment of water
  - more food than bugs
  - biomass will be poorly flocculated

What should it look like?

- Air operating
- DO > 2 mg/l
- Musty odor
  - Rotten eggs
- Chocolate color-
  - On the Media
- Plugging
  - From one ball to the other
- Effluent quality

Biomass (Sludge) Wastage

- Accumulated sludge must be removed
  - ATU owners have a service contract with a Service provider



Pros and Cons of ATUs

- Pros
  - Small land use requirement
  - Have success dealing with high strength waste
  - Lots of research data on performance, NSF etc
- Cons
  - Odors are noticeable if system is not being used or maintained properly
  - Less passive then some other systems

Sizing Example

- 3 bedroom home
- Full time residents
- Domestic strength waste
- Limited space and separation
- Clay loam soil with Redox features at 24”

Design Process

- Hydraulic flow = 450 gpd
- Organic load = Estimated BOD X Flow (conversion to pounds)
  - 200 mg/l BOD X 450 gpd * 8.35 E-6
  - = 0.8 lbs of BOD/day
- Need pretreated effluent to design trenches
- Select ATU which meets treatment standard at required hydraulic and organic loading
- Size trash tank according to manufactures requirements
- Pressure distribution and time dosing to trenches

Three Tank System Installed

Soil mounded over system to assist in shedding rainfall

Management Plan

- Product specific
- General considerations covered in management plan developed by manufacture
  - Alarms
  - Air filters
  - Mechanical and electrical
  - Check effluent quality odor, color, turbidity, and dissolved oxygen
  - Sample effluent as required in the local Operating Permit
  - Check sludge level in all sewage tanks; follow manufacturers recommendations for solids removal

Summary

- ATU's are an option for sites with limited soil conditions
  - used to provide secondary treatment
- Site still must be able to discharge the treated effluent
  - highly treated effluent can sometimes be applied to marginal soils
  - ATUs are not a solution to every onsite problem

Aerobic Treatment Can Help Solve Problems!

- May be a solution if:
  - Not enough vertical separation or if soil is coarse
    - Effluent has fewer pathogens
  - Site is too small
    - Reduced BOD/TSS may allow for less square footage
  - Waste is high strength
    - Reduce BOD/TSS
  - System is near or failing
    - May recover due to reduced BOD/TSS
  - Nitrogen is a problem
    - Some systems reduce nitrogen

Summary

- ATUs and Media Filters can provide reliable, long term service and excellent effluent quality if they are:
  - Properly sited
  - Properly designed
  - Properly used by the owner/occupant
  - Properly maintained on a regular basis

Why use a Cluster?

- Site conditions
  - Soil
    - Using the best soils
  - Topography
    - Best locations
  - Size
- Planning problems
  - Small lots
- Good planning
  - Cluster
  - Green space

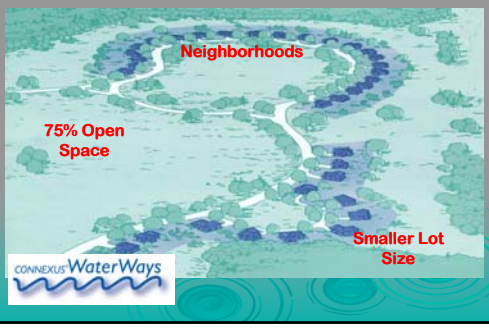
Clusters?

- Best soil
- Best sites?
  - Working with developer
- Set for Services
- Management happens

Cluster Systems for Existing Communities

- Pros
  - Serves those who need/want it and skips those who do not
  - Subsidized interest rate financing and possible grants
  - Gives holding tank only properties another option
- Cons
  - Need to obtain land in close proximity
  - More local coordination

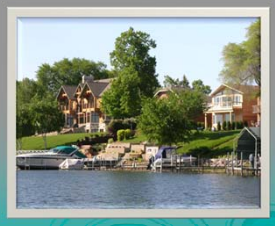
Cluster Development



Traditional Zoning
Two Acre Lots
Total Lots: 100
Developed Area: 200 Acres
Open Space: 0 Acres

Cluster Zoning
3/4 Acre Lots
Total Lots: 100
Developed Area: 75 Acres
Open Space: 125 Acres

Evaluating Existing Communities Wastewater Treatment Needs



The Community Process Finding a Viable Solution

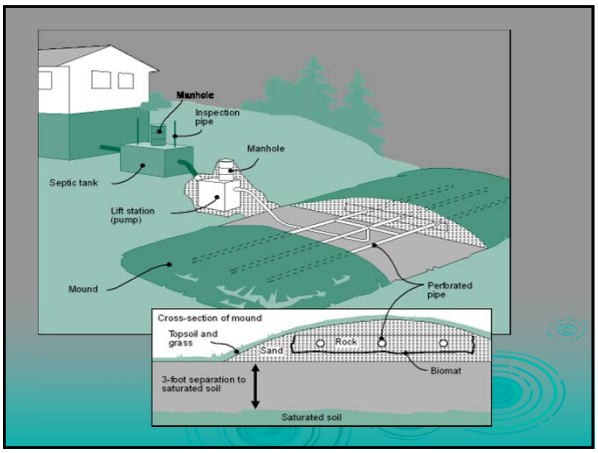
- That provides
  - Effective protection of public & environmental health
  - Reasonable cost - Life cycle costs = capital costs & O & M[18]
  - Socially acceptable - community values, culture, esthetics
- Key steps
  - Community agreement that wastewater MUST be treated
  - Full understanding of existing situation on each property
  - Full evaluation of available options on each property
  - Full evaluation of potential soil based cluster sites
  - Community decision based on full understanding

A Community Assessment Report (CAR)

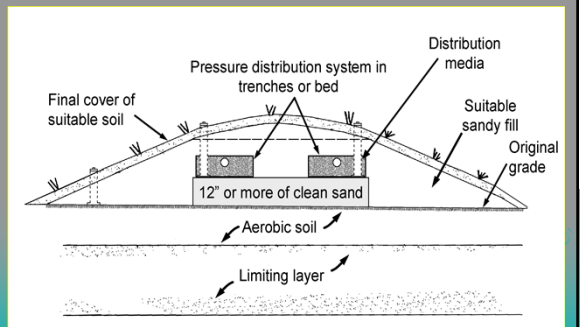
- Integrate preliminary and field evaluations results for each parcel in the community
- Formulate soil-based treatment options for the entire community
  - Individual:
    - Standard
    - Holding tanks
    - Performance
  - Cluster systems
  - Combination
- Estimate costs for each option including
  - Construction
  - Management
  - Repair
  - Replacement
- Identify preferred alternative with rationale
- Integrate CAR into Preliminary Engineering Report if desired or required

What is a Mound?

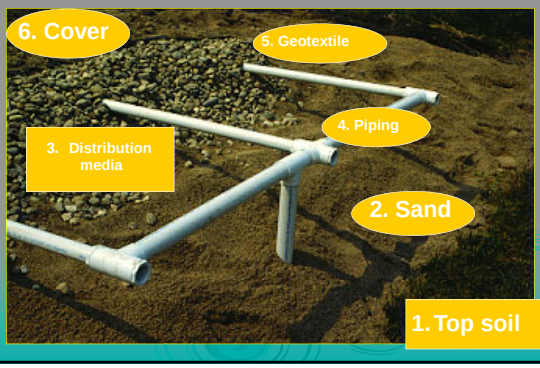
- 1-3 feet of clean sand is brought onto site to achieve 3 feet of soil treatment
- Septic tank, pump tank and pressure distribution are used
- Rock is typically used as distribution media, pressure distribution – typical rock bed is < 10 feet wide
- Sand is placed in absorption width
- Soil extends to provide at least a 3:1 sideslope (4:1 is better) for landscaping, but can be reduced if site conditions are limited



Mound system

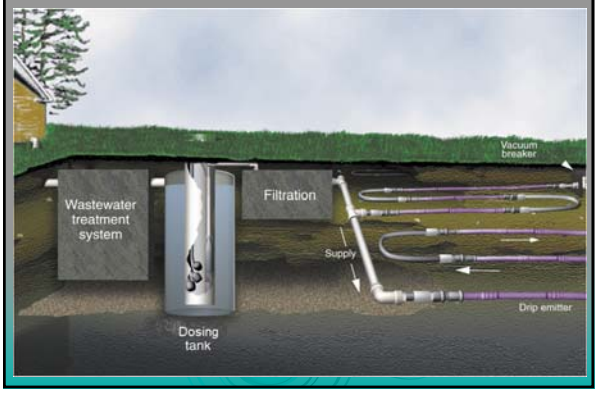


Mound components



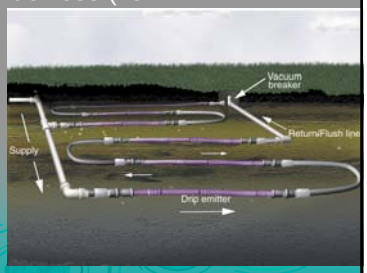
Subsurface drip distribution

- Distributes wastewater to the landscape, through a network of drip tubing installed below the ground surface.
- The system is composed of
  - Pretreatment device(s)
  - Dosing tank
  - Pump and controls
  - Flow metering device
  - Filtration headworks
  - Drip field(s)



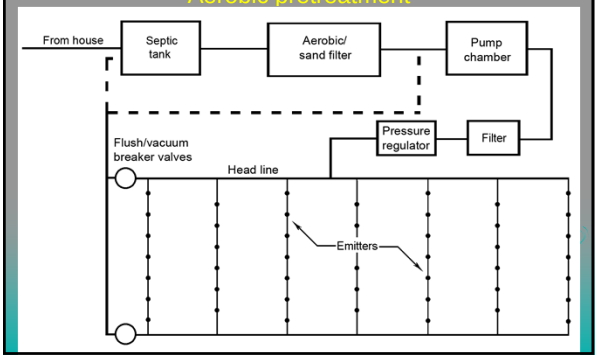
Drip field components

- Supply line
- Water distribution devices (flow splitters)
- Zones
- Supply manifold
- Drip laterals
- Return manifold
- Air relief/ Vacuum breaker
- Return line



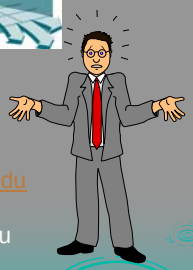
Drip field layout

Aerobic pretreatment



University of Minnesota
Onsite Sewage Treatment Program

Questions?



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