Selecting Appropriate Pretreatment

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Background on the University of Minnesota

Water Resource Center, Onsite Sewage Treatment Program (OSTP)

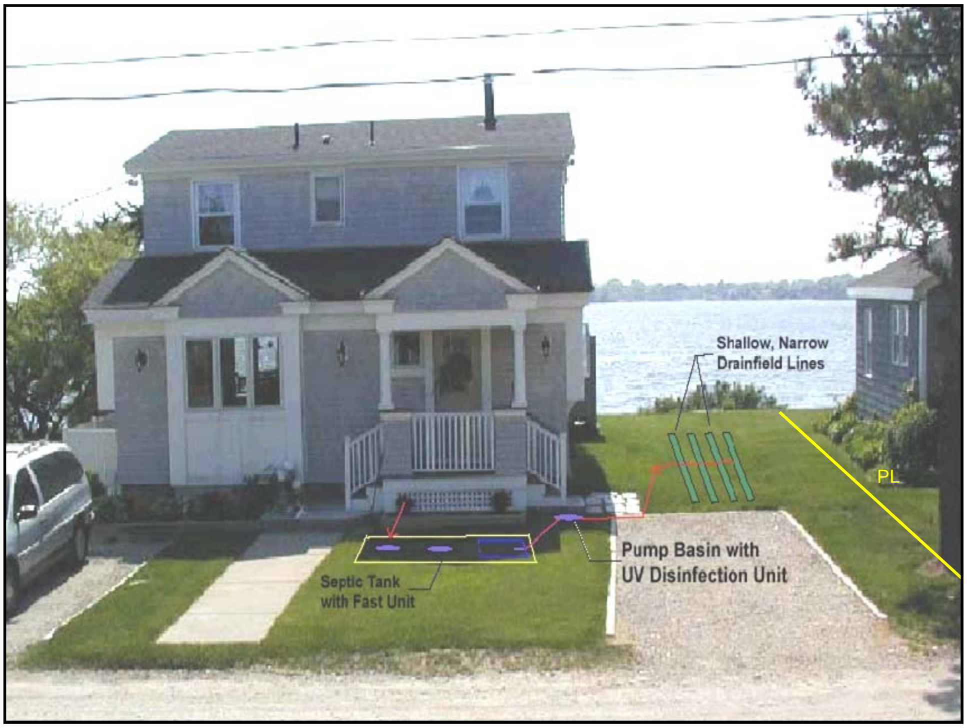
1. Education for Professionals started in 1974
2. Education for Homeowners & Small Communities started in early 1990s
3. Ongoing research and demonstration supporting educational efforts

Challenging Project Issues

- Hydraulics
  - Low flows
  - High flows
  - Combination
- Organics
  - Low
  - High
- Pathogens
- Nutrients
- Soil treatment/dispersal
  - Poor soils (coarse sands – heavy clay)
  - Damaged soils
  - Small lots
- Economics
- Maintenance

How Do You Solve These Challenges?

- May include advanced treatment units
- Systems will need management
- As the site becomes more challenging the risk often goes up

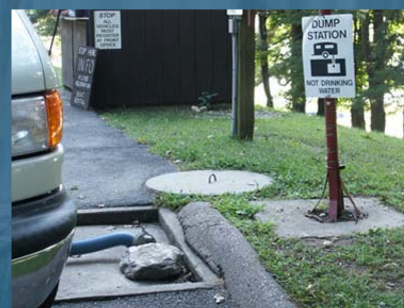


How Do I Select the Right System?

- Must know the soil and site conditions
  - Detailed description of soil characteristics
  - Hydrology of the site - drainage
  - Encumbrances
  - Sensitivity of a site
  - Area available for components

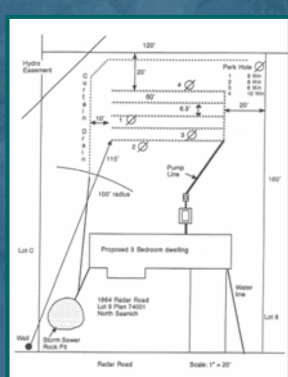
How Do I Select the Right System?

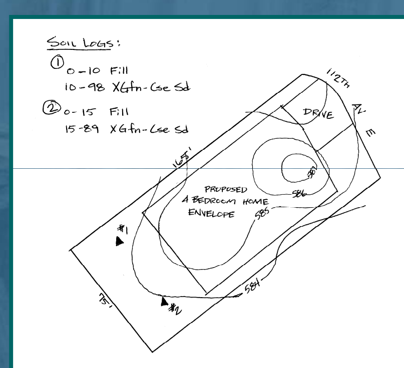
- Must know:
  - Client needs and financial limitations
  - Health, planning and building requirements
  - Limitations on neighboring properties
  - Availability of system management



How Do I Select the Right System?

- Select set of components that best matches the “needs”

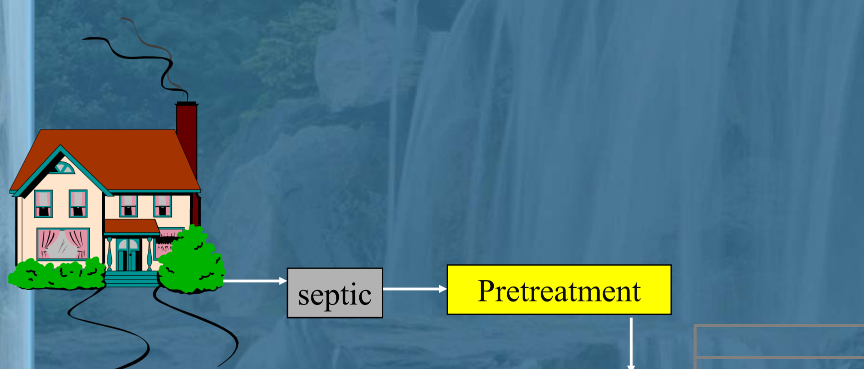




Pretreatment Purpose and Goals

- Purpose:
  - "Pretreat" wastewater so downstream component(s) can function more reliably for longer terms
  - Move much of the treatment from the natural soil conditions – can not forget about dispersal!
  - Generally provide high quality effluent ~ secondary treatment
- Options
  - Aerobic Treatment Units – saturated
    - Typical
    - Membranes
  - Media Filters - unsaturated
    - Single pass
    - Recirculating
  - Constructed Wetland – saturated
  - Disinfection

Pretreatment Systems



House → Septic Tank(s) → Pretreatment → Drainfield or Discharge

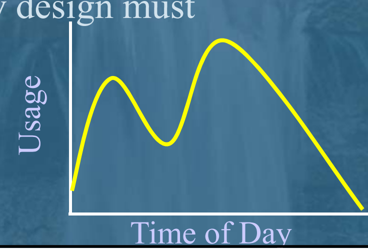
What Do These Technologies Need?

- We need informed decision-makers
  - Developing rules and policies
  - Making good land use decisions
  - Doing good water/wastewater planning
- Local Unit of Government
  - Understanding
  - Permitting
  - Tracking
- Designer
  - Range of Options
  - Application
- Installer
  - Understanding
- Service provider/Maintainer
  - Understanding
- System Users who understand the need for doing things right the first time, for on-going monitoring and maintenance of their system.

How Do I Select the Right System?

Hydraulic Considerations

- Must know wastewater source
  - Quantity - Peak flows throughout day/week
  - Design versus actual flows
  - Actual flow measurement whenever possible on commercial properties
    - Safety factor
- If surges are part of the facility design must accommodate
  - Surge capacity
  - Time dosing



How Do I Select the Right System?
Organics Considerations

- Must know wastewater source
  - Quality
    - Organic content -BOD
    - Solids - TSS
    - Oil and grease, etc.
    - Organic loading rates
  - Components must be designed to handle
  - Other chemical, cleaner, medicine inputs

Nutrients - Phosphorus

- Growing concern with clusters and lake shore homes
- Removal
  - Septic tank
  - Pretreatment units
    - Advanced techniques
  - Soil treatment units

Phosphorus

- Phosphorus adsorbed to iron, aluminum, calcium, and magnesium in soils
- The complexes are insoluble/immobile
- P will move if the soil moves (erosion)
- Some of the P is used by the vegetation
- Vegetations must be harvested to complete the cycle
- Soils have finite capacities to absorb P

Phosphorus Removal in Standard Septic Systems

- P removal depends on soil surface area
  - Sands have less surface area than finer soil particles
- Wet soils have potentially less iron in them, so less P removal potential
- With the use of pretreatments and extended drainfield lives could we saturate the soil with P?

Advanced P Removal

- Greater setbacks to water bodies
- Chemical
  - Addition of aluminum, iron, and calcium compounds with subsequent flocculation and sedimentation
  - High operation and maintenance of mechanical equipment problems and excessive sludge production.

Advanced P Removal

- Physical
  - Ion exchange has had limited success
  - Special filter materials being studied
    - high-iron sands and high-aluminum muds
    - supplemental iron powder mixed with natural sands,
  - 50 to 95 percent of the phosphorus can be removed
  - 1 commercially available product - RID Phosphorus Removal System – upflow filter
- Biological
  - Aerobic treatment systems have the natural ability to remove 10 to 20 percent of the influent phosphorus
  - Certain processes such as the sequencing batch reactor (SBR) can improve on this removal by proper sequencing of aeration periods

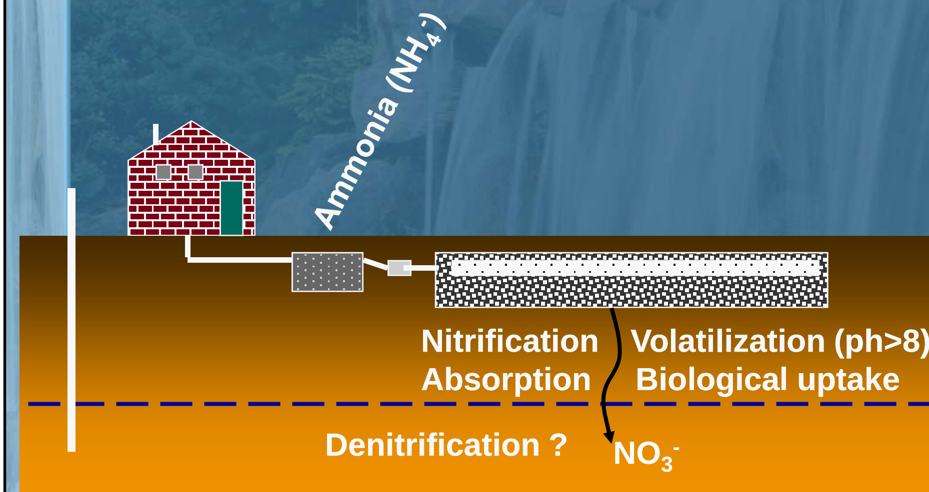
Nutrients - Nitrogen

- Soil removal
- Dilution
- Advanced treatment
  - Level 1 – using BOD as carbon source with recirculation
  - Level 2 – adding carbon source to meet carbon

Nitrogen Removal in Standard Septic System

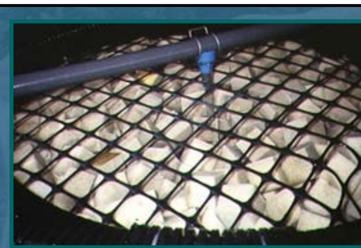
- Less than 15 percent removal in septic tank
- Septic tank effluent composed of organic-N and ammonium-N
- Conversion to nitrate-N in drainfields
- Nitrate-N very mobile
- 10 ppm EPA nitrate-N drinking water standard

N Cycle in Septic Systems

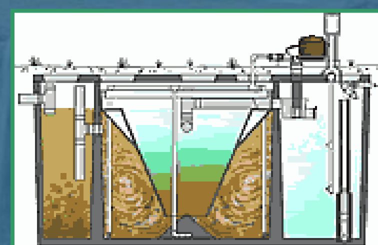


How Much Nitrogen Needs to be Removed?

- Greater setbacks to sources of drinking water ~ dilution
- Reparian zones – plants/natural wetlands utulization
- Pretreatment need to remove significant amounts (>15%)
  - Level 1
    - Mound systems over heavy textured soils
    - Remove toilets from system
  - Level 2 – Media filter or ATU with recirculation back to septic or recirculation tank (BOD serving as carbon source)
  - Level 3 – Addition of alternate carbon source after media filter or ATU



General Considerations for Pretreatment Units



Aerobic Treatment Unit

- **What is it and why is it used?**
  - A tank used in lieu of a septic tank or following one
  - Provides aerobic treatment in **saturated** conditions using artificial/mechanical aeration
  - Provides better quality effluent – organics & solids, especially
  - In some locations, reductions in soil depth and sizing permitted
  - High level of O&M required

ATU Considerations

- Small land use requirement
- Out-put depends on unit
- Sizing based on hydraulics and organics
- All proprietary systems some designed to handle high strength waste
- Some units have a better ability to handle flow and organic fluctuations
- Time dosing will improve consistency of treatment
- Septic tank capacity may be reduced to assure sufficient food for bacterial and limit production of hydrogen sulfide

ATU Considerations

- NSF testing
  - BOD
  - TSS
  - Fecal is coming on-line
- Typical treatment levels
  - BOD <25
  - TSS < 25
  - Fecal ~ 10,000
  - Nutrients, minimal with conventional design
- Monitoring/Maintenance Essential
  - Frequency (6 months) and contracts for single family homes

Membrane BioReactors (MBR)

- What is a Membrane?
  - Typically a polymer - polypropylene, cellulose acetate, aromatic polyamides or thin-film composite
  - Microfiltration and ultrafiltration membranes are normally used
  - Pore size is < 0.5 µm (one millionth of a meter)
  - Bacteria cannot pass through the membrane
  - Membranes come in flat sheets and in hollow fiber form

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

Why would you use a MBR?

- Less sensitivity to sedimentation
- Improved effluent quality
- Faster treatment rates
- Smaller bioreactor size
- Higher loading rates
- Better removal of recalcitrant compounds

Why would you use a MBR?

- When greater assurances of pathogen reduction needed or desired – coarse soils, reuse, surface discharge
- Where final discharge is to surface
- Where wastewater will be reused
- Where O&M will occur

MBR Performance

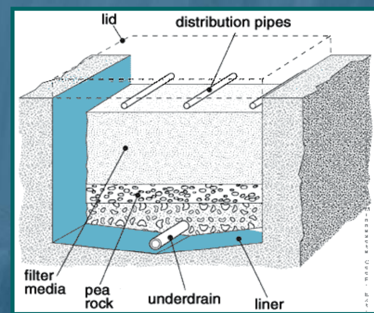
- >95% biochemical oxygen demand (BOD) and total suspended solids (TSS)
- 99.9% removal of fecal coliform with 2 to 5 log virus removal and > 5 log removal of protozoa
- A thin biofilm forms on the membrane, which in turn reduces the pore size of the membrane and further limits the diameter of organism which can pass through the barrier

MBR Performance – Nutrients

- MBRs with advanced removal process design have been found to eliminate:
  - 60-90% of total nitrogen and phosphorus
  - In order to achieve these types of nutrient reductions special design considerations are required
  - Include varying aeration schemes and recirculation of effluent to an anaerobic mixing tank

Media Filter

- **What is it?**
  - A container or lined excavation containing a specific media through which wastewater flows
  - An aerobic, fixed-film bioreactor
  - Treatment occurs in an unsaturated flow

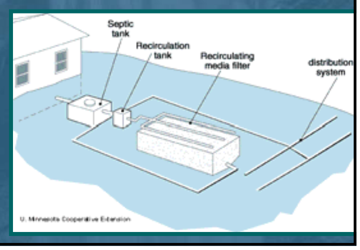


Single Pass Media Filter Considerations

- Large land use requirement
- Pressure distribution and time dosing typical
- Typically loaded around 1 gpd/ft^2 with filter septic tank effluent
- Typical treatment levels
  - BOD, TSS <10
  - Fecal 99 - 99.99% reduction
  - Limited nutrient removal dependent upon media
- Monitoring/Maintenance Essential
  - Frequency annual for single family home

Recirculating Media Filter (RMF) Considerations

- Time dosing required
- Wide range of medias
- Typical loading rates:
  - Typically around 5 gal/ft^2/day, but accelerated loading rates are used with some medias
  - Dosing frequency - 12-72+ times/day
  - Recirculation ratios of 5:1 – 20:1



RMF Considerations

- Small land use requirement
- Designed for N removal
- Treatment levels
  - BOD_5 - <25mg/l
  - TSS - <25 mg/
  - Fecal coliform - 99 – 99.9 %
  - Nitrogen - 30 – 90%
  - Phosphorus - limited dependent on media

Constructed Wetland

- **What is it?**
  - Largely anaerobic reactor unless air is artificially injected
  - Usually contained in a lined cell
  - Cell is filled with 20-24 inches of solid media, usually gravel
  - Appropriate wetland vegetation is planted
  - Liquid surface is 3 or more inches below the surface

Constructed Wetland Considerations

- Large land use requirement
- In cold climates, the liquid depth may be lowered during the winter & mulch is commonly added
- Expected treatment efficiencies:
  - BOD_5 < 30 mg/l
  - TSS < 30mg/l
  - Fecal coliform 99 – 99.9 % reduction
  - Nutrients Media dependent but limited
- Bi-annual maintenance if wastewater levels are being adjusted on single family home

Soil Treatment Challenges

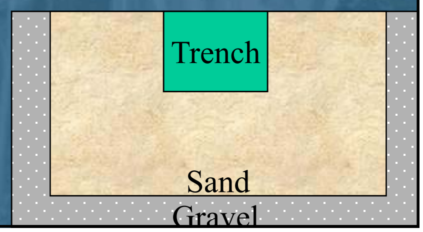
- Poor natural soil conditions
  - Bedrock
  - Permeabilities
    - coarse sands
    - heavy clay
- Damaged soils
- Small lots

Bedrock

- Potential solutions:
  - Soil separation with imported soil material (mound)
  - Pretreatment to 12 – 36” of soil treatment

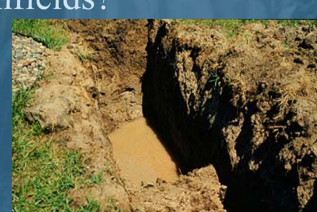
Permeability – Too Fast

- Gravelly soil
- Solutions:
  - Soil treatment with imported media (mound)
  - Pretreatment to 12 – 36” of soil treatment
- Liner System
  - >12” clean sand



Permeability – Too Slow

- High clay contents (60 - 120 mpi)
- These soils are usually wet as well
- Solutions:
  - Mounds – reduced contour loading rate?
  - Pretreatment to shallow drainfields?
  - Pretreatment to at-grades?



Permeability – Too Slow

- Very high clay content (> 120 mpi)
- Solutions:
  - No in-ground systems
  - Smearing potential too high
  - NO Digging
- Mounds with reduced linear loading rates
- Pretreatment to at-grade

Damaged Soil

- Compacted/Smeared
  - Solutions:
    - Loosen up soil?
    - Replace soil?
      - Clean sand
    - Run hydraulic tests – i.e. perc test
    - Size on worse case scenario adding a SSF

Damaged Soil

- Fill sites
  - Solutions
    - Determine source of fill
    - Remove fill if really bad (i.e. old building site)
    - Conducted a lot of borings/pits to determine variability
    - Run hydraulic tests
    - Design on worse case scenario adding a SSF
    - Water table?
      - Piezometer are the only way to really know
      - Nearby “natural” site at similar landscape position

Small Lots

- Limited area
  - Small lots
  - Shallow and deep well setbacks
  - Lakes, rivers and streams setbacks
- Solutions
- Pretreatment system to reduced sized drainfield
- Separation technologies
  - Reuse
- Holding Tanks

Economics

- Initial costs
  - Pretreatment typically will add $3,000 – $10,000 in to the cost of a system
- Operational costs need to be factored in
- Maintenance cost over a 30 yr period should be considered
- Long term costs – pretreatment systems used in the right application and operated and maintained properly will likely increase the life of a standard system

Management/Maintenance

- Every 6 – 12 months on a single family home
- Performed by a properly trained professional
- Follow through by local government unit to track management
- Owner must understand that this service is required and that it has a cost because without the unit will not perform long term.

Questions

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