

Aerobic Treatment Units

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University Curriculum Development for Decentralized
Wastewater Management

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Aerobic Treatment Units (ATUs)

➤ Objectives

- provide descriptions of various engineered systems that maintain high-rate aerobic digestion of organic compounds found in domestic wastewater
- provide an understanding of the operation and maintenance required to keep these systems functional

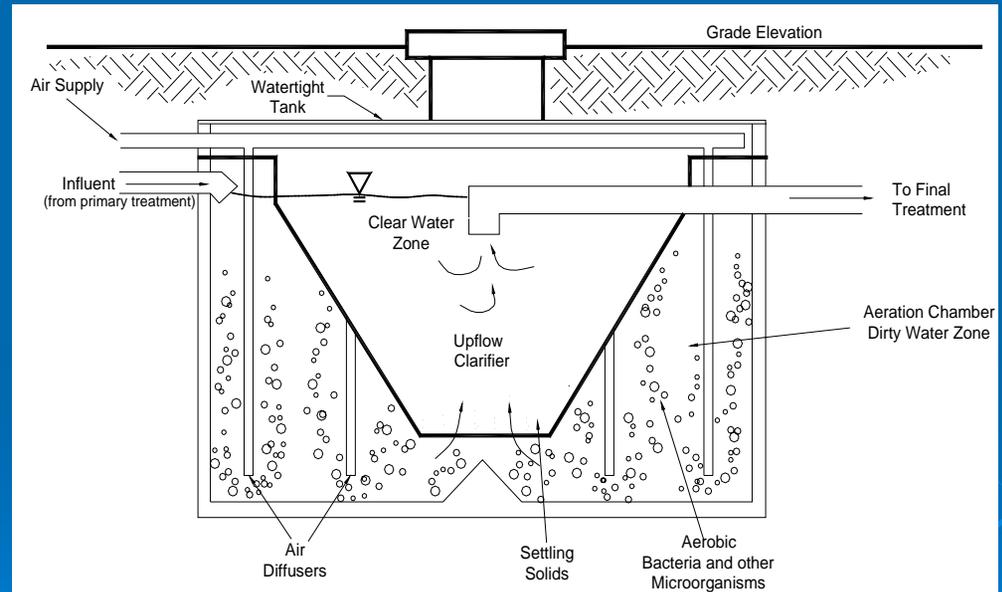
Application

- To provide predictable wastewater renovation when conventional methods will not work
 - shallow soils
 - too shallow to provide treatment
 - high BOD loads
 - too much organic loading into soil
 - wastewater from bakeries
 - wastewater from dairies
- Still must have someplace to discharge water
 - either surface or subsurface

ATUs are Biological Reactors

➤ Miniature Wastewater Treatment Plants

- the biological processes are well-understood
- the ability to mix microbes, wastewater, and dissolved oxygen is a fundamental expectation of environmental engineers



Packaging

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

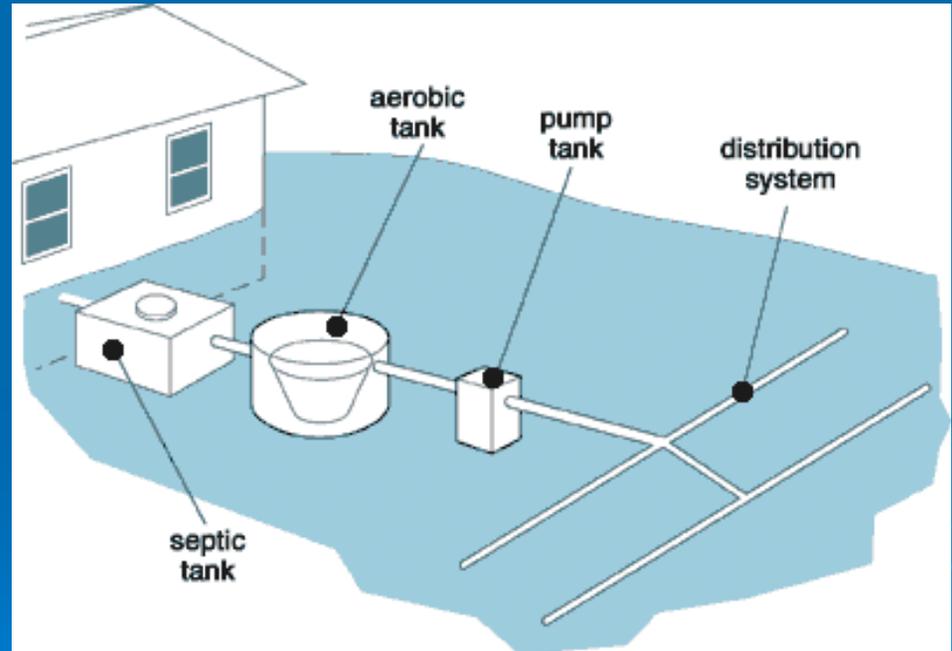


Primary Function is to Provide Secondary Treatment

- 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

Layout

- Positioned after primary tank (septic tank)
 - must minimize the solids that enter an ATU
 - primary tank can provide some flow equalization



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

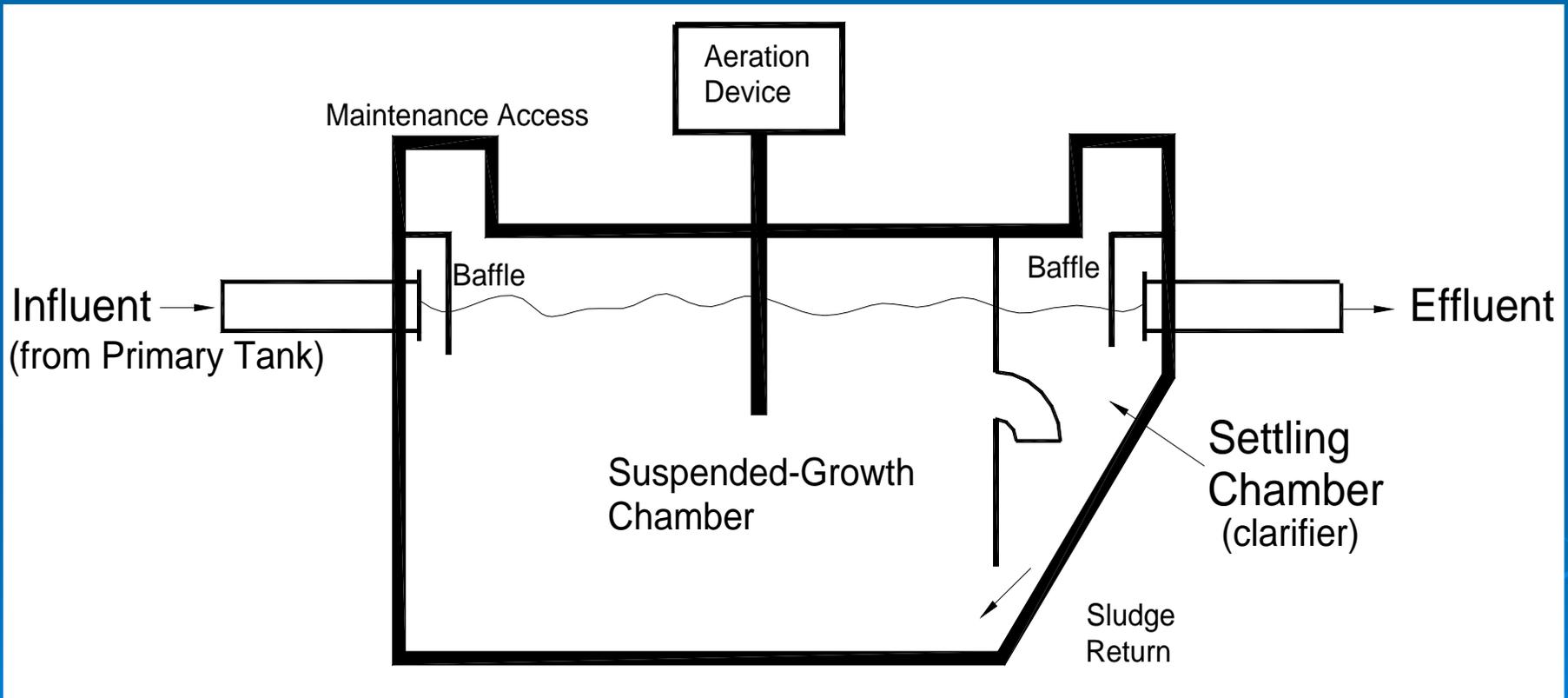
- ATU's are Saturated
 - water and solids
 - minimal air-water interface
 - mechanical aeration
- Pack-Bed Media Filters are Non-Saturated
 - water-air-solids
 - maximum air-water interface
 - passive aeration

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

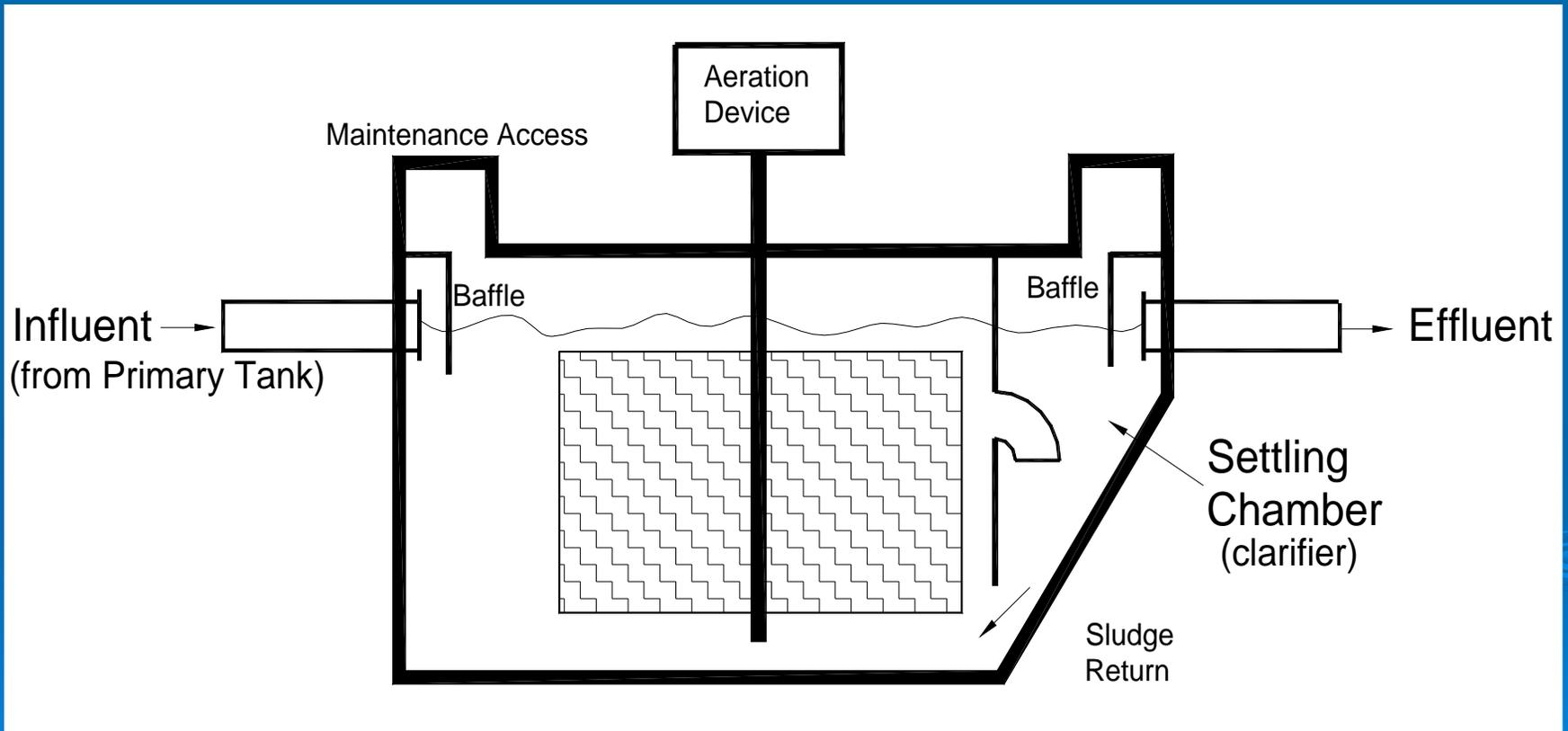


Attached Growth Reactors

➤ 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



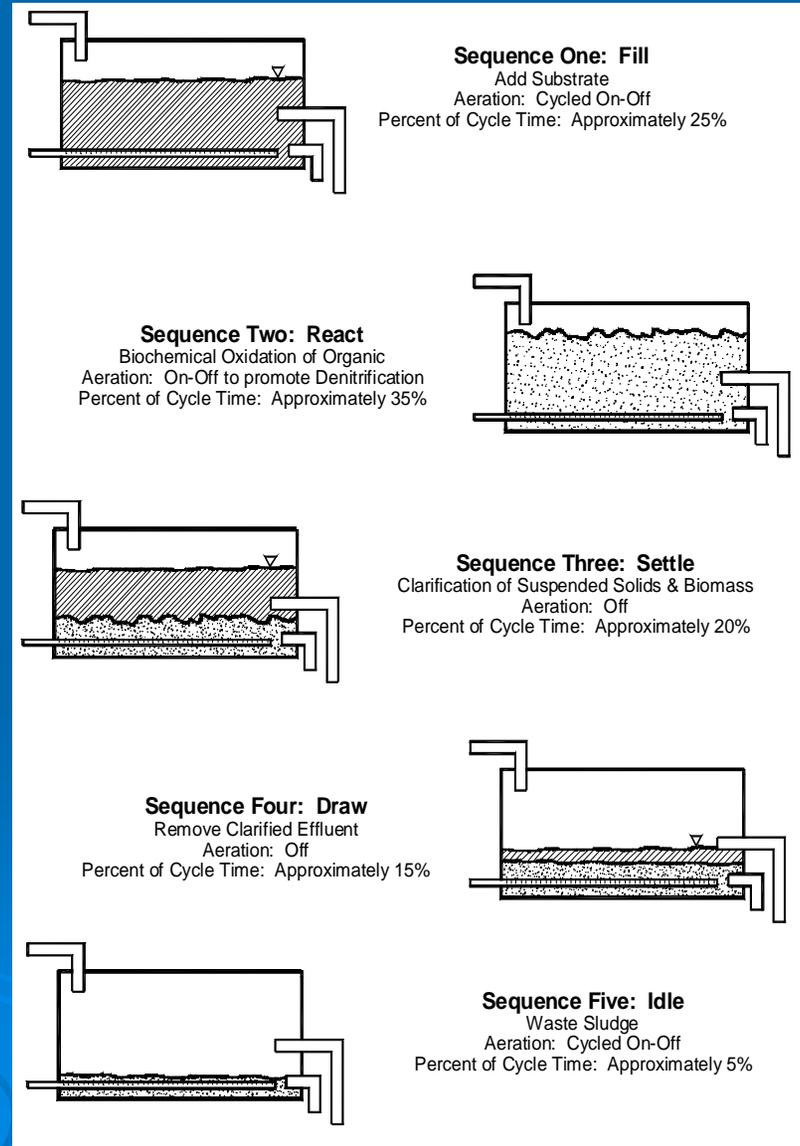
Rotating Biological Contactor (RBC)

- Combines attached growth with suspended growth
- Rotating disks provide aeration and substrate
- Modular



Sequencing Batch Reactor

- Periodic process
 - flow equalization, aeration, clarification, and biomass wasting
 - sequential processes in same tank
- Typical application is two reactors in parallel

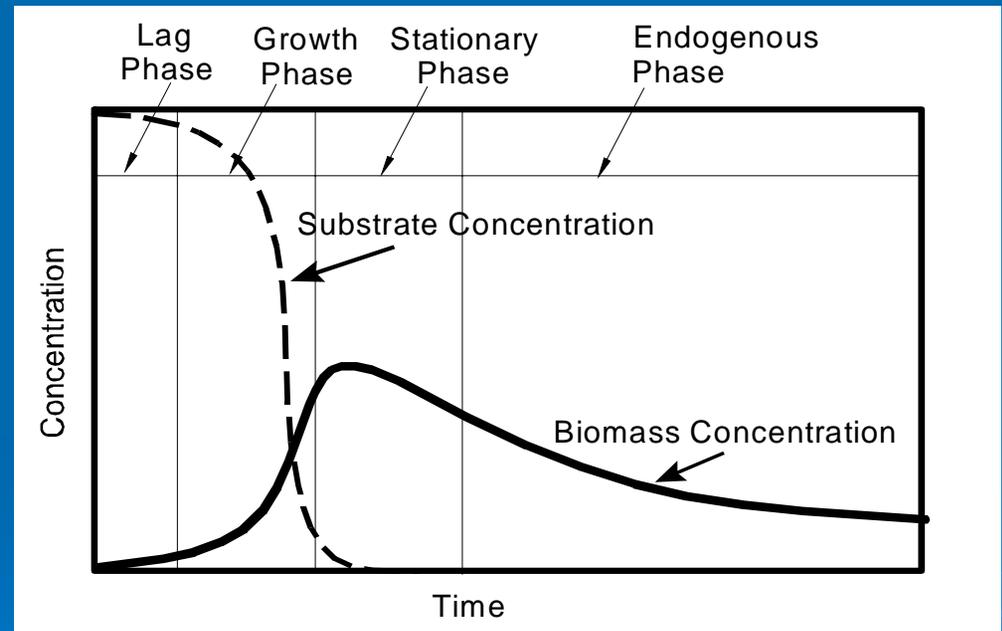


ATU's Operate in Endogenous Respiration Mode

- Goal is to minimize the accumulation of biomass
 - provide plenty of oxygen
 - substrate becomes the limiting factor
 - microbes will feed on each other, resulting in the net decrease of cellular mass
 - process is not 100 percent efficient, stable cell components (not readily bioavailable) will accumulate

Typical Response Curve

- Remember, this graph is easy to understand in batch mode
- Most ATU's are more nearly continuous-flow and complete mix



Aeration and Mixing

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



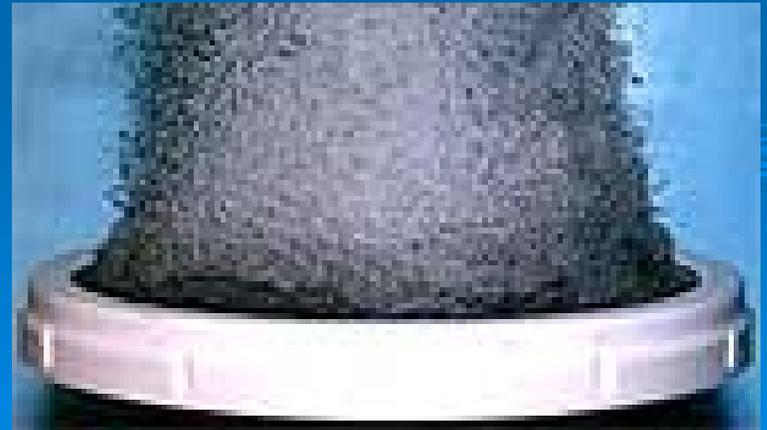
Oxygen Transfer into Solution

- 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
 - transfer takes place through interface between air and water
- Spargers
 - small interconnected passageways inside a ceramic matrix



Blowers

➤ Regenerative Blowers

- provide aeration and agitation
- mounted in an accessible location
- maintenance item
- constant source of noise

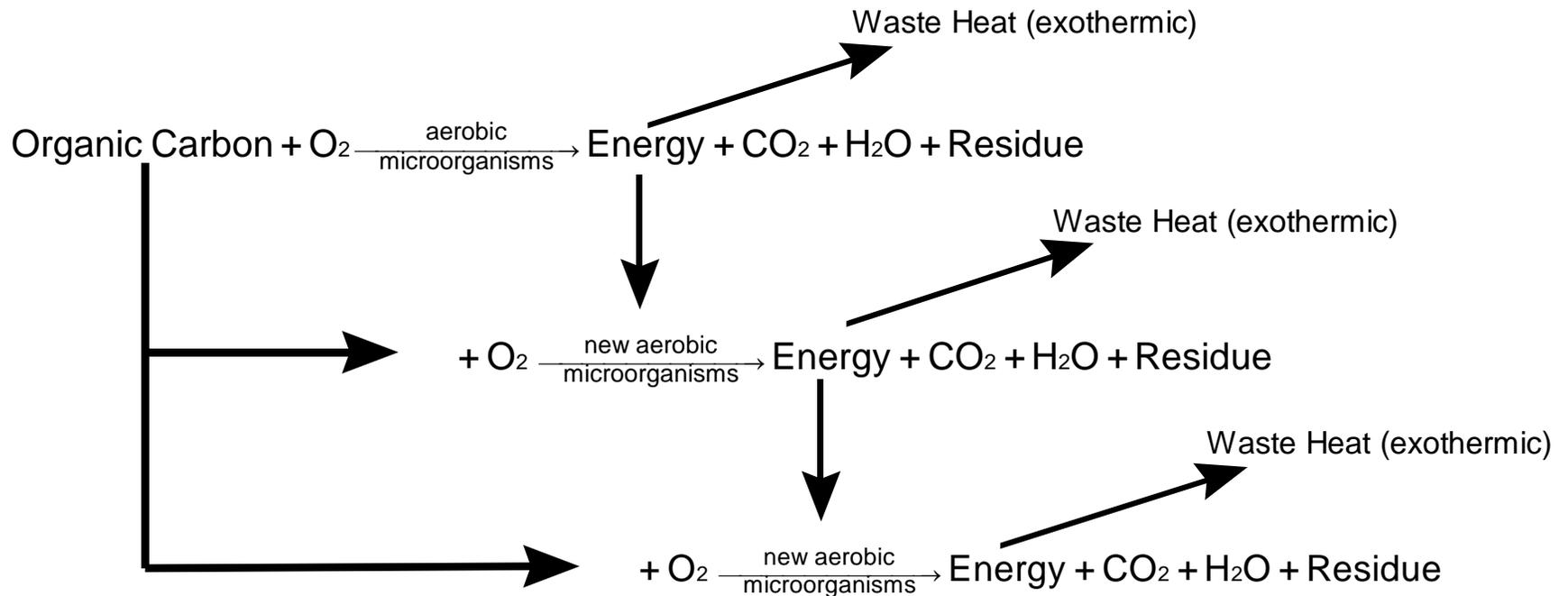


Aspirated Propeller

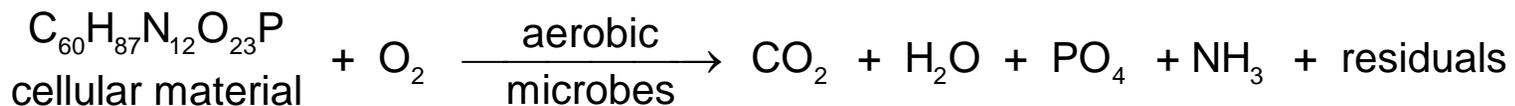
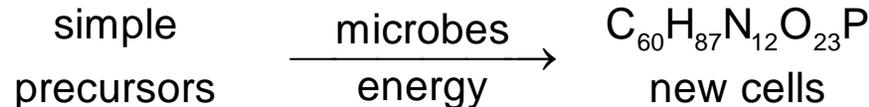
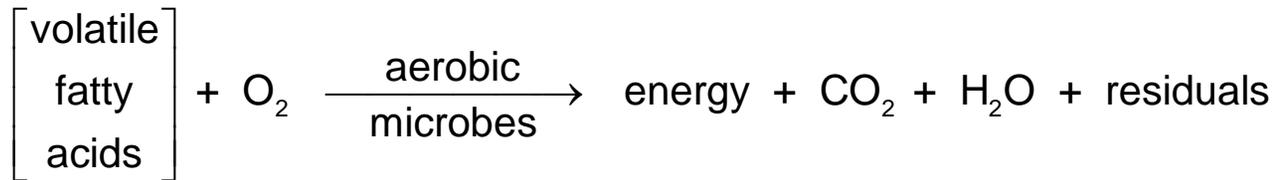
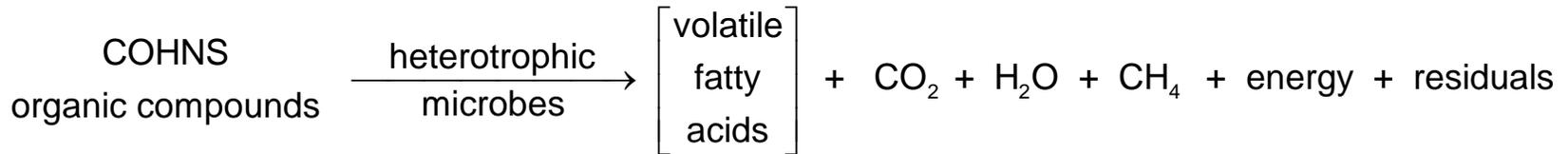
- Hollow Shaft
 - air is drawn by a venturi-type effect as the shaft spins



Big Picture - Bioenergetics



Cycling of Compounds



Environmental Effects

➤ ATU Influent

- must have primary treatment
- strong biocides must not be used within the home or business
 - bleaches must be highly diluted
 - medications (such as antibiotics and chemotherapy drugs) can cause kill-off of bugs
 - latex paints contain mold and fungus inhibitors

Environmental Effects

➤ ATU Influent

- pH
 - microbes will adapt to ranges of slightly acidic to slightly basic influent
 - may cause a population shift
- Temperature
 - units will operate at soil temperature
 - cool temperatures - slow degradation
 - warm temperature - faster degradation

Hydraulic and Organic Loading

➤ Two Primary Design Parameters

- Hydraulic Loading

- rate that water will pass through the device
- must provide sufficient retention time
- wash-outs can occur on laundry day

- Organic Loading

- food (substrate)
- more food than bugs – poor quality effluent
- more bugs than food – high quality effluent

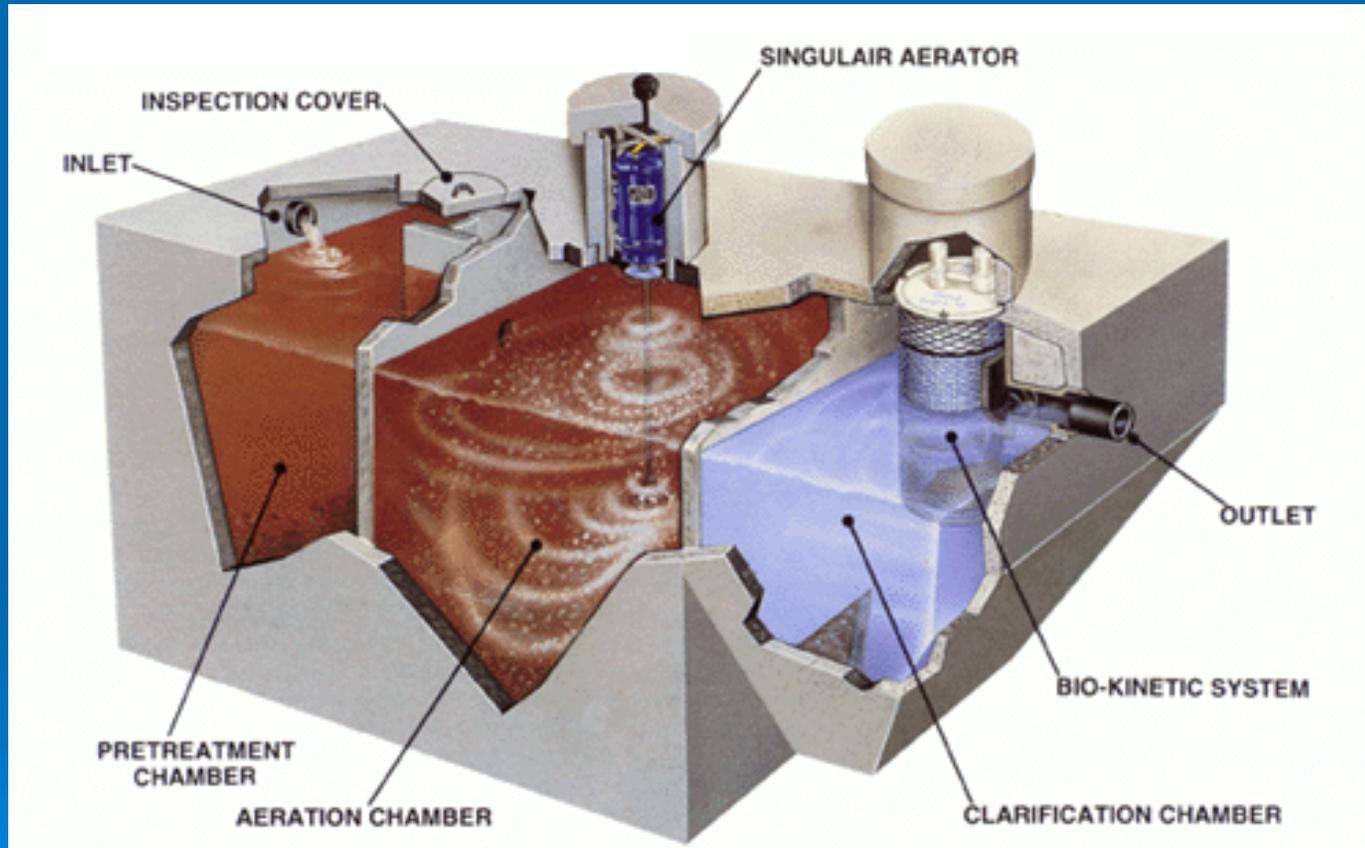
Flow Equalization

- 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

What About N & P

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

Examples of ATU's



Bio-Microbics FAST

- Suspended and attached-growth
 - bubbles trickle up through honeycombed surfaces
 - common application is aboard ships

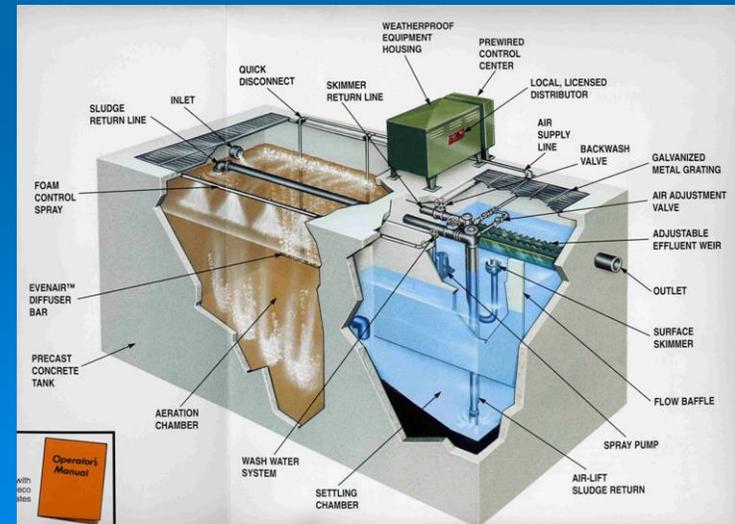
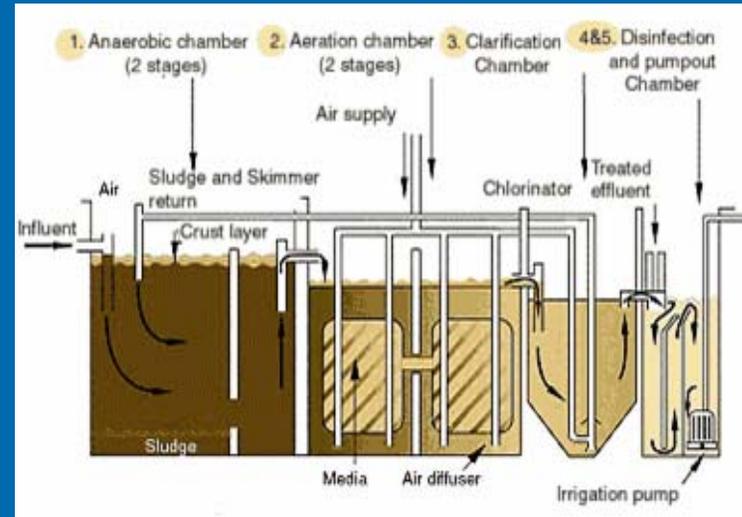


Installing a Bio-Kinetic System

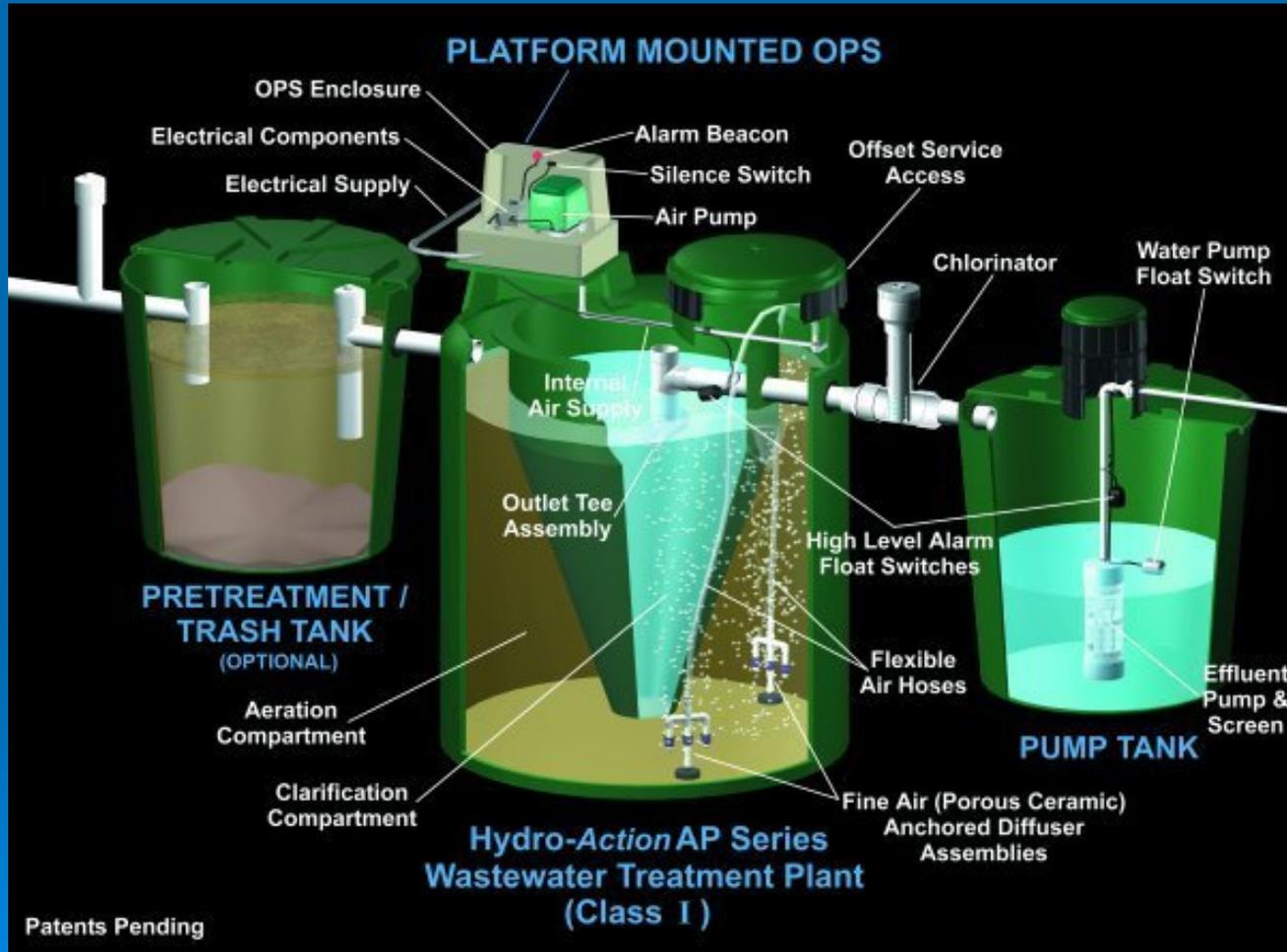


Package Plants

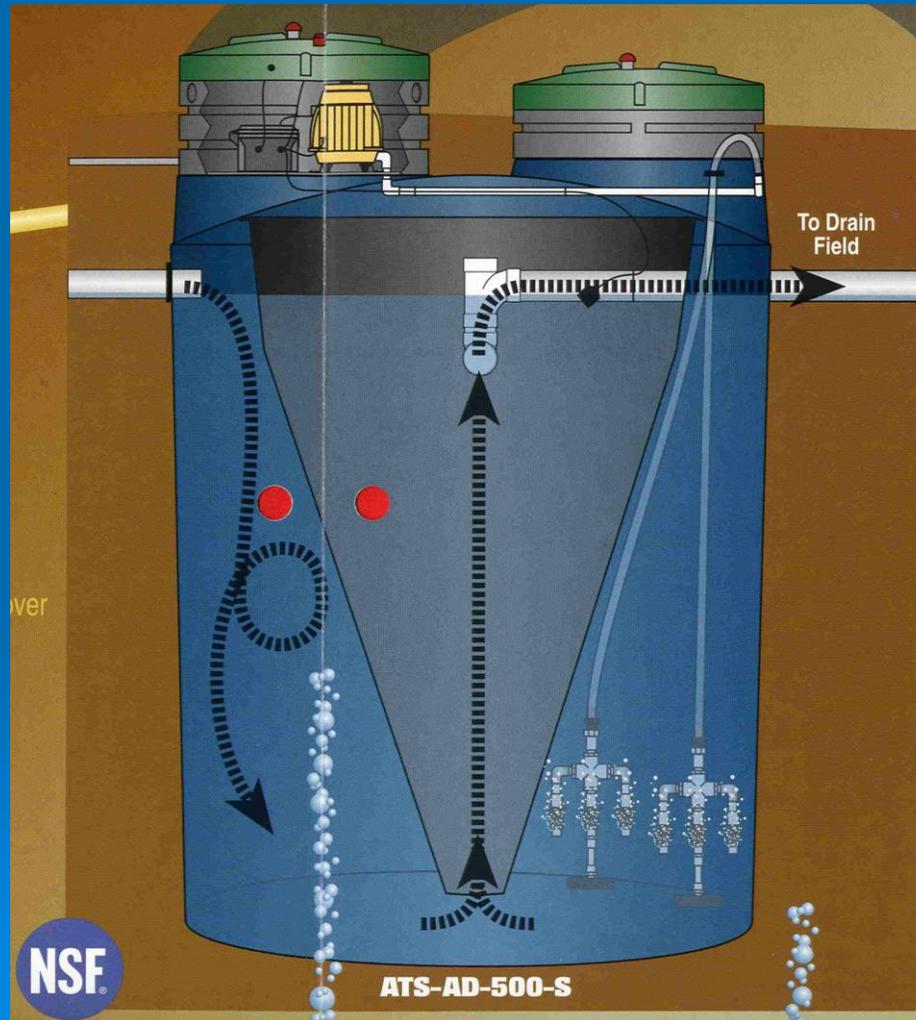
- Includes additional unit processes
 - anaerobic digestion with denitrification
 - disinfection
 - sludge recycling



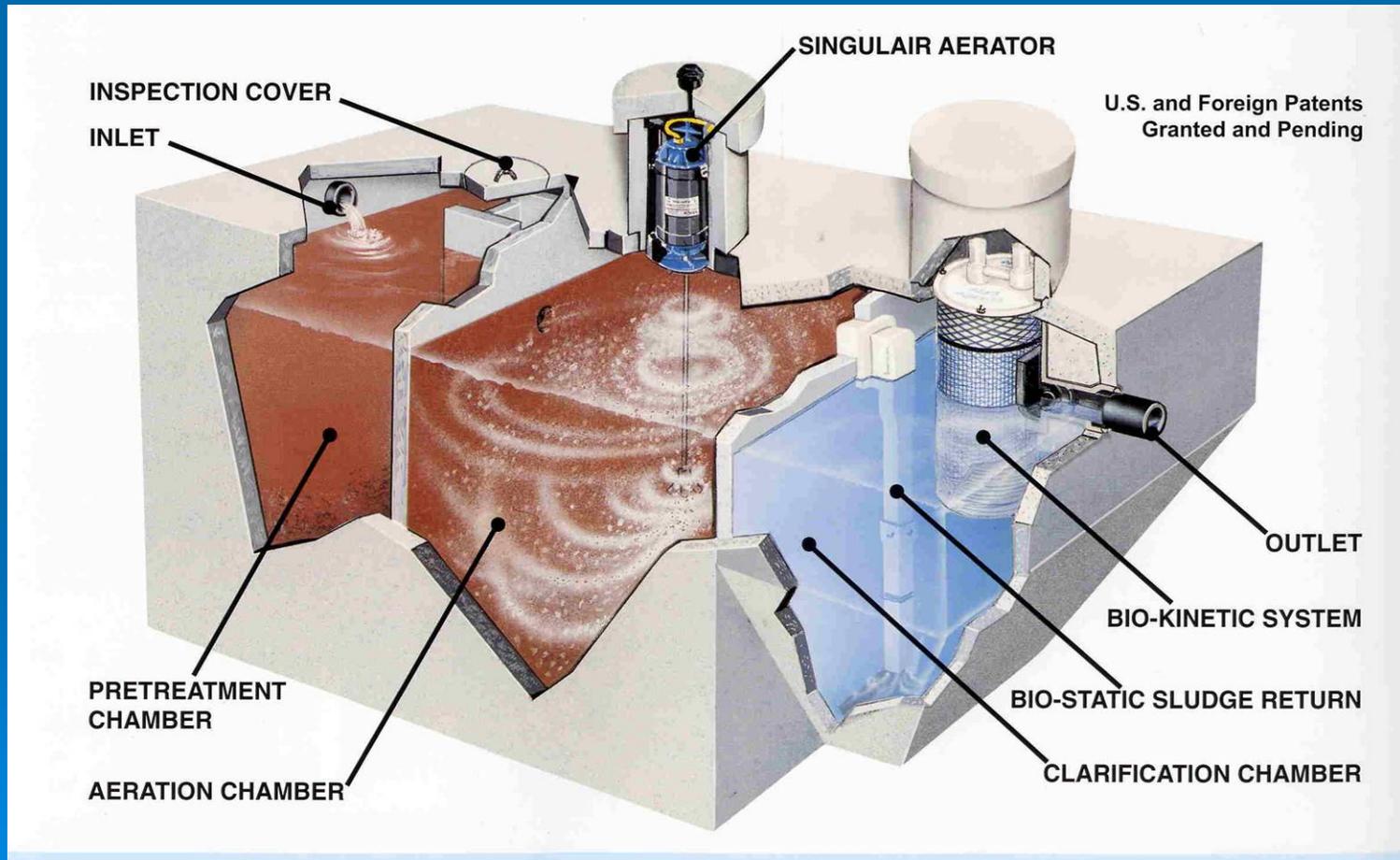
Hydro-Action Plant



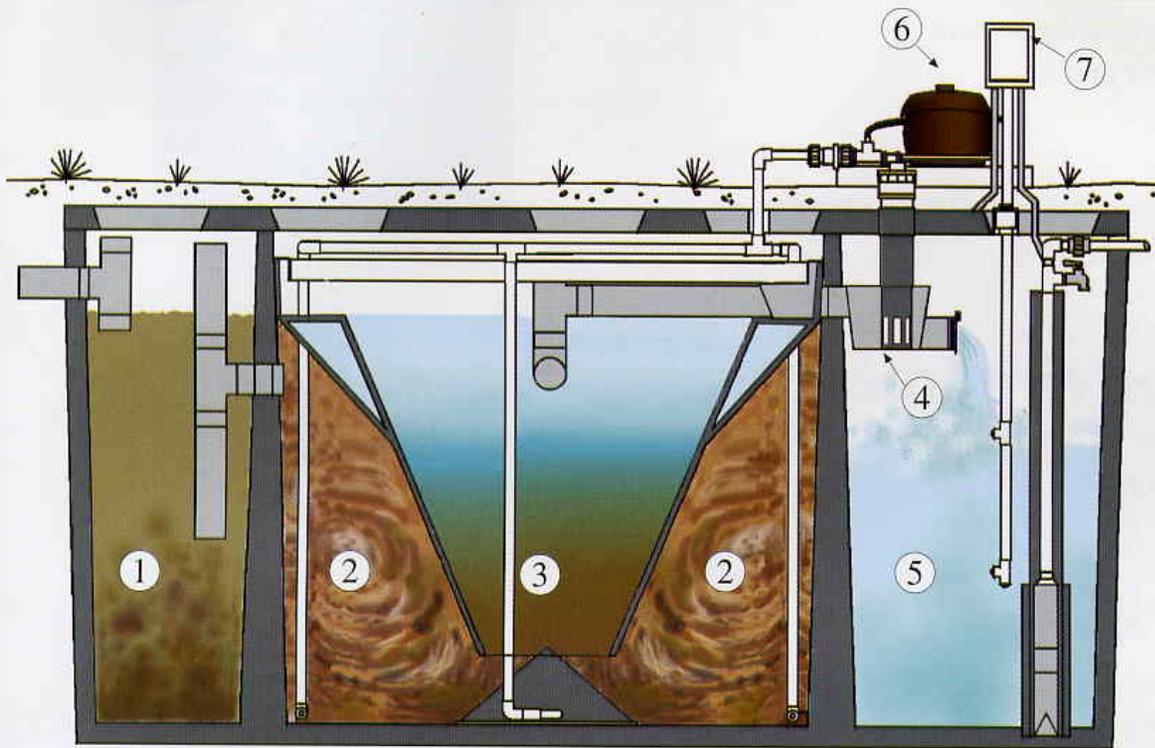
Aerodiffuser



Tank is Separate Component



Zabel's HOOT Plant



1. Pretreatment tank where influent enters.
2. Aeration chamber where oxygen is pumped into the waste water.
3. Clarifier chamber where the clear, odorless effluent rises.
4. Chlorinator the clear effluent passes through for disinfection.*
5. Holding tank for disinfected* effluent ready for discharge.
6. Extremely quiet, efficient aerator and pump.
7. Unique solid-state HOOT Control Center monitors and controls the system.

Pre-Engineered

- Units are specified for flow and for BOD reduction
- Additional capacity is added by additional parallel units



Operational Issues

➤ Biological

- need to sustain a microbial population
- what happens if the electricity goes off?

➤ Mechanical

- need low-maintenance equipment
 - homeowners are very poor maintenance providers
- what happens if blower fails on Friday night?

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

Typical Problems

➤ Sludge Bulking

- extreme growth of filamentous bacteria
- attach to floc particles and impede settling

➤ Foaming on Water Surface

- growth of hydrophobic bacterium
- causes foaming and frothing on surface
- froth spray available to reduce surface tension

➤ Burping

- biogas release from sludge that disperses solids

Biomass (Sludge) Wastage

- Accumulated sludge must be removed
 - most ATU owners have a service contract with a maintenance provider
 - need to save some biosolids to serve as seed to repopulate the biological floc



Performance Certification

- NSF/ANSI Standard 40-2000, Residential Wastewater Treatment Systems
 - National Sanitation Foundation
 - American National Standards Institute
- Standardized procedure for evaluation of performance and reliability of aeration units
 - minimum standards for materials, design and construction, and performance
 - for units that operate between 400 & 1500 gpd

Mechanical Evaluation

- ATUs are mounted *in situ*
 - structural integrity
 - watertightness
- Moving parts in a highly corrosive environment
 - certification procedure evaluates frequency of required maintenance and difficulty of providing maintenance
 - electricity and water DO MIX !!!!

Mechanical Evaluation

➤ Controls and Sensors

- ATU's must have sensors and controls that can detect failure
- must be able to deliver visible and audible signal to homeowner

➤ Must have ground-level access

- for maintenance
- covers must be secured for safety

Performance Evaluation

- Systems are evaluated for 96 consecutive days
 - 16 weeks of design organic and hydraulic loading
 - 7.5 weeks of stress loading
 - 2.5 weeks of design loading

Performance Evaluation

➤ Design loading

- Influent

- cBOD5 100-300 mg/L
- TSS 100-350 mg/l
- flow equals one-day of hydraulic retention

➤ Stress loading

- Simulates

- laundry day
- working parents
- power or equipment failure
- vacation

Classifications

Table 2. NSF/ANSI Standard Number 40-2000 performance classifications.

Class I		
Parameter	30 day average shall not exceed	7 day average shall not exceed
CBOD ₅	25 mg/L	40 mg/L
TSS	30 mg/L	45 mg/L
Color	Individual samples shall be less than 15 NTU units.	
Threshold Odor	Non-offensive	
Oily Film	None visible other than air bubbles	
Foam	None	
pH	The individual effluent samples shall be between 6.0 and 9.0	
Class II		
Not more than 10% of the effluent BOD ₅ values shall exceed 60 mg/L and not more than 10% of the effluent TSS values shall exceed 100 mg/L.		

Summary

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

Questions

