TROUBLESHOOTING TREATMENT PROCESSES FOR OPTIMUM DISSOLVED OXYGEN CONCENTRATION

NOWRA
National Onsite Wastewater Recycling Association

RCAP

PRESENTED BY

BRUCE LESIKAR, PH.D., P.E.

THE MATERIALS PRESENTED ARE THE OPINIONS OF THE AUTHOR AND NOT AN OFFICIAL REPRESENTATION OF NOWRA OR RCAP

NOWRA
National Onsite Wastewater Recycling Association

RCAP

Learning Objectives

Upon completion of this module, participants should be able to:

1. Explain the importance of air exchange for proper system performance.
2. Evaluate dissolved oxygen (DO) concentrations in treatment components and describe how they affect performance.
3. Describe methods to change the circulation ratio in treatment systems to optimize performance.

Overview

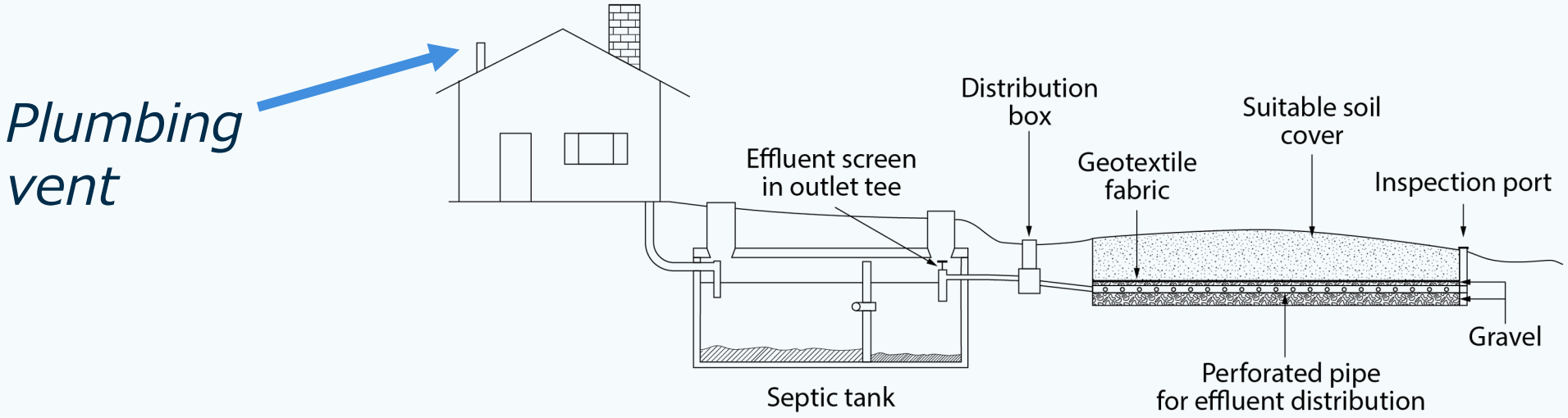
- Physical effect of air exchange on liquid movement through OWTS components
- Chemical effect of air exchange (DO availability)
- Oxygen state in treatment components
- Identifying and troubleshooting barriers to liquid movement through the STA

The basics...

- Liquid flow through components in the system is physically impossible without air exchange – THEY MUST BREATHE.
- Air exchange provides dissolved oxygen (DO) necessary for:
  - Treatment processes
  - Final treatment and dispersal
- Our atmosphere is the source
  - 21% oxygen by volume

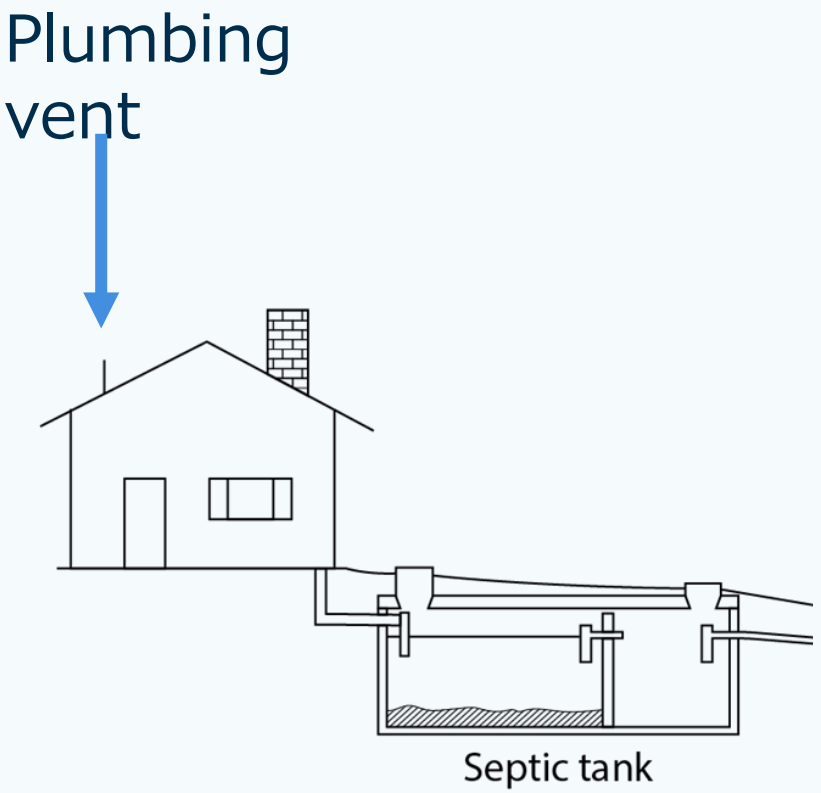
Air exchange in through an OWTS

- Air exchange results in a “chimney” effect
- Pulls air up from the OWTS through the plumbing vent
- From lower to higher elevation



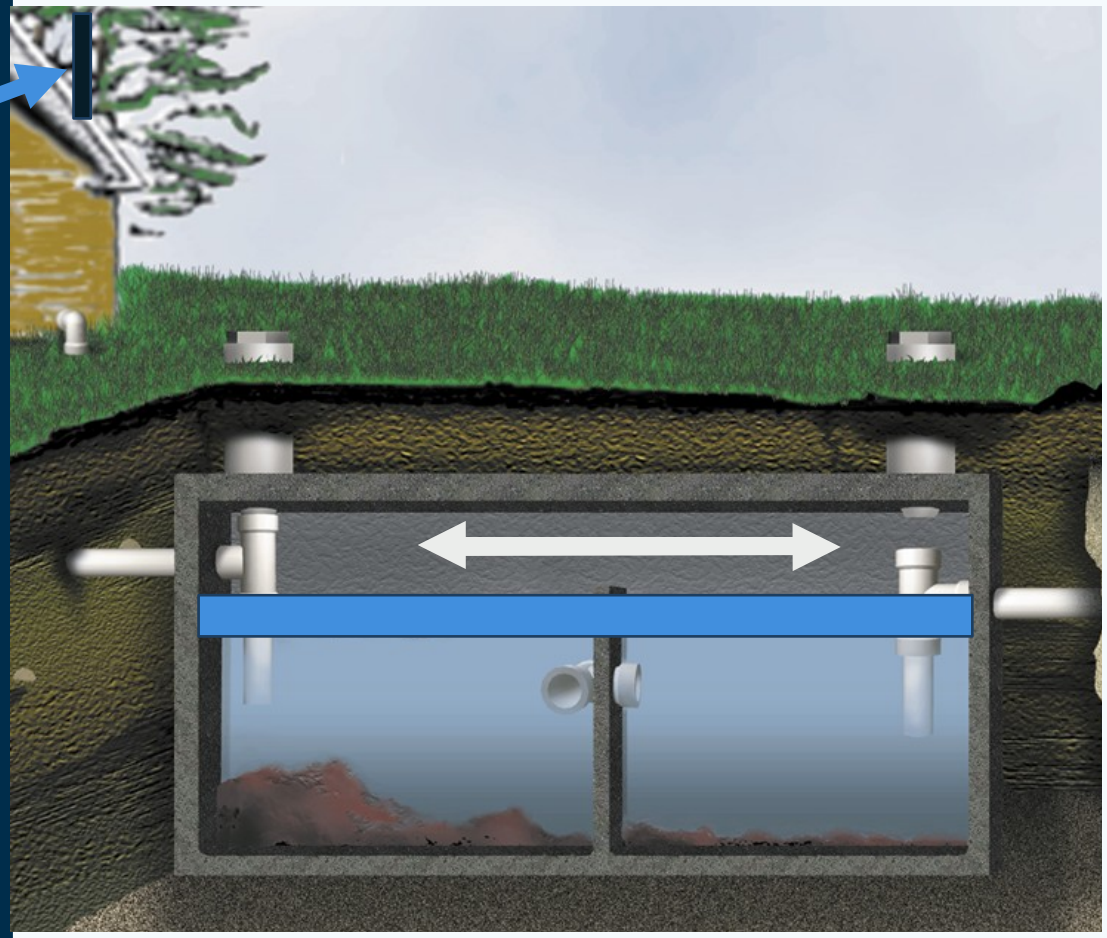
Air exchange in septic tanks

- Head space air exchange
  - Water enters tank and displaces air which must vent
  - As liquid leaves the tank – air must enter head space or flow stops
- Air locked tanks
  - Restricted air movement results in restricted liquid entry/exit



AIR

Liquid/air entry & exit - septic tank

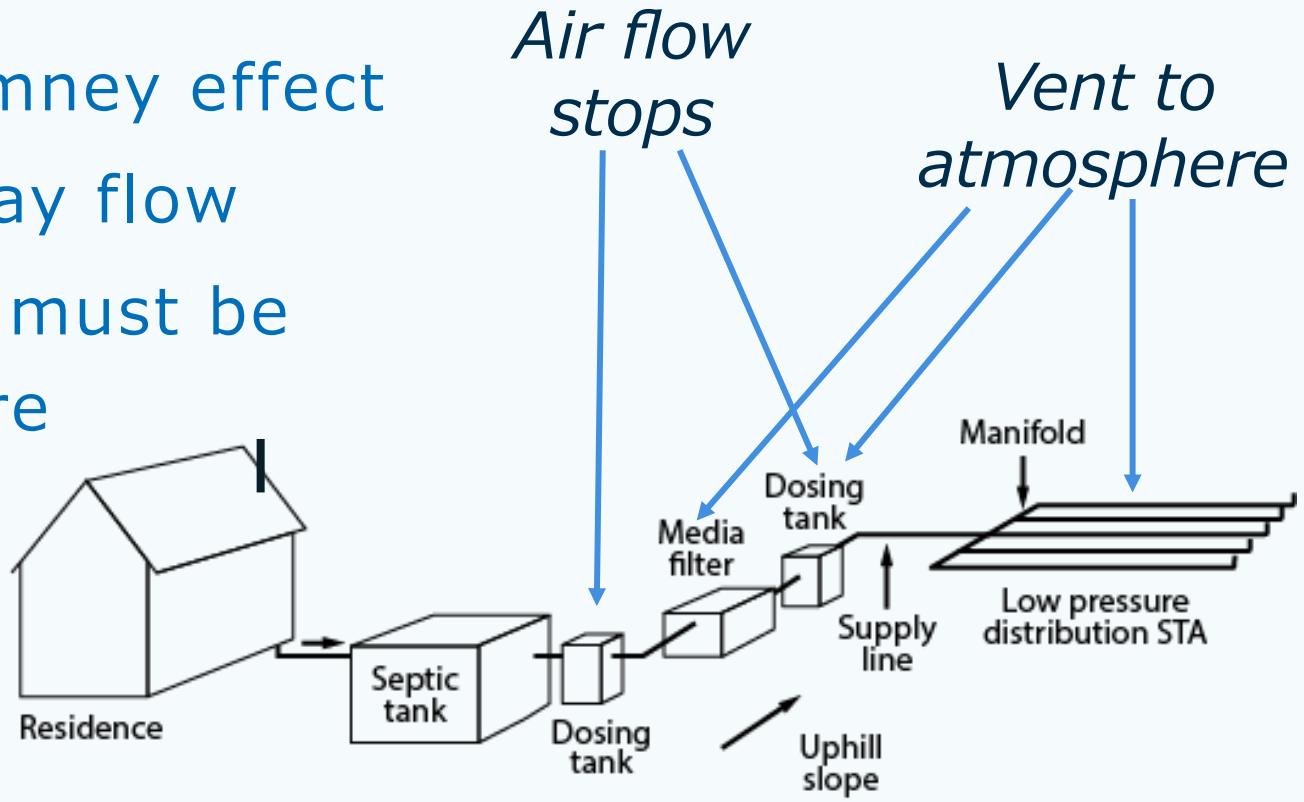


- Inlet at higher elevation than tank outlet
- Components “breathe” through building plumbing vent
- 35 gallons/17.5 gal/inch
- Two (2) inch increase in water surface

Water level in discharge pipe

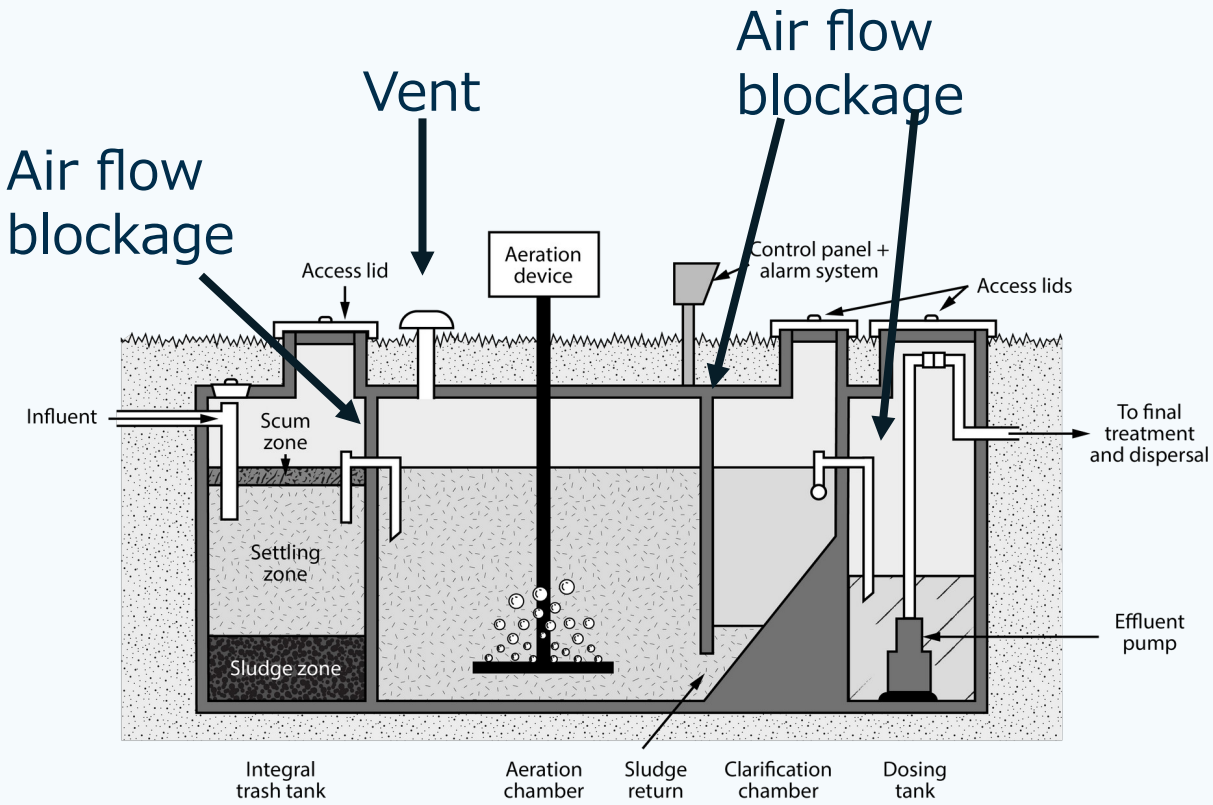
Air exchange through dosing systems

- Dosing tanks stop the chimney effect
  - Pumping system: one-way flow
  - Succeeding components must be vented to the atmosphere
    - Media filters, ATUs, STA



Air exchange through treatment systems

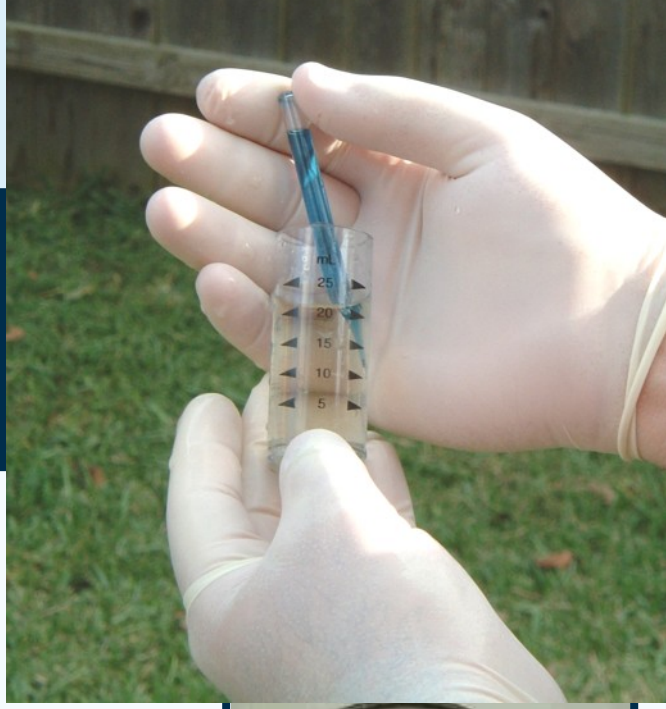
- Identify air flow pathways in treatment systems
- Identify “blockages” to air exchange
- All components must be vented
- Some require direct venting to atmosphere



Oxygen state in treatment components

- Optimal growing conditions promote healthy microbial populations for specific processes
- Dissolved oxygen (DO) concentration defines oxygen state
  - Aerobic: 2.0 mg/L
  - Anaerobic: <1.0 mg/L, typically <0.1 mg/L
- Anoxic condition is a subset of anaerobic
  - <0.5 mg/L with bound oxygen in the form of nitrate (NO_3^-)
  - Optimum range: 0.1 to 0.3 mg/L DO

Dissolved Oxygen (DO)



Concentration of O_2 dissolved in water

- Measured with meter and probe or colorimetric kit in field
- DO expressed as mg/L
- DO low in septic tank <0.3 mg/L
- DO>2 from advanced treatment systems



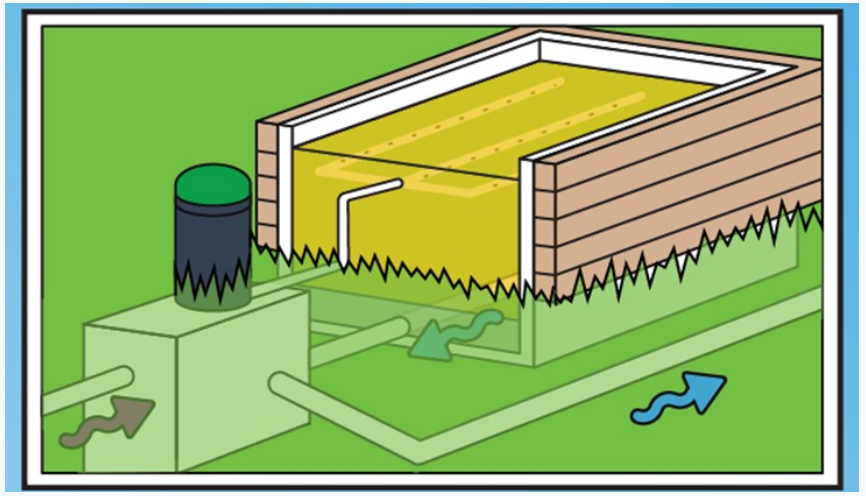


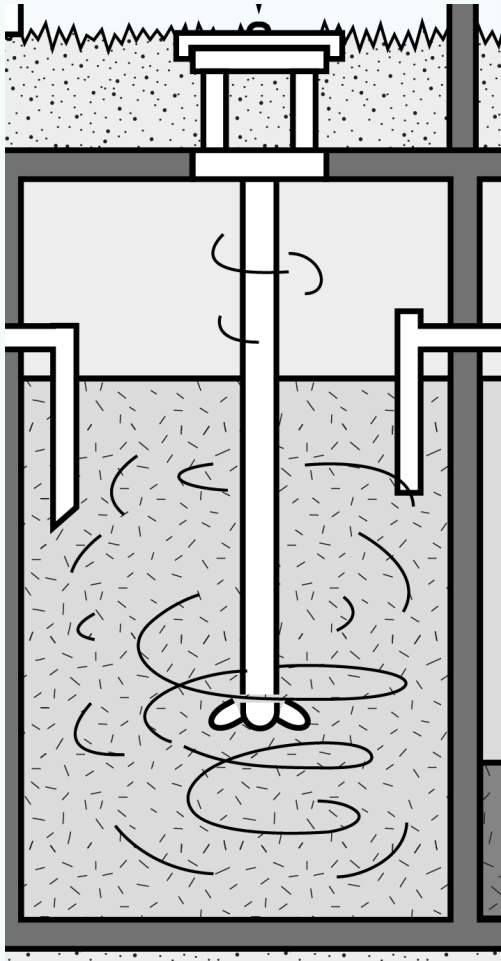
Treatment configurations and aeration approach

- Aerobic treatment media configurations
  - Unsaturated medium
    - Media filters
  - Saturated medium
    - Submerged media or
    - Suspended growth systems
    - Integrated fixed-film activated sludge
- Aeration approach
  - Passive
  - Active

Passive aeration aerobic systems

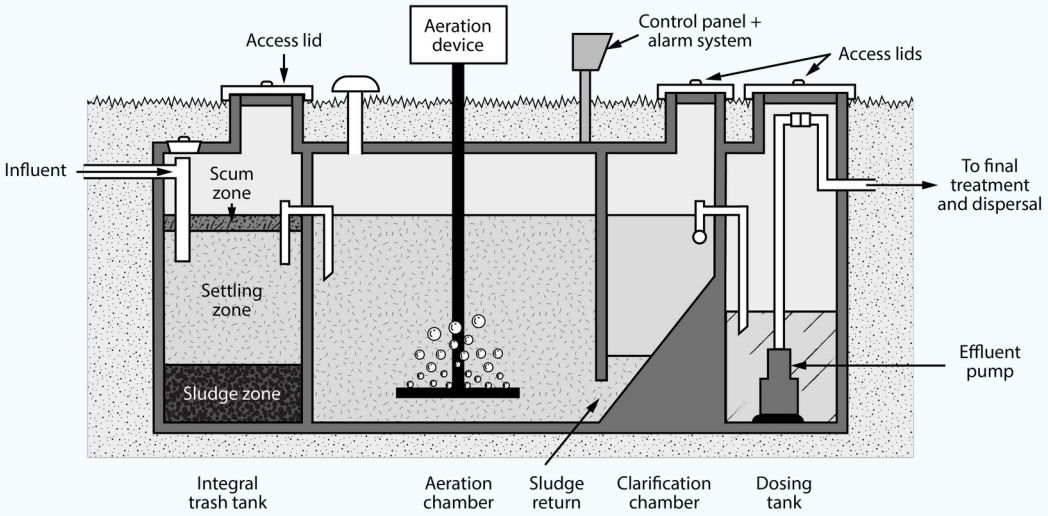
- Media filter: direct air exchange with atmosphere
- Mechanical mixing
  - Circulates gases from headspace of treatment tank into liquid
  - Head space air exchange is critical





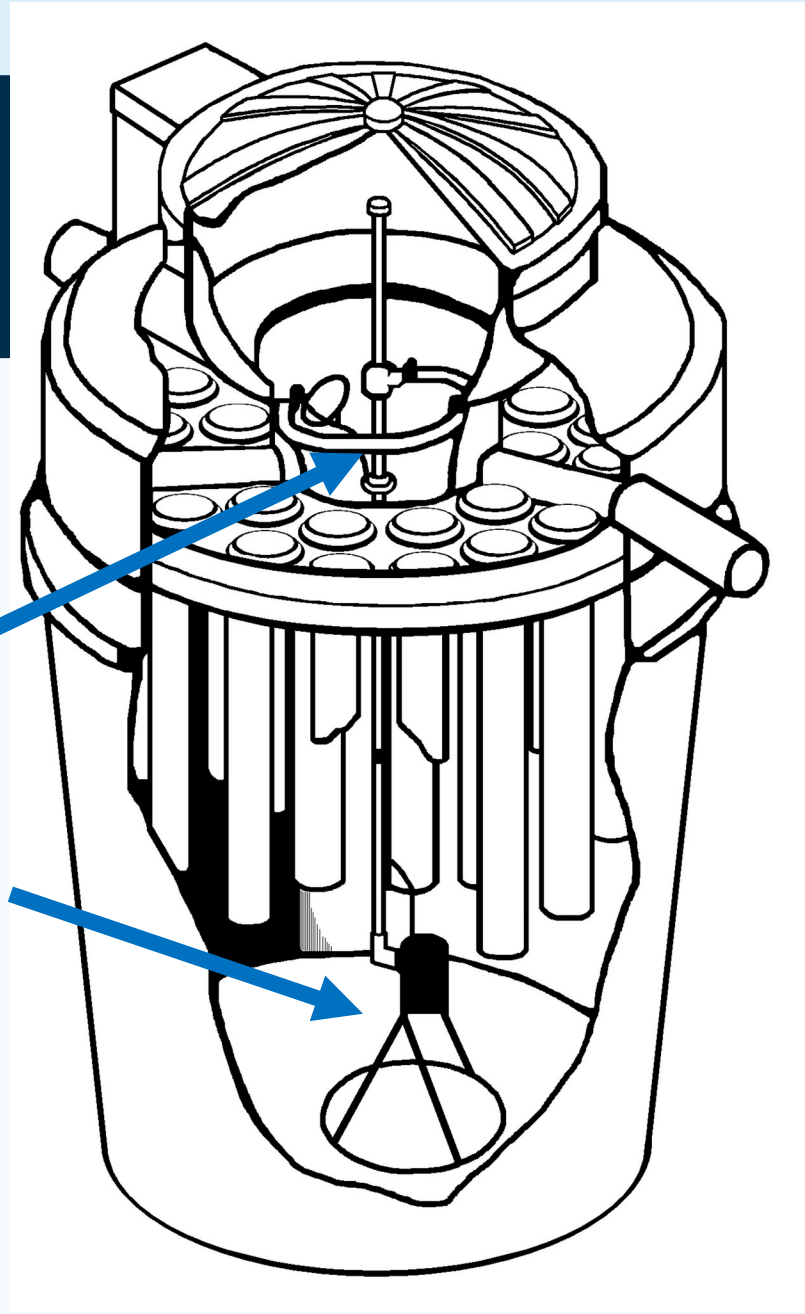
Compressed aeration aerobic systems

- Positive air movement
  - Compressor
  - Blower
- Forced air movement from atmosphere into liquid
- Diffusers generate air bubbles
- Oxygen diffuses from air bubbles into the liquid



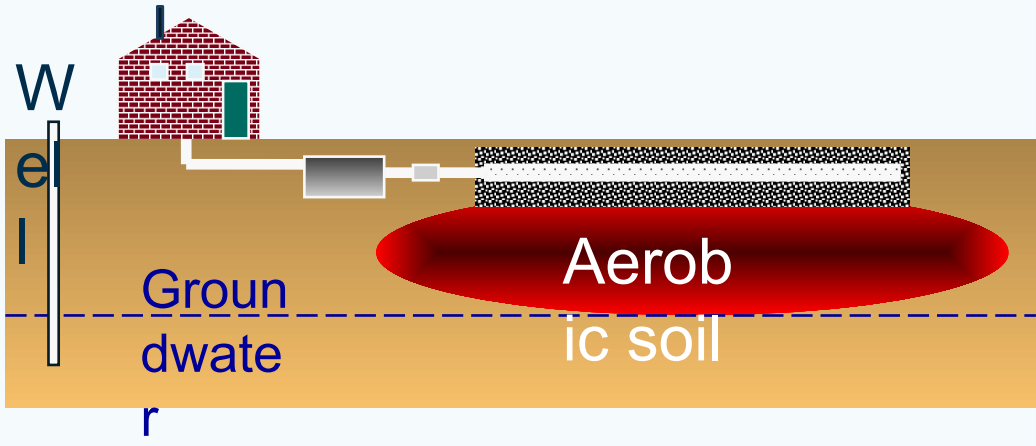
Vacuum venturi effect aeration

- Air flows from location of greater pressure to a location with lower pressure
- Air breathing tube connects to atmosphere
- Impeller spinning moves liquid away from the impeller to develop area of low pressure
- Air enters low pressure zone through breathing tube
- Turbulence of impeller develops air bubbles



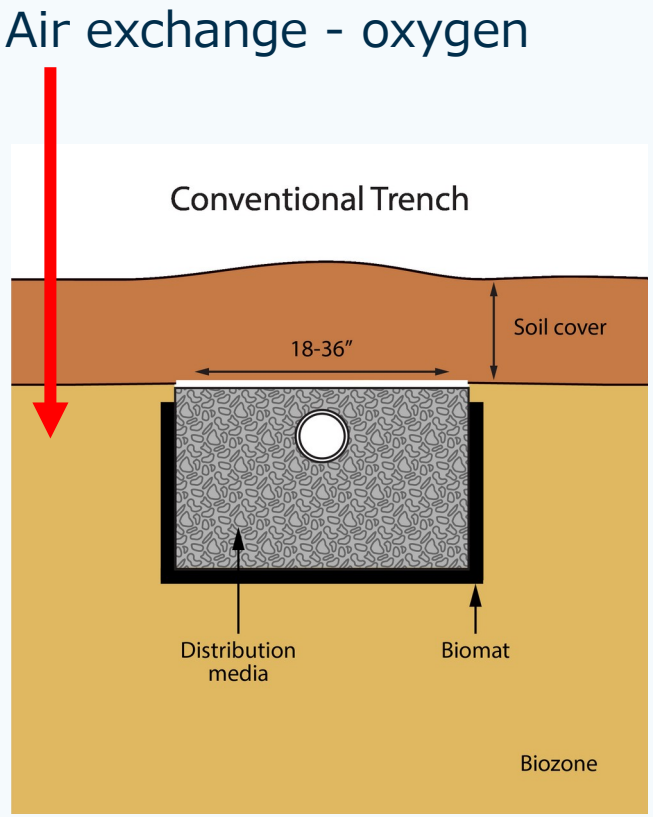
Soil oxygen management

- Air exchange is critical in the STA
  - In the soil volume
  - Within the trench
- Liquid flow facilitates air flow
- Maintains aerobic soil conditions critical to effective treatment



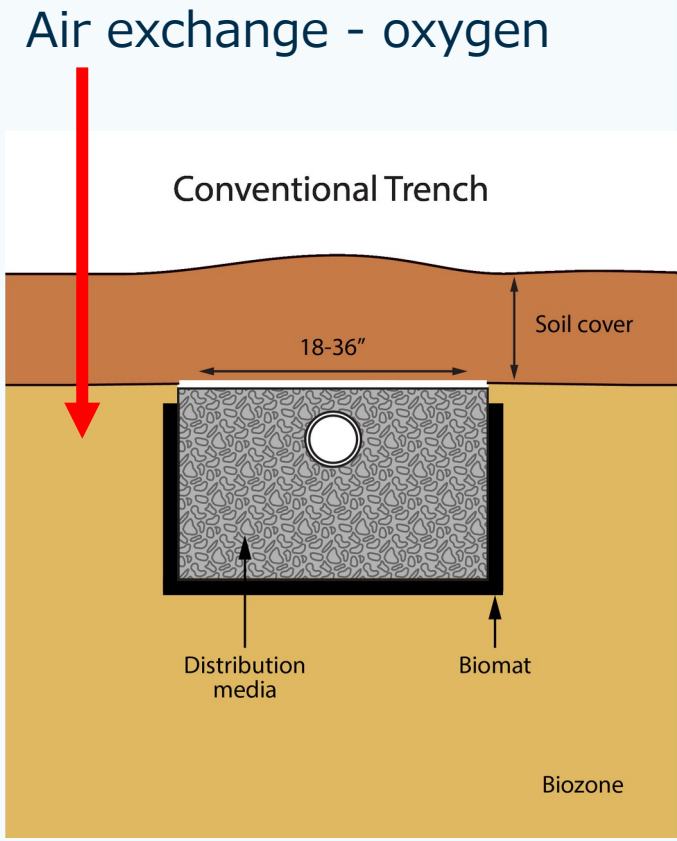
Optimal conditions for air exchange in the soil treatment volume

- System depth: shallow placement
- System configuration: narrow trenches with sufficient spacing
- Soil surface: open surface for air exchange
- Soil texture: coarser texture (more sand-sized)
- Soil structure: strong, well defined, vertically oriented
- Soil moisture: unsaturated conditions
- Root growth: healthy vegetation



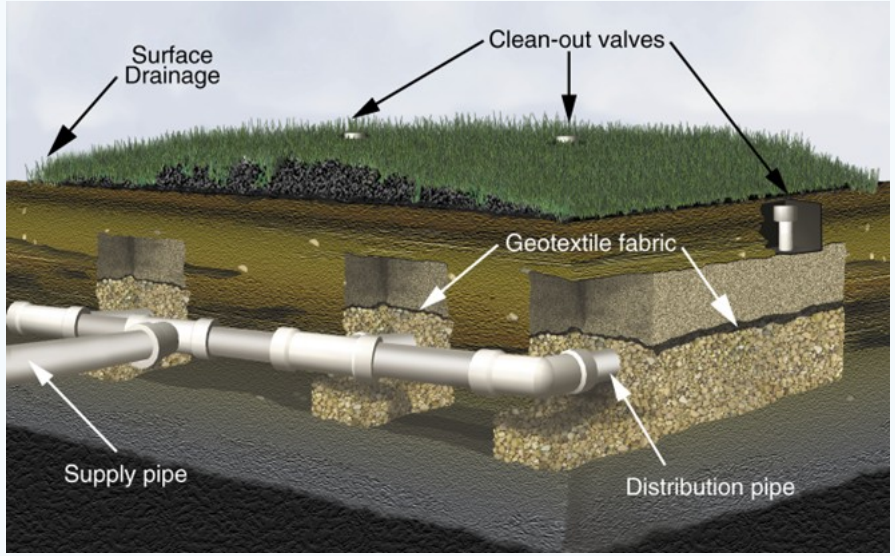
Conditions restricting air exchange in the soil treatment volume

- System depth: deeper placement
- System configuration: trenches closely spaced, use of beds
- Soil surface: impervious covers
- Soil texture: finer texture, more silt and clay
- Soil structure: massive, horizontal orientation
- Soil moisture: higher moisture content
- Root growth: poor or no vegetation
- Compaction: reduces pore space and restricts aeration

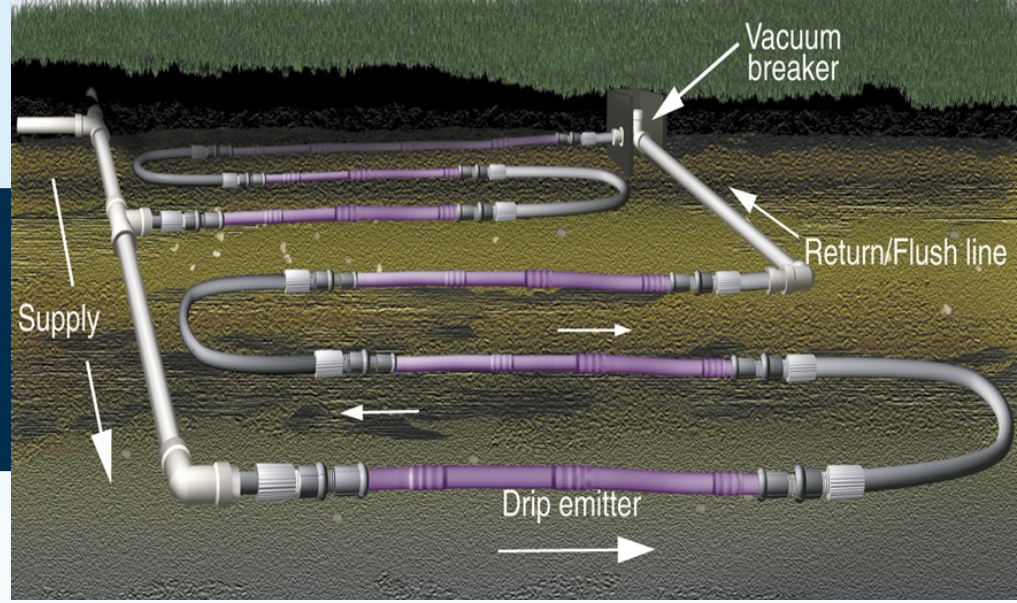


Air exchange within a pressure-dosed or LPD trench

- Pressurized distribution forces air exit and entry
  - Liquid enters trench, forcing air out
  - Air exits trench through the soil as pumped liquid enters
  - Air reenters trench as liquid disperses
- Dosing and resting forces the trench and surrounding soil volume to breathe



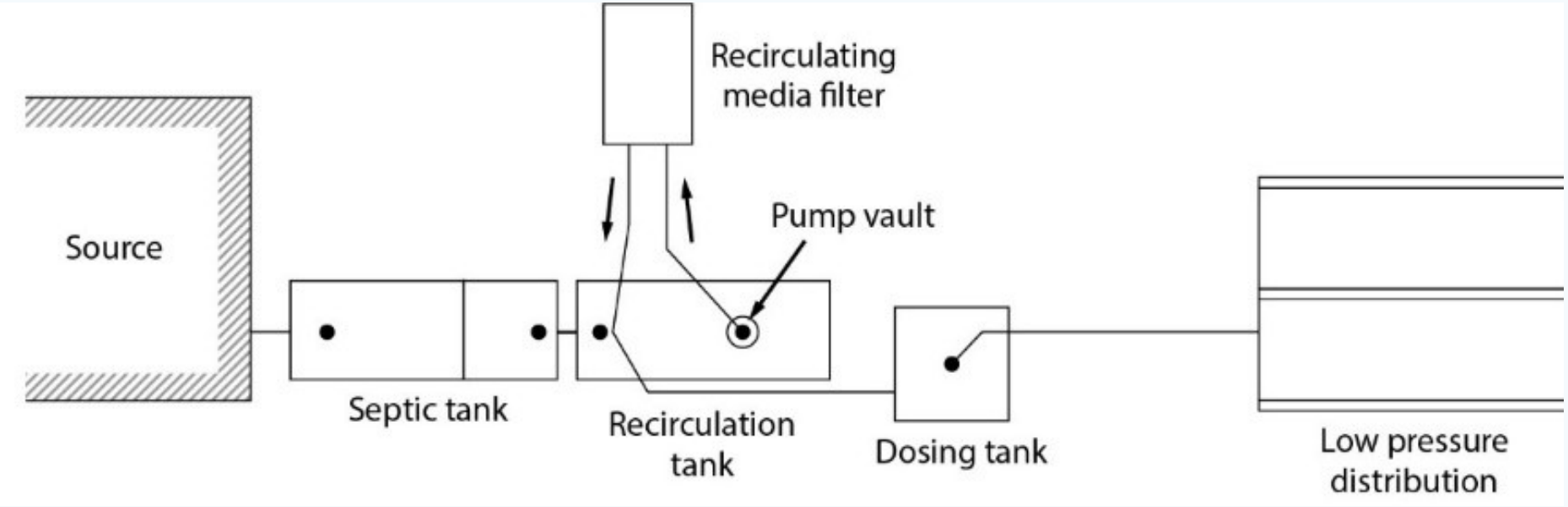
Air exchange within a drip distribution STA



- Tubing in direct contact with soil – no reservoir
- Air release/vacuum breaker allows air to exit tubing during pressurization
- Liquid is forced out of the tubing and into surrounding soil
  - Air exits soil pores as pumped liquid enters
  - Air reenters soil pores as liquid disperses
- Forces soil pores to breathe
- Dosing/resting cycles are critical to air exchange

Oxygen state management in recirculating media filters

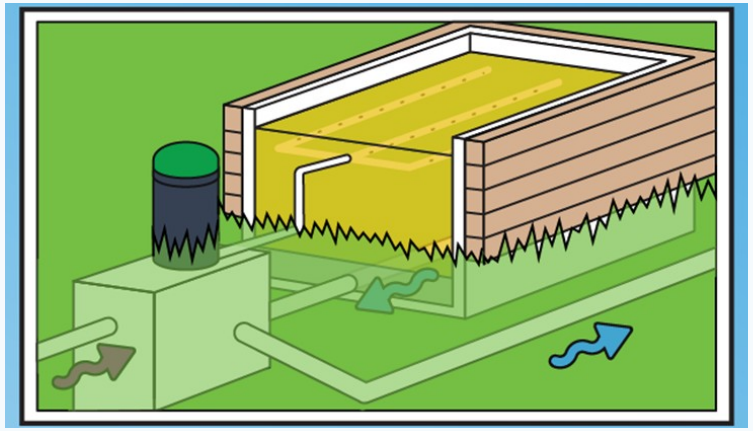
- Monitor and manage DO level in both the media filter and the recirculation tank



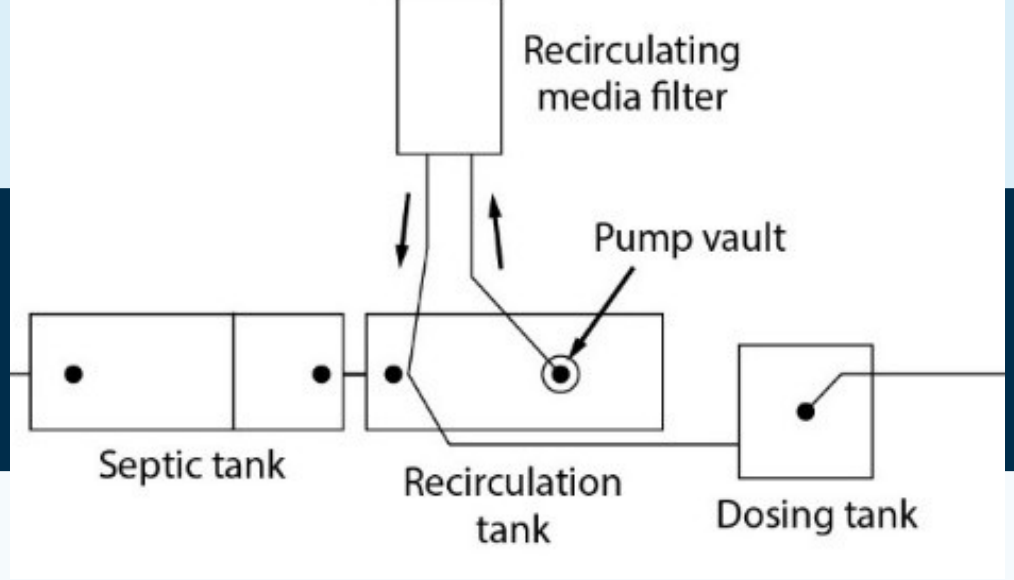
Oxygen management in recirculating media filters

Goal: Nitrification, reduce BOD and TSS

- Small doses
  - Promotes thin film flow over attached microbial growth
- Resting cycles
  - Allows the filter to breathe
- Effective air exchange from porous media to atmosphere
  - Free surface
  - Vented if in a box



Oxygen management in recirculation tanks



Goal: denitrification in recirculation OR processing tanks

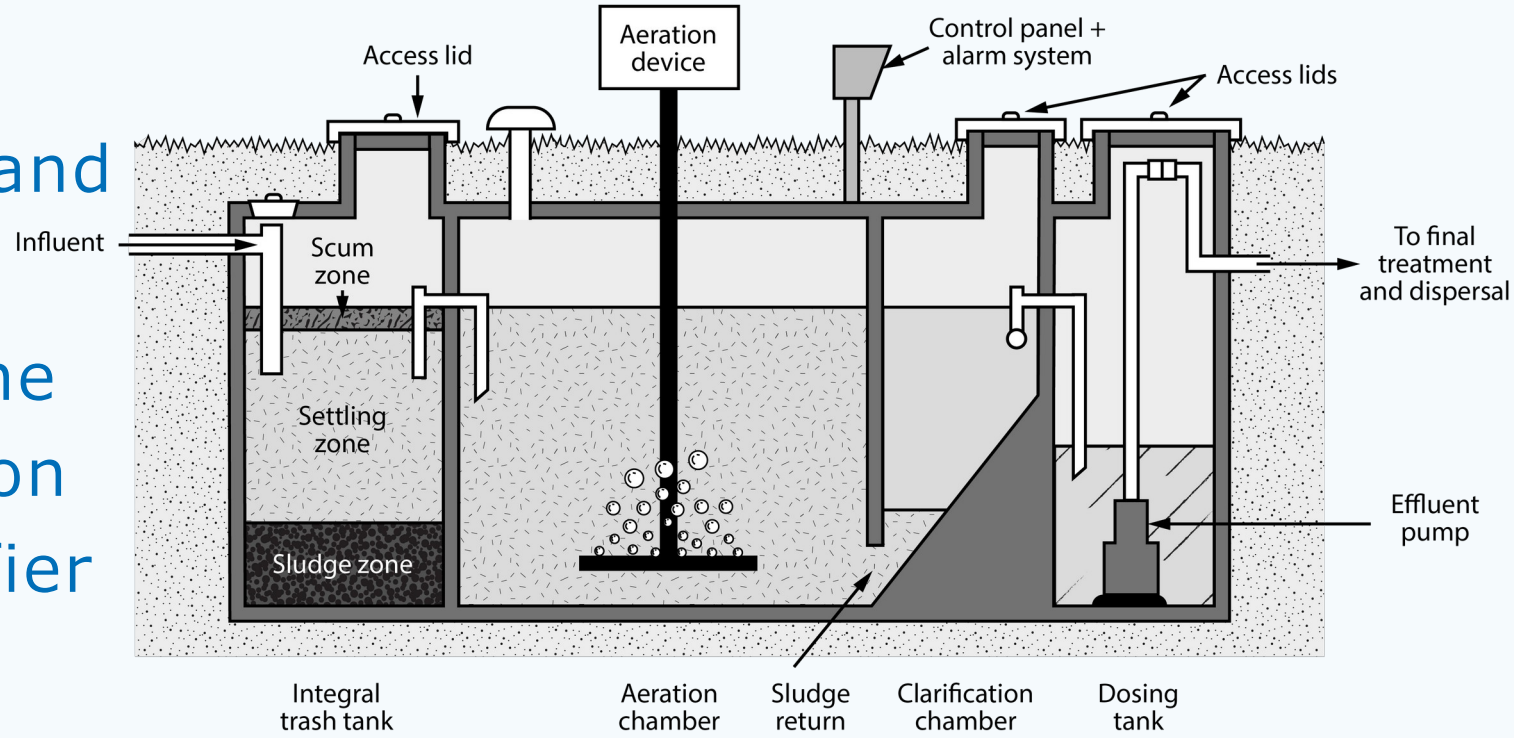
- Manage oxygen state
  - DO of liquid returned defines the mass of oxygen per unit volume of liquid returned
  - Amount of oxygen required based on BOD in the wastewater
  - Adjust recirculated volume to adjust oxygen to match BOD
- Manage the carbon source
  - From the septic tank
  - External addition

Oxygen management in aeration systems

- Goal: depends on system treatment goals:
  - Meeting a standard
  - Site-specific constraints
- Performance requirement based on contaminant(s) to be removed
- Unit processes adjusted to comply with performance requirements

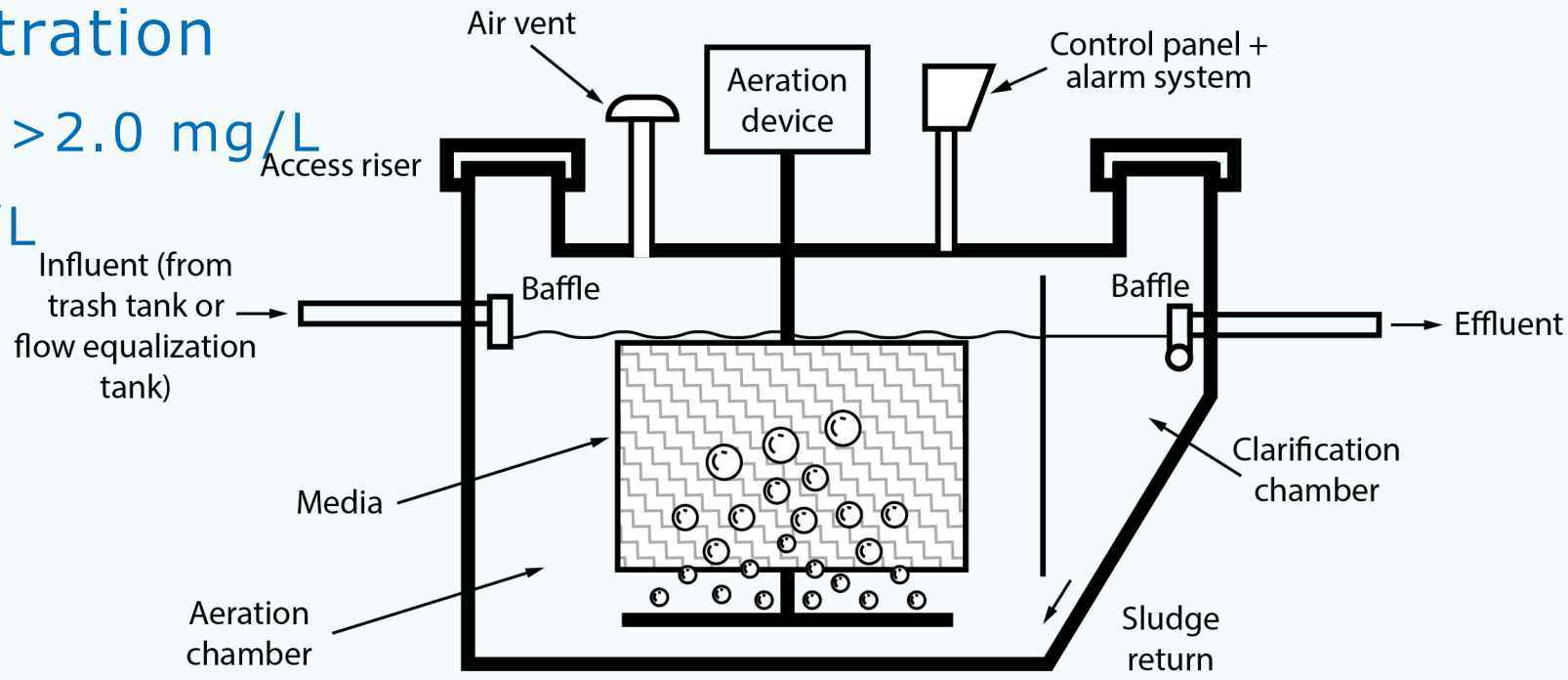
Oxygen management in submerged aeration systems

- Manage oxygen state
  - Single pass: in the aeration chamber and the clarifier
  - Recirculating: in the septic tank, aeration chamber and clarifier



Oxygen management in submerged aeration systems

- Single pass oxygen management
- Target DO concentration
  - Aeration chamber: >2.0 mg/L
  - Clarifier: >1.0 mg/L



Air pressure check



d. Pressure at air supply unit:

Where

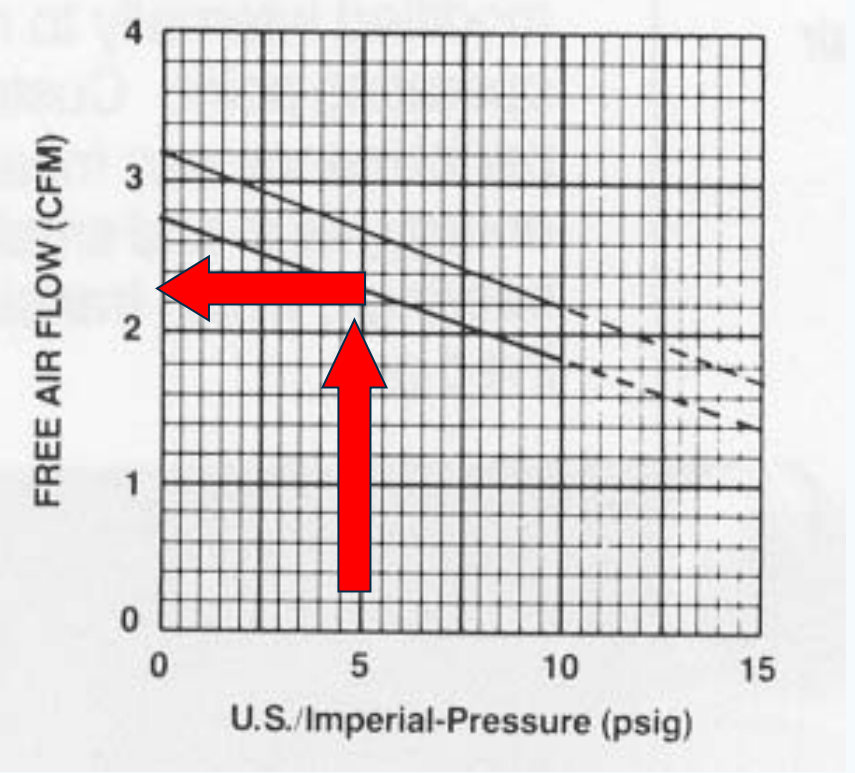
- Measured at the unit
- Pressure gage
- Schrader valve

What should it be?

- Flow-pressure curve

How to read it





Air Pressure Monitoring

Decreased Pressure:

- Loose fitting in the air distribution system
- Broken air line
- Broken diffuser
- Aerator is not performing

Increased Pressure:

- Blockage in Distribution Line
- Crushed Distribution Line
- Plugged Diffuser
- Increased water level in the aeration chamber

Air flow rate check

Measured at the supply unit
Positive pressure
- Compressor
- Blower

Vacuum
- Aspirator

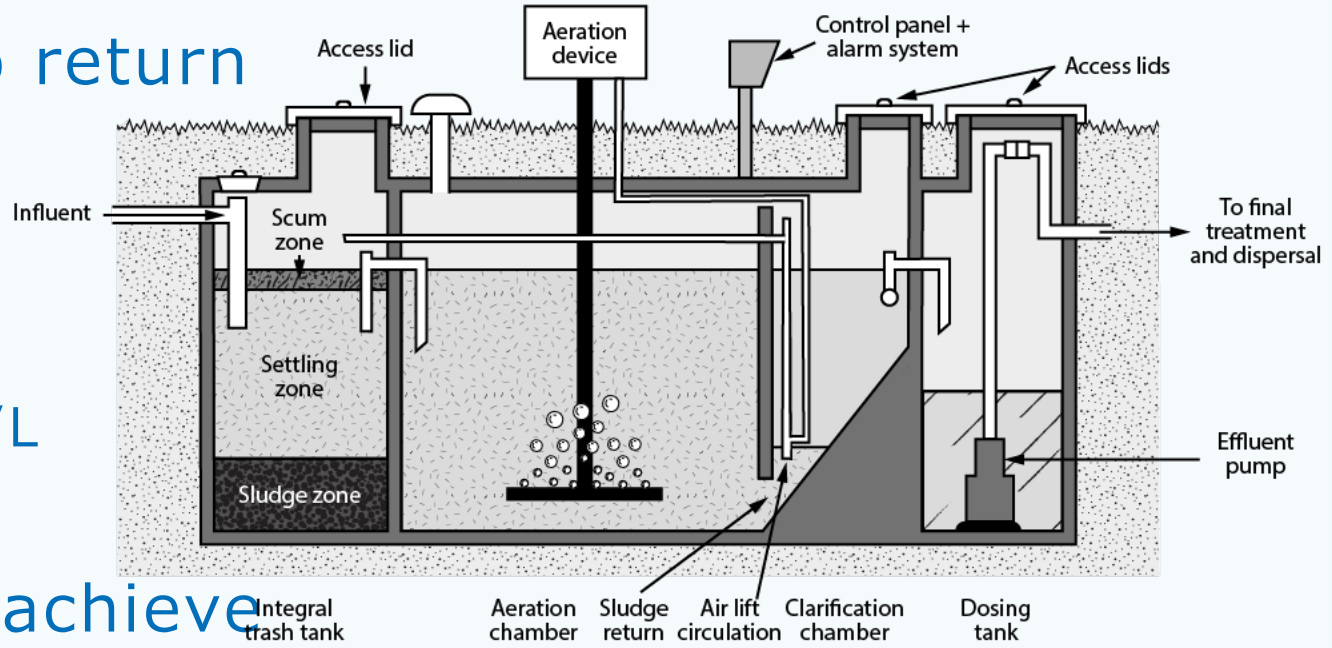






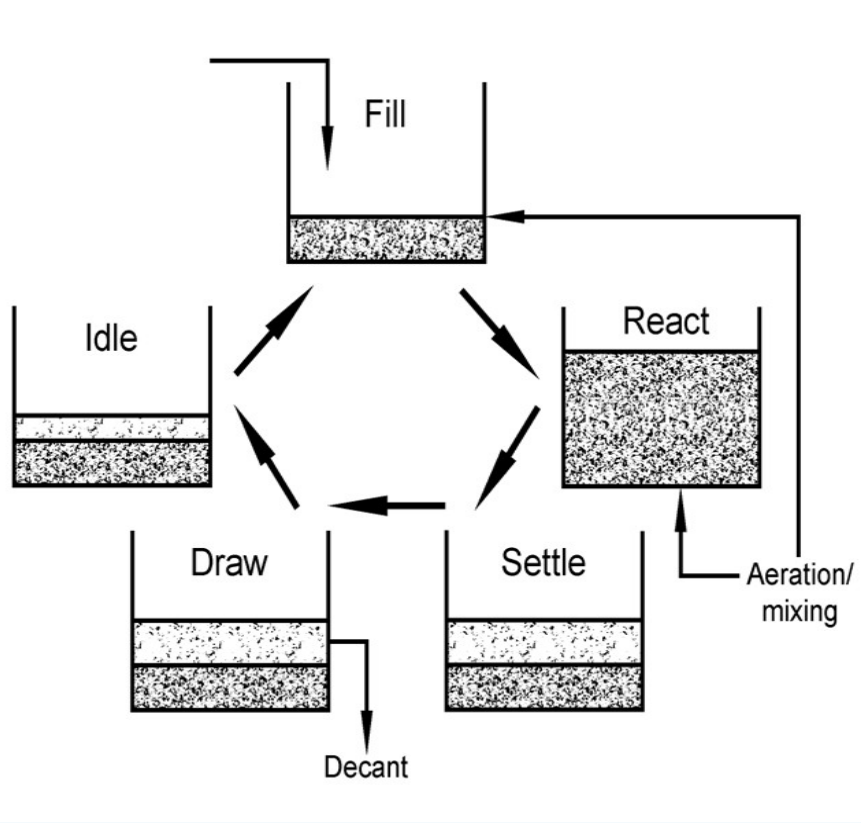
Oxygen management in submerged aeration systems

- Recirculating oxygen management
  - Configure airlift pump to return liquid to trash tank
- Target DO concentrations
  - Trash tank: 0.1 to 0.3 mg/L
  - Aeration chamber: >2.0 mg/L
  - Clarifier: >1.0 mg/L
- Adjust circulation ratio to achieve target DO in each component



Oxygen management in timer-controlled aeration systems

- Sequencing batch reactor tank
  - Measure DO during idle cycle
  - Change time in “idle” stage
- Aeration tank – aeration/mixing time
  - Timer controls aeration system
  - Measure DO in tank during “OFF” period
  - Adjust Time “ON” and Time “OFF” settings



Summary

- Physical effect of air exchange on liquid movement through OWTS components
- Chemical effect of air exchange (DO availability)
- Oxygen state in advanced treatment components
- Identifying and troubleshooting barriers to liquid movement through the STA

QUESTIONS?

Instructor's Contact information here