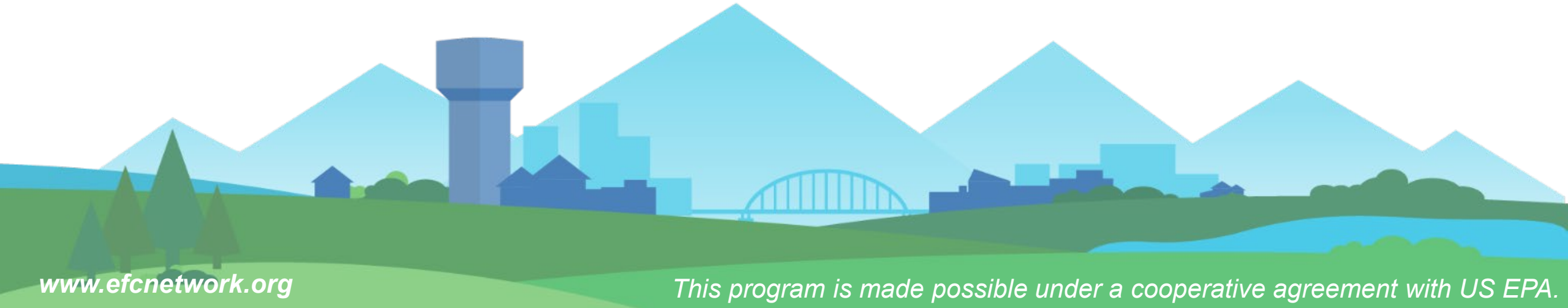
Activated Sludge Characteristics and Trouble Shooting

A.J. Barney 10/9/2023



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About Us

The Environmental Finance Center Network (EFCN) is a university- and non-profit-based organization creating innovative solutions to the difficult how-to-pay issues of environmental protection and environmental infrastructure.

The EFCN works collectively and as individual centers to address these issues across the entire U.S, including the 5 territories and the Navajo Nation. The EFCN aims to assist public and private sectors through training, direct professional assistance, production of durable resources, and innovative policy ideas.

The Wastewater Treatment Works Program Team

- Southwest Environmental Finance Center at the University of New Mexico
- Environmental Finance Center at Wichita State University
- Syracuse University Environmental Finance Center
- Environmental Finance Center at The University of North Carolina at Chapel Hill
- Environmental Finance Center at the University of Maryland
- EFC West
- Moonshot Missions
- Mississippi State Water Resources Research Institute

Areas of Expertise

Asset Management

Rate Setting and Fiscal Planning

Leadership Through Decision-making and Communication

Energy Management Planning

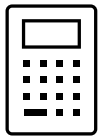
Accessing Infrastructure Financing Programs

Workforce Development

Collaborating with Other Systems

Resiliency Planning

Mapping and Data Collection



Wastewater Operator Certification

Infohub.swefc.unm.edu

Featured Projects

Agenda

- Activated Sludge Control and Characteristics Introduction
- Activated Sludge Characteristics/ Variables
  - Values
  - Troubleshooting and Remediating Issues

Activated Sludge Characteristics and Controls Introduction

Why are activated sludge process characteristics and control important?

Biological process with more variables than physical and chemical processes

Operational data must be used to make process control adjustments

Characteristics change daily and the ASP process must be maintained in a balance state

Objectives of ASP:

- Maintain the aeration tank to produce floc-forming bacteria
- Flocculate and settle the flocs inside the secondary clarifier
- Manage the activated sludge to maintain a healthy proportion of microorganisms in the system

Healthy Activated Sludge

Visual

- Solid brown and sometimes grey colored activated sludge
- Diffused air should produce fine, crisp, white bubbles
- Formation of well-structured and dense flocs of microorganisms that settle easily for a distinct and dense sludge blanket

Olfactory (smell)

- Earthy smell
- Lack of foul odors

Influent

Analysis of influent characteristics helps with treatment and making process control adjustments

Infiltration/ Inflow

- Grit and silt
- Organic washout
- Changes in temperature

Septic shocks due to sitting wastewater

Industrial discharges can contain harmful pollutants

Influent Characteristics

- Flow Rate
- Total Suspended Solids (TSS)
- Volatile Suspended Solids (VSS)
- Biochemical Oxygen Demand (BOD)
- Chemical Oxygen Demand (COD)
- Total Kjeldahl Nitrogen (TKN)
- Ammonia (NH_3)
- Nitrate (NO_3)
- Temperature
- pH
- Alkalinity

ASP Variables

- Dissolved Oxygen (DO)
- Food-to-Microbe ratio (F/M)
- Mixed Liquor Suspended solids (MLSS)
- Mixed Liquor Suspended solids (MLVSS)
- Solids Retention Time (SRT)
- Mean Cell Residence Time (MCRT)
- Sludge Volume Index (SVI)

Common ASP Issues

- Bulking Sludge
- Foaming
- Settling Problems
- Sludge Overproduction
- Nutrient Imbalance
- Organic Overloading
- Poor Flocculation

Activated Sludge Characteristics/ Variables

Influent Flow Rate

Normal variations based on design, population served, and daily patterns.

Unusual increases and decreases in flow rate can impact the following:

- Hydraulic Residence Time
- Wastewater Dilution
- Solids Settling
- Oxygen Transfer
- Shock Loadings
- Operating Costs

Influent Flow Rate Troubleshooting

Increased Flow Rates

- Increase DO
- Divert flow
- Increase MLSS or Return Activated Sludge (RAS) return rate

Decreased Flow Rates

- Decrease DO
- Decrease MLSS or RAS

TSS/ VSS

Influent 150-400 mg/L Effluent 1-20 mg/L

- Increased TSS/ VSS can lead to issues such as bulking and foaming, reduced oxygen transfer, and decrease in overall treatment efficiency.
- Adequate primary clarification is important to remove excessive suspended solids

Activated Sludge Bacteria

- Nitrifying bacteria- Use oxygen to convert ammonia to nitrite and nitrite to nitrate.
  - Nitrosomonas and Nitrobacter
- Denitrifying bacteria- Convert nitrate to nitrite and nitrite to nitrogen gas.
- Heterotrophic bacteria- Primary consumers of organic material. Use unbound or bound oxygen.
- Floc-forming bacteria- filamentous bacteria that form flocculent biomass.
  - Flocs are large settleable clumps of microbial biomass.

BOD/ COD

BOD Influent 150-400 mg/L

BOD Effluent 10-20 mg/L

BOD and COD indicate how much oxygen the wastewater would consume if left untreated and how the wastewater may impact the environment.

Increased BOD/ COD requires more energy, microbial activity, and Oxygen to treat.

It is important to make adjustments to account for these types of increase and maintain proper sludge production.

Ammonia and TKN

Ammonia Influent 10- 60 m/L

Ammonia Effluent 1-10 mg/L

- Untreated ammonia and TKN results in eutrophication in receiving waters
- Urine>Urea>Ammonia
- Ammonia can be analyzed with laboratory analytics or a probe.

Ammonia Troubleshooting

- DO should be increased to remove elevated ammonia concentrations
- Increase recirculation
- Optimize pH or add alkalinity

Nitrate

Nitrate Effluent < 10 mg/L

- Nitrate is a nitrogen compound found in wastewater and the by-product of nitrification.
- Removed by denitrifying bacteria in the absence of oxygen.
- Large amounts of nitrate in water used as a drinking water source can result in methemoglobinemia.

Nitrate Removal

- Add anoxic zone
- Increase recycle rate (modified processes)

Temperature/ pH/ Alkalinity

- High Temperature- Increases microbial activity, increase nitrification, increases bulking/ foaming
- Low Temperature- decreases BOD removal, increases denitrification, increases oxygen solubility
- Mesophilc (68-95°F) range is preferred
- Excessive temperature change either way kills microbes and inhibits treatment
- pH- microbial activity inhibited outside of 6.5-8.5

Dissolved Oxygen (DO)

DO concentration .5-4.0 mg/L

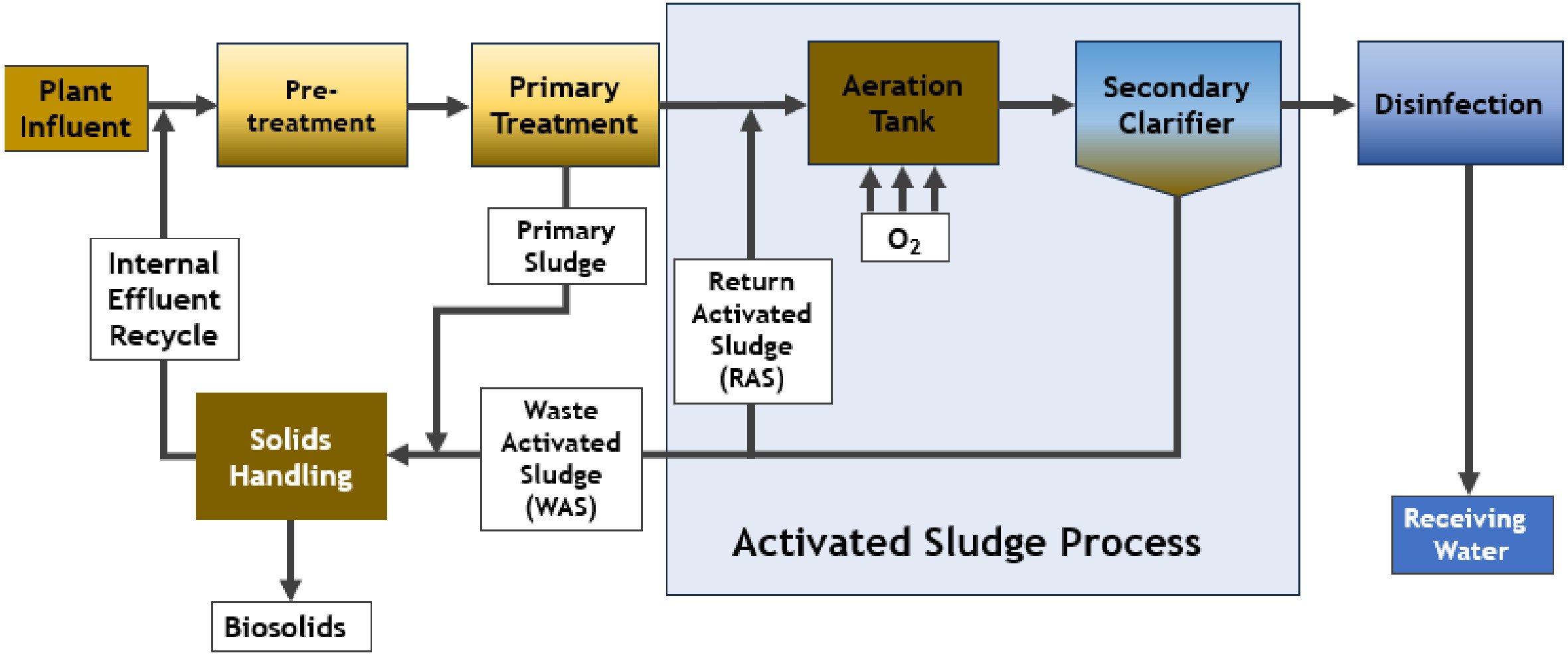
- Provides final electron acceptor for aerobic respiration and nitrification
- DO provided by blowers in and aeration tank and distributed by diffusers

Dissolved Oxygen Issues

- Can be observed or analytically determine
- Inadequate Aeration
- High Temperatures
- Clogging and Fouling
- High Organic Loading, Microbial Overgrowth, and Excessive solids
- Toxic shocks

Secondary Clarifier Sludge

- Return Activated Sludge (RAS)- Sludge that is pumped back to the activated sludge process.
- Waste Activated Sludge (WAS)- Sludge that is removed from the secondary clarifiers and activated sludge process in general and pumped to solids management process.
- Both control the sludge blanket in the secondary clarifier.


Plant Influent
Pre-treatment
Primary Treatment
Aeration Tank
Secondary Clarifier
Disinfection
Primary Sludge
O_2
Internal Effluent Recycle
Return Activated Sludge (RAS)
Solids Handling
Waste Activated Sludge (WAS)
Activated Sludge Process
Receiving Water
Biosolids

Food-to-Microbe Ratio (F/M)

Desired Range 0.2 – 0.6

- Ratio of BOD to concentration of microbes in the form of MLVSS in the system.
- Low F/M correlates with high-efficiency organic matter removal and longer sludge age
  - Decrease F/M by increasing wasting, increasing DO
- High F/M encourages the growth of specialized microbes that remove nutrients such as nitrogen and phosphorus
  - Increase F/M by decreasing sludge wasting, decreasing DO, add supplemental carbon source

Mixed Liquor Suspended Solids (MLSS)
Mixed Liquor Volatile Suspended Solids (MLVSS)

1000-4000 mg/L

- MLSS is concentration of microorganisms and other suspended solids, such as inert particles and organic matter in the activated sludge process.
- MLVSS represents biomass present in activated sludge and is 70-80% of MLSS.
- Increase MLSS by decreasing sludge wasting, increasing sludge return rate, increasing aeration, and adding a supplemental carbon source.
- MLSS is decreased by increasing sludge wasting, decreasing the return rate, and decreasing aeration.

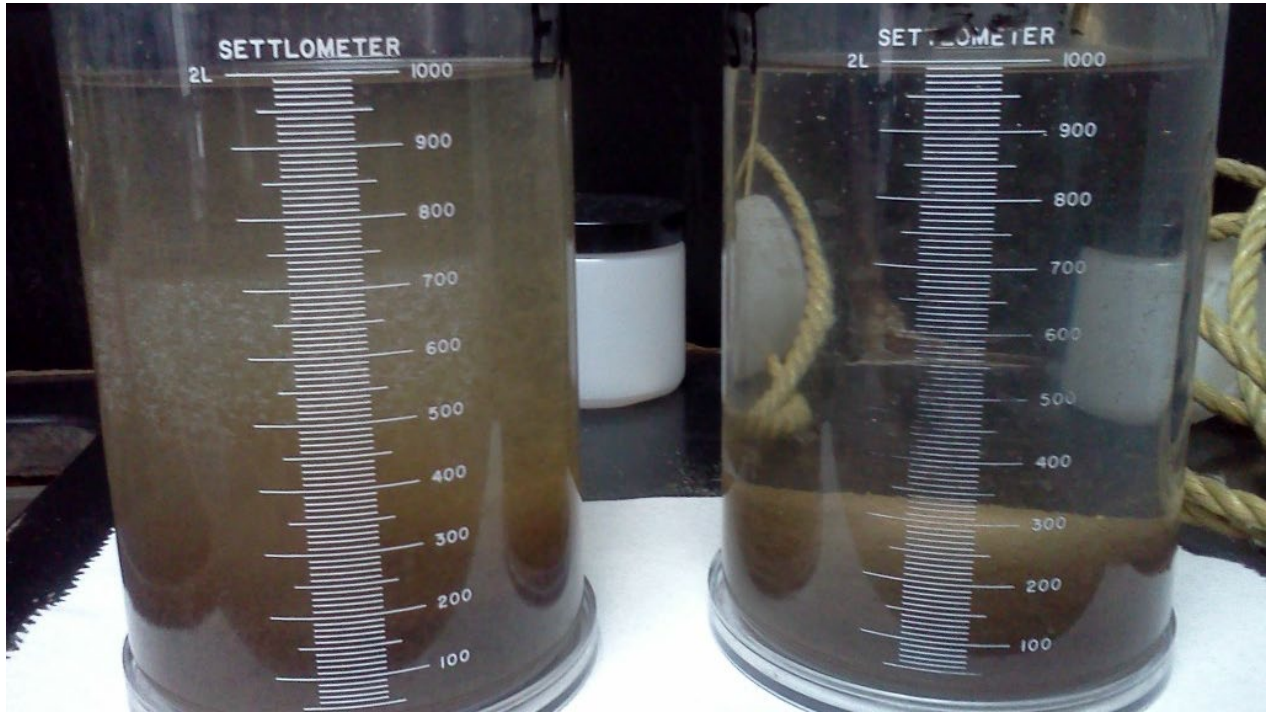
Solids Retention Time (SRT)
Mean Cell Residence Time (MCRT)

- Represents the average time solids or cells are retained in the activated sludge process.
- SRT is most commonly used.
- Directly relates to microbial activity, nutrient removal, sludge production, effluent quality, and energy efficiency.
- SRT is determined by design parameters. Conventional plants = 3.5 – 10.0 days.
- Primarily controlled through WAS- increasing sludge wasting reduces SRT and decreasing sludge wasting increases SRT.

Sludge Volume Index (SVI)

Good SVI = 80 - 120

- SVI measures settleability
- Mixed sample is allowed to settle for 30 minutes
- Initial volume = 1000 mL
- Final sludge volume = SVI
- SVI < 80 indicates old sludge age
- SVI > 150 typically indicates filamentous issues
- SVI is controlled by optimizing MLSS through adjusting RAS and WAS



Bulking Sludge

Abnormal growth of microorganisms (filamentous bacteria).

Flocs are bulky and settle poorly.

Controls

- Monitoring and process control
- Identify and reduce filamentous bacteria
- Nutrient balancing
- Sludge age control

Foaming

- Excessive foaming in activated sludge treatment processes.
- Results from filamentous bacteria Nocardia and Microthrix parvicella, and excessive surfactants.

Controls

- Ensure proper MLSS, aeration, and nutrient balance
- Chemical agents
- Mechanical removal
- Community out reach and pretreatment to minimize surfactants.
- Monitor for seasonal changes.

Sludge Overproduction

Can lead to bulking, increased sludge age, additional disposal costs and reduced water quality.

Controls

- Maintaining proper:
  - SRT
  - MLSS
  - Nutrient balance
  - Aeration.

Nutrient Imbalance

- Unequal ratio of essential nutrients (nitrogen and phosphorus)
- Leads to bulking, sludge over production, and increased DO and energy consumption.

Controls

- Nutrient monitoring
- Nutrient dosing and balancing
- Nutrient addition
- Carbon source optimization
- Return activated sludge control

Poor Flocculation

- Inability of microorganisms to form well-defined and settleable floc structures.
- Leads to to difficulties in solids-liquid separation, increased effluent turbidity, and reduced treatment efficiency.

Controls

- Aeration control
- Proper mixing
- Limiting bulking and sludge overproduction

Toxic Loading

- Can be causes by a variety of contaminants from domestic, commercial, and industrial sources
- Leads to odor Issues, sludge discoloration, decreases in treatment efficiency, and microbial die-off

Control

- Educational outreach and industrial pretreatment
- Redundancy to divert flow and dilute


Questions?

CONTACT INFORMATION

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