How to Help Your Process Be More Efficient Without Even Trying

Inline Process Monitoring and How It Applies to the Lab

Plant Operations &
Laboratory Analysis
Workshop
October 21/22, 2015

Today's topics

1) Compare and contrast compliance monitoring and process monitoring

2) Describe the available types of online sensors

3) Compare and contrast laboratory instruments and different types of online instruments

4) Describe proper measurement verification techniques for online sensors including sampling, sample preparation, and measurement

5) Describe the 4 most important activated sludge operating parameters and provide examples of how online measurements are used for AS process control

Compliance Monitoring

Compliance monitoring

1 sample every day

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Compliance monitoring

Analysis

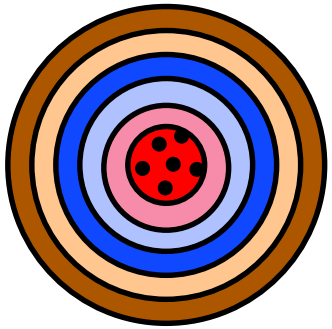
Compliance monitoring

Let’s be specific….

- …. parameters
- …. methodology
- …. location
- …. frequency
- …. sampling method
- …. reporting

The Goal for Compliance Monitoring

High Accuracy & High Repeatability



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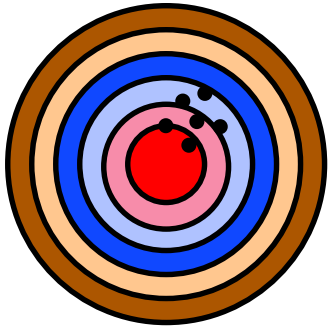
Process Monitoring

The Goal for Process Monitoring

It’s all relative



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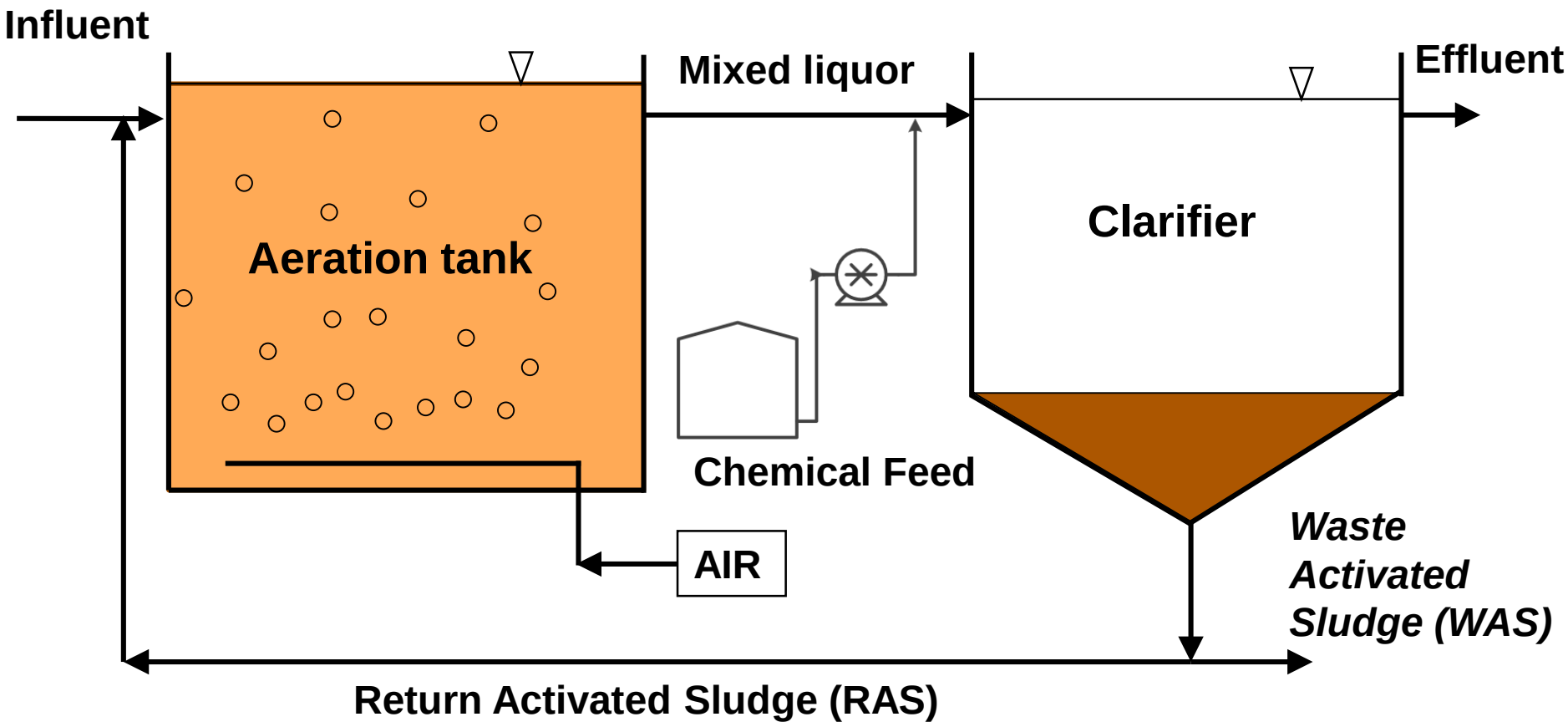
Activated Sludge Process Control



Process Monitoring Parameters

Aeration

- Dissolved Oxygen (D.O.)
- ORP
- Ammonia
- Nitrate
- COD

Sludge Wasting

- Ammonia
- Total Suspended Solids

Sludge Recirculation

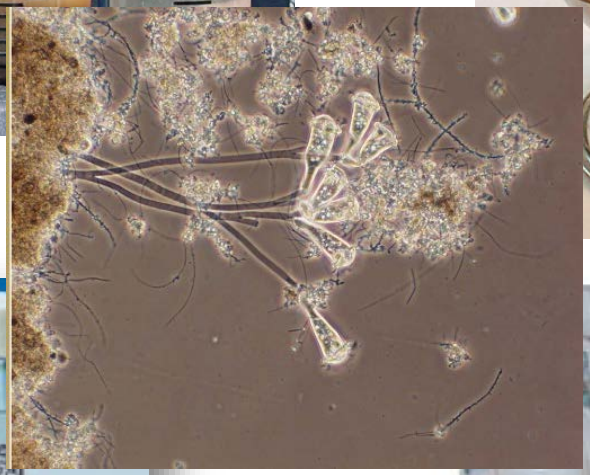
- Sludge blanket level
- Nitrate

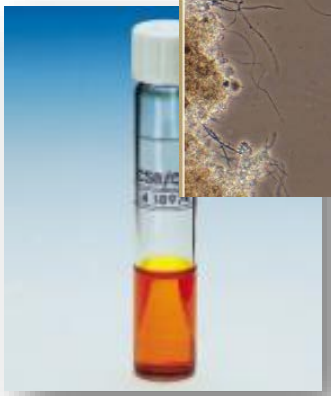
Process monitoring

Sampling

Process monitoring

Analysis





Dissolved Oxygen Uptake
(DOUR) Test

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Process monitoring

Sampling & analysis

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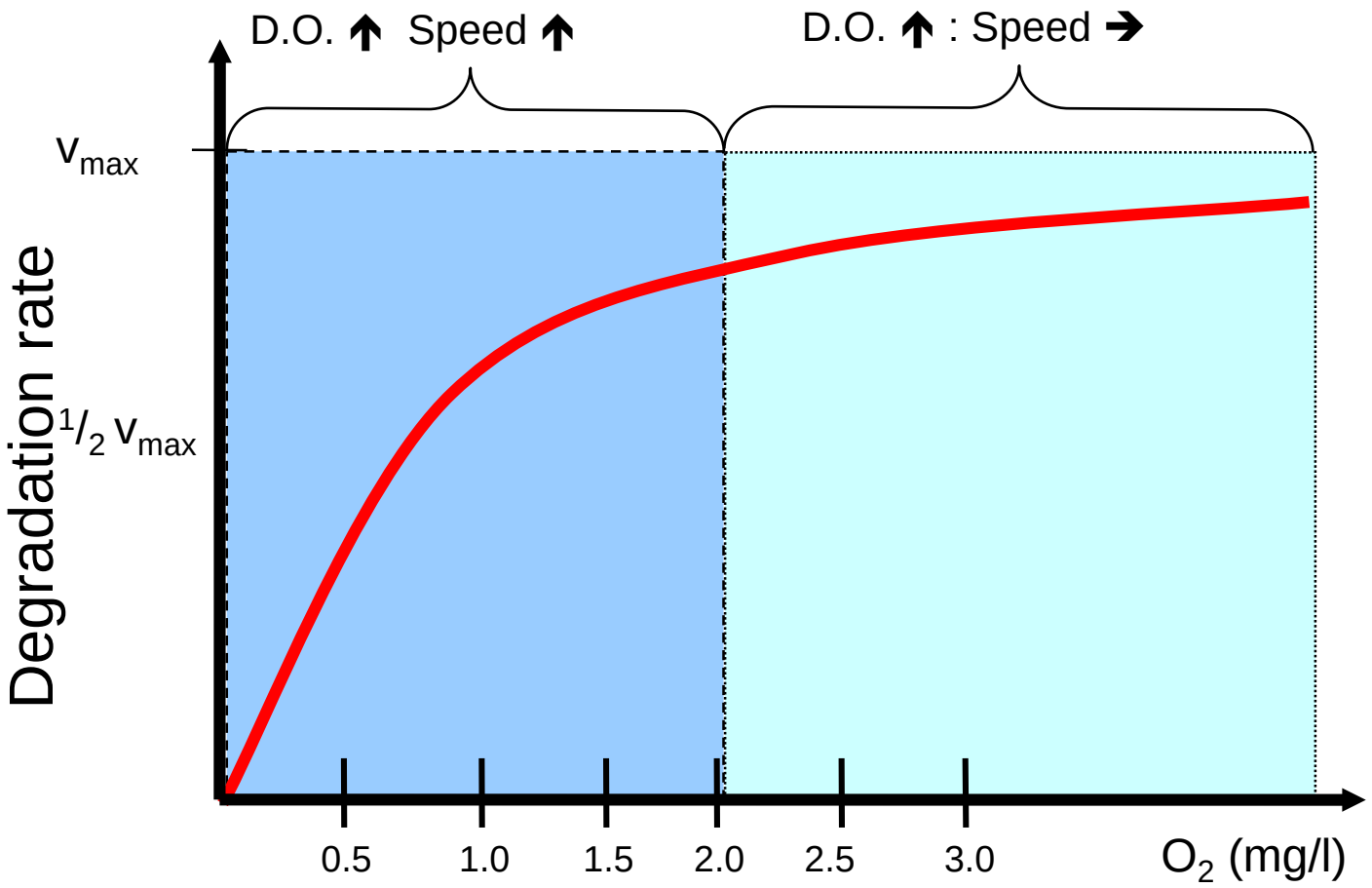
Aeration Control – Dissolved Oxygen

Dissolved Oxygen (DO)



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An Optical Process DO Sensor

- Calibration: Automatic transfer of factory calibration
- Cleaning: Wipe off biomass/slime
- Replace sensor cap every 2 to 3 years.

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DO sensors verification

Check saturation in air saturated water

- By definition PO_2 water = PO_2 air
- True BP = [Corrected BP] – [2.5 * (Local Altitude in ft above sea level/100)]
  - Today's True BP = 735 mm Hg
  - 735 / 760 = 97%
- Today's air temperature = 20 °C
- Saturation for 0 Salinity = 9.092 mg DO / L
- 9.092 * 0.97 = 8.82 mg DO / L
- Verify 0 mg DO / L in sodium sulfite*
- Relative slope should 90% to 110%

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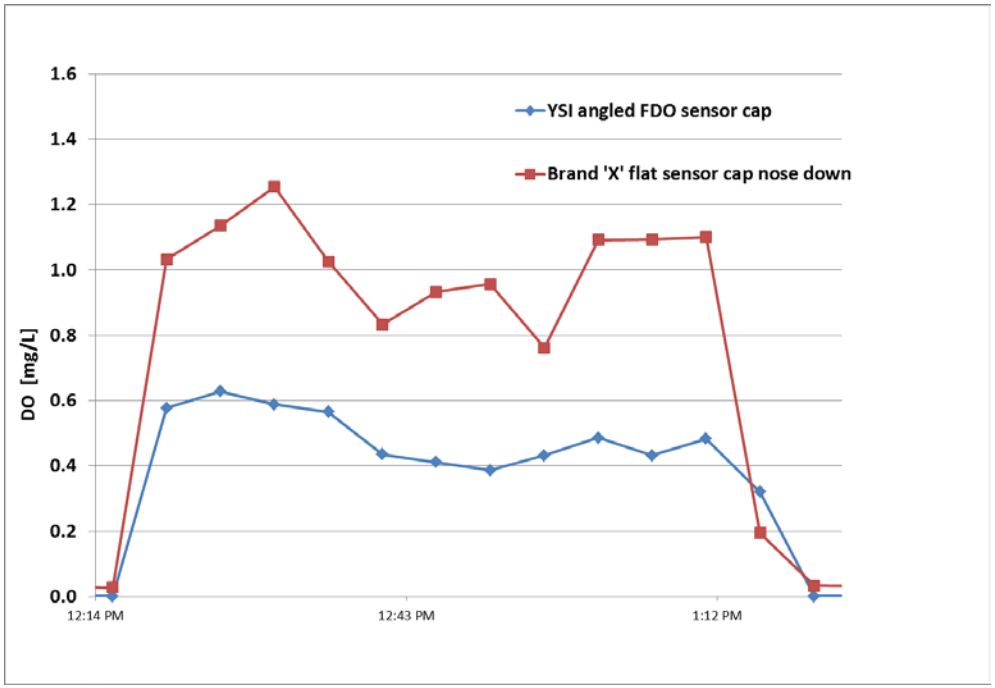
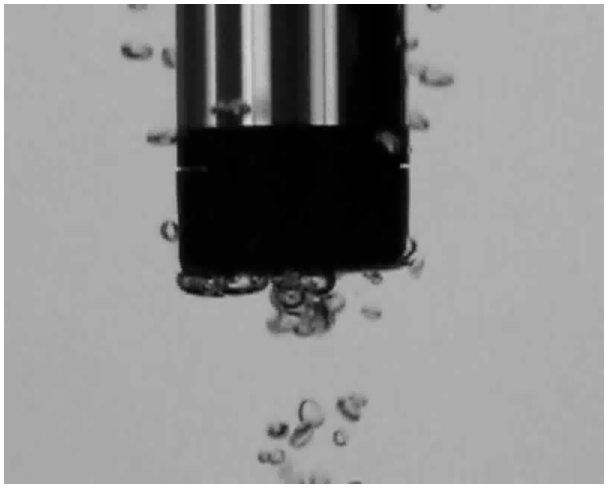
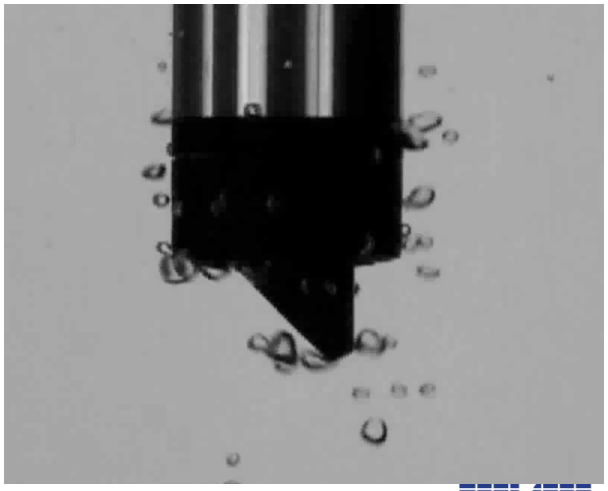
Interferences

Air bubbles effect on accuracy/stability







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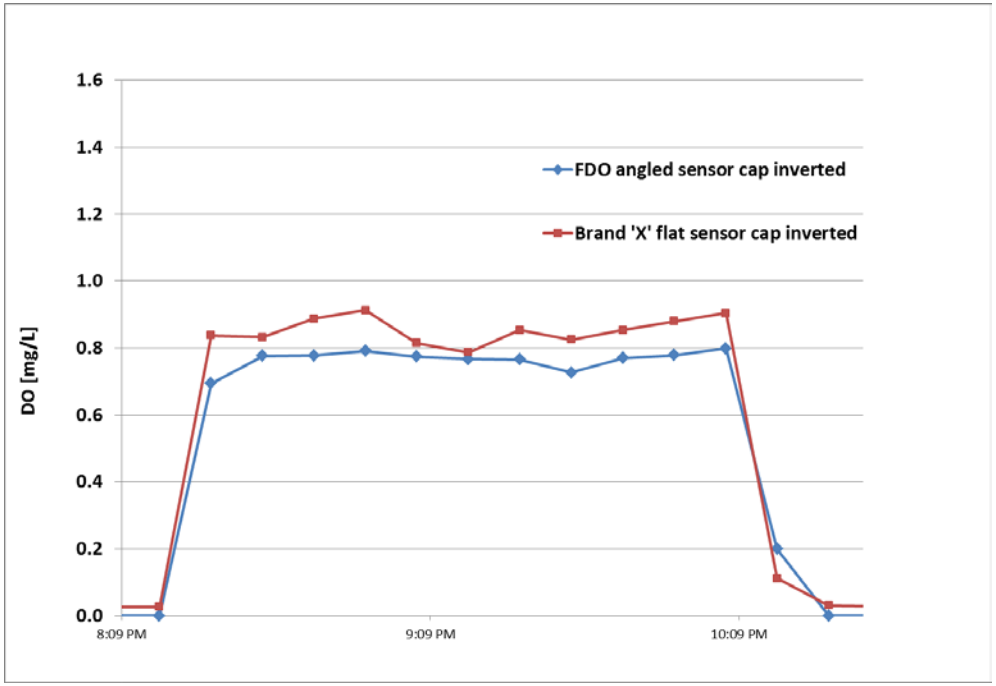

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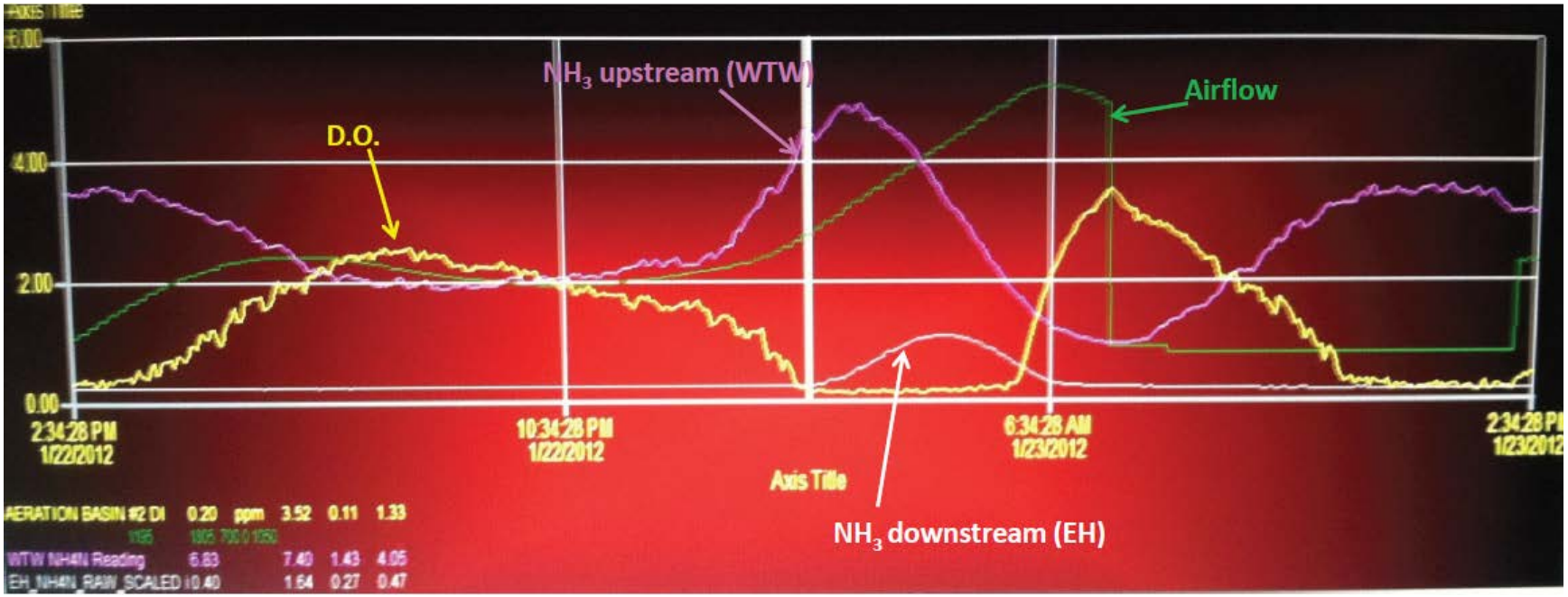
Aeration Control – Ammonium & Nitrate

What is Not Measured Can Hurt You



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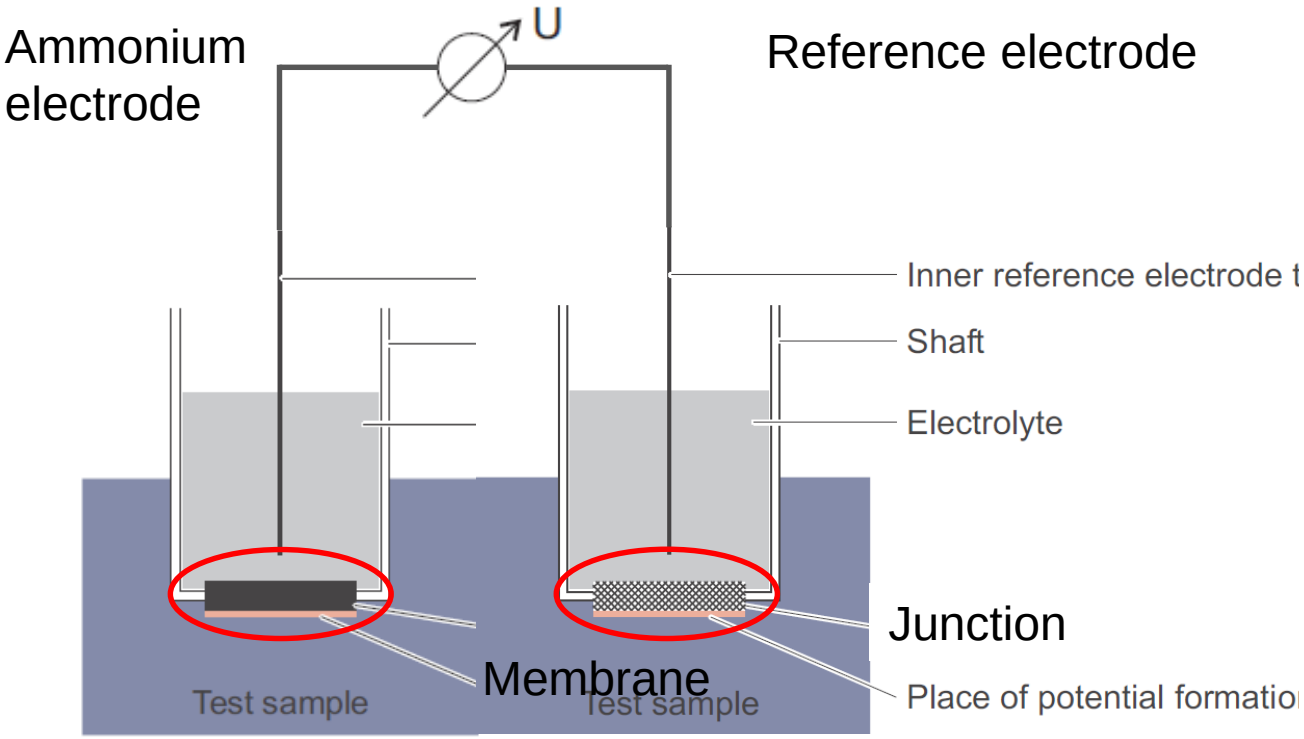
Ion selective electrode (ISE)

A system for measuring ammonium (NH_4^+), nitrate (NO_3^-)



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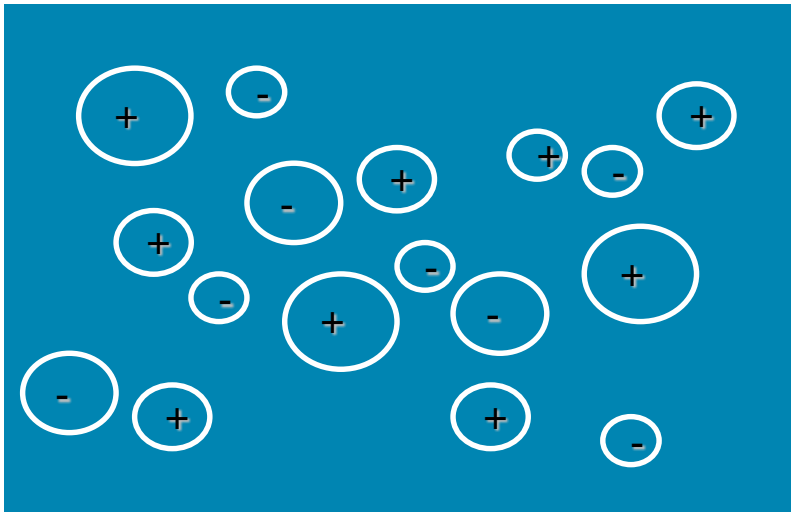
Process ISEs Cannot Be Calibrated in the Lab with Standard Solutions

ISEs Measure Activity, not Concentration



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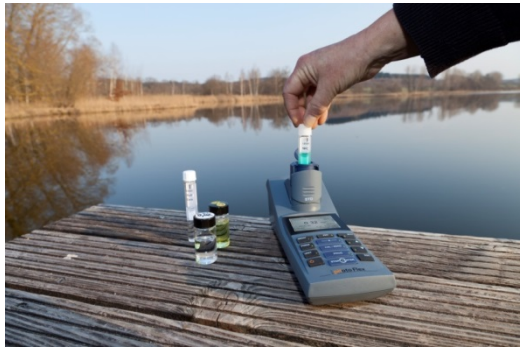
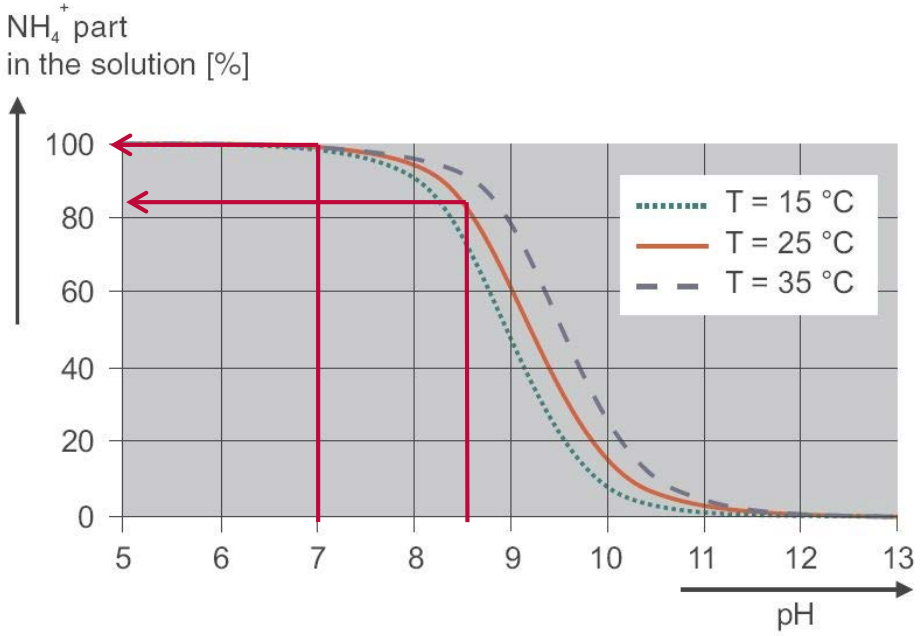
Verification of Ammonium ISEs - Matrix Adjustment



Ammonium ISEs Do Not Detect Free *Ammonia*

$NH_4^+ \Leftrightarrow NH_3 + H^+$



- pH = 7;
  - NH_4= 100%
  - NH_3 = 0
- pH = 8.5;
  - NH_4 = 85%
  - NH_3 = 15%
- Lab ISEs and colorimeters methods measure NH_3 + NH_4^+

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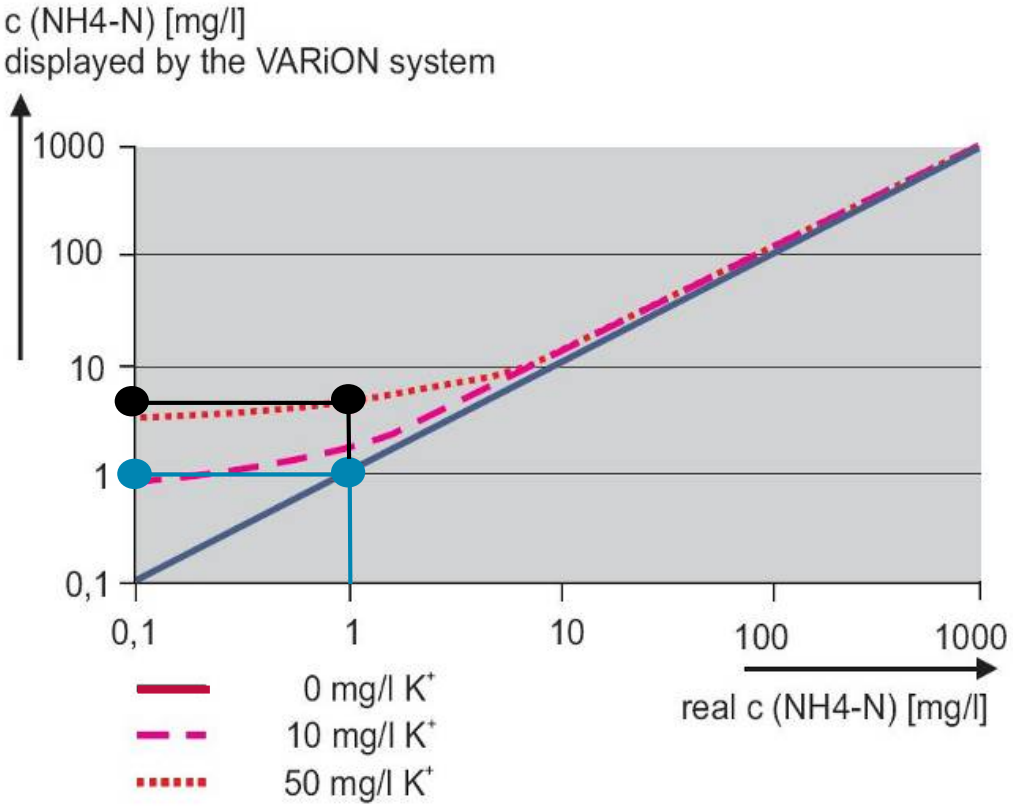
Ammonium ISE Membranes

Potassium is a positive interference



- For 1 mg/l real NH4-N:

Potassium contents	Ammonium value increased by approx.
10 mg/l	0.7 mg/l
50 mg/l	3.4 mg/l

- Most wastewaters have 15 to 20 mg/L potassium
- More variation likely in EBPR systems

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Expressing nitrogen compounds as ‘N’

Comparing Apples to Apples?

Element / Compound	Atomic / Molecular Weight	Weight of ‘N’
Hydrogen, H	1	0
Oxygen, O	16	0
Nitrogen, N	14	14
Ammonia, NH_3	17	14
Ammonium, NH_4	18	14
Nitrate, NO_3	62	14

$$NH_4 - N = NH_4 \div 1.28$$

$$NO_3 - N = NO_3 \div 4.4$$

Chemical Dosing Control – Ortho-Phosphate

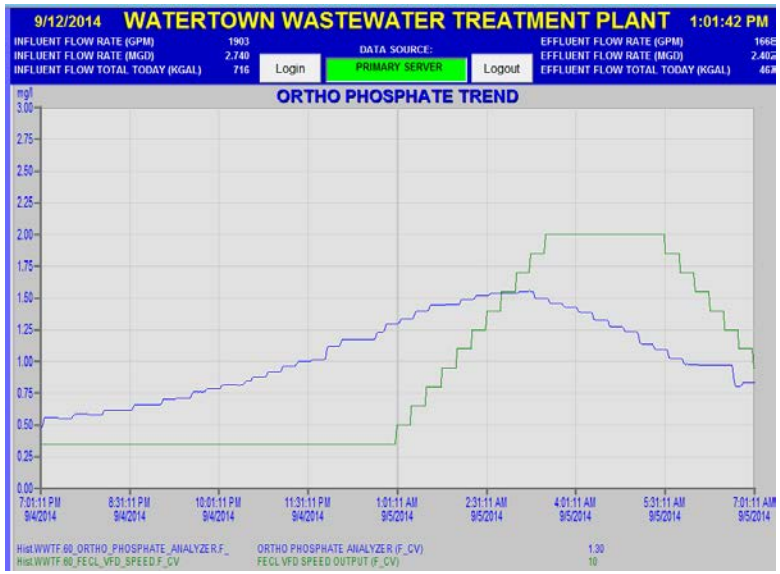
What's in a Name?

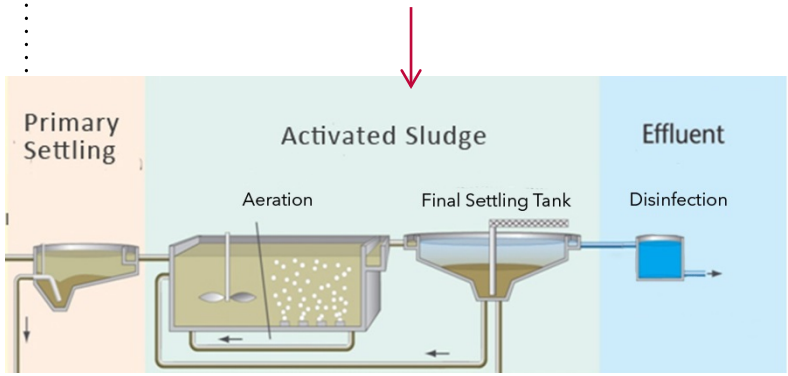
P, TP, Ortho-P

- 'P' = phosphorus (in general)
- TP = total phosphorus = particulate + dissolved phosphorus (compliance)
- Ortho-phosphate = dissolved phosphorus = PO_4^{3-} (process control)

How to Convert Ortho-P to Particulate P

Ferric Chloride Addition





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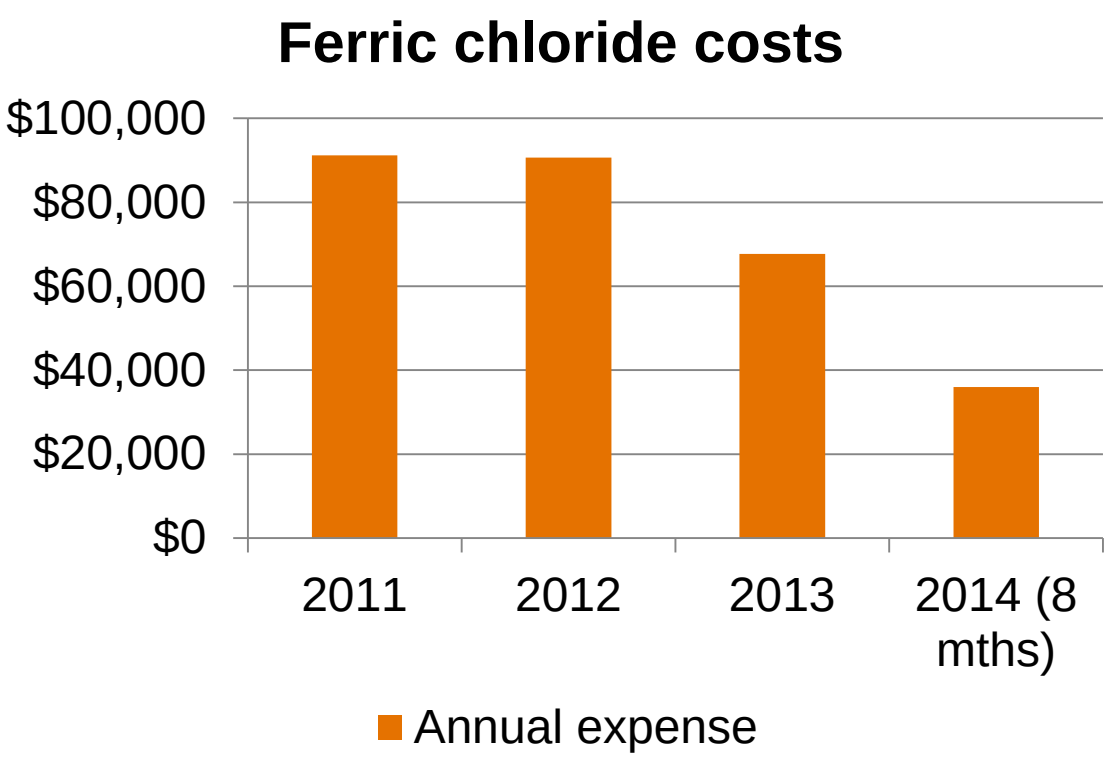
Fast Payback

Analyzer installed in 2012



- 3.0 mgd
- Limit = 1.0 mg TP /L
- Paid for itself in 1 year
- Decreased sludge production

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Ortho-phosphate Cabinet Analyzers

Wet Chemistry

- Cleaning & Calibration are automated
- Replacement: Filter, tubing, reagents

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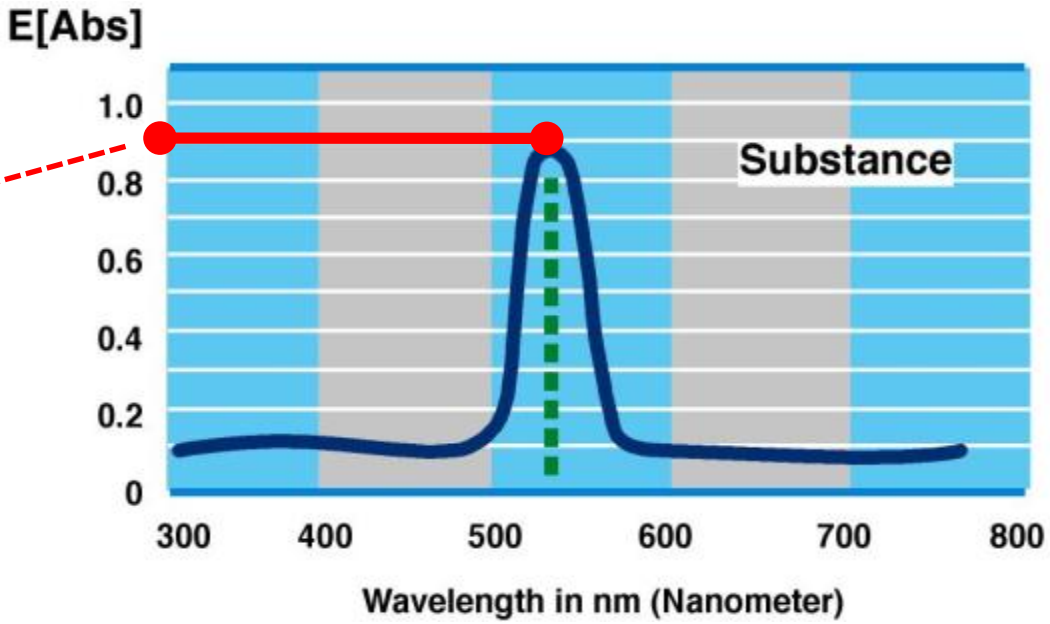
How it works



Absorbance is translated into "direct" (mg/L) reading

In this example, 0.9 Abs units converts to 7.13—which shows up on the instrument display

Transmission [%]	T[%]	0 10 20 30 40 50 60 70 80 90 100
Extinction [Abs]	E[Abs]	∞ 1.00 0.50 0.30 0.15 0.05 0.00

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Expressing Phosphate as as ‘P’

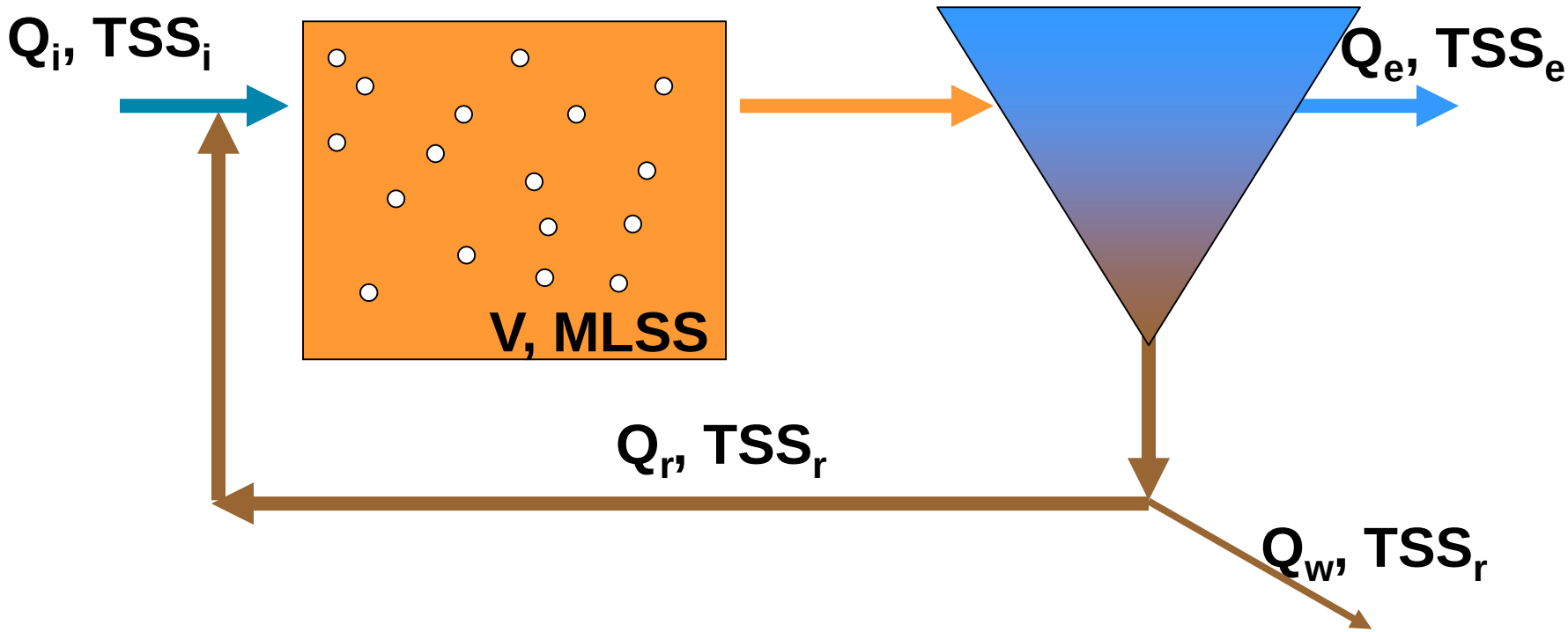
Comparing Apples to Apples?

Element / Compound	Atomic / Molecular Weight	Weight of ‘P’
Phosphorus, P	31	0
Oxygen, O	16	0
Phosphate, PO_4	95	31

$$PO_4 - P = PO_4 \div 3.1$$

Sludge Wasting Control -Total Suspended Solids

Sludge Age, MCRT, SRT, CRT

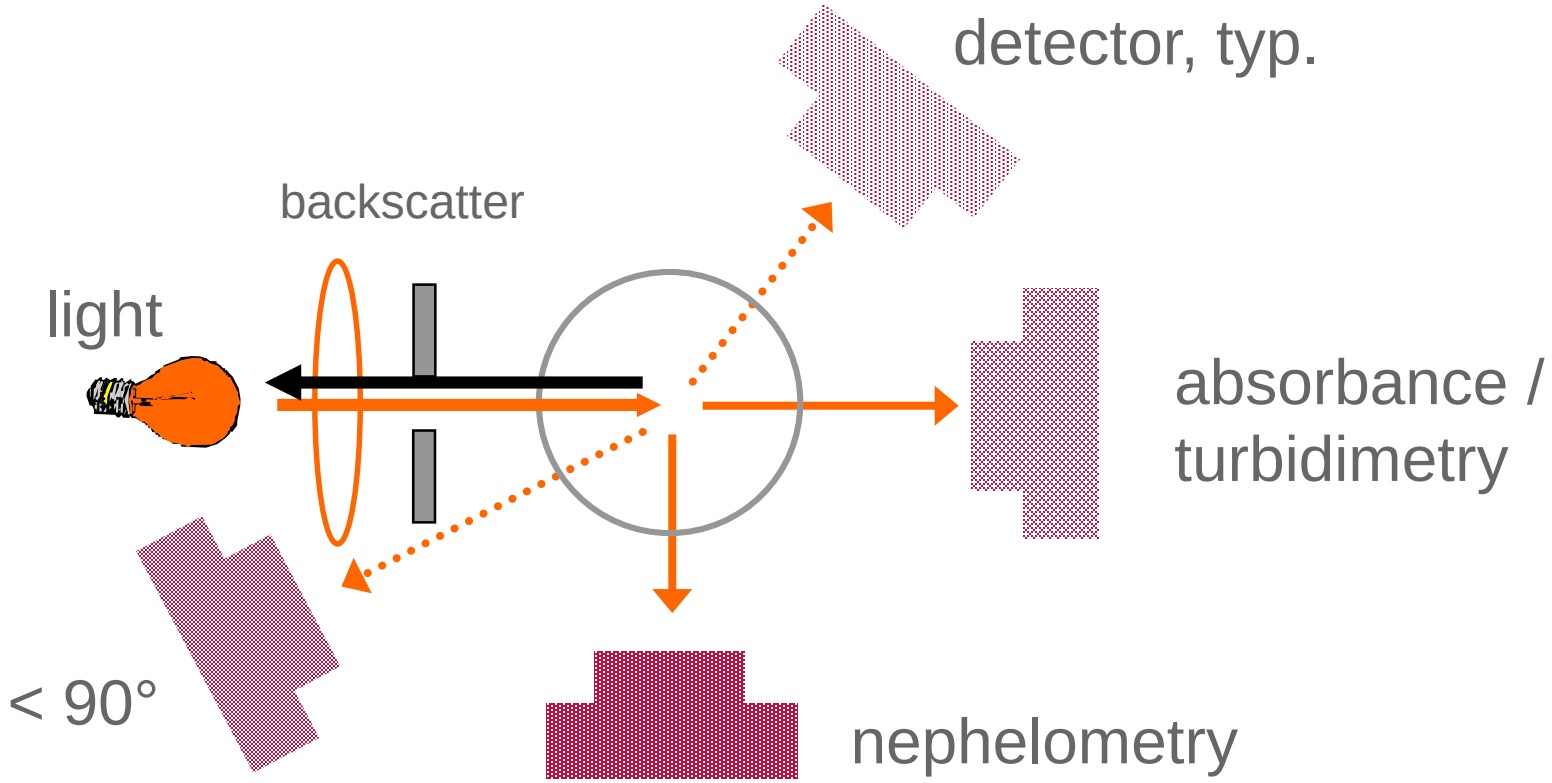


Biomass in the system ÷ **Solids entering / leaving the system**

Note: F:M is related to these parameters through constants for growth and decay

How a Process TSS Sensor Works

Measurement of scattered light



Process TSS sensor verification

Requires skill, art

- Take a sample
- Filter the sample (weight filter first)
- Dry the sample and filter
- Weight filter + sample
- Subtract filter weight

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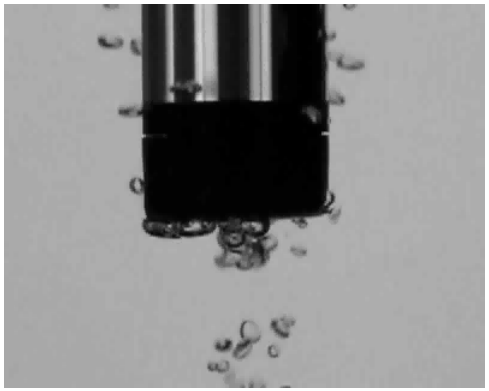
Commissioning & Cleaning



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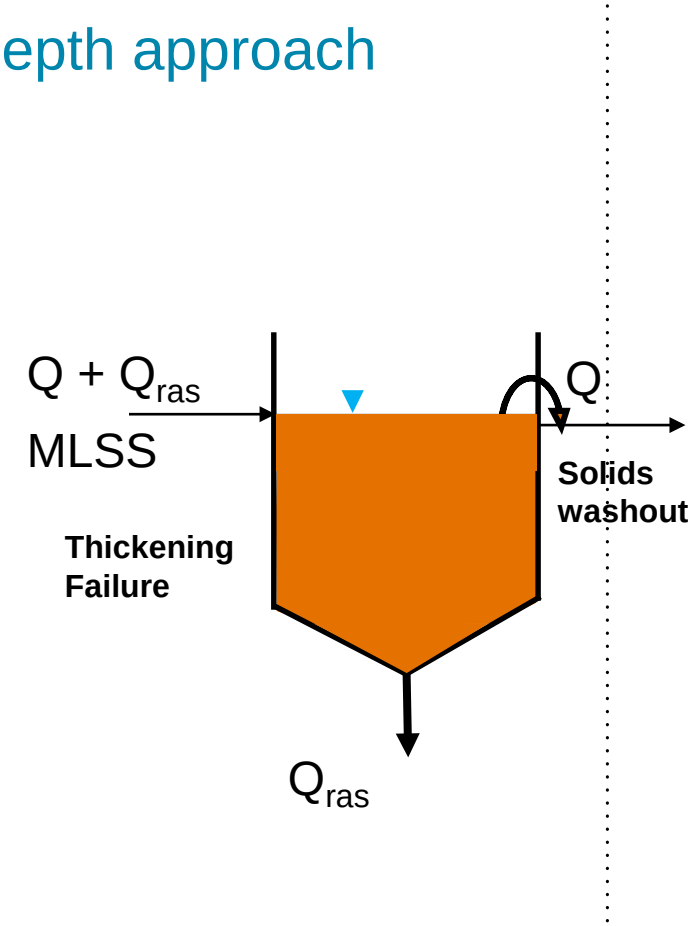
Sludge Recirculation Control – Sludge Blanket Depth

RAS flow rate control

Sludge blanket depth approach



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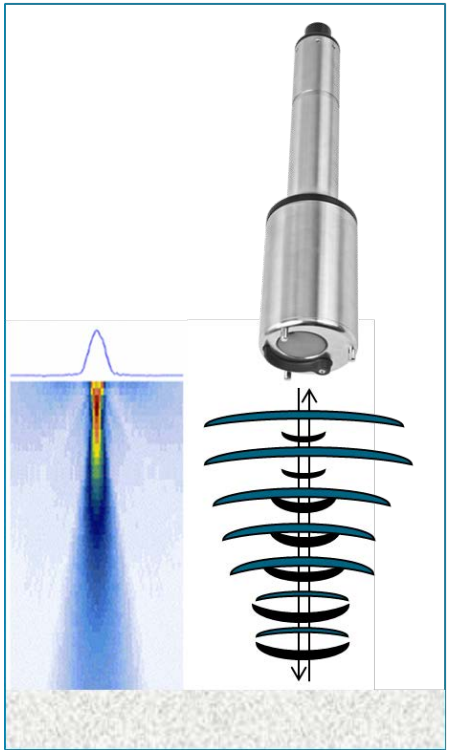
Sludge Blanket Depth Measurement – Acoustic Technology

There is more to it than meets the eyes



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Sludge Judge is an Optical Method

2-inch

1-inch

Sludge Judge Orientation

Summary

What is the history of your sample?