Process Control
for
Small Wastewater Treatment Plants

Know How Well Your Treatment Plant Is Running Before You Sample for Your Permit

Presented By
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Introduction

My name is Jon van Dommelen and I work in the Ohio Environmental Protection Agency in a small group called The Compliance Assistance Unit

Introduction

The Compliance Assistance Unit goes to Wastewater Treatment Plants and Helps Operators return to NPDES Compliance.

We work with the operators by collecting process control data in their system and based on that data, we diagnose why they are out of compliance.

…And we continue to work with the operators to solve noncompliance.

Video 1

Insert video 1 here from 1:25 to 4:29

The Tools

The Tools we use are for the concepts of wastewater

Conversion Tools

1. **Wastewater Centrifuge**
2. **Ammonia Test Kit**
3. **Alkalinity Test Kit**
4. **Dissolved Oxygen Probe**

The Tools

Separation Tools

5. **Settleometer**
6. **Core Sampler**
7. **Wastewater Centrifuge**

The Tools

The tools are:

Cheap (because small systems do not have much money)

Easy (because if it’s hard to do, no one will do it)

Effective (because if it’s not effective, why bother?)

The Tools

The big secret is that these tools are not just for small systems…

…We use them at every WWTP….

BECAUSE THEY WORK!

They provide data so good decisions can be made

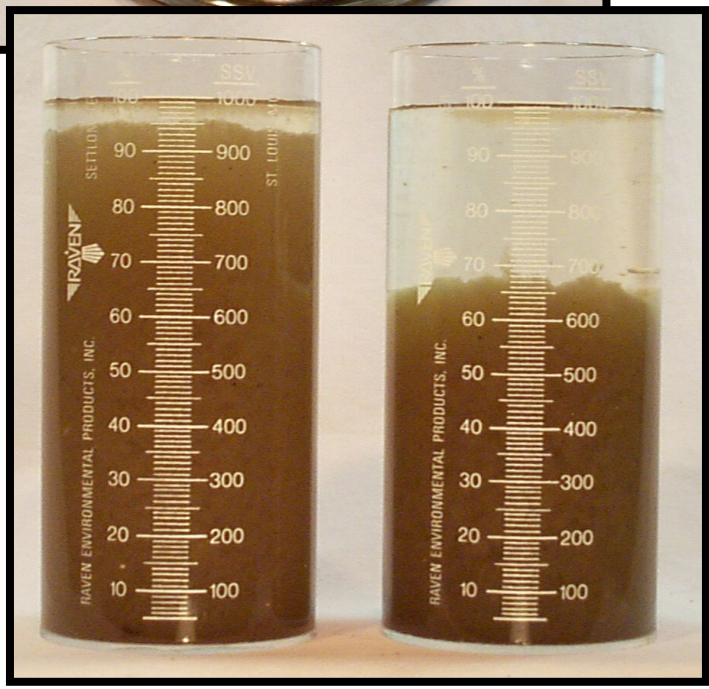

HACH
DR 900
385 N Ammonia Salic.
0.59
mg/L
NH3-N
Options
Zero


HACH


TWC #4


API
AMMONIA
NH3/NH4+
TEST KIT
FRESH WATER / SALT WATER
EAU DOUCE / EAU DE MER
Monitor ammonia to help prevent fish loss
Surveillez le taux d'ammoniaque pour éviter la perte de poissons


Pro DO
746.3
10.19
YSI


RAVEN
RAVEN ENVIRONMENTAL PRODUCTS, INC.
SETTLOMETER
ST. LOUIS

The Walk Through

Now we will walk through the WWTP (Video #2)

I will explain the process units and what they do

I will explain what *might* go wrong

We will see the Equalization Basin, the Aeration Tank, the Clarifier, and the Sand Filter

Video 2

Second video clips:

EQ Basin (form 1:05 to 2:49)

Aeration Tank (from 2:50 to 5:00)

Clarifier (from 5:02 to 7:39)

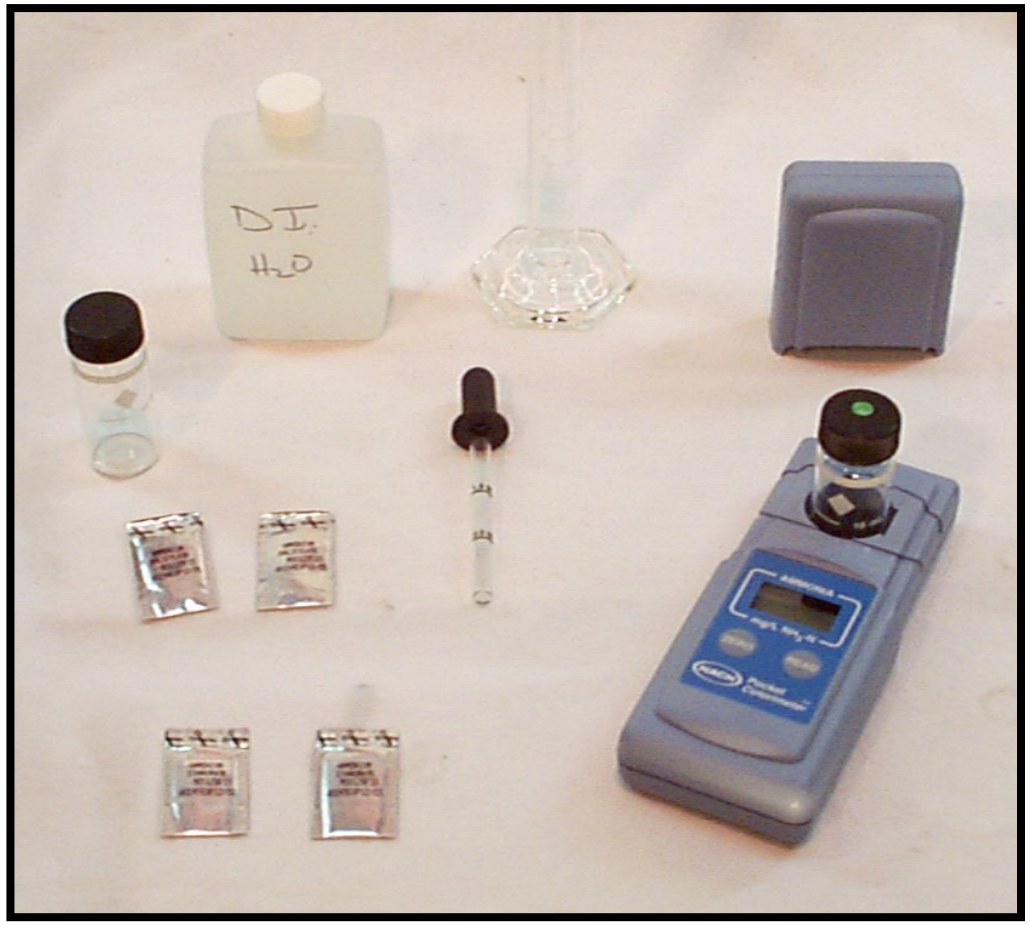
Sand Filter (from 8:00 to 9:48)

Questions?

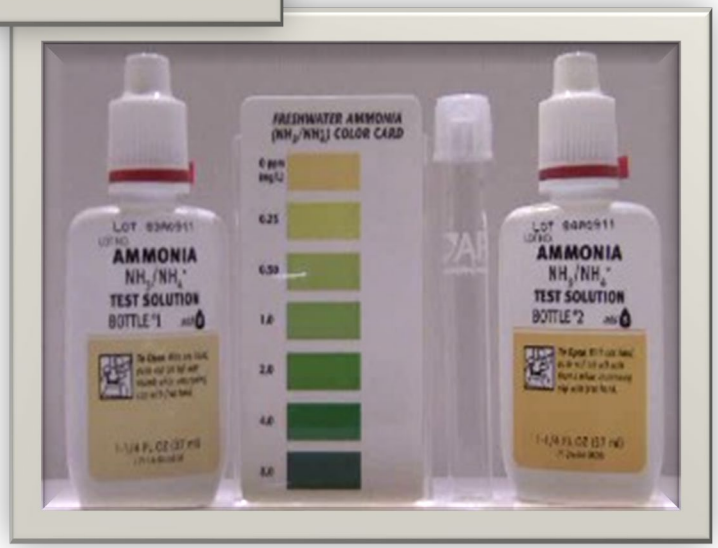
The Tools Close Up

For this next Segment, I will just talk through the process, mainly because of the wind noise in Video #3.

Ammonia Test Kit



Ammonia Test Kit



Ammonia Test Kit

Check Ammonia because:

A CBOD5 is at least 5 days too late to do anything

It is rare to have high CBOD5 and low ammonia in a WWTP

Ammonia Test takes 18 minutes to get a concentration and it can be done almost anywhere!

The Centrifuge

The Tools Close Up

The Centrifuge

One of the most used tools in my truck:

I can get the amount of mass in any tank

I can use the clear water on top to run chemical analysis

I can use it to determine how much to waste

I can use it to set the Return Activated Sludge rate

Alkalinity Test Kit

Alkalinity Test Kit

Alkalinity is important for nitrification:

Nitrifying bacteria use 7.14 mg/L of alkalinity to convert 1 mg/L of ammonia into 1 mg/L nitrate

When alkalinity gets low, nitrification will STOP

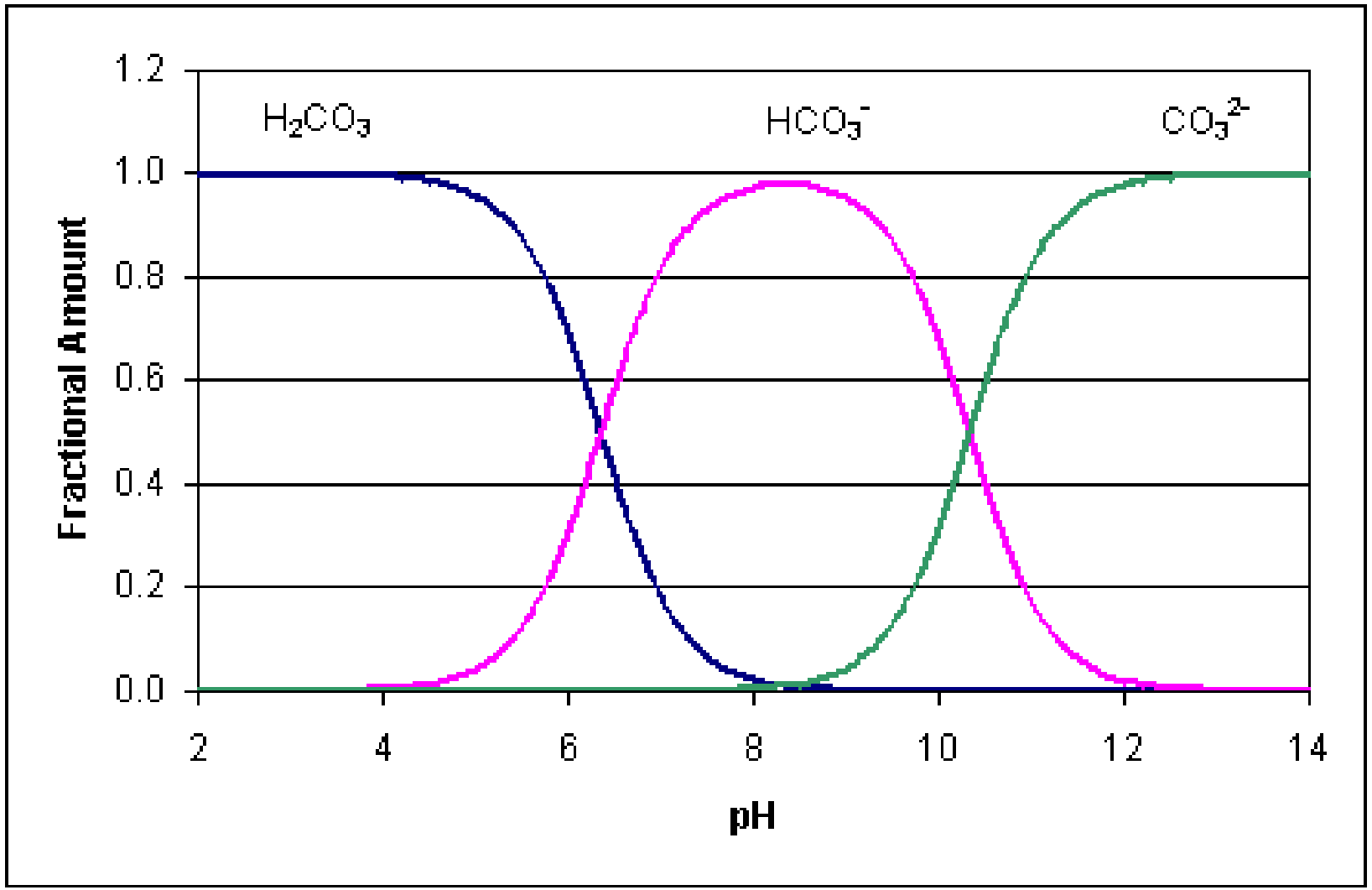
Alkalinity Test Kit

The CAU recommends that when the ammonia is less than 1 mg/L,

Then the alkalinity should be around 80 – 100 mg/L

Why?

Alkalinity Test Kit



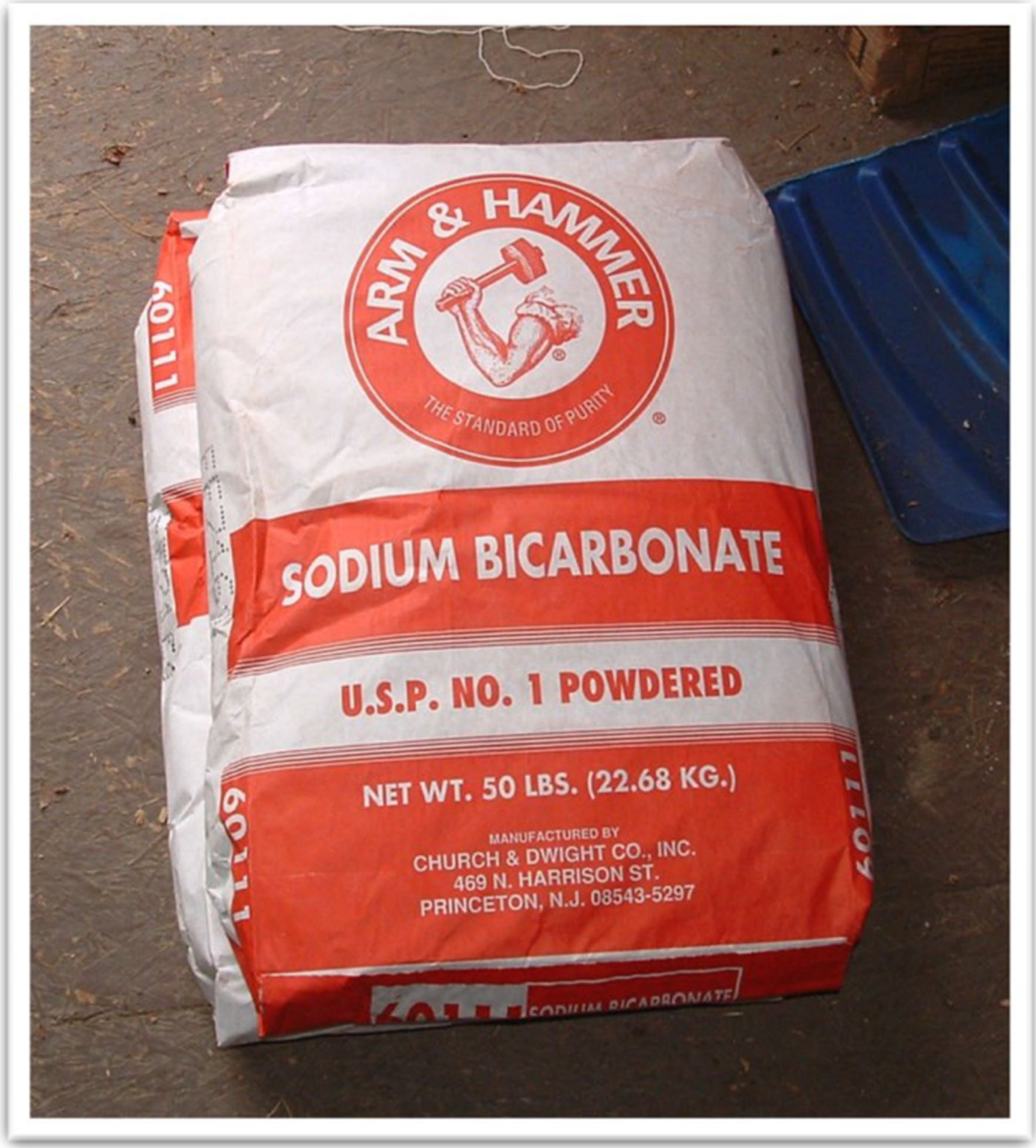
Alkalinity Test Kit

If you are Alkalinity limited,

Add Sodium Bicarbonate

This is what the Nitrifying Bacteria use as a carbon source

When the alkalinity is low, Nitrification Stops



Dissolved Oxygen Meter

The DO probe will reveal what you can't see

The DO probe shows the bulk DO but not what the aerobic bacteria is using

If the pump station just pumped influent into the tank, the DO will likely be low, because the bacteria will use it as fast as it is provided. The DO will rise again once the food has been consumed by the bacteria

Dissolved Oxygen Probe and Meter

Dissolved Oxygen is important for nitrification

The nitrification bacteria need enough oxygen to convert the influent ammonia into nitrate

If the aeration is oxygen limited most of the time, the ammonia will be high

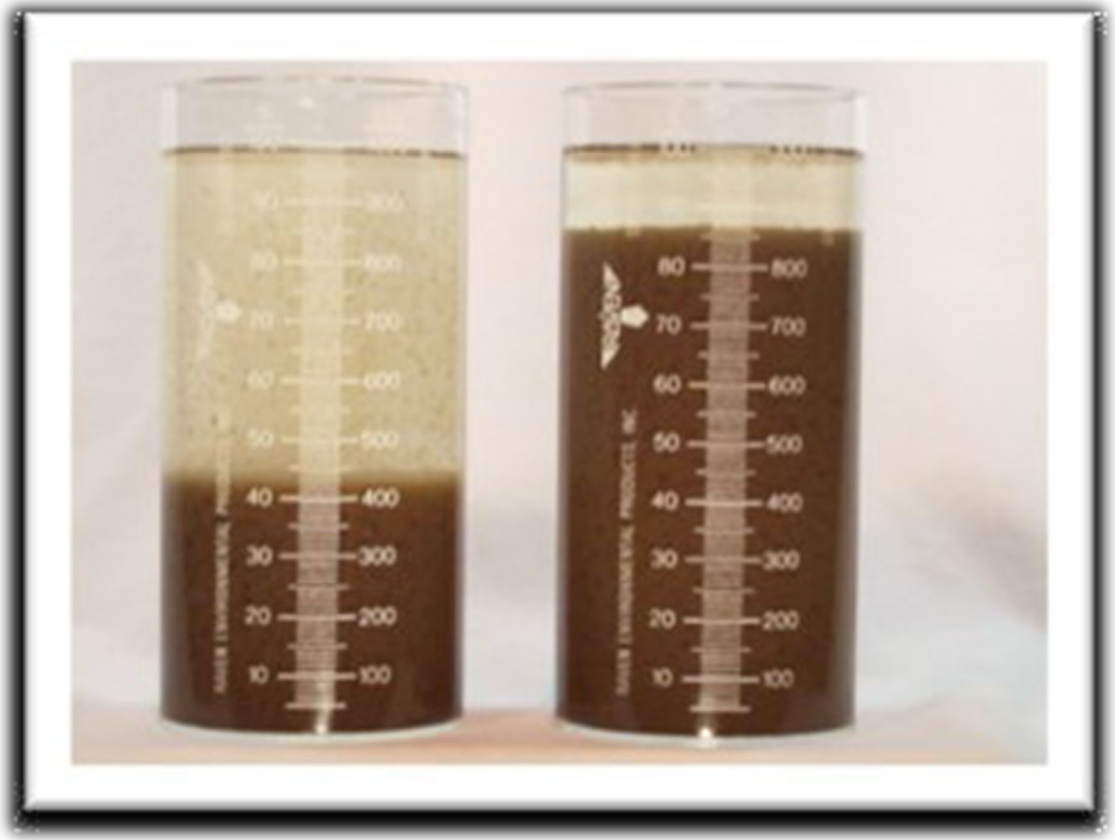
Settleometer

The Settleometer is the perfect “Clarifier”

There is nothing going into it, being pumped off the bottom, of going over a weir

It shows the actual settling of the biology that was grown in the aeration tank

Settleometer



The Settleometer on the LEFT in each photo - the mixed liquor is diluted 50% with clarifier effluent
The Settleometer on the RIGHT in each photo is 100% mixed liquor

Settleometer

If the settleometer does not settle to at least 800 in 5 minutes or 400 in 30 minutes, there are 2 reasons for this:

1. Too much mass to settle. Solution: Waste Sludge

2. Too much filaments. Solution: Figure out which filament is dominant and select and environment that will reduce it.

   (but you will need a phase contrast microscope and guidebook)

Settleometer

Settleometer and Core Sampler

Core Sampler

This clarifier is full of solids. Nothing good happens when a clarifier is full of solids. Usually there is a Total Suspended Solids violation.

It might be filamentous, or it might just have too much mass and it needs to be wasted.

Core Sampler

The Core sampler will tell you how much mixed liquor is in:

1. **Your clarifier**

2. **Your chlorine contact tank**

3. **Anywhere else where the solids will settle out**

Core Sampler

Do a settleometer to see which is the cause

Do a 100% mixed liquor and a 50% mixed liquor and 50% clarifier water

If the diluted settles better than undiluted, then waste sludge

If the diluted does not settle better than the undiluted,

then you grew filaments, and you need to figure which filament

Wasting Sludge

The wastewater centrifuge is a great tool to determine how much to waste.

The settleometer needs to be less than 400 in 30 minutes, and

The ammonia needs to be less than 1 mg/L

This is good quality biology

To determine the mixed liquor you need to waste:

Wasting Sludge

To waste sludge:

1. **Get the spin from the end of aeration and from the clarifiers**
2. **Total them up**
3. **Spin the RAS (if more than one, average them)**
4. **Plug them into this formula:**

Solids Inventory

AT #1: 0.020 MG x 3.2 Spin = 0.064 Sludge Units (a)

AT #2: _____ MG x _____ Spin = _____ Sludge Units (b)

AT #3: _____ MG x _____ Spin = _____ Sludge Units (c)

Clarifier #1: 0.008 MG x 1.2 Spin = 0.0096 Sludge Units (d)

Clarifier #2: _____ MG x _____ Spin = _____ Sludge Units (e)

Total Sludge Units (g) = a+b+c+d+e 0.0736 TSU (f)

Wasting Rate

RAS #1 Spin : 6.2

RAS #2 Spin : 4.2

RAS Spin (avg) : 5.2 (g)

Desired MCRT : 10 (h) (free choice)

WAS Rate: $\frac{\text{Total Sludge Units (f)}}{\text{MCRT (h)}} = \frac{0.0736 \text{ TSU}}{10} = 0.0073$ Sludge Units to Remove

$\frac{\text{S.U. Removed/Day (i)}}{\text{Avg RAS Spin (g)}} = \frac{0.00736}{5.2} = 0.00014$ Sludge to Waste

Digester Surface Area: $\frac{6 \text{ ft} \times \text{ft wide} \times 13 \text{ ft} \times \text{ft long} \times 1 \text{ ft} \times 7.48 \text{ gal/ft}^3}{1 \text{ MG}} = 0.000583$ MG gal/ft

Feet To Waste = $\frac{0.00014 \text{ MG Sludge to Waste (k)}}{0.000583 \text{ MG/ft digester (l)}} = 0.24$ feet to Waste

Return Rate

The Process:

Do a centrifuge sample of the contents of the settleometer.

Note the centrifuge reading

Do a settleometer and note the settleability every 5 minutes.

Note the 5 minute settleometer readings

Calculate the settled sludge concentration in every 5 minute reading

$$\text{Concentration} = \frac{1000 \times \text{Centrifuge Spin}}{\text{settled sludge number}}$$

Return Rate

For example:

The centrifuge spin = 3.2

The settleometer reading are:

5 minute	780 settled	4.1 calculate spin of settled sludge
10 minutes	640 settled	5.0 calculate spin of settled sludge
15 minutes	510 settled	6.2 calculate spin of settled sludge
20 minutes	420 settled	7.6 calculate spin of settled sludge
25 minutes	390 settled	8.2 calculate spin of settled sludge
30 minutes	380 settled	8.4 calculate spin of settled sludge

Return Rate

Once you have all the data, you plot the data and look for the
“Knee of the Curve”

The Knee of the Curve is where it begins to flatten out.

Once that is determined, move up one 5-minute position
That is the spin that you shoot for in the RAS
Grab a sample from the RAS pipe and spin it to see how far you need to go

Troubleshooting Noncompliance

Troubleshooting is what I do in Ohio

Operators who are in noncompliance call me to help them out

I have been doing this for 22 years and I have become pretty good at it

So lets go…

Troubleshooting Noncompliance

The EQ basin:

To sample the EQ basin, just collect a sample from the splitter box or just dip it out the basin if it is not too deep.

Sample it for ammonia and if there is a nitrate limit or orthophosphate limit, perform test on those parameters as well.

Troubleshooting Noncompliance

What can go wrong in an EQ basin?

Pumps might not be working properly

Floats might not be working properly

Floats lines might be tangled up on each other

But most of all, the operator needs to know what is coming into the WWTP

Troubleshooting Noncompliance

The Aeration Tank

Sampling the Aeration Tank is essential Process Control

Best to sample at the end the tank prior to the MLSS going to the clarifier

If you are using a DR900 for an ammonia test, you may have to dilute the sample to get a reading. If you are using the fish kit, it is a pass/fail test.

If the concentration is less than about 2 mg/L, then it is probably ok.

If it is higher, then a dilution is in order.

Troubleshooting Noncompliance

Alkalinity is essential to Nitrification

To Measure Alkalinity, fill the cuvette to the top with centrifuged mixed liquor (the clear stuff on top)

Pour it into the bottle that is provided, and put the indicator powder into the bottle

Drop the sulfuric acid into the bottle and count the drops.

Each drop is 20 mg/L of alkalinity until the contents changes from blue to pink. When it is pink, the test is over

Troubleshooting Noncompliance

If the drop count is less than 4 (i.e., 80 mg/L alkalinity) there is a probability that the pH is close to 5 SU.

5 SU is too low of a pH for the nitrifying bacteria to convert the ammonia to nitrate. They do not work well at the pH

If the system is small, add sodium bicarbonate to the aeration tank. Add a couple of coffee cans full and check alkalinity to see if is above 6.5 SU or more.

Troubleshooting Noncompliance

Sampling the Clarifier

Sampling the clarifier is pretty easy. The water is usually clear, and it is easy to sample. And it is after the aeration tank where the conversion takes place.

Depending on the solids in the bottom of the clarifier, there may a heavy sludge blanket or possibly no blanket at all.

Troubleshooting Noncompliance

If there is a deep heavy blanket, check the aeration tank spin to see if it should be wasted

If there is no blanket, check the aeration tank spin to see if the aeration tank has low Mixed Liquor Suspended Solids.

If there is a diffuse blanket, then the MLSS is probably filamentous, and the filament will need to be identified to see what the solution is

<insert Clarifier Video here>

Troubleshooting Noncompliance

The clarifier had a deep and heavy first hopper, but it also had about a foot of solids in the second hopper. This is unusual for a system.

This means that the first hopper probably has a very high peak in the middle of the 2 hoppers.

This setup keeps the solids out of the sand filter, but it might cause the RAS of the first hopper to go septic at the bottom of the blanket.

Troubleshooting Noncompliance

Sand filters

Sand filters catch the solids that leaves the clarifier.
This is the final defense against noncompliance.

When the sand filter fills with solids, they need to be cleaned out.

This is big job for slow sand filters, but it is easy for a fast sand filter.

Troubleshooting Noncompliance

Sand filters

The fast sand filter in this WWTP is somewhat unusual for a package plant

The fast sand filter here is self cleaning.

The sand filter effluent was very clear probably due to the high peak in the middle of the clarifier

Troubleshooting Noncompliance

Sand filters will bind up when they have a lot of solids sealing them off

When sand filters bind, then water does not flow through them very well and it must percolate through sometimes septic sludge on the way to the chlorine contact chamber or the UV system

The sand filters must be cleaned out. This is a tough job.

Troubleshooting Noncompliance

Troubleshooting Noncompliance

Disinfection

Disinfection processes will kill any pathogens that may be in the wastewater prior to discharge in the receiving stream

Disinfection can be chlorination / dechlorination or UV

The Plant that was visited had chlorination / dechlorination

Troubleshooting Noncompliance

Process Control is Important

If you are not doing process control…

You are missing your chance to see if you are compliant

You are missing your chance to change the situation
if you are in noncompliance.

Process Control is Important

Use the *Process Control and Troubleshooting Manual and Flow Chart* (each video in this series contains a link to the manual!)

It will tell you if your WWTP is in compliance

It will tell you what to do if your WWTP is in noncompliance

Questions?

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To access the videos, click on this link:

https://www.epa.gov/enforcement/national-compliance-initiative-reducing-significant-non-compliance-snc-npdes-permits

Scroll down the page to “Technical Resources, Assistance and Training”