How to Utilize Your Lab Data to Optimize Process Control

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Why Do Lab Results Matter?

- Valuable record of plant operations
- Tell you how efficiently your plant is running
- Required by regulatory agencies
- Help troubleshoot your process
- Help determine when an expansion is necessary

For these reasons, lab tests should be performed carefully and consistently!

What Can Impact the Quality of Your Data?

- Representative Sampling
- Sample Handling
- Sample Contamination
- Equipment Contamination
- Sample Hold Time
- Biological Changes
- Chemical Changes
- Physical Changes

Know What to Expect…

What is my wastewater comprised of?

- **Domestic Only Flow**
- **Significant or Categorical Industries**
- **Inflow or Infiltration**
- **Combined Sewers**

If your influent changes significantly, you should be asking why?

Know Your Expected Load…

Flow – 75 to 130 gpd / capita

BOD – 0.18 to 0.22 ppd / capita

TSS – 0.20 to 0.25 ppd / capita

TKN – 0.029 to 0.032 ppd / capita

If your CBOD is 483 mg/l and flow is 1.5MGD = 6042 ppd BOD

Loading = 6042 ppd / 30,000 people
= 0.20 ppd / capita

PERFECT!

But What If ?

What if there are only 7,000 people in your town?

Loading = 6042 ppd / 7000 people
= 0.86 ppd / capita

Now that's a problem… Extreme example unless you have a food processing plant or dairy etc.

Laboratory Analysis and the Correlation to Process Operations

pH


0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Battery acid
HCl in stomach acid
lemon juice
vinegar
orange juice
acid rain
black coffee
urine
saliva
pure water
sea water
baking soda
ammonia solution
soapy water
bleach
oven cleaner
Drain cleaner

pH

- **pH is a numerical expression of the acidity or basicity of a sample.**
- **Acidic – 0 to 7**
- **Basic – 7 to 14**
- **Neutral – 7 is considered neutral**
- **pH is a log scale – so pH of 4 is 10 times more acidic than pH of 5 and 100 times more acidic than pH of 6.**

pH

- **3 standard calibration is ALWAYS preferred; starting with 7.**
- **Should run duplicates**
- **Check standard from another manufacturer than calibration standards.**

pH

- **Ensure slope is within equipment manufacturer standards.**
- **Oils, greases and fats can interfere with the analysis by coating the probe.**

pH as it Relates to Process Control

<u>Preliminary and Primary Treatment</u>

- pH less than 7 can cause greases to stay in suspension and pass through to other processes.
- Consistently low pH at the influent can be a sign of anaerobic conditions in the collection system due to decomposition – or an industrial user. System sampling and/or cleaning should be performed.

pH as it Relates to Process Control

Fixed Film Systems

- Applies to RBCs, trickling filters or roughing towers
- pH outside the range of 6.5 to 7 can cause reduced treatment of carbonaceous compounds; above 8.5 will prohibit nitrification.
- pH >10 or <5 can cause excessive sloughing.
- Chemical adjustment may be necessary

pH as it Relates to Process Control

Activated Sludge Processes

- Optimum growth for nitrifiers is between 7 and 8.3 and inhibition will occur at pH less than 7.
- pH consistently less than 6.5 can support filamentous growth and create bulking and MLSS settleability problems.

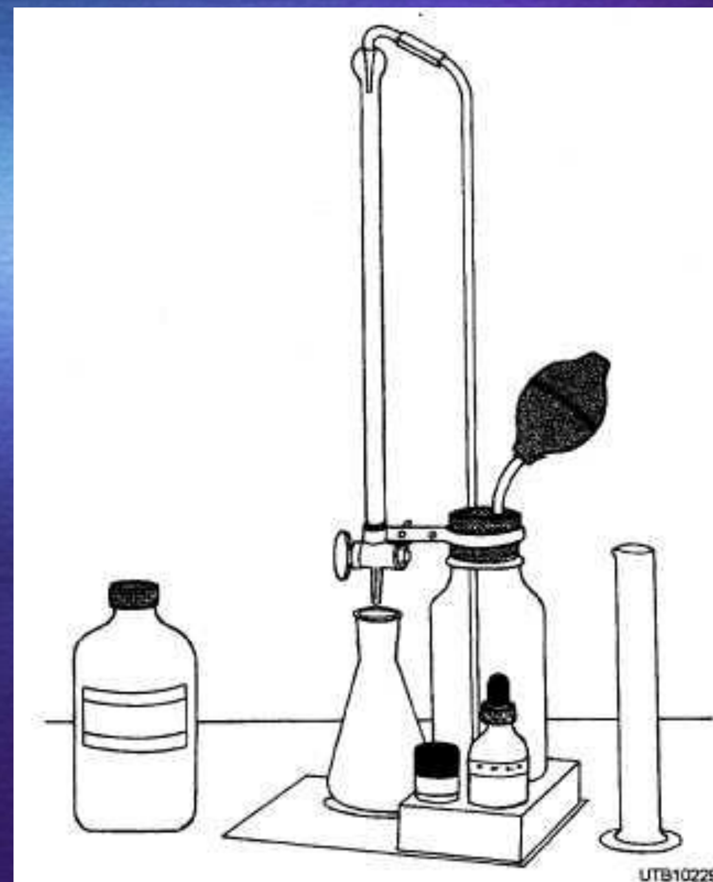
pH as it Relates to Process Control

Sludge Digestion

- Aerobic digestion is best done around pH of 7; if less than 6 – look for causes – low alkalinity, nitrification or carbon dioxide
- Anaerobic digestion is best done between 6.8 and 7.2. pH less than 6 will cause VFAs to become toxic to methane formers and above 8 will cause dissolved ammonia to become toxic to methane formers.

Don't just record your influent and effluent pH – pay attention to the numbers and ask yourself what kind of impact it could be having on your process. pH is often our first indication of a problem and also a clue as to what might be causing the problem!

Alkalinity



Alkalinity

- Alkalinity is the acid neutralizing capability of the water or how much acid can the water absorb before there is a substantial change in pH.
- Typically a color titration method so turbid or colored water can cause interferences.
- Great process control parameter!

Alkalinity

- Samples can be collected in glass or plastic.
- Technically there is a 14 day hold time; however, because biological processes occurring in the sample can change the available alkalinity, the sample should be analyzed as soon as practical or cooled to 0-6°C to slow the biological action of the sample.

Alkalinity as it Relates to Process Control

- **In wastewater alkalinity is measured and reported in terms of equivalent calcium carbonate (CaCO3).**
- **For wastewater, the measurement is total alkalinity which is measured to a pH of 4.5 SU.**
- **Alkalinity is utilized as an indicator of biological activity.**

Alkalinity as it Relates to Process Control

- In wastewater there are 3 types of oxygen that are typically available – dissolved O2, nitrate NO3 and sulfate SO4.
- Aerobic microorganisms use dissolved oxygen to convert food to energy.
- Nitrifiers use O2 to convert ammonia to nitrate

Alkalinity as it Relates to Process Control

- In an anoxic environment, bacteria use the oxygen from the nitrate and it is converted to nitrogen gas.
- And finally, in anaerobic conditions when DO and Nitrate are no longer available, microbes will use the oxygen from sulfate which is converted to hydrogen sulfide and other sulfur compounds.

Alkalinity as it Relates to Process Control

- Alkalinity is lost in an activated sludge system during nitrification.
- 7.14 mg of alkalinity is utilized for every mg of ammonium that is oxidized.
- A lack of carbonate alkalinity can effectively stop nitrification.

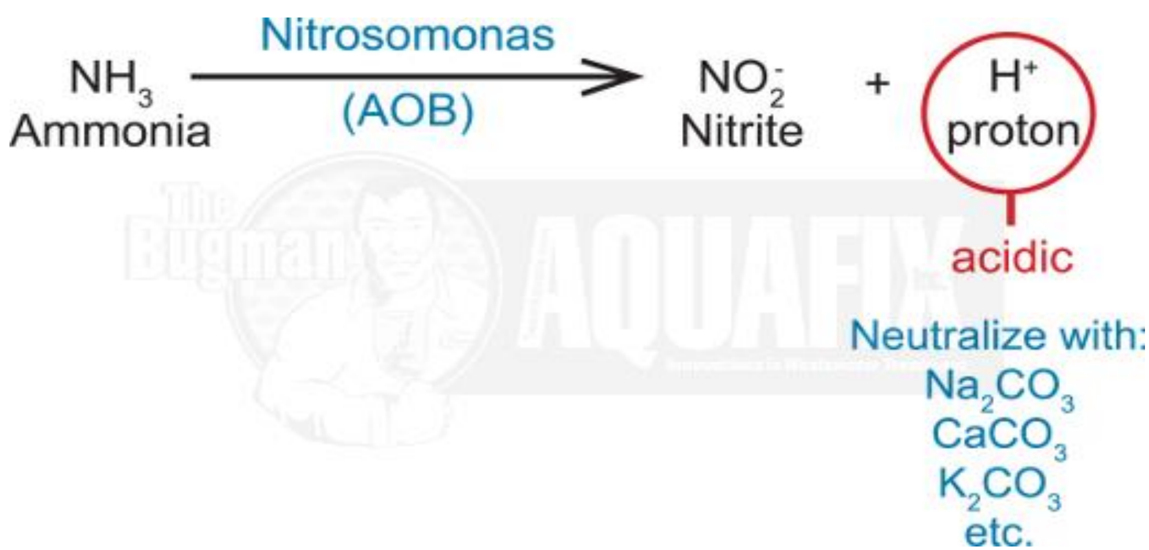
Alkalinity as it Relates to Process Control

- In addition, nitrification is pH sensitive and will decline significantly at pH values below 6.8
- Maintaining an appropriate level of alkalinity will help buffer the pH and provide inorganic carbon for the nitrifiers – A Double Benefit!

Alkalinity as it Relates to Process Control

Basically aerobic wastewaters are net acid producing. Influencing factors are:

- Biological nitrification in aeration tanks or aerobic digesters
- Acid forming stage of anaerobic digestion
- Gas chlorination for disinfection
- Chemical addition of aluminum or iron salts



Alkalinity as it Relates to Process Control

So how much alkalinity is enough?

- Alkalinity levels should be at least 8 times the concentration of influent ammonia.
- Denitrification does add back some alkalinity if your plant has that ability.
- Rule of thumb is to ensure at least 75 to 150 mg/l residual alkalinity to push nitrification to completion.

How Much Alkalinity Do I Need?

Example:

Influent ammonia – 30 mg/l

So, 30 mg/l x 7.14 mg/l alkalinity
= 214.2 mg/l alkalinity required

214.2 mg/l is the <u>minimum</u> amount of alkalinity required to fully nitrify 30 mg/l ammonia.

How Much Alkalinity Do I Need?

And if the actual influent alkalinity is 145 mg/l then,

214.2 mg/l needed – 145 mg/l actual
= 69.2 mg/l alkalinity deficiency

Supplemental alkalinity will be necessary through denitrification or chemical addition of calcium carbonate etc.

How Much Alkalinity Do I Need?

In addition, most experts recommend an alkalinity residual (effluent alkalinity to be between 75-150 mg/l.

- Assists in stabilizing the pH range in the process in the near neutral range.
- BOD removal efficiency and proper microorganism balance is best at neutral pH (7 to 7.4)
- Leads to better settleability.

Alkalinity is the Key to Steady State Operations! Maintaining a Sufficient Amount of Alkalinity can Provide for Improved Performance and Expanded Treatment Capacity!

Total Suspended Solids

Total Suspended Solids / Mixed Liquor Suspended Solids

- One of the most important test an operator / analyst can run
- Routinely utilized for:
  - Process Loading / Removal Efficiencies
  - Calculate the Mean Cell Residence Time (MCRT) and Sludge Age
  - Determine Sludge Wasting Rate
  - Calculate the Sludge Volume Index (SVI)

Total Suspended Solids

- Wastewater put through a filter that has been pre-washed and then dried and weighed
- Filter has a pore size of 2.0 micron or less; and varies in size depending on what type of funnel is being utilized
- Vacuum applied and liquid pulled through leaving residue on the filter to be dried at 104°C
- Weight of filter and residue – filter divided by sample volume in ml multiplied by 1000

Total Suspended Solids

Interferences with analysis:

- Trying to filter too large a sample volume can create a water tight mat on the filter paper
- Water trapping can occur in the mat that will not evaporate at 103-105°C resulting in a falsely high result
- Samples with visible oil and grease should be mixed in blender to disperse oil prior to analysis

Troubleshooting TSS

Standard result too low – Sample not mixed or poured properly

Standard result too high – Filter paper not dried long enough or if used previously, standard could be concentrated in bottle

Filter blank changed more than 0.5 mg/l between weighing – filter papers not pre-washed, balance not calibrated properly, loss of filter paper (stuck to drying pan)

TSS as it Relates to Process Control

- **Average Raw Wastewater 120 to 400 mg/l**
- **Primary clarification should remove between 50 and 70% of influent TSS**
- **Average MLSS is typically between 1000 and 4000 mg/l; however some systems run considerably higher (MBRs)**

TSS as it Relates to Process Control

- Also utilized in the solids loading rate calculations; refer to design criteria for your facility to check capacity
- Key use is MCRT calculations, % removal efficiencies, % loadings… these can be used in conjunction with SVI etc. to develop a key operating window for your facility.

Settleability

Settleability

- Requires 3 pieces of equipment:
  - Settleometer
  - Paddle
  - Timer
- Should be performed daily at activated sludge facilities
- Information that can be noted:
  - Settled volume at 5 minutes
  - Settled volume at 30 minutes
  - Time if and when the blanket "pops"

Settleability

- Ensure the sample is representative of the mixed liquor flowing from aeration basin into the secondary clarifier
- Always sample after basins combine (but can occasionally sample from each basin and note any significant differences)

Settleability

- **Test conditions and sampling technique can have strong influences on the test results!**
  - **Always collect in a wide-mouth container**
  - **Testing should begin within 10 minutes of collection**
  - **Sample should not be shaken or agitated during transport to testing site**

Settleability – The Procedure

- Mix the MLSS sample carefully but thoroughly
- Pour rapidly with the least amount of additional turbulence or aeration into the settleometer
- Stir the settleometer gently with paddle
- Stop all movement of the mixed liquor with the paddle and slowly remove and immediately set timer at 5 minute intervals

Settleability – The Observations

- **During the first 5 minutes watch the visual characteristics of the sludge**
  - **How do they agglomerate?**
  - **What do the particles look like?**
  - **What does the "clear" water look like?**

Then take a reading at the 5 minute mark – what is the volume occupied by the sludge?

Settleability – The Readings

- Readings should be taken every 5 minutes for the first 30 minutes
- Readings should be taken every 10 minutes for the remaining 30 minutes of the 60 minute test
- After the test is complete, allow sample to sit for several hours. Make note of when / if the sludge finally swells and floats to the surface.

Settleability as it Relates to Process Control

- The main purpose of the test is to give the operator an idea of how the sludge is settling in the secondary clarifier
- If the sludge rises or "pops" quickly (less than 90 minutes), measure depth of sludge in clarifier and sludge detention time
  - The lower the overflow rate, the higher the detention time the more opportunity for denitrification to occur

Settleability as it Relates to Process Control

Calculation of the Sludge Volume Index (SVI) **– volume of sludge in milliliters occupied by 1 gram of activated sludge after settling for 30 minutes**

SVI will help the operator evaluate the settling characteristics of the activated sludge as the conc. of the solids in the system change over time.

Sludge Volume Index (SVI)

$$SVI = \frac{SSV_{30} \times 1000\ mg/g}{MLSS \times mg/l}$$

- SVIs between 75 and 150 ml/g typically indicate a good settling sludge; however, since every plant is different the optimum or best SVI varies plant to plant.
- Set your benchmark when plant is running well!

Sludge Volume Index (SVI)

<u>80 ml/g or less</u> – usually dense and settles rapidly. Denotes old and over-oxidized sludge. Sometimes leaves pin-floc in the supernatant because of rapid settling.

Sometimes accompanied by higher than allowable TSS in the effluent.

Sludge Volume Index (SVI)

100 to 200 ml/g – Most facilities produce clear effluent in this SVI range. Slightly slower settling blanket that does not leave behind pin floc.

Typically irregular shaped floc with small amount of filaments forming a backbone for bacteria to colonize on.

Sludge Volume Index (SVI)

<u>250 ml/g or higher</u> – very slow to settle with poor compaction. MLSS looks light and fluffy and not dense.

Sign of a young sludge or could also indicate filamentous sludge bulking. Microscopic examination may be necessary to determine actual cause. Also check pH (less than 6.5 can encourage filamentous growth.

Why Are All of These Process Control Parameters So Important?

Conclusions

- **Process control parameters can help us optimize our facility output and routinely meet our NPDES limits.**
- **You have to know what to expect to be able to recognize when something has changed!**
- **Biology and chemistry within your systems can be controlled and optimized if you take the time to perform the tests.**

Questions?

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