DIGESTERS

How the technology of Milk of Magnesia, Magnesium Hydroxide, can play a role

GOALS

1. Recognize common sources of hydroxide
2. Crash course on some magnesium hydroxide applications
3. Show how these applications are transferring into digestion

Common Hydroxides

This section will discuss the three common sources of hydroxide chemistry encountered in the wastewater industry, their relative strength, handling/safety, quality and application

- Lime – Calcium Hydroxide – $Ca(OH)_2$
- Caustic – Sodium Hydroxide – NaOH
- Milk of Magnesia – Magnesium Hydroxide –$Mg(OH)_2$

Lime –Calcium Hydroxide

Lime can be obtained in the powder or slurry form. If sludge sludge disposal and scaling are not a concern, it can be cheap chemical for controlling pH (alkalinity). Within a few feet of the addition point, it can raise the pH anywhere to 12- 14 standard units (s.u.).

- Slurry concentrations up to 40%.
- EPA states that lime addition in some cases can add as much a 50% more sludge for disposal.
- Certain dosages can kill treatment plant bacteria and form sludge through water softening.

Caustic Soda –Sodium Hydroxide

Caustic soda is general supplied in the liquid form with a freezing point of 50 ° F at 50% concentration by weight. If storage can be maintained above freezing and scaling is not a concern, it can be an alternative for controlling pH (alkalinity). Within a few feet of the addition point, it can raise the pH anywhere to 12- 14 standard units (s.u.) and the concentrated liquid can cause sever burns.

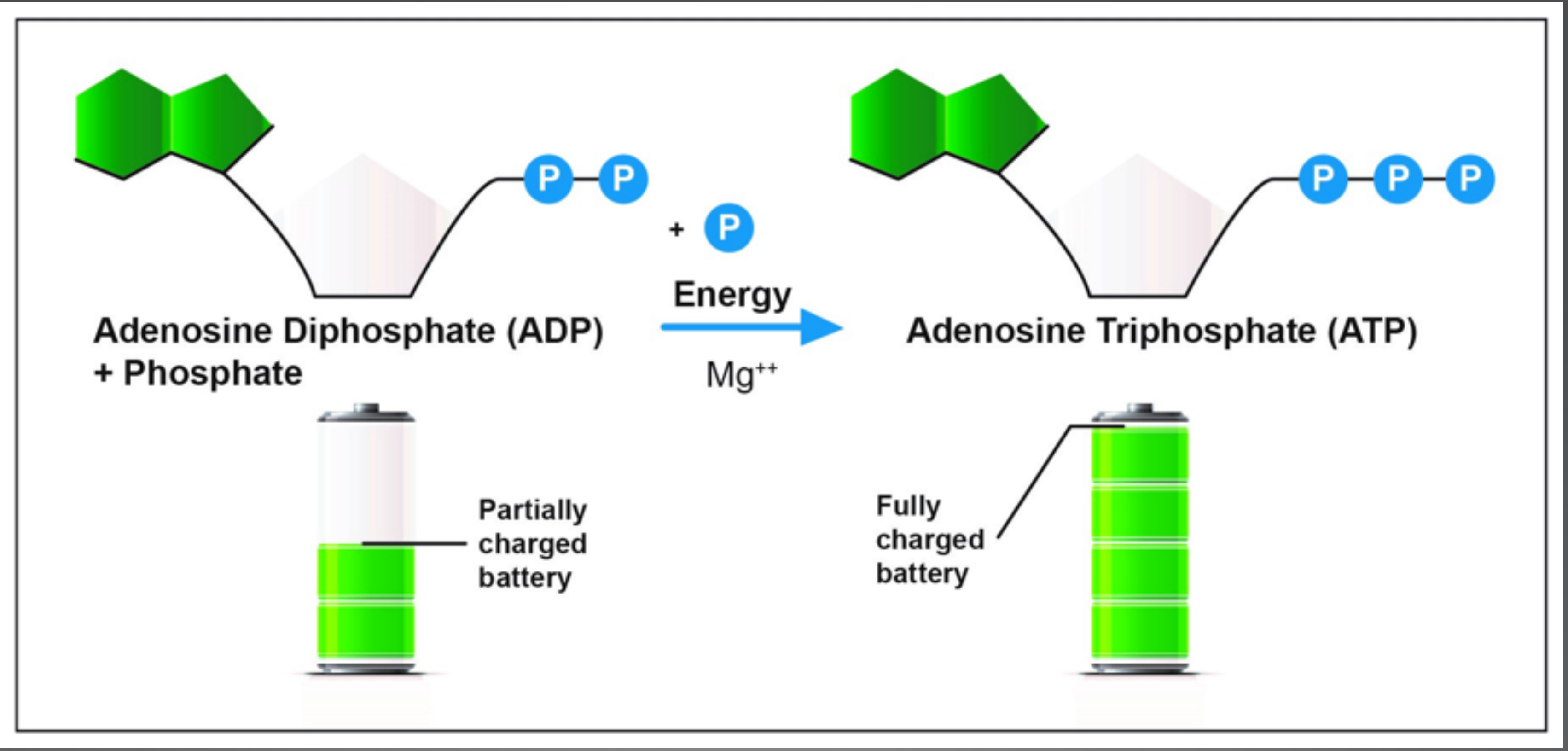
- Increased single charged ions, like sodium, can cause problems with pin floc, dispersion, and settling.
- Accidental overdose will almost certainly kill treatment plant bacteria.

Milk of Magnesia–Magnesium Hydroxide

Magnesium Hydroxide can provide alkalinity as a slurried hydroxide ranging 58-59% by dry solids weight or as a Magnesium Oxide powder. The slurry has a freezing point at or just below that of water. Overdosing of the slurry will have little impact on the biology or effluent discharge limits.

- Magnesium is a big part of the energy production in biology.
- For batch systems visited once or twice a week, a couple days worth of chemical can be added all at once.
- No reportable spill amounts or fish kills.

MAGNESIUM IS THE BRIDGE



Quality Pitfalls

- Caustic – hard water used to dilute to lower percentages
- Lime – Sea Shell lime
- Milk of Magnesia – Brucite (Magnesium Hydroxide Marble).

Greatest Advantage/Caution

Caution

- Caustic – chemical burn risk
- Lime – softening/scaling/sludge costs
- Milk of Magnesia – turbidity

Advantage

- Caustic - completely soluble
- Lime - get it anywhere
- Milk of Magnesia - doesn’t drive pH above 9 su

Magnesium Hydroxide is a safe, cost saving and environmentally responsible chemical strategy which prolongs infrastructure life, manages wastewater odor, prevents plant upsets, improves treatment and enhances biosolids quality.

PH

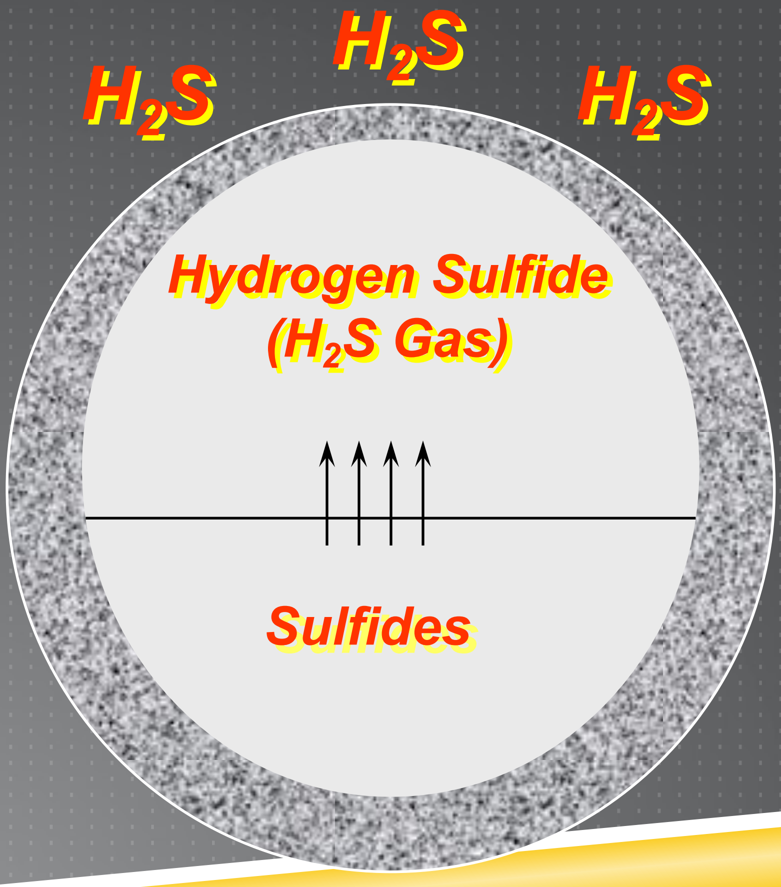
THE MASTER VARIALBLE

CORROSION OF PIPES
EFFECTIVENESS OF DISNINFECTION
RATES OF BIOLOGICAL ACTIVITY
ODOR

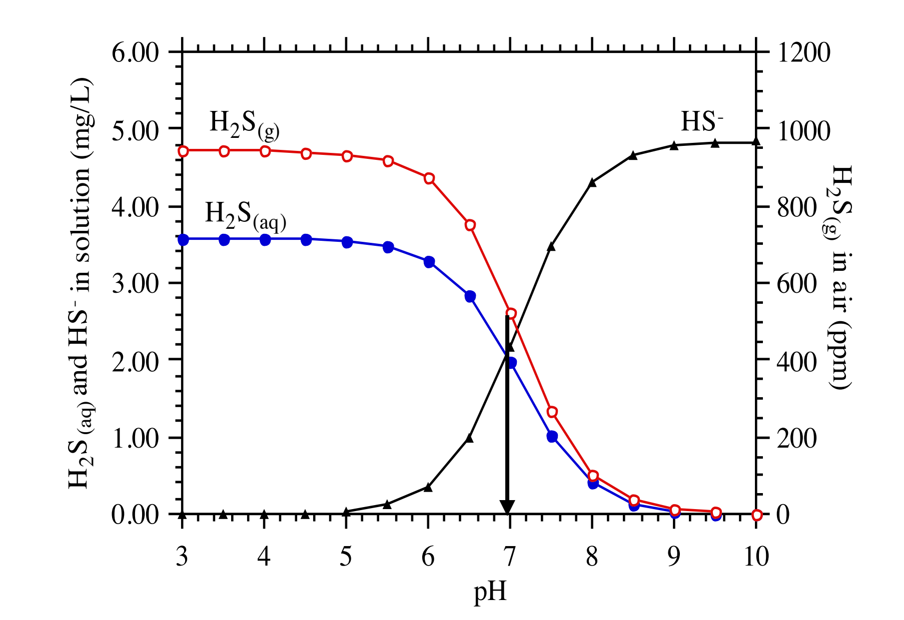
ODOR

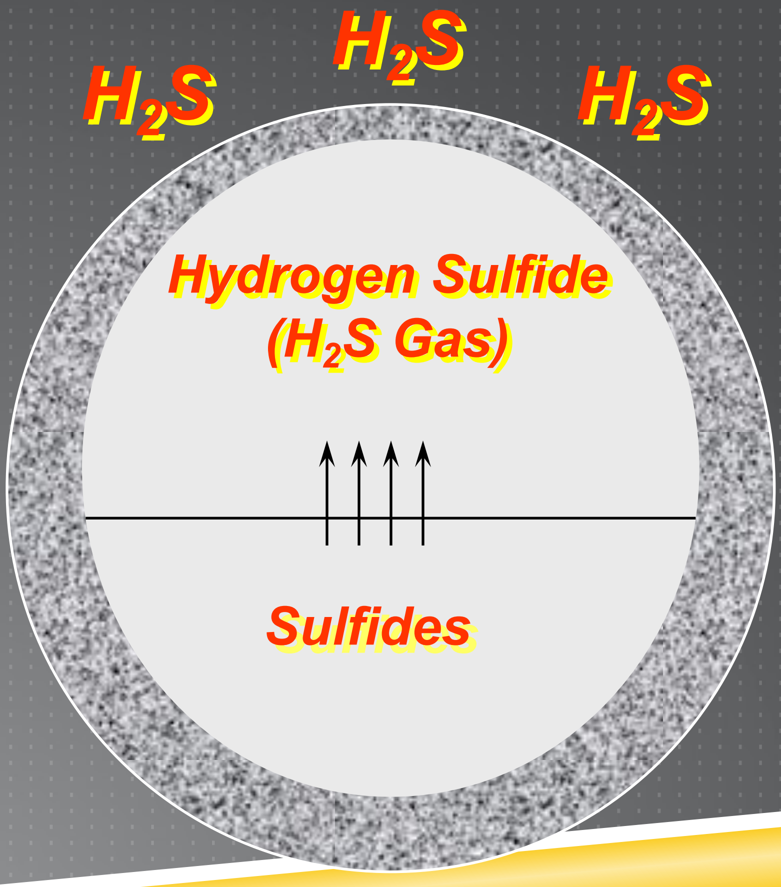
Raising wastewater pH from 7 to 8 eliminates hydrogen sulfide gas and extends the useful life of infrastructure subject to corrosion by over 80%.

Hydrogen sulfide ($H2S$) is a colorless, poisonous, flammable gas that produces foul odors like rotten eggs and contributes to acid corrosion to sewer pipes and equipment in collection systems.



In water at pH 7, about 50% of the dissolved sulfide converts to H2S gas.

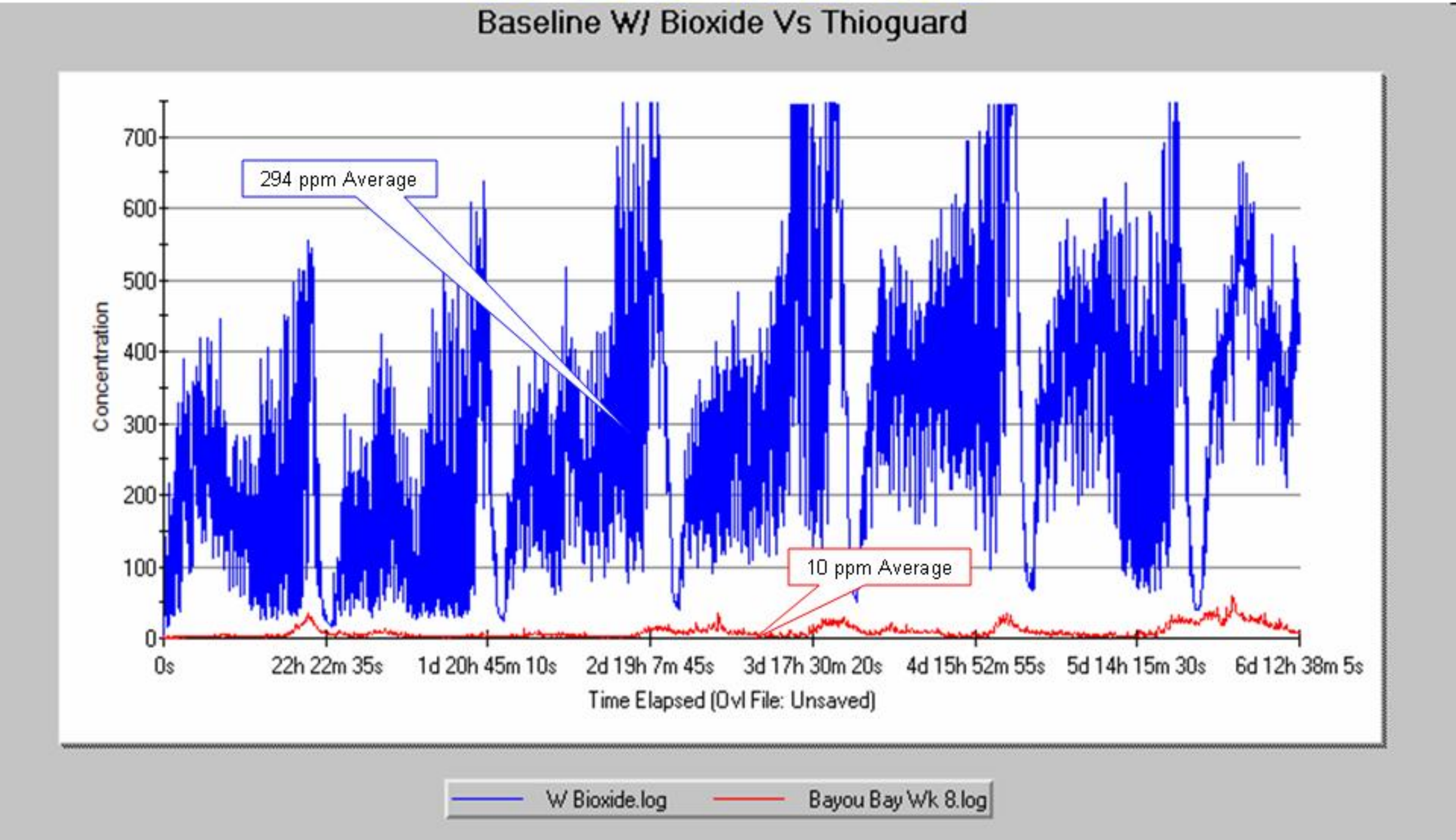




Headspace Hydrogen Sulfide Gas Concentration

Calcium Nitrate vs Magnesium Hydroxide

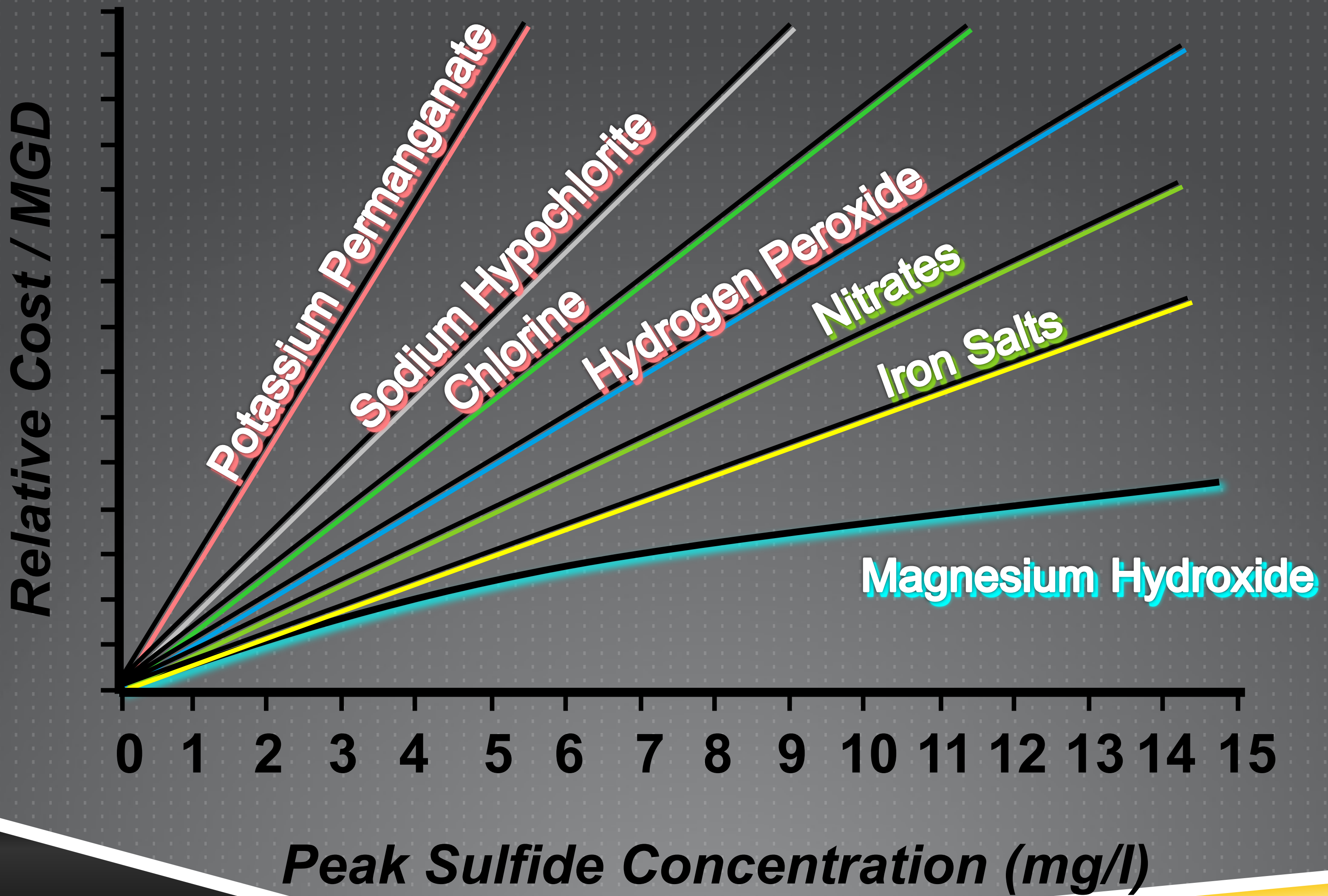
80 GPD vs 36 GPD



COMMON CHEMISTRIES

When comparing unit cost of chemical some chemistries may appear much cheaper than others, the chemical potency and impact on the overall system operational cost should also be taken into consideration.

Relative Total Treatment System Impact Costs



IMPACT POSSIBILITIES OF SOME CHEMISTRIES

- **Potassium Permanganate** – Increases effluent manganese and oxidizes everything
- **Sodium Hypochlorite** – attacks all biology indiscriminately and chlorine gas corrodes
- **Chlorine** – forms hypochlorous acid and requires addition of alkali
- **Hydrogen Peroxide** – Breaks biological membranes and prematurely ages assets
- **Nitrates** – can cause a biological "grease" mat
- **Magnesium Hydroxide** – can consume man-hours

EXAMPLE COST COMPARISON

EQUAL PRICE ≠ EQUAL PERFORMANCE

- LET'S ASSUME THAT CALCIUM NITRATE AND MAGNESIUM HYDROXIDE HAVE THE SAME PER GALLON COST - $2.85

USING THE PREVIOUS EXAMPLE…

- $2.85 PER GALLON X 80 GPD OF NITRATE = $228 PER DAY

  @ 294 PPM AVERAGE GAS LEVEL

- $2.85 PER GALLON X 30 GPD OF MAGNESIUM HYDROXIDE SLURRY = $85.50 PER DAY

  @ 10 PPM AVERAGE GAS LEVEL

- MAGNESIUM HYDROXIDE IS CLEARLY THE BETTER CHOICE IN PERFORMANCE AND COST

Magnesium Hydroxide is safe for personnel, the environment and the wastewater system.

Undissolved Magnesium Hydroxide particles react directly with H_2S converting H_2S to magnesium polysulfide.

These particles dissolve as they travel through the collection system allowing for just a few addition points.

CALCULATING/ESTIMATING DOSAGE

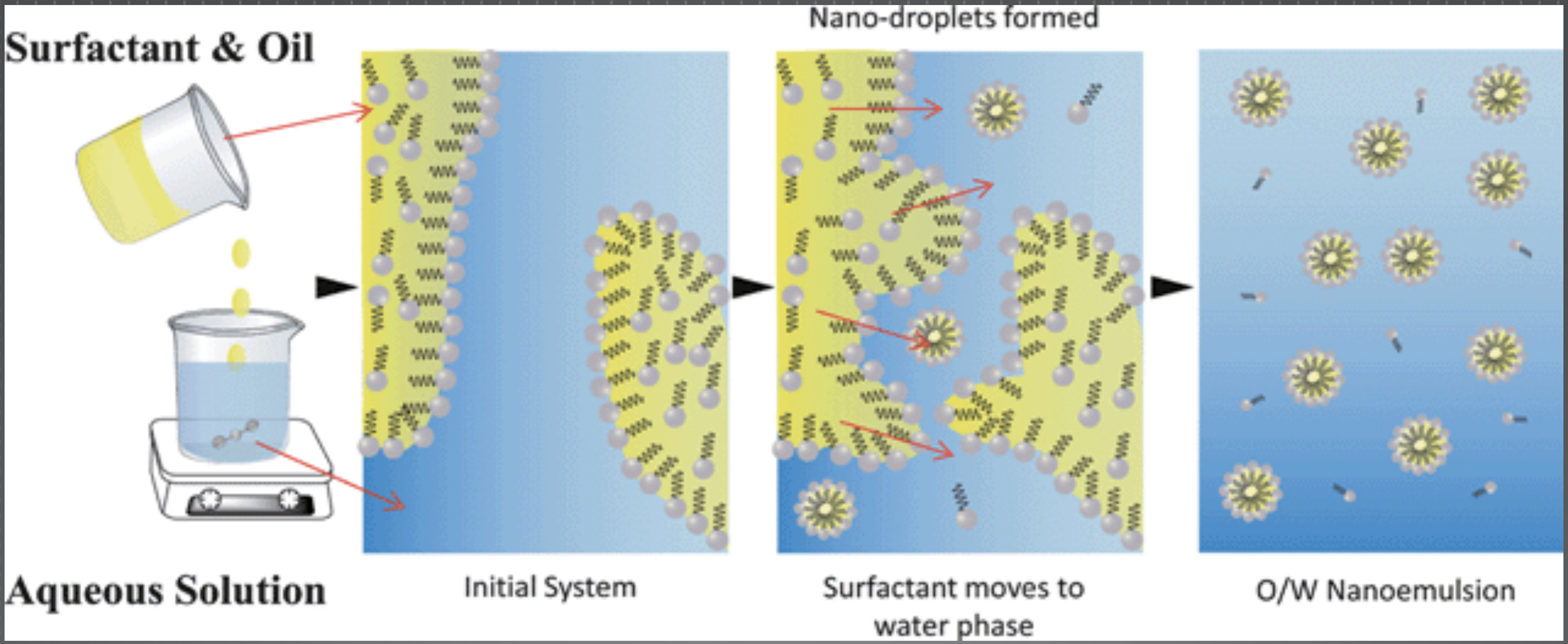
The best way to get a good approximation of how much magnesium hydroxide you will need for odor control is to do a jar test to an endpoint of 8.2 su with a wastewater sample from the point where the odor is a problem.

- **For odor control**: the rule of general thumb dosage for gravity or force-main odor control is 50-60 gallons of slurry per MGD. (Full range is 30-100 gallons per MGD). If using MgO powder, that is 30 dry lbs per 100,000 gallons of wastewater.
- **For alkalinity supplementation**: 1 gallon of slurry provides approximately 13 lbs of alkalinity as Calcium Carbonate (that's about 5 lbs of MgO powder). So you get about 1.5 ppm carbonate alkalinity for every gallon (or 5 lbs of MgO) into 1 MGD of wastewater. Every ppm of Ammonia then requires about 7.14 ppm of alkalinity as Calcium Carbonate.

APPLICATION FOR GREASE CONTROL

A large percentage of wastewater collection blockages (even in mains) can be traced to FOG. Blockages are serious, causing sewage spills, manhole overflows, or sewage backups in homes and businesses. You can disperse/emulsify to **BREAK UP** the grease (which may coagulate later) or **BREAK DOWN** by mild saponification to eliminate downstream FOG blockages and odor.

EMULSIFY…………..DISPERSE



Saponification-

BREAK DOWN……………….Decompose

By raising the pH of the wastewater to 8 or higher, Magnesium Hydroxide breaks fats (FOG) down into a mild soap and glycerol. Glycerol is then consumed at the plant or in the collection system by the biology.

FATTY ACID

GLYCEROL

CARBOXYLATE SALTS - SOAP

Wastewater Treatment Plant Effects

Biological treatment operations and collection systems operate better with wastewater that has proper, stable pH, lower acidity and higher available alkalinity.

Take Full Advantage of Your Plant Design Capacity

- **Utilize the entire tank volume to improve contact time.**
- **Deliver Magnesium nutrition to biology for improved respiration.**
- **Decrease settling volume to improve dewatering and effluent TSS.**
- **Save money over other alkalinity and pH control sources.**

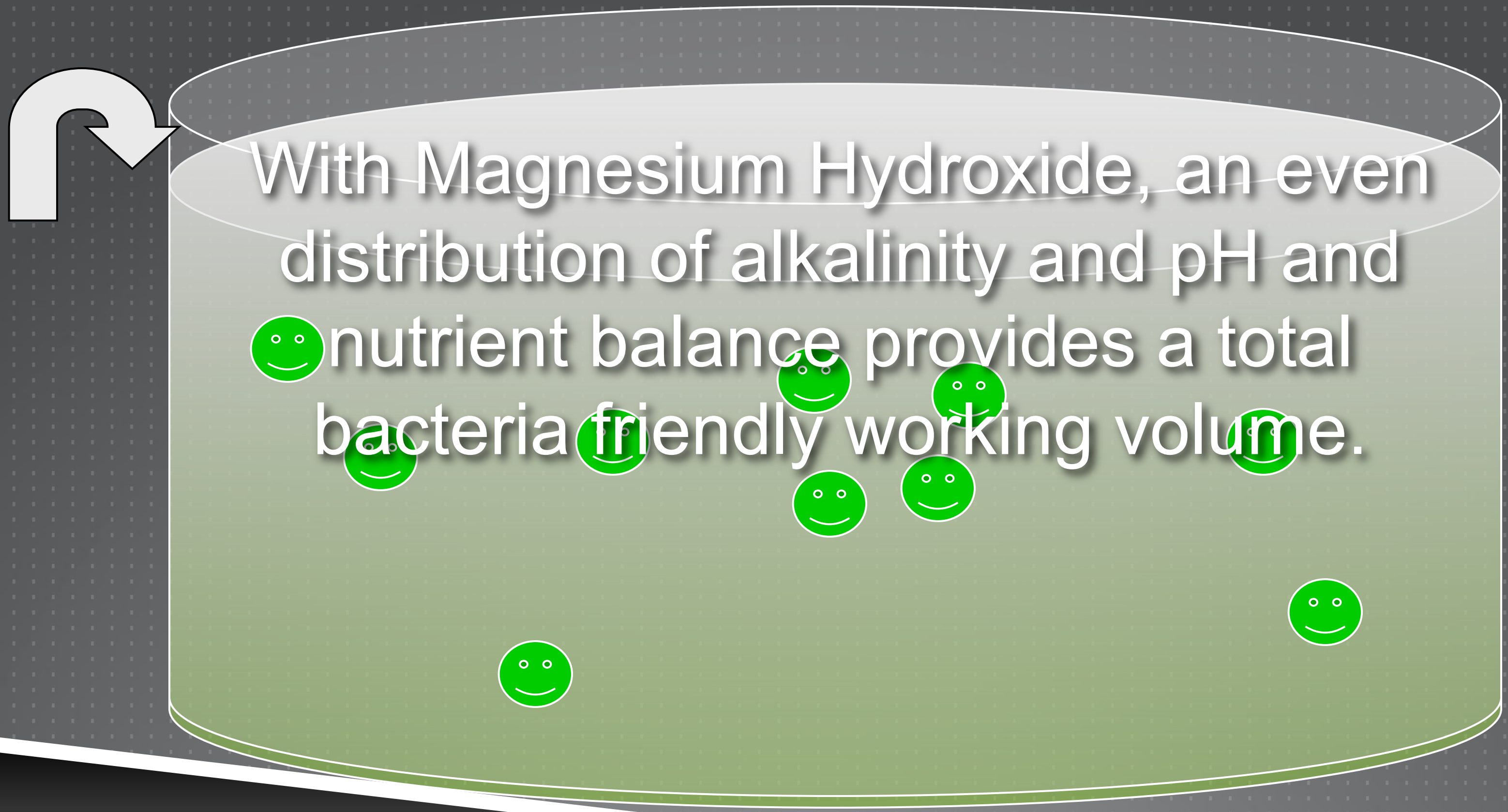
CAUSTIC SODA ADDITION

Because it is highly soluble, caustic causes “HOT” zones near the addition point.

pH distributions across a basin are less stable and contribute to variability away from optimal biological operating conditions.

IF IT BURNS YOU, IT HURTS THEM

WITH MAGNESIUM HYDROXIDE



DIGESTION

MORE VOLATILES DESTRUCTION
CLEANER GAS
BETTER FOOD

THE MAIN IDEAS FROM MAGNESIUM HYDROXIDE PERSPECTIVE

1. Simplifying the food you are supplying to the system. Recall the grease discussion above. The more complex the food, the slower the kinetics of destruction and reduced digester capacity. Glycerol is "jet fuel" for digesters.

2. Buffer the pH at the same time. As with all biological treatment plant if left unchecked, they are all "net acid" producing.

3. Provide magnesium which is the top essential nutrient for engery transfer in biological systems.

4. Keep undesirable gases in solution.

ANAEROBIC DIGESTION

PH

FOOD

TOTAL GAS VS TOTAL BTU

ANEROBIC DIGESTION GOALS

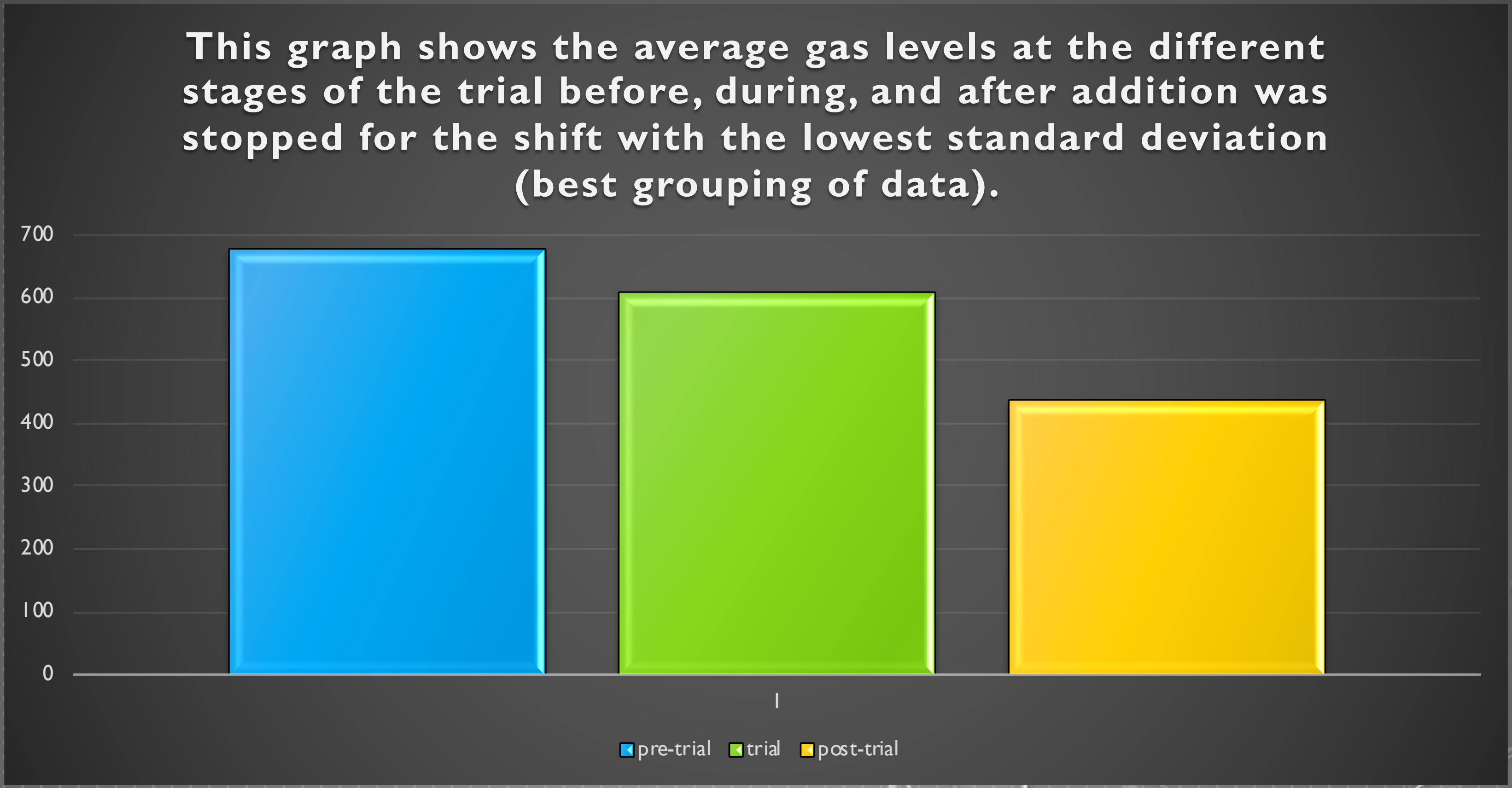
1. CLEAN THE GAS – Remove H_2S
2. MAKE MORE GAS – Give the bugs candy
3. BUFFER THE PH – neutralize the acid

BASIC SYSTEM

ACETOGENS – ACID PRODUCERS

METHANOGENS –METANE PRODUCERS

WHAT WAS THE RESULTING GAS RESPONSE

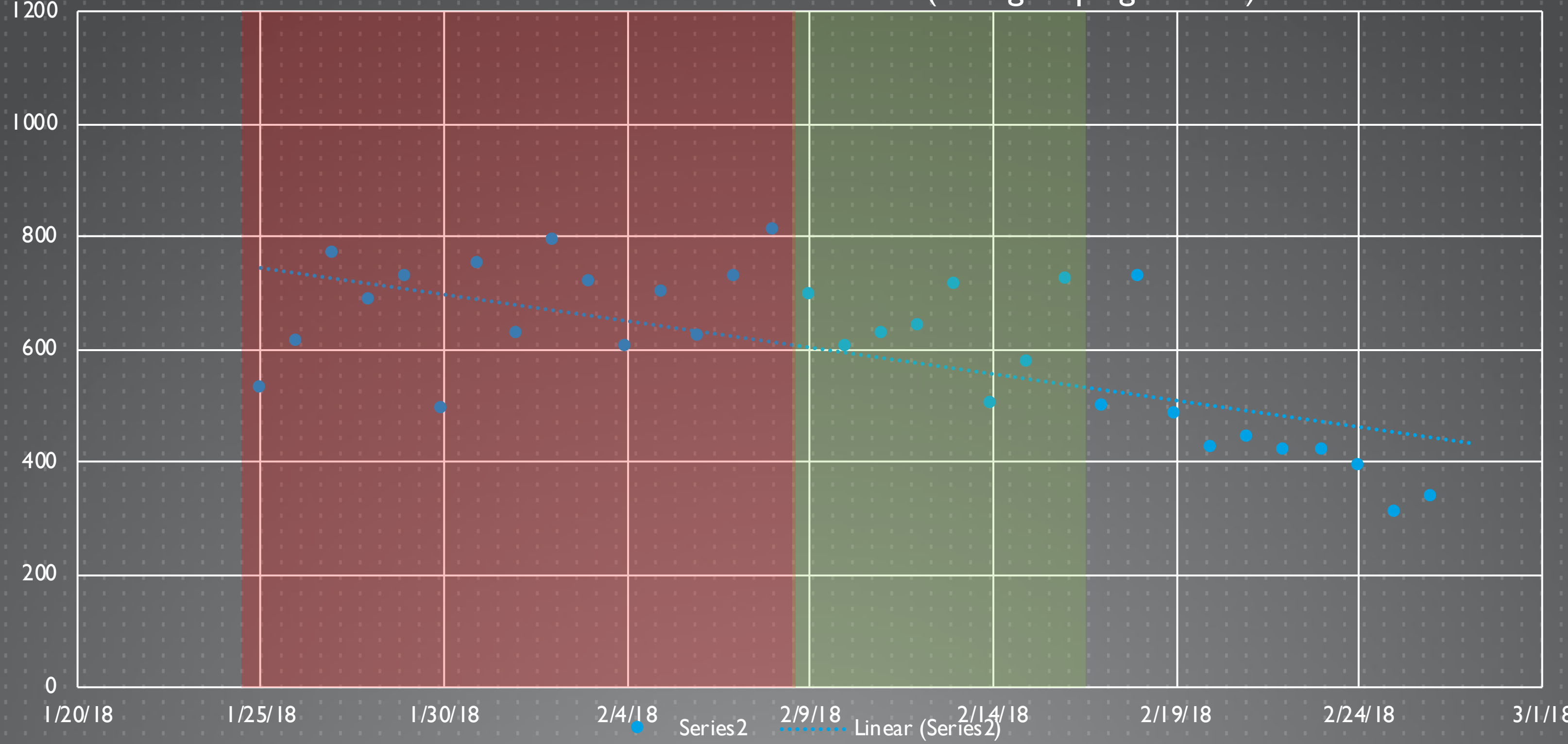


FOCUS ON DIGESTER 1 RESPONSE

LAB Digester Data Daily 1/1/2018 - 2/28/2018	Digester #1 Ph S.U.	Digester #1 Alkalinity MG/L	Digester #1 Alkalinty-Dup QC MG/L	Digester #1 Volatile Acids MG/L	Digester #1 Volatile Acids QC-Dup MG/L	Digester #1 Vol Acid:Alkalinity Ratio	Digester Volatile Reduction (Cake) %
2/9/2018	7.3	3950	3970	130	160	0.032911392	43.01163362
2/10/2018							
2/11/2018							
2/12/2018	7.6	4280	4290	120	120	0.028037383	45.98820538
2/13/2018	8.3						
2/14/2018	7.4	4630	4650	110	130	0.023758099	45.62450688
2/15/2018	8.5	4850	4810	360	350	0.074226804	48.06044189
2/16/2018							24.92748368
2/17/2018	7.4	4350	4360	150	160	0.034482759	
2/18/2018							
2/19/2018							
2/20/2018	7.5	3810	3940	100	130	0.026246719	19.91947934
2/21/2018	7.3	3820		120		0.031413613	
2/22/2018							28.12878657
2/23/2018	7.3	3290	3330	110	110	0.03343465	
2/24/2018							
2/25/2018							
2/26/2018	7.3	3120	3140	160	170	0.051282051	
2/27/2018							
2/28/2018							
Pre trial Average	7.30	3850.00	4046.67	150.00	160.00	0.039	42.8
Trial Average	7.84	4527.5	4527.5	185.0	190.0	0.040	46.6
Post trial Average	7.35	3510.0	3470.0	122.5	136.7	0.036	28.1

TREND IN GAS LEVELS

This graph shows the data for the entire period of data collection so far from the shift with the lowest standard deviation (best grouping of data).



AEROBIC DIGESTION

PH
AIR
TEMPERATURE
TIME

ANY BIOLOGIGICAL SYSTEM FUNCTIONS BEST WITH A CONSISTENT ENVIRONMENT.

AEROBIC DIGESTION OCCURS BEST IN A TEMPERATE, OXYGENATED ENVIRONMENT WHERE SIMPLE FOOD IS SCARCE ENOUGH THAT THE BIOLOGY CONSUMES ITSELF OR ITS NEIGHBORING PROTOPLASM

THE CHEMICAL REACTIONS

Biomass destruction:

$C_5H_7NO_2 + 5O_2 \longrightarrow 4CO_2 + H_2O + NH_4HCO_3$

(cell mass) (ammonium carbonate)_

Nitrification of released ammonia nitrogen:

$NH_4^+ + 2O_2 \longrightarrow NO_3 + 2H^+ + H_2O$

Overall equation with complete nitrification:

$C_5H_7NO_2 + 7O_2 \longrightarrow 5CO_2 + 3H_2O + HNO_3$

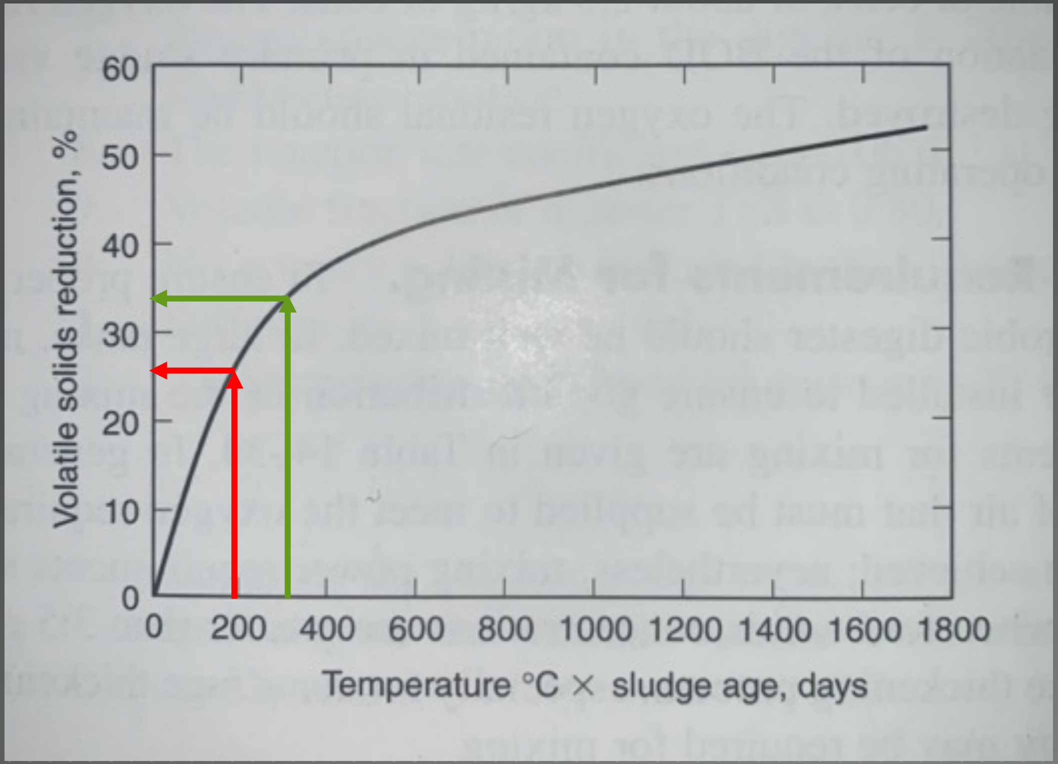
Using nitrate nitrogen as electron acceptor (denitrification):

$C_5H_7NO_2 + 4NO_3 + H_2O \longrightarrow NH_4 + 5HCO_3 + 2NO_2$

With complete nitrification/denitrification:

$2C_5H_7NO_2 + 11.5O_2 \longrightarrow 10CO_2 + 7H_20 + 2N_2$

VOLATILE SOLIDS REDUCTION



(From WEF, 1995a.)

Example: WAS feed from Oxidation ditch Western, PA.

Average Aerobic Digester Temperature: 19.12 °C
Approximate Volume: 500kgal
Average Daily Feed: 30kgal
Average DO: 0.55
Average VSR%: 26.5% ± 5.5

Digester SRT = 500k gal/30kgal per day
= 16.67 days

Temperature x SRT = 318.67
VSR% at 318.67 ➞ ~33.5%

Missing about 7% of the potential to ship less sludge.

What is the cost?

WHAT IS THE COST OF LESS DIGESTION?

Estimation from previous example:

7% less sludge digested ➡ 30,000 gpd WAS processed per day of 2% sludge by weight

1. 30,000 gpd WAS x 8.34 lbs/gallon x 0.02 lbs of solids/lb of WAS

2. Therefore: 5004 of WAS solids at 100% dryness

3. 33.5% digested to the press: 3327.66 lbs optimally
4. 26.5% digested to the press: 3677.94 lbs actually (**350.28 dry lbs more**)

5. For 25% cake:

$$0.051 \text{ cuft/dry lb solids} \times 350.28 \text{ lbs} \times 7.48 \text{ gal/cuft} \times 10.42 \text{ lbs/gal} \div 2000 = 0.69 \text{ tons}$$

ANS: 0.69 x $75 a wet ton x 365 days = $18,888.75 (~3 MGD Plant)

Supporting Data

Wet cake solids %	cu feet wet cake per 500 lbs dry solids	Cu Yards of wet cake per 500 lbs dry solids	Sludge Bulk Density lbs/gal
0.05			8.344
0.5			8.38
1			8.42
2			8.51
2.5			8.55
3			8.59
3.5			8.63
4			8.67
5			8.76
10	68.17	2.60	9.17
20	33	1.26	10.01
25	25.5	0.97	10.42
30	20.5	0.781	10.84
35	17	0.648	11.26
40	14.5	0.553	11.67
45	12.5	0.476	12.09
50	11	0.419	12.51

CONSIDER AMENDMENTS

WITH DOWNSTREAM EFFECT

1. Chemical pH Control
    1. Lime (max 12.5 s.u.)
    2. Soda Ash (max 11.8 s.u.)
    3. Magnesium Hydroxide (max 8.5 s.u.)

2. Dewatering Improvements
    1. Lime (bulking to "dry", no harm to polymer)
    2. Soda Ash (little cake solids impact, sodium polymer interference)
    3. Magnesium Hydroxide (50% increase in , overdosing-charge imbalance)