
Water Quality
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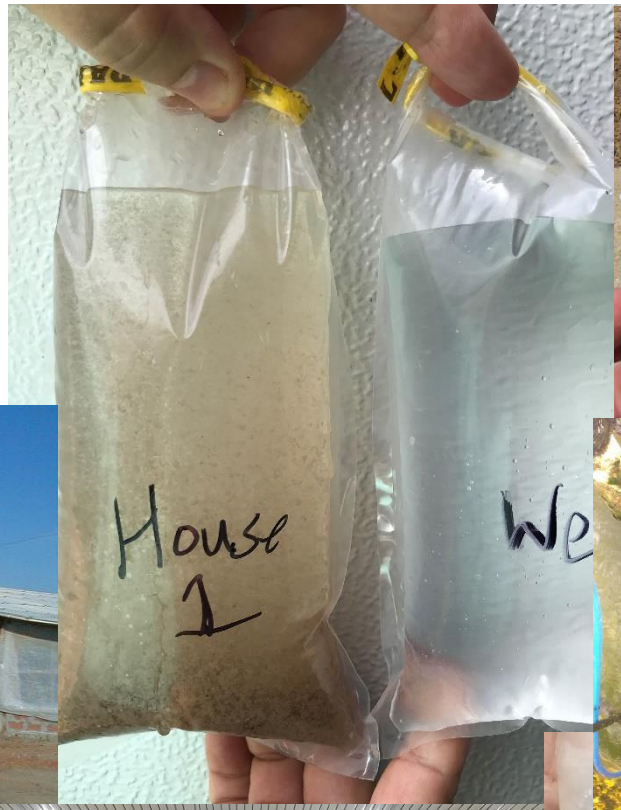
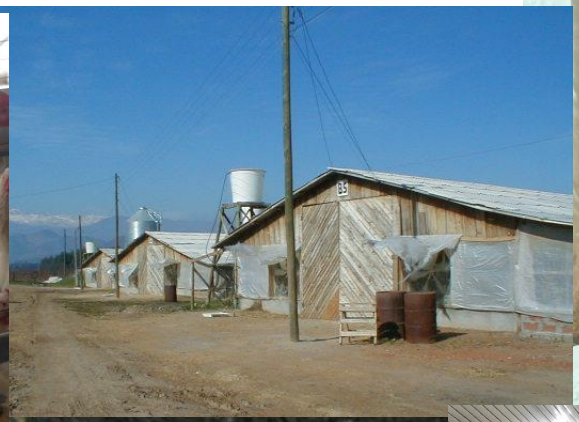
Keys to a successful water program

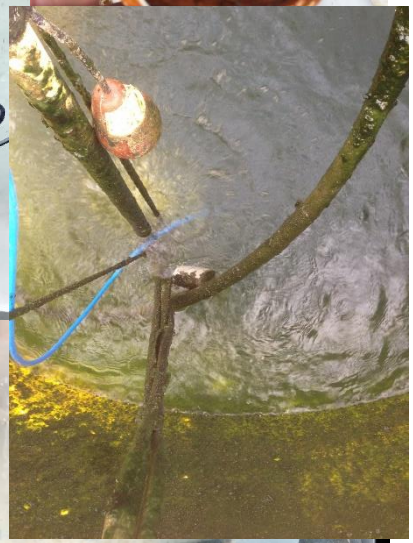
- Assess farms & production to identify "opportunities"
- Know the water
  - Microbial, pH and mineral content
  - Source and system strengths and weaknesses
- Develop programs that compliment the water
- Be consistent
- Monitor & verify what works
- Make water quality part of the team culture

Inspect what you expect

- Start with visual inspection
  - Inspect source, pipes, storage
  - Look at water
  - Review farm health

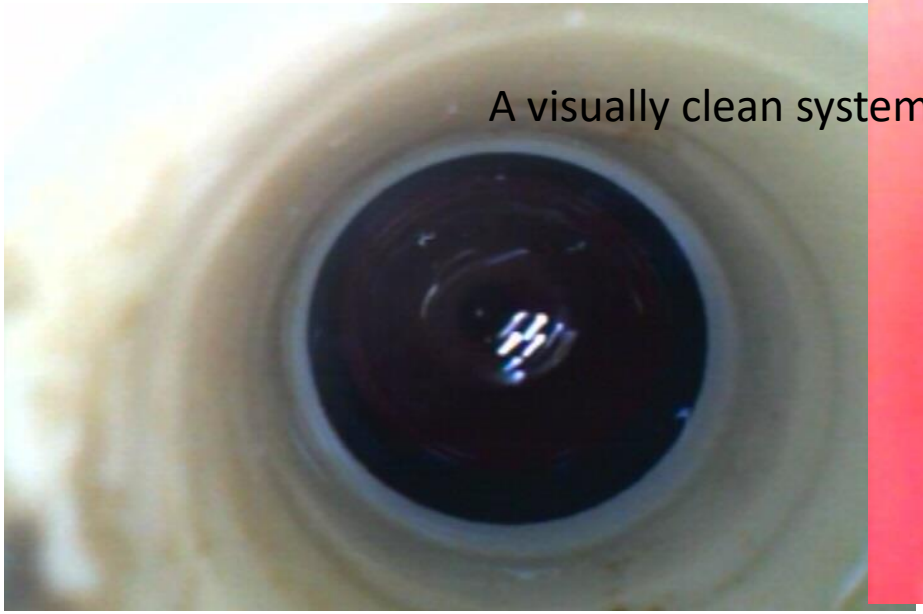


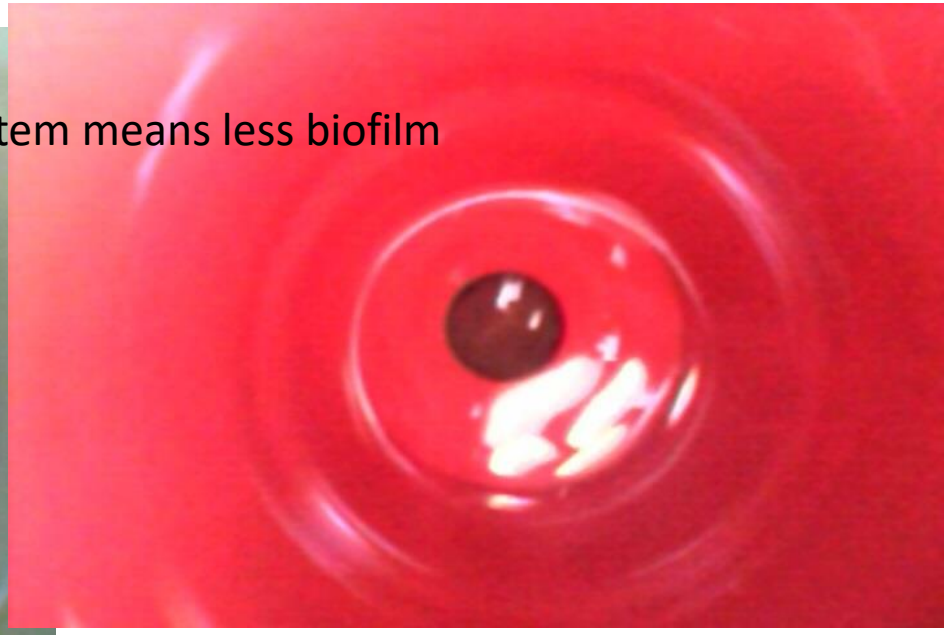




Go inside the water system with an inspection camera

A visually clean system means less biofilm





Visual inspection
of this water line
shows biofilm sludge
that can release into the
water and travel to the birds

Test for Total Bacteria
Inexpensive Quality Assurance Test
>10,000 cfu/ml-potential problem

Farm	Source	End of Line in Poultry Barn
	colony forming units of Bacteria/ml	
A	2,700	26,600
B	203,000	2,340,000
C	0	4,775,000
D	0	0

Water lines loaded with bacteria that could be h

Acceptable levels of Bacteria

APC-Total bacterial or also called aerobic bacteria meaning it needs oxygen to survive

- Drip sample- less than 10,000 cfu/ml
  - cfu/ml is colony forming units/milliter
- Swab sample- less than 100,000 cfu/ml

E. Coli and coliforms

0 cfu/ml is the desired level because…

E Coli can grow fast

A single E coli held at 90 ° F for 24 hours can turn into trillions

Do products used in water have a good or bad influence on water quality?

Specimen	Genus/Species	Result	Level
Water		mixed aerobic culture	4 +
	Bacillus sp.	cultured	4 +
Water		mixed aerobic culture	4 +
	Escherichia coli	cultured	2 +
	Pseudomonas aeruginosa	cultured	3 +
	Staph. coagulase Negative	cultured	3 +
	alpha Streptococcus species	cultured	2 +
Water		mixed aerobic culture	3 +
Water		mixed aerobic culture	4 +
	Pseudomonas aeruginosa	cultured	2 +
Water		mixed aerobic culture	4 +
	Klebsiella sp.	cultured	1 +
	Bacillus sp.	cultured	2 +
	Staph. coagulase Negative	cultured	3 +
Water		mixed aerobic culture	4 +
	Staph. coagulase Negative	cultured	4 +
Water		mixed aerobic culture	2 +
	Staph. coagulase Negative	cultured	2 +

Products being used in water were detrimental to quality
And supporting pathogens harmful to birds

Water Supplies
Dynamic and Influenced by Many Factors

- Can change from season to season
- Droughts and floods
- Agriculture, industry and septic systems
- Well depth and placement
- Rock and soil it passes through
- Usage level

- Surface water supplies like ponds most vulnerable
- Document quality-test for minerals, pH and bacteria

When to Test for Bacteria

- Noticeable change in color, odor or taste
- Flooding has occurred near well
- Person or animal becomes sick from waterborne disease
- Maintenance on water supply system
- Persistent poor performance
- Loss of pressure in water system
- Unfortunately we rarely drink same water supply

Sanitized Water is An Insurance Policy

- Water supplies are like flies and rodents-can harbor almost EVERY pathogen challenge
- Short list of pathogens isolated from poultry water supplies
  - Cholera/Bordetella
  - Pseudomonas
  - E. coli
  - Campylobacter
  - Klebsiella pneumoniae
  - Avian Influenza
  - Salmonella (1700 species)
  - Staph, Strep. …….
- LT vaccine harbored in biofilm
- City water/Reverse Osmosis water
  - No guarantee water will remain pathogen free
- Dirty water systems means biofilm- a place for pathogens to thrive

Water is Perfect Carrier of Health Challenges

- Poultry drinking systems easily contaminated
  - Water slow moving/warmed
  - Water lines have many hiding places-pinch points
  - Water often contains food the organisms need
  - We add food-vitamins, organic acids

Control the Biofilm
Proven Facts

- Clean pipes can rebuild biofilm in 3-5 days if poor quality water is re-introduced
  - Systems need line cleaning AND daily sanitation
- If E. coli is introduced into the water systems, can incorporate into the biofilm

Take home: Problems can get introduced, consistent water reduces the risks opportunistic pathogens create

Water (Drip) Sample May Not Identify A Challenge Situation

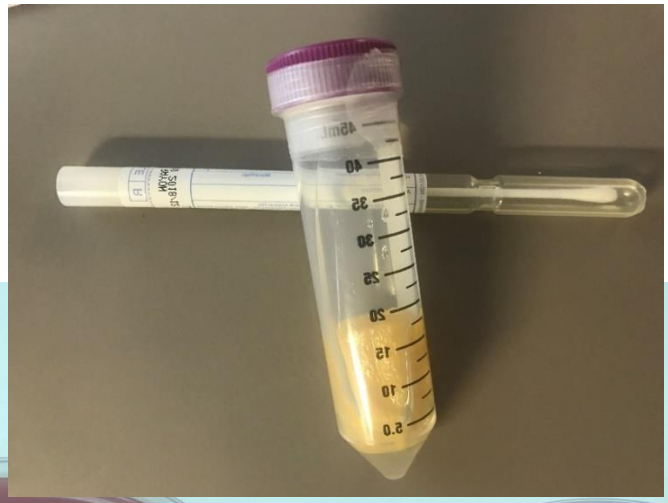
- Established biofilm changes the rules for determining water challenges
- Biofilm may not be releasing organisms when you pull a sample
- A better monitoring tool is swab the water system
- A swab will wipe off the biofilm which can then be cultured to determine what is present

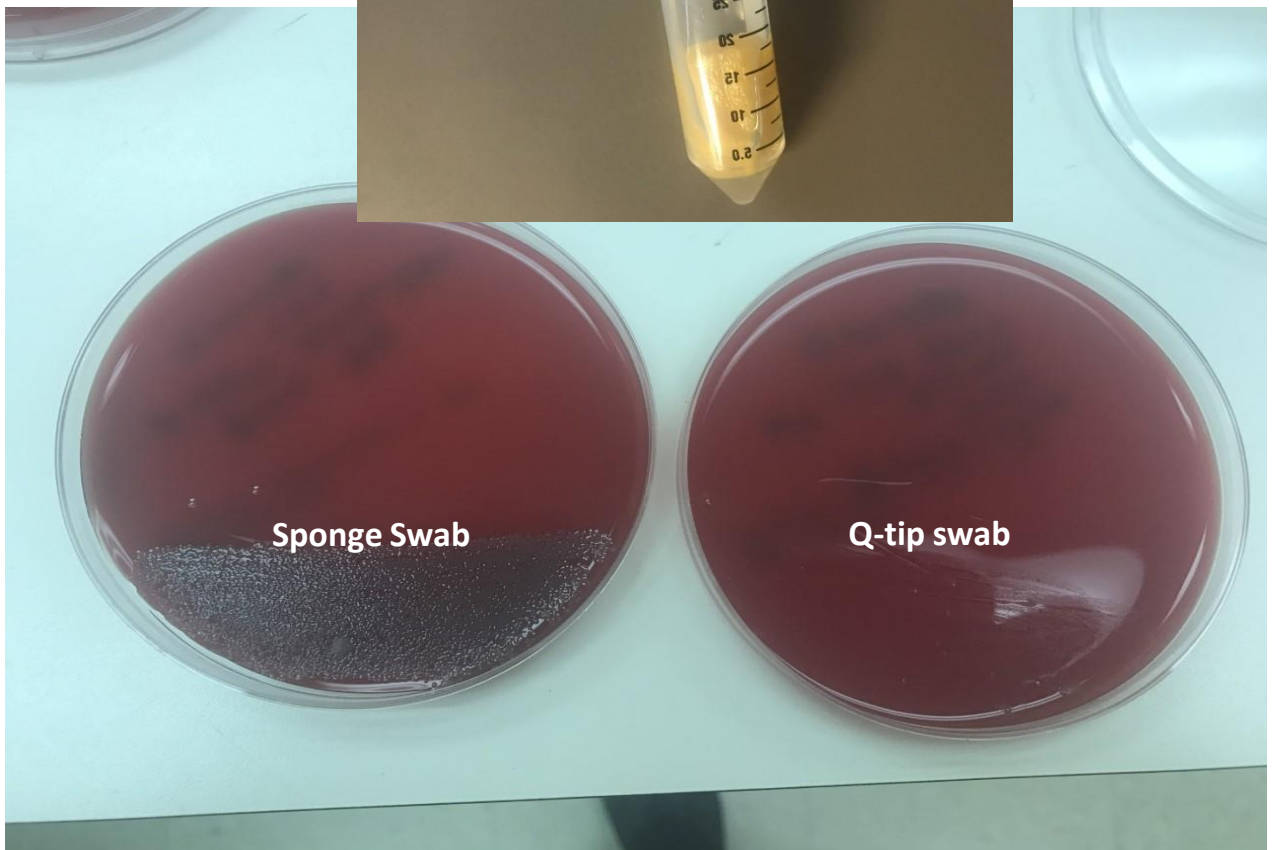
Even more Accurate for Problem Solving Line Swab Procedure

Drip sample may not always reflect what's present in the lines-swab inside of the line at end of line

Use a swab that will thoroughly wipe the surface

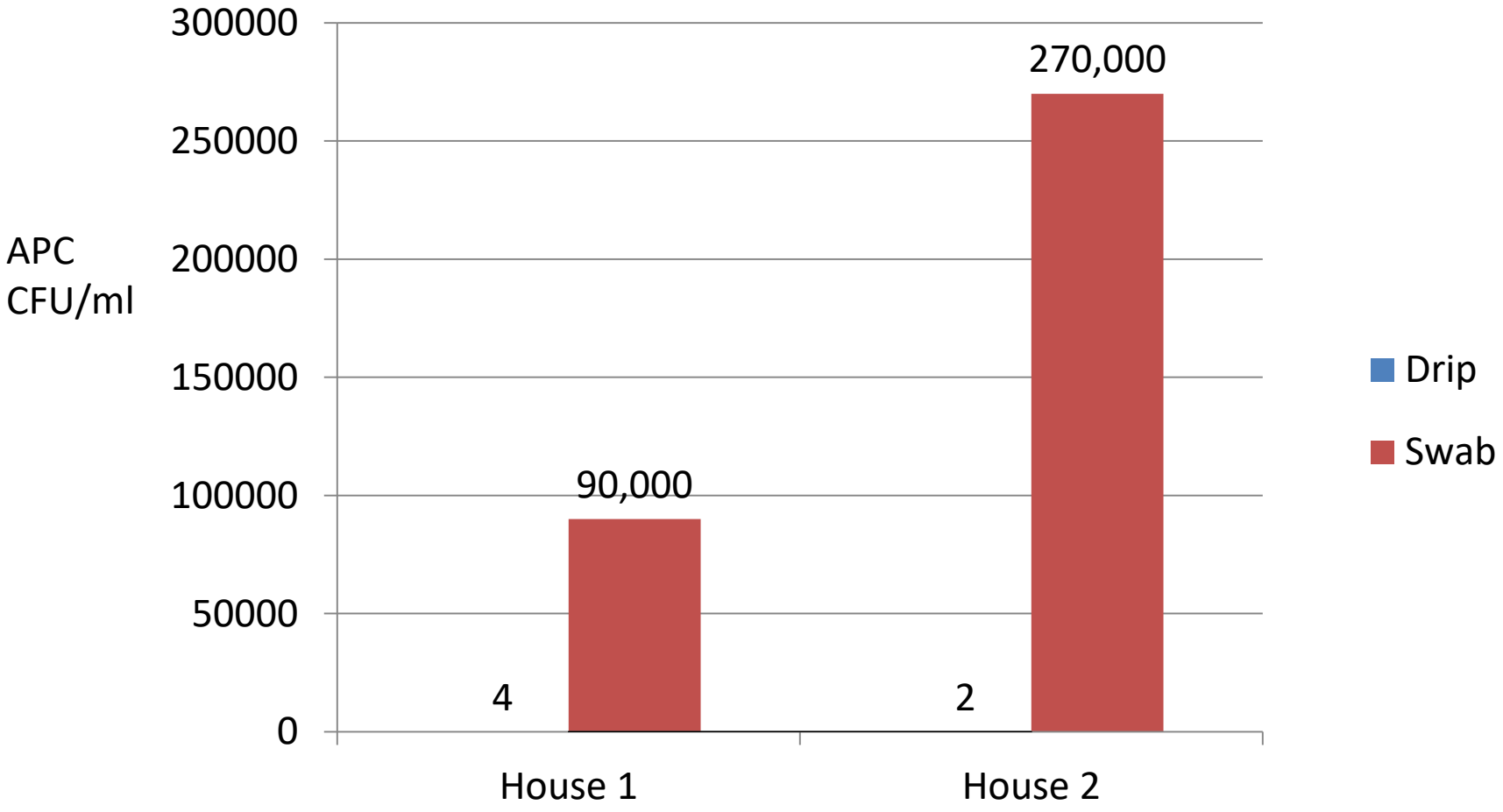
Tested inside of line leaving the holding tank
Loaded with Bordetalla but not detected by Q-tip culture swab
Only the hydrated sterile sponge removed the biofilm





Drip Versus Swab Sampling for Evaluating Water Lines

water sanitation was keeping the water clean but swabs showed there was biofilm that needed to be cleaned out



Farm using gas chlorine- drip samples were acceptable but swab showed lines full of biofilm

Monitoring Water System With Drip and Swabs Helps Identify Weaknesses

Drip/Swab	APC (aerobic) (CFU/ml)	Yeast	Mold	E. Coli	Coliforms
Drip	150,000	85	0	0	0
Drip	57,900	457	63	0	0
Drip	35,100	183	33	0	0
Drip	482,000	587	4	1	1
Swab	2,680,000	40,000	0	0	14
Drip	0	0	0	0	0
Swab	25,000,000	50,000	0	0	0
Drip	454,000	29	2	0	0

Water System Cleaning Essentials
Cleaning between flocks is important

- The right concentration of an effective cleaner left the proper amount of time is the key to success
  - Improper cleaner concentration or not leaving long enough are both failures
- Cleaning the whole system is essential
  - Water lines
  - Standpipes
  - Regulator
  - Distribution pipes
- There are lots of great products, DOCUMENT which one is best for your operation(s)
  - Collect swabs pre and post cleaning

- Flush the system post cleaning with sanitizer the birds can drink
  - This helps kill any bugs that survived line cleaning

Correct Cleaner Concentration is Important

Product Evaluation Bacteria Results

total bacteria/ml of water

Treatment	Pre Clean	Post Clean 4 Hours	Post Clean 24 Hours
Control	1,202,000	977,200	2,691,500
Bleach 3%	660,700	832	813
Citric Acid	36,307,800	33,113,100	21,379,600
PAA-2%	7,943,200	100	<1
50% H2O2- 1%	1,659,500	12,300	316
50% H2O2- 3%	537,000	457	<1

Clean Regulators

- Cleaning regulators and standpipes are key for success
- Make sure regulators are not in flush mode
- Make sure stand pipes are working


Add dye to water
line cleaning products to
assure it is in the system
or completely removed

Flush after line cleaning with water that contains a sanitizer safe for animals to prevent recontamination

Product	Pre Bacteria cfu/ml	48 Hours Post Cleaning Cfu/ml
50% H2O2- 3% solution	155,000	530
	579,000	43,000
	603,000	10,200
	164,000	23,3000

Don’t let biofilm rebuild-Flush system with sanitizer at a level safe for birds

Flush Waterlines to Reduce Bacteria Load

(cfu/ ml Aerobic Bacteria)

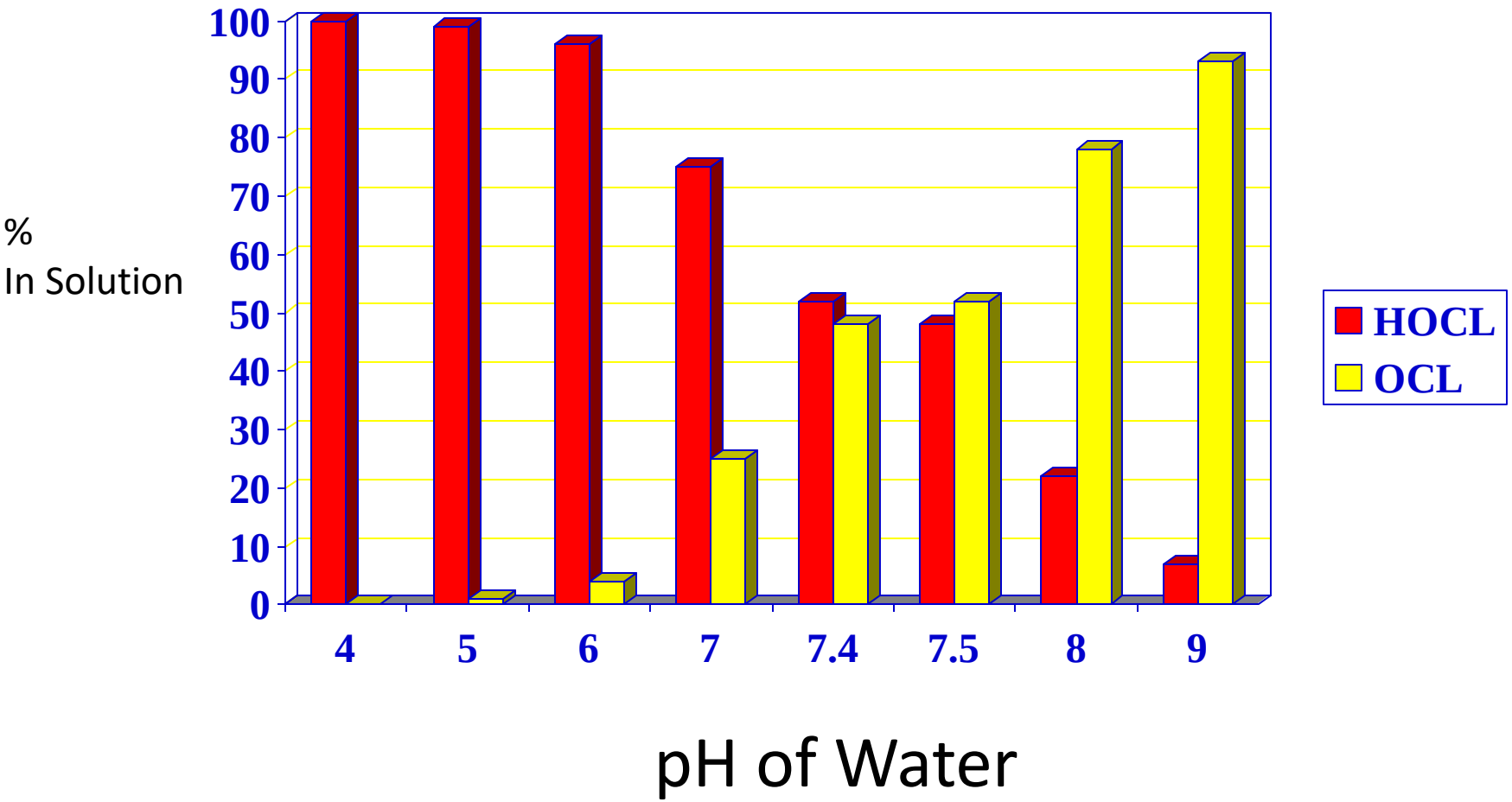
Treatment	Dosage	Pre APC	Post APC	Residual ppm
Control	City water flush	1,326,900	2	0.6
50% H_2O_2	8 oz/5 gal stock H_2O_2	1,674,300	207	40
Chlorine tablets	6.7 g tablet/gal stock Chlorine	326,419	<1	3.4
Anolyte System	highest setting Chlorine	92,170	0	40

Water Sanitation

- Chlorine is good but not perfect
- Affected by:
  - pH, needs pH 4.0 to 7.0
  - Not enough bacteria will survive
  - Cold water, loses effectiveness
  - Turbidity (dirty water)
  - Short exposure time, will not work
  - Growth stage and type of bacteria
  - Age/ storage conditions of bleach

Abuse and misuse of chlorine results in resistant organisms

How pH Affects Chlorine
Ratio of Hypochlorous Acid to Chloric Ion



What Form is Your Chlorine?

- Hypochlorus acid is 80-300 times more effective as a sanitizer than chloric ion
- Free chlorine not considered effective unless it is 85 % Hypochlorus acid

Alternative Chlorine to High pH Products-Bleach Crystals

- Active ingredient-Sodium Dichloro-s-triazinetrione dihydrate 99 %
- Provides 55% available chlorine
- Acid to neutral pH stabilized
- May be the best chlorine choice for high pH water
- Compared to sodium hypochlorite
- Mixed a stock solution
  - Bleach crystals = 2.50grams of crystals + 1,893ml of de-chlorinated water
  - Liquid bleach = 29.6mL of liquid bleach + 946 mL of de-chlorinated water

How much chlorine is too much?
The more appropriate question is:
How much product am I putting in the water?

- Chlorine is stabilized at pH 11, this requires
  - **sodium hydroxide or**
  - **calcium hydroxide**
  - **Both have a bitter taste the birds do not like**
- So how much free Cl residual you can achieve without affecting water consumption will depend on the following:
  - What is product concentration?
    - 6 % Chlorine versus 12% Chlorine?
      - Stronger concentration requires less product
  - How has the product been stored?
    - Sunlight causes significant loss of Cl
  - What is the storage temperature?
    - Warmer temperature increases Cl loss

What to test when using chlorine

- Measure ORP-oxidation reduction potential-this is the oxidizing energy of the free chlorine
  - Target ORP-750-800 mV
  - Only measuring ORP may not detect over chlorination

- Monitor free and total chlorine residual to confirm not over using chlorine product to achieve sanitizing goal
  - Free chlorine range-2-6 ppm
  - Total chlorine no more than 8-10 ppm

- Difference between free and total indicator of biofilm and/or minerals present which is tying up the Cl
  - The closer Free and Total Cl readings are-the cleaner the system
  - Ideally these numbers should be the same

pH, ORP, Total and Free CL
Oxidizing energy dependent on pH and Cl residual

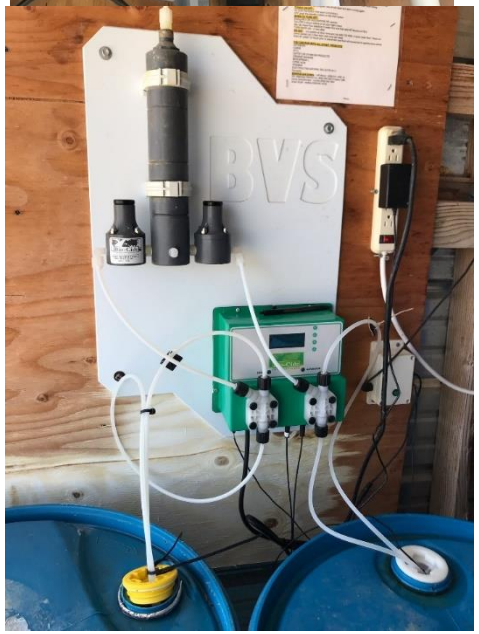
pH	ORP mV	T Cl ppm	Free Cl ppm	APC CFU/ml
6.86	20	0	0	1,250,000
6.47	425	5	2.5	<10
5.85	540	5	2.5	<10
5.17	615	5	2.5	<10
3.91	705	5	2.5	<10

Bleach 8 oz/gallon stock then 1:128
Sodium bisulfate used to adjust pH

Chlorine Dioxide

- Strong oxidizer
  - Better virucide than Cl
- Effective at higher pH
  - **More effective pH 8 versus 6**
- Target residual
  - Total ClO_2-up to 5 ppm
  - Free residual ClO_2- 1 ppm
  - Monitor free
- Available as:
  - Ready to use products-5-7% solutions of sodium chlorite
  - Dry acid/Na-chlorite added together in stock solutions
  - Liquid Sodium chlorite + acid = 60-80 % chlorine dioxide
    - Liquid inorganic acids best activator
    - Quality acid reduces risk of mineral contaminants

Best when the activation chamber promotes mixing



Hydrogen Peroxide

- Target- 50-125 ppm in drinking water
- Good for surface water cleaning- controls taste issues/no chlorine by-products
- Not as good at oxidizing iron and manganese
- Stabilized products last longer

5 Day Residual for Different H_2O_2 Products

(ppm or mg/l)

Products, stock concentration	Day 0	Day 1	Day 2	Day 3	Day 4	Day 5
50% stabilized , 2 oz/gal	79.0	76.7	64.2^{gh}	58.6^{hijk}	55.5^{klm}	$>50^{lmn}$
20% stabilized , 2 oz//gal	44.4	37.1	32.9	27.0	26.3	>10
34 % stabilized , 2 oz/gal	53.5	49.6	41.2	36.5	32.6	>10
28% non-stabilized, 2 oz/gal	36.3	34.1	26.6	22.1	19.2	>10

Each product was mixed at the concentration shown then added at a rate of 1 ml to 128 ml of drinking water

Stabilized hydrogen peroxide can be a good sanitizer during low water flow because residual lasts

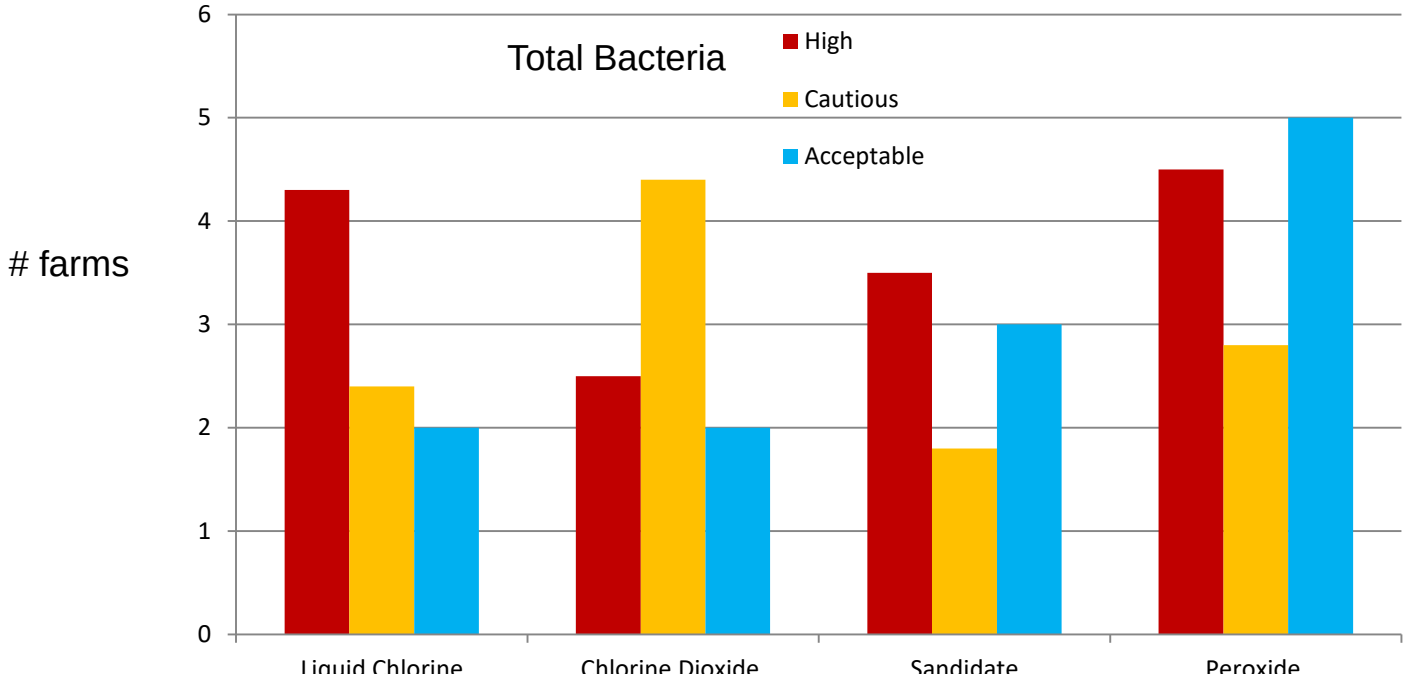
Monitor and Document
A consistent monitoring program is necessary for assuring sanitizer residual is always present
Documenting is an essential tool for correlating performance with water quality

Sanitation Verification
Document what works

Farm Name	Source	Drip/Swab	APC (aerobic) (CFU/ml)	Yeast	Mold	E. Coli	Coliforms
Farm A	Waterline	Swab	2	0	0	0	0
Farm A	Waterline	Swab	3	0	0	0	0

Farm Name	Source	Drip/Swab	APC (aerobic) (CFU/ml)	E. Coli	Coliforms
Farm B	Well	Drip	109	0	0
Farm B	End of line	Drip	0	0	0

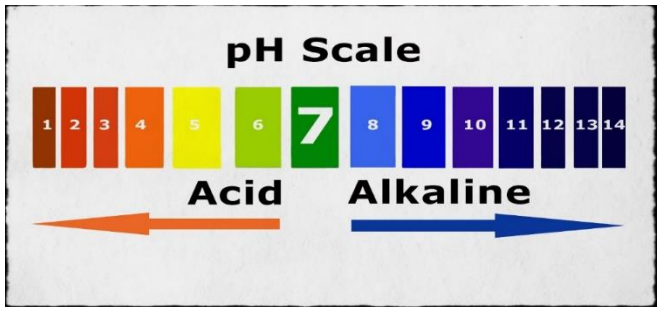
Evaluate your sanitation program: All products work and fail-understanding your challenges is key for success

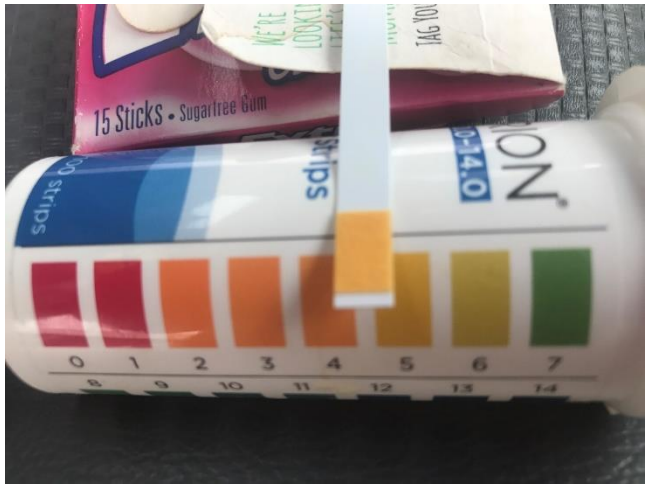


Source: Dr. Brian Wooming-Cargill

Understanding pH

- Measures how acidic or basic water is





- Factors affecting pH
  - Alkalinity of water-bicarbonate, sulfates,
    - buffers against pH becoming more acidic when acid is added
  - Type of acid
    - Inorganic or mineral acids-typically strong-phosphoric, sulfuric, hydrochloric, sodium bisulfate converts to sulfuric acid- tend to easily shift the pH
    - Organic acids-weak acids-acetic, citric, proprionic, formic

Organic Acid Benefits

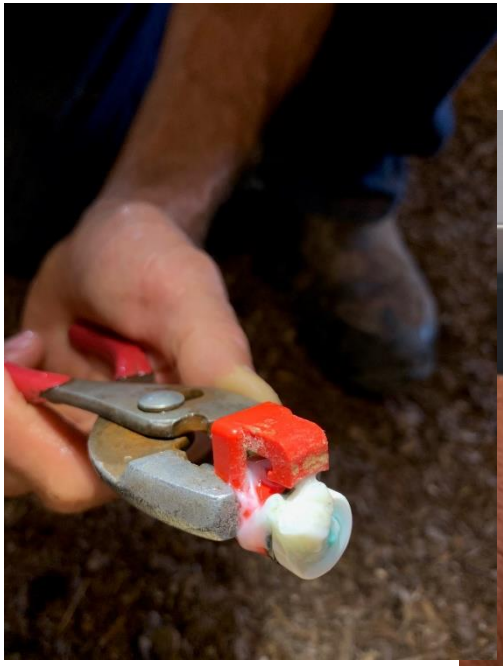
- Microbial control benefits of organic acids center around the weak acid remaining intact
  - Weak acid does not want to give up its H^+
- Can readily enter microbial cell where the higher pH of the cell causes the weak acid to give up its H^+
- Cell frantically tries to pump out the H^+- the work load kills the cell

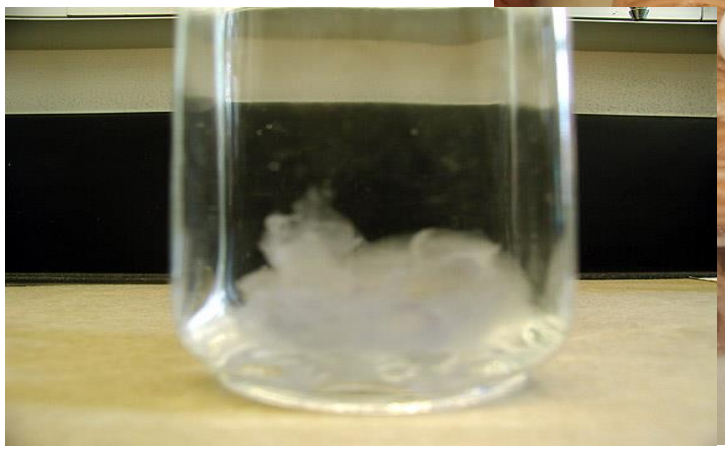
pH Bottom Line

- Focusing only on pH without understanding the alkalinity or buffering capacity of the water as well as what type of acid can lead to problems
  - Adding acetic acid to water with a high buffering capacity won't give much pH drop but the presence of the weak organic acid can still provide gut health benefits
  - Dropping the pH of water with little or no alkalinity and naturally low pH can be detrimental to bird performance

Slime challenges

- Increased organic acid use for gut health and food safety- resulting in water system slime issues
- Isolated following:
  - Pseudomonas aeruginosa
  - Brevundimonas vesicularis
- Conducted disinfectant sensitivity test

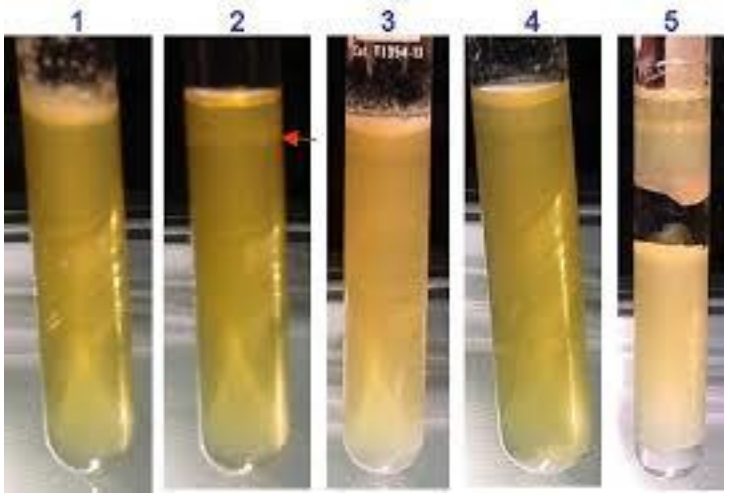




Disinfectant sensitivity

- 50 % stabilized H2O2
  - 2 ml/128 ml stock solution
  - Add 1:128
- 10% sodium hypochlorite
  - 4 ml/128 ml stock solution
  - Add 1:128
- 56% acetic acid
  - 1 ml/128 ml stock solution
  - Add 1:128
- Acetic acid/bleach
  - Combined at above rates
- Acetic acid/H2O2
  - Combined at above rates
- Control-no treatment

- 100 ul of each product/combo added to 3 BHI tubes per organism



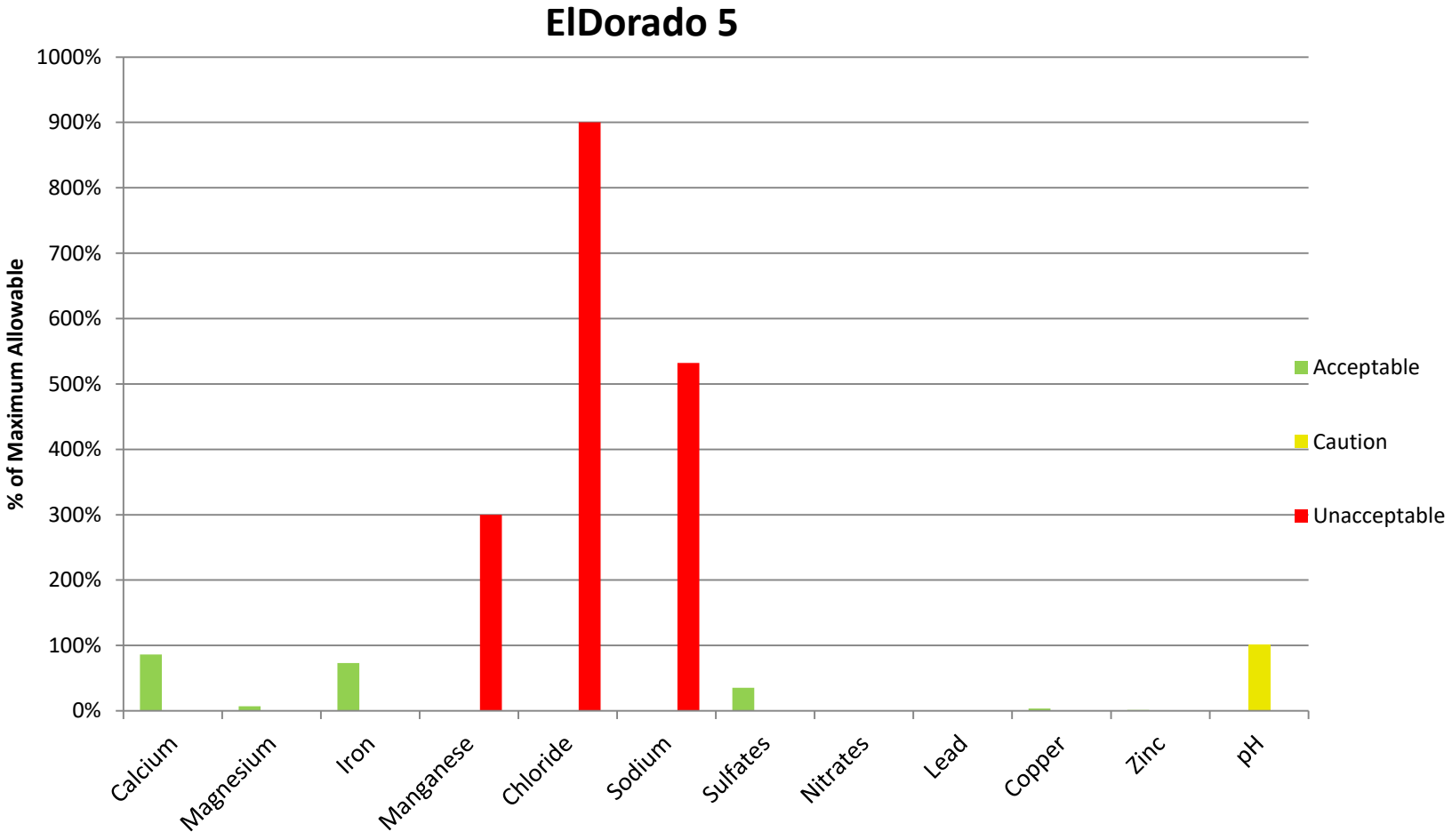
Results-Organism response (24 hours)

Treatment	P. aeruginosa	B vesicularis
Acetic acid	**1 in 3 tubes (24 hours)**	**3 in 3 tubes (48 hours)**
H2O2	**3 in3 tubes**	**No growth**
Bleach	**No growth**	**No growth**
Acetic acid/H2O2	**No growth**	**No growth**
Acetic acid/bleach	**No growth**	**No growth**

Control-3 of 3 growth for both organisms (24 hours)

Analyze water for mineral content

some issues must be fixed
to prevent production challenges



Checklist for Water Mineral Analysis

- pH
- Minerals
  - Sodium
  - Chloride
  - Iron and manganese
  - Calcium and magnesium-Hardness/alkalinity
    - Bicarbonate (HCO_3)
  - Nitrates/nitrites
  - Sulfur-sulfates
  - Heavy metals-lead, arsenic, copper

Mineral Analysis Provides Valuable Information for Treatment

Sample ID	B	Mg	Ca	Mn	Fe	Ba	S	Na	Cl	pH
Farm A	0.09	1.54	4.74	N.D.	0.02	0.07	3.53	3.38	0.12	3.79
Farm A	0.23	1.49	4.32	0.01	0.01	0.07	8.97	7.65	N.D.	3.71
Farm A	0.08	1.54	4.36	0.02	0.02	0.07	2.94	2.74	N.D.	4.60

Acid water common in sandy soil areas

Symptom-Low weights, high feed conversion but good livability, poor water consumption

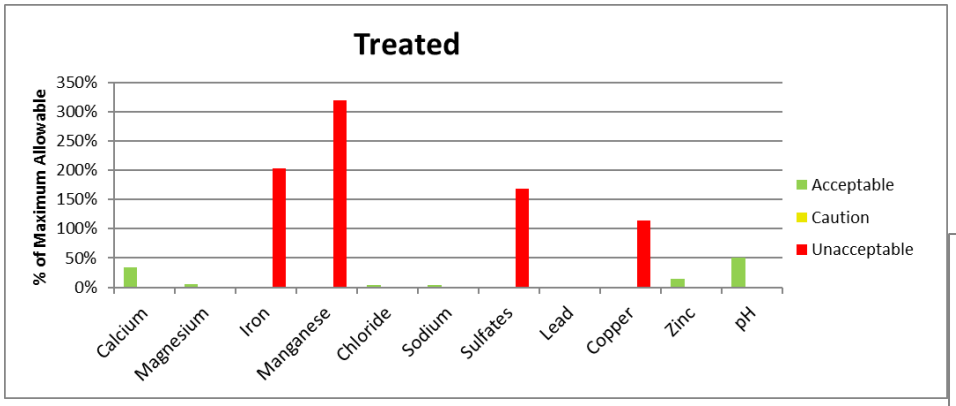
Diagnosis-water with low pH

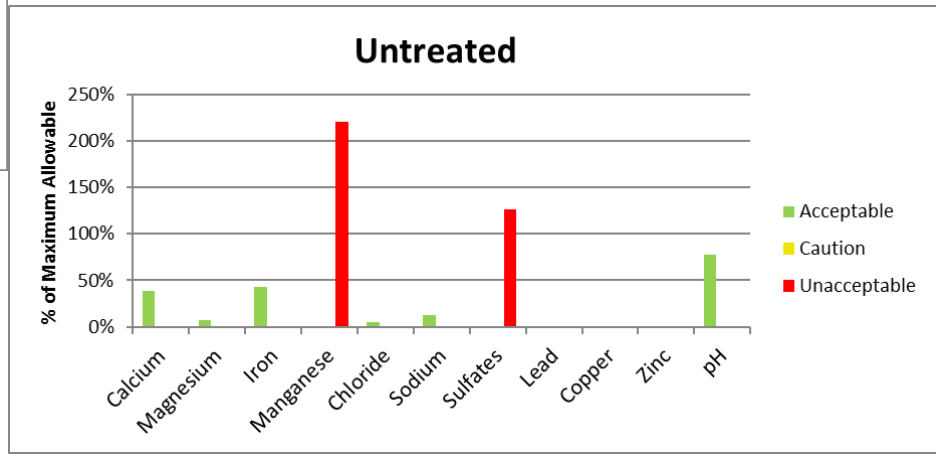
and very little mineral content to provide buffering capacity

Solution: Neutralize with sodium bicarbonate/carbonate

Check Pre and Post Treatments
Treatment may not be working

Farm 9	Calcium	Magnesium	Iron	Manganese	Chloride	Sodium	Sulfates	Sulfur	Lead	Copper	Zinc	pH
After Cl & Filter												
Treated	36.7	7.12	0.61	0.16	6.51	6.41	337.87	113	N.D.	0.68	0.22	4.1
Untreated	42.6	8.95	0.13	0.11	6.61	18.20	251.45	84.1	N.D.	N.D.	N.D.	6.24
Unacceptable Levels	121	137.5	0.33	0.055	165	165	220	220	0.055	0.66	1.65	8





Minerals that are biggest challenges

- Iron-red water
- Manganese- black solids
- Sulfur-black solids or rotten egg smell
- Small quantity- bitter metallic taste for people
  - .3 ppm Fe-Iron
  - .05 ppm Mn-Manganese
  - ~250 ppm Sulfate
- Birds not sensitive to mineral tastes
  - Pigs more sensitive??
- Promote the growth of organisms
  - Form heavy gelatinous stringy masses
  - Reduces pipe volume
  - Clogs drinkers
- Promotes *Pseudomonas* and *E. coli*, other pathogens
- Mineral deposits cause drinkers to stick
- Hydrogen sulfide bacteria (rotten egg smell) can airlock water lines
- Over time can create scale in pipe-water quantity issue
- Chlorinate and then filter to remove

Hardness/Alkalinity

- Hardness-Calcium and magnesium
  - Birds very tolerant ~250 ppm
  - Primary concern is mineral deposit on equipment and pipes
- Alkalinity-Refers to the amount and types of chemicals that can shift pH > 7
- Usually expressed as calcium carbonate ($CaCO_3$)
- Also dependent on bicarbonate, (HCO_3), and sulfate (SO_4)
- Poisons in nature usually alkaloid so high alkaline, content may back birds off water

Cool Cell tank needs extra management with Alkalinity issues

Water Sample	Iron	Copper	Calcium	Sulfates	Sodium	Chloride	pH
Well	0.05	.01	28	5	46	228	8.63
Recirculation Tank	0.29	.07	7.54	439	126	2302	9.88

Diagnose this water

WATER ANALYSIS REPORT:
Complete Test

pH	7.98	Ca(Calcium)	26.00 mg/l
Hardness	88 mg/l	Mg(Magnesium)	5.70 mg/l
Conductivity	1837 umhos/cm	Na(Sodium)	342.20 mg/l
Fe(Iron)	0.17 mg/l	K(Potassium)	6.10 mg/l
Mn(Mangenese)	0.02 mg/l	SO4(Sulfate)	0.06 mg/l
NonPurageable Organic Carbon-	0.00 mg/l	Cl(Chloride)	449.69 mg/l
HCO3(Bicarbonate)	245.6 mg/l	Cu(Copper)	0.00 mg/l
Aggressive Index	12.32	PO4(Phosphate)	0.25 mg/l
Aggressive Index is	LOW	NO3(Nitrate)	4.12 mg/l
Nitrate-Nitrogen(NO3-N)	0.93 mg/l	Fluoride(F)	0.89 mg/l

Aggressive Index - is a general indicator of the tendency for corrosion to occur and should be used with proper reservation.
(Highly Aggressive- <10, Moderately Aggressive- 10 to 12, Nonaggressive- >

Diagnose this water

WATER ANALYSIS REPORT:
Complete Test

pH	6.89	Ca (Calcium)	3.10 mg/l
Hardness	11 mg/l	Mg (Magnesium)	0.77 mg/l
Conductivity	258 umhos/cm	Na (Sodium)	52.60 mg/l
Fe (Iron)	0.20 mg/l	K (Potassium)	1.70 mg/l
Mn (Mangenese)	0.00 mg/l	SO4 (Sulfate)	3.31 mg/l
NonPurageable Organic Carbon	0.00 mg/l	Cl (Chloride)	12.33 mg/l
HCO3 (Bicarbonate)	111.9 mg/l	Cu (Copper)	0.02 mg/l
Aggressive Index	9.98	PO4 (Phosphate)	1.20 mg/l
Aggressive Index is	HIGH	NO3 (Nitrate)	0.04 mg/l
Nitrate-Nitrogen (NO3-N)	0.01 mg/l	Fluoride (F)	0.15 mg/l

Aggressive Index - is a general indicator of the tendency for corrosion to occur and should be used with proper reservation.
(Highly Aggressive- <10, Moderately Aggressive- 10 to 12, Nonaggressive- >

Is there enough water?

- RainWave available at Amazon.com ~$15
- Can be used to check gallons/liters flow
- Also useful to check medicators

Injector Verification

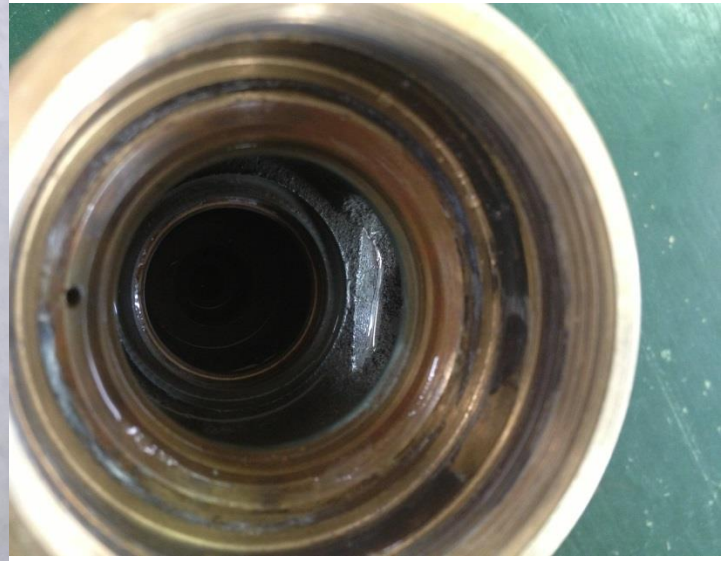
- Has the injector/medicator been checked to assure it injects the proper amount?
  - Best done by running 80-100 liters
  - Only running 4-8 liters not enough to accurately evaluate the injection rate
  - Also note the liter per minute rating of medicators-
    - Undersized medicators create water restrictions

Pressure Reducers Require Maintenance

- Pressure reducers have screen which can clog
- Acids can damage
- Remember volume and pressure are not the same


Do injector connectors
restrict flow?

Make sure connectors and hoses do not restrict flow



Watkin's List
Most Significant Water Challenges

- NO or POOR System Cleaning between flocks
- Failure to implement a water program that complements the water system's strengths and weaknesses
- Lack of consistency
- Reliance on water system to deliver therapeutics
- Failure to make water management part of the company culture

Problem solving water: Start with the right questions

- What is the water supply?
  - Municipal
  - Well
  - Pond/Stream/Spring
  - Combination of the above
- Water test
  - Minerals
  - Bacteria
  - Drip and swab samples?
  - When was the last test?
- How old is the water system?
  - Drinkers
  - Plumbing
  - Distribution lines
- Has a thorough water system inventory been conducted?
- Has there been any changes or work to the water system?
- Does the producer clean the system between flocks?
  - How?
  - With what?
  - The whole system?
- What products are used in the water?
  - Sanitizers
  - Acids
  - Vitamins/Electrolytes
  - Probiotics
  - Other?

The Watkin's Water Recipe

- Accept water can create risks for flocks
- Identify and quantify water contaminants
  - Minerals, pH
  - Bacteria, yeast, mold, other
- Prepare a strategy to reduce/eliminate challenges
- Use between flock line cleaning to reduce challenges
- Utilize a daily water sanitizer best suited for the operation
  - Compatible with water
  - Easy to use
  - Easy to monitor
  - Cost effective-in the scheme of things
- Monitor and verify program works
- If you believe in a water program, your people will too