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Coliforms - Control and Disinfection 2021

John Doe ▪ 16-08-19 ▪ Location

Coliforms Indicate

Since we believed that they lived only in the gut of animals, we reasoned their presence in water indicated contamination from a waste-water source.

What Kind of Bacteria are Coliforms?

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"Mixed group of bacteria that are found in the gut of warm blooded animals and free living in the environment"

More importantly they are *facultative organism* meaning they can liv
or without oxygen.

The problem is……

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Coliforms are found free living in the environment, able to reproduce and live in a natural area over an extended period.

Regulations, however dictated that if coliforms are detected the systems must be disinfected o shut down.

Coliforms: Control & Disinfection

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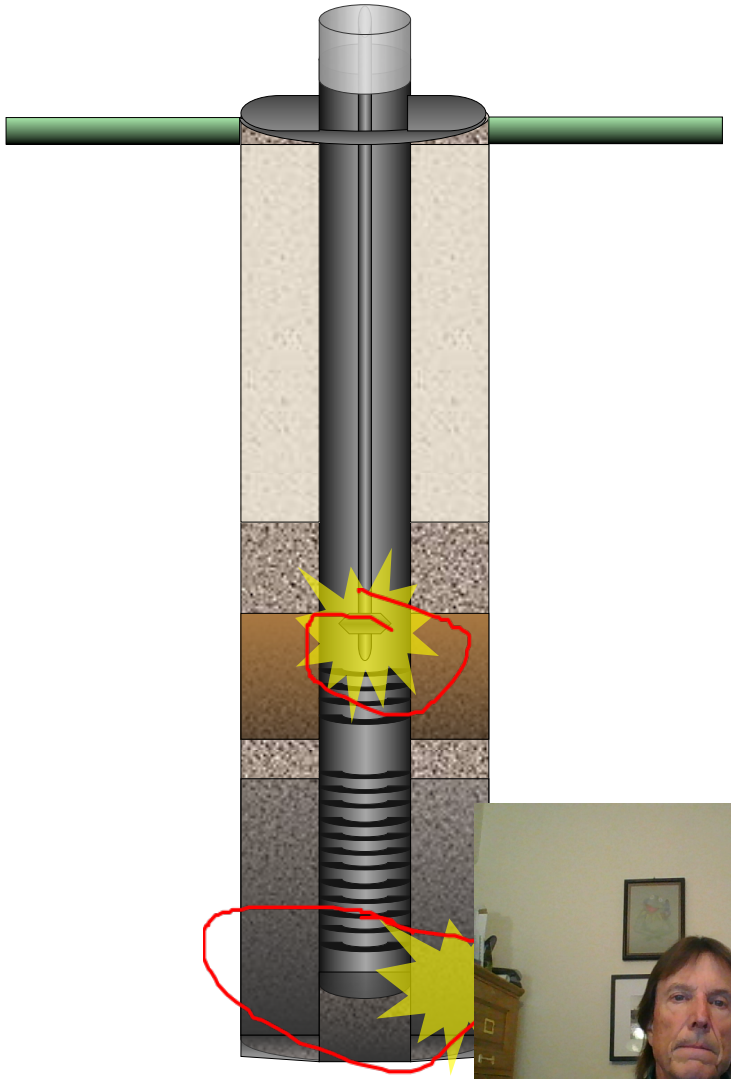
- Can exist in both aerobic and anaerobic environments
- May impact where the organism is and how we respond



Overview of Response Steps

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So the Coliform test hit Positive…

- Are fecal coliforms present?
- What is the coliform species and what are the likely sources?
- How many are present?
- How does this information tie in with the well use, formation, site, etc.?

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How has the well been utilized?

Most coliform occurrences are tied with fouled wells and/or wells that have been idle or out of service for an extended period

Facts About Bacteria

- For every free swimming organism there are as many as 1×10^6 bacteria (a million) residing in Biofilm
- Attached Biofilm is the natural habitat for bacteria

Biofilms & How They Form

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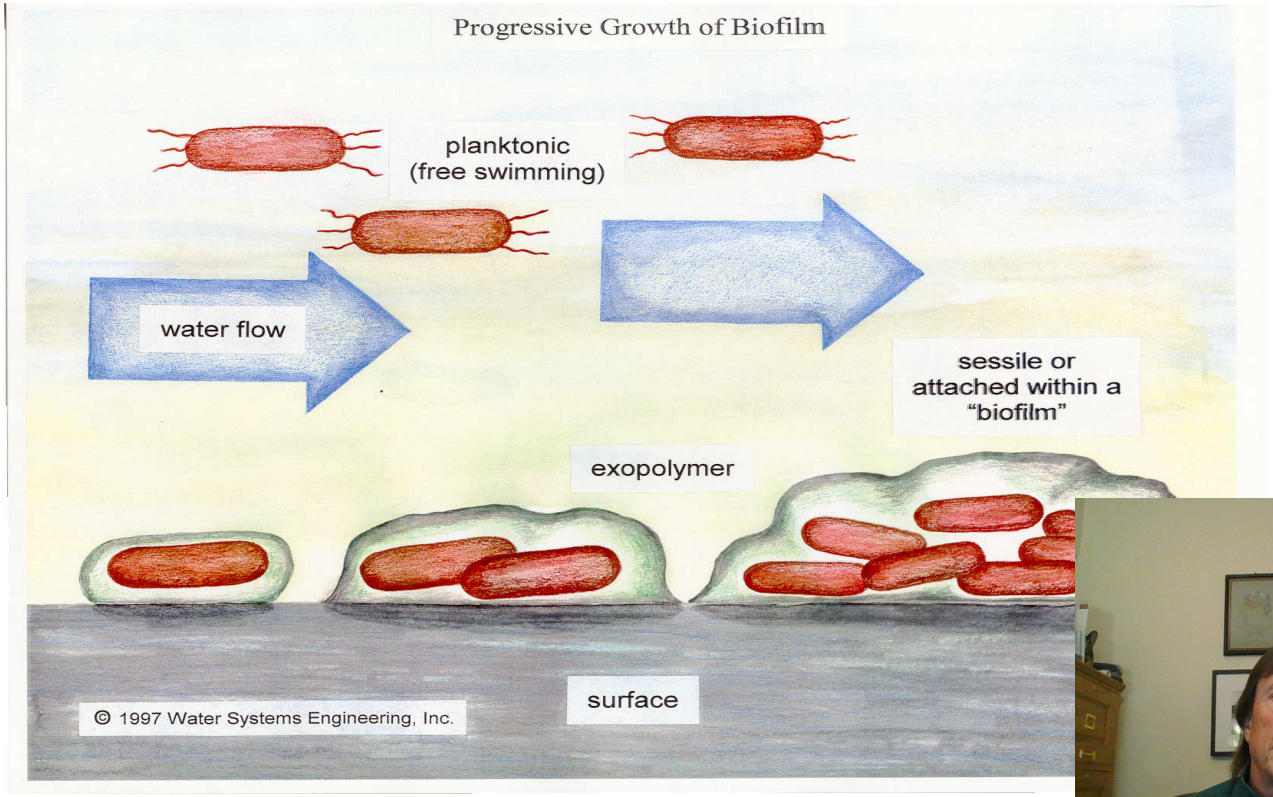
For every free swimming organism there are as many as 1 x 10^6 bacteria (a million) residing in Biofilm

Attached Biofilm is the natural habitat for bacteria



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How do we respond?

- ID the Problem
- Pump the Well
- Clean the Well *if necessary*
- Chlorinate *Correctly*
- Keep the Well Active

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Common Problem Indicators:

- **Anaerobic occurrence greater than 20%**
- **Larger "resident" bacterial populations**
- **Excessive presence of**
  - **Slime forming bacteria and/or**
  - **Sulfate Reducing Bacteria (SRBs)**

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Investigate the Well

- Does the well show signs of flooding, erosion, surface impact or subsidence?
- Does the well show signs of corrosion?
- Is the well site secure and free of possible impact?
- Is the recharge area susceptible to influence?

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Pump the Well

- Purge the stagnant water column
- Evacuate the bottom of the well
- Clean out debris that may be influencing the coliform occurrence and/or reducing the effectiveness of disinfection efforts

Pumping the Well to Remove Detritus

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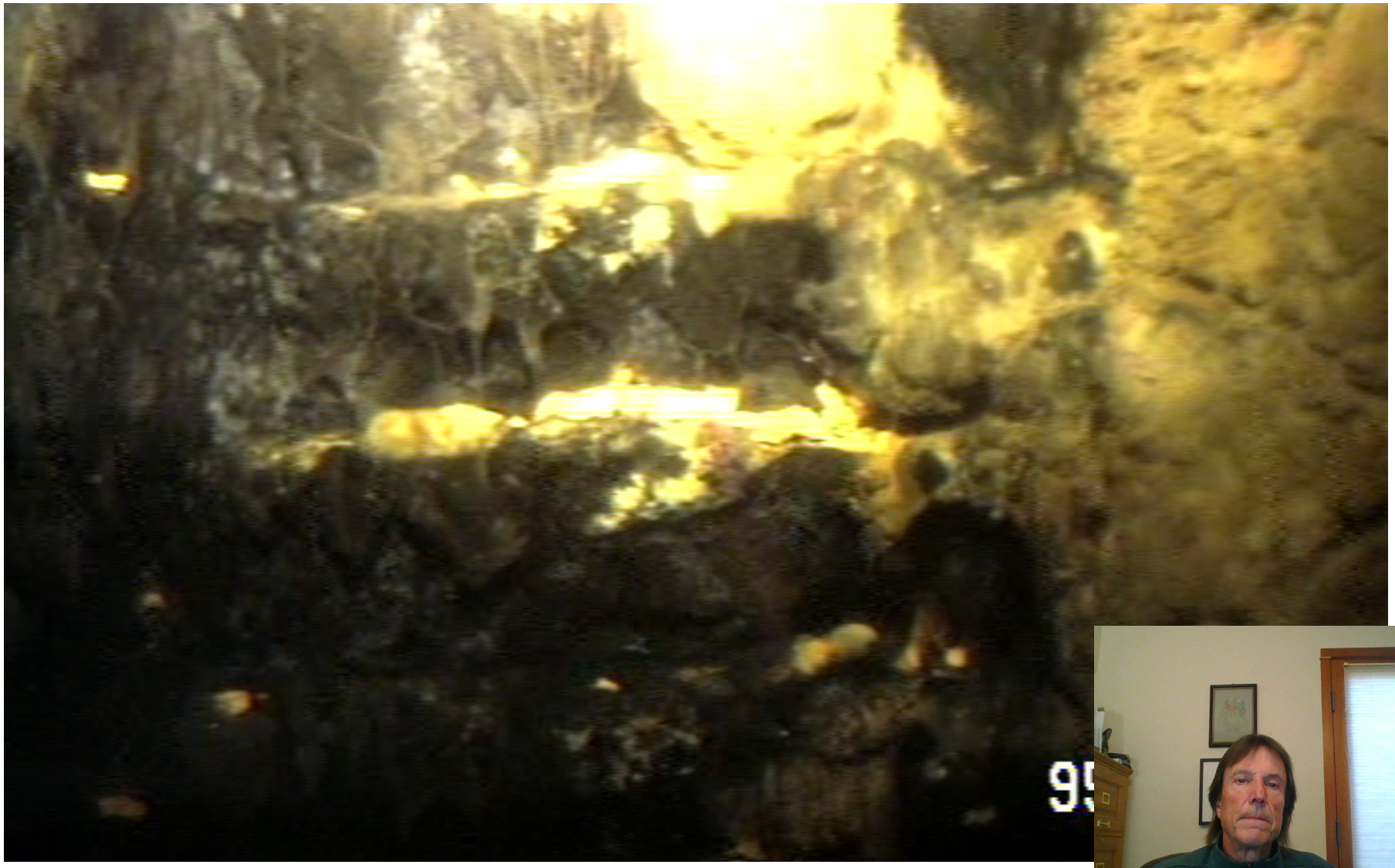

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Clean the Well? For Coliforms?

- Laboratory studies have shown that most environmental coliform occurrences are a result of a dirty well
- Biomass and scale accumulations provide hiding places for coliforms and reduce the effectiveness of treatment efforts

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Cleaning the Well

- When Coliforms are present, cleaning the well should incorporate a combined chemical and mechanical cleaning
- Including removal of the pump and cleaning of all associated parts

Chlorination for Disinfection

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- Myth of “shock chlorination”
- Choosing the right Chlorine
- Controlling the pH
- Targeted Treatment Area
- Contact Time

Location of Coliforms

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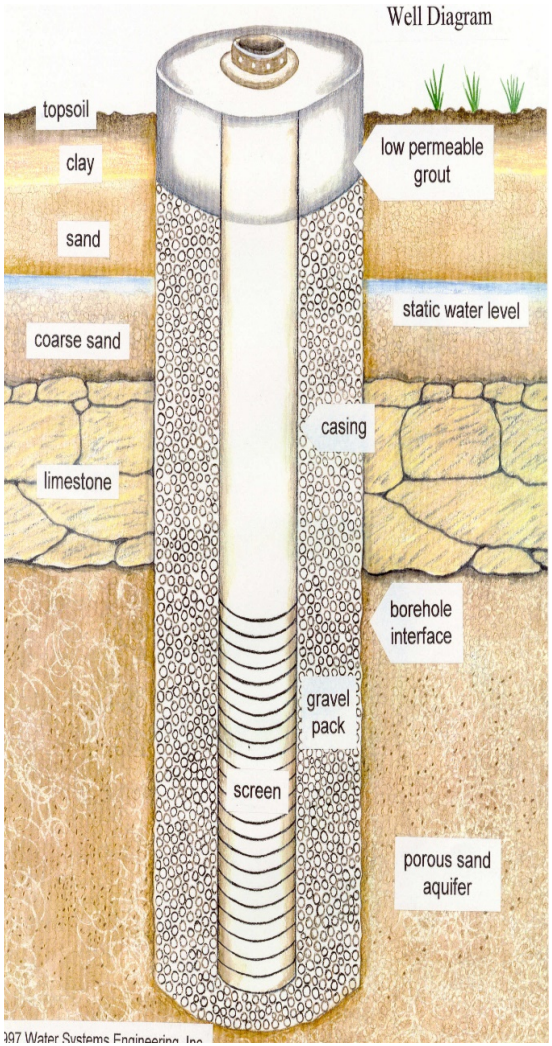
Coliforms can be located in the biofilm deep in the well



Well sump or bottom has accumulation of anaerobic biofilm and other debris which hide the coliform

Effects of Chlorine on Biofilm

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Chlorine changes the slimy polysaccharide to a more dense less soluble material.

Chlorine is over 1500 times less effective against bacteria that are in a biofilm.

Chlorine damage can be accur

Effects of Chlorine on Biofilm

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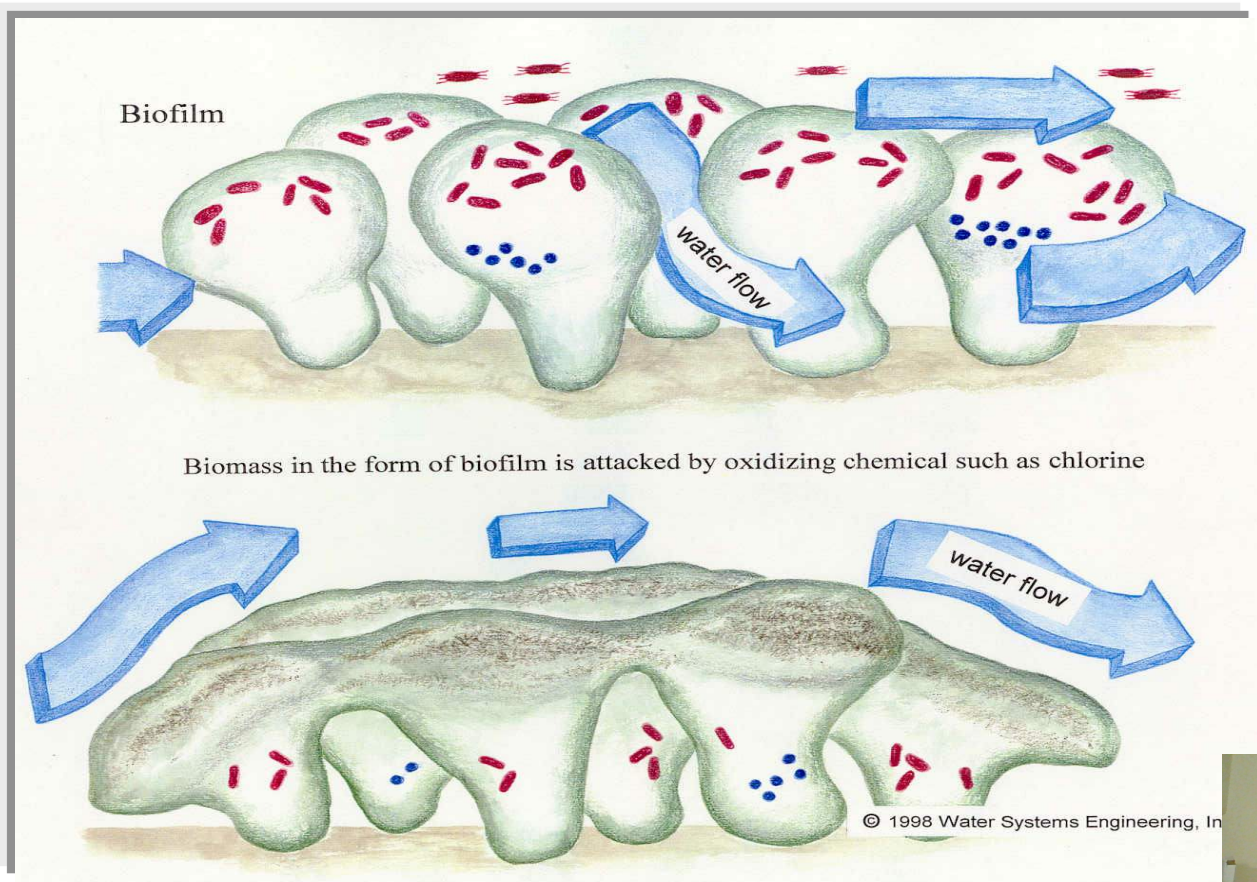

What is the Significance?

- That the facultative bacteria, the coliforms uses the anaerobic dominant biofilm as a protective habitat from the chlorine.
- That disinfection must incorporate mechanical and other means to reach these areas (“Cleaning”).

What needs to be done

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1. Rule out contamination from a waste-water source.
2. Rule out contamination from poor construction or structural failure.
3. Incorporate cleaning procedures as part of the disinfection process.
4. Use pH control when chlorinati

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Laboratory Study *"Effective Levels of Chlorination"*

Laboratory Study

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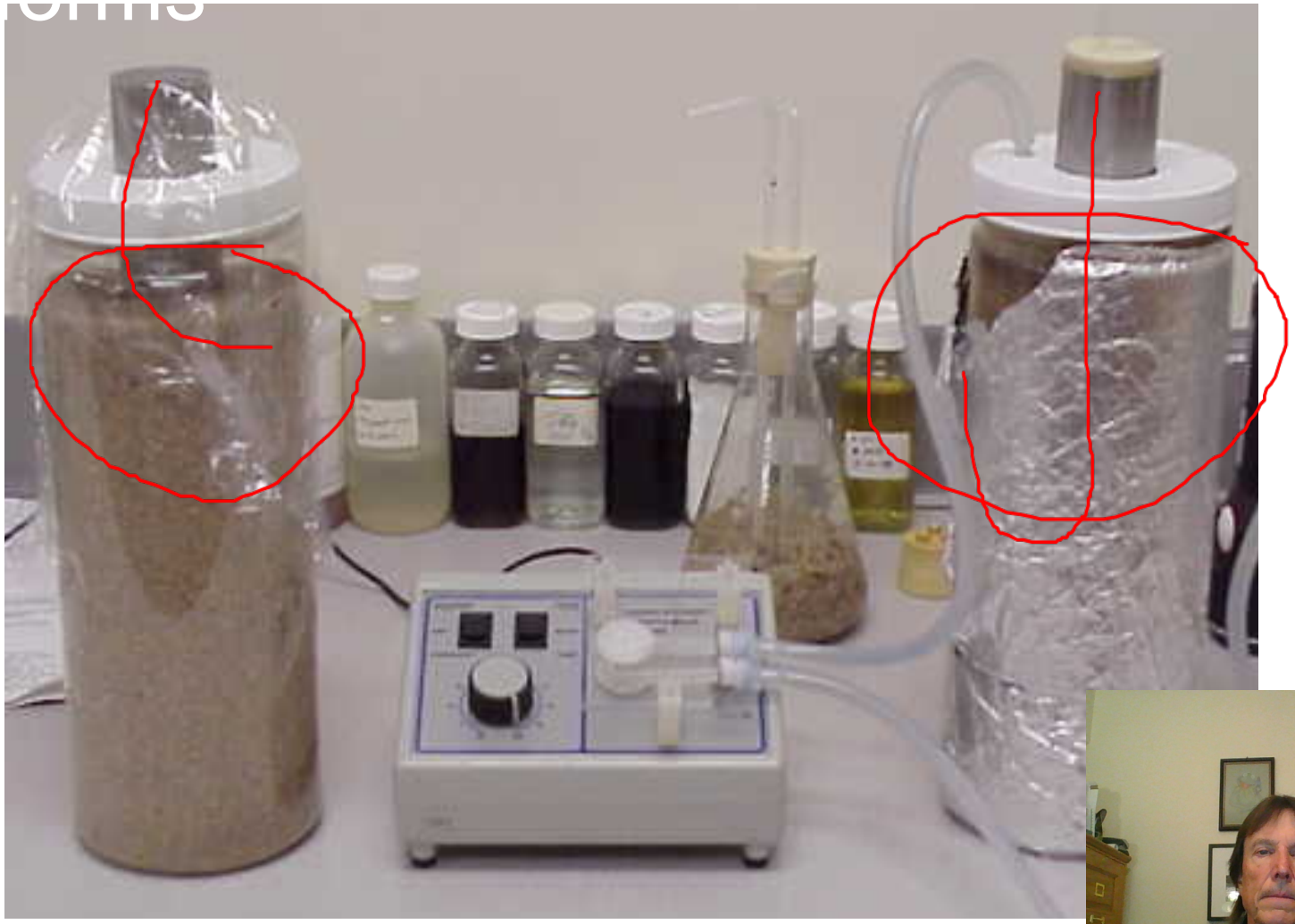
Flasks used to produce an aerobic biofilm in the laboratory.

Typical incubation period for a strong biofilm is about ten days

Mock Wells with Both Aerobic and Anaerobic Biofilms with



Concentration Levels

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Mock wells were treated at various chlorine levels:

20 mg/l 50 mg/l 100 mg/l 200 mg/l

500 mg/l

Super Chlorination

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Wells were treated at super chlorination Levels of :

1000 mg/l

2000 mg/l

5000 mg/l

Finding of Laboratory Study

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Most effective levels were the 50 mg/l and the 200 mg/l of chlorine

500 mg/l failed about 50% of the time

Effectiveness was measured as a function of zero coliforms in the pumped discharge.

- All Levels of Super Chlorination failed as a function of total coliform removal

Why Did Chlorine Fail at The Higher Dosages ?

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- High Concentrations are Very Oxidative
- Strong Oxidation Changes the Polysaccharide to a more protective film
- Higher Levels of chlorine are > pH 10
- High pH Promotes Mineral Precipitation which can hide and protect bacteria

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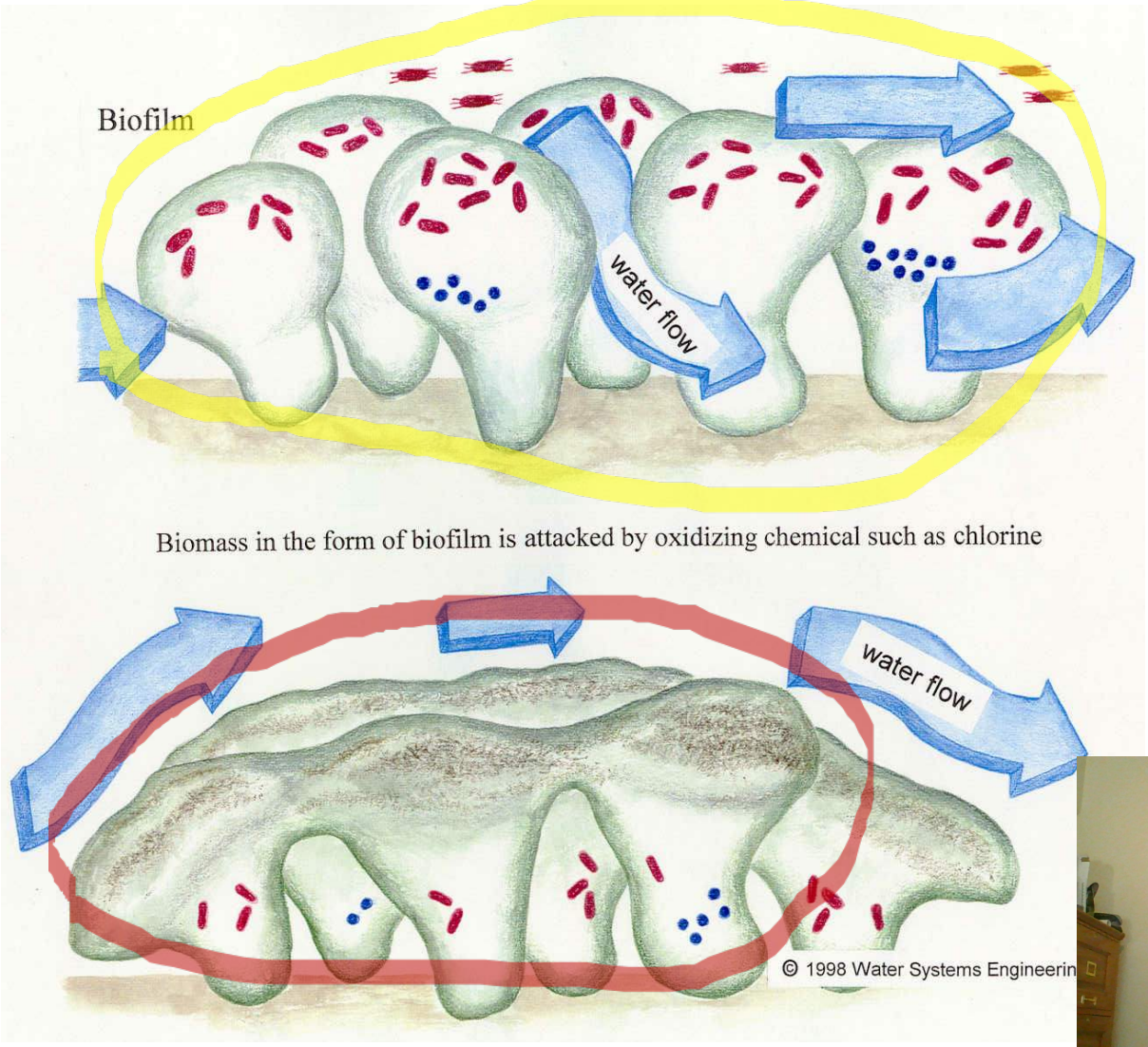

Chlorine Guidelines

- Fresh, active form
- Target concentration:
  - Disinfection: 50 – 200 ppm
  - Development: 1200-1500 ppm
- Compatibility with other chemicals (Oxidizer – hydrogen peroxide, ozone)
- pH buffering, if necessary (target pH: 6.5-7.25)
- Safety:
  - Off-gassing
  - Reactivity with other chemicals
  - Corrosion

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Chlorine Choices

- Chlorine Gas Cl_2
- Calcium Hypochlorite $Ca(OCl)_2$
- Sodium Hypochlorite NaOCl

Calcium Hypochlorite $Ca(ClO)_2$

- Granular or tablet
  - Must be dissolved
- Variety of trade names
- Physically changes with exposure, chemically degrades
- 20 - 73% strength
- Adds calcium to the well

Sodium Hypochlorite NaClO

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- **Liquid “bleach”***
- **Strength between 4 – 15%***
- **Degrades with time, exposure**
- **Buffered for safety**
- **Household variety is often blended with surfactants, perfumes**

** Less common granular form available*

Improving Chlorination

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Improving Chlorination for Disinfection:

- Control the pH
- Flood the Well Improving Dispersal of the chlorine solution
- Allow Sufficient Contact Time
- Monitor the Reaction

Effects of pH on the Hypochlorite Ion

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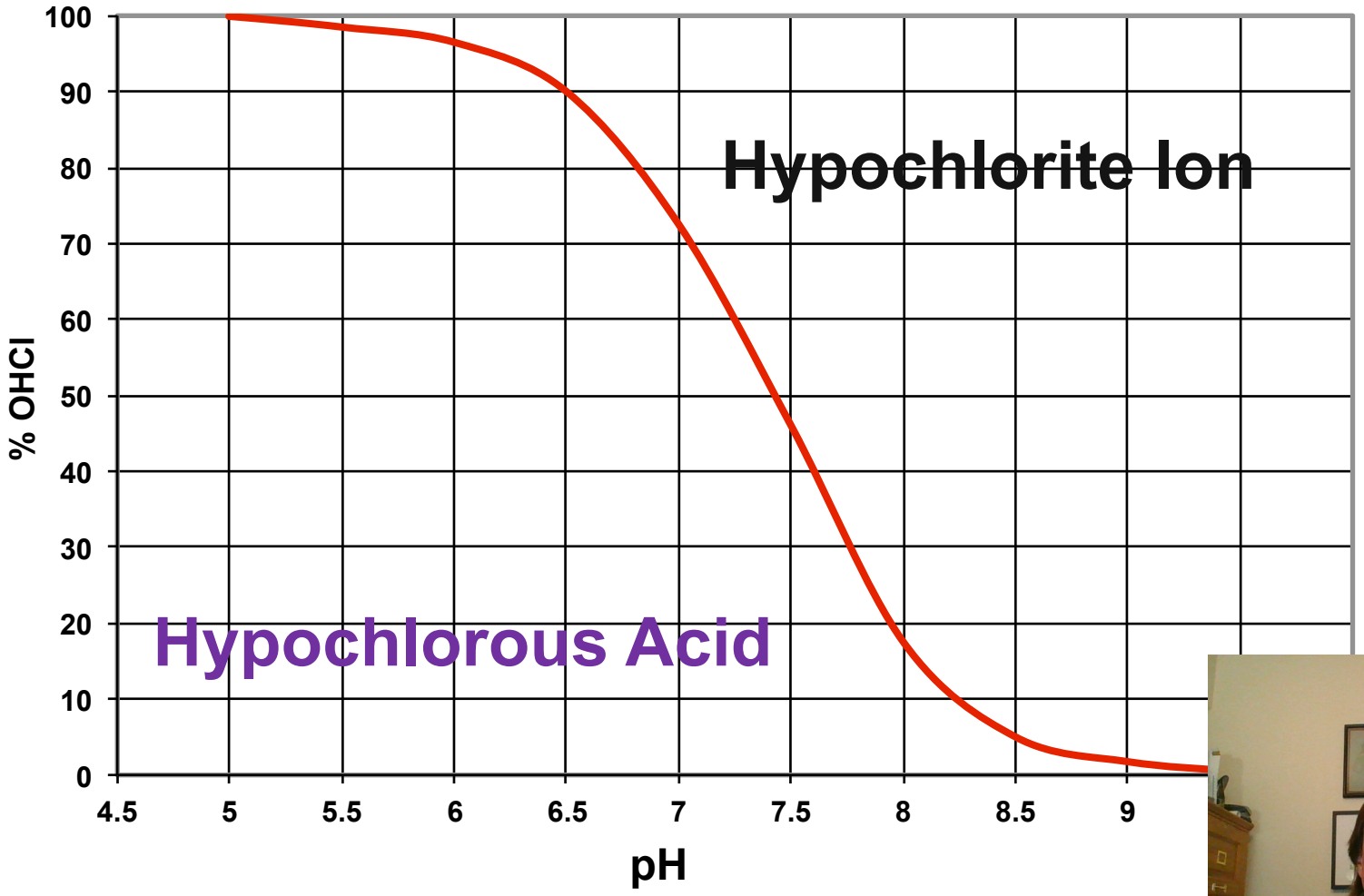

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How do I adjust the pH?

- There are a number of commercial products available that bring additional benefits such as improved penetration of the chlorine solution and control of the excess hardness in the water.

- Only products which are dosed according to the alkalinity of the water, the level of hypochlorite used, and the volume to be adjusted should be considered.

- Typically offer secondary benefits:
  - Secondary cleaning / bio-penetration
  - Increase of treatment zone

NuWell 410 Chlorine Enhancer Application

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Amounts of NuWell 410 Chlorine Enhancer and chlorine disinfectant needed per foot of static well depth.					
Nominal Well Size	Well Volume in (Gal/Ft)	Amount of NuWell 410 (Quarts/Ft)	Amount of Chlorine Product		
			CaHypocl-65% (Lbs/Ft)	SodHyp-12% (Gal/Ft)	SodHyp-5% (Gal/Ft)
2	0.16	0.0007	0.0004	0.0003	0.0006
3	0.37	0.0015	0.0010	0.0006	0.0014
4	0.65	0.0026	0.0017	0.0011	0.0025
5	1.02	0.0041	0.0027	0.0017	0.0039
6	1.47	0.0059	0.0038	0.0025	0.0056
8	2.62	0.010	0.007	0.004	0.010
10	4.09	0.016	0.011	0.007	0.016
12	5.89	0.024	0.015	0.010	0.022
14	8.02	0.032	0.021	0.014	0.030
16	10.47	0.042	0.027	0.018	0.040
18	13.25	0.053	0.034	0.023	0.050
20	16.36	0.07	0.043	0.028	0.062
22	19.80	0.08	0.051	0.034	0.075
24	23.56	0.09	0.061	0.040	0.090
26	27.65	0.11	0.072	0.047	0.105
28	32.07	0.13	0.083	0.055	0.122
30	36.82	0.15	0.096	0.063	0.140
32	41.89	0.17	0.109	0.071	0.159
34	47.29	0.19	0.123	0.080	0.180
36	53.01	0.21	0.138	0.090	0.201
40	65.45	0.26	0.170	0.111	0.249
46	86.56	0.35	0.225	0.147	0.329
Note: Amounts based on application of 200-ppm chlorine concentration into well water with Alkalinity of 100-ppm.					

Chlorine Calculation

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Gallons *of Chlorine*=*Total Treament Volume x Percent Chlorine/Chlorine Strength*

Example: assumes 200 ppm chlorine
Disinfect a 16 inch well, TD = 550 ft, SWL = 50ft with Sodium Hypochlorite 12% active

Step 1: Static Ht = 600ft - 50ft = 550 ft

Step 2: 550 x 10.47 gal/ft = 5758 gal

Due to well size 3 time volume recommended = 5758 gal x 3 = 17,275 gal

Step 3: Amt Ca Hyp = 17,275 gal x 0.02% (200m
12% (SodHyp) = 29 gal

Chlorine Buffering

- Monitor pH during chlorination 6.5 to 7.5
- Small chance of foaming-will dissipate-
- Mix chorine buffer into water, followed with chlorine solution, before addition downhole

Contact Time

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Minimum Contact Time Requirements

Goal: Target "1000 contact units"

$$\text{Contact Unit (hours)} = \frac{1000}{\text{chlorine concentration (ppm)}}$$

So, for 200 ppm chlorine, you'll need 5 hours

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Monitor the Reaction

- Check your pH: well water treatment solution
- Verify your Chlorine Concentration
- Verify your Chlorine Concentration

Chlorine Alternatives

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- Chlor Right, Chlorapal
- Sodium dichloroisocyanurate dihydrate
- Dose not require pH control
- Primary use disinfecting smaller, new wells
- Not as effective as buffered chlorine and no additives for removing some biofilm

Chlorine Neutralization

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- **USEPA regulations and certain state regulations dictate that no chlorine or a maximum of 1 mg/L can be discharged on to the ground or into navigable water ways or their tributaries.**
  Some have a max of 0.1 mg/L
- **Discharge following well disinfection must either be treated to remove chlorine or be hauled to a treatment facility.**

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Once treatment is finished, Keep the Well Active!

Coliform issues are common in wells that are not active. In general, strive to keep the well active. This limits stagnation and reduces the potential for biomass growth

11 Step Disinfection Protocol

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1. ID the problem, Investigate Well, Pump the Well
2. After pumping the well, remove pump and swab or brush the well. Evacuate all the debris from the well.
3. Prepare a chlorine solution in a tank large enough to contain 4 well volumes.
4. To the tank of water add a pH buffering solution.
5. After mixing add the sodium hypochlorite to achieve 50 to 200 ppm.
6. Mix the hypochlorite solution.
7. First wash down the exposed casing by adding 20% to the top of the well.
8. Tremie 20% into the area between the static and the top of the screen. Place 20% at the top of the screen, 20% midway in the screen zone and 20% at the well bottom.
9. Swab or surge the well spending at least ½ to 1 minute per foot of casing. Swab the screen area for at least 3 minutes per foot.
10. Let stand overnight or at least sufficient time to achieve 1000 contac
    Repeat swabbing at ½ time and evacuate the well. Pump a minimum
    volumes.
11. All associated piping, pump, etc. should be washed with the chlorin

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