FLOW CYTOMETRY IN COMBINATION WITH CHLORINE DISINFECTION:

APPLICATIONS FROM TREATMENT TO DISINFECTION TO DISTRIBUTION

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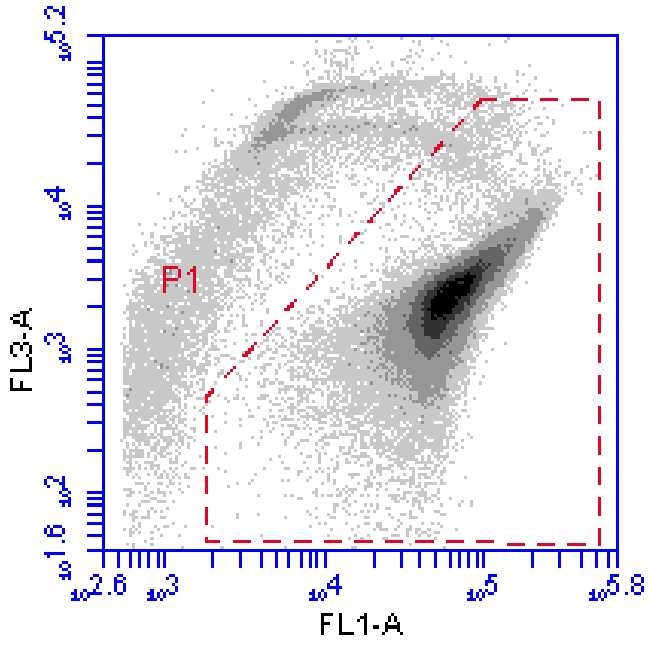
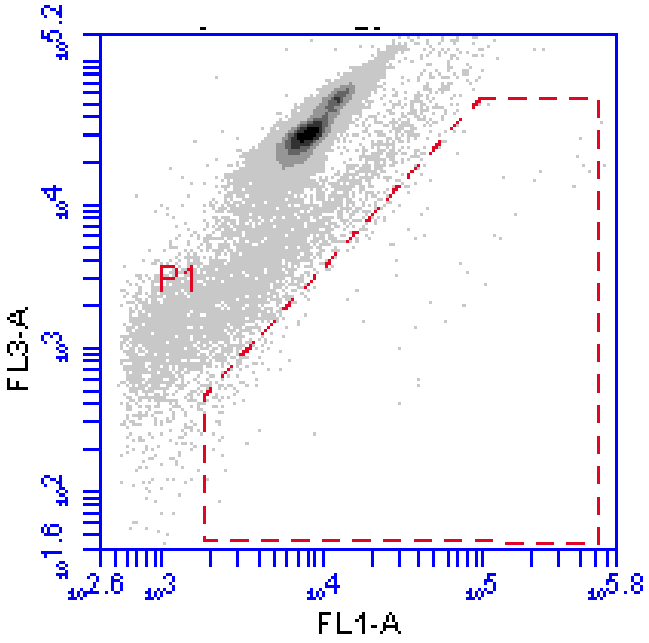
Bacterial inactivation by chlorine

Water treatment with chlorine

Before treatment:

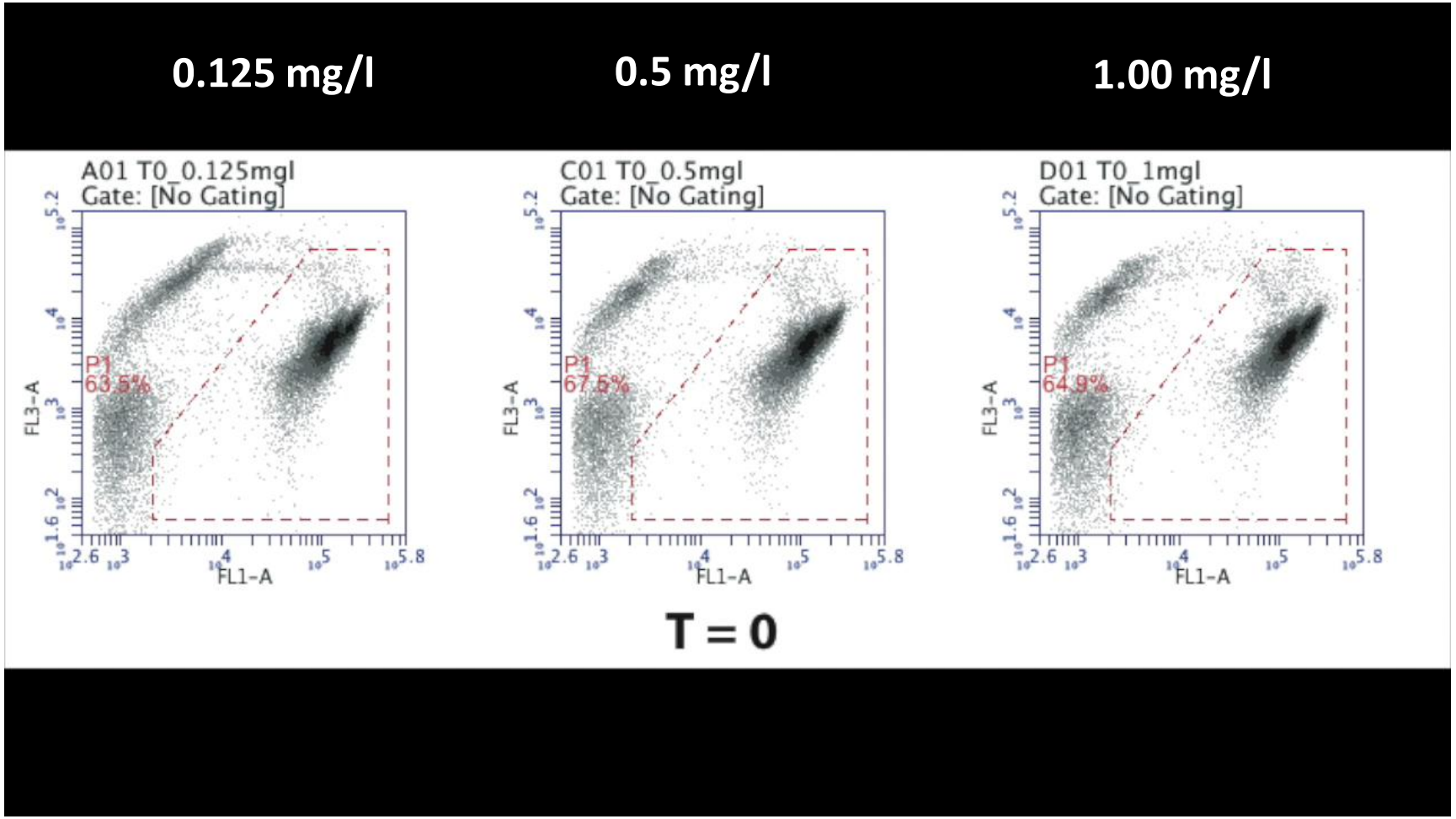


After treatment:



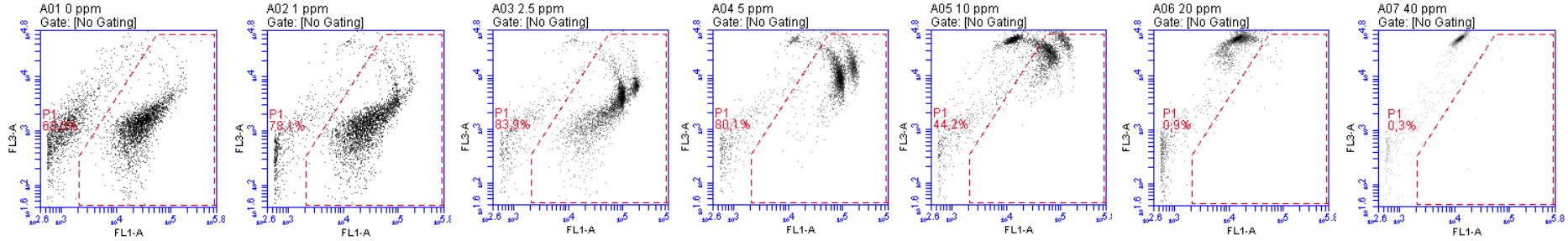
Example for successful treatment

Kinetics of chlorine treatment

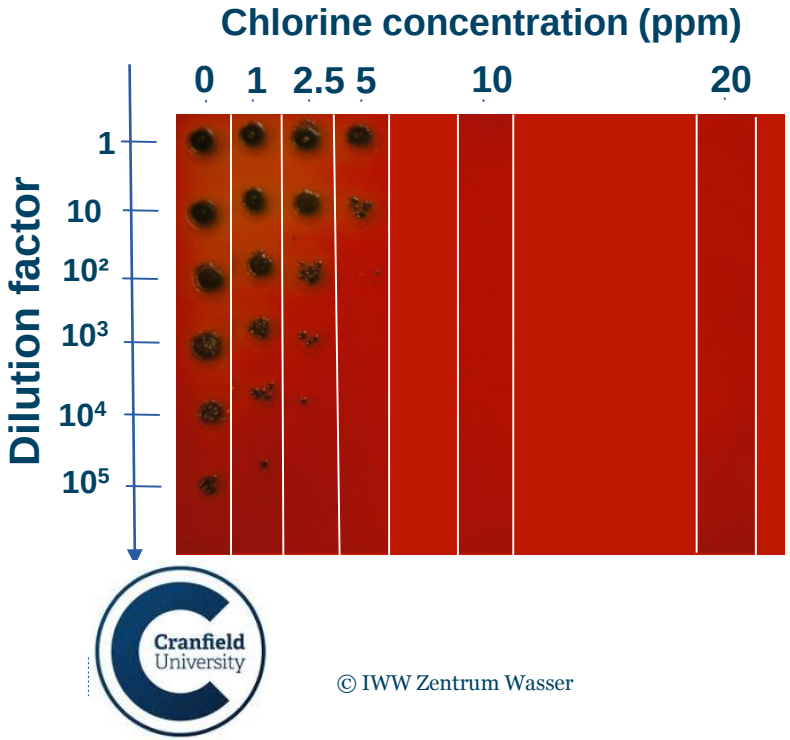


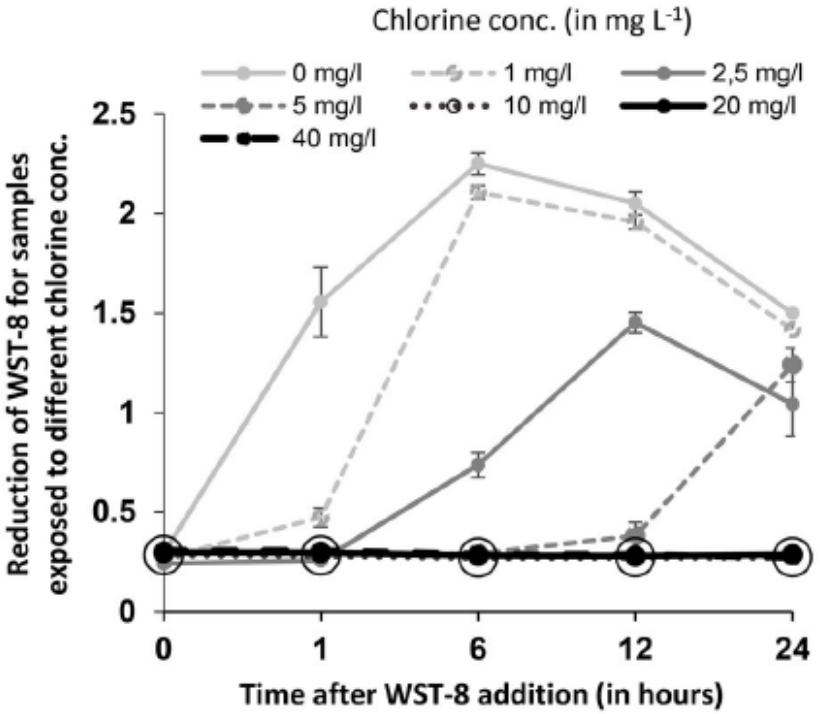
Effect of increasing chlorine concentrations

0 ppm **1 ppm** **2,5 ppm** **5 ppm** **10 ppm** **20 ppm** **40 ppm**

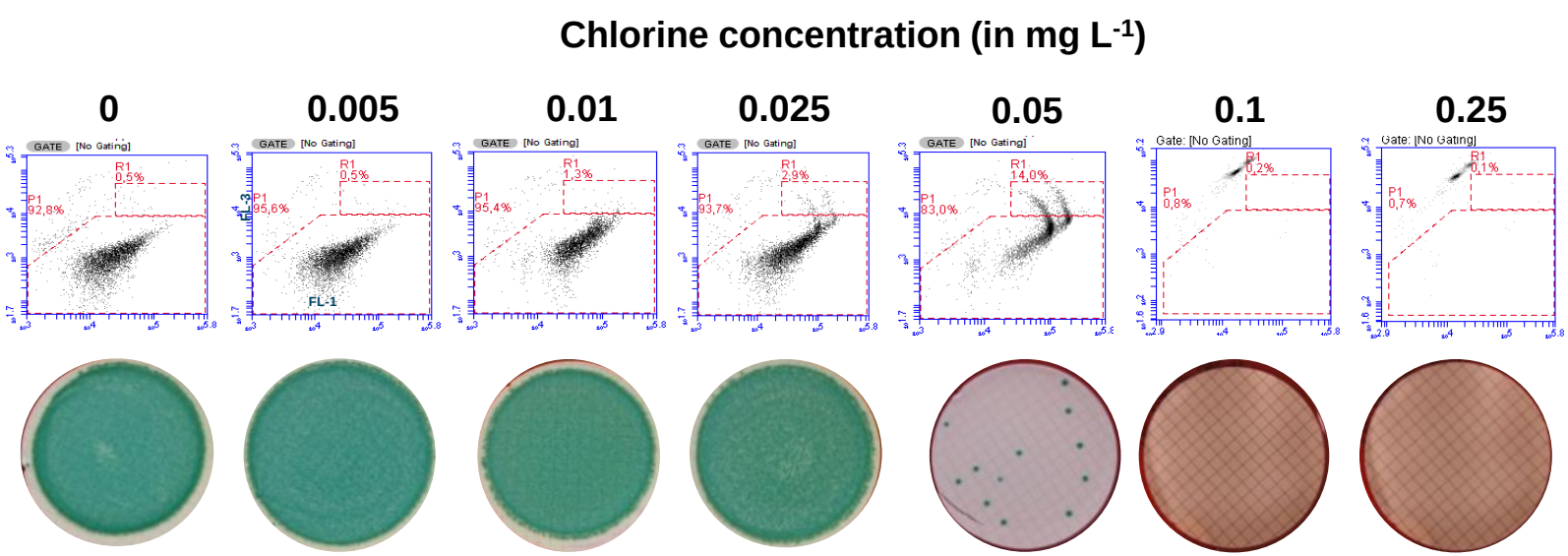


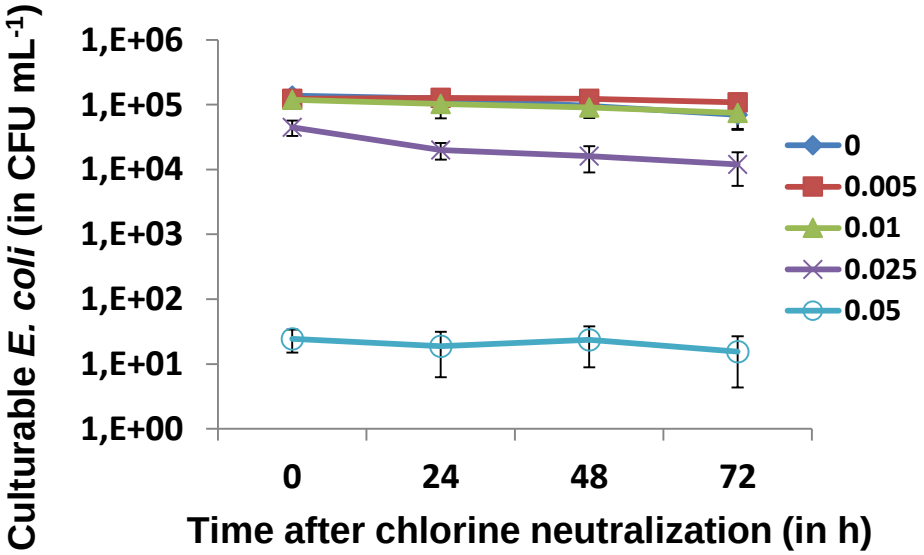
Culturability



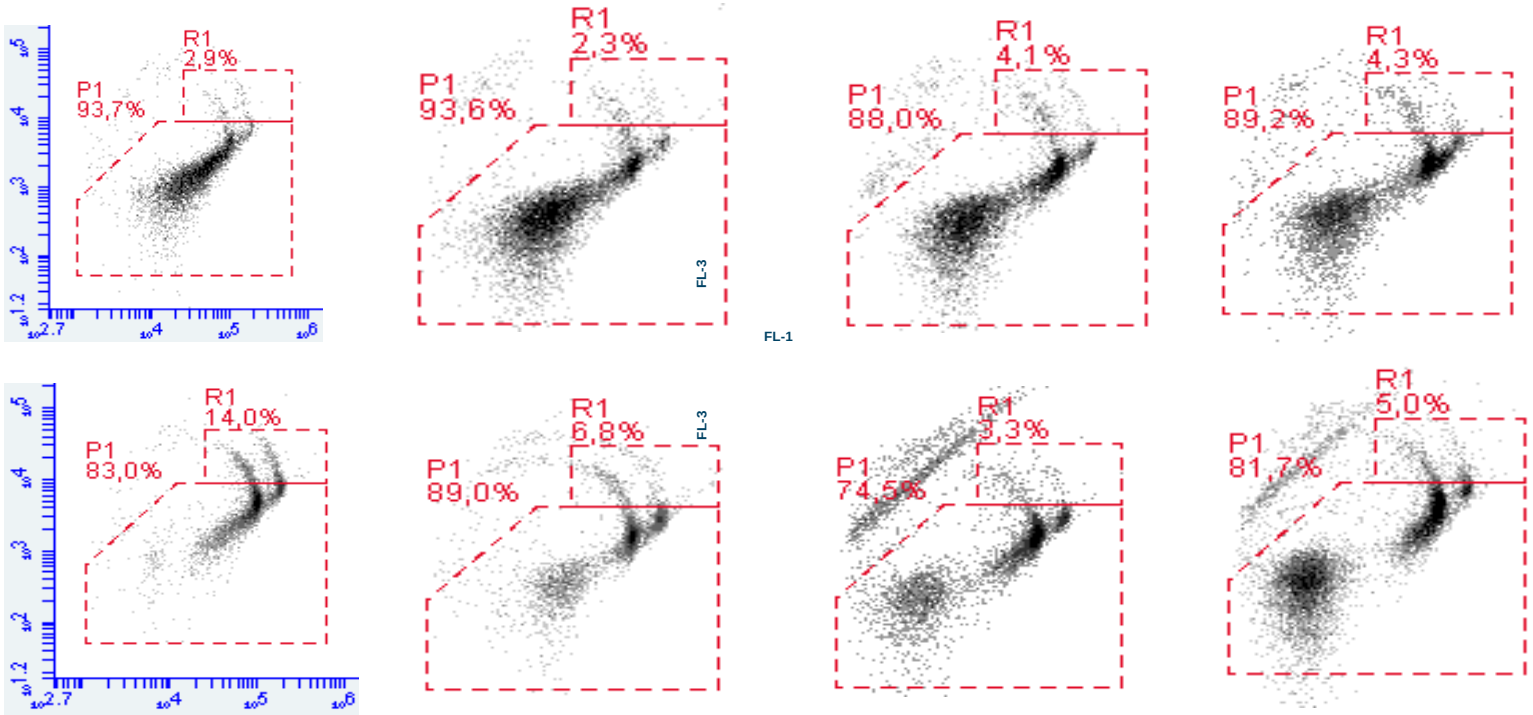


Measuring bacterial viability in chlorinated systems





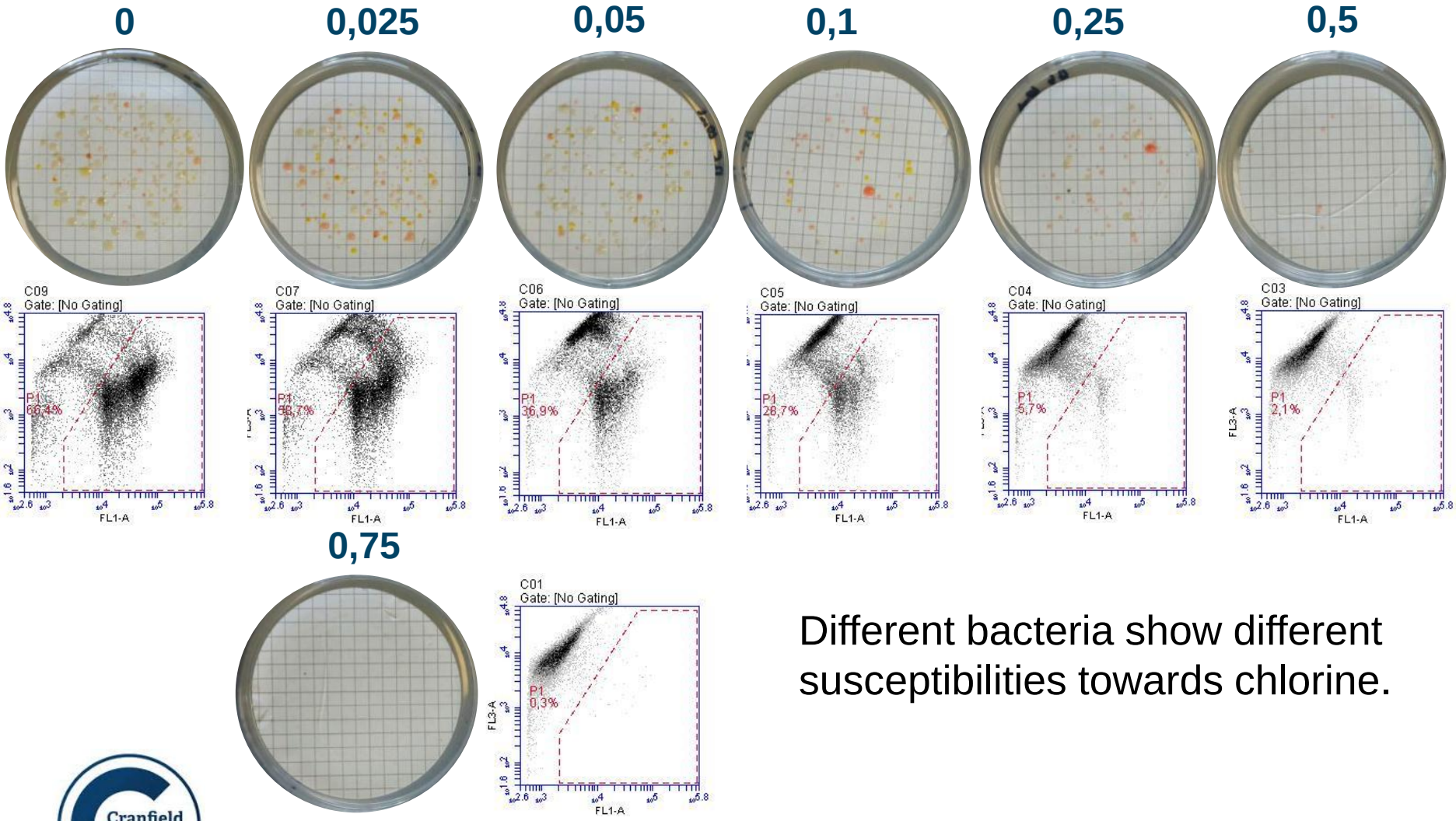
Regrowth after chlorination



Time after exposure to 0.05 mg L-1 chlorine and neutralization.

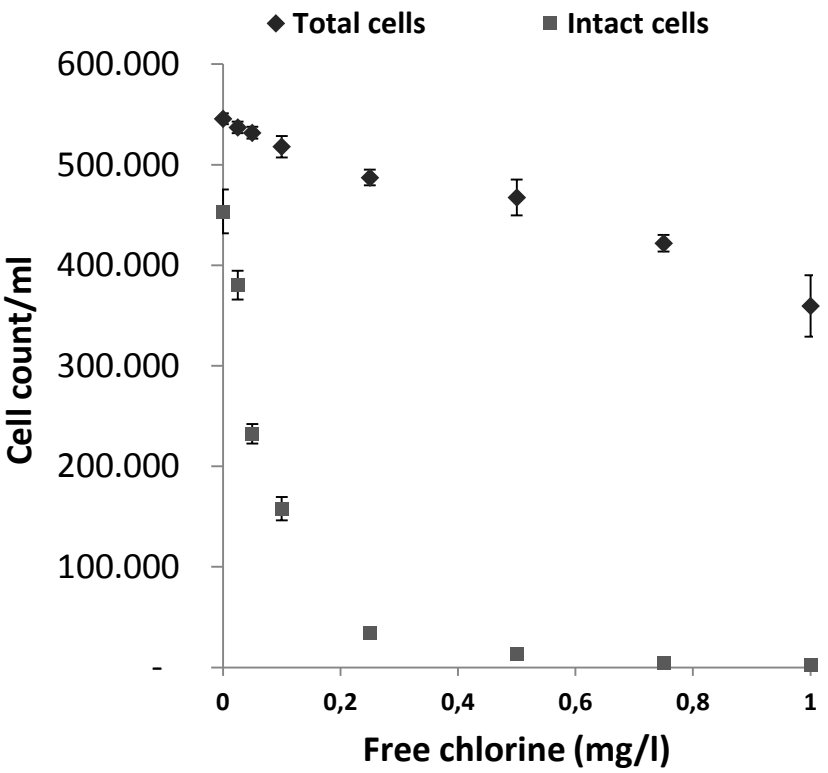
Chlorination of water – comparison of FCM with cultivation

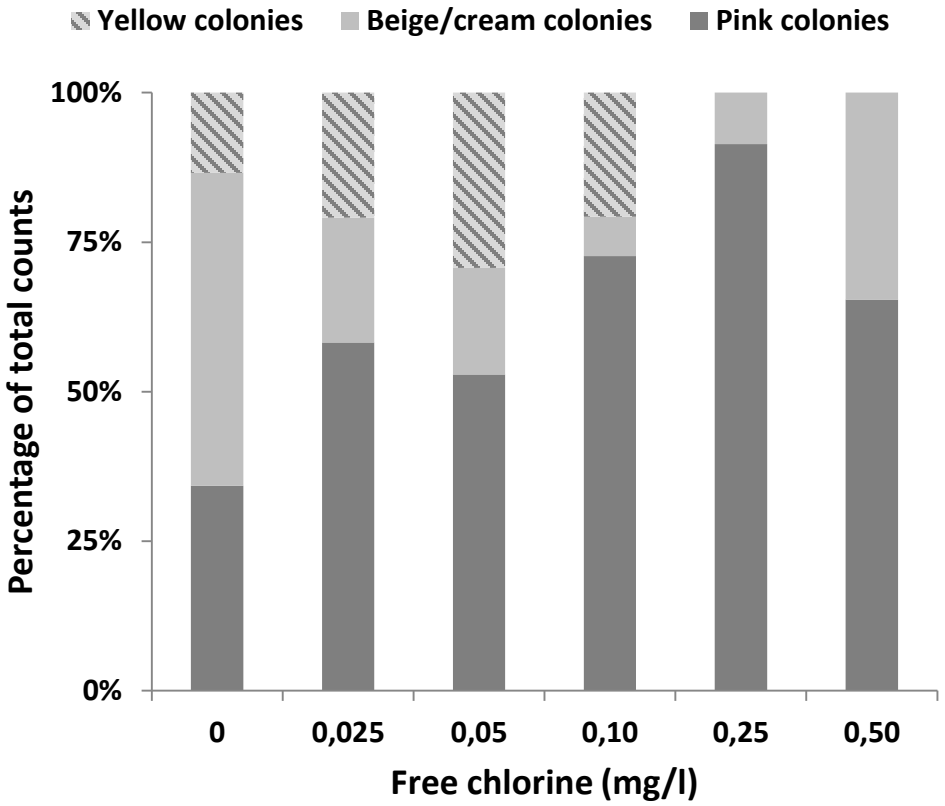
Chlorine concentration (in mg/L), exposure time 30 min



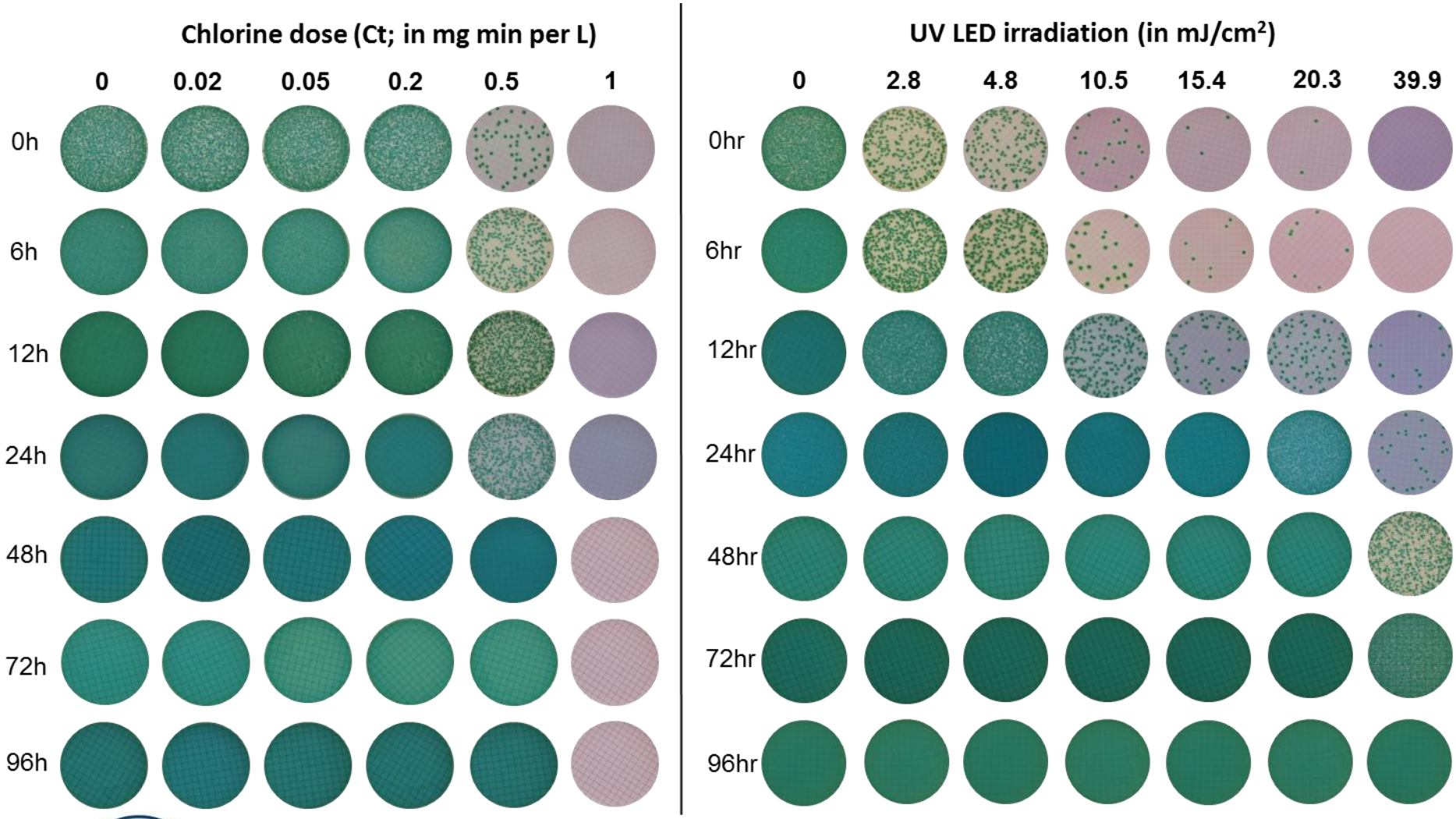
Different bacteria show different susceptibilities towards chlorine.

Measuring bacterial viability in chlorinated systems

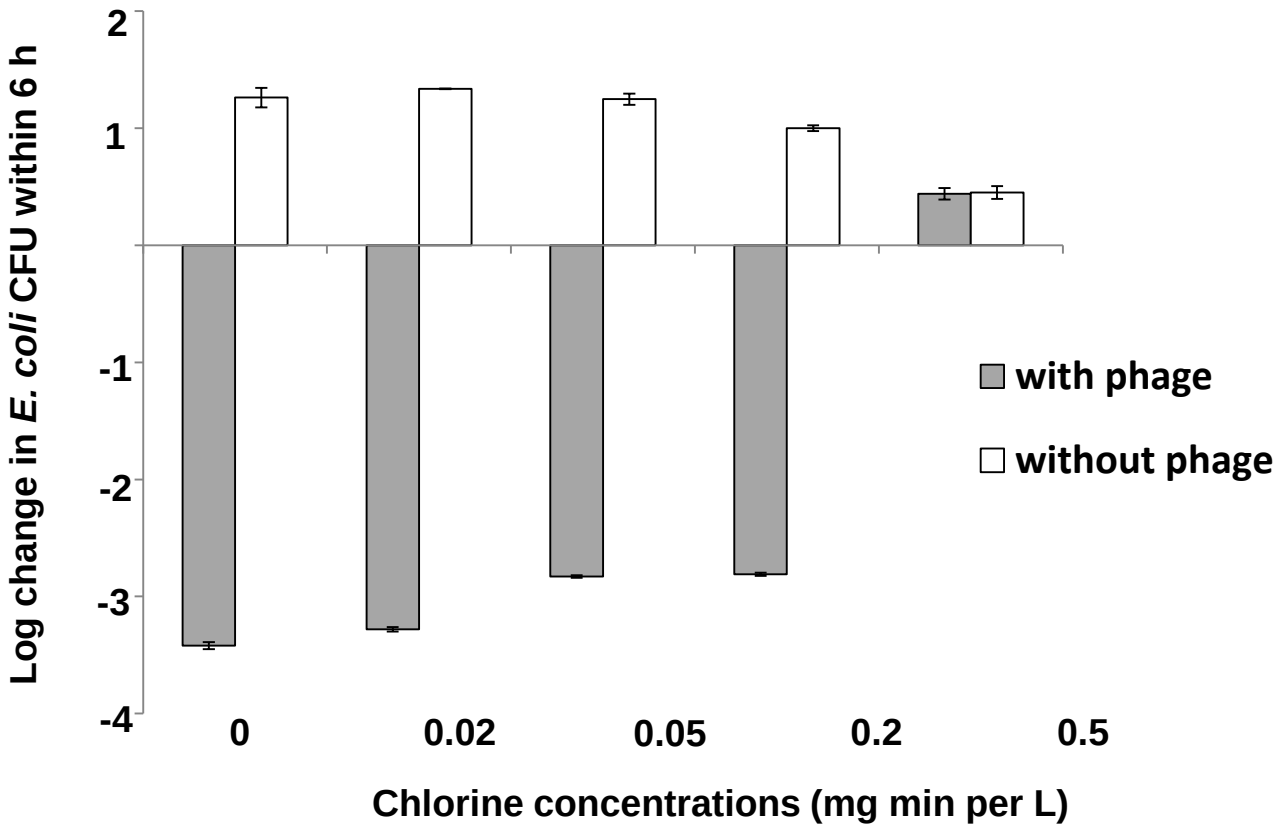




Regrowth after chlorination and after UV



Chlorine and UV can cause a phage-resistant phenotype



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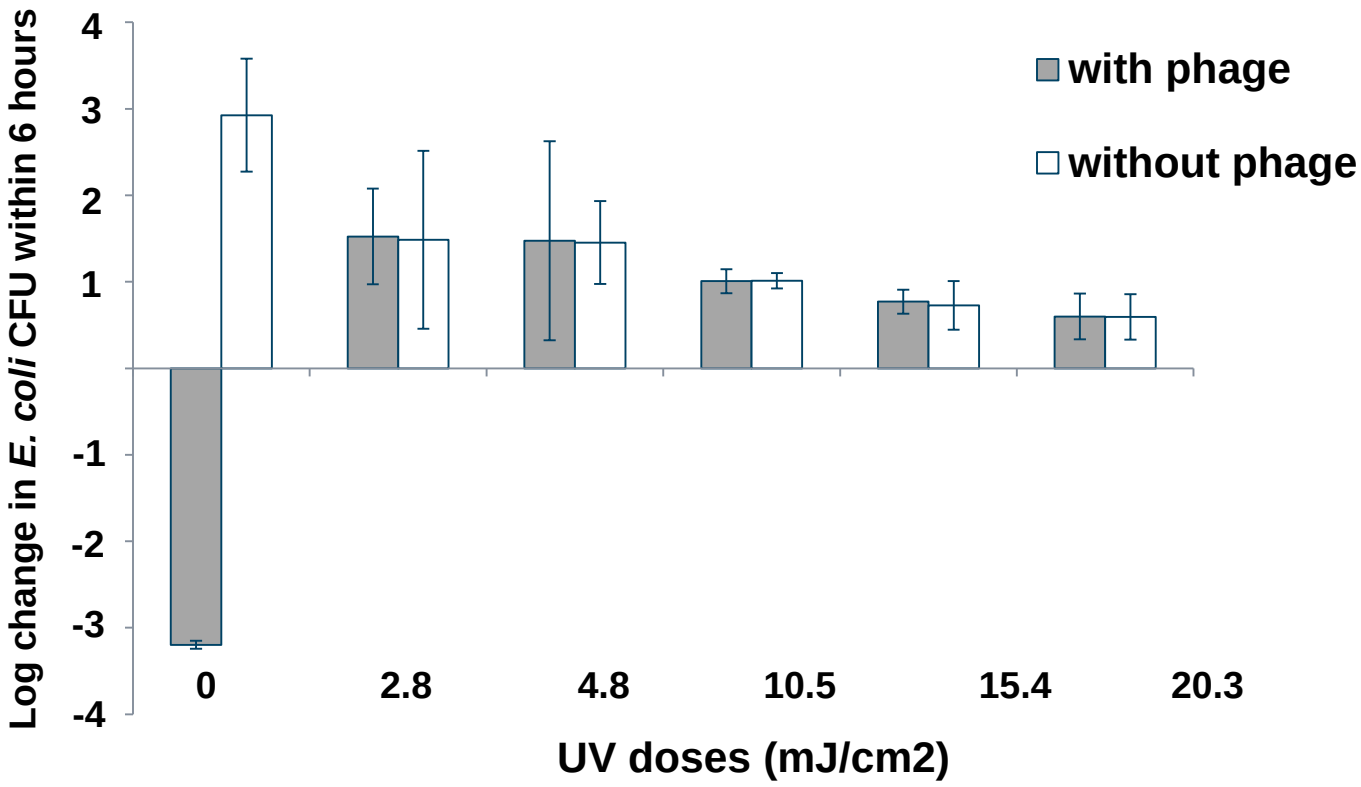
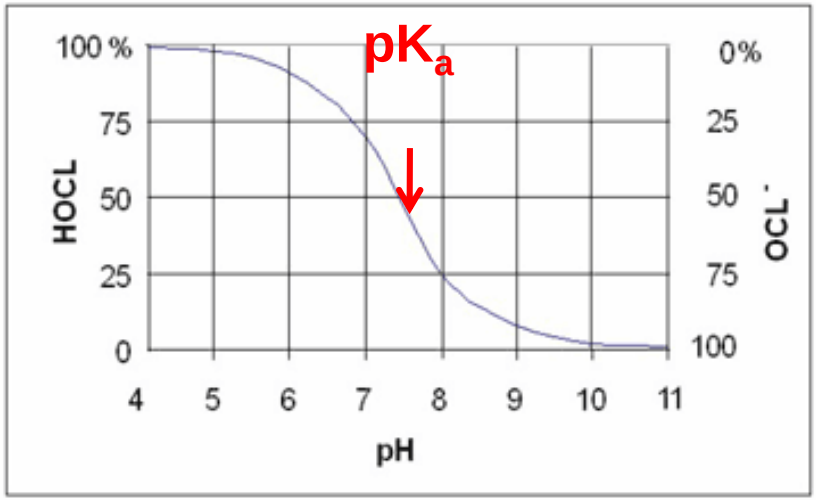


The importance of pH

pH dependence of chlorine

$$HOCl \xleftrightarrow{pH} H^+ + OCl^-$$

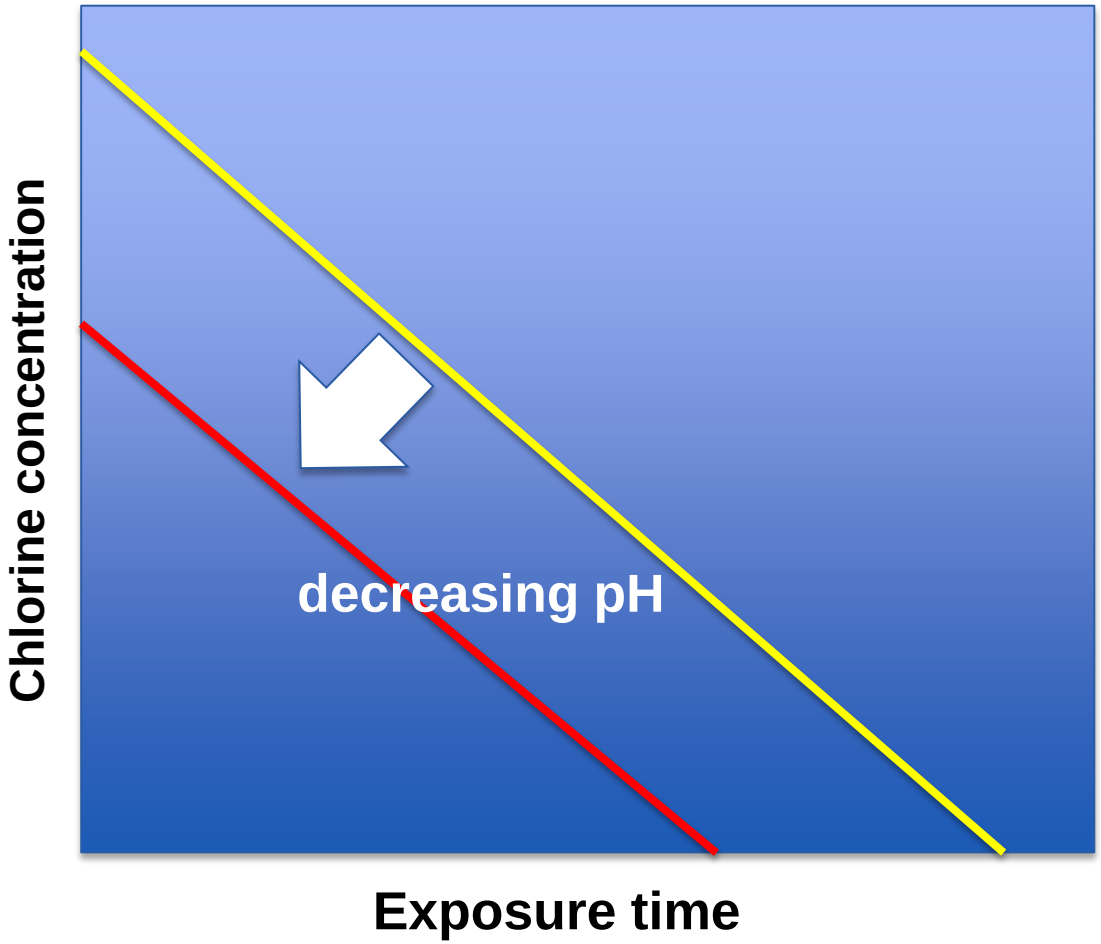
80%	pH6	20%
50%	pH7.5	50%
20%	pH8	80%



Hypochloric acid (HOCl) reacts faster than hypochlorite ions (OCl^-); it is 80-100% more effective. Chlorine disinfection is most effective at 5.5 < pH < 7.5. Even a 0.1 unit change in pH can cause a significant change in the ratio between HOCl and OCl^-.

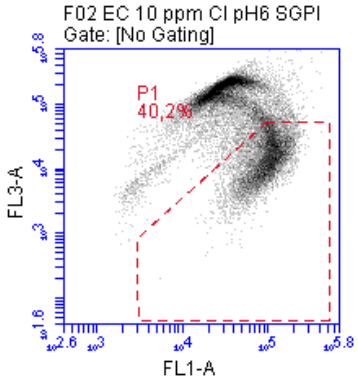
http://www.lenntech.com/processes/disinfection/chemical/disinfectants-chlorine.htm
http://www.lenntech.com/processes/disinfection/chemical/disinfectants-chlorine.htm#ixzz1cDM7T7vL

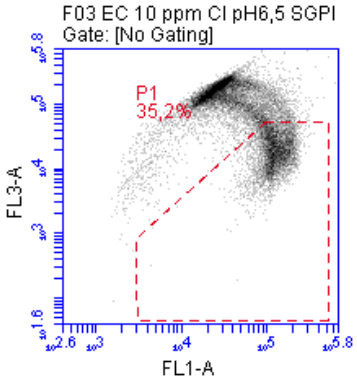
pH dependence of chlorine

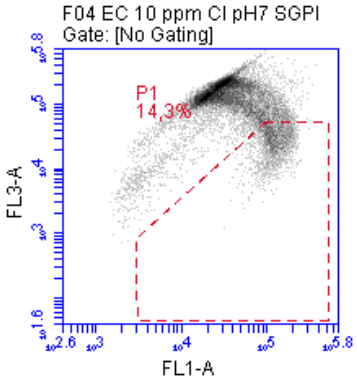


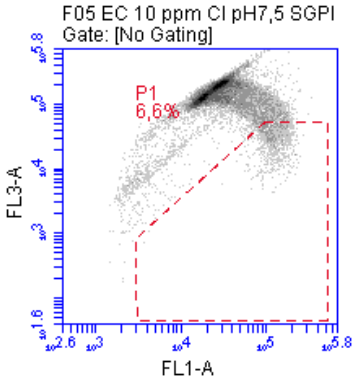
pH dependence of chlorine

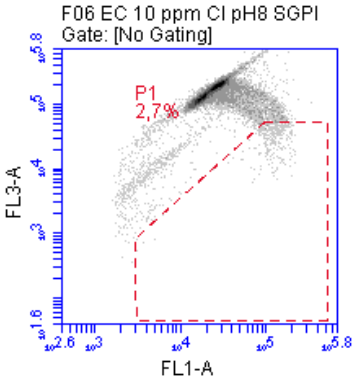
pH6 **pH6.5** **pH7** **pH7.5** **pH8**



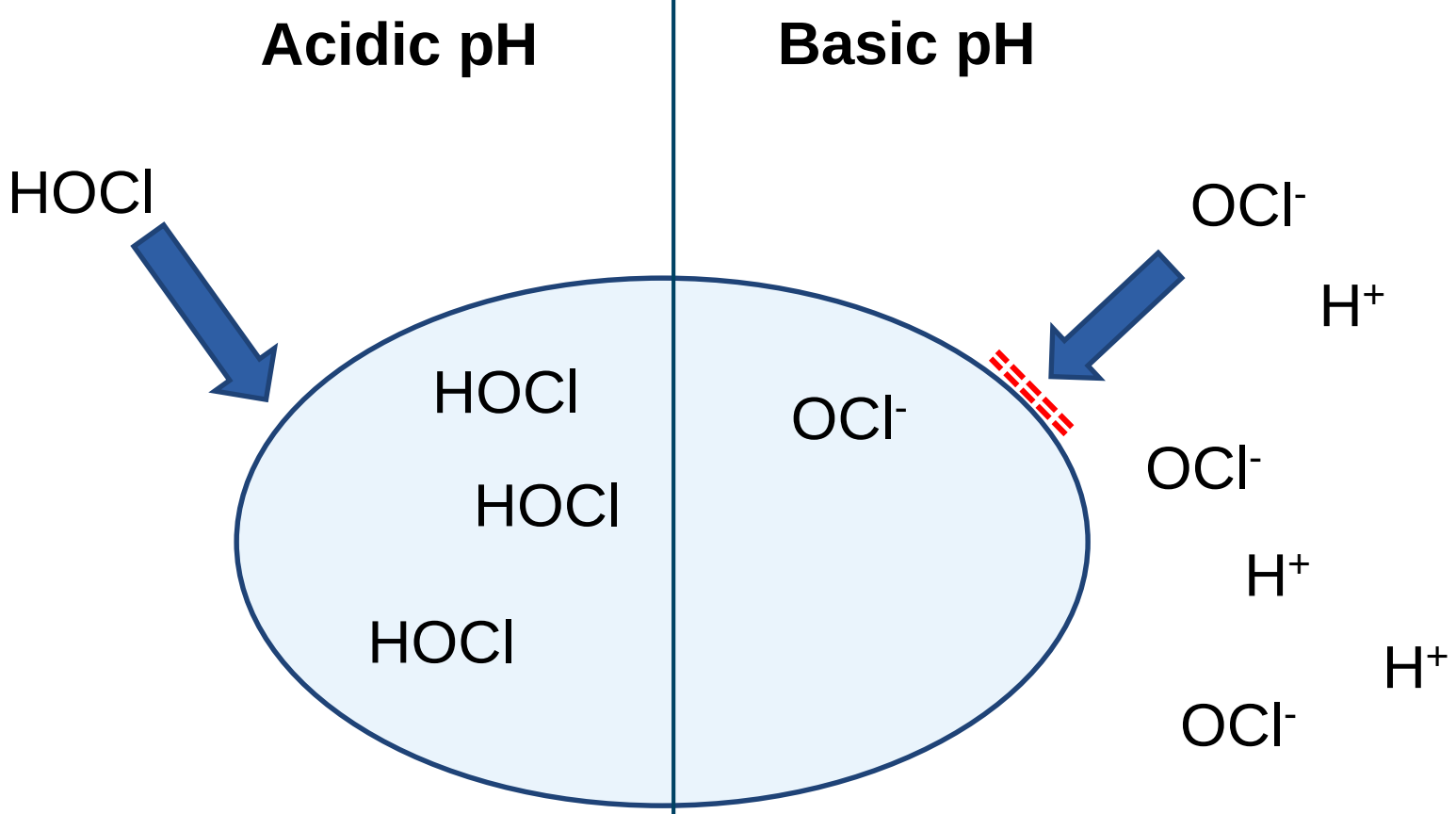






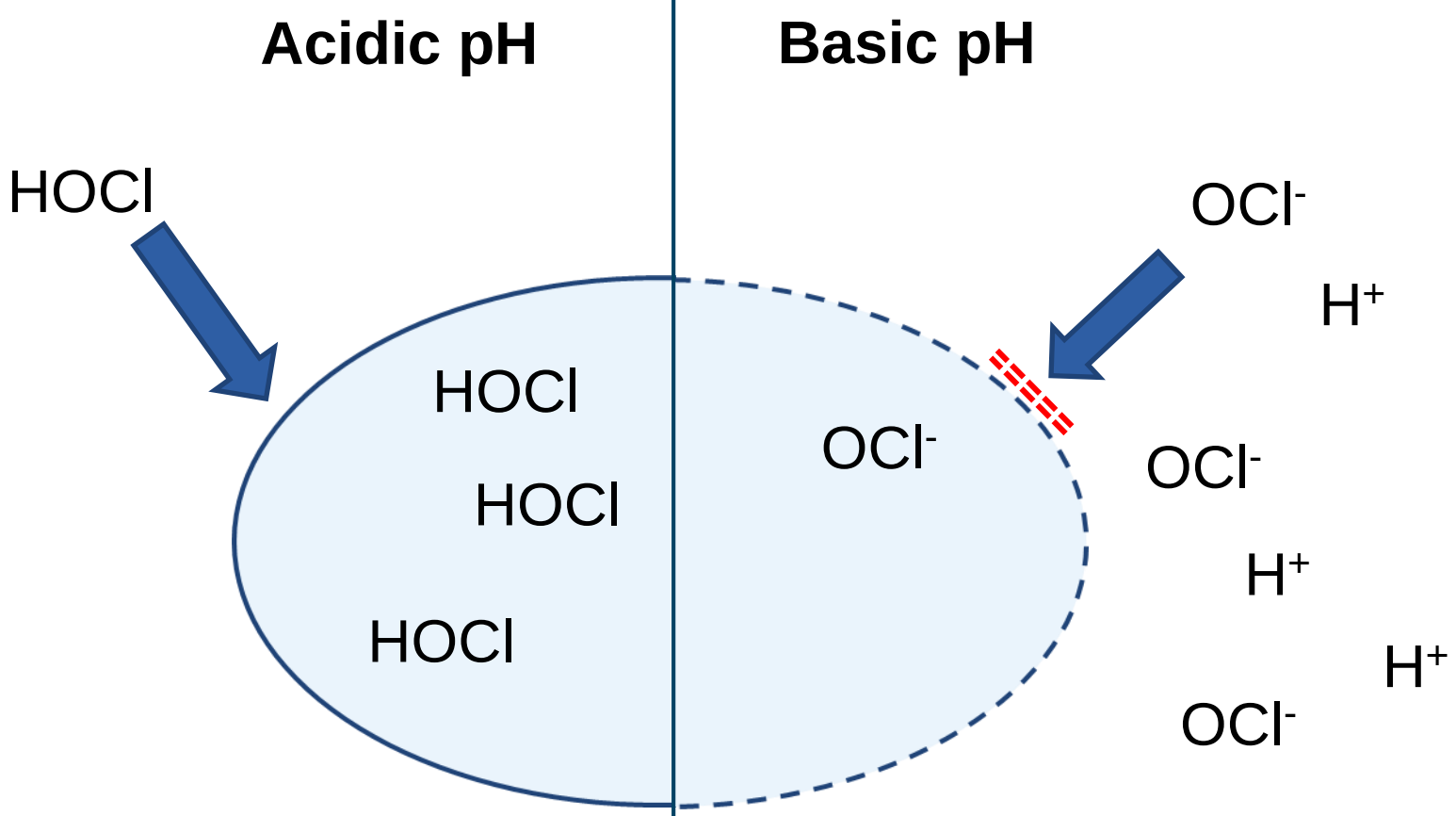


pH dependence of chlorine



The efficacy of disinfection is determined by the pH of the water.

pH dependence of chlorine



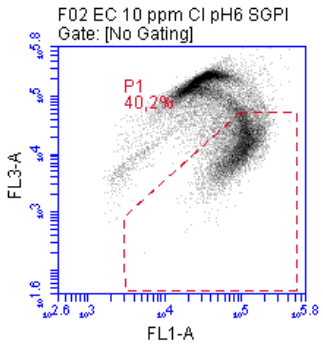
pH dependence of chlorine

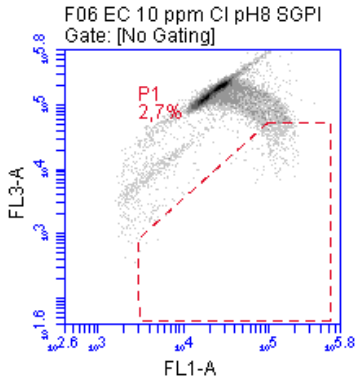
Acidic pH

Efficient killing

Basic pH

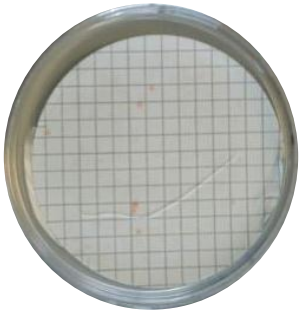
Efficient membrane damage

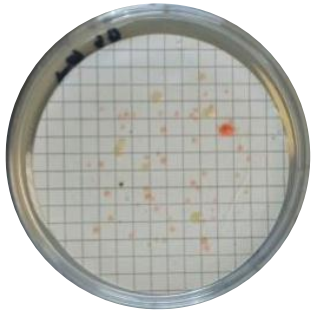




Intact bacteria

Plate counts





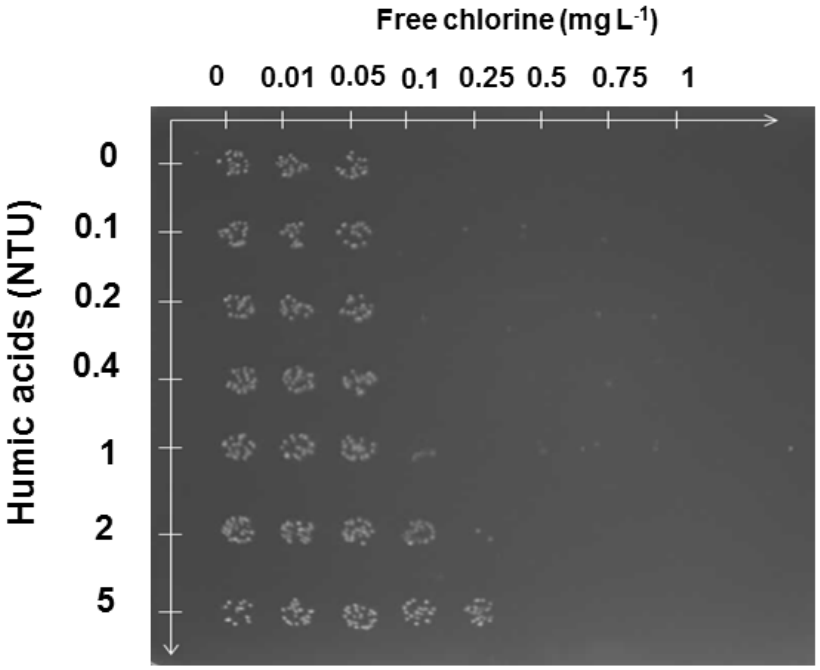
Efficient killing

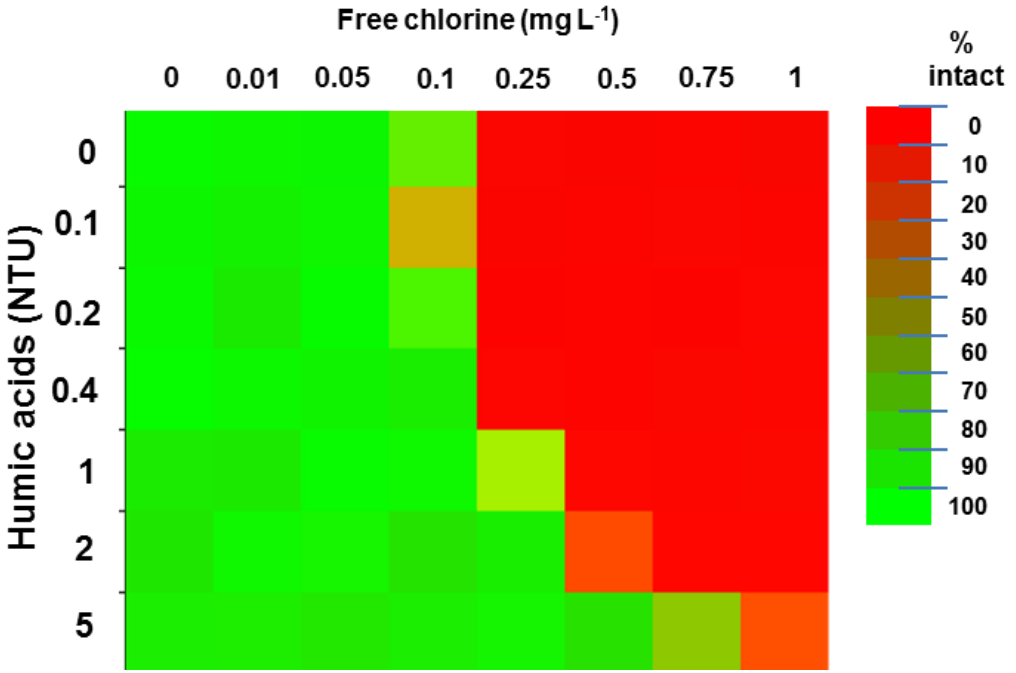
Necessity of correction factors !

Chlorination in the presence of turbidity

Chlorination in the presence of turbidity: humic acids

E. coli





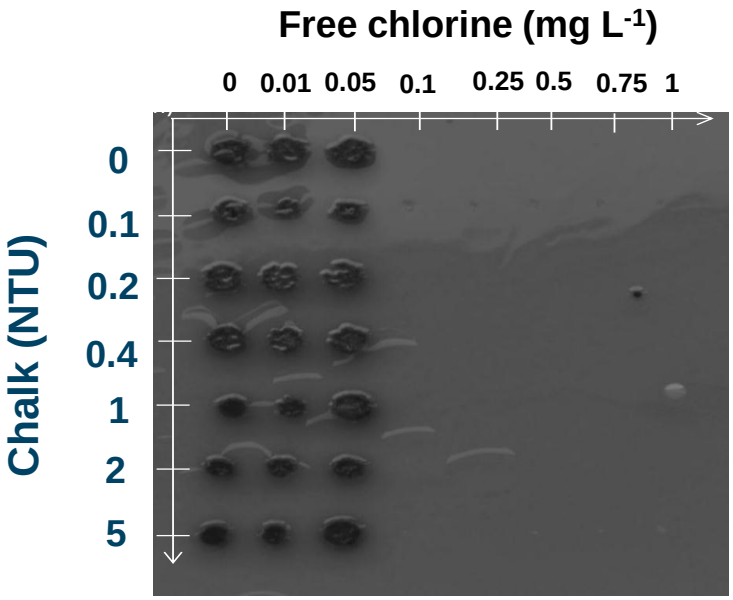
Humic acids affect chlorination efficiency at ≥1 NTUs

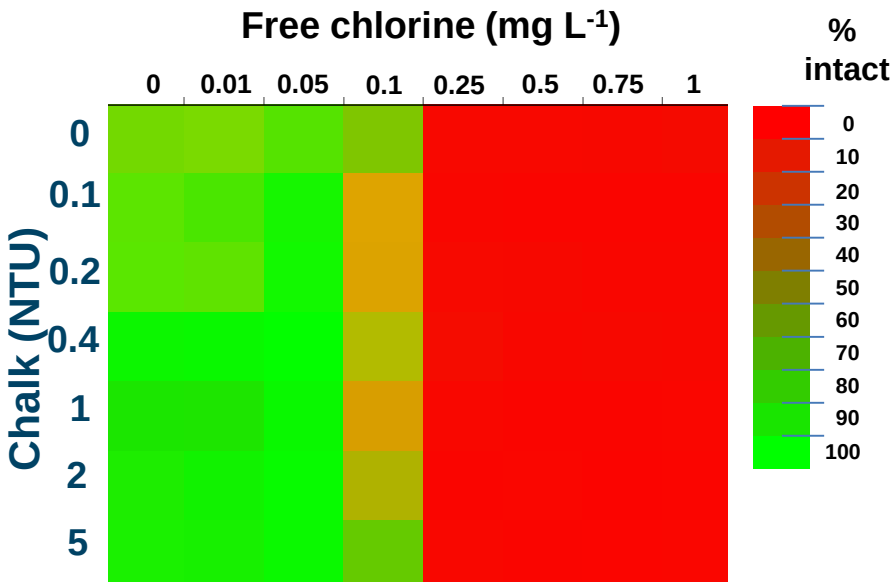
Cranfield University

UKWIR UK Water Industry Research

Chlorination in the presence of turbidity: chalk

E. coli





Chalk without effect on chlorination efficiency up to 5 NTUs

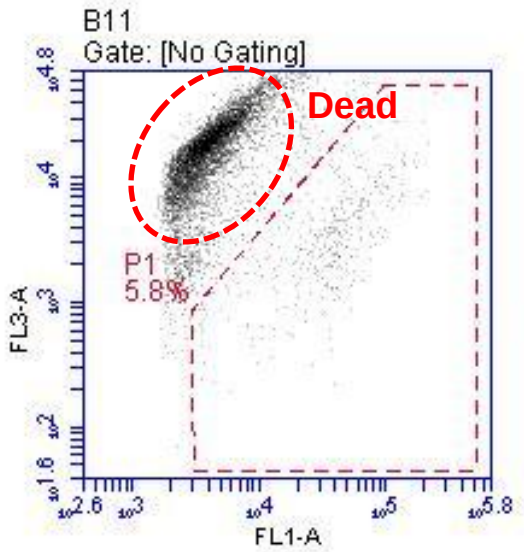
Cranfield University

UKWIR UK Water Industry Research

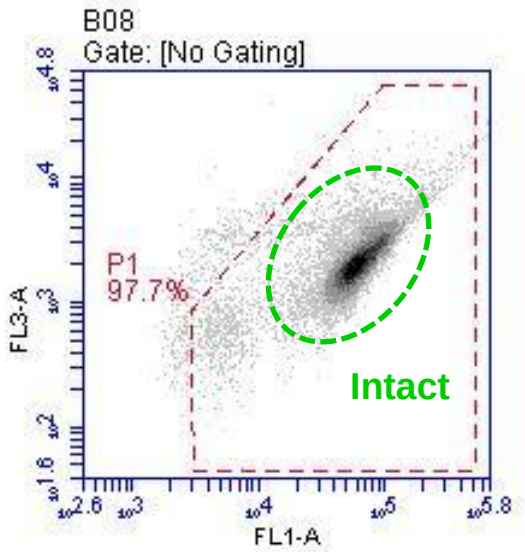
Regrowth in distribution systems

Distribution network re-growth

Day 0

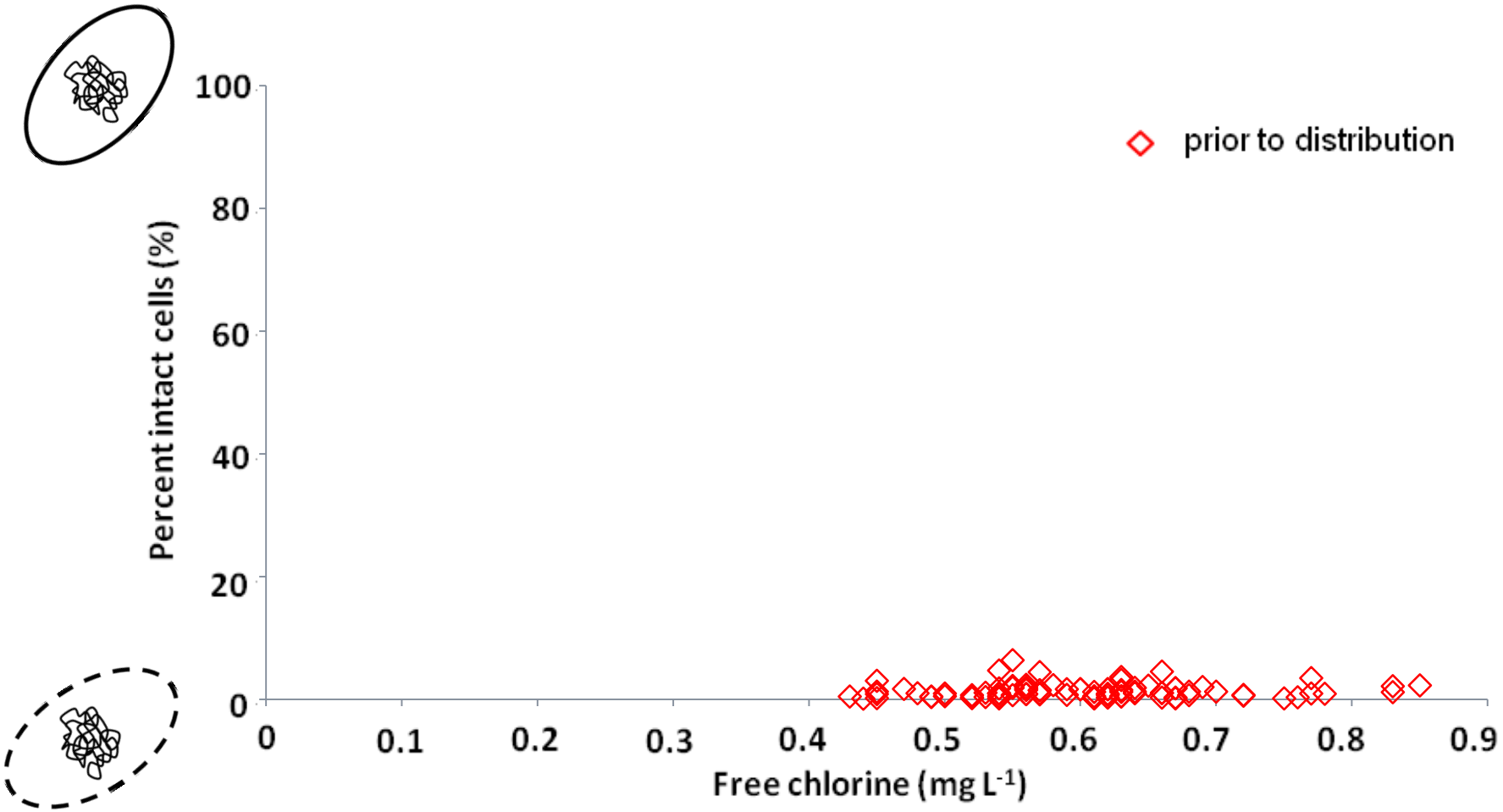


Day 7

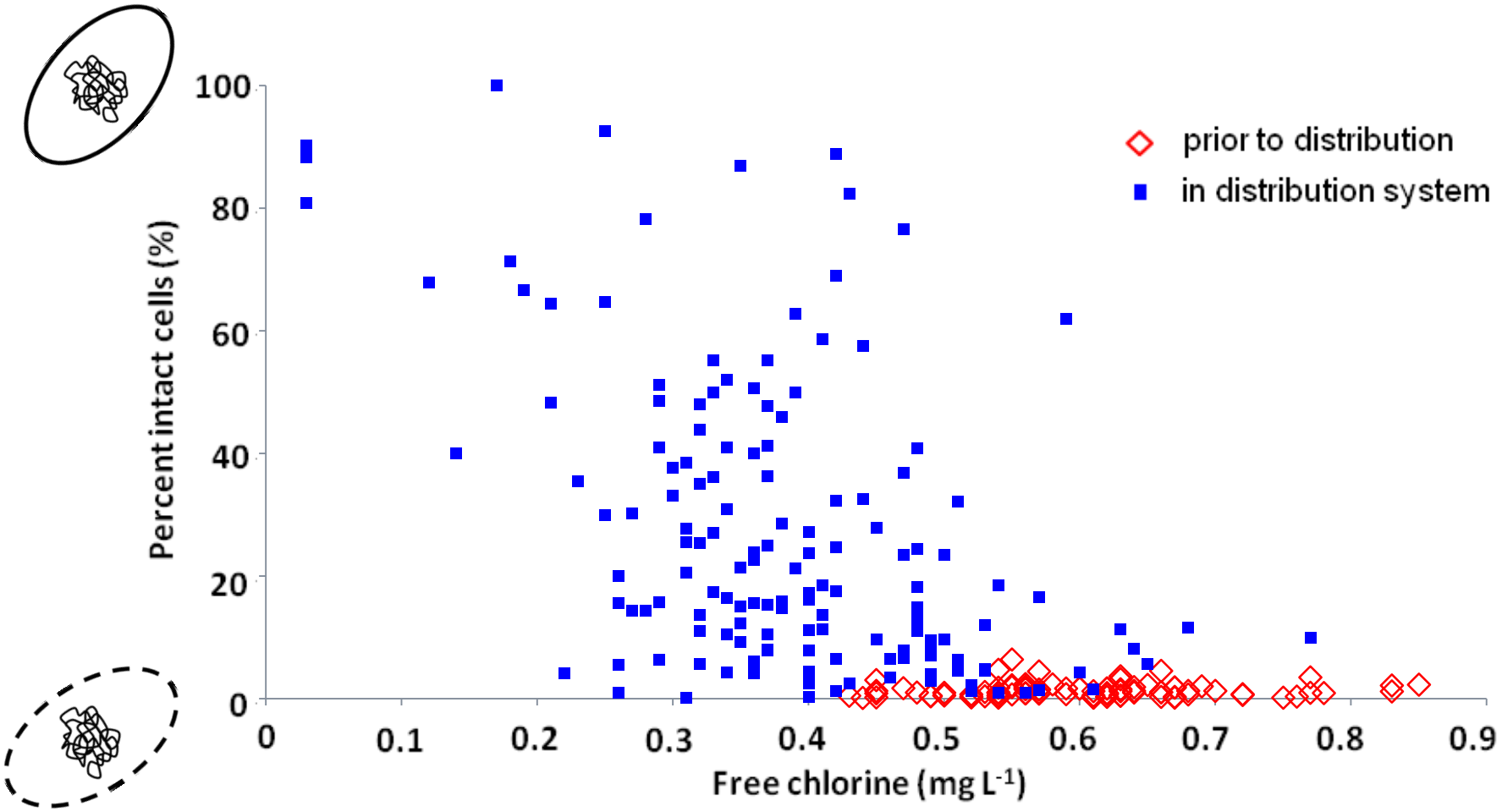


Conversion of dead biomass into live biomass over re-growth period

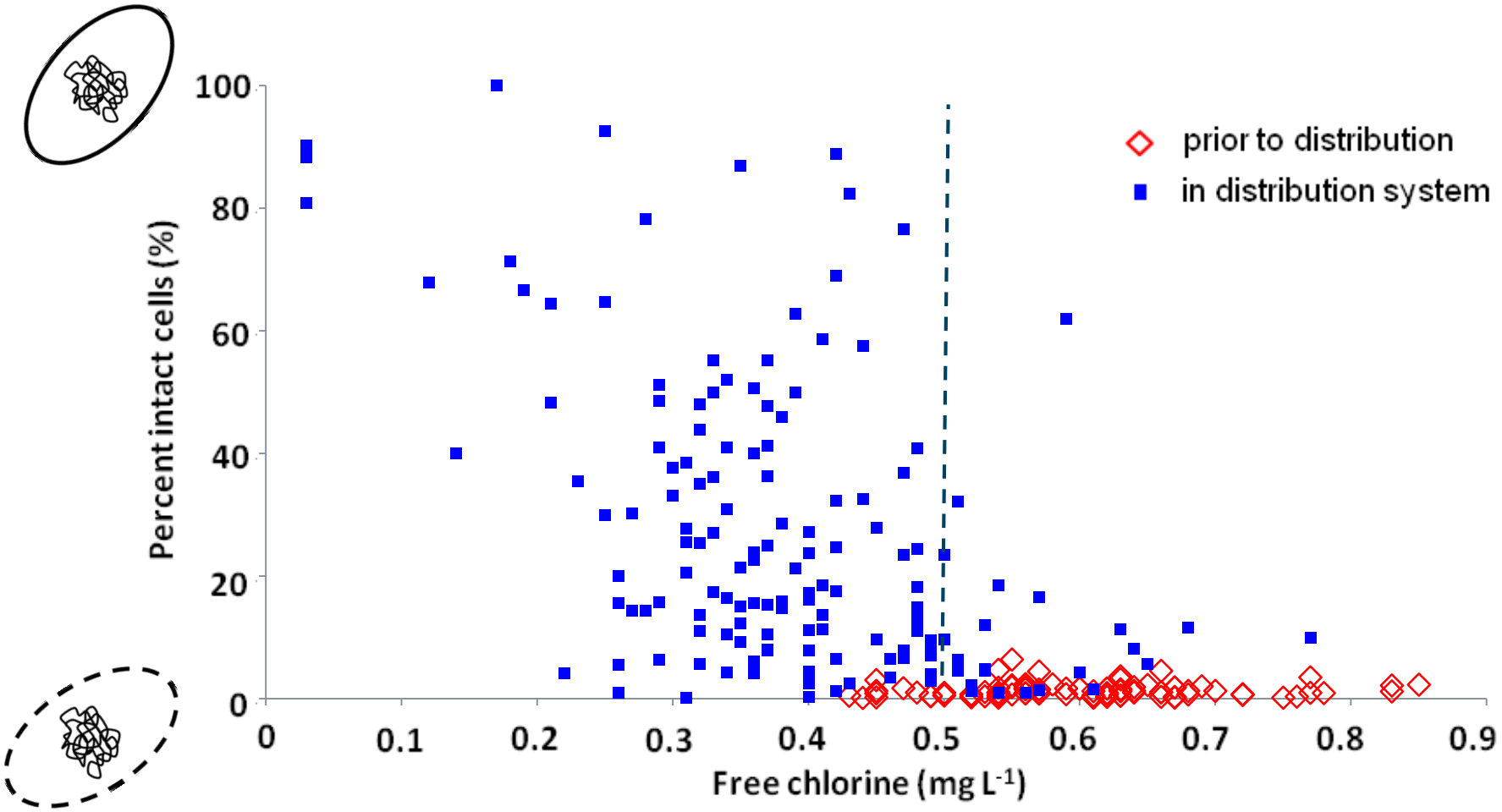
Bacterial integrity in chlorinated DWDS



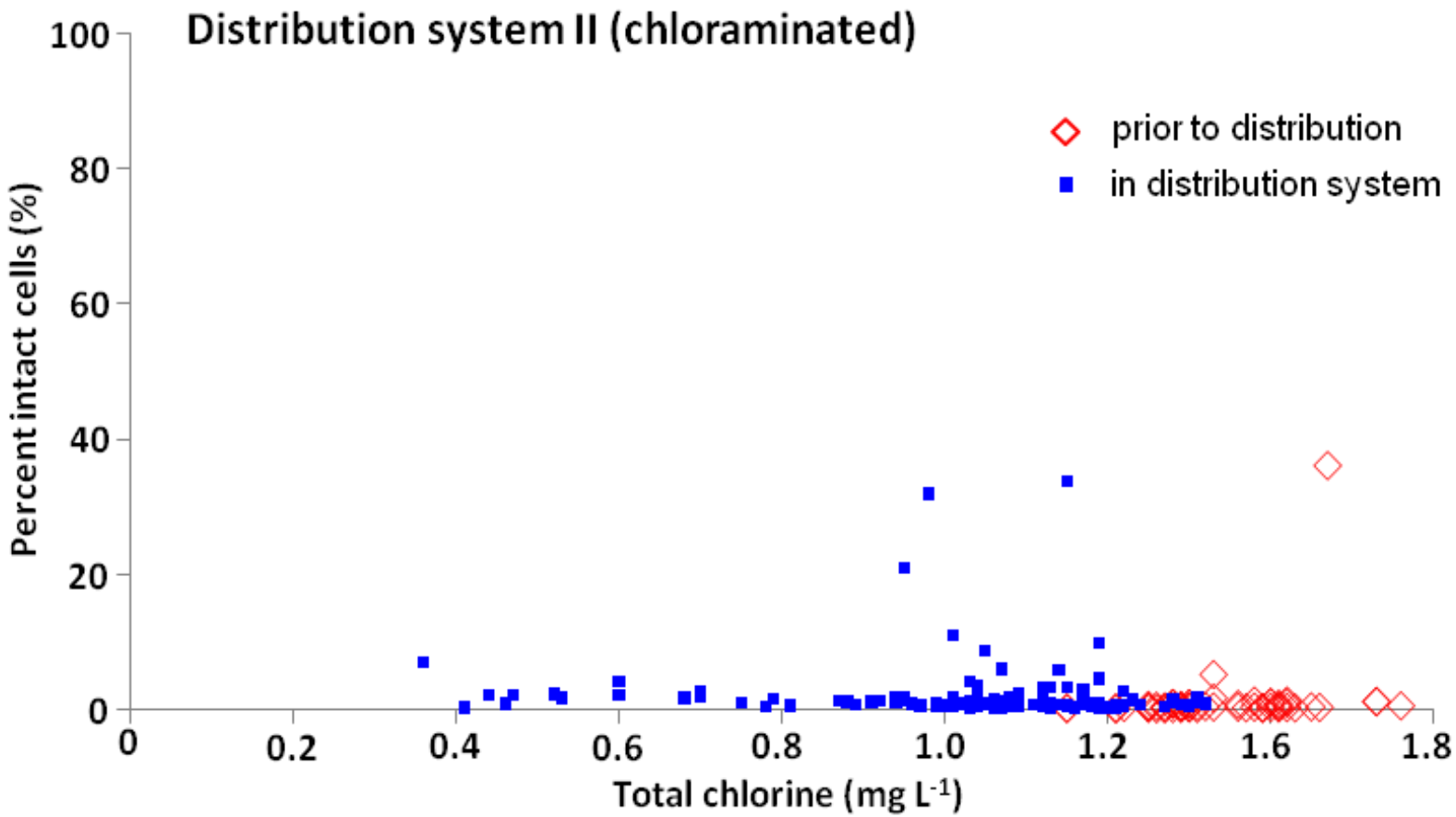
Bacterial integrity in chlorinated DWDS



Bacterial integrity in chlorinated DWDS



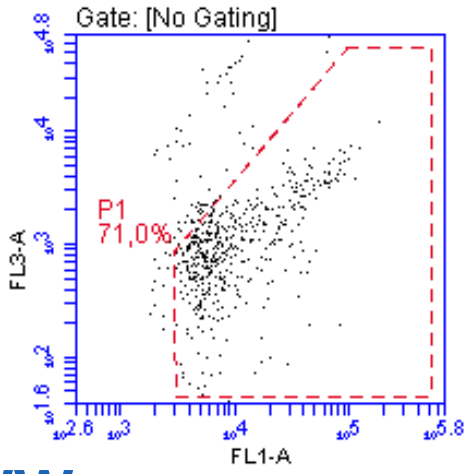
Bacterial integrity in chloraminated DWDS



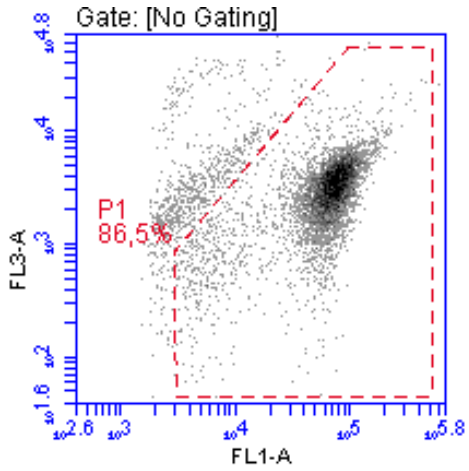
Regrowth potential

22˚C

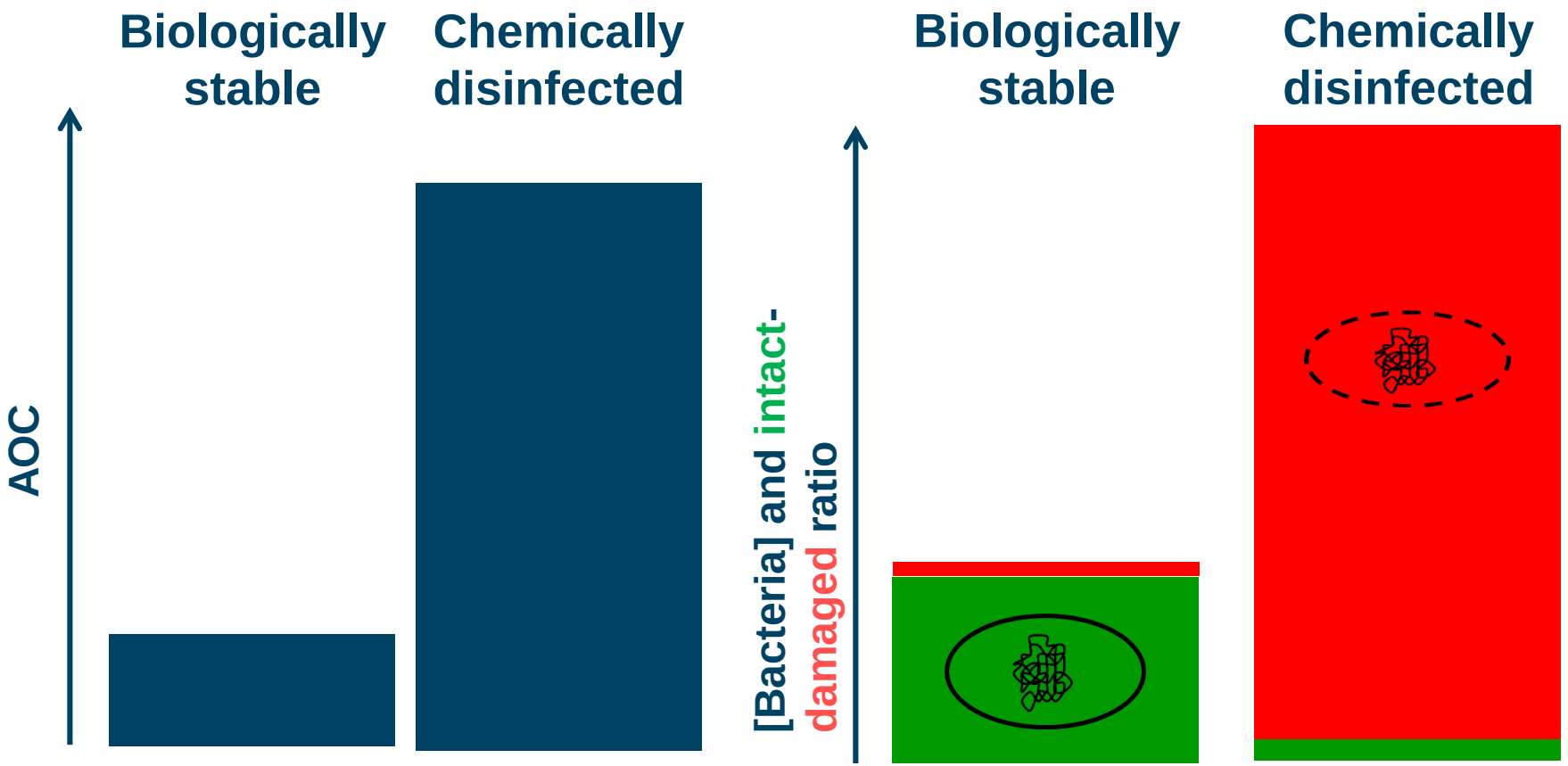
Day 0



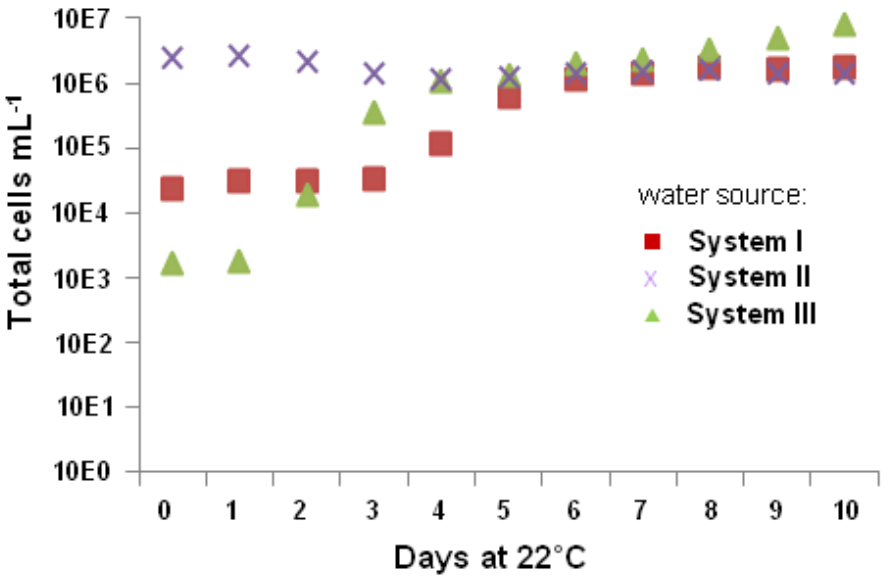
Day 7

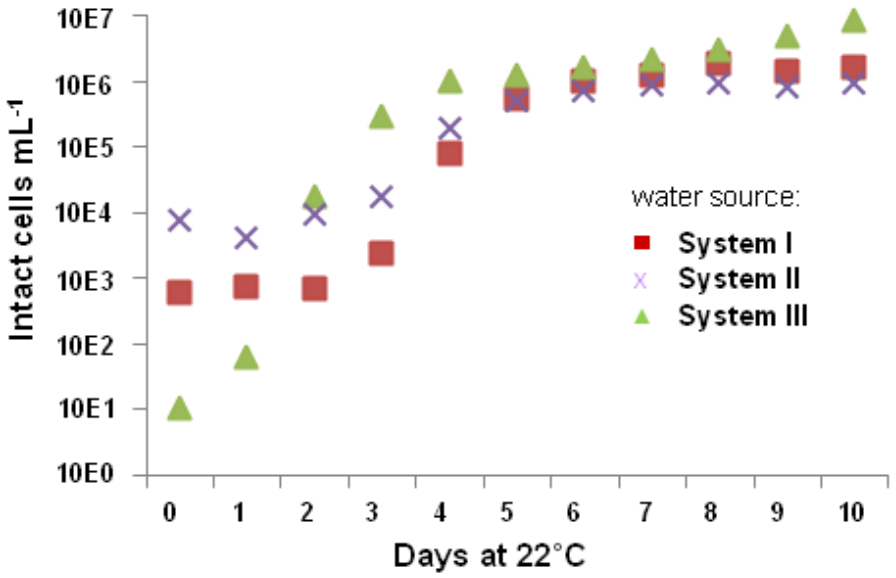


Biologically stable water vs. water with chlorine residual

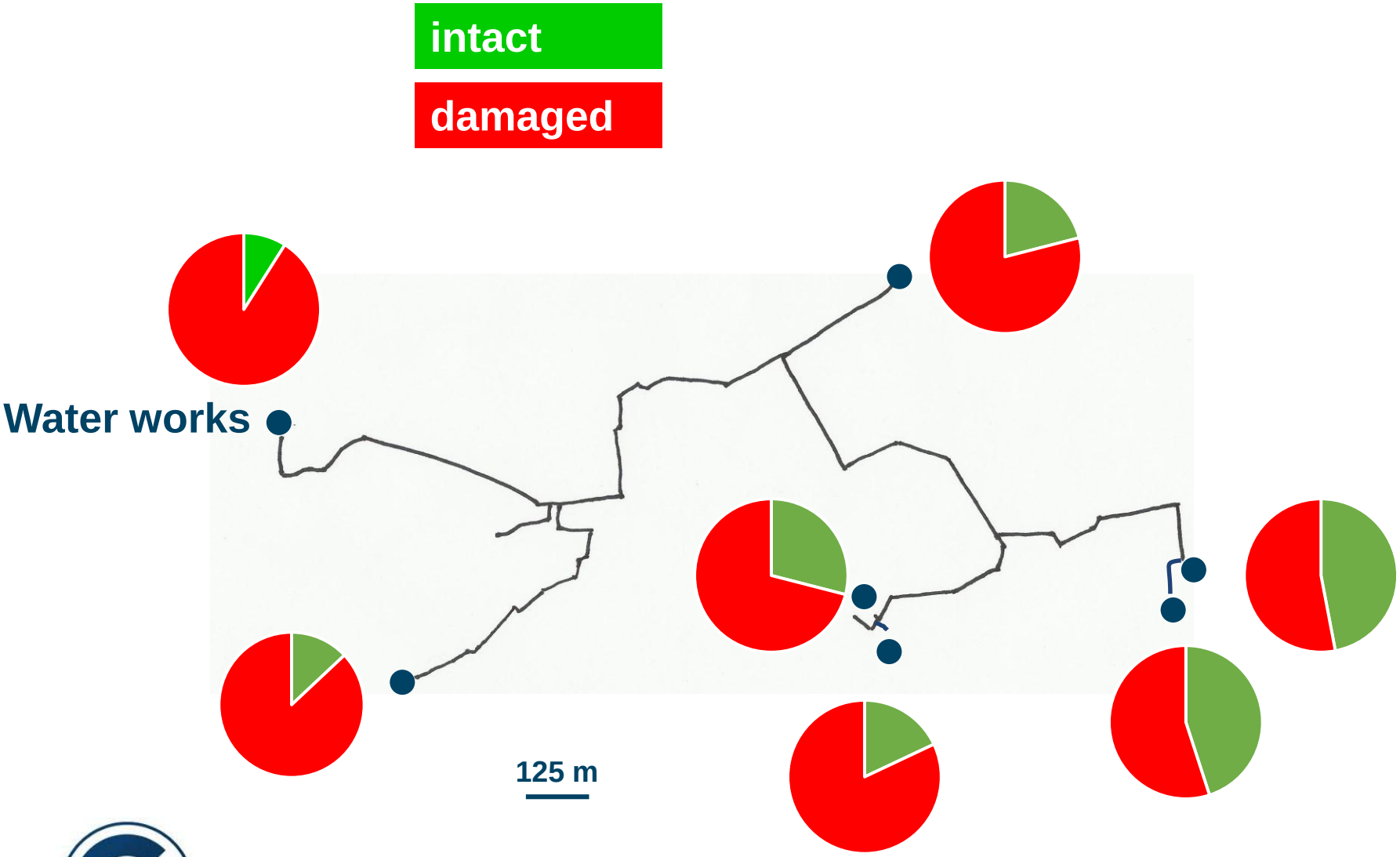


The importance to measure ICC

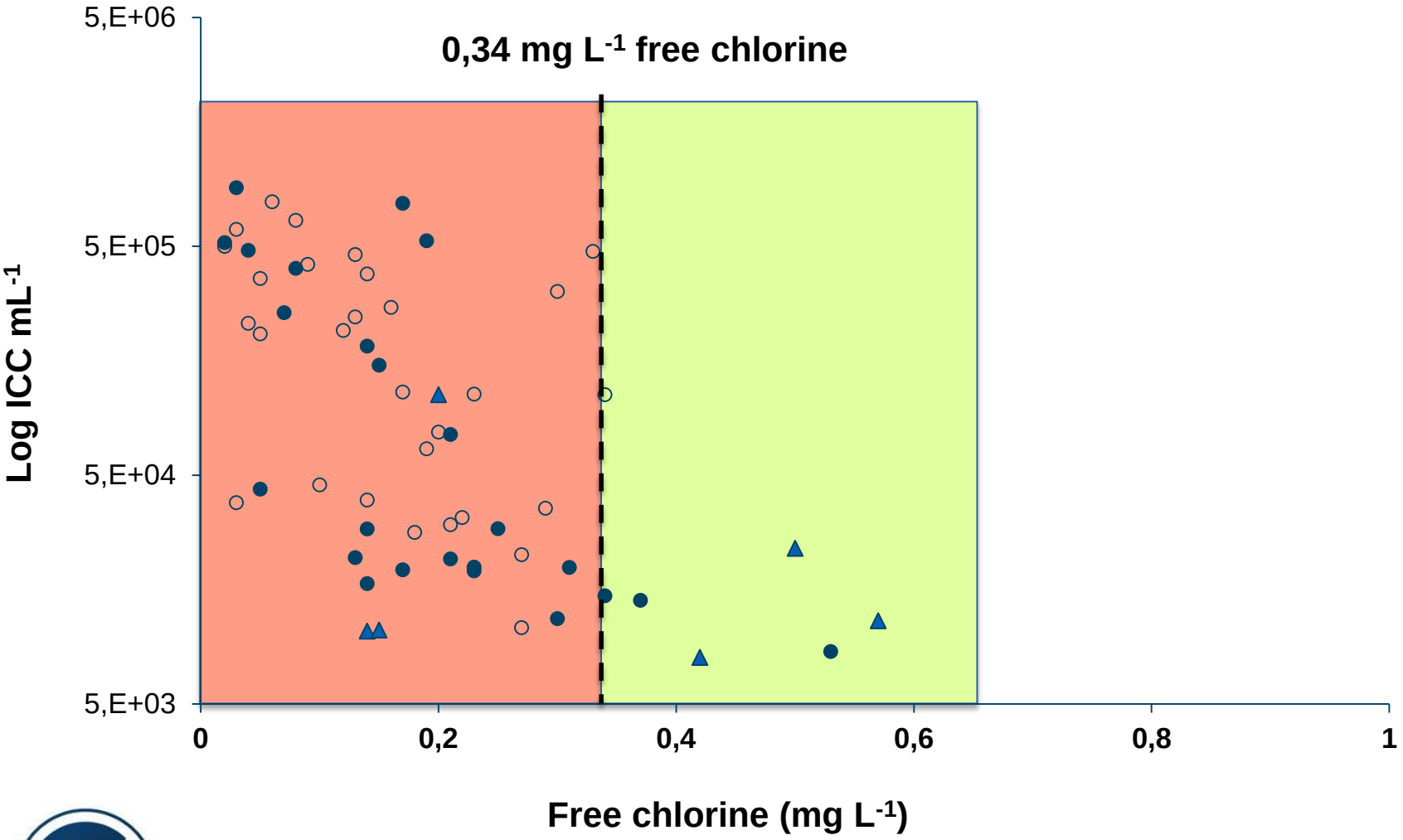




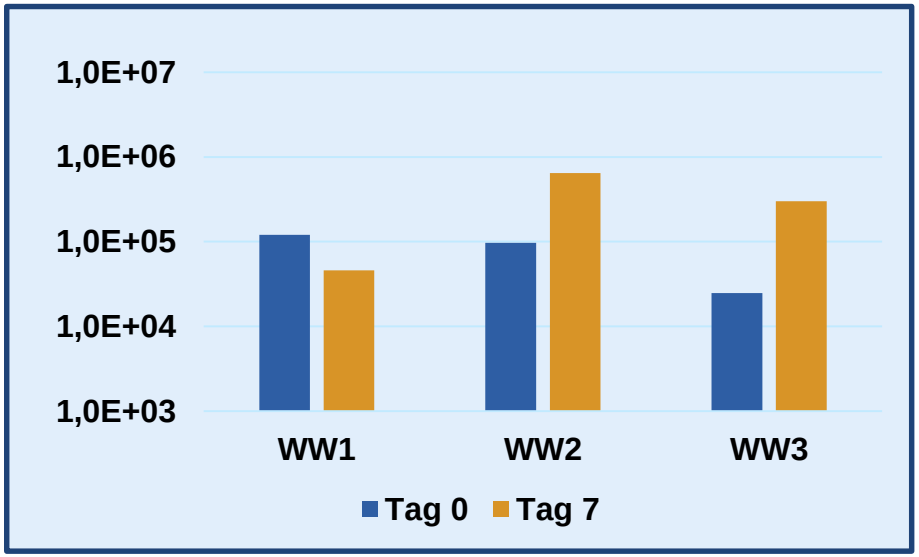
Water Reuse – distribution system



Assessment of required chlorine concentration



Regrowth potential of works final water



						Regrowth factor (ICC)
WW1	Sedimentation	ground passage	ozonation	GAC	UV	**0**
WW2	Sedimentation	ground passage			UV	**7**
WW3	Sedimentation	Ground passage	ozonation		UV	**12**

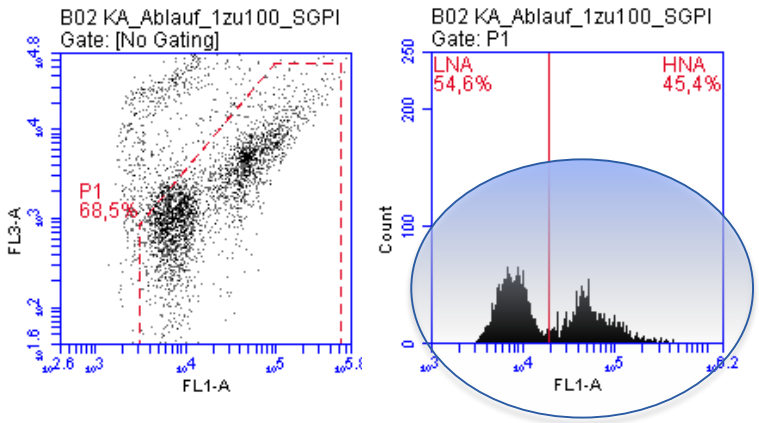
AOC-reducing AOC-elevating

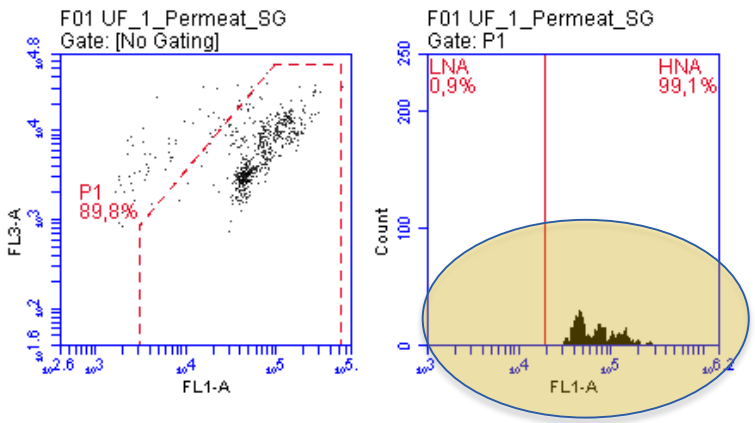
Flow cytometry for process control

Process monitoring: ultrafiltration

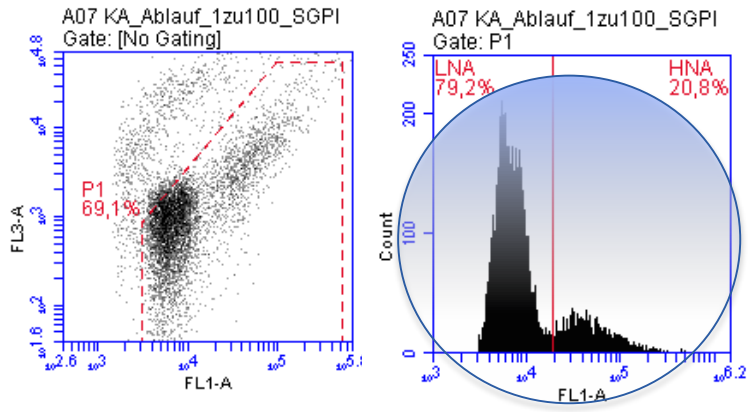
Feed | **Permeate**

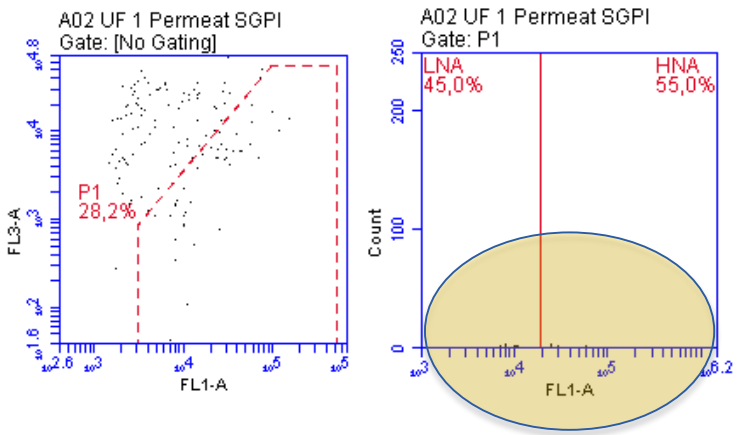
ddiscontinuous





continuous





- Microbiology of raw water subject to variations
- Fast discrimination btw. leaky membrane and regrowth.

Thanks