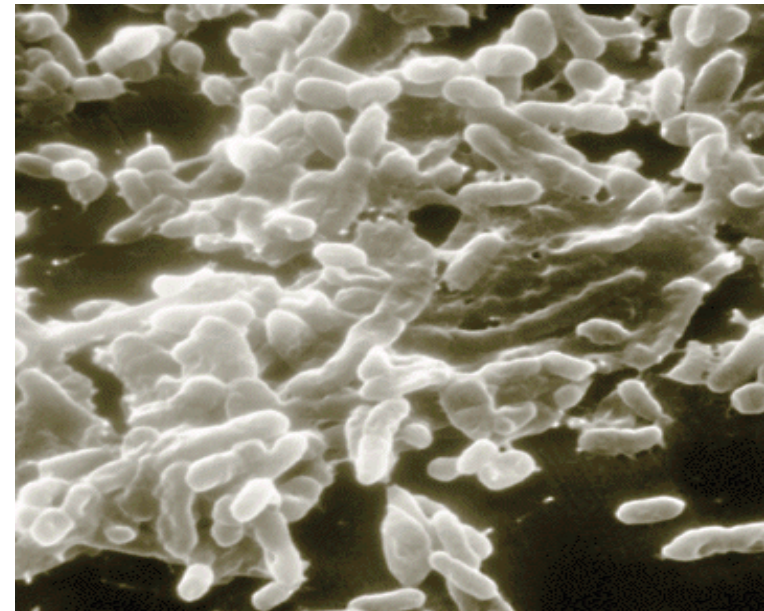




Chlorine dioxide as effective biocide for microbiological and antifouling control water system

Biofilm - a universal problem

- slimy coatings of microorganism and extracellular compounds in pipelines, tanks and heat exchanger surface
- pathogenic germs (e.g. E. coli or Legionella) are living in biofilms
- biofilm reduces the efficiency of heat exchangers
- biofilm causes corrosion in metal surfaces MIC
- biofilms are extremely resistant against most disinfectants
- chlorine dioxide and ozone are the only suitable disinfectants, able to kill and to remove biofilms in water pipes and tanks



Microbiological control in water systems

- mechanical methods
 - manual cleaning of piping
- chemical methods
 - oxidizing chemicals
 - chlorine, chloramine
 - chlorine dioxide
 - ozone, peroxides and other oxidants
 - organic biocides and other chemicals

Comparison of chemical disinfectants

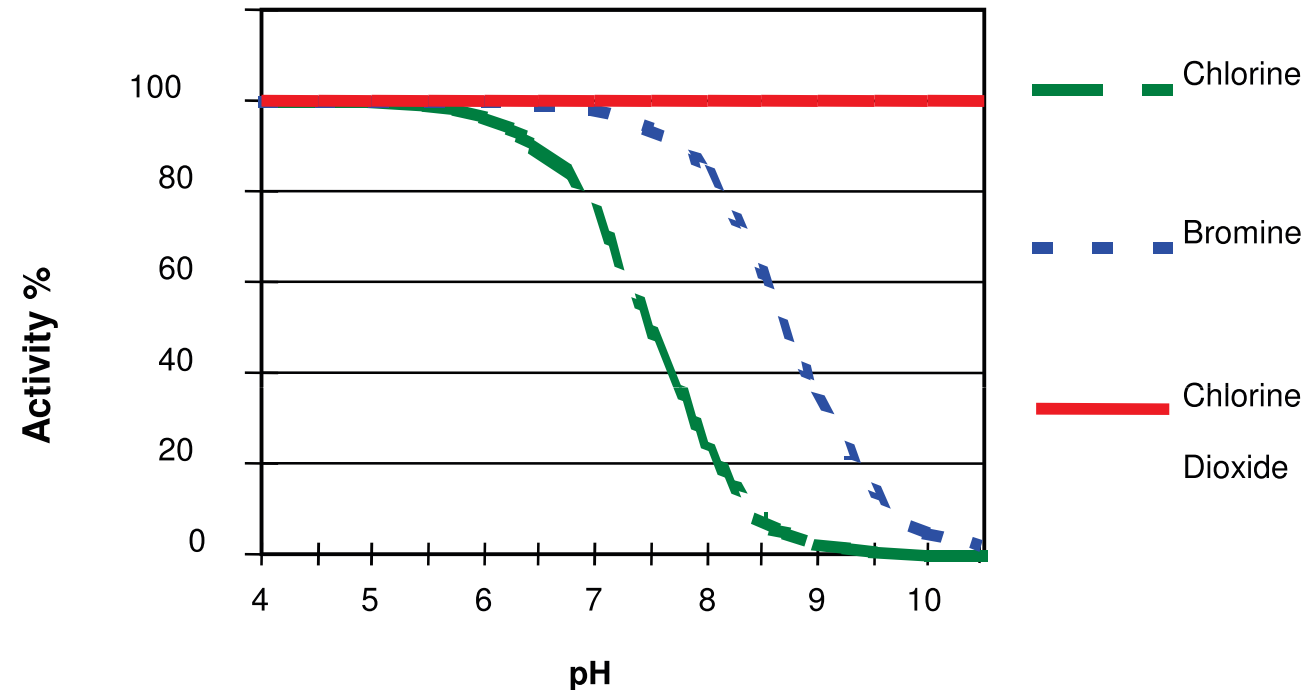
	chlorine	ClO ₂	ozone
disinfection capacity	medium	strong	strongest
Oxidation potential [V]	1,49	0,95	2,07
dependence from pH-value	extreme	none	low
depot effect	hours	days	minutes
disinfection by-products	THM, AOX and other chlorinated organics	chlorite	evt. bromate
resources	Cl ₂ -gas, hypo-chlorite or electrolysis	HCl & NaClO ₂	electr. energy, air or oxygen

Comparison of Disinfectants

Micro-organism	Reduction Rate	Chlorine	Chlorine Dioxide	Ozone
	(%)	c x t (ppm x min)	c x t (ppm x min)	c x t (ppm x min)
Crypto-sporidium parvum	99.9	1440	> 120	> 5
Giardia lamblia	99.9	104-122	23	1.4
Escherichia Coli	> 99.99	3-4	1.2	0.012 - 0.4

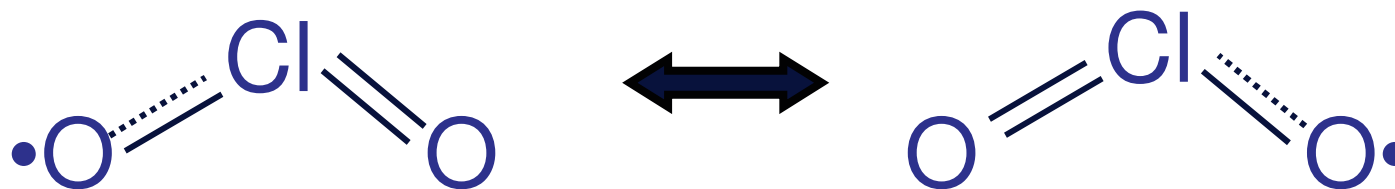
Chlorine based treatment – the best solution??

- Efficiency highly pH-dependent



- AOX formation
- Contribution to inorganic load
- High chlorine/chloride concentrations promote corrosion in metals
- High chlorine level necessary due to bioresistance

Properties of Chlorine Dioxide



- unpaired electron, considered to be a free radical:
high reactivity for oxidation and disinfection
 $\text{ClO}_2 + e^- \rightarrow \text{ClO}_2^-$ (Chlorite) $E^0 = 0.95 \text{ V}$
- soluble in water as a gas
 - *reactivity independent of pH*
 - *able to penetrate cellular membranes*
 - *able to kill and remove biofilm*
- high depot action due to low rate of self-decomposition in water and selective reactant

Ecological Aspects

- ClO₂ reacts only as an oxidant
 - no formation of THM (trihalomethanes)
 - no formation of chlorophenols
 - no formation of AOX (adsorbable organic halides)
 - no reaction with ammonium
- 75 ppm chlorite is non-toxic to Rainbow trout larvae
- 0,3 ppm chlorine dioxide influences growth parameters of Rainbow trout larvae after 20 days exposition
- 0,1 ppm chlorine dioxide: only little influence on planctonic organism such as foraminifera and diatom algae

Summary

- chlorine dioxide is a better biocide against industrial biofouling than chlorine
 - better biocide performance
 - better environmental performance
- design of systems against industrial biofouling
 - treatment's aim has to be defined
 - disinfection to yield organism-free systems
 - treatment to effect organism's settling-inactivation
 - lowest possible concentration of chlorine dioxide has to be determined by tests
- chlorine dioxide is a very economical water treatment

