



Chlorination and Dechlorination A Brief Chemical Overview

2017 Baird Symposium

Chlorination

Chlorine gas (Cl_2) or hypochlorite salts ($\text{Ca}(\text{OCl})_2$ or NaOCl) are added to wastewater as a disinfectant.

Chlorine gas rapidly reacts with water and forms hypochlorous acid:



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Aqueous solutions of sodium or calcium hypochlorite hydrolyze too:



Hypochlorous acid is a weak acid and disassociates:

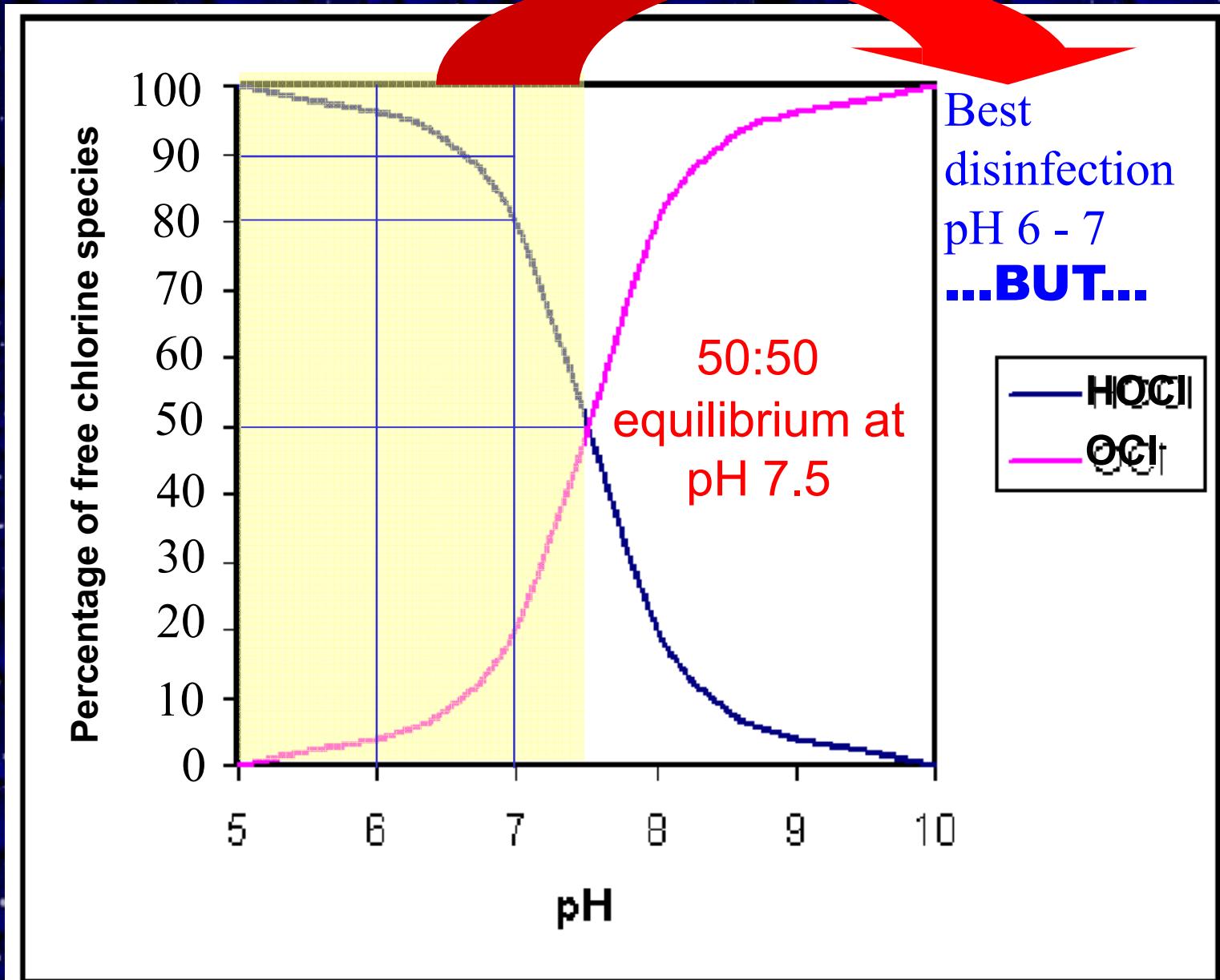


The two chemical species formed by chlorine in water, hypochlorous acid (HOCl) and hypochlorite ion (OCl⁻), are commonly referred to as **“free” or “available”** chlorine.

In waters with pH between 6.5-8.5, the reaction is incomplete and both species (HOCl and OCl⁻) will be present.

Hypochlorous acid is the more germicidal of the two.

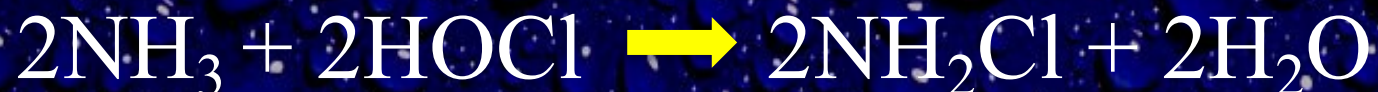
Free Chlorine Distribution with pH



Chloramine Formation

If ammonia (NH_3) is present, HOCl will react to form one of 3 chloramines depending on pH, temperature, & reaction time.

Monochloramine: (stinky)



Dichloramine: (stinkier)

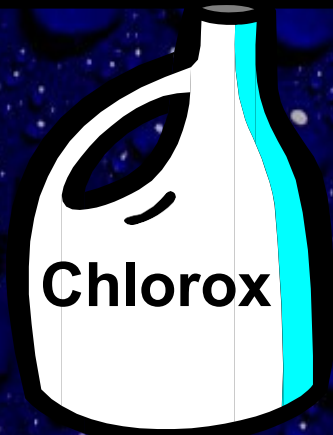


Trichloramine: (stinkiest!)



c) additional free chlorine + chloramine = H^+ , H_2O , and N_2 gas which will come out of solution.

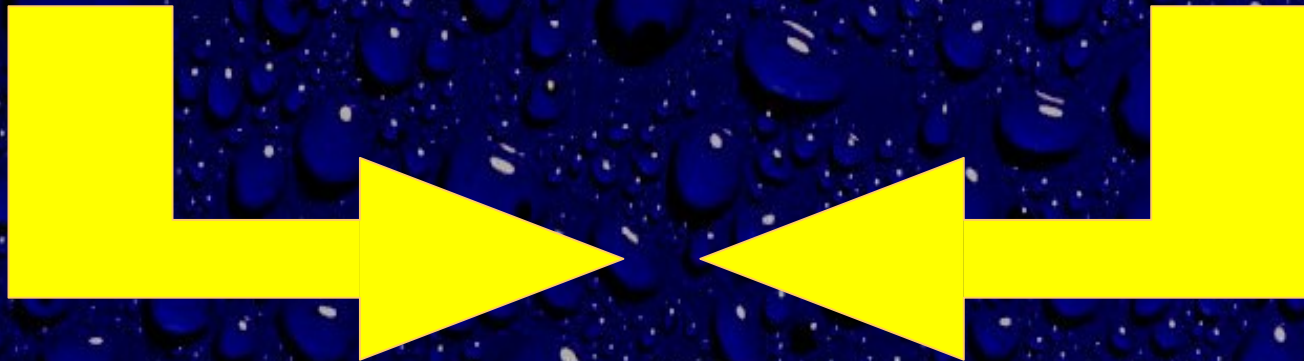
Ooooh...that smell!



Clean, fresh smell
Slight chlorine odor



Pungent, acrid smell
Confused w/ strong
"chlorine" odor



It's the difference that causes those burning eyes
and skin rashes after using a pool or hot tub

To minimize the amount of reactive chlorine released, sulfite (SO_3^{-2}) is added to the wastewater.

Chemical equation for dechlorination with sulfite producing sulfate (SO_4^{-2}) and chloride (Cl^-):



This reaction is fast and effective.

What about the sulfite?

Excess sulfite is converted to sulfate by reaction with dissolved oxygen.

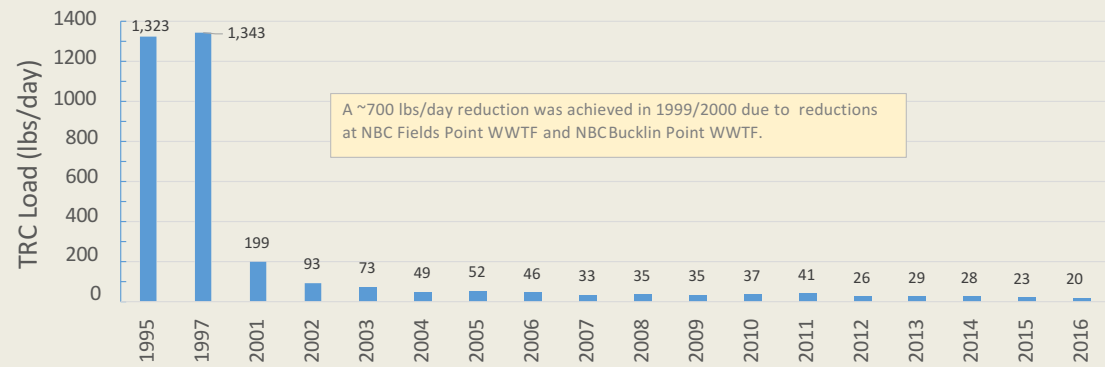
The two products sulfate and chloride are natural major components of seawater.

The major products of chlorination/dechlorination add a tiny amount of sulfate and chloride to the Bay compared to the natural abundance



Free chlorine + Combined chlorine = Total Chlorine
Residual

Annual Total Residual Chlorine (TRC) Load



A ~700 lbs/day reduction was achieved in 1999/2000 due to reductions at NBC Fields Point WWTF and NBC Bucklin Point WWTF.

RI WWTFs: Bristol, Burrillville, East Greenwich, East Providence, Jamestown, NBC Bucklin Point, NBC Fields Point, Newport, New Shoreham, Quonset, Scarborough, Smithfield, South Kingstown, Cranston, Warren, Warwick, Westerly, West Warwick, Woonsocket

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