Disinfecting Irrigation Water for Disease Management

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Knowledge to Go Places

High Quality Irrigation Water

High quality irrigation water is getting hard to find

Runoff and irrigation return flow in the greenhouse

Water to 10% excess

Irrigate prior to wilting

Current Irrigation Practices

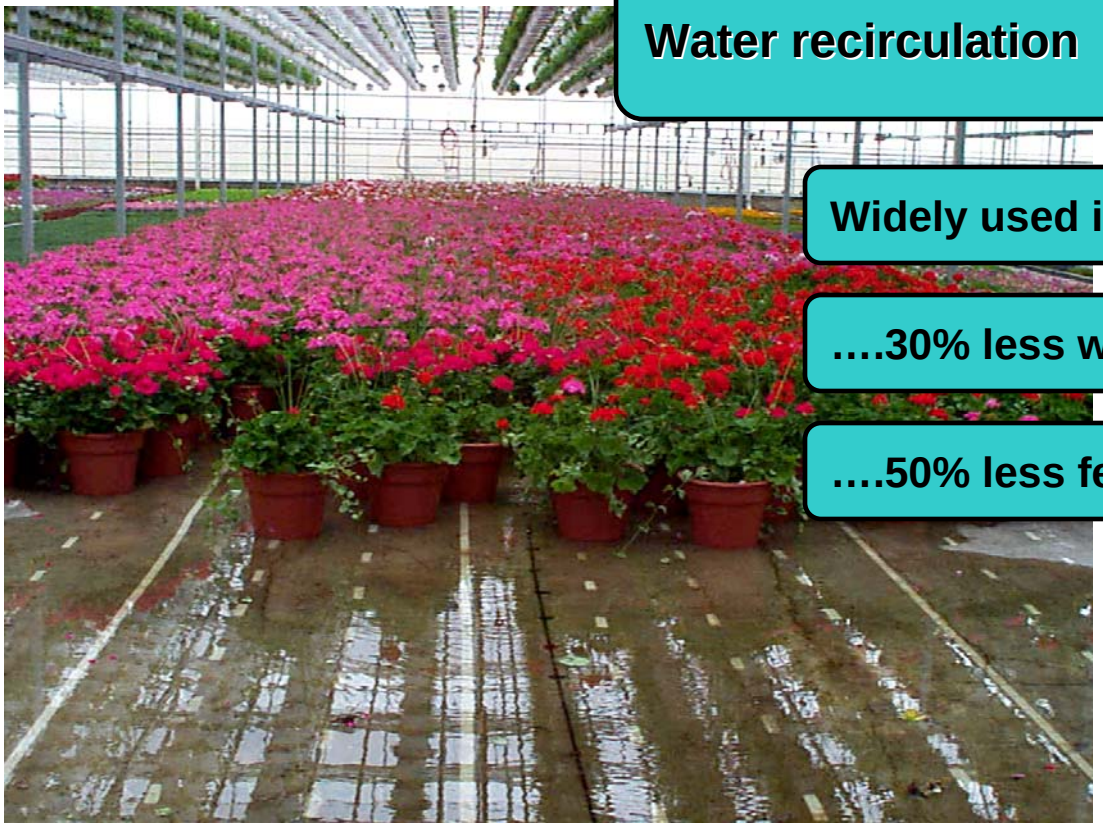
- Best watering practices
- Prevent soluble salts
- Complete wetting
- Insures some stress

Current Irrigation Practices

In reality, what happens…..

- **Most leach 30-40%**
- **Loss between containers**
- **Wasted water**

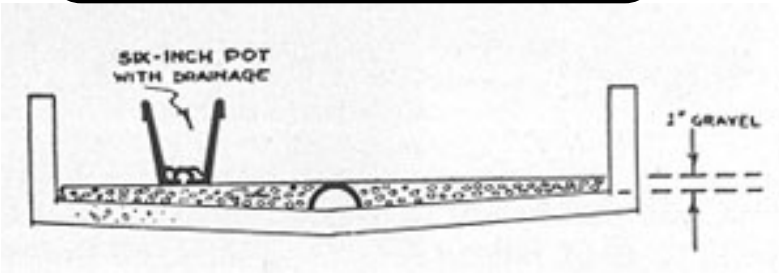
Closed and Sub-irrigation



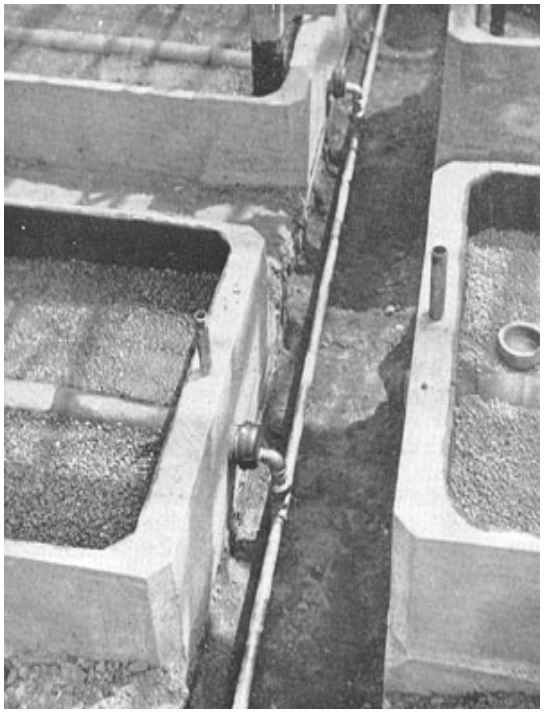
- Water recirculation
- Widely used in Europe
- ….30% less water
- ….50% less fertilizer

Sub-irrigation Not New

Constant Level System for Potted Plants



Post, Ken. 1949. Florist crop production and marketing



Greenhouse Pathogens

Greenhouse pathogens are easy to find

- **Containers and root substrates**
- **Under the bench**
- **On the floor**

Greenhouse Pathogens

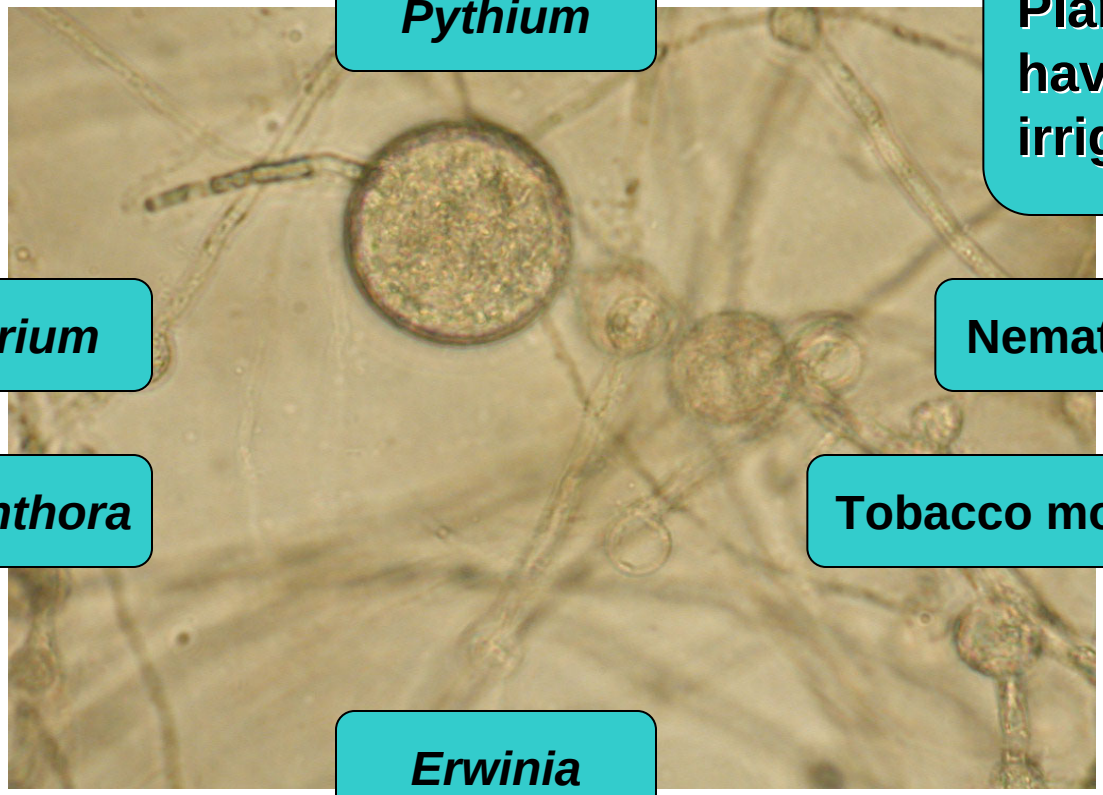
Greenhouse pathogens are easy introduce

- **Plugs and transplants**
- **Shoes and guests**

Water Supplies for Irrigation

Irrigation water is often overlooked as a source of infection

Irrigation Water Sanitation



Pythium

Plant pathogens have been found in irrigation water

Fusarium

Nematodes

Phytophthora

Tobacco mosaic virus

Erwinia

Irrigation Water and Fungicides

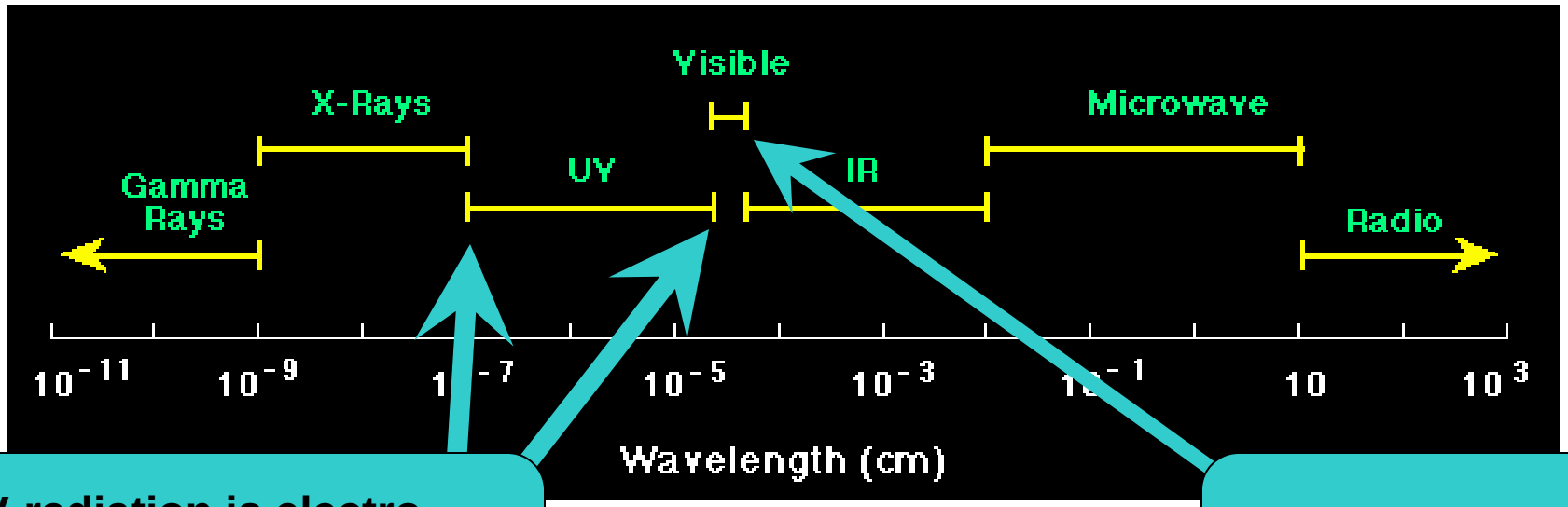
Fungicides are often considered to be the gr s first line of defense.

- **Intended to be applied to the substrate**
- **May be applied through the irrigation systen**
- **Blending with irrigation is a violation of the la**

Irrigation Water Disinfection

- UV-C Sterilization
- Heat Treatment
- Chlorination
- Ozone Treatment
- Hydrogen Peroxide

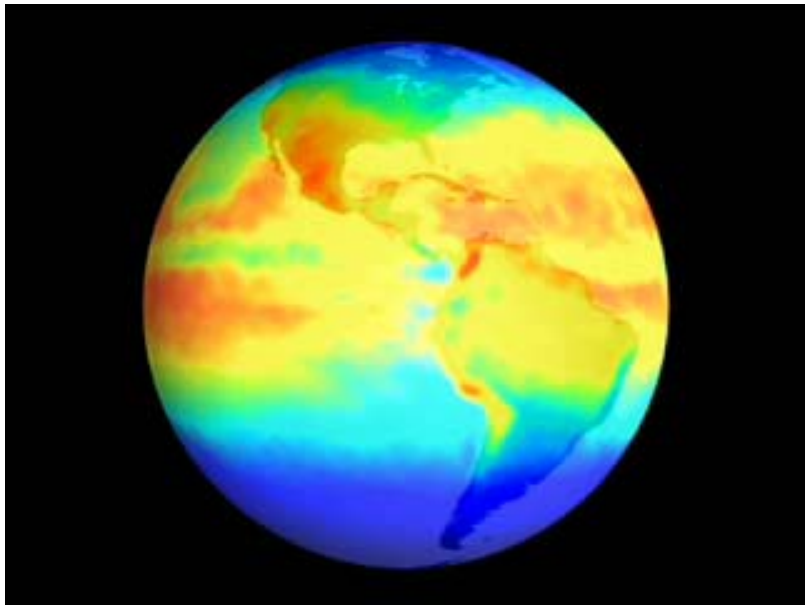
Ultraviolet (UV) Radiation



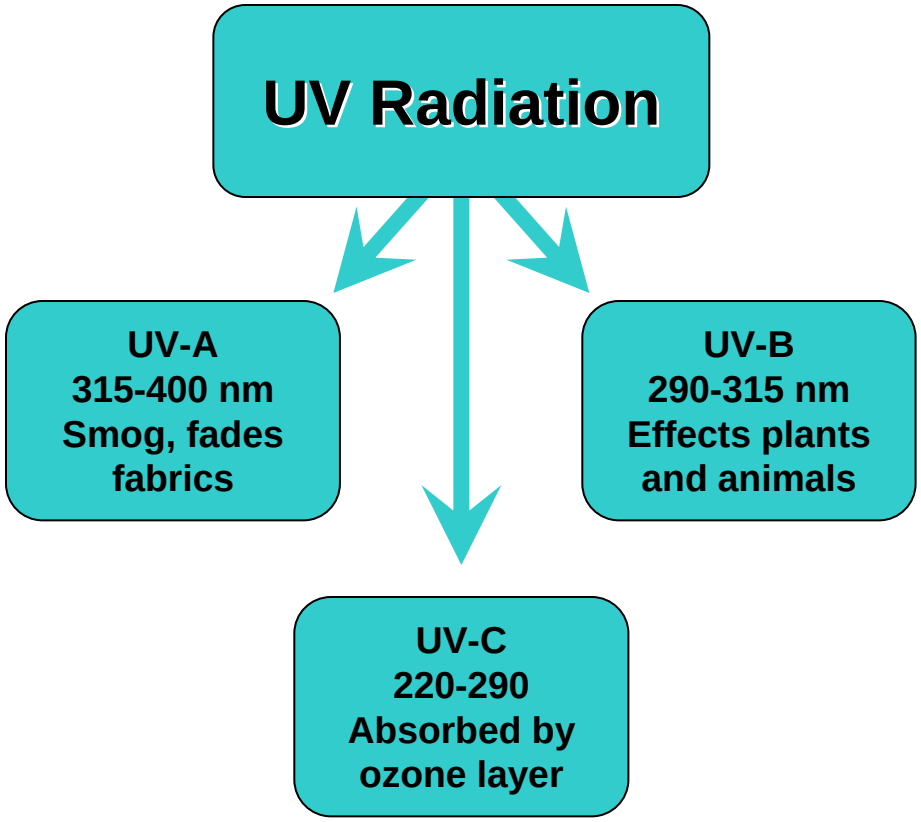
UV-radiation is electro-magnetic energy between 200 and 400 nm

Visible light 200 and 400 nm

UV Radiation



Movie courtesy of the NASA/Goddard Space Flight Center Scientific Visualization Studio



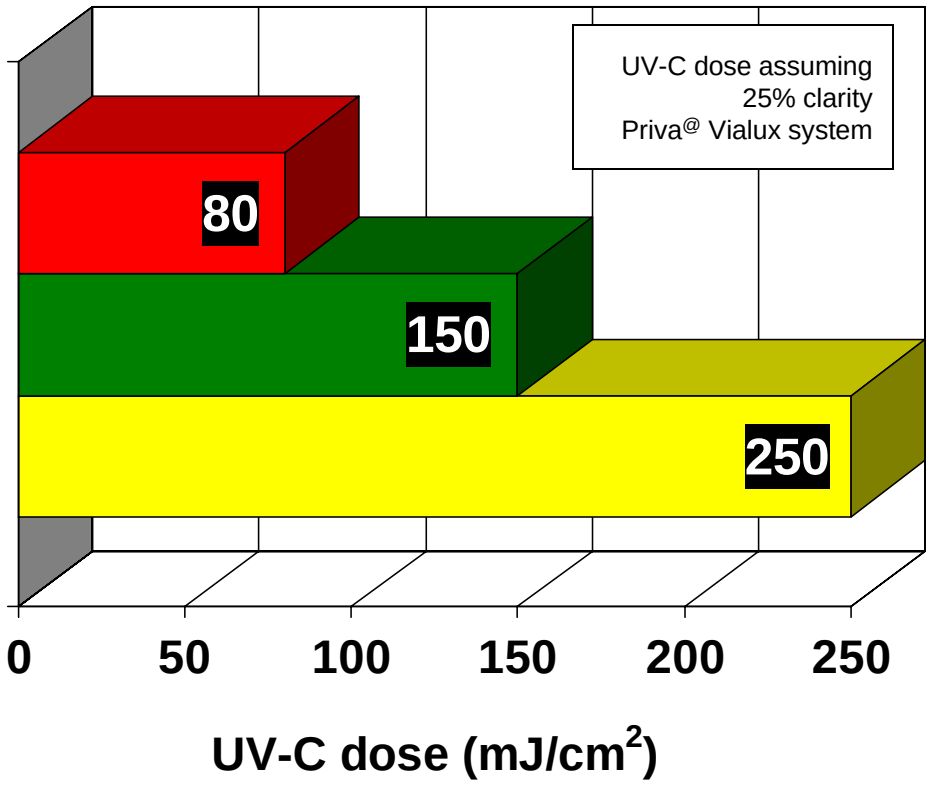
UV-C Sterilization

Plant Diseases

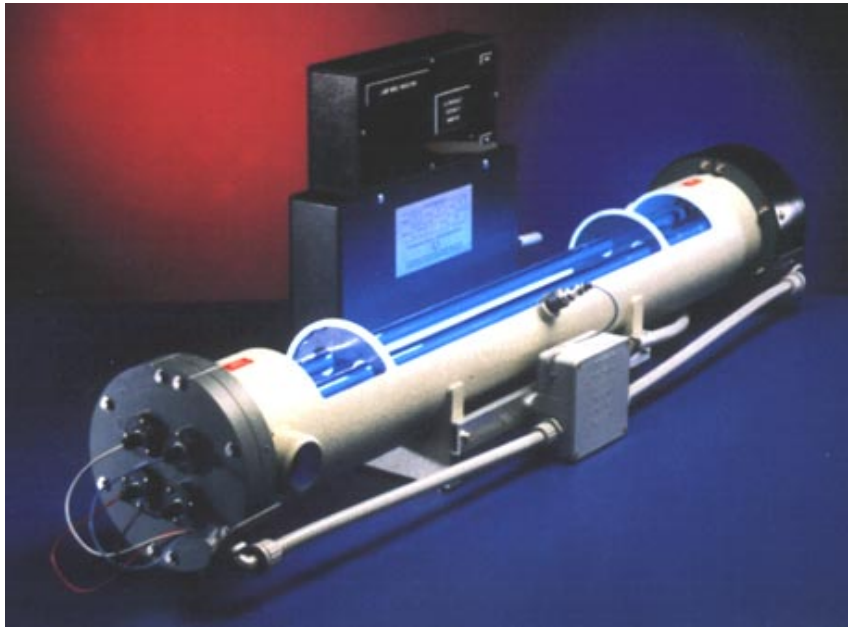
Bacteria, nematodes *Pythium*, *Phytophthora* and *Fusarium*

Pepino mosaic virus

Other viruses



UV-C for Greenhouse Irrigation



Vialux Disinfection System

SunBlest Farms
Fort Lupton, Colorado

Vialux Disinfection System

Multimedia filter

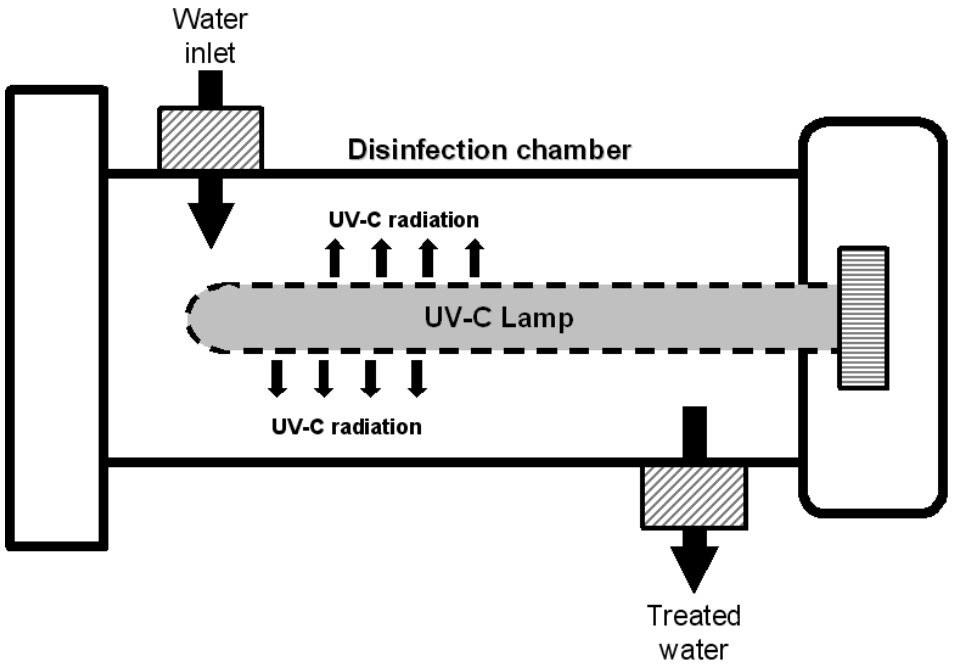
Acid injection

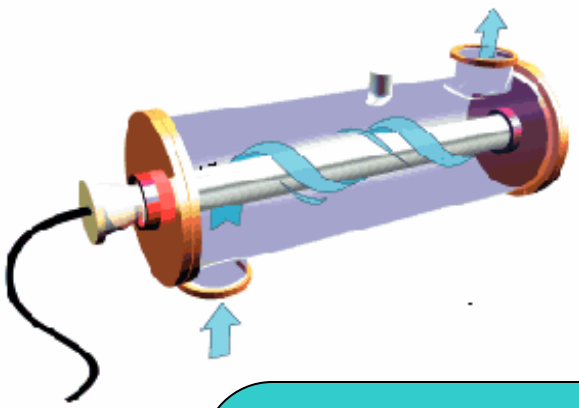
SunBlest Farms
Fort Lupton, Colorado

Vialux Disinfection System

SunBlest Farms
Fort Lupton, Colorado

Issues With UV-C Disinfection





Issues:

- Turbidity
- Scale
- No residual disinfection

Heat Pasteurization of Water

Heat Pasteurization of Water

Hot water pasteurization for greenhouse irrigation water

Cost of Heat Pasteurization

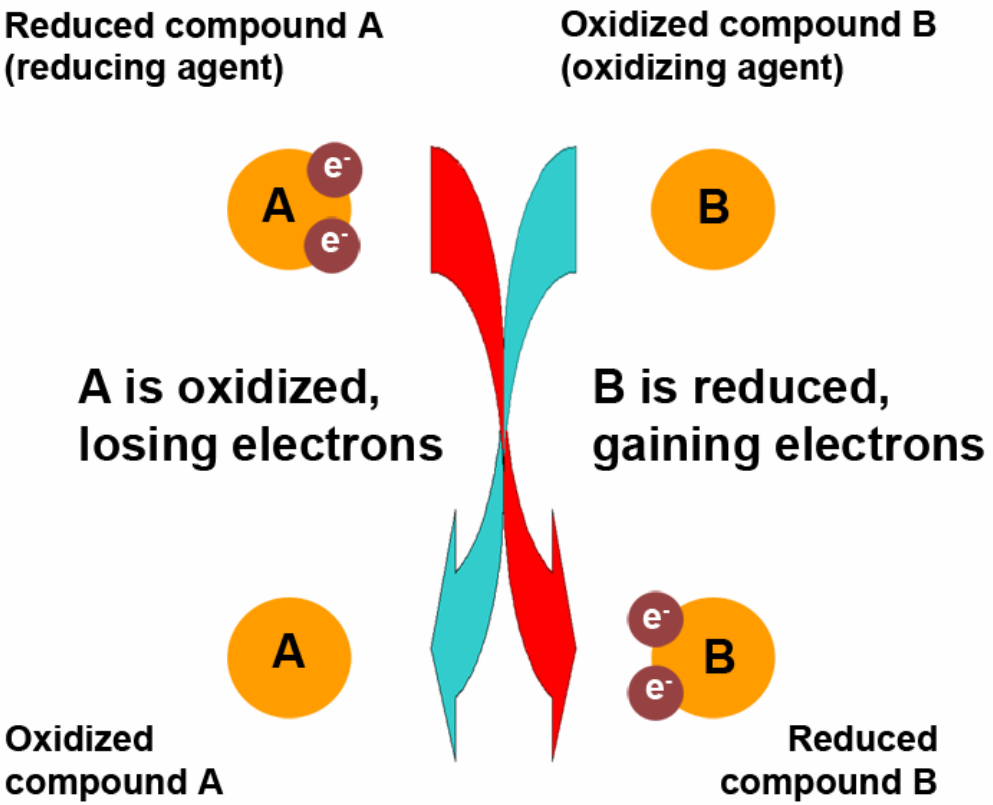
Natural Gas Consumption

270-530 ft^3 fuel / 100 gallons water
or 3-5 therms / 100 gallons water

Oxidation Reduction

Oxidation **is defined as an increase in the positive oxidation number with a corresponding loss of electrons**

Reduction **is a decrease in the positive number of ions with a corresponding gain in electrons**



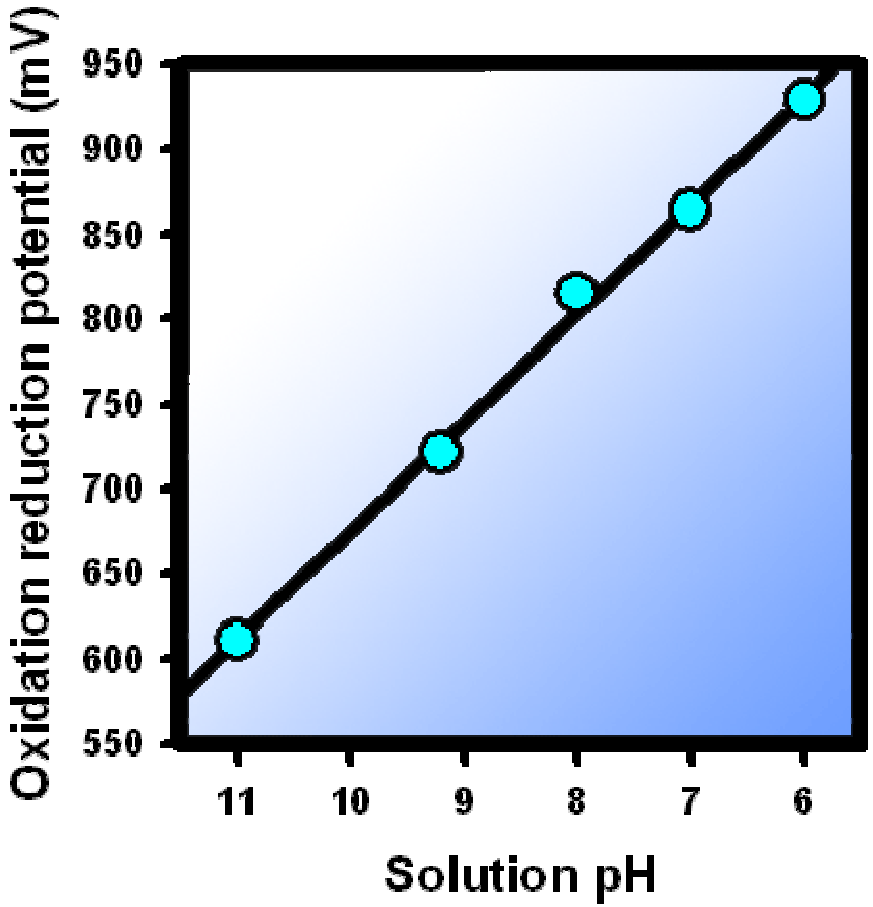
Industrial Oxidizing Compounds

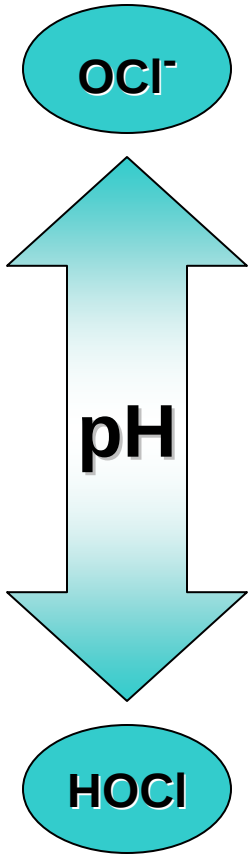
Common industrial oxidizers and their potential relative to chlorine		
Oxidant	Oxidation potential (mV)	Oxidation relative to chlorine
Fluorine	3,050	2.25
Ozone	2,070	1.52
Hydrogen peroxide	1,780	1.31
Potassium permanganate	1,680	1.25
Chlorine dioxide	1,570	1.15
Chlorine	1,360	1.00
Bromine	1,070	0.70

Hypochlorous Acid and pH

Water solutions of sodium hypochlorite and its impact on oxidation reduction potential and pH		
NaOCl (%)	Oxidation potential (mV)	pH
Water	210	6.8
0.3	715	8.9
0.5	690	9.6
1.0	655	10.1
1.5	630	10.6
2.0	599	11.2
3.0	570	11.7

Oxidation Reduction and pH

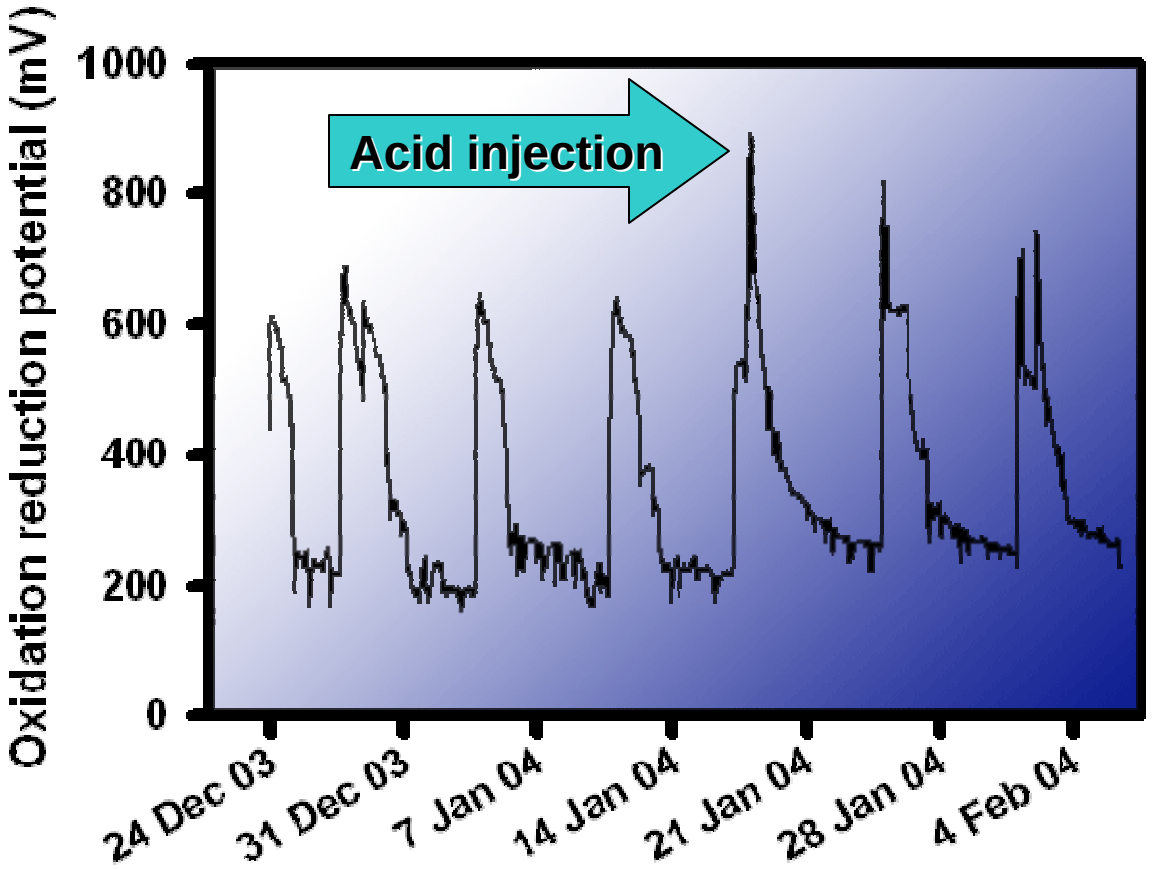




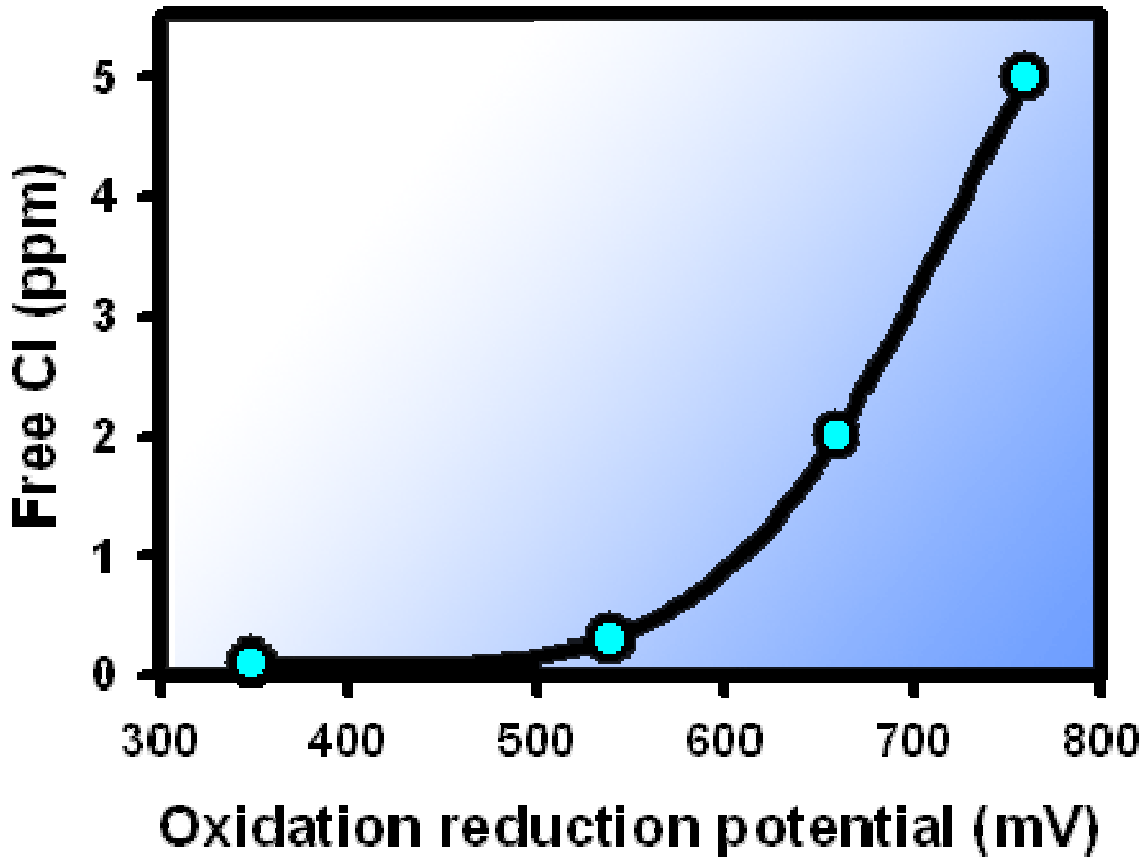
Oxidation Reduction and pH

Regal geranium stock plants

Hypochlorous acid injected into irrigation water



Oxidation Reduction and Cl



Colorado Greenhouse Example

With acid injection
ORP=825 mV
Free Cl=1.4
Total Cl=2.25

ORP and Pathogen Survival

Pathogen survival from laboratory simulations and hydrocooler studies according to Suslow (2003)			
	Survival at ORP (mV)		
Pathogen	< 485	550<X<620	>665
E. coli O157:H7	> 300 s	< 60 s	< 10 s
Salmonella spp.	> 300 s	> 300 s	< 20 s
L. monocytogenes	> 300 s	> 300 s	< 20 s
Thermotolerant coliform	> 48 hr	> 48 hr	< 30 s

ORP Measurement and Chlorine

Panel Mount with Installed ORP Electrode

Handheld ORP Meter

$135-$150

Free Chlorine

Chlorine Sources

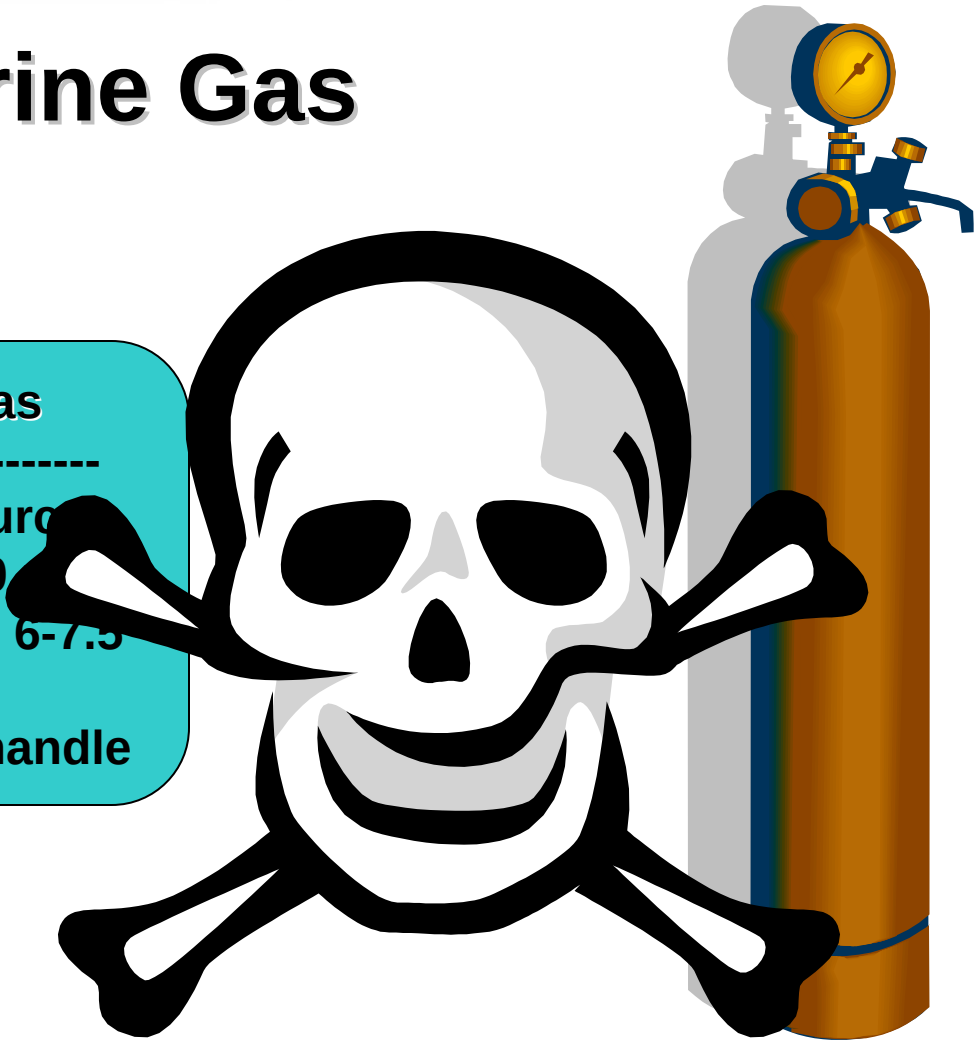
Sources	Chlorine reaction in water
Chlorine gas	$Cl_2 + H_2O \dashrightarrow HCl + HOCl$
Sodium hypochlorite	$NaOCl + H_2O \dashrightarrow NaOH + HOCl$
Calcium hypochlorite	$Ca(OCl)_2 + 2\ H_2O \dashrightarrow Ca(OH)_2 + 2\ HOCl$
Chlorine dioxide	$HOCl+HCl+2NaClO_2 \dashrightarrow 2ClO_2+2NaCl+H_2O$

Chlorine Gas

Chlorine Gas

Cheapest sourc
Inject at 25-200
Most active pH 6-7.5

Dangerous to handle



Sodium Hypochlorite

Chemical Injectors

Hypochlorous Acid (Oxcide™)

Metering Pumps

Calcium Hypochlorite

Tablet reservoir

High volume system

HOCl concentrate

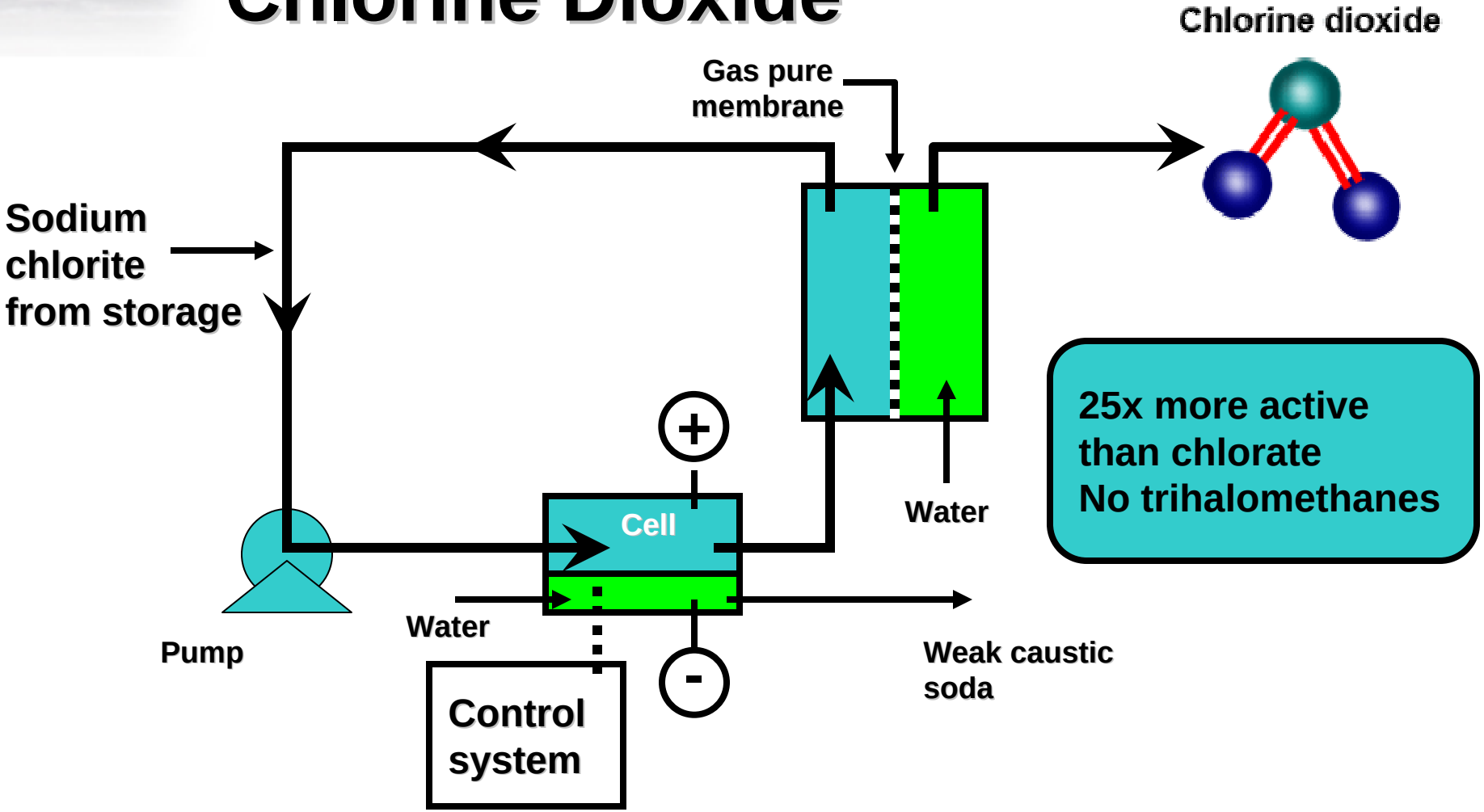
Calcium Hypochlorite

Medium volume system

Water Storage

Tablet feeder

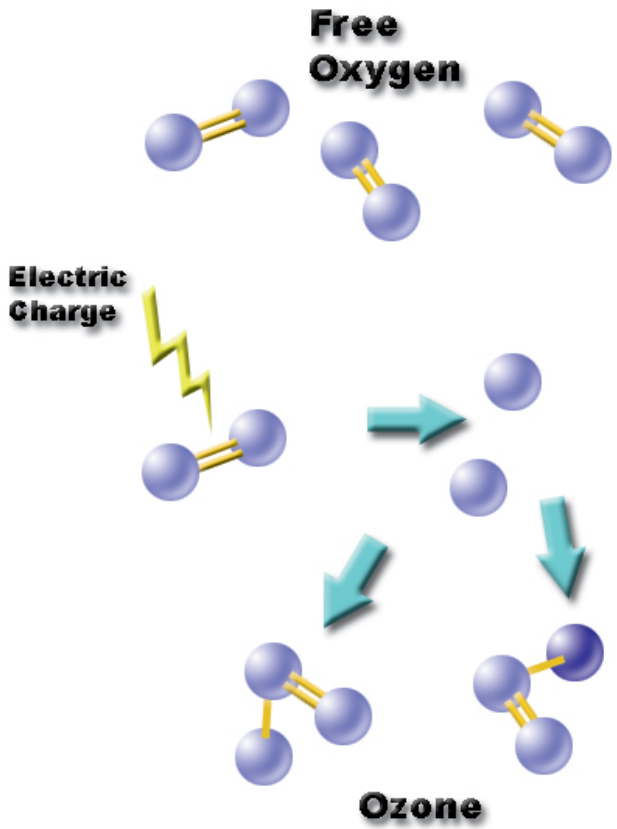
Chlorine Dioxide



Ozonation of Irrigation Water

Ozone occurs naturally

Lightening
Automobile exhaust
Arc welders
Copy machines



Single bond of ozone is unstable and will oxidize organic materials

Ozone Generator

Electrode chambers

Air inlet

O_3 outlet

Air pump

Ozone Generator

Hydrogen Peroxide

Common industrial oxidizers and their potential relative to chlorine		
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Hydrogen Peroxide

3% as a disinfectant

10% for hair treatment

35% for greenhouse and industrial

Hydrogen Peroxide

- ZeroTol (hydrogen dioxide)
  - Contaminated water
    - 1:500 dilution
    - 540 ppm H_2O_2
  - Clean water
    - 1:10,000 dilution
    - 27 ppm H_2O_2

CSU Cooperative Extension

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