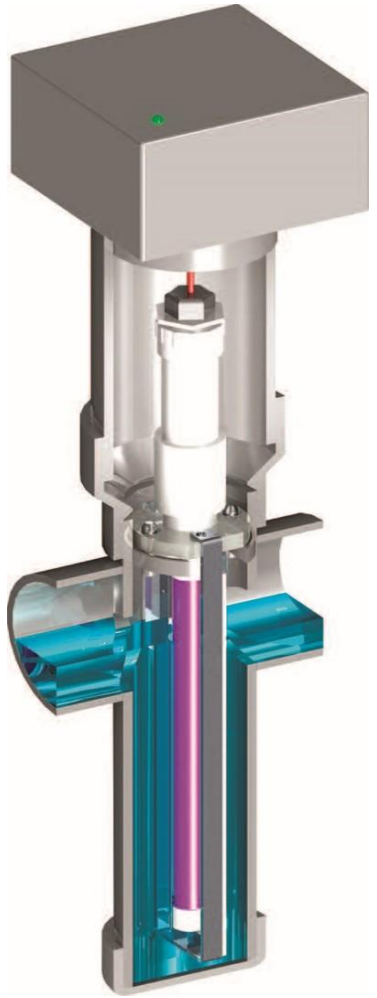
Environmenttechnology
sustainable wastewater treatment

SALCOR INC

Ultraviolet Disinfection

"40 Years of Innovative Excellence"

The Facts and Figures



Typical Wastewater Influent Concentration Ranges for Pathogenic and Indicator Organisms

(Casson *et al.,* 1990; Rose, 1988; and U.S. EPA, 1979b)

Organism	Minimum, no./100 mL	Maximum, no./100 mL
Total coliforms	1 000 000	-----
Fecal coliforms	340 000	49 000 000
Fecal streptococci	64 000	4 500 000
Virus	0.5	10 000
Cryptosporidium oocysts	85	1 370
Giardia cysts	80	320

Secondary Effluent Ranges for Pathogenic and Indicator Organisms Before Disinfection (U.S. EPA, 1986)

Organism	Minimum, No./100 mL	Maximum, No./100 mL
Total coliforms	45 000	2 020 000
Fecal coliforms	11 000	1 580 000
Fecal streptococci[a]	2 000	146 000
Viruses	0.05	1 000
Salmonella sp.	12	570

[a] Assuming removal efficiencies for fecal streptococci similar to the fecal coliform removal efficiencies.

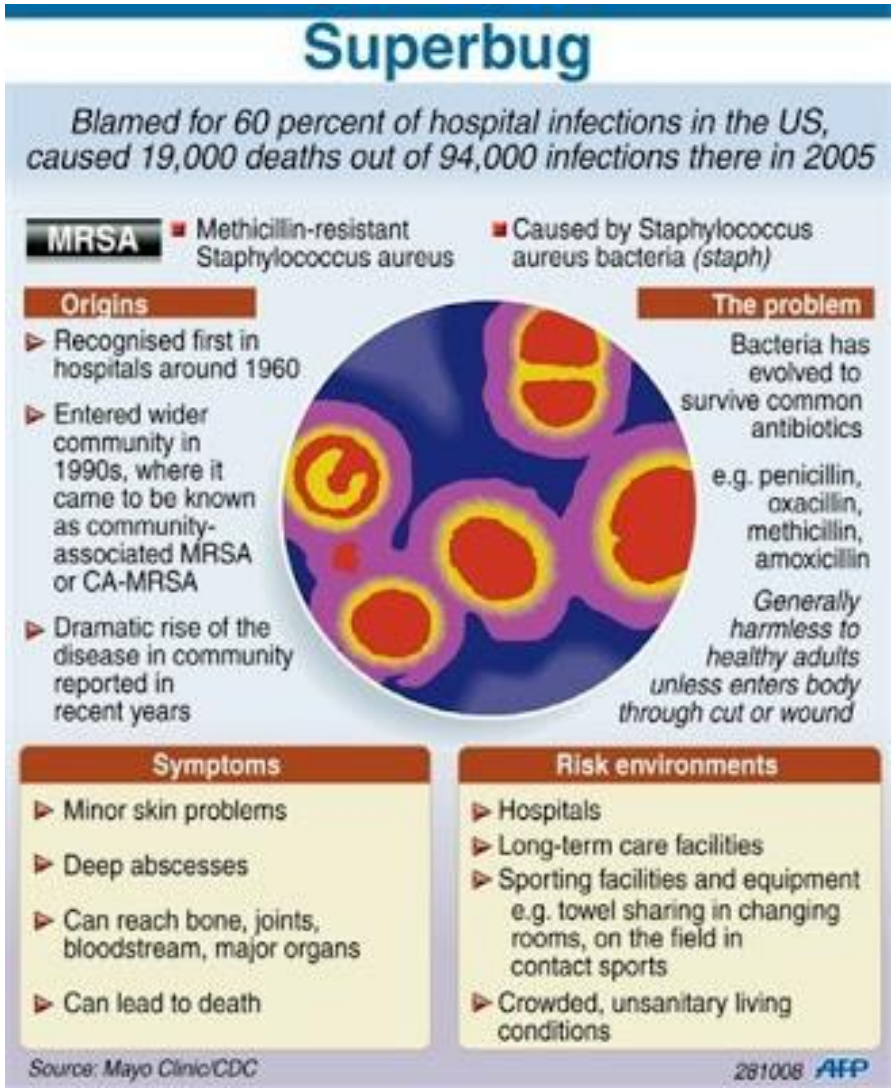
Survival Times of Pathogens in Soil and on Plant Surfaces (U.S. EPA, 1992)

	Soil		Plants	
Pathogen	Absolute maximum[a]	Common maximum	Absolute maximum	Common maximum
Bacteria	1 year	2 months	6 months	1 month
Viruses	1 year	3 months	2 months	1 month
Protozoan cysts [b]	10 days	2 days	5 days	2 days
Helminth ova	7 years	2 years	5 months	1 month

a Greater survival time is possible under unusual conditions such as consistently low temperatures or highly sheltered conditions (for example, heminth ova below the soil in fallow fields).

b Few, if any, data are available on the survival times of Giardia cysts and Cryptosporidium oocysts.


caution
Super Bug!


Superbug
Blamed for 60 percent of hospital infections in the US, caused 19,000 deaths out of 94,000 infections there in 2005
MRSA
Methicillin-resistant Staphylococcus aureus
Caused by Staphylococcus aureus bacteria (staph)
Origins
Recognised first in hospitals around 1960
Entered wider community in 1990s, where it came to be known as community-associated MRSA or CA-MRSA
Dramatic rise of the disease in community reported in recent years
The problem
Bacteria has evolved to survive common antibiotics
e.g. penicillin, oxacillin, methicillin, amoxicillin
Generally harmless to healthy adults unless enters body through cut or wound
Symptoms
Minor skin problems
Deep abscesses
Can reach bone, joints, bloodstream, major organs
Can lead to death
Risk environments
Hospitals
Long-term care facilities
Sporting facilities and equipment e.g. towel sharing in changing rooms, on the field in contact sports
Crowded, unsanitary living conditions
Source: Mayo Clinic/CDC
281008 AFP

SUPERBUGS!!

- Superbugs are on the rise in chlorinated wastewater effluent.
- The multidrug resistant gene NDM - 1 is able to give antibiotic resistance to E. Coli, Salmonella, and other bacteria.
- A Rice University study of Asian treatment plants indicated a minimal NDM - 1 reduction in spite of chlorine disinfection.
- **They recommended using a UV disinfection system.**
- See the ACS Journal, *Environmental Science and Technology*, December, 2013.

Key Superbug Facts

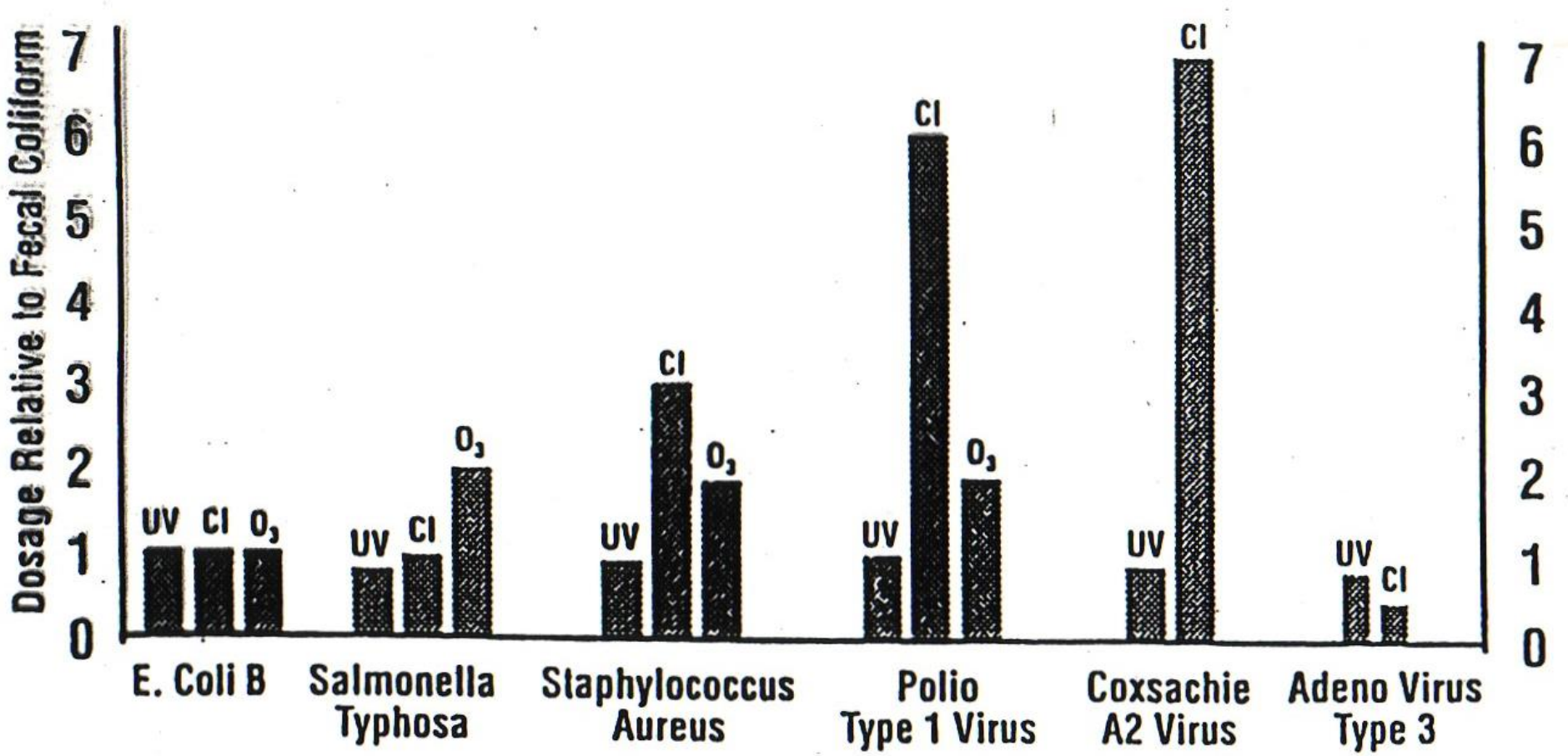
- 60,000 tons/year of antibiotics consumed to raise livestock and for human health
- Bacteria are becoming resistant e.g. MRSA
- Antibiotic Resistant Genes, ARG transfer to human pathogens, ARB
- Wastewater plants are incubators for ARG and ARB

UV VS CHLORINE FOR SUPERBUGS

- UV dose for inactivation is roughly the same as for normal and ARB
- ARG transfer can be nearly eliminated by a UV dose of 10 mj/cm^2
- Chlorine doses above 80 mg-min per/liter prevented ARG transfer
- Chloramine stimulated the bacteria and further helped ARG transfer
- UV is clearly superior to chlorine for reducing the ARG problem

Summary Comparison of UV, Chlorine & Ozone Disinfection for Small Wastewater Flows

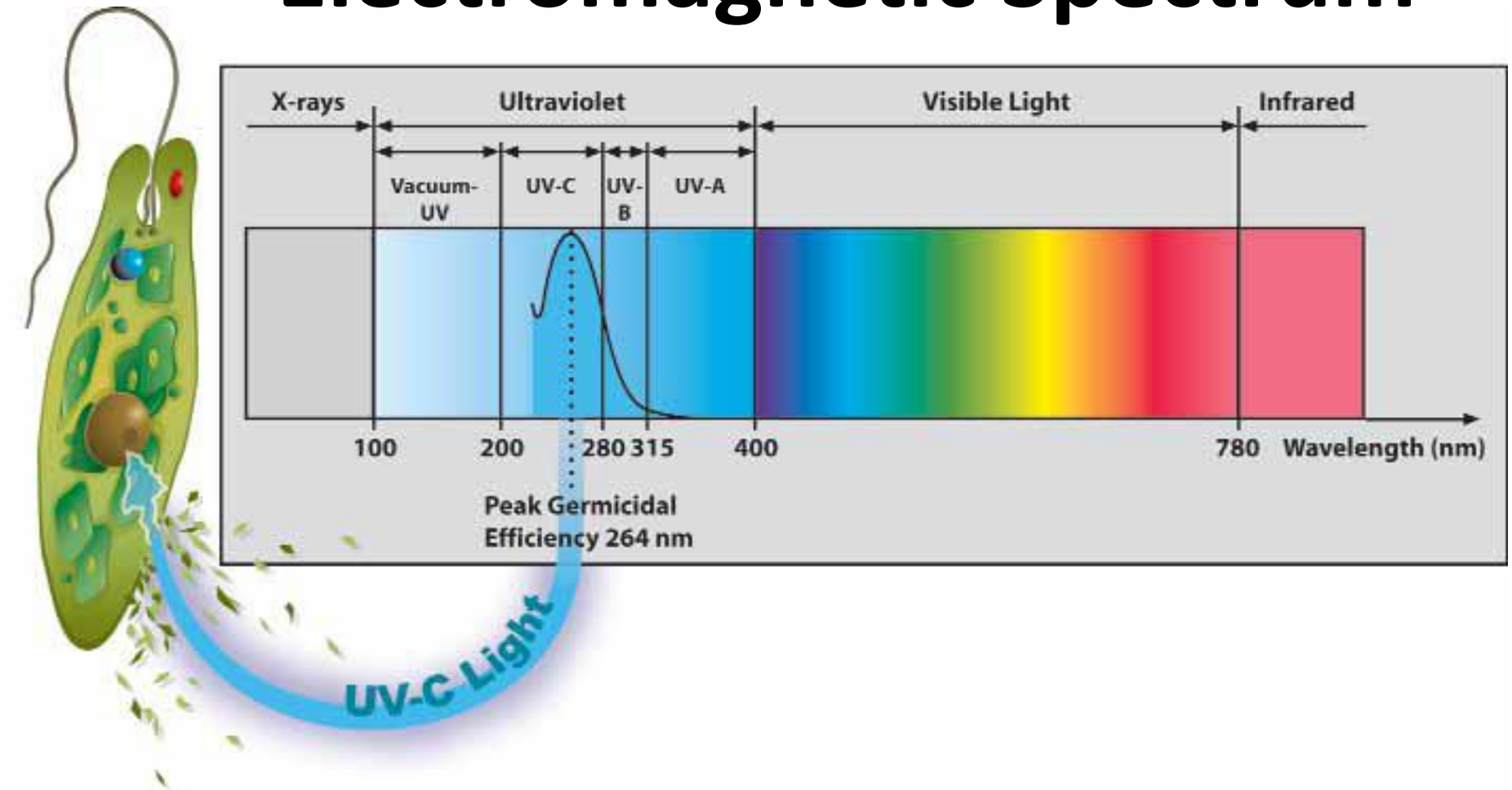
EFFECT	UV	CHLORINE (tablets)	OZONE
pH	No	Yes	Yes
Temperature	No	Yes	Yes
Residual	No	Yes	Dependent on pH & temp.
Contract time required	Very short	Very long	Medium
Operator skill required	Little	Little	Moderate
Equipment maintenance	Little	Moderate	High
Ammonia interference	No	Yes	Yes
Water chemistry change	No	Yes	Yes
Dissolved iron interference	Yes	Yes	Yes
Dissolved organic interference (e.g. phenol, humic acid, lignin sulfonates)	Yes	Yes	Yes
Capital cost	Low	Medium	High
Operating cost	Low	High	Medium


Dosage Relative to Fecal Coliform
0
1
2
3
4
5
6
7
UV
Cl
O3
E. Coli B
Salmonella Typhosa
Staphylococcus Aureus
Polio Type 1 Virus
Coxsachie A2 Virus
Adeno Virus Type 3

UV Disinfection – Basic Facts

- 240-260 nm UV light destroys microorganisms
- Dose is product of UV intensity and exposure time
- UV light transmission and suspended matter important variables
- Low-pressure mercury UV lamps are readily available at low cost
- Reliable delivery of UV dose to the fluid is the engineering design challenge

Electromagnetic Spectrum



UV Destruction Dosages (>99.9% Inhibition) for Important Microorganisms (mj/cm²)

BACTERIA	
Clostridium tetani (Tetanus)	22.0
Dysentery bacilli	4.2
Escherichia coli (indicator organism)	6.6
Legionella pneumophila (Legionnaires' disease)	2.76
Mycobacterium tuberculosis	10.0
Pseudomones aeruginosa (slime former)	10.5
Salmonella typhosa (Typhoid fever)	4.1
Salmonella enteritides (Enteric fever)	7.6
Staphylococcus aureus	6.6
Streptococcus lactis	8.8

UV Destruction Dosages (>99.9% Inhibition) for Important Microorganisms (mj/cm²)

YEAST AND MOLD	
Bakers Yeast	8.8
Saaccharomyces sp.	17.6
Penicillium roqueforti	26.4
Aspergillus niger	330
Mucor racemosus A & B	35.2
Oospora lactis	11

UV Destruction Dosages (>99.9% Inhibition) for Important Microorganisms (mj/cm²)

OTHER	
Chlorella vulgaris (algae)	22
Fungi (typical)	45
Cryptosporidium (Oocysts)	20 – 30
Giardia lamblia (cysts)	20 – 30

UV Destruction Dosages (>99.9% Inhibition) for Important Microorganisms (mj/cm²)

VIRUS			
Influenza	6.6	Influenza A	2.3
Polio Type I	6.0	Bacteriophage MS 2	23.7
Coxsachie A2	4.8	Papilloma Virus	9.8
Ebola (Zaire)	2.3	Hepatitis C	23.3
Mumps	4.7	Adeno Virus Type III	4.5
Norwalk	5.6	Herpes Virus Type 4	5.3

Dose requirements needed for inactivation of viruses by UV light exposure (mj/cm^2)

Virus	90.0%	99.0%	99.9%	99.99%
Echovirus 1	8	16.5	25	33
Echovirus 2	7	14	20.5	28
Coxsackievirus B5	9.5	18	27	36
Coxsackievirus B3	8	16	24.5	32.5
Poliovirus 1	8	15.5	23	31
Adenovirus type 32	40	78	119	160

From: Appl Environ Microbiol. 2002 October; 68(10): 5167-5169.
Doi: 10. 1128/AEM.68. 10.5167-5169.2002

Typical Ultraviolet Transmission Data on Water and Wastewater

Water Type	Percent Transmission of 253.7 nm UV per cm	Absorption Coefficient (253.7 nm UV) (cm^{-1})
Distilled or High Purity Water	99	0.01
High Purity Drinking Water (no ferric iron or absorbing organics)	95	0.05
Poor Quality Drinking Water (<0.3 ppm iron, slight amount of absorbing organics)	82	0.2
Filtered Secondary Effluent (<10 SS, <10 BOD)	71	0.35
Unfiltered Secondary Effluent (<30 SS, <30 BOD)	65	0.43
Lagoon Effluent (<100 SS, < 30 BOD)	61	0.5
Water containing 10 ppm Humic Acid	56	0.58
Water containing 10 ppm Ferric Iron	25	1.4