

# **A NEW METHOD FOR REMOVING AND INACTIVATING WATER-BORNE PATHOGENS UTILIZING SILANE TREATED MATERIALS**

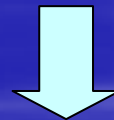
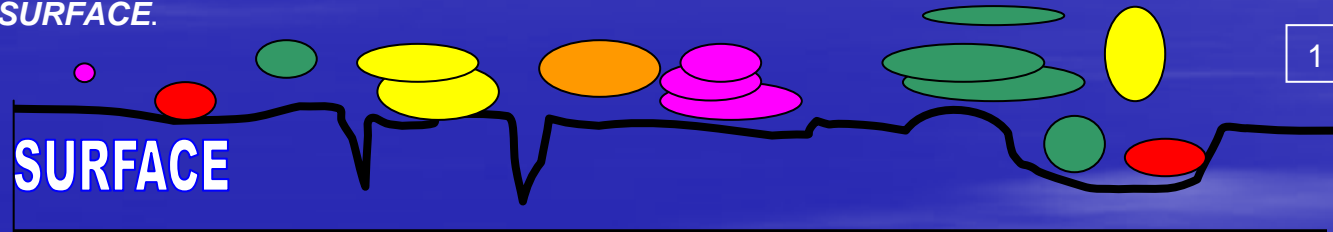
**Coating Systems Laboratories, Inc.**

**William R. Peterson, Ph.D. and Renee E. Berman**

# METHOD OF INACTIVATION AND REMOVAL OF PATHOGENS

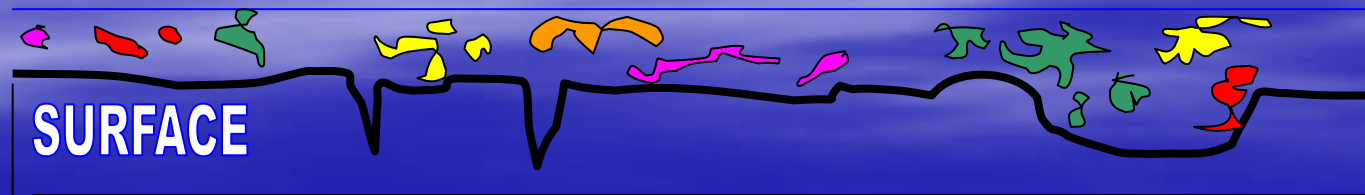
INACTIVATION OCCURS THROUGH LYSIS (DISRUPTION) OF CELLULAR WALLS

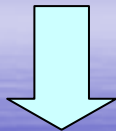
*BACTERIA, VIRUS, PROTOZOA AND FUNGUS PRESENT ON SURFACE.*



TREATMENT WITH SILANE SOLUTION

*SILANE SOLUTION DESTROYS AND ELIMINATES PATHOGENS ON CONTACT*

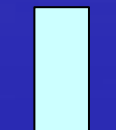




EVAPORATION OF WATER

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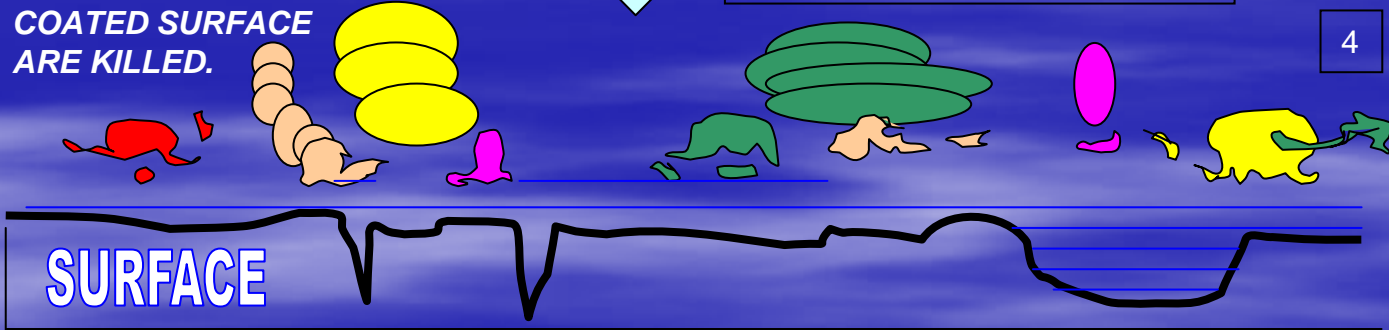
ANTISEPTIC SURFACE COATED WITH POLYMERIC FILM; PATHOGENS DESTROYED



POST-SILANE SOLUTION TREATMENT

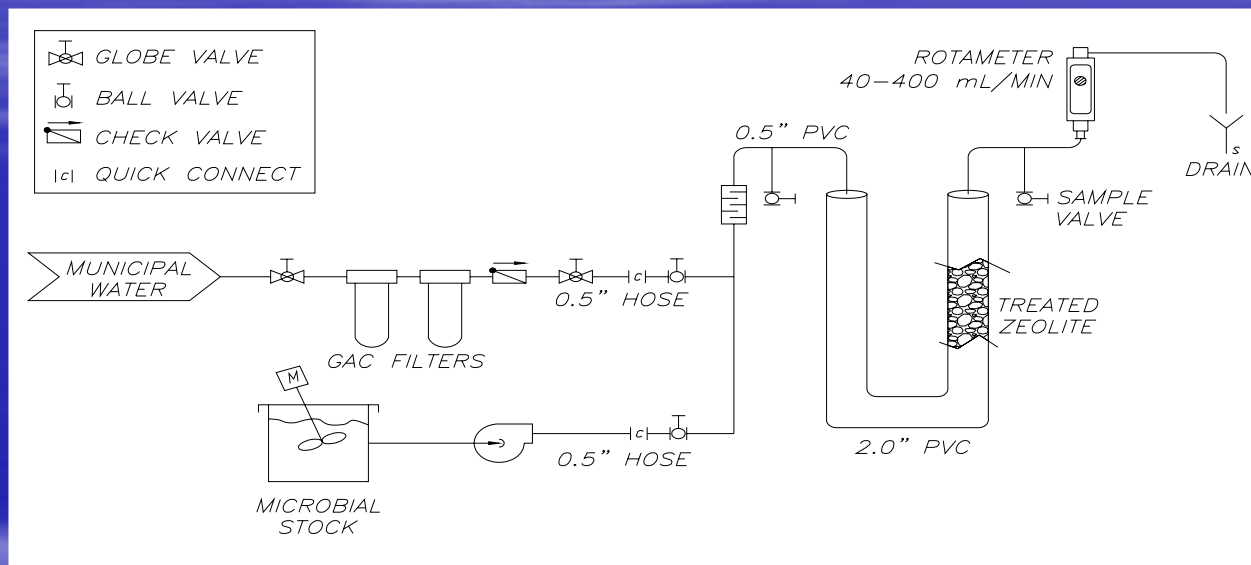
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ADDITIONAL BACTERIA, VIRUSES, PROTOZOA AND FUNGI CONTACTING COATED SURFACE ARE KILLED.



# TESTING OF POINT OF USE (POU) DEVICES

SET OF THREE FILTERS PACKED WITH TREATED  
ZEOLITES - ALL RESULTS ARE SINGLE PASS

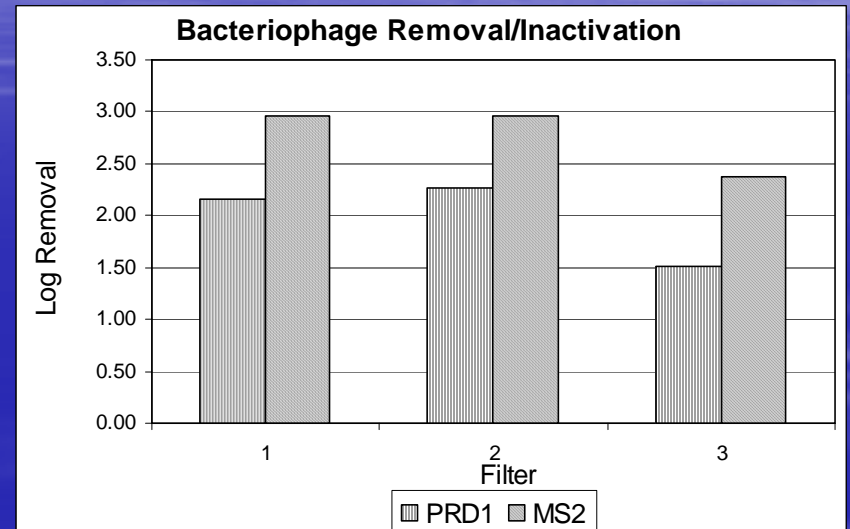


## EXPERIMENTAL SETUP

Testing was done at Arizona State University, Water Quality Center, Tempe, AZ US  
Zeolites supplied by Northern Filter Media, Inc., Muscatine, IA US

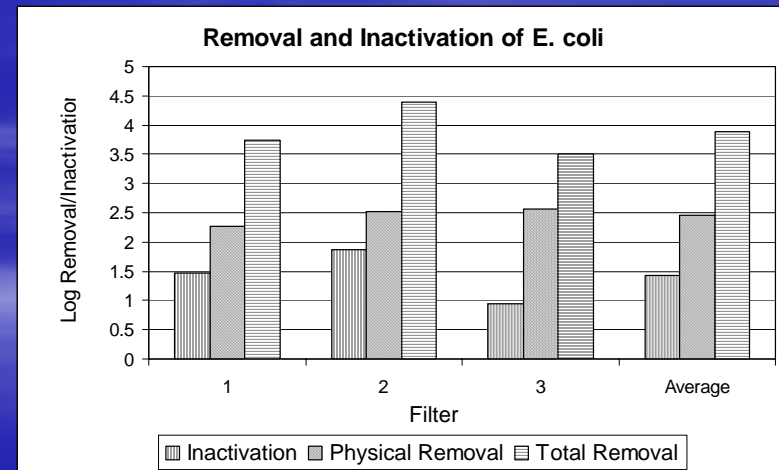
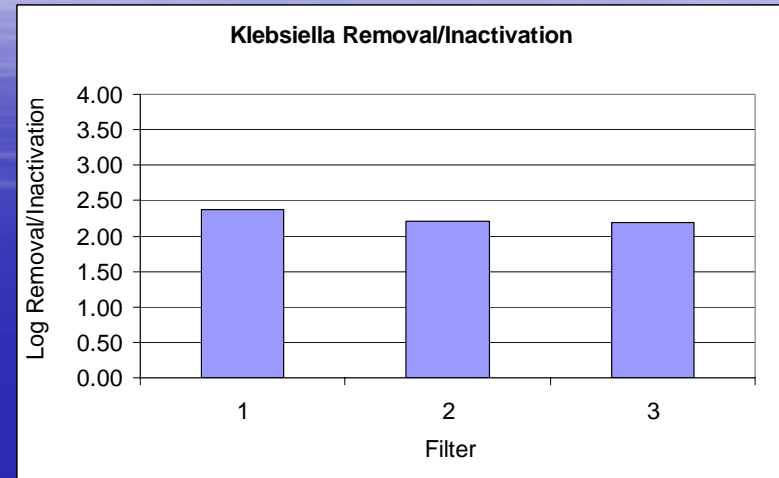
# BACTERIOPHAGE INACTIVATION/REMOVAL

- 3 Filter Sets Employed
- Bacteriophages tested MS2, PRD1
- Log Inactivation/Removal for MS2 ranged 2.40 (99.60%) to 2.96 (99.89%)
- Average Inactivation/Removal MS2 2.8 log (99.84%)
- Log Inactivation/Removal for PRD1 ranged 1.50 (96.83) to 2.27 (99.46%)
- Average Inactivation/Removal PRD1 2.0 log (99.00%)

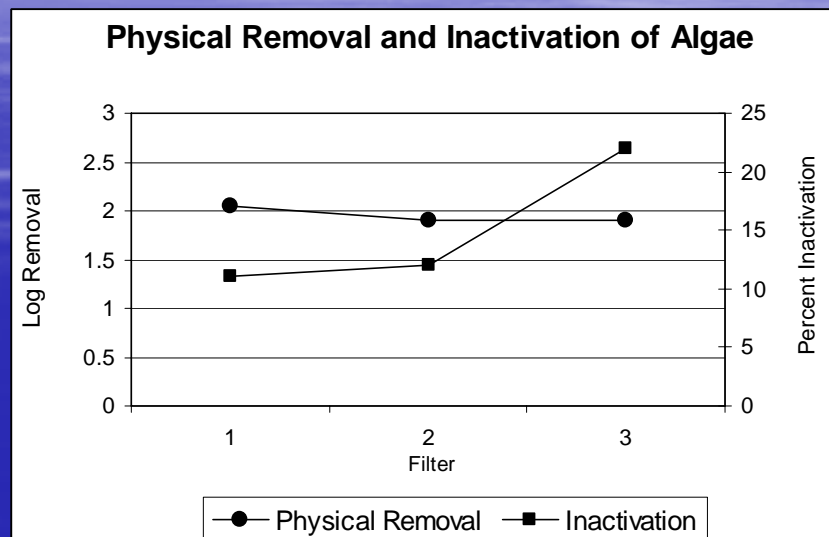


# BACTERIA INACTIVATION/REMOVAL

- 3 Filter Sets Employed
- Bacteria tested *Klebsiella terriena* and *E. coli*
- Log Inactivation/Removal for *Klebsiella terriena* ranged 2.20 (99.37%) to 2.40 (99.60%)
- Average Inactivation/Removal *Klebsiella terriena* 2.3 log (99.50%)
- Log Inactivation/Removal for *E. coli* ranged 3.50 (99.96) to 4.39 (99.99%)
- Average Inactivation/Removal *E. coli* 3.88 log (99.98%)

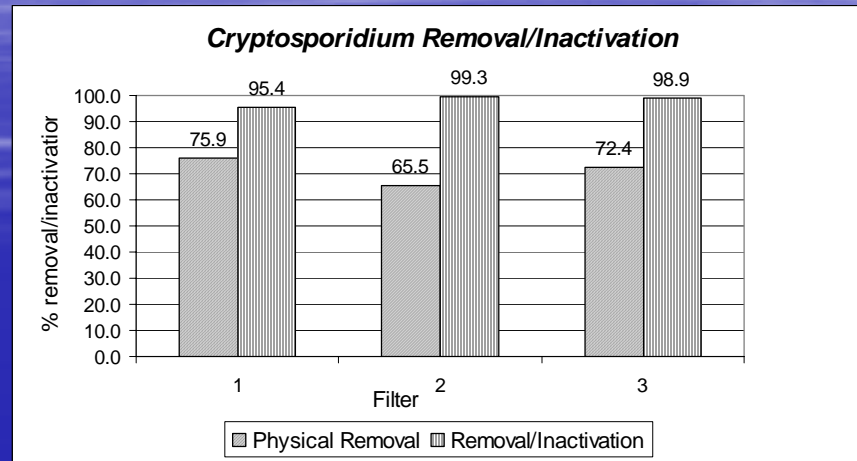


# ALGAE INACTIVATION/REMOVAL



- 3 Filter Sets Employed
- Algae tested *Chorella vulgaris*
- Log Inactivation/Removal for *Chorella vulgaris* ranged 1.90 (98.74%) to 2.05 (99.11%)
- Average Inactivation/Removal *Chorella vulgaris* 1.95 log (98.86%)

# CRYPTOSPORIDIUM INACTIVATION/REMOVAL



- 3 Filter Sets Employed
- *Cryptosporidium parvum* oocysts tested
- Log Inactivation/Removal for *C. parvum* oocysts ranged 1.34 (95.40%) to 2.15 (99.30%)
- Average Inactivation/Removal *C. parvum* oocysts 1.68 log (97.90%)

# DYNAMIC SHAKE FLASK TEST

- Inactivation of *Staphylococcus aureus* with treated cotton

Exposure (Min.)	# Viable cells/ml Untreated	# Viable cells/ml Treated
0	$2.3 \times 10^6$	$2.8 \times 10^6$
10	$2.7 \times 10^6$	$2.5 \times 10^6$
30	$3.9 \times 10^6$	$1.0 \times 10^6$
120	$4.3 \times 10^6$	<1

# DYNAMIC SHAKE FLASK TEST

- Inactivation of *Staphylococcus aureus* with treated leather (pigskin)

Exposure (Min.)	# Viable cells/ml	#Viablecells/ml
	Untreated	Treated
0	$3.4 \times 10^6$	$5.0 \times 10^6$
10	$4.4 \times 10^6$	$5.6 \times 10^6$
30	$4.0 \times 10^6$	$3.4 \times 10^6$
120	$5.0 \times 10^6$	1

# DYNAMIC SHAKE FLASK TEST

- Inactivation of *Staphylococcus aureus* with rinsed leather

Number of 1 second Water Treatments	# Viable cells per ml	
	Time Zero	30 Min. Exposure
0	$1.0 \times 10^6$	$< 1 \times 10^4$
1	$2.5 \times 10^6$	$< 1 \times 10^4$
2	$1.7 \times 10^6$	$< 1 \times 10^4$
3	$8.0 \times 10^6$	$< 1 \times 10^4$
4	$1.3 \times 10^6$	$< 1 \times 10^4$
5	$1.1 \times 10^6$	$< 1 \times 10^4$
6	$1.4 \times 10^5$	$< 1 \times 10^4$
9	$4.1 \times 10^5$	$< 1 \times 10^4$
Untreated	$1.0 \times 10^7$	$1.2 \times 10^7$

# DYNAMIC SHAKE FLASK TEST

- Inactivation of *Staphylococcus aureus* with polypropylene fabric

Exposure (Min.)	# Viable cells/ml	
	Untreated	Treated
0	$2.6 \times 10^6$	$3.1 \times 10^6$
10	$2.8 \times 10^6$	$4.0 \times 10^5$
30	$3.7 \times 10^6$	$2.1 \times 10^3$
120	$4.0 \times 10^6$	<1

# DYNAMIC SHAKE FLASK TEST

- **Inactivation of Pathogens in Containers**

Eight-ounce containers constructed of glass, polyethylene (HDPE), polypropylene (PP) and poly vinyl chloride (PVC) were coated with 1% aqueous solution of silane.

Water containing  $10^7$  bacteria/ml introduced Time 0. After 24 hours, bacteria counts measured  $<10^3$ /ml.

Two-ounce containers constructed of glass, polyethylene (HDPE), polypropylene (PP) and poly vinyl chloride (PVC) were coated with 1% aqueous solution of silane.

Water containing  $10^7$  bacteria/ml introduced Time 0. After 8 hours, bacteria counts measured  $<10^3$ /ml.

# BROAD SPECTRUM ACTIVITY

## Gram Positive Bacteria

Bacillus sp. (vegetative cell)

Micrococcus lutea

Mycobacterium tuberculosis

Propionibacterium acnes

Staphylococcus epidermidis

Streptococcus mutans

Streptococcus pyogenes

Corynebacterium diphtheriae

Micrococcus sp.

Mycobacterium smegmatis

Staphylococcus aureus

Streptococcus faecalis

Streptococcus pneumonia

# BROAD SPECTRUM ACTIVITY

## Gram Negative Bacteria

Acinetobacter calcoaceticus  
Citrobacter deversus  
Enterobacter aerogenes  
Enterobacter cloacae  
Escherichia coli  
Klebsiella pneumoniae  
Legionella pneumophila  
Proteus mirabilis  
Pseudomonas aeruginosa  
Salmonella cholerae suis  
Salmonella typhimurium  
Serratia marcescens

Aeromonas hydrophilia  
Citrobacter freundii  
Enterobacter agglomerans  
Enterococcus  
Klebsiella oxytoca  
Klebsiella terrigena  
Morganella morganii  
Proteus vulgaris  
Pseudomonas fluorescens  
Salmonella typhi  
Serratia liquefaciens  
Xanthomonas campestris

# BROAD SPECTRUM ACTIVITY

## Viruses

Adenovirus Type II & IV

Feline pneumonitis

Herpes Simplex Type II

Influenza A2 (Aichi)

Influenza B

Parinfluenza (Sendai)

Reovirus Type I

Vaccinia

PRD1

Bovine Adenovirus Type I & IV

Herpes Simplex Type I

HIV-1 (AIDS)

Influenza A2 (Asian)

Mumps

Rous Sarcoma

Simian Virus 40

MS2

# BROAD SPECTRUM ACTIVITY

## Fungi, Algae, Mold, Yeast, Spores

Alterania alternata  
Aspergillus niger  
Aspergillus terreus  
Aspergillus verrucaria  
Candida albicans  
Chaetomium globsum  
Chlorella vulgaris  
Epidermophyton sp.  
Gloeophyllum trabeum  
Microsporium audouinii  
Oscillatoria  
Pencillium commune  
Penicillium pinophilum  
Phoma fimeti  
Poria placenta  
Saccharomyces cerevisiae  
Trichoderma viride  
Trichophyton maidson  
Trichophyton sp.

Aspergillus flavus  
Aspergillus sydowi  
Aspergillus versicolor  
Aureobasidium pullans  
Candida pseudotropocalis  
Cladosporium cladosporioides  
Dreschlera australiensis  
Gliomastix cerealis  
Microsporium sp.  
Monilia grisea  
Penicillium chrysogenum  
Penicillium funiculosum  
Penicillium variable  
Pithomyces chartarum  
Scenedesmus  
Scolecobasidium humicola  
Trichophyton interdigitale  
Trichophyton mentogrophytes

# BROAD SPECTRUM ACTIVITY

## Protozoa Parasites

Cryptosporidium parvum (oocysts)

# DURABILITY

- Testing results on treated sand utilizing the British Abrasion Test indicate retention of antimicrobial activity for 5-7 years.

# LEACHABILITY

- Testing of the treated zeolites used in the POU challenge studies above by NSF, Ann Arbor, MI to the rigorous Standard 42 protocol for drinking water found no extractable materials from the antimicrobial silane coating. NSF Standard 50 and Standard 61 tests produced identical results of a non-leaching coating.

# Before/After Pond



# Before/After Pond



# Before/After Pool



# Before/After Pool



# CONCLUSION

The foregoing tests indicate inactivation and removal of pathogens through use of treated surfaces, including sand, zeolites and plastics is possible. The new process for inactivation/removal demonstrates:

- Antimicrobial activity against a wide variety of pathogens including bacteria, fungi, viruses and protozoa.
- No disinfection byproducts. Carcinogenic, halogen-containing byproducts (chloroform, methylene chloride, etc.) are not formed in the inactivation process.
- Durable, long-lasting antimicrobial activity through chemical bonding of the coating to the treated material. Estimated average media life 5 years.
- Non-additive process. No chemicals, oxidizers or energy are required to be added to the water to inactivate and eliminate pathogens.
- Non-leaching process. Treated phase does not leach, dissolve or migrate into contacting water.

# CONCLUSION

- Inactivation of pathogens occurs through cellular membrane disruption. Process is rapid and efficient.
- No pathogen mutagenicity or increasing pathogen resistance on continued exposure to the treated material.
- Treated materials will not harm humans, fish and aquatic plants.
- Effective inactivation and elimination of up to 99.9% for waterborne viruses, bacteria, algae and protozoa on single pass exposure.
- Effective inactivation of *cryptosporidium parvum* oocysts.
- Cost effective water purification process.
- Reusable media. Backwashing regenerates media.

# Contacts

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Patents Pending