

Water Treatment Benefits of Ultrasound and Liquid Arc Induced Cavitation

Presentation
to
Aquatic Animal Life Support Operators
Orlando, Florida
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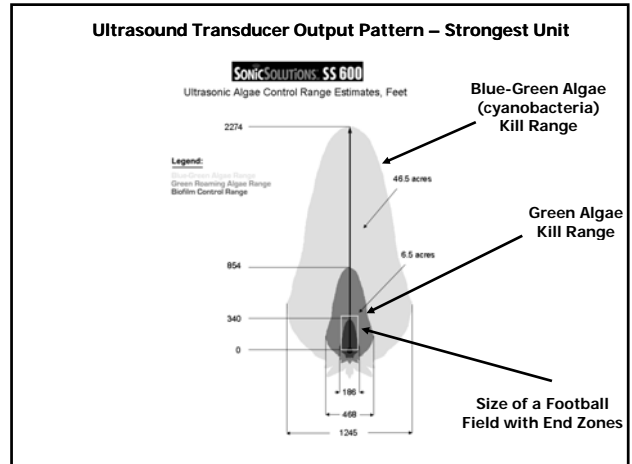
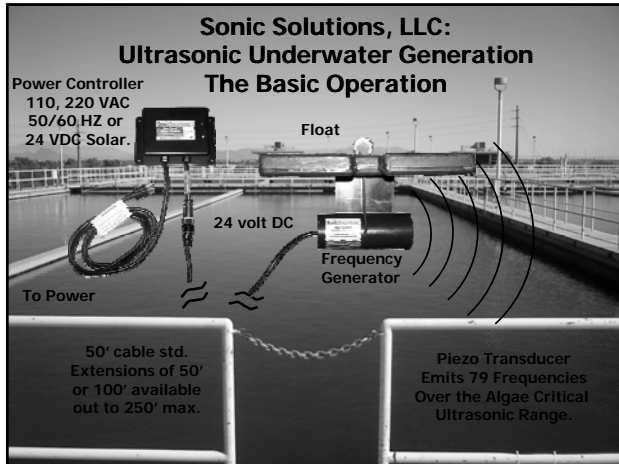
Part 1: Ultrasound

Primary Effects:

**Blue-Green Algae – Collapse of Gas Vesicles
Causes Buoyancy Loss**

**Green Algae and Diatoms: Resonance Causes
Loss of Internal Pressure Control and Fluid
Transfer Resulting in Internal Cell Wall
Collapse**

**Biofilm Initial Formation is Prevented Due to
Near Field Sound Vibration Sensed as
Turbulence by Facultative Anaerobic Bacteria**



Before and After Results Using Sonic Solutions Ultrasound



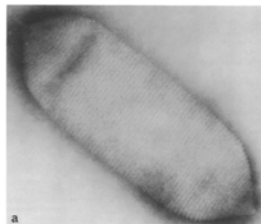
BEFORE

using SonicSolutions® Algae Control

AFTER

using SonicSolutions® Algae Control

Algae Biological Parts Make Them Susceptible To Critical Resonance Vibration



Gas Vesicle:

Rigid hollow cylindrical structures with conical ends made of proteins. As blue-green algae create carbohydrate mass or better termed ballast during sunlight hours, they will gain enough weight to be heavier than water and sink. This allows them to find necessary nutrients near the bottom or at lower depths. As the carbohydrate ballast is consumed, they slowly rise to the surface.

Intact gas vesicle of *Anabaena flos-aquae* negatively stained with phosphotungstate showing corrugated profile of the ribbed structure x300000.

Ref. Fig. 12 Structure and function of gas vacuoles. A E Walsby, 1972.

Blue-Green Algae Can Have Thousands of Gas Vesicles

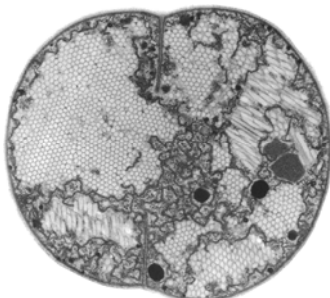


FIG. 1. Transverse section of a dividing cell of the cyanobacterium *Microcystis* sp. showing hexagonal stacking of the cylindrical gas vesicles. (Micrograph by H. S. Padgett.) Magnification, x31200.

Ref. "Gas Vesicles", Anthony E. Walsby, Microbiological Reviews, March, 1994

Targets of Ultrasound Resonance Vibration

How this works:

Vacuoles take up water through specialized membrane transporters called aquaporins. They control the internal pressure needed for cell growth by controlling rates of water and ion movement across the algae cell walls.

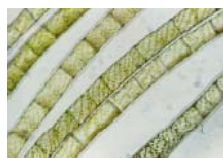
In fresh water algae and fungi lacking cell walls, **contractile vacuoles** fill with excess water from the algae cell and expel it from the cell. Ultrasonic resonance vibration damages these specialized membranes causing loss of critical life functions and ultimately death.

Effects Of Ultrasound On Algae

The following pictures of *Spirogyra* were taken over a three week period from a tank experiment done in controlled glasshouse conditions. The mode of action appears to be by disruption of the connections between the plasmalemma and the algal cell walls causing loss of membrane integrity, probable leakage of cytoplasm and a collapse of the cell into a dense brown mass. The cells remain buoyant for at least 4-5 weeks after exposure, although they are no longer viable.

Effects Of Ultrasound On Algae

Centre for Aquatic Plant Management, UK Work
Commissioned by Sonic Solutions, LLC



The picture on the left shows healthy *Spirogyra*, with cells full of cytoplasm, and the characteristic spiraling chloroplasts. The algae was sourced from a tank at the CAPM in Sonning and had been healthy for at least 5 years.

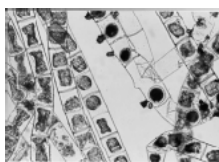


This picture was taken after only 7 days exposure to ultrasound. Already the plasmalemma is coming away from the cell wall, and the cells have shrunk. There is increased granulation of the cytoplasm, indicating loss of chloroplast structure, and loss of connectivity with other cells and the external environment.

Effects Of Ultrasound On Algae

Centre for Aquatic Plant Management, UK Work

Commissioned by Sonic Solutions, LLC



This picture was taken after 14 days exposure. The cells have continued to shrink, with some forming denser circular brown agglomerations in the center of the cell. There is some evidence of cytoplasm leakage from the cells, indicating further damage to the cell walls.



The picture on the right was taken after 21 days, and shows complete breakdown of cell structure.

Ultrasound Side Benefit: Biofilm Impact

Biofilm formation, made primarily from initial bacterial layers and then colonized by algae and other organisms, is greatly reduced in the presence of ultrasonic waves. The ultrasound causes the bacteria that form the initial layer to sense turbulence, a place they naturally avoid.

In cooling towers, interruption of the biofilm colony by ultrasound has been shown to reduce Legionella count.

Numerous water facilities have reported a stark drop in biofilm formation after ultrasound is introduced.

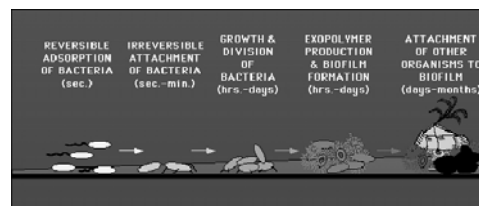
In water tanks, use of ultrasound reduces the amount of chlorine residual needed to maintain the water disinfection. This is due to reducing the biogrowth on the tank inner surfaces.

Ultrasound Side Benefit: Biofilm Impact

How does this work?

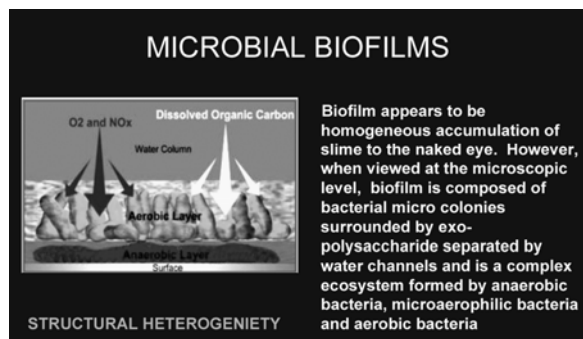
The base layer of biofilm is comprised of anaerobic bacteria. These bacteria spread in water systems by becoming oxygen tolerant for a short period. In turbulent water, studies have shown that these types of bacteria withdraw their pili (small filament used for attachment) and do not excrete polysaccharide glues that they use to attach to surfaces, so they do not form colonies in turbulent water. The ultrasonic waves give them a sense that the water is turbulent, though it is not.

Ultrasound Side Benefit: Biofilm Impact



Ultrasound keeps the bacteria in the reversible absorption stage by producing a sensation of turbulence.

Ultrasound Side Benefit: Biofilm Impact



Ultrasound Side Benefit: Biofilm Impact

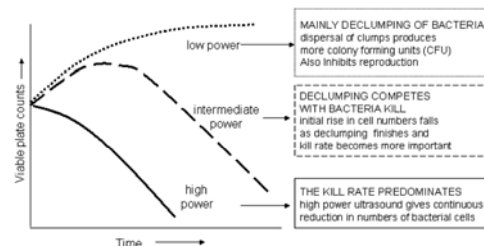


Figure 2: The effects of sonication alone on the survival of bacteria in water.

USES OF ULTRASOUND IN THE BIOLOGICAL DECONTAMINATION OF WATER
Sonochemistry Centre, School of Science and the Environment, Coventry University, T. J. Mason

Ultrasound Side Benefit: Biofilm Impact

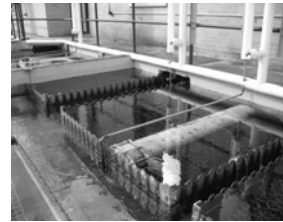
Will it remove existing biofilm?

Typically, existing biofilm will brown out on the edges, but will not always completely go away.

Again, mother nature has provided bacteria a means of "quorum sensing", so an existing colony will give out a chemical that tells other bacteria of like genetics, that a compatible colony exists. Despite the ultrasonic vibrations, new bacteria will attach.

For best results, starting with a mechanically or chemically cleaned surface will prevent reattachment of strongly attached biofilm.

Ultrasound Side Benefit: Biofilm Impact

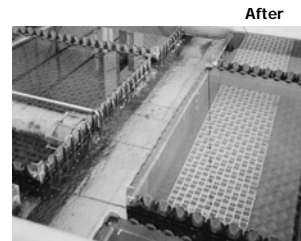


Before

Their Jan-08 THM level measured 34.4 ppb, well under the specified regulated threshold of 80 ppb. The HAAS level is 22 ppb compared to the 60 ppb maximum level.

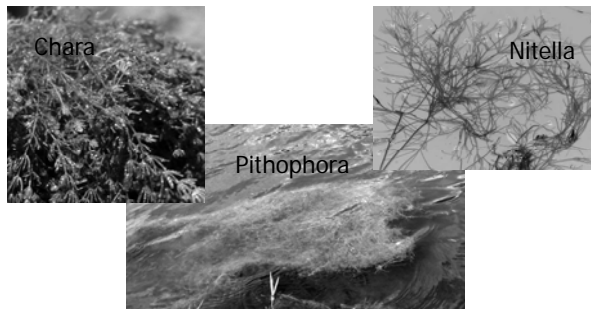
Union, SC Potable Water Plant

Cleaning cycles increased from two to six weeks after introduction of Ultrasound.



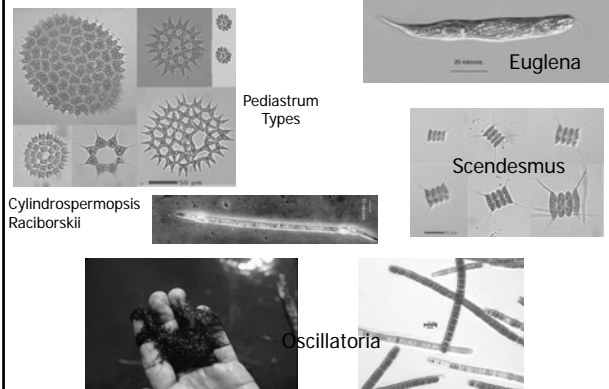
After

Macrophytic Algae Not Controlled With Ultrasound



If it looks like a plant, it is unlikely that ultrasound will harm it.

Types of Algae Not Controlled With Ultrasound



Advantages of Ultrasonic Algae Control

- ✓ 100% environmentally friendly.
- ✓ No generation of by-products.
- ✓ No genetic mutation of survivors.
- ✓ Simple to install.
- ✓ Very little maintenance is required.
- ✓ No chemicals or additives needed.
- ✓ Very low energy consumption.
- ✓ Relatively inexpensive to purchase.
- ✓ Large water bodies are no problem.
- ✓ Wall biofilm where significant quantities of bacteria are produced can be significantly reduced or eliminated.

Disadvantages of Ultrasonic Algae Control

- ✓ Macrophytic or plantlike algae are more difficult to eliminate or are unaffected.
- ✓ Thick plants or these plantlike macrophytic algae structures can prevent ultrasound vibration to reach other parts of the water to be treated.
- ✓ A "line of sight" to the algae must be available for the transducer output to be effective.
- ✓ A few algae types will not be affected by ultrasound (euglenoids, oscillatoria, scenedesmus, macrophytic, and some colonial types like pedicellina are resistant).
- ✓ Patience is required as weeks are sometimes needed for full effectiveness.
- ✓ Biofilm control must start with a clean surface for best results.

Summary of Ultrasonic Algae and Biofilm Control

- Ultrasonic algae control is now a viable and cost effective way to control most nuisance algae types.
- This technology offers an environmentally friendly approach, eliminating many chemicals and chemical handling issues.
- Other than a few fungi that have gas vesicles and certain bacteria that will stop propagating in the near field zone, the ultrasound technology using resonance frequency has not been shown to affect life forms other than algae.

Part 2: Liquid Arc Induced Cavitation

1) Primary Effects:

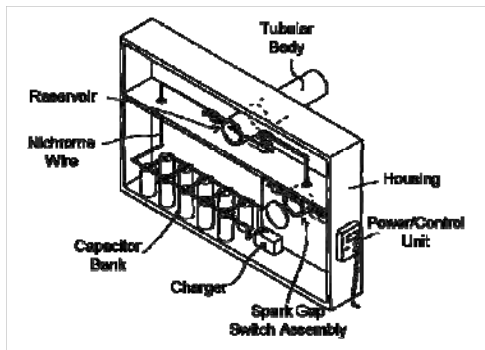
Electric Arc Creates Electrohydraulic Shock Wave Pulse

Pulse Breaks Organic Cell Matrix Killing Bacteria and Removing Biofilm

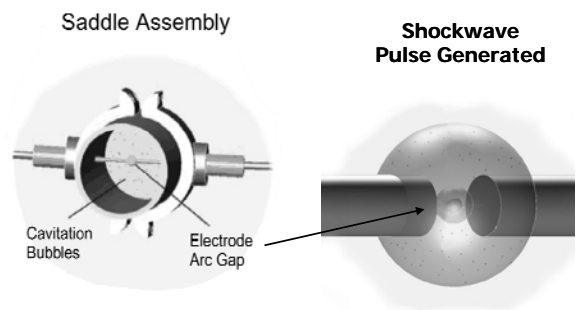
Pulse Generates Cavitation Bubble Field that Produces Hydroxyl Radicals that Reform to Peroxide, Ozone, Oxygen

UV Luminescence from Cavitation Bubble Collapse Increases Oxidation Rates

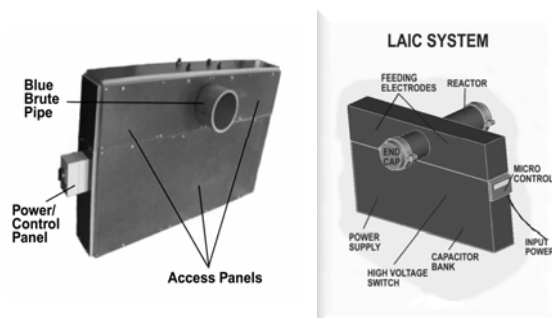
Liquid Arc Induced Cavitation Device by Dajere Technology Inc.



Liquid Arc Induced Cavitation Action



Liquid Arc Induced Cavitation Device



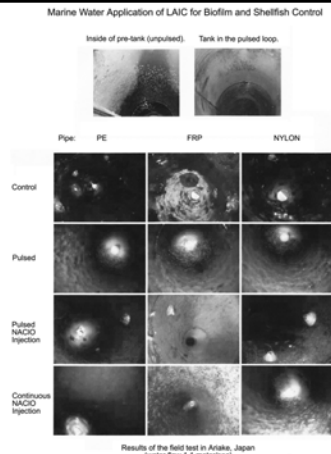
Water Acoustic Pulse Generator

The LAIC 'Sparker' is a water acoustic pulse generator formed by an electric arc impressed between two spaced liquid opposing electrodes. The power for this arc is fed from a newly developed low cost high energy discharge capacitor bank and switch.

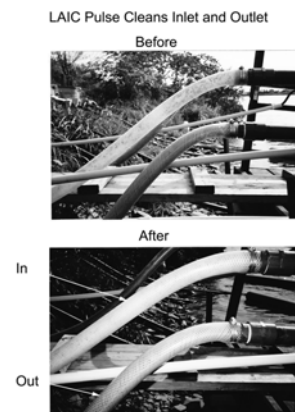


The arc at the gap between the electrodes vaporizes the water and launches a powerful millisecond acoustic pulse into a water filled section of a plastic water main pipe.

Liquid Arc Induced Cavitation Marine Biofilm and Shellfish Attachment Control



Liquid Arc Induced Cavitation Biofilm Removal Via Shockwave Pulse



Dajere's Technology



Electro Technology is a reliable low cost and environmentally superior alternative to existing chemical methods of water treatment



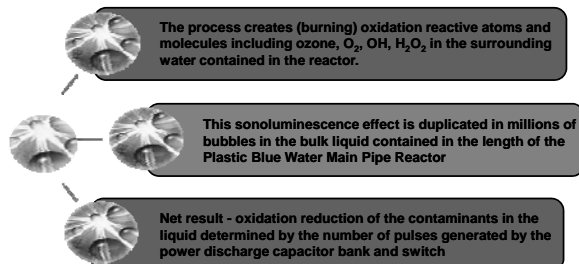
Non-chemical method for controlling or eliminating unwanted microorganisms from industrial and municipal water systems



Immediately applicable to a wide array of water treatment applications and has the potential to solve many world-wide environmental issues currently unaddressed

Low Cost - Environmentally Friendly - Many Applications

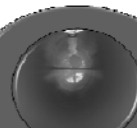
Oxidation Reduction



System Design Features



The device attaches directly to a standard plastic water main pipe. The electrodes pass through a saddle assembly which facilitates dry electrode connections



Electrical connections to the submersed electrodes are not in water as compared with older sparker designs



Controlled feeding with repetitive use through program control maintains an accurate spaced discharge gap in the water

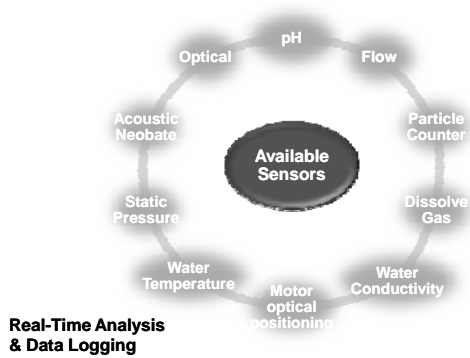
Device Reliability and Operator Safety

System Design Features

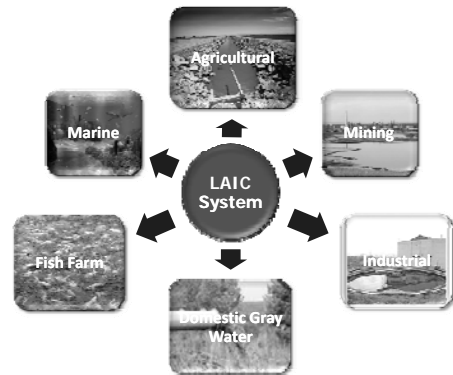


- The system cabinet is made of composite materials and aluminum shielding (Faraday Cage) that facilitates the necessary safety and operating regulations associated with this type of device
- The end caps that are standard hardware for water main pipes are efficient acoustic reflectors minimizing wave spreading losses that will enhance the bubble cavitations effect

System Design Features



LAIC System – Areas of Use



Liquid Arc Induced Cavitation

Summary of Benefits

Bacterial Control, including Biofilm Removal in Tanks and Pipes for Off-Tank Applications

Oxidation Products Created In Situ (Ozone, Peroxide, Hydroxyl Radicals, Oxygen) for Enhanced Bacterial Control and Precipitation of Contaminants

Sludge Dewatering via Bacterial Cellular Matrix Destruction and Oxidation