Sound Water Practices

Ultrasonic Technology Controls Algae and Biofilm

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Ultrasound waves are a natural way to minimize algae-related problems by reducing THM levels, maintenance cycles, and taste and odor problems.

IMPLEMENTING ULTRASOUND, a new "green" technology, is helping utilities improve water quality and decrease operating costs by controlling algae growth in ponds, lakes, and reservoirs and eliminating biofilm growth inside water treatment plants.

ULTRASOUND ZAPS ALGAE

When algae propagation in a water source is controlled, fewer algae are brought into a plant at the intake. Ultrasonic technology controls algae growth by matching the resonance frequency of the algae cells with just enough power to influence cell structure.

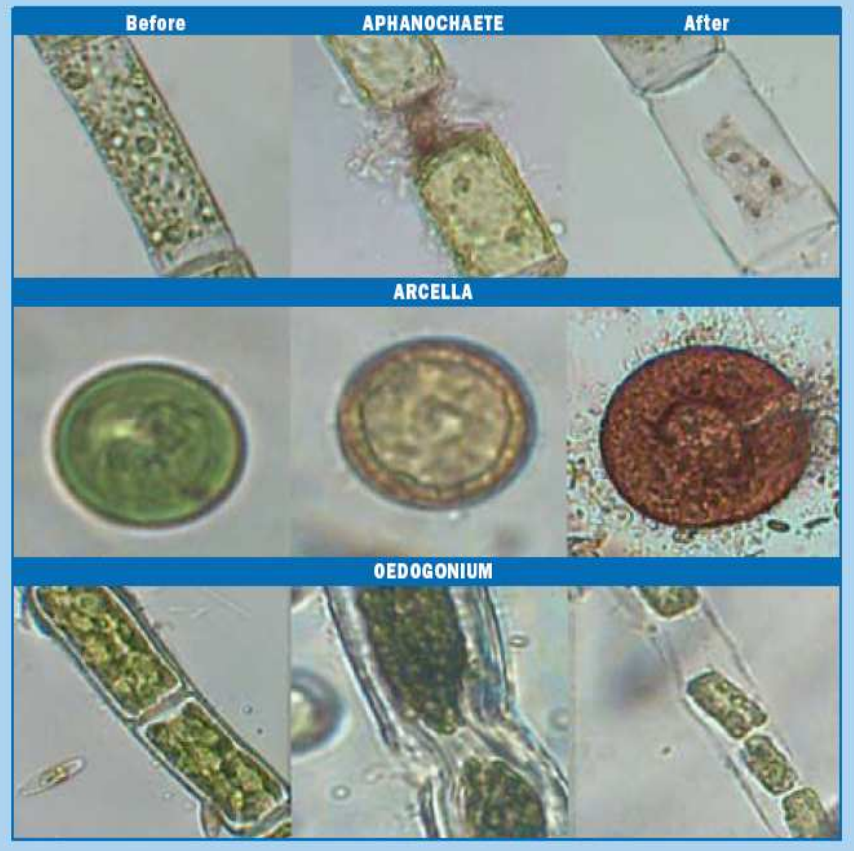
For example, blue-green algae (cyanobacteria) have a gas vesicle system of hundreds to thousands of tiny organelles per cell that's easily broken by ultrasonic sound waves. As a result, the algae lose buoyancy and sink, their life cycle processes are disrupted, and their ability to guard against bacteria is weakened.

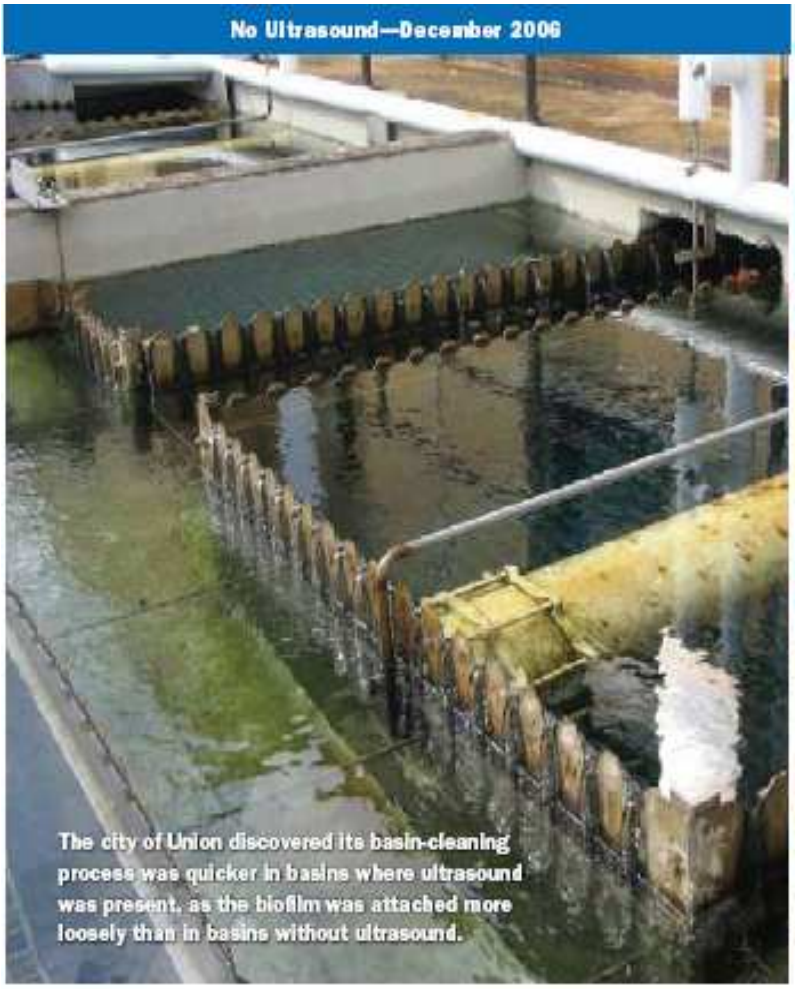
Roaming algae (green, brown, black, filamentous, etc.) don't have gas vesicles, but the ultrasonic unit affects the algal inner cell membrane, causing it to separate from the outer sheath. When separation is complete, the cell can no longer obtain nutrients, control internal pressure, or expel waste products through its contractile vacuole.

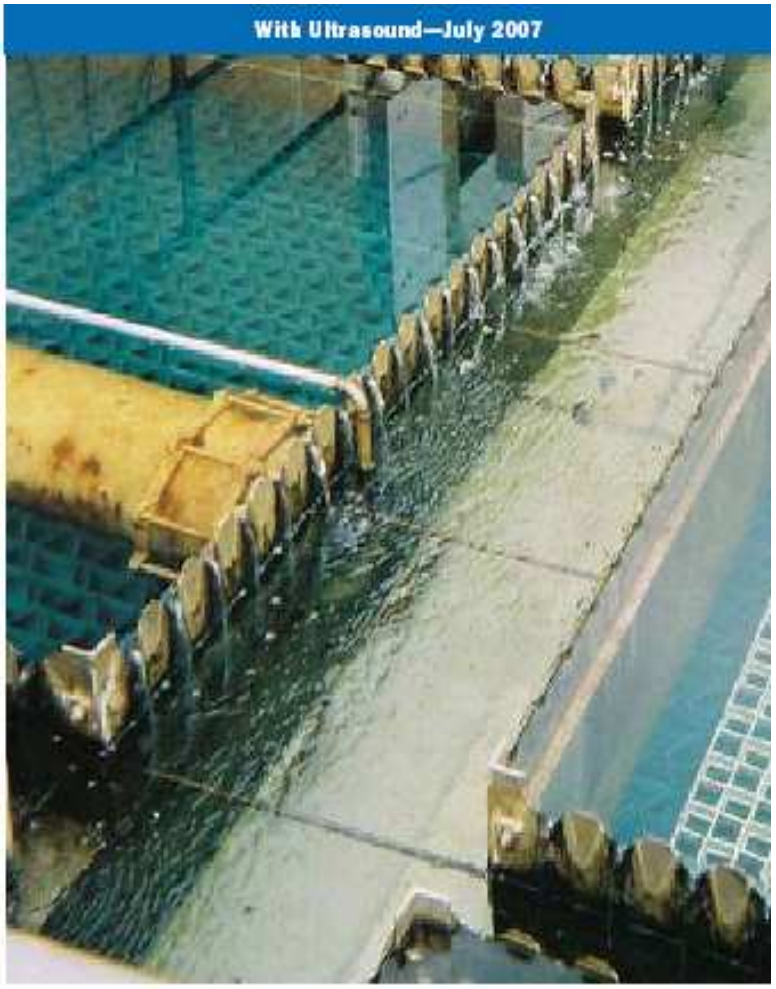
Controlling biofilm growth on equipment surfaces inside the plant eliminates an environment in which algae attach and thrive. Biofilm consists of layers of bacteria that form on host surfaces, creating attachment points for algae. Ultrasound

Before and After Ultrasonic Treatment

Ultrasonic vibrations pose no threat to people, animals, or fish, but devastate algae.







The city of Union discovered its basin-cleaning process was quicker in basins where ultrasound was present, as the biofilm was attached more loosely than in basins without ultrasound.

PHOTOGRAPHS: SOUTH SANTEE AQUACULTURE

waves prevent formation of the biofilm base layer by preventing most free-swimming planktonic bacteria from becoming strongly attached sessile bacteria, which grow on a surface.

Biofilm typically starts forming as quickly as 20 min to 3 hr after cleaning. Recent US Department of Agriculture aquaculture studies conclude that as much as 60 percent of coccoid bacteria—critical to biofilm formation—are killed by ultrasound waves in a 4-day period, though many types of bacteria are unharmed. The ultrasonic sound waves vibrate the bacteria, and the bacterial pili retract as if they are in turbulent water. The bacteria don't excrete the polysaccharide glue necessary to attach to a surface, so biofilm growth is hindered.

A CASE IN POINT

The city of Union, S.C., pumps water 7 mi from the Broad River into its potable water plant and processes 3.2–5.4 mgd, depending on the season. To reduce THM disinfection byproducts in potable water, the city stopped chlorinating at the river intake in the summer of 2006, which resulted in a 50 percent reduction in sodium hypochlorite use. However, by eliminating the chlorination at the intake, bacteria and algae quickly began to adhere to the sedimentation basin walls and v-notch weirs, forming biofilm. The city was concerned that algae growing inside the plant would soon cause taste and odor problems.

To eliminate the biofilm, plant personnel stepped up maintenance by cleaning the basin walls and v-notch weirs every 2 weeks instead of every 6 weeks. The biofilm and algae formation made the task difficult and increased maintenance time and costs. Keeping the plant compliant had turned into a maintenance nightmare.

A TESTING GROUND

After learning about the use of ultrasonic technology for algae control at the SC Rural Water Association annual show, Arnold Franklin, Union's lead water treatment plant operator, arranged for the technology to be tested at the city's plant. The basins and weirs were cleaned thoroughly, and two ultrasonic units—one in a sedimentation basin and another aimed at the v-notch weirs—were installed.

Almost immediately, plant personnel observed that biofilm and algae weren't accumulating in basins or on weirs that were under the influence of the ultrasound waves. Without biofilm, the algae didn't have an environment in which to adhere and propagate. When biofilm did form, the basins and weirs were easier to clean because the biofilm was more loosely attached.

The city subsequently implemented the ultrasound technology plantwide and has continued to reduce THMs and haloacetic acid (HAA) levels. Once again, cleaning can be conducted every 6 weeks, a welcome improvement during the area's summer heat and drought conditions, which necessitate reduced cleaning.

LOOKING AHEAD

November 2007 THM levels measured 34.4 µg/L, well below the regulated threshold of 80 µg/L. In January 2008, THM levels dropped again to 18 µg/L, and HAAs, for which the maximum contaminant level is 60 µg/L, dropped from the November 2007 level of 22 µg/L to 12 µg/L in January 2008. Wastewater Supervisor Donnie Johnson is so pleased with the results that he is planning to install ultrasound technology in the wastewater clarifiers to eliminate biofilm formation and reduce the maintenance cycle from weekly to monthly.

water environment 21

Ultrasound in water treatment:

suppressing algal growth and biofilm formation

Recent research projects have underlined the potential of ultrasound as a chemical-free treatment in water-related applications. **DUDDY HEVIANDI OYIB** reviews the use of one such system, with a focus on wastewater, irrigation and aquaculture applications.

Among the numerous applications of ultrasound, the approach is used in the field of water treatment. In this scenario, forces other than cavitation forces are being used to achieve a certain goal. An example of such ultrasound systems which can be found on the market are the LG Sonic systems, which are manufactured to suppress algal growth and biofilm formation.

The ultrasounds produced by using the LG Sonic technology does not induce any stable (non-inertial) nor unstable cavitations. They do not even come close to reaching cavitation levels. Other mechanical forces induced by the produced mechanical pressure waves are used to suppress algal growth and reduce biofilm growth, e.g. resonance forces, longitudinal and transverse sound wave forces.

To reach this goal, the LG Sonic systems for example use a 'blend' of very specific ultrasound frequencies of certain power which are emitted into the water by specific transducers. This will enhance the specificity and selectivity of the ultrasonic treatment. The algae are treated with ultrasonic sound waves set in precise frequencies that directly target the cellular structure of the algae. The amount of algae in the water is reduced and controlled in an efficient, cost-effective manner, and further growth is inhibited. Green layers disappear, biofilm formation is prevented, and the appearance and clarity of the water is visibly improved. The continuous use of such a device prevents the water from becoming polluted again.

These kind of ultrasound algae control systems can be used in all situations where water is stored, from large industrial water applications to small private pools or ornamental ponds. These systems range from large capacity units to small ones, enabling a 'tailor-made' solution to all purposes.

The amount of time needed to see improvements depends on parameters, such as the type of the algae present in the algal population, water temperature, the amount of light, the amount of nutrients present (especially phosphate and nitrate), size and depth of the water body, Total Suspended Solids (TSS) levels, Total Dissolved Solids (TDS) levels, turbidity, retention time, etc.

To obtain the successful treatment of the water, one should first know that no water body is the same – every water body is unique and should be treated uniquely.

LG Sonic system. Credit: LG Sound

Ultrasound systems like the LG Sonic do not use chemicals, only needs a low supply of electrical energy, and does not harm plants, fishes, zooplankton, and other types of life present in the water, thus having a low environmental impact.

Wastewater application

Wastewater is any water that has suffered in quality by human intervention. Often, wastewater is being treated for re-use as drinking water or for other purposes. As high levels of nutrition are available in these waters, algae may grow rapidly as well as other micro-organisms such as bacteria. Algae can compete for nutrients against the bacteria in charge of sludge reduction and can also clog complete systems. LG Sonic uses the newest ultrasound techniques to remove the threat of algae from wastewater treatment plants and reclaimed water reservoirs.

A research project executed by LG Sound (the producers of the LG Sonic systems) to study the effect of ultrasound in the treatment of wastewater was the Chem-Free project, a three-year project that ended late last year. This was a European project (of about €2 million ($2.6 million)) which focused on the development of a chemical-free water treatment system for the treatment of (secondary treated) municipal wastewater. Chem-Free is a Co-operative Research Project (CRAFT) funded within the European Union (EU) 6th Framework Programme Horizontal Research Activities.

Briefly, some of the results achieved in wastewater applications using the LG Sonic systems are:

- Strong reduction in algae concentration (± 90% reduction of chlorophyll-a)
- Reduction of biofilm formation
- Reduction of TSS, turbidity, BOD, COD levels etc.
- Reduction of free bacterial counts (*E. coli*, Enteroccoci etc.)
- Ultrasound vibrations make it more efficient for bacteria present in the sludge to obtain nutrients, and speeds up the utilisation of nutrients, accelerating the degradation of organic waste and the consumption of nitrate and phosphates.
- Secondary effect, improvement of the UV/ozone performance in elimination of microorganisms

The LG Sonic systems can be applied, for example in DAF (dissolved air floatation) tanks, flocculation tanks, clarifiers, sedimentation ponds, etc.

Irrigation

Water used for irrigation can contain high levels of nutrients. Some of these nutrients are beneficial for the plants watered, but they can also lead to extensive algal growth. Algae in irrigation tanks can clog the irrigation system and can also be spread over the irrigated area. In addition, some types of fungi (e.g. *Pithium*, *Fusarium* and *Phytophthora*), which can also be present in these waters, can be harmful for the plants being cultivated. Therefore, the quality of water in an irrigation system can be critical to the performance of a nursery.

The overall results obtained when applying the LG Sonic systems to irrigation were:

- Strong reduction in algae concentration (about 90% reduction)

- Reduction of biofilm formation
- Reduction of TSS, Turbidity, BOD, COD levels etc.
- Reduction of total aerobic bacterial counts.
- Reduction of fungus (*Pithium*, *Fusarium* and *Phytophthora*) concentration
- Reduction of iron and sulfur related problems (conserving irrigation network system).

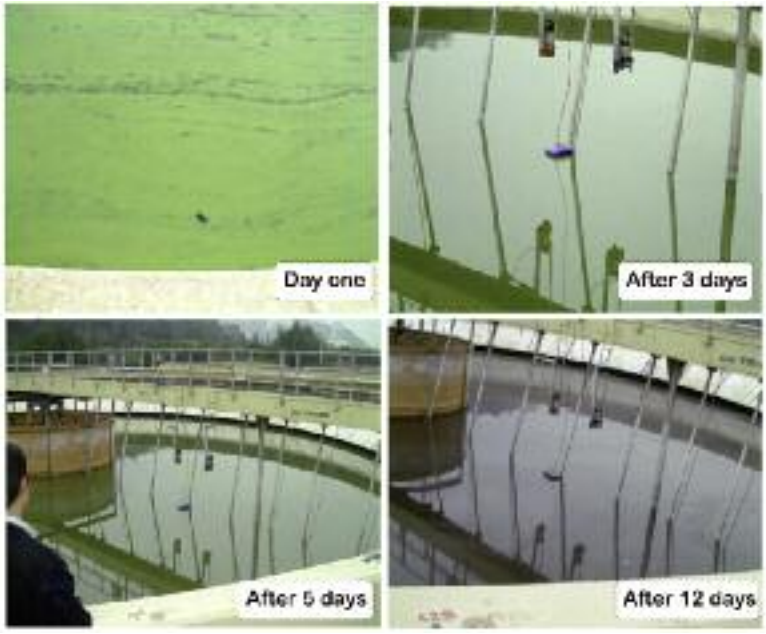
Aquaculture application

On the basis of the results obtained from two projects, Chem-Free (mentioned above) and a research project executed in 2007 in collaboration with USDA-ARS (US Department of Agriculture Agricultural Research Service) and Catfish Genetics Research Unit (USA) using the LG Sonic ultrasound systems, LG Sound developed and launched a new LG Sonic system, LG Sonic Aquaculture, especially designed for aquaculture purposes.

Some of the results achieved in the aquaculture using the LG Sonic Aquaculture models are:

- Strong reduction in algae concentration (about 90% reduction)
- Reduction of biofilm formation

Algae removal at a wastewater treatment plant. Credit: LG Sound



About the author
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- Reduction of fouling and other growth on fish cages (inland and open sea)
- Reduction in β-cyclocitrol, 2-methylisoborneol concentration
- Reduction in microcystines (cyanobacteria toxins)
- Reduction of TSS, turbidity, BOD, COD levels etc.
- Reduction of free bacterial counts (*E. coli*, Enteroccoci, total coliforms etc.)
- Reduction of ammonium and nitrite
- Slightly heavier fish yield ●

PUBLICATIONS

Industrial Water Quality 4th edition

Authors: W Wesley Eckenfelder Jr, David L Ford and Andrew J Englande Jr

The fourth edition of Industrial Water Quality provides the technical approaches, latest information, and current regulations which guide the reader to conceive, design, and operate industrial pollution control facilities, either as an upgrade or as a newly developed industrial complex. Advanced technologies are discussed as well as updating existing approaches to control, troubleshooting, and solving the complex issues of controlling industrial wastewaters and residuals.

Water Environment Federation Press, 2008
896pp. Hardback
ISBN: 9780071548663
WEF members price: $140
List price: $160
To order, visit: www.wef.org

Calcium and Magnesium in Drinking-water Public Health Significance

Can calcium and magnesium ('hardness') in drinking water contribute to preventing disease? This book documents the outputs of an unprecedented group of experts assembled by the World Health Organization to address this question. It includes their comprehensive consensus view on what is known and what is not about the role and possible health benefit of calcium and magnesium in drinking water.

In both developed and developing countries, diets are often deficient in calcium and magnesium, essential minerals which are necessary for the development of strong bones and teeth, and for cardiovascular function. At the same time, there is evidence that drinking 'hard' drinking-water may be associated with reduced risk for some diseases.

World Health Organization, 2009
191pp. Paperback
ISBN: 9789241563550
Price: $40
In developing countries: $28
To order, visit: www.who.int/bookorders

Rainwater harvesting: a lifeline for human well-being

This report has been prepared for the United Nations Environment Programme (UNEP) by the Stockholm Environment Institute (SEI). Achim Steiner, Executive Director of UNEP states: 'This publication highlights the link between rainwater harvesting, ecosystems and human well being and draws the attention of readers to both the negative and positive aspects of using this technology and how the negative benefits can be minimized and positive capitalized.'

UNEP and SEI, 2009
This report can be downloaded free from: www.unep.org/Themes/Freshwater/PDF/Rainwater_Harvesting_090310b.pdf

Water Safety Plan Manual: Step-by-step risk management for water suppliers

In 2004, the WHO Guidelines for Drinking Water Quality recommended that water suppliers develop and implement 'Water Safety Plans' (WSPs) in order to systematically assess and manage risks. Since this time, governments and regulators, water suppliers and practitioners have increasingly embraced this approach, but they have also requested further guidance. This much-anticipated workbook answers this call by describing how to develop and implement a WSP in clear and practical terms. Stepwise advice is provided through 11 learning modules, each representing a key step in the WSP development and implementation process.

World Health Organization, 2009
This report can be downloaded free from: www.who.int

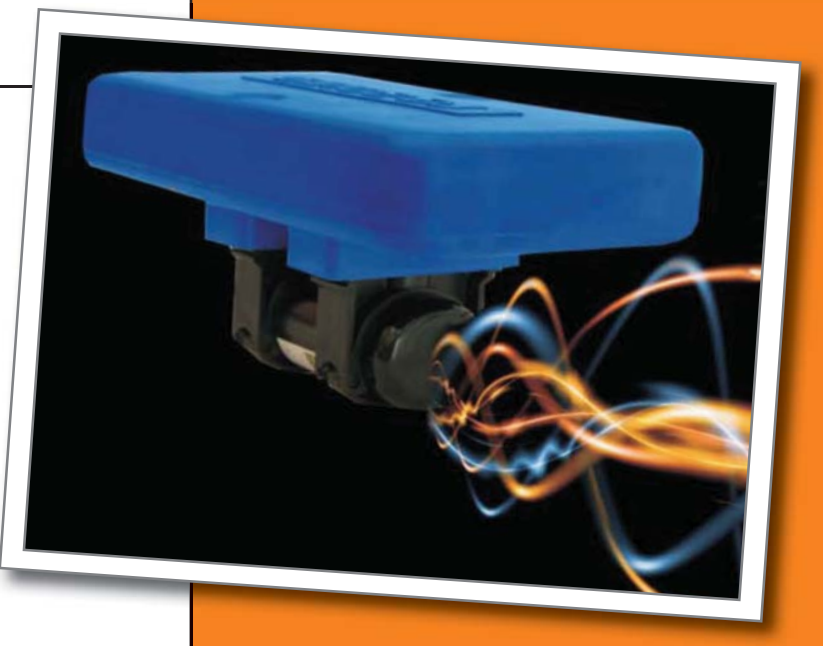
The World's Water 2008-2009: The Biennial Report on Freshwater Resources

Authors: Peter Gleick, Heather Cooley, Michael Cohen, Mari Morikawa, Jason Morrison, and Meena Palaniappan

Produced biennially by the Pacific Institute, The World's Water provides a timely examination of the key issues surrounding freshwater resources and their use. Each new volume identifies and explains the most significant trends worldwide, and offers the best data available on a variety of topics related to water. This new volume contains an updated chronology of global conflicts associated with water, as well as brief reviews of issues regarding desalination, the Salton Sea, and the Three Gorges Dam.

Island Press, 2008
432pp. Paperback
ISBN: 9781597265058
Price: $35
To order, visit: www.islandpress.org

ALGAE CONTROL



Water Treatment by Means of Ultrasound

By Duddy H. Oyib

To achieve successful treatment of the water, one should first know that no water is the same, every water is unique and should be treated uniquely.

Sound

Sound can be described as mechanical energy transmitted by pressure waves in a material medium. Thus, sound can be described as a form of energy or a sound is said to be mechanical.

This distinguishes sound energy form other forms of energy, such as electromagnetic energy. This general definition encompasses all types of sound, including audible sound, low frequency seismic waves (infrasound), and ultrasound.

Ultrasound

Ultrasound is cyclic sound pressure with a frequency greater than the upper limit of human hearing. Although this limit varies from person to person, it is approximately 20 kilohertz (20,000 hertz) in healthy, young adults and thus, 20 kHz serves as a useful lower limit in describing ultrasound.

Ultrasound applications

Current applications of ultrasound includes, for eg, sonochemistry (emulsification, acceleration of chemical reactions, extraction etc) dispersion, and disruption of biological cells (ultrasonic disintegration), removal of trapped gases, cleaning of microscopic contamination, ultrasonic humidifier, ultrasound identification (USID), and typically to penetrate a medium and measure the reflection signature or supply focused energy. The reflection signature can reveal details about the inner structure of the medium. Most well known application of this technique is its use in sonography to produce pictures of fetuses in the human womb. Other application is using ultrasound in cancer diagnose. The numbers of ultrasound application is numerous. Combining the right frequencies, the right amplitude and using the right transducer numerous types of ultrasound application can be achieved. The sky is the limit.

Ultrasound forces

Exposing liquids to high mechanical pressure waves (or sound waves), forces as acoustical streaming, stable cavitation and transient (unstable or inertial) cavitation can be induced. For eg, ultrasonic disintegration, sonochemistry and sonoluminescence arises from acoustic cavitation: the formation, growth, and implosive collapse of bubbles in a liquid. Cavitational collapse produces intense local heating (~5000 K), high pressures (~1000 atm), and enormous heating and cooling rates (>10 9 K/sec). Acoustic cavitation provides a unique interaction of energy and matter, and ultrasonic irradiation of liquids causes high energy chemical reactions to occur, often accompanied by the emission of light. This can only be achieved in specific situation involving specific frequencies of high ultrasound power (high W/h & dB) exposed to relatively low liquid volumes of relatively low temperatures.

Ultrasound and water treatment

At present, ultrasound is also being used in the field of water treatment. In this scenario, forces other than cavitation forces are being used to achieve a certain goal. An example of such ultrasound systems which can be found on the market are the LG Sonic® systems which are manufactured to suppress algal growth and biofilm formation.

The ultrasounds produced by these kind of systems does not produce any stable (non inertial) nor unstable cavitations. They do not even come close to reaching cavitation levels. Other mechanical forces induced by the produced mechanical pressure waves are use to suppress algal growth and reduce biofilm growth, such as resonance forces, longitudinal and transversal sound wave forces. To reach this goal, the LG Sonic systems for example use a "blend'' of very specific ultrasound frequencies of certain power which are being send into the water by very special transducers. This will enhance the specificity and selectivity of the ultrasonic treatment. The algae are treated with ultrasonic sound waves set in precise frequencies, which directly target the cellular structure of the algae. The amount of algae in the water are reduced and controlled in an efficient, cost effective manner and further growth is inhibited. Green layers disappear, biofilm formation is prevented, and the appearance and clarity of the water is visibly improved. The continuous use of such a device prevents the water from becoming polluted again.

These kinds of ultrasound algae control systems can be used in all situations where water is stored, from large industrial water applications to small private pools or ornamental ponds. These systems range from large capacity units to small ones, enabling a "tailor-made" solution to all purposes. The amount of time needed to see improvements depends on certain physicochemical parameters of the water such as the type of the algae present in the algal population, water temperature, the amount of light, the amount of nutrition (especially phosphate and nitrate), size and dept of the water body, TSS levels, TDS levels, turbidity, retention time, etc. To achieve a successful treatment of the water, one should first know that no water is the same, every water is unique and should be treated uniquely. Such a ultrasound system does not use chemicals, needs a low supply of electrical energy, and does not harm water plants, fishes, zooplankton, and other types of life present in the water. Thus, the environment is spared. At the other hand many of the traditional methods to fight algae or biofilm growth are either insufficient, cumbersome, environmentally unfriendly, or all of these.

Algal growth control mechanism by means of ultrasound

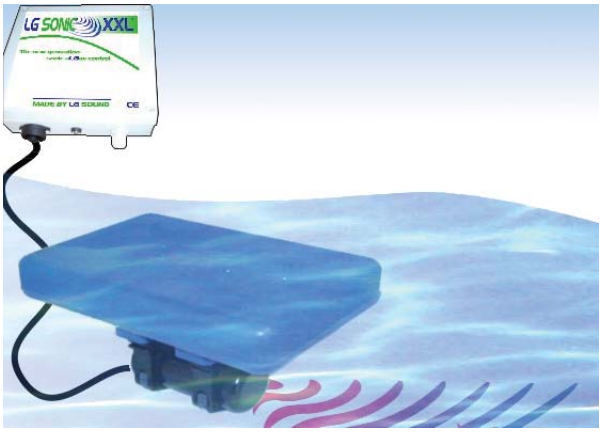
The ultrasound produced these devices are target to different types of algae such as unicellular algae, colonial forming algae, filamentous algae and cyanobacteria.

Eukaryotic algal cells and ultrasound

Each Eukaryotic (unicellular and filamentous) algal cell has one or more relatively big cell compartment(s), the vacuole(s). This compartment can occupy about 70-90% of the cell volume and can have different functions. Lipids, water, starch, pigments, other nutrients and some biochemical components can be stored in this vacuole. Some of these cellular compartments also function to maintain the fluid balance (turgor). These specific ultrasound frequencies can negatively affect the membrane (tonoplast) of the vacuoles and cause the detachment of the cell membrane from the cell wall. Other cell components can also be affected by these ultrasounds forces. All these are lethal to the algae cells.

Blue-green algal cells and ultrasound

Blue-green algae (cyanobacteria) are bacteria (prokaryotic organisms) capable of photosynthesis and nitrogen fixation. Most of them have small cell compartments (gas vesicles). These gas vesicles are small and hollow, air filled structures of a cylindrical shape that provide buoyancy to these cyanobacteria. Each cyanobacteria cell can contain up to 5000 gas vesicles. The gas vesicles enable the bacteria, after periods of water mixing, to float up from the deeper water layer back into the eutrophic zone, where light for photosynthesis is provided, or to reach deeper nutrient-rich layers by sinking when the loose the air form there gas vesicles. Therefore, these organisms have means to overcome spatial separation of nutrition and light. The ability to regulate their buoyancy is discussed as a major advantage over other phytoplankton species and may partly explain the enormous success of the toxin-producing species in the field.



The produced ultrasound forces will fracture these gas vesicles, thus causing the blue-green algae to sink and (eventually) die. Furthermore, some cyanobacterial types (strains) are able to produce toxins. Older and senescent blooms tend to release toxins into the water as the cells break open (or via treatment with copper sulphate). Cyanobacteria can produce a wide array of neurotoxins, hepatoxins, cytotoxins and skin irritants. In addition, many genera, such as Anabaena, can produce multiple toxins. By reducing the amount of the cyanobacteria, reduction of the produced toxins will be achieved. Thus, used for anti algae and growth inhibition purposes, the ultrasonic water treatment system can have an outstanding effect on the reduction of toxins by the control of toxic cyanobacterial growth. In several scientific publications, scientists showed that degradation of these toxins can be achieved at lab scale by certain ultrasound forces.

Biofilm control by means of ultrasound

Biofilm: Many industrial and professional applications use water. Whether streaming or stagnant, algal growth and biofilm formation may occur, which can damage the installations and reduce the efficiency. Many methods to control biofilm formation involve chemical treatment which is expensive, damages the circuit or lowers the water quality. Ultrasound treatment can inhibit the formation of biofilm on an environmentally friendly, cost effective manner without inducing damage to the installation in which the treatment is being applied. A biofilm can grow on different types of substrates which can be found in water. When temperatures are high, for eg, in cooling towers, a matrix of different microorganisms such as bacteria, fungi, protozoa and algae can grow very rapidly.

The formation of biofilm

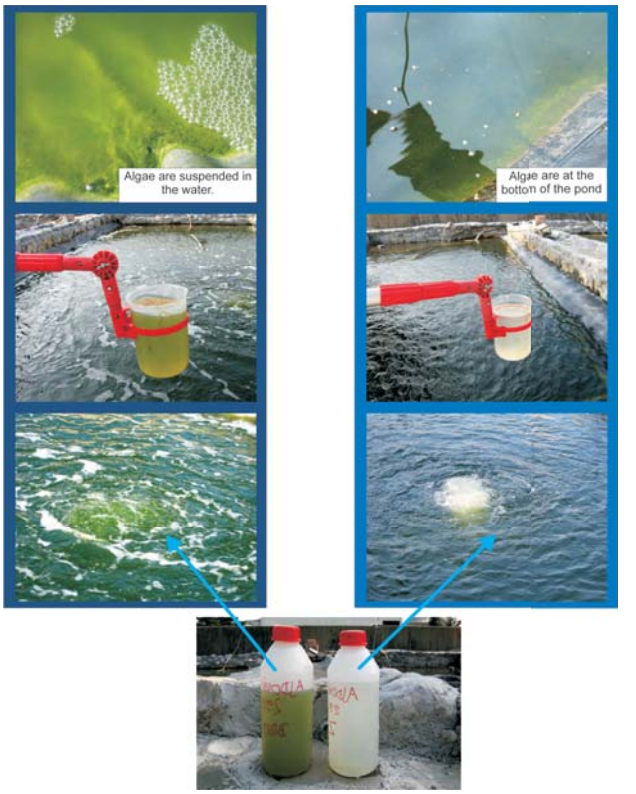
Biofilm consists of communities of microorganisms, which develop on surfaces in natural and artificial environments. Under certain conditions, many bacteria can be induced to produce Extracellular Polymeric Substances (EPS) which include polysaccharides, proteins, and nucleic acids. EPS are the "cement" of biofilm. Subsequently, other microbial aggregates settle in the pore spaces of the EPS, thus helping in the further formation the biofilm. Some of the bacterial species that can produce EPS are Pseudomonas, Burkholderia, Aeromonas, Pasteurella, Pantoea, Alcaligenes and Sphingomonas. Microalgae can also contribute to biofilm formation by the production of exopolysaccharides (EPS) under certain stressed conditions. In particular, surface adherent biofilm and bacteria living within protozoa pose potential health problems that are unrecognised by conventional laboratory culture methods. A host is required for Legionella pneumophila multiplication, but in the absence of a host, L. pneumophila can survive within a biofilm layer (sessile Legionella) and yet others will be suspended in the water (planktonic Legionella). Mostly, protozoa serve as host cells for the intracellular replication of certain Legionella species in a variety of environmental settings.

The disadvantages of biofilm formation

Even a small layer of biofilm within a pipe reduces the diameter of the pipeline. This means that less water can be pumped around the circuit but also the hydraulic pressure needs to be increased to still cope with the system/industrial demand. This can result in higher energy costs and lower performance efficiency of the cooling tower. A biofilm consists for 85-95% of stagnant water, this can function as a insulating layer around the grids and pipes, thereby reducing the cooling efficiency of the tower. A Biofilm can contain several bacteria who can produce corrosive chemicals. For eg, anaerobic sulphate reducing bacteria. These bacteria produce sulphuric acid which can cause corrosion of metal pipes. Also the so called iron-oxidising bacteria can cause corrosion of metal, resulting in expensive repairs of leaking pipes. Biofilm can be a host for the pathogenic Legionella bacteria. These bacteria can become aerosol and infect humans when they inhale them causing severe pneumonia.

Ultrasound treatment

The produced ultrasound attacks most of the unicellular and blue-green algae as well as certain bacteria responsible for the formation of the biofilm. Further algae (and other micro organisms) growth will be inhibited, the biofilm will slowly deteriorate, thus enabling easy cleaning and removal/maintenance operations. Legionella control strategies should also include the control of cyanobacteria, which enhance growth and improve the survival of Legionella in an aquatic reservoir which subsequently enhance the chance that Legionella bacteria will be present in formed aerosols. The ultrasound makes the environment in the water



less favourable for the Legionella bacteria to multiply and/or attached to surfaces including post formed biofilm surfaces to help in the formation (or further formation) of biofilm.

Reduction of other micro organisms

In the irrigation, ultrasound treatment seems to suppress and control the growth of funguses such as Pithium, Fusarium and Phytophthora. Pithium (ed. P. insidiosum) are plant pathogens that produce motile oospores. Organisms of this genus are sometimes called aquatic fungi, but they really are not considered to be true fungi. These organisms may now actually be placed into a new Kingdom, Kingdom Stramenopila. They are often studied as part of medical mycology due to their ability to produce a chronic granulomatous process in which one sees hyphal structures. The disease is sometimes called "swamp cancer" due to its association with water exposure. Fusarium are parasitic type of fungus which can affect plants and animals. Furthermore, they can produce mycotoxines (trichothecenen and fumonisines) which can cause food contamination. The growth of another plant pathogen Phytophthora (ed. Phytophthora infestans) can be suppress and control. Phytophthora belongs to the water-funguses, Oömycetes. The usually infect dycotile plants. In other applications (inlcluding irrigation), ultrasound treatment can also suppress and control the amount of E.coli, Enteroccocus and total coliforms.

About the Author

Duddy Heviandi Oyib is Manager big/special projects and chief biologist of LG Sound. He has done MSc in molecular cell biology, medical biology and microbiology. LG Sound produces and worldwide markets the newest generation of ultrasonic algae control units.

We look forward to your feedback on this article. To know more about the author, you can write to us at content@eawater.com