WaterWorld

Ultrasound technology in water treatment: Suppressing algal growth and biofilm formation

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Recent research projects have underlined the potential of ultrasound as a chemical free treatment in water-related applications. This article reviews the use of ultrasound produced by the LG Sonic technology, with a focus on wastewater, irrigation and aquaculture applications.

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 example: 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. The 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 example 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•cm-2, high dB) exposed to relatively low liquid volumes of relatively low temperatures.

Water Treatment by Means of Ultrasound

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, 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 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, 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.

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. 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 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
- Reduction of fouling and other growth on fish cages (inland and open sea)
- Reduction ß-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

About the Author

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