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Evaluation of Ultrasonic Technology in Removal of Algae from Surface Waters

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Abstract: The current available strategies to inhibit growth of algae population include chemical addition, flushing with clean water, selective discharge of nutrient-rich water and decomposition of thermal stratification and biological treatment. However, some of these treatments have shortcomings, foremost of which is the generation of secondary pollutants. For example, chemical treatment (algaecides) may show immediate effect but this process may also indirectly kill or destroy other organisms due to the sudden release of toxic chemical components from the algae. Therefore, alternative methods for the control of algae population in water supplies are required. A novel method that is proposed is the use of ultrasonic irradiation. Ultrasonic irradiation in a liquid medium has been used for many years to lyse biological cells. Ultrasonication may have the potential to reduce their capacity to float and control their buoyancy thereby reducing their concentration near the surface of water bodies and lesson their growth and survival. Ultrasonication may also inhibit or reduce growth of algae population through its affect on metabolic processes. Application of ultrasonic irradiation for removal of algae population was investigated. Experiments demonstrated that frequency and input power are the major factors that affect the ultrasonic irradiation intensity. Short exposure (150 sec) to ultrasonic irradiation (155 W input powers, 42 kHz) effectively settled naturally growing algae suspension. Sedimentation was caused by the disruption and collapse of gas vacuoles after ultrasonic exposure. Moreover, was found to be more effective in decreasing the photosynthetic activity of algae population. This research will provide basic information on the fundamental of ultrasonic irradiation as a novel means for algae population control.

Key words: Ultrasonic irradiation, algae, frequency, input power, irradiation intensity

INTRODUCTION

Algal population is a major water quality issue in drinking water supply reservoirs and waters used for recreation. Algal population is considered as an offensive nuisance in water supply, where they cause problems during the filtration process. In Fig. 1 the factors and the causes for formation of blue-green algae are shown[1]. Algal population not only increase water turbidity but also is the source of serious taste and odor concerns[2,3]. Moreover, algal compounds such as microcystins and nodularins have been recognized as being potentially toxic to humans and animal[4,5]. The toxicity, effects and health significance of several types of blue-green algae are given (Table 1)[1].

The current available strategies to inhibit growth of algal population include chemical addition, flushing with clean water, selective discharge of nutrient-rich water, decomposition of thermal stratification and biological treatment. However, some of these treatments have shortcomings, foremost of which is the generation of secondary pollutants. For example, chemical treatment (algaecides) may show immediate effect but this chemical may indirectly destroy other organisms due to the sudden release of toxic chemical components from the algae. Therefore, alternative methods for the control of algal population in water supplies are required[2,6].

A novel method that is proposed is the use of ultrasonic irradiation. Ultrasonic irradiation in a liquid medium has been used for many years to lyse biological cells. Ultrasonication may have the potential to reduce their capacity to float and control their buoyancy there by reducing their concentration near the surface of water bodies and reduction their growth and survival. Ultrasonication may also inhibit or reduce growth of algal population through its affect on metabolic processes[7].

This study will provide basic information on the fundamental of ultrasonic irradiation as a novel means for control of algal population.

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Table 1: Blue-green algae toxins

Toxin	Type of Blue-green algae	Effects	Significance for public health
Hepatotoxin (affects liver)	Microcystis Nodularia Anabaena Cylinderospemopsis	Hepatoenteritis Liver damage Tumor promoter	Severe hepatic and gastrointestinal effects. Chronic liver damage. Possible tumor promoter
Neurotoxin (affects nerves)	Anabaena	Neuromuscular blocking Agent acute poisoning Symptoms in animals include Muscle tremors, staggering, paralysis, respiratory arrest	Acute poisoning and symptoms of toxicity are unlikely to be seen
Endotoxin (affects body surfaces)	Most blue-green algae	Gastro-enteritis. Skin, eye irritation skin rashes. Allergic reactions	Contact irritation and reaction from bathing and aquatic recreation

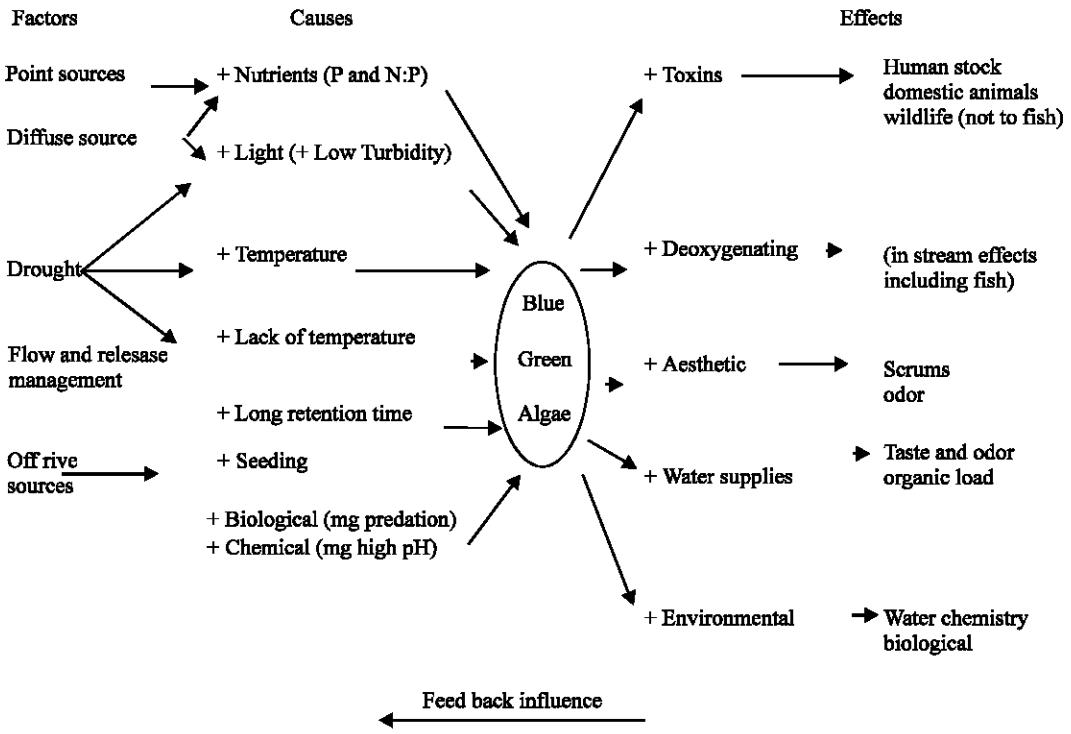

Fig. 1: Causes and effects of blue-green algae

MATERIALS AND METHODS

Experiments were conducted using of Bransonic ultrasonic cleaner and operating conditions. Histories of the contaminant concentration reductions and destruction of algal population were obtained from periodic sampling. In this study, the major objective was determining ultrasonic effectiveness in control of algal population of water.

Ultrasonic was applied to samples using a Laboratory cleaning bath with the following characteristics:

Model : 1510 E-DTH
Input : 220-230 V, 155 W and 0.7 A
Output : 70 W, 42 kHz

A series of experiments involved sonicating of algal population and observing the effects of ultrasonic irradiation upon its control. Before sonication, the concentration of algae in water determined. This test involves collecting the sample, concentrating it and examining the sample under the microscope in order to count the number of algal cells per mL. After cell counts using a microscope, samples were added to the batch reactor for sonication. For algal destruction investigation in ultrasonic bath, small volumes (400, 700 and 1000 mL) of water have been used. The effect of sonicating different volumes of water was measured for the same time intervals. The samples were sonicated in periods of 30, 60, 90, 120 and 150 sec. For each trial, each sample was exposed to all of the durations. The number of trials per

the mentioned exposure levels was variable. Finally, required samples for analyses were taken after 30, 60, 90, 120 and 150 sec and determination was performed according to the standard method technique[8].

RESULTS AND DISCUSSION

The application of ultrasonic irradiation to control algal population was evaluated in the laboratory conditions. In this study, we showed that short exposure to ultrasonic irradiation collapsed algae gas vacuoles resulting in the loss of buoyancy and regulating ability and thus localizing the cells. Thus, the effect of ultrasonic irradiation on the lysis of algae by ultrasonic irradiation was investigated to explore the possibility of control of algal population in eutrophic lakes.

Short exposure to ultrasonic irradiation resulting in the loss of buoyancy and regulating ability and thus localizing the cells. As it is considered by 30, 60, 90, 120 and 150 sec of sonication about 8.55, 35.22, 67.22, 90.67 and 100% of the algal population present are destroyed, respectively.

Besides, the results show that increasing the sonication time has a significant effect on removal of algal population. The results indicate that there is no significant reduction in algal population in less than 30 sec contact time to 42 kHz but considerable reduction in control can be expected at higher periods. The results using Bransonic bath at 42 kHz for the biological decontamination of water show that destruction of algal population occur rapidly. Using this frequency it is concluded that 100% of the algal population can be destructed in 150 sec (Table 2).

Cavitation is a nonthermal mechanism of ultrasonic irradiation that occurs when the gas vesicles are acted upon by a sufficiently intense ultrasonic irradiation of 42 kHz. Observation of differential interference microscopy showed the collapse of the gas vesicles after irradiation, for the collapse caused parts of the cell wall to cave in and consequently the cell surface became uneven. Studies are continuing in order to understand the bases for structural alterations at the electron microscope level. Further more, free radical and sonochemical effects can arise when inertial cavitation occurs, which greatly affects passive membrane permeability's, active transport processes and metabolic rates. Performing 150 sec of ultrasonic irradiation resulted an effective inhibition. The growth rate of irradiated cells was reduced to 100% of the control during short-term culture. For a particular level of energy input, it is suggested that distributed ultrasonic irradiation is a practical method to prevent algal population from fast growth. In summary, 42 kHz ultrasonic irradiation was effective in preventing water bloom-forming algal population from growing rapidly due to changes in the functioning and integrity of cellular and sub- cellular structures.

Table 2: Percent of algal population removal in the different volume

Sonication time (sec)	Sample volume (mL) 400	700	1000	Average (%)
30	11.33	9.00	5.33	8.55
60	50.67	28.00	27.00	35.22
90	81.33	59.00	61.33	67.22
120	97.00	89.33	85.67	90.67
150	100.00	100.00	100.00	100.00

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