Application of Ultrasound Technology for Agricultural Product Improvement and Environmental Renovation

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ABSTRACT

Ultrasound radiation has been applied for analytical observation of lake sediment as well as improvement of aquaculture and agricultural products. Optimum conditions for each application was determined by using small ultrasound device where different frequency, input power can be adjusted. Under optimum condition, lake sediment can be observed with information of textures of bottom soil, which could indicate contents of organic matters and degree of pollution. For the improvement of sea water aquaculture products and fresh water aquaculture products, one of the major programs in fresh water aquaculture was applying used to ultrasound technology to minimize musty odor. As a result, growth of phytoplankton which produces musty odor compounds was able to be controlled by destroying gas vacuole in it cells and musty odor compounds were able to be decomposed by applying ultrasound radiation coupled with photocatalytic material. For decomposition of residual agri-chemicals in agricultural products, ultrasound radiation coupled with ozonation was applied and results showed that ultrasound radiation coupling with ozonation was able to achieve removing more than 75% residual agri-chemicals.

Keywords: Ultrasound radiation, Phytoplankton, Musty odor compounds, Agri-chemicals, Decomposition

INTRODUCTION

Ultrasound technology has been widely utilized for 2 purposes. First purpose is to obtained ultrasound signals from target substances through reflection echoes: a) Imaging the target substances with minimum physical damage or stress on the substances (Nakao et al., 2003); b) Medical application and clinical uses: devices to observe some parts of animal bodies such as internal organs, tumor masses or fetus have been

developed. C) Fish finder: fish finder has been used to detect school of fish for sea-catch fishery activities. Second purpose is by utilizing kinetic power of ultrasound for physico-chemical reaction to improve quality of target subsntances (Takumi et al., 2015, Sarunya et al., 2011, Kanda et al., 2013). For this purpose, ultrasound technology was applied to a) Observe lake sediment, and to b) Removal or decomposition of chemical substances causing quality issues in aquaculture and agricultural crops.

ANALYTICAL OBSERVATION OF LAKE SEDIMENT

Many of enclosed water bodies in Japan are suffering from water quality deterioration due to eutrophication. Although local and central government has been improving water quality in rivers or creeks flowing into these water bodies, water quality in the water bodies is still in same situation in most of the cases, meaning that internal nutrition load is a main cause of water quality deterioration. Through several analysis and survey to clarify source of internal load such as nutritional input by rainfall, birds, fishery industries, it was found that main part of internal nutrition load in enclosed water bodies are from nutrient release from sediment in many cases. However, monitoring and analysis of sediment in large scale takes lots of time and cost. This is because current sediment analysis depends on laboratory analysis of the sediment sample taken from the water bodies by using core-sampler or Ekman bottom grab sampler. Therefore, the ultrasound technology was applied to detect the bottom of the water body and analyze the textures of sediment, particularly softness and particle sizes of the bottom soil. The team aim to determine optimized ultrasound condition for the testing site Kasumigaura Lake. When observing bottom soil of Lake Kasumigaura, it was found that the optimum frequency is 20- 40 kHz. The same methodologies also applied in different locations in Japan (Mikawa Bay in Aichi prefecture, Lake Senba in Ibaraki prefecture) and were both found effective.

IMPROVEMENT OF FRESH WATER FISHERY PRODUCTS BY MINIMIZING MUSTY ODOR COMPOUNDS

Nile Tilapia is one of the successful and profitable aquaculture products in Thailand. Since Tilapia can be cultured both in sea and fresh water, it has been widely cultured in many regions of Thailand. Nowadays, inland farming of Tilapia is increasing due to coastal regions farmers tend to shift from Tilapia to prawn aquaculture, which bring higher profit. Tilapia cultured in sea water often encounter problems of pathogenic halophilic bacteria outbreak. And inland Tilapia culture has serious musty odors problem that derived from some metabolic products of phytoplankton, those are abundant in fresh water Tilapia farms. In this study, ultrasound technology applied to solve musty odor problem in 2 ways. First was to minimize growth of phytoplankton by destroying gas vacuole in the cell of phytoplankton. The optimum condition of ultrasound to treat phytoplankton was determined (200kHz) and the treatment was applied. Fig. 1 illustrate photographs of phytoplankton before (0 min) and after (20, 60 min) ultrasound treatment, showing that majority of the phytoplankton sank down to the bottom of volumetric cylinder due to disruption of gas vacuole. Second was to decompose musty odor substance such as geosmin and MIB (2-methyl sobornol). As shown in Fig. 2, results indicated that with ultrasound radiation only (sonolytic treatment) is not enough for full-decomposition of geosmin (Result with MIB was in almost same trend). This was confirmed by determining concentration of residual geosmin or MIB by GC-MS. However, when applying TiO_2, a photo-catalytic material, together with ultrasound radiation (sono-photocatalytic treatments) effectively decomposed musty odor substances. This indicated ultrasound radiation coupling with other oxidation materials could assist the decomposition process.

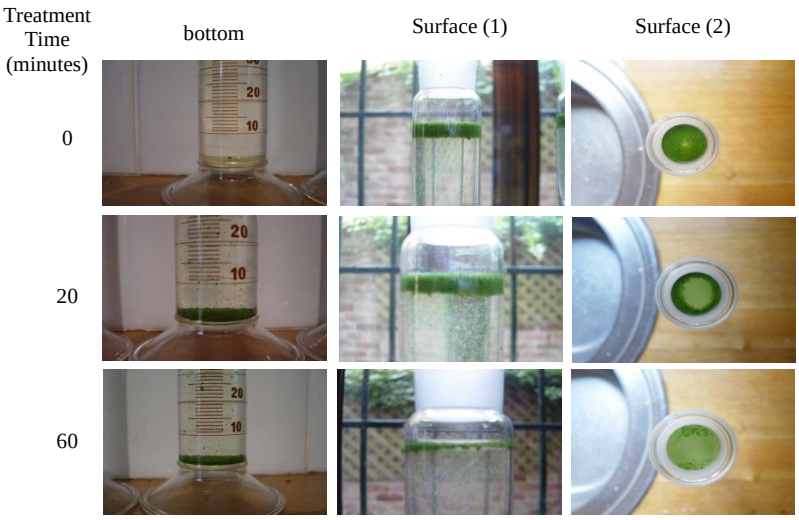

Fig. 1. Photographs of phytoplankton in a fresh water pond after treatment of ultrasound radiation

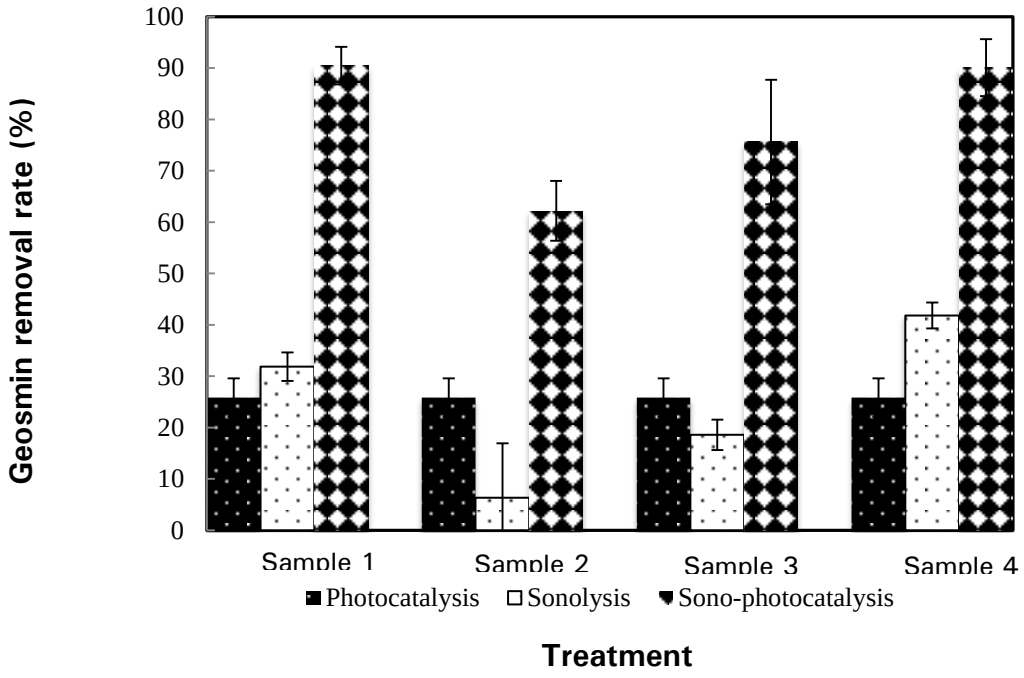

Fig. 2. Geosmin removal rate after photocatalytic, sonolytic and sono-photocatalytic treatments.

IMPROVEMENT OF AGRICULTURAL PRODUCTS BY REMOVING RESIDUAL AGRI-CHEMICALS

Ultrasound radiation was applied to remove agri-chemicals in agricultural crops. Similar result as above mentioned "musty odor substance elimination" experiment shown that single ultrasound radiation treatment also not enough to remove target chemicals in agricultural crops.

Ultrasound has effect to wash and polish up solid surface of several substances; it was expected to enhance detachment of the agri-chemicals from crop surfaces into liquid phase by applying a chamber equipped with ultrasound transducers (Figure 3) filled with water and agricultural crops contaminated with target agrichemicals. Ethion is widely applied to fruit tangerine and Chlorpyrifos widely applied to bird chili. The objective of this experiment is to remove agri-chemicals Ethion and Chlorpyrifos. Results showed that ultrasound radiation coupling with ozonation was able to remove more than 75% of Ethion and Chlorpyrifos.

Fig. 3. Photographs of ultrasound chamber for treatment of agricultural crops

CONCLUSION

In this study, ultrasound radiation was applied for environmental renovation and improvement of aquaculture and agricultural products. The optimum condition for each ultrasound radiation application was determined. It was found that ultrasound radiation coupled with photocatalytic materials or ozonation was effective for decomposition of musty odor compounds and residual chemicals in crops. The information obtained in this study is expected to contribute for further development of commercial devices towards environmental renovation or products improvement in industrial scale.

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