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論 文 内 容 の 要 旨

Study for removal of toxic *Microcystis* cells and nutrients by electrochemical treatment (電気化学的処理法による有毒藍藻細胞と栄養塩の除去 に関する研究)

Cyanobacteria dominate the freshwater phytoplankton community under certain conditions (usually a combination of high nutrient load and warm temperature), during which times they can form blooms. Cyanotoxins produced by freshwater cyanobacteria have been reported to cause negative effects in both wild and domestic animals and humans. Current drinking water treatment systems cannot remove all contaminants from freshwater supplies containing toxic cyanobacteria blooms. Also, the vicious circle caused by eutrophication of lake exists. Occurrence of cyanobacteria bloom, anaerobic sediment and release of inorganic phosphorus are caused by eutrophication of lake. Therefore, if algal cells and their toxins enter drinking water supplies, they pose a serious threat to human health.

Electrochemical oxidation is a powerful method for the removal of harmful organic materials and the supply of oxygen. However, to the best of our knowledge, no studies have been conducted to investigate the simultaneous removal of *Microcystis* cells and their microcystins by electrochemical oxidation, despite the fact that microcystins present in *Microcystis* cells can be released when the cells are damaged. No studies have been conducted to investigate using constant voltage system. No studies have been conducted to investigate the mechanism of phosphate adsorption on the cathode.

Therefore, this study was conducted to evaluate the dynamics of simultaneous *Microcystis* and its microcystin removal by electrochemical oxidation. Specifically, MC-LR was divided into intracellular MC-LR and extracellular MC-LR and the cell morphology was observed by scanning electron microscopy (SEM) analysis. The effects of different current densities and algal suspension volume on *Microcystis* cells and MC-LR removal and variations of cells size by electrochemical oxidation were

evaluated. The change of cations, nitrogen species and phosphorus species during electrochemical oxidation were evaluated. In addition, I provide a possible mechanism for the removal of phosphorus.

The results of laboratory studies using unicellular strain could not explain natural environmental phenomenon. In addition, the electrode material has a significant impact on the electrochemical kinetics and the reactions occurring. Therefore, this study was conducted to evaluate the possibility of removal for colonial *Microcystis* cells using electrochemical oxidation and removal efficiency of *Microcystis* sp. (colonial cells) by electrode material (Pt/Ti electrode and oxide electrode) of electrochemical oxidation.

Moreover, an electrochemical treatment equipment was established in a pond (Chikato pond, Matsumoto, Japan) and evaluated the change of biomass, nutrient (N and P) and concentration of dissolved oxygen.

In the 4 L volume, *Microcystis* cells and MC-LR were removed at applied charges of 3×10^4 C and 6×10^4 C, respectively. The removal efficiency of *M. ichthyoblabe* cells and MC-LR was unaffected by initial cell density, initial MC-LR concentration and solution conductivity, but was heavily compromised by large algal suspension volume.

The concentration of Na^+ ions and K^+ ions gradually increased as the treatment proceeded. Ca^{2+} ions decreased because of deposition of these ions on the cathode surface. Nitrogen was not removed by the electrochemical treatment though internal species are changed. Total phosphorus was decreased by 29% after 71 h because of the deposition of inorganic phosphorus on the cathode surface. Phosphorus was deposited on the cathode surface along with calcium ions as CaHPO_4 (monetite) and/or $\text{CaHPO}_4 \cdot 2\text{H}_2\text{O}$ (brushite).

The removal of *Microcystis* sp. cells and colonies using electrochemical oxidation was possible. In addition, the removal efficiency for *Microcystis* sp. cells and colonies of oxide electrodes were better than Pt/Ti electrodes.

The removal of *Microcystis* cells, N and P species by the electrochemical treatment equipment in Chikato pond (Matsumoto, Japan) was not efficient. However, it is possible that oxygen generated from the electrodes was carried into deeper water by the rotating W-motion.