INVESTIGATION OF MEMBRANE SEPARATIONS, OZONATION AND BIOFILTRATION FOR THE REMOVAL OF MICROCYSTIN-LR

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Cyanobacteria popularly referred to as “blue-green algae” is a phylum of bacteria that obtains energy through photosynthesis. They produce a group of chemicals known as microcystins, some of which are toxic. Microcystins are cell bound and a large amount of the toxins are present within healthy cells. Potential dangers from microcystins include liver damage and in severe cases death. On August 2, 2014, the greater Toledo area woke up to a Do Not Drink or Boil Water Advisory. The advisory was due to the presence of a cyanotoxin (algal toxin) produced by cyanobacteria in Lake Erie called microcystin-LR in the drinking water supply that has a WHO provisional guideline of 1 microgram/L. Upon entering the City of Toledo Collins water treatment plant crib at the Lake Erie intake, potassium permanganate is added to the water for mussel control. While potassium permanganate is needed to control mussels, it lyses cyanobacteria cells, releasing algal toxins to the water. The water is then pumped nearly three miles to the Low Service Station, where powdered activated carbon (PAC) is added to the water for taste and odor control, and the water is transported approximately six miles to the WTP (High Service Station). PAC is generally effective for removal of algal toxins through adsorption onto its surface. At High Service, alum, lime and soda ash are added to the water for coagulation-flocculation, softening, and removal of metals. The water is then sand filtered, carbonated and chlorinated before being sent to the distribution system. However, traditional physicochemical water treatment processes, such as coagulation-sedimentation-filtration, have been shown to only be partially effective for the removal of whole algal cells and not effective for the removal of algal toxins. Furthermore, chlorination is effective for oxidizing algal toxins at relatively high free chlorine concentration as long as the pH is below 8; however, for corrosion control, Toledo water is kept at a pH above 9. Therefore, the treatment process was not enough of a barrier to prevent microcystin-LR from entering the drinking water supply. By August 4, the water treatment plant increased its PAC dosage by nearly four times, and while the toxin was removed, a significant amount of PAC sludge was produced and the cost of PAC addition was unsustainable. The objective of this project is to study alternative water treatment processes, namely membrane separations, biofiltration and ozonation, for the effective removal of algal toxins.