Evaluating removal of microcystin-LR from drinking water using Granular Activated Carbon with various amounts of NOM Preloading

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Increases in cyanotoxin containing harmful algal blooms in recent years has raised the level of concern within the water treatment industry to remove these dangerous bacteria and chemicals. Typical methods used to treat intracellular and extracellular cyanotoxins include pretreatment oxidation, coagulation/sedimentation/filtration, membranes, dissolved air flotation (DAF), ozone, chlorination, powdered activated carbon (PAC), and granular activated carbon (GAC). In some cases, extracellular cyanotoxins will require removal. Various treatment options are available, however, in many cases water utilities already have GAC installed for reducing disinfection byproduct formation. While GAC can be effective for removing cyanotoxins, there is not much information available on GAC bed life. Furthermore, GAC adsorption of cyanotoxins in the presence of competition from NOM and with various amounts of NOM preloading is not well studied and it is difficult to predict the adsorption in such situations. Therefore, the objectives of this research were to assess the effectiveness of GAC in treating cyanotoxins, particularly microcystin-LR (MC-LR), determine the extent to which NOM affects the removal of cyanotoxins through simultaneous competitive adsorption, and evaluate the adsorption capacity when columns are preloaded with NOM at various levels.

This study was conducted with granular activated carbon influent (GACI) water collected from an Ohio water utility using an impounded river water source and freshly regenerated GAC from the same utility, which was supplemented with 15% virgin makeup. According to a previous study, MC-LR was found to be the dominant cyanotoxin in this source water during a bloom event. Rapid Small Scale Column Tests (RSSCTs) were used to simulate full scale GAC processes applying the proportional diffusivity (PD) design. RSSCTs are used for long term GAC assessment because of the considerable decrease in operation time, total volume, and costs associated with the assessment. NOM, measured by TOC, and MC-LR, measured by LC/MS/MS, were monitored before and after the GAC PD-RSSCTs.

Initial experiments resulted in MC-LR biodegradation in the influent water. To overcome biodegradation in the influent water and throughout the experimental system, sodium azide (NaN_3) and sterilization techniques were used. Experiments were conducted with the GACI water supplemented with an influent target of approximately 10 µg/L MC-LR. MC-LR breakthrough exceeded the Ohio EPA action level of 0.3 $\mu g\ L^{-1}$ in 3,000 bed volumes and reached full breakthrough in 39,000 bed volumes. The MC-LR breakthrough curve was very flat, indicating a long mass transfer zone within the GAC bed. NOM breakthrough occurred prior to the MC-LR breakthrough and NOM preloading appears to affect the rate of MC-LR breakthrough. These results of experiments with varying amounts of NOM preloading highlight the issues that occur in real world operation by water utilities that use GAC.