

論文の内容の要旨

Dissolved Organic Matter Removal by Anion Exchange Resins in Water Treatment Processes (浄水処理プロセスにおける陰イオン交換樹脂による溶存有機物の除去)

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The presence heterogeneous of dissolved organic matter (DOM) and inorganic anions in natural waters is known to affect directly or indirectly the surface water quality. The concerning of treated water quality in drinking water treatment and its stable drinking water is usually based on the efficacy of DOM and inorganic anions removal as precursor of disinfection by-products (DBPs) along the treatment process. The improvement the performance of existing physico-chemical treatment process or development of new technologies was continuously targeted to produce the treated water quality with minimum of dissolved organic matter as precursor of DBPs and stability of drinking water.

Anion exchange resins (AERs) is one of interested technologies due to simultaneously remove both the various DOM characteristics and inorganic anions as precursor toxic compounds in drinking water treatment. The complex mixture of DOMs and inorganic anions in natural waters were resulted in efficiency of DOM removal by AERs. The removal efficiency of DOM by AERs depends on DOM characteristics, AER properties and mixture compositions. In addition, the AERs application has several advantages compared with the existing conventional water treatment or advance water treatment such as simple operation, low installation cost, low energy consumption and chemical requirement.

The objectives of this study were (i) to investigate competitive effect inorganic anions in natural waters on DOM removal, (ii) to investigate effect of AERs properties on DOM removal regarding to DOM removal mechanisms of DOM surrogate compounds, (iii) to investigate the effects of DOM characteristics on DOM removal by AERs from various aquatic sources and (iv) to investigate effect of AER properties on bromide removal resulting to control the brominated-DBPs.

Ultrafiltration (UF) membrane was employed to concentrate high DOC and sulfate condition of the coagulated-rapid-sand-filtered water from drinking water treatment plant to represent the worst condition of algal bloom phenomenon of Aragawa River. Even though there was high sulfate in water sample, AERs removed 23–50% of DOC and 70–80% of UV₂₅₄ within 30 min. UV₂₅₄ reduction did not affect by AER materials and structures but DOC removal was affected. The macroporous polystyrene (IRA910) had the lowest DOC removal whereas the highest DOC reduction was achieved by a macroporous polyacrylic AER (Purolite). The rate constant and initial sorption of polyacrylic AERs from pseudo-second order model were higher than polystyrene AERs, probably due to hydrophilicity of polystyrene-AERs. Large molecular weight (MW) of aromatic DOM 800–3,000 Da was almost completely removed by AERs, whereas smaller 800 Da was removed only by half. Adsorbed DOC comprised less than 6% of all exchanged anions, whereas the adsorbed sulfate was about 90% due to comparatively high concentration of sulfate in the water sample.

DOM surrogate compounds (tannic acid, glutamic acid, resorcinol and serine) were used to identify DOM removal mechanisms by AERs such as ion exchange, hydrophobic interaction and hydrogen bonding. The results indicate that ion exchange is a mechanism for DOM removal by AERs due to the highest removal (80%) of anionic-DOM (tannic acid and glutamic acid). Polystyrene-AERs provided higher hydrophobic interaction than polyacrylic-AERs because of higher hydrophobicity of polystyrene-AERs as 70–80% of resorcinol removal by polystyrene AERs. In addition, hydrogen bonding mechanism was attributed to hydrophilic neutral (serine) DOM removal (40%) by IRA910 as compared with other AERs. This result suggested that there are multi-DOM removal mechanisms such as ion exchange resin, hydrophobic interaction and hydrogen bonding involved in the adsorption of DOM by AERs depending on DOM characteristics and AER properties.

Effect of AERs properties on DOM removal behaviors by AERs was extensively investigated with several surface waters having different water characteristics. The results suggested that hydrophobic dominant water, polystyrene-AERs exerted higher affinity to remove hydrophobic DOM. While the water contained major of hydrophilic DOM fraction polyacrylic-AER preferred to remove hydrophilic fraction of DOM. Although the large MW of aromatic DOM higher than 1600 Da showed greater removal than small MW aromatic DOM (800–1100 Da) but the removal of small MW exerted faster rate than the large MW. AER materials

significantly affected bromide removal in surface waters. Polystyrene-AERs exerted high affinity of bromide removal than polyacrylic-AERs.

Effect of AER materials on bromide removal and its mechanism was investigated in synthetic water having 300 µg/L of bromide concentration and 333:1 of chloride/bromide ratio. The results confirmed that polystyrene-AERs exhibited higher bromide removal than polyacrylic-AERs. At 2 g/L of AERs dose, polystyrene-AERs showed 70–85% of bromide removal while 51–56% of bromide removal was achieved by polyacrylic-AERs. Bromide removal was ion exchange mechanism followed by film diffusion as rate limiting step. Polystyrene-AERs exerted greater bromide removal than polyacrylic-AERs either synthetic water or natural waters which expected a potentially effective AERs for controlling brominated-DBPs. Even MIEX as polyacrylic-AER exerted lower bromide removal than polystyrene-AERs but they remove appreciable amount of DOM, it could be effective technology for controlling both brominated and non-brominated-DBPs in drinking water treatment process.