Recent developments in aqueous phase bromate (BrO$_3^-$) species treatment using adsorption, reduction, and ion-exchange processes

A.J. Kedir$^a$, M.S. Vohra$^b$

$^a$Environmental Science Program, Memorial University of Newfoundland, Canada A1B 3X7, email: ajkedir@mun.ca
$^b$Civil and Environmental Engineering Department, King Fahd University of Petroleum & Minerals, 31261, Saudi Arabia, email: vohra@kfupm.edu.sa

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ABSTRACT

Recently, bromate (BrO$_3^-$) presence in the drinking water sources and its health-related concerns (e.g., carcinogenic) has initiated a lot of attention both within the regulatory bodies across the globe (such as WHO, US EPA, EU, etc.) and also within the scholarly community that look for efficient bromate removal techniques to meet the desired bromate water quality standards. Bromate species is typically formed during disinfection–ozonation of bromide containing water. Considering its carcinogenic and mutagenic threat toward human health, several recent research studies have investigated different processes for efficient bromate removal from the aqueous phase under a varying set of conditions and also report the optimum process variables. In this review paper, we have presented and summarized findings from the respective recent work on bromate removal techniques and have also discussed the effect of various process variables on bromate removal efficiency. The adsorption process is noted to be the most common and widely studied technique. Some of the adsorbent materials used included activated carbon, both unmodified and modified. The respective adsorbent samples are noted to have varying specific surface area, pore size, and surface morphology. In most studies, the effect of pH, initial bromate concentration, contact time, temperature, adsorbent dose, mixing speed, and coexisting ions was investigated to get optimum bromate removal. The adsorption equilibria and kinetics were mainly predicted by Langmuir/Freundlich isotherms and pseudo-second-order models, respectively. Also, the Donnan dialysis and electrodialysis ion-exchange processes removed bromate ions to acceptable concentrations.

Bromate reduction can also be achieved using advanced reduction processes where ultraviolet light has been used as an activating agent and mainly sulfite as the reducing agent. Furthermore, chemical reduction, electrochemical reduction, and bio-reduction-based bromate removal processes are also discussed. The reduction-based processes indicated the formation of different reduced species including bromine. The ferrous-based reduction processes are noted to be very effective and several variations of ferrous-based technologies including adsorption and reduction processes are presented and discussed. In summary, this review work indicates a very positive development in the respective area of study, that is, bromate removal from the concerned aqueous streams, and hopefully will also serve as a focal point for further scientific innovations and endeavour for a better human health.

Keywords: Bromate; Adsorption; Activated carbon; Reduction; Ion exchange; Bio-reduction