University of Macau

Abstracts

Effects of Bromide and Natural Organic Matter on the Formation of Trihalomethanes in Chlorination of Drinking Water

by

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This study investigates the effects of bromide and natural organic matter existing in the fresh water system of Macau on the formation of trihalomethanes in chlorination. Bromide exists in seawater as one of the main ions; it enters the raw water system of Macau through seawater intrusion to the water source. With the presence of bromide (Br^-) and natural organic matter, brominated trihalomethanes (THM-Br) form during chlorination of water. The increase of brominated trihalomethanes in the finished water imposes health hazards. Analyses of Macau water-quality data show that the salinity values of raw water surges during dry seasons hence introducing Br^- into the water system. The subsequent THMs concentrations of the finished water in those periods can be more than double those of the normal seasons. The increase of THMs concentration and their speciation are considered to relate mainly to the initial bromide/chlorine ratio. A formation model based on the reaction scheme introduced by Nokes *et al.* (1999) is developed to model the process. Experimental results of Macau water show that the molar fraction of each of the four THM species varies with the bromide/chlorine ratio and the developed model with a bromine-to-chlorine reaction ratio of 23.1 describes their variations well. The effects of natural organic matter (NOM) on the formation of THMs are also studied in terms of molecular weight distribution. Ultrafiltration is used to separate the molecular weight spectrum of NOM in the tested water. It is found that the fresh water of Macau has a low humic content and the existing NOM concentrates in the

portion with apparent molecular weight (AMW) lower than 3000 Daltons. Trihalomethanes reactivity also shows a comparatively higher value in this AMW portion in Modaomen water. The raw water generally has a SUVA value lower than 3; therefore indicating humic substances in Macau water are mainly aqueous fulvic acid containing more of the aliphatic ketone groups hence favoring formation of bromoform. The dissolved organic carbon is hard to be removed during water treatment process as indicating by the low removal efficiency of less than 20% in both treatment plants. Different from the dissolved organic carbon, humic substances show larger removal efficiency (40%) along each molecular weight fraction. The trihalomethanes precursors removal in terms of THMFP shows a consistent trend with respect to the removal trend of humic substances in terms of UV254 readings. Taking advantage of the NOM studies that are done in two treatment plants of Macau with one using the conventional treatment process and the other using the direct filtration process, efficiency of NOM removal in both processes are compared. It is found that the conventional treatment process removes about 20% of the total dissolved organic carbon while the direct filtration process removes almost none. This should be due to in-sufficient coagulation and sedimentation done in the direct filtration process. Nonetheless, the removal efficiencies of both UV254 and THM precursors in both plants are similar with the conventional treatment process performing slightly better. Finally the THM cancer risks of Macau water are assessed showing that the carcinogenicity of the water increases with salinity up to approximately 130 mg/L and then decreases. This behavior is a result of the speciation shifts in THM species with increasing salinity or Br^- concentration. The dominating species shifts from chloroform to bromodichloromethane, to dibromochloromethane and finally to bromoform as salinity increases. Hence it also shifts the risk level as each of the species has different carcinogenic level. The highest risk in Macau water occurs at salinity level of about 130 mg/L with the main contributor being dibromochloromethane.