

Evaluation of THMs in Tehran's Drinking Water and Comparison with Archive of SID Drinking Water outside the City Water District

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Extended Abstract

This study intends to monitor and evaluate the THMs concentration in the 6 different water districts in the city of Tehran as well as one district outside the city water district but inside the city limits. THMs are the main disinfectant by products (DBP) of chlorination, which are suspected to be human carcinogens. Formation of Trihalomethanes (THM) in drinking water depends mostly on raw water qualities such as pH, temperature, treatment process, residence time of water in the distribution system, as well as the bromine, chlorine and naturally occurring organic matter (NOM) concentrations. Because of the low cost of chlorine and convenience of application, chlorination is the most widely used disinfection process for drinking water. This led to a sharp reduction in mortality rate from many water born diseases, but the chlorine from the disinfection process reacts with NOMs in the raw water to form a series of undesired by-products. The most significant group of DBPs is trihalomethanes (THMs), which include chloroform (CHCl₃), bromodichloromethane (CHCl₂Br), dibromochloromethane (CHClBr₂), and bromoform (CHBr₃). The concentration of NOM in raw water is the most important parameter in the DBP formation. Increase in the bromine ion concentration shifts the DBPs from the chlorinated compounds to the brominated ones. Chlorination is used as the main disinfection process for the drinking water in Tehran, therefore; it is important to monitor and evaluate the THM's concentration in Tehran's drinking water. Samples were taken from twenty one locations across the city of Tehran in triplicates during the first week-end of April, May, June, July, August and September of 2009 They were collected directly from taps of consumers after letting the water run for several minutes before collecting the water in pre-cleaned glass containers with sodium-thio-sulfate preservative to eliminate any residual chlorine. The samples were analyzed for THMs using EPA method 524.2. A Purge & Trap device (Tekmar) was used to extract all the THMs and trap them in a sorbent tube. Using heat and inert N₂ gas the trapped compounds were transferred to a gas chromatograph coupled with a mass spectrometer (6890 GC/5973 MSD, Agilent). A 30 meter DB-5 capillary column with a 0.25 mm I.D and 1μ film thickness was used to separate the trihalomethanes before sending them to the mass spectrometer detector for identification and quantification. Spiked and duplicated samples were analyzed with every batch to determine the accuracy and precision of the analytical procedures.

The data indicates that, the concentration of THMs are much higher in districts which are supplied mostly with surface water sources such as areas in the northern part of Tehran, compared to districts with well water as their main water source which are located mostly in the south and south west part of Tehran. The average concentration of chloroform, bromodichloromethane, dibromochloromethane and bromoform were 2.49 ppb, 2.08 ppb, 0.95 ppb and 0.15 ppb for the city of Tehran. The observed THMs concentrations are below the EPA's recommended MCL value of 80 ppb thus not causing a major adverse health effect on the population of Tehran.

The highest average concentrations of chloroform during spring and summer seasons were observed in district 1, and 2 (Figure 1). The measured concentrations for CHCl₃ during the study period ranged between N.D in district 7 to 9.9 ppb in district 1.

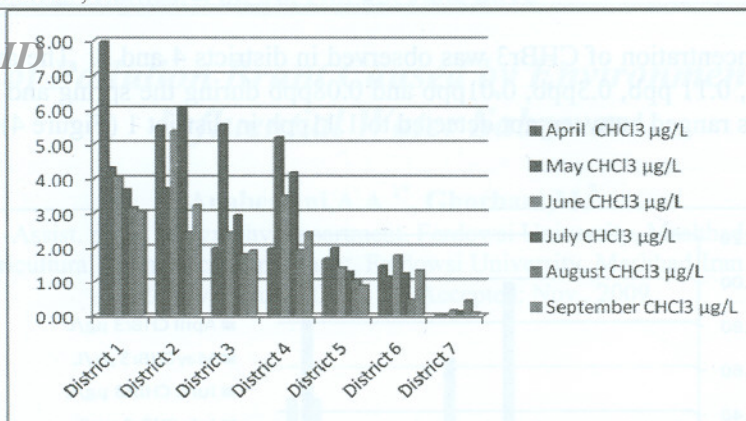


Fig. 1: Average monthly concentration of CHCl3 in Tehran's water districts during spring & summer of 2009.

The highest average concentrations of CHCl2Br were observed in districts 2, 1 and 3 and the average monthly concentrations during the six month study period were 2.29ppb, 2.27 ppb, 2.7ppb, 2.6ppb, 1.2ppb and 1.43 ppb , while the measured concentration were between not detected in district 7 to 6.4 ppb in district 2 (Figure 2).

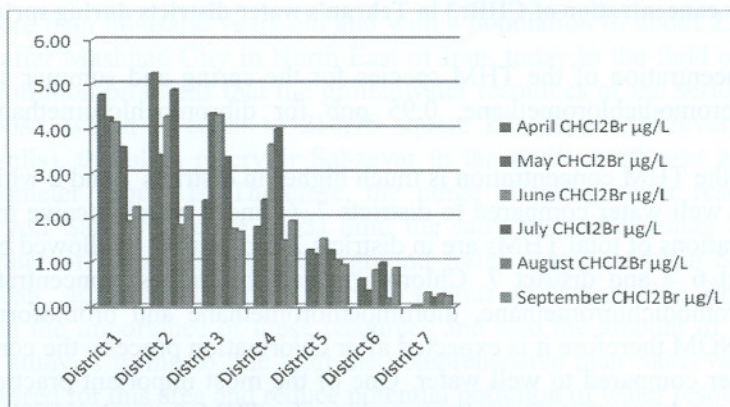


Fig. 2: Average monthly concentration of CHCl2Br in Tehran's water districts during spring & summer of 2009.

The highest average concentrations of CHClBr2 were measured in districts 1 and 2. The average monthly concentrations were 1.68ppb, 0.68 ppb, 0.86 ppb, 1.43ppb, 0.43ppb and 0.6ppb during the spring and summer months. The measured concentrations ranged between not detected in district 7 to 5.5ppb in district 1 (Figure 3).

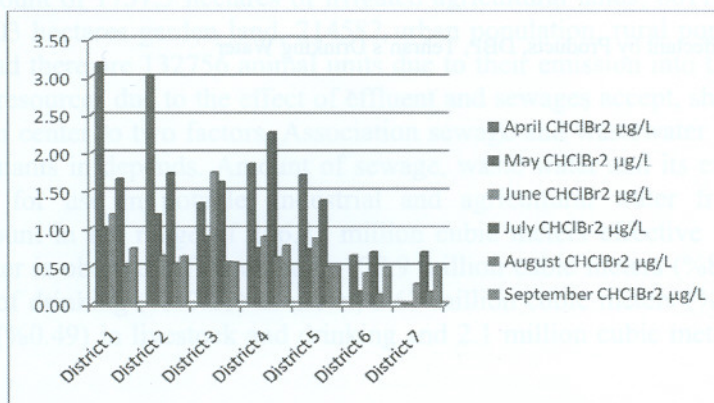


Fig. 3: Average monthly concentration of CHClBr2 in Tehran's water districts during spring & summer of 2009

The highest average concentration of CHBr₃ was observed in districts 4 and 5. The average concentrations were 0.36ppb, 0.06 ppb, 0.11 ppb, 0.3ppb, 0.01ppb and 0.08ppb during the spring and summer months. The measured concentrations ranged between not detected to 1.11ppb in district 1 (Figure 4).

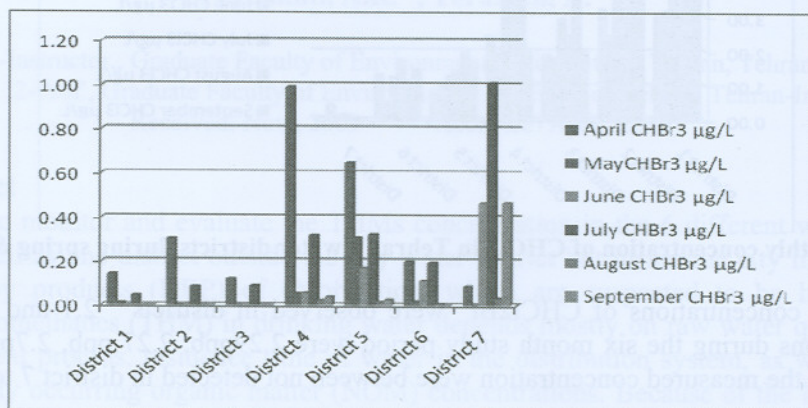


Fig. 4: Average monthly concentration of CHBr₃ in Tehran's water districts during spring & summer of 2009

The overall average concentration of the THM species for the spring and summer season is 2.49 ppb for Chloroform, 2.08 for bromodichloromethane, 0.95 ppb for dibromochloromethane and 0.15 ppb for bromoform .

The results indicate that the THM concentration is much higher in districts 1 and 2 which receive the highest ratio of surface water to well water compared to districts 7, 6, and 5 which receive mostly well water. The highest average concentrations of total THMs are in districts 2 and district 1 followed by districts 4 > District 3 > District 5 > District 6 > and district 7. Chloroform had the highest concentration among the THM species, followed by bromodichloromethane, dibromochloromethane and bromoform. Surface water has higher concentration of NOM therefore it is expected after chlorination process, the concentration of THM to be higher in surface water compared to well water. One of the most important practices in water treatment process is to eliminate pre-chlorination in order to reduce the THM formation in the drinking water. The districts in the south and south west part of Tehran (districts 4, 5, and 6) get the highest portion of their drinking water from well water sources but the districts in the northern part of the city receive most of their drinking water from surface water. The data clearly distinguishes between districts with different water sources. Northern districts have substantially higher concentration of THM, specially the chlorinated species. The Bromoform ratio increase in the southern districts, due to the presence of bromine in the well water.

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Key words

Trihalomethanes, THMs, Disinfectant by Products, DBP, Tehran's Drinking Water