Bull. Environ. Contam. Toxicol. (1995) 54:440–443

Environmental Contamination and Toxicology

Comparison of Trihalomethane in Tap Water with and without Activated Carbon Adsorption during the Preparation Process of Tap Water

A. Adachi, T. Kobayashi

Kobe Pharmaceutical University Motoyamakitamachi, 4-Chome, Higashinada-ku Kobe 658, Japan

Received: 20 December 1993/Accepted: 15 August 1994

Trihalomethanes are found in all chlorinated tap waters. These compounds are formed as a result of the reaction between chlorine and organic precursors, typically naturally occurring substances like humic acids (Rook 1974, 1976). A National Cancer Institute (NCI) report showed that chloroform caused cancer in rats and mice under laboratory test conditions (Anon 1976). Japanese law has defined the regulations on trihalomethanes in tap waters. Preparing processes of tap water in Japan are fundamentaly constructed with coagulation, sedimentation, filtration and chlorination. In some cities activated carbon adsorption method is added to these steps before chlorination. In order to clarify difference between trihalomethane concentrations in tap water with and without active carbon adsorption process, the concentrations of these compounds in tap water obtained from Kinki area in Japan were determined.

MATERIALS AND METHODS

Samples of tap water were taken from 48 stations in 12 cities from Kinki area in Japan (Figure 1) during ten days (September, 1992). Concentrations of trihalomethanes in water samples were assayed by a gas chromatographic method as described in the following. One hundred mL of a water sample was placed in a separatory funnel, and 5 mL of o-xylene was added to the water. The mixture was shaken for 1 min. The separated o-xylene layer was subjected to gas chromatography to assay the concentration of these compounds. The peak heights were estimated on the gas chromatograms obtained from a sample and organohalides standard solutions (carbon tetrachloride : 0.01mg/L, the other compounds : 0.05mg/L). The assay was perfomed on a Shimazdu Model GC-3BE gas chromatograph equipped with an electron capture and a glass column (2.6 m x 3 mm I.D.) packed with 20 % silicon DC 550 on 60 - 80 mesh Chromosorb W was used. Both the column and the injection port operated at 70 ℃ and the detector at 130 ℃. A flow rate of carrier gas was kept at 40 mL/min. The detection limit of carbon tetrachloride was 0.001 mg/L and that of the other compounds was 0.005 mg/L.

Correspondence to: A. Adachi

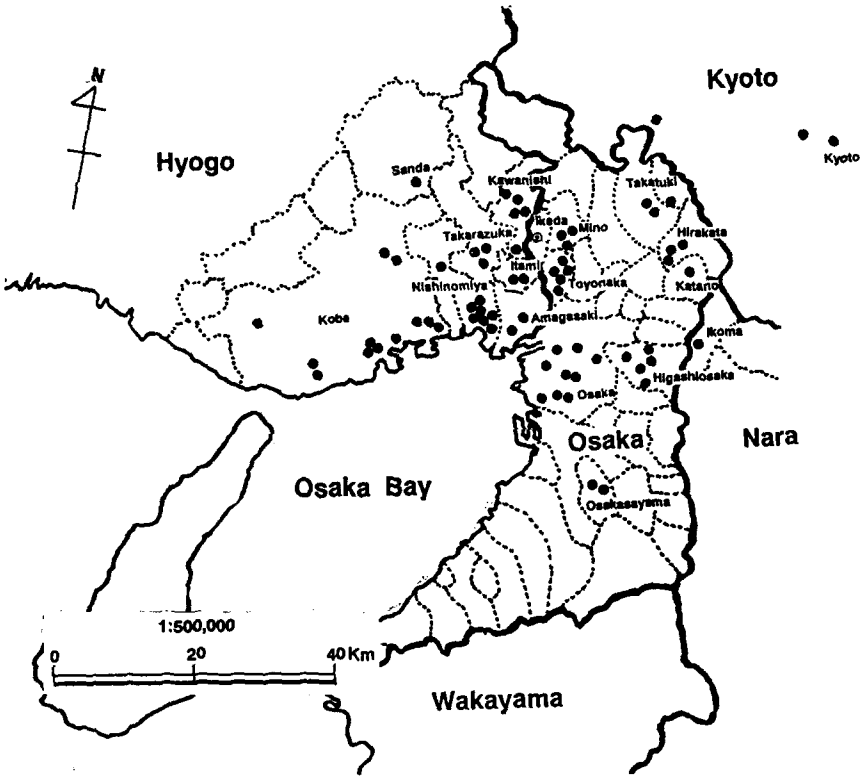

Figure 1. Sampling points of tap water

Table 1. Assayed values of trihalomethane in tap water

Sample	n	Total trihalomethane (mg/l)		$CHCl_3$	$CHBrCl_2$	$CHBr_2Cl$	$CHBr_3$
		Min - Max	M ± SD	M ± SD (mg/l)			
A	5	0.034 - 0.053	0.047 ± 0.009	0.029 ± 0.007	0.014 ± 0.002	0.004 ± 0.001	n.d.
B	12	0.021 - 0.042	0.037 ± 0.006	0.019 ± 0.004	0.012 ± 0.003	0.006 ± 0.002	n.d.
C	8	0.011 - 0.072	0.035 ± 0.019	0.019 ± 0.018	0.010 ± 0.003	0.006 ± 0.002	n.d.
D	3	0.027 - 0.039	0.035 ± 0.004	0.018 ± 0.001	0.012 ± 0.003	0.005 ± 0.002	n.d.
E	5	0.024 - 0.037	0.033 ± 0.007	0.016 ± 0.005	0.012 ± 0.002	0.005 ± 0.001	n.d.
F	5	0.017 - 0.039	0.032 ± 0.007	0.014 ± 0.005	0.011 ± 0.003	0.007 ± 0.002	n.d.
G	5	0.019 - 0.033	0.029 ± 0.005	0.014 ± 0.005	0.010 ± 0.002	0.005 ± 0.002	n.d.
H	10	0.007 - 0.030	0.027 ± 0.008	0.011 ± 0.004	0.010 ± 0.004	0.006 ± 0.002	n.d.
I	3	0.013 - 0.029	0.027 ± 0.008	0.011 ± 0.006	0.010 ± 0.005	0.006 ± 0.006	n.d.
J	3	0.008 - 0.019	0.016 ± 0.004	0.006 ± 0.003	0.006 ± 0.001	0.004 ± 0.001	n.d.

n.d. : not detected

Table 2. Comparision of trihalomethane in tap water with and without activated carbon adsorption during the preparation process of tap water

Sample	Total trihalomethane (mg/l)		CHCl3	CHBrCl2 (mg/l)	CHBr2Cl	CHBr3
	Min - Max	M ± SD	M ± SD			
with activated carbon adsorption	0.005 - 0.033	0.025 ± 0.008	0.011 ± 0.005	0.009 ± 0.003	0.005 ± 0.002	n.d.
without activated carbon adsorption	0.011 - 0.072	0.041 ± 0.012 a)	0.022 ± 0.011	0.013 ± 0.003	0.006 ± 0.002	n.d.

a) Significantly different from those with activated carbon adsorption, $p<0.01$.
n.d. : not detected

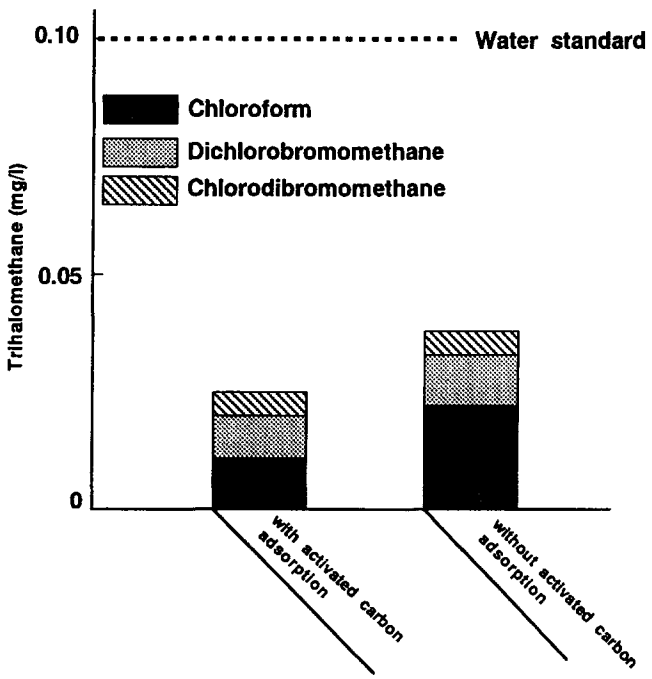

Figure 2. Comparision of trihalomethane in tap water with and without activated carbon adsorption during the preparation process of tap water

RESULTS AND DISCUSSION

Table 1 shows the assayed values of trihalomethane in the tap water collected from the ten cities. Samples from A, B, C, and I cities were without active carbon adsorption process. On the other hand, those from D, E, F, G, H and J cities were with this process. When the mean values of total trihalomethane were compared, 0.047 mg/l of A was highest, while the lowest was J (0.016 mg/l). In all cities, chloroform was highest, the next was dichlorobromomethane. Bromoform was below the detection limit (0.001 mg/L) in all tap water tested.

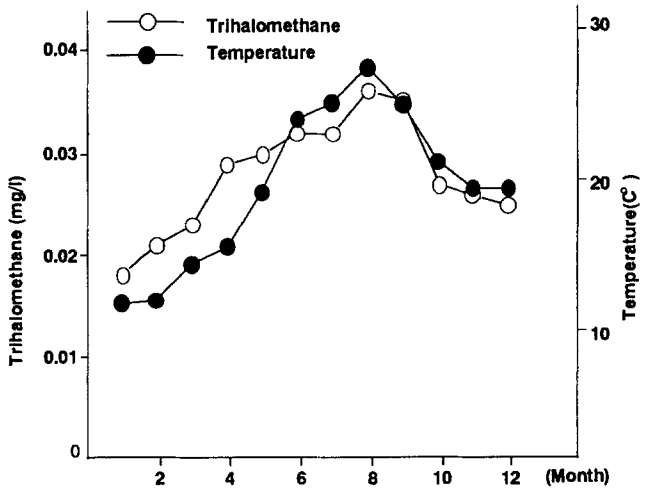

Figure 3 . Variation of trihalomethane and temperature in tap water collected from Kobe city from april of 1992 to march of 1993

Table 2 shows the assayed values of these compounds in the tap water with and without activated carbon adsorption during the preparation process of tap water. The average values of total trihalomethane in the tap water with and without this process were 0.025 mg/L and 0.041 mg/L, respectively. The former was significantly lower than the latter ($p<0.01$). When the mean values of four trihalomethane were compared, chloroform was highest and the next was dichloro - bromomethane in both cases. Figure 2 shows the comparison between the levels of trihalomethane in the two groups. Total trihalomethane in tap water with activated carbon adsorption was about two-third of that without activated carbon adsorption process. Ishikawa (1982) reported that trihalomethane concentrations in tap water depend on the pollution of water source. Kroneld (1986) reported that the variation in trihalomethane concentration in tap water was probably due to seasonal temperatures influencing the rate of the haloform reaction. We determined the monthly concentrations of trihalomethane in tap water over a year in Kobe city (Figure 3). The lowest concentration occurred in January, when total trihalomethane concentration was 0.018 mg/L, and peaked in August, when the concentration reached 0.036 mg/L. Since the concentration of trihalomethane in tap water is affected by atmosphere temperature, samples were taken in a short term, i. e., within 10 days. Our results suggest that carbon adsorption process is effective to remove trihalomethane. All the tap water tested were under the water standard of total trihalometane in Japan (0.1 mg/L).

REFERENCES

Rook JJ (1974) Formation of haloform during chlorination of natural waters. Water Treat Examin 23 : 234 -243

Rock JJ (1976) Haloforms in drinking water. J Am Wat Works Assoc 68 : 68 -172

Anon. (1976) Report on the Carcinogenesis Bioassay of Chloroform, National Cancer Institute, Bethesda, Maryland.

Ishikawa T (1982) Precursors of trihalomethane in the natural environment. Eisei Kagaku 28 : P10 -15

Kroneld R (1986) Chloroform in tap water and human blood. Bull Environ Contam Toxicol 36 : 477 - 483