

## Determination of Trihalomethanes in the Drinking Water of Jeddah City

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**ABSTRACT.** 125 drinking water samples were collected from eight locations in Jeddah city, Saudi Arabia. Trihalomethanes (THMs) concentration in the collected samples was determined. The mean values obtained for THMs at all selected locations in Jeddah city are very low, compared with the maximum allowable limits of total THMs in United States Water.

### Introduction

Drinking water of Jeddah city is obtained mainly from four sea water desalination plants that produce 350,000 m<sup>3</sup>/day and groundwater, transferred from Wadi Khulays, a nearby watershed. Chlorination is the disinfection method applied to the blended water before it is pumped into the distribution system.

Symons *et al.* (1975) showed that chlorination of water containing organic compounds results in the formation of trihalomethanes (THMs). Occurrence of THMs in the drinking water may constitute a health hazard to humans. A National Cancer Institute report (1975) indicates that chloroform causes cancer in mammals under laboratory test conditions (NCI 1975). Cantor and McCabe (1978) showed statistically that significant differences in the incidence of human cancer exist between drinking waters with and without THMs present (*i.e.*, with and without chlorination).

The present study was carried out in order to determine the extent occurrence of THMs in finished drinking water in the major districts of Jeddah city.

### Material and Methods

Drinking water samples were collected from eight locations in Jeddah city (see Fig. 1) in order to represent THMs concentration in various places in the distribution system. 15 to 18 water samples were collected from each location in 40 ml glass vials without head space in order to prevent the loss of volatile organic compounds. 10 mg of sodium thiosulphate were added to each sampling vial to remove any free residual chlorine and thereby quench further formation of THMs. THMs were extracted from water samples with glass distilled n-pentane (see Fayad and Iqbal 1985). One  $\mu\text{L}$  of the pentane extract was injected into the gas chromatograph. A 1.5 OV 17 + 1.95 OV 210 column of 2 m length was used for chromatograph separation of the THMs components. The analysis of THMs was carried out using a Varian Vista 3400 gas chromatograph. The GC oven temperature was programmed from 40°C to 120°C at a ramp rate of 10°C/min with an initial time of 2 minutes. Nitrogen was used as a carrier gas with a flow rate of 27 ml/min.

### Results and Discussion

The results obtained from the analysis of the collected water samples from 8 districts in Jeddah city are shown in tables 1 and 2. As is evident from these tables, the

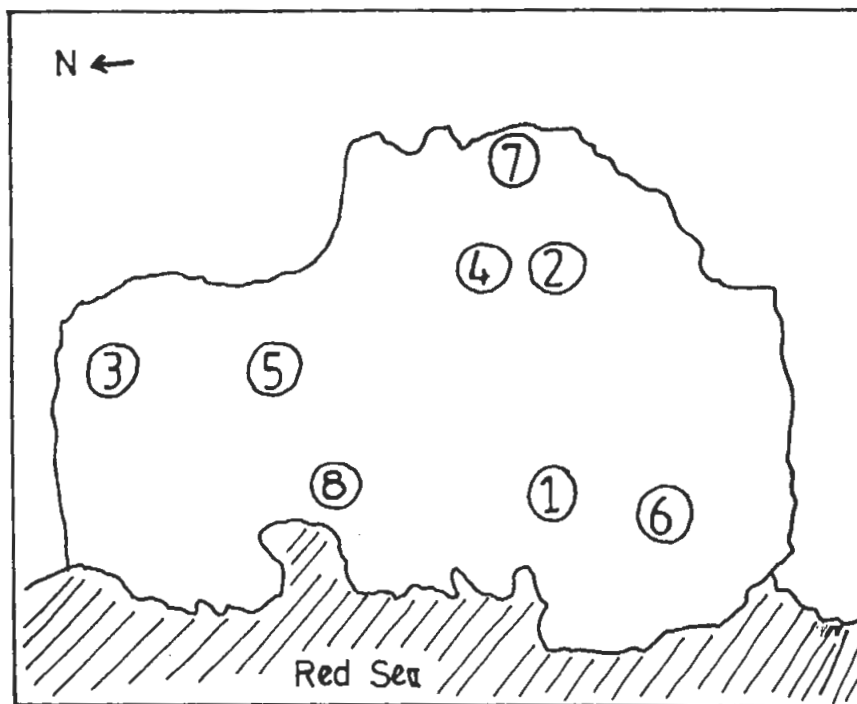


FIG. 1. Schematic map of Jeddah city and the eight locations (numbered) from which water samples were collected.

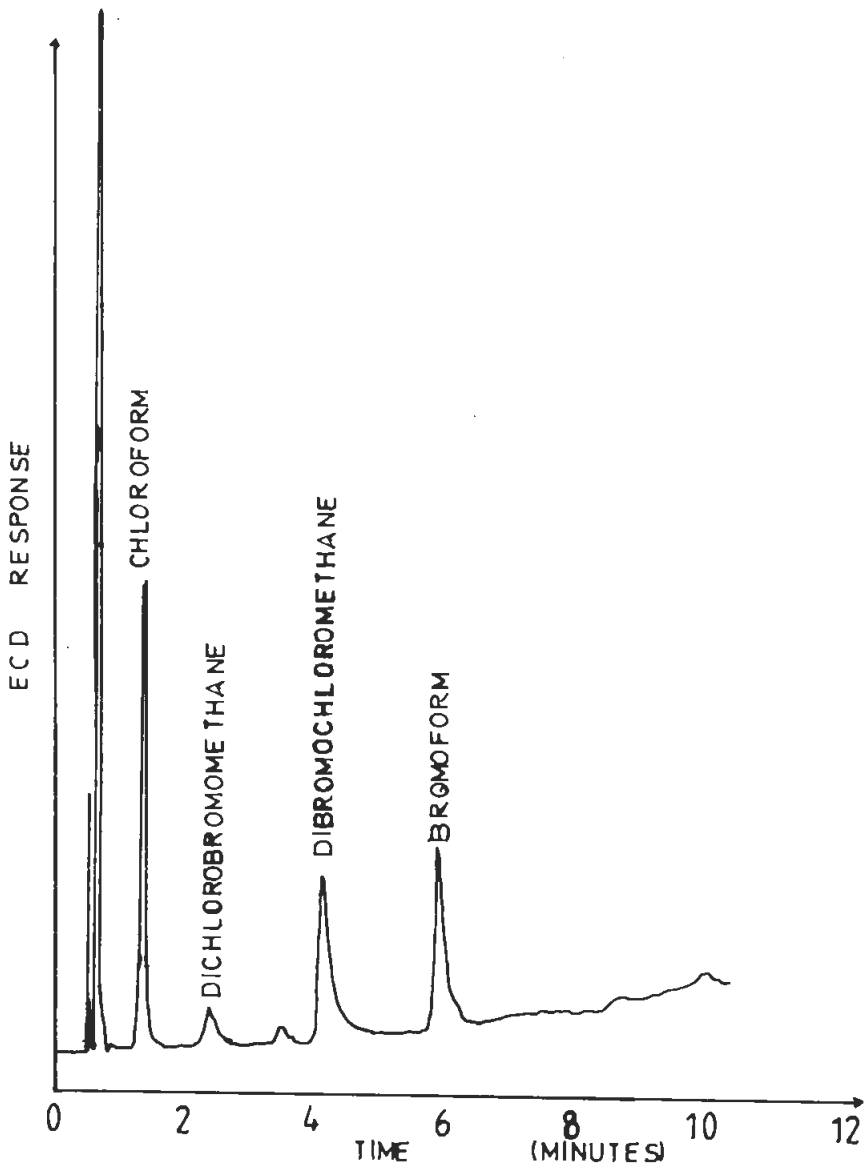


FIG. 2. Typical chromatogram of THMs found in the main water tanks of King Abdulaziz University at Jeddah city.

determined values range from a minimum of 0.629  $\mu\text{g/L}$  (for Gholeil district) to a maximum of 0.873  $\mu\text{g/L}$  (for KAAU main water tanks).

TABLE 1. Trihalomethanes in Jeddah drinking water.

Location no.	District	Mean concentration $\mu\text{g/L}$			
		$\text{CHBr}_3$	$\text{CHClBr}_2$	$\text{CHCl}_2\text{Br}$	$\text{CHCl}_3$
1	Hindaweyah	0.11	0.011	Undetected	0.669
2	University district	0.13	0.017	Undetected	0.552
3	Al-Bawadi	0.141	0.012	Undetected	0.589
4	University main water tanks	0.122	0.060	0.011	0.679
5	Tahlia station main distribution tanks	0.095	0.007	Undetected	0.553
6	Gholeil	0.082	0.002	Undetected	0.544
7	Guczah	0.128	0.011	Undetected	0.527
8	Al-Hamra	0.134	0.013	Undetected	0.533

TABLE 2. Total trihalomethanes in Jeddah drinking water.

Location no.	District	No. of samples	Mean $\mu\text{g/L}$	Standard deviation (S.D.)
1	Hindaweya	17	0.790	0.032
2	University district	15	0.699	0.068
3	Al-Bawadi	15	0.742	0.077
4	University main water tanks	18	0.873	0.011
5	Tahlia station tanks	15	0.655	0.020
6	Gholeil	15	0.629	0.057
7	Guczah	15	0.666	0.022
8	Al-Hamra	15	0.680	0.014

N.B. See location numbers on the schematic map of Jeddah city.

Notably, Fayad and Iqbal (1985) obtained almost similar results for most major cities in the Eastern Province of Saudi Arabia except for Dammam city where they estimated THMs concentration to be as high as 40.3  $\mu\text{g/L}$ .

The values obtained in the present study were also lower than those reported for other world locations. For example, Trussell *et al.* (1979) surveyed drinking water in twelve countries for THMs and other volatile organic contents and have found a mean concentration of 15.8  $\mu\text{g/L}$  for THMs. The mean values obtained for THMs in all Jeddah districts were very low, compared with the maximum allowable limit for total THMs in the United States drinking water which is 100  $\mu\text{g/L}$  as proposed by the United States Environmental Protection Agency (Fed. Reg. 1978).

The function of THMs is known to depend, among other factors, upon the applied initial chlorine dose (Kajino and Yagi 1980, Stevens and Symons 1980). The resulting free chlorine residual, which is also dependent on the initial dose, could further contribute to THM formation. Normally a larger chlorine dose results in a larger free residual, although the chlorine demand also varies as a function of the initial dose. The

general practice in regard to chlorination of potable waters is to use the smallest possible initial chlorine doses just enough to produce a minimal amount of chlorine residual (usually < 1 ppm). The reason behind this kind of practice is to avoid unnecessarily excessive concentration of a toxic material which is also capable of producing toxic derivatives, and also to avoid intensification of offensive taste and odour which may result from formation of certain traces of chlorinated organic compounds if present in the water. Free chlorine was analyzed in this study for replicate samples obtained from the same sites as for THMs. The analysis revealed residual chlorine levels lie below the detection limits of the iodometric method used in the analysis. The detection limit of this method is normally about 1 ppm (APHA, iodometric method I, 198 ).

However, these low levels of free residual found in the analyzed samples could be an indication of a low initial chlorine dose resulting in an even lower chlorine demand and free residual, with the ultimate result of relatively low THMs levels.

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## قياس تركيز مركبات (تراي هالوميثانات) Trihalomethanes في مياه الشرب بمدينة جدة

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المستخلص . في هذا البحث جمعت ١٢٥ عينة من مياه الشرب في مدينة جدة ، وقد  
اختيرت ثمانية مواقع تمثل كامل نظام توزيع المياه ، فتم حساب تركيز مواد تراي هالوميثانات  
(Trihalomethanes, THMs) في هذه العينات المجموعة ، وقد كان متوسط المقادير  
المتحصل عليها لهذه المواد منخفضاً جداً في تلك العينات مقارنة بالحد الأعلى المسموح به  
لمواد THMs في مياه الشرب في الولايات المتحدة الأمريكية .