Division Control No. ECD-60

This manuscript has been submitted as a
CCIW-IWD Unpublished Report

TRIHALOMETHANES (THMs) IN WATER FROM THE ZAI WATER TREATMENT PLANT AND FROM CHLORINATION EXPERIMENTS ON EAST GHOR CANAL WATER, JORDAN

Barry G. Oliver

NWRI CONTRIBUTION No. 86-32

Environmental Contaminants Division
National Water Research Institute
Canada Centre for Inland Waters
Burlington, Ontario, Canada L7R 4A6

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PO Box 5050
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EXECUTIVE SUMMARY

Expertise on trihalomethanes (THMs) developed through several years of research at CCIW was used to aid Jordan in assessing potential THM problems from their new water treatment plant. I was able to demonstrate that THMs should not be a serious problem in their treated drinking water. Although the Jordanian government covered the trip expenses, the Canadian government contributed my time and expertise and, therefore, provided aid to this third world country.

LES TRIHALOMÉTHANES DANS L'EAU DE LA CENTRALE D'ÉPURATION DE ZAI ET DANS L'EAU DU SECTEUR ORIENTAL DU CANAL GHOR, EN JORDANIE, AYANT FAIT L'OBJET DE CHLORATIONS EXPÉRIMENTALES

Barry G. Oliver

Division des contaminants environnementaux
Institut national de recherche sur les eaux
Centre canadien des eaux intérieures
Casier postal 5050
Burlington (Ontario) Canada L7R 4A6

RÉSUMÉ À L'INTENTION DE LA DIRECTION

L'expérience acquise sur les trihalométhanes au cours de plusieurs années de recherche à l'Institut national de recherche sur les eaux a été mise à profit pour aider la Jordanie à évaluer les problèmes que sa nouvelle usine d'épuration de l'eau risque de présenter avec ces substances. J'ai réussi à établir que les trihalométhanes ne devraient pas constituer un grave problème dans leur eau potable. Le gouvernement jordanien a payé les frais de transport, mais c'est le gouvernement canadien qui, en contribuant mon temps et mon expérience, venait en aide à un pays du Tiers monde.

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A. JORDANIAN ITINERARY (August, 1985)

August 21	Arrive Amman.
August 22	Zai Treatment Plant visit and sample collection from plant.
August 23	Collection of water and sediment samples from East Ghor Canal.
August 24	Chlorination and alum treatment experiments, and sample extraction in WAJ Laboratory.
August 25	Sample extractions in WAJ Laboratory.
August 29	Sample analysis in WAJ Laboratory.
August 30	Sample analysis in WAJ Laboratory.
August 31	Sample analysis in WAJ Laboratory and return to Canada with sample extracts and sediments to complete analyses.

B. INTRODUCTION

In this report I will discuss work carried out during by second visit to Jordan (August 21-31, 1985). During my initial visit to Jordan in March 1985, I conducted several chlorination and water treatment experiments on water from the East Ghor Canal in order to estimate the trihalomethane (THM) production during water disinfection. The August trip was designed to obtain samples from the

newly completed Zai Water Treatment Plant (which uses East Ghor Canal water) to find out whether the experiments performed in March and the approximations made from these experiments were correct.

Although the plant was not in service on my arrival, officials started up the plant on August 22 so I could obtain samples of treated water. In addition, raw water samples from the storage basin at the plant were collected for chlorination and simulated water treatment experiments. On August 23, water samples were obtained from the East Ghor Canal for chlorination experiments. Also bottom sediment samples were recovered at 10 km intervals along the canal. These sediment samples were analyzed in Canada to find out whether or not significant inputs of pesticides or herbicides were entering the canal. Such inputs could potentially have an adverse impact on the water quality at Deir Alla.

C. TRIHALOMETHANES

The trihalomethanes were extracted from the samples with pentane using a simple liquid-liquid extraction procedure. Equal volumes of pentane and water were hand shaken for about five minutes, then the pentane layer was recovered and stored in small vials. The analyses of the pentane exttracts were carried out in Canada using capillary column gas chromatographic analysis. A few analyses were also completed at the Water Authority of Jordan (WAJ) Laboratory during my visit.

Unfortunately, pentane extraction solvent supplied by the WAJ Laboratory contained about 450 ppb of chloroform so no analyses could be performed for this THM. Previous data from my May report[1] showed that chloroform comprised only about 20% of the total THM's in chlorinated water from the East Ghor Canal. This percentage was used to approximate the total THM's in the last column of the tables.

The THM data for samples from the Zai Water Treatment Plant are shown in Table 1. The samples for which the chlorine residual was quenched on site contained about 80 ppb total THM's. Samples which were allowed to react for 24 and 72 hours to simulate continued reaction in the storage and distribution systems produced THM values of 140 and 180 ppb, respectively.

Table 2 shows the results of chlorination and alum treatment experiments on raw water collected from the Zai storage basins. The data for the sample to which an alum dose of 20 mg/L was applied, the same dose as used at the treatment plant, produced virtually the same THM concentrations as the treatment plant treated water. The alum dosage experiments showed that this was the optimum alum concentration and that alum treatment reduced the total THM's by about 40%.

Table 3 shows the data for Deir Alla-East Ghor Canal water which was collected on August 23. Not surprisingly, this data is virtually identical to that obtained in Table 2 for the chlorination and treatment of the raw water from the Zai Treatment Plant. This shows that the experimental and analytical methods are quite reproducible.

The change in THM potential for water collected from the East Ghor Canal at the tunnel, 30 km from the tunnel (Tell Arbaein), and 60 km from the tunnel (Deir Alla) is shown in Table 4. The tunnel and Tell Arbaein samples contain about one half the level of THM precursors as the Deir Alla sample in agreement with the March study[1]. Over the last 30 km of the canal, there must be a major input of organic material entering the canal. If this source or sources could be eliminated, the final THM concentrations from the treatment plant would be reduced to one-half current values.

The data from the treatment plant samples and from the other experiments are in good agreement with the experiments and predictions of my May 1985 report[1]. The DOC value at Deir Alla in August 1985, 2.7 (mg/L), was virtually the same as that observed in March 1985. This shows that there is probably little seasonal variation in the concentration of THM precursors in the East Ghor Canal. The March chlorination experiments, after alum treatment, produced total THM values of 87 ppb at 20°C and 180 ppb at 35°C. The high temperature value (180 ppb) is in excellent agreement with the data observed for treatment plant water (after distribution system reaction time, 72 hrs) during the hot summer months. The water temperature seems to be the main factor which controls the THM concentration in the treated water.

The current data and the results of the March study show that the total THM value in treated water from the new treatment plant will

vary from about 80 ppb in the winter to about 180 ppb in the summer. The yearly mean THM value should be in the 120-140 ppb range. This value is somewhat higher than the United States THM guideline of 100 ppb but considerably lower than the Canadian limit of 350 ppb. In my opinion, this THM level is not a cause for concern.

D. PESTICIDES AND HERBICIDES

Sediment samples were collected at 10 km intervals along the canal from the tunnel to Deir Alla. Most pesticides and herbicides have a strong affinity for sediments so this is a good media to assess their importance. Also sediments provide a reasonable integration of water column concentrations over the long term. Surficial sediments were collected from the canal using small plexiglass core tubes with the help of local population, young swimmers. These samples were extracted, cleaned-up and analyzed by our usual capillary gas chromatographic procedures[2].

The parameters quantified were: chlorobenzenes, polychlorinated biphenyls (PCBs), α-benzenehexachloride, lindane, γ chlordane and 1,1,1-trichloro-2,2-bis (4-chlorphenyl)-ethane (pp-DDT) and other DDT derivatives. We did not detect any of these chemicals in the sediments of the canal. Moreover, full scan gas chromatography/mass spectrometry (GC/MS) analysis of sample extract concentrates showed the complete absence of other pesticides and herbicides in the canal

sediments. This data indicates that pesticide and herbicide used in the Jordan Valley probably does not cause any severe contamination problems to the canal water.

E. RECOMMENDATIONS

1. Based on the measurements to date, the yearly mean total THM concentration in water from the Zai Treatment Plant should be in the 120-140 ppb range. In my opinion, these THM concentrations are not a serious problem. The THM levels could be reduced to about one-half of these values by finding and eliminating the sources of organic THM precursors which enter the canal over the last 30 km stretch above Deir Alla.

2. Based on sediment analyses, the usage of pesticides and herbicides in the Jordan Valley does not cause any severe contamination problems in the East Ghor Canal.

F. ACKNOWLEDGMENTS

I would like to thank Dr. A.A, Khatib and his staff at the Water Authority of Jordan Laboratory for the excellent cooperation and help they provided during my visit.

G. REFERENCES

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2. "Gas Chromatographic Determination of Chlorobenzenes and Other Chlorinated Hydrocarbons in Environmental Samples Using Fused Silica Capillary Columns". (B.G. Oliver and K.D. Nicol). Chromatographia 16, 336 (1982).

TABLE 1 THMs in Zai Treatment Plant Water in parts per billion (ppb). (Alum dose 20 mg/L).

Reaction Time	$CHCl_3$	$CHBrCl_2$	$CHBr_2Cl$	$CHBr_3$	Total** THMs
At plant	I*	16	25	23	80
+24 hrs	I	26	48	40	140
+72 hrs	I	32	62	47	180

* Interference from large amount of $CHCl_3$ in pentane.
** Calculated assuming $CHCl_3$ is 20% of THMs.

TABLE 2 THMs from Chlorination of Raw Water from Zai Treatment Plant (parts per billion) and in Raw Water Treated with Alum.
(Temperature = 30°C, chlorine dose = 8 ppm, DOC = 2.7 mg/L)

Reaction Time (hours)	$CHCl_3$	$CHBrCl_2$	$CHBr_2Cl$	$CHBr_3$	Total** THMs
		Alum Dose = 0 mg/L			
4	I*				
24	I	36	73	52	200
50	I	55	112	70	300
		Alum Dose = 10 mg/L			
4	I	13	26	24	79
24	I	26	63	52	180
50	I	32	88	69	240
		Alum Dose = 20 mg/L			
4	I	13	26	23	78
24	I	25	62	52	170
50	I	26	67	56	190
		Alum Dose = 30 mg/L			
4	I	10	18	16	55
24	I	24	50	42	150
50	I	23	79	69	210

* Interference from large amount of $CHCl_3$ in pentane.
** Calculated assuming $CHCl_3$ is 20% of THMs.

TABLE 3 THMs from Chlorination and Alum Treatment (ppb) of East Ghor Canal Water from Deir Alla.
(Temperature = 30°C, chlorine dose = 10 ppm, DOC = 8 mg/L)

Reaction Time (hours)	$CHCl_3$	$CHBrCl_2$	$CHBr_2Cl$	$CHBr_3$	Total** THMs
		Alum Dose = 0 mg/L			
24	I*	48	80	41	210
48	I	73	108	49	290
		Alum Dose = 10 mg/L			
24	I	31	56	46	170
48	I	62	92	58	270
		Alum Dose = 20 mg/L			
24	I	32	46	23	130
48	I	55	64	28	180
		Alum Dose = 30 mg/L			
24	I	21	38	34	120
48	I	60	92	59	260

* Interference from large amount of $CHCl_3$ in pentane.
** Calculated assuming $CHCl_3$ is 20% of THMs.

TABLE 4 THM Potential (ppb) of East Ghor Canal Water from the Tunnel to Deir Alla.
(Temperature ≈ 30°C, chlorine dose = 10 mg/L)

Reaction Time (hours)	$CHCl_3$	$CHBrCl_2$	$CHBr_2Cl$	$CHBr_3$	Total** THMs
		At Tunnel (DOC = 0.8 mg/L)			
24	I*	14	47	55	150
48	I	18	57	62	170
		At Tell Arbaein (DOC = 0.7 mg/L)			
24	I	16	40	26	100
48	I	20	50	40	140
		At Deir Alla (DOC = 2.7 mg/L)			
24	I	48	80	41	210
48	I	73	108	49	290

* Interference from large amount of $CHCl_3$ in pentane.
** Calculated assuming $CHCl_3$ is 20% of THMs.