Organic Chemicals in Drinking Water

Summary of the National Organics Monitoring Survey

The United States Environmental Protection Agency (EPA) has conducted the National Organics Monitoring Survey (NOMS) since March 1976, to determine the frequency of occurrence of specific contaminants in drinking water supplies and to provide data for the possible establishment of additional maximum contaminant levels for organic compounds or for a treatment requirement for the control of organic compounds in drinking water.

Included in the NOMS were 113 community water supplies, representing various types of sources and treatment processes. These were monitored three times (phases) during a twelve month period. A fourth phase is currently underway.

The source of these compounds may be: (1) naturally occurring organic matter (e.g. humus); (2) contaminants introduced as a result of treatment (e.g. trihalomethanes); (3) synthetic chemicals from point sources; and (4) chemicals from non-point sources. The naturally occurring substances constitute by far the major portions of the organic chemicals found in drinking water.

Compounds selected for the NOMS study include: chloroform, 1,2-dichloroethane, carbon tetrachloride, bromodichloromethane, trichloroethylene, dibromochloromethane, bromoform, benzene, vinyl chloride, bis (2-chloroethyl) ether, p-dichlorobenzene, 1,2,4-trichlorobenzene, 2,4-dichlorophenol, pentachlorophenol, polychlorinated

biphenyls, fluoranthene, 1,12-benzoperylene, 3,4-benzopyrene and indeno(1,2,3-cd)pyrene. These compounds were chosen on the basis of possible occurrence, available toxicological data, and the existence of analytical methodology for their identification and quantification. In addition, several general organic class parameters, such as total organic carbon (non-purgeable), carbon chloroform extract, ultraviolet absorbance and emission fluorescence scan were studied in an attempt to determine a possible relationship between one or more of them and specific compound occurrences. Certain sampling and analytical modifications were instituted in Phase III to take into consideration the findings of the earlier phases. NOMS data for trihalomethanes (THMs) are summarized below. (Table I).

TABLE I - Analytical results of chloroform, bromoform, bromodichloromethane, and dibromochloromethane and total trihalomethane in water supplies from NOMS

(Concentrations in milligrams per liter)

	Phase I	Phase II	Phase III	
Chloroform:		Dechlorinated	terminal	
Median.....	0.027	0.059	0.022	0.044
Mean.....	0.043	0.083	0.035	0.069
Range.....	NF-0.271	NF-0.47	NF-0.20	NF-0.540
Bromoform:				
Median.....	LD	LD	LD	LD
Mean.....	0.003	0.004	0.002	0.004
Range.....	NF-0.039	NF-0.280	NF-0.137	NF-0.190
Dibromochloromethane:				
Median.....	LD	0.004	0.002	0.003
Mean.....	0.008	0.012	0.006	0.011
Range.....	NF-0.190	NF-0.290	NF-0.114	NF-0.250
Bromodichloromethane:				
Median.....	0.010	0.014	0.006	0.011
Mean.....	0.018	0.018	0.009	0.017
Range.....	NF-0.183	NF-0.180	NF-0.072	NF-0.125
Total Trihalomethane:				
Median.....	0.045	0.087	0.037	0.074
Mean.....	0.068	0.117	0.053	0.100
Range.....	NF-0.457	NF-0.784	NF-0.295	NF-0.695

NF=not found
LD=less than detection limit

In Phase I, samples were collected and analyzed in a fashion similar to that employed in the National Organics Reconnaissance Survey (NORS). Samples were shipped from the utility and stored at 2-8°C for 1-2 weeks prior to analyses. In Phase II samples were allowed to stand at 20-25°C for 3-6 weeks prior to analyses. Under these conditions THM formation was permitted to proceed to reaction end points (terminal values) generally corresponding to the consumption of free chlorine residual in the

sampling vial. All supplies were sampled in Phase III both with and without a chlorine reducing agent present at the time of sampling (quenched and terminal). In addition, samples with a reducing agent added were collected at five points in the distribution system in each of ten cities. A site at a distant point in most systems was sampled. These experiments were incorporated in Phase III in order to more fully understand the distribution of total trihalomethanes (TTHM) concentrations that can reach the consumer, since it is recognized that the extent of THM formation depends on the type and chemical composition of raw water, pH, water temperature, chlorine contact time, treatment method, and in certain cases, season.

The NOMS demonstrated that considerable amounts of THMs could form in the water after it had entered the distribution systems on the way to the consumer's tap. It also showed that THMs far exceeded the concentrations of other synthetic organic contaminants in finished drinking water, and that brominated THMs could also exceed the chloroform concentrations in some situations. Part of the THM concentration variation between Phases I, II and III might also be attributable to seasonal effects.

Other than trihalomethanes, compounds studied in the NOMS are generally present in finished drinking water due to raw water contamination (Table 2). An exception is

2,4-dichlorophenol which is produced on treatment by chlorination of phenol, or related precursors.

TABLE 2

Compound	Phase	Number of Positive Analyses per Number of Analyses I	II	III	Mean Concentration, ug/l Positive Results Only I	II	III	Median Concentration, ug/l All Results I	II	III
Chloroform	Quenched+	102/111*	10/18	98/106	47*	68	38	27*	68	22
	Terminal@		112/113	101/105		84	73		59	45
Bromodichloromethane	Quenched+	88/111*	18/18	100/106	22*	16	9.2	9.6	18	5.9
	Terminal@		109/113	103/105		18	17		14	11
Dibromochloromethane	Quenched+	47/111*	15/18	83/106	17*	13	7.5	<0.6-3*	1.9	2.1
	Terminal@		97/113	97/105		14	11		3.5	3.1
Bromoform	Quenched+	3/111*	6/118	19/106	21*	28	13	<3-5*	<0.3*	<0.3-0.6*
	Terminal@		38/113	30/105		12	13		<0.3*	<0.3-0.6*
Dichloroiodomethane	Terminal@		85/111	50/105		b	b		b	b
1,2-Dichloroethane	Quenched+	1/111*		1/106	2.0*		1.3	<1-2*		<0.05-2*
	Terminal@		2/113	1/105		0.9	1.2		<0.05-1*	<0.05-2*
1,1,1-Trichloroethane	Quenched+			4/105			1.5			<0.2-0.4*
	Terminal@		19/111	4/104		b	1.0		b	<0.2-0.4*
Carbon Tetrachloride	Quenched+	3/111*		8/106	2.9*		6.4	<1-2*		<0.2-0.4*
	Terminal@		10/110	11/105		2.4	4.3		<0.2*	<0.2-0.4*
1,1,2-Trichloroethylene	Quenched+	4/112*		10/106	11*		2.4	<1-5*		<0.2-0.5*
	Terminal@		28/113	19/105		2.1	1.3		<0.03*	<0.2-0.5*
Tetrachloroethylene	Quenched+			8/106			1.1			<0.2*
	Terminal@		48/111	9/105		b	0.81		b	<0.2*
Benzene		0/111	7/113	4/16	--	0.4	0.95	<2*	<0.1-0.2*	<0.1-0.2*
o-Dichlorobenzene			0/113	4/110		--	2.5		<0.005*	<0.005*
m-Dichlorobenzene			0/113	2/110		--	0.10		<0.005*	<0.005*
p-Dichlorobenzene		2/111	20/113	29/110	2.0	0.14	0.067	<1*	<0.005*	<0.005*
1,2,4-Trichlorobenzene		1/112	2/113	10/110	10	0.29	0.090	<0.4-1*	<0.005-0.1*	<0.005*
Vinyl Chloride			2/113			0.14			<0.1*	
Methylene Chloride		15/109			6.1			<1-2*		
2,4-Dichlorophenol		56/108	0/9		0.18	--		<0.01-0.1*	<0.1*	
Pentachlorophenol		86/108	5/10		0.07	0.008		<0.01*	<0.004*	
Bis (2-chloroethyl) ether		0/112	13/113	8/110	--	0.10	0.024	<5*	<0.01*	<0.01*
Bis (2-chloroisopropyl) ether			8/113	7/110		0.17	0.11		<0.01*	<0.01*
PCB's		2/110	4/113	2/110	0.76	0.13	0.15	<0.12*	<0.1-0.2*	<0.1*
Fluoranthene		17/110	0/9		0.02	--		<0.01*	<0.05-0.1*	
3,4-Benzofluoranthene		0/110	0/9		--	--		<0.02-0.05*	<0.05-0.1*	
1,12-Benzoperylene		0/110	0/9		--	--		<0.02-0.05*	<0.05-0.1*	
3,4-Benzopyrene		0/110	0/9		--	--		<0.02-0.05*	<0.05-0.1*	
Indeno (1,2,3-cd)pyrene		0/110	0/9		--	--		<0.02-0.05*	<0.05-0.1*	
NPTOC		108/112	108/113	107/110	2.1 mg/l	2.1 mg/l	2.4 mg/l	1.8 mg/l	1.8 mg/l	2.0 mg/l
COD		80/80			7.0 mg/l			6.9 mg/l		
CCE		111/111	107/107	109/109	0.55 mg/l	1.1 mg/l	1.2 mg/l	0.53 mg/l	0.92 mg/l	1.0 mg/l

* Samples were shipped ICED (4°C), stored at 2°-8°C for 1-2 weeks prior to analyses.
\+ Samples were preserved with Sodium Thiosulfate at time of sampling, shipped at ambient temperature, stored at 20°-25°C for 3-6 weeks prior to analyses.
@ Samples were shipped at ambient air temperature, stored at 20°-25°C for 3-6 weeks prior to analyses.

In general, the data shows that the trihalomethanes (chloroform, bromodichloromethane, dibromochloromethane, bromoform and dichloroiodomethane) are by far the most ubiquitous synthetic organic contaminants in drinking water, and they also occur at the highest concentrations (up to 784 ppb were detected). They are produced by chlorination during treatment of their naturally occurring precursors, probably humus, but algae and other chemicals may also be precursors. Pentachlorophenol was also commonly found in parts per trillion levels.

Although a large number of other synthetic products were also detected in various waters, the concentrations were generally very low (usually sub parts per billion) and the number of occurrances was generally small. The common volatile halogenated solvents and chemical intermediates (i.e. chlorinated ethanes, ethylenes and benzenes) were typical. Carbon tetrachloride when found in finished water was probably a result of contamination of the chlorine. Chemical oxygen demand (COD) and Non-purgeable Total Organic Carbon (NPTOC) correlated reasonably well with the THM formation potential.

Besides the above mentioned organic contaminants, Table 3 lists additional organic compounds that have been detected at least once in the NOMS study.

The EPA has published in the Federal Register on February 9, 1978, proposed regulations to establish a

maximum contamination level of 100 parts per billion for THMs and to require the installation of granular activated carbon treatment to control general synthetic organic contaminants.

Environmental Protection Agency
Criteria and Standards Division
Office of Drinking Water (WH-550)

TABLE 3

Additional Organic Compounds Detected in NCMS

Acetone
Aniline
Benzaldehyde
Bromotrichloroethylene
n-Butyl acetate
Di-n-butyl ether
Chlorobenzene
Chlorostyrene
Chlorotoluene
Chloroxylene
Dibromodichloroethylene
Ethylbenzene
Isobutyl acetate
1,2-Dichloropropane
Isopropyl ether
Methylene bromide
Methycyclohexane
Methylmethacrylate
4-Methyl-2-pentanone
Naphthalene (or Azulene)
Phenol
cis-beta-Terpineol
Terpineol isomer
1,1,2,2-Tetrachloroethane
Tetrahydrofuran
Toluene
Tribromochloroethylene
Trichlorobenzene isomer
Xylenes
Heptadecane
N-Methylaniline
Benzyl cyanide
Atrazine
Alpha-Bergamotine and
  3 related compounds
Trimethylisocyanurate
tris-Chloroethyl
  phosphate
hexachloroethane
1,1,2-Trichloroethane
Trichlorofluoromethane
Styrene
Tetralin
1,1 and 1,2-Dibromoethane
Methylstyrene
Chloropicrin
Iodomethane
Bromochloromethane
1-naphthyl-N-methyl carbamate
Fluorobenzene
Bromoethane
Methyl bromide
Dimethyl disulfide
Phenol
Terpinenes
Nitrotoluene
Trichlorobutane
Acetonitrile
cis and trans-Dichloroethylene
Diethyl adipate
Dioctyl adipate
Trichlorophenol
2-Chloropropane
Ethyl ether
1,1 Dichloroethene