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Polycyclic Aromatic Hydrocarbon Levels in Eastern Ontario Drinking Waters, 1978

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The drinking waters of 5 municipalities in Eastern Ontario were monitored for 12 selected low molecular weight (128-228) polycyclic aromatic hydrocarbons (PAH) and 4 oxygenated PAH derivatives (O-PAH) using Amberlite XAD-2 macroreticular resin for analysis at the ng/L level. The compounds monitored were selected on the basis of their prominence in the results of our previous analysis of Ottawa tap water for PAH and O-PAH (BENOIT et al. 1979).

SAMPLING AND ANALYSIS

In June and October 1978, ca 200 L samples of drinking water at 6 water treatment plants (A-F) serving 5 communities in eastern Ontario were passed through Amberlite XAD-2 macroreticular resin according to the procedure of LEBEL et al. (1979). At two water treatment plants (E and F), the raw water supply was sampled at the same time as the treated water in October, 1978. The resin was subsequently eluted with 300 mL acetone/hexane (15:85, v/v) and the eluates dried by percolation through a sodium sulfate filter and were then concentrated to 1 mL. The recovery levels for the PAH monitored and the method blank results have been reported (BENOIT et al. 1979). The concentrated eluates were analyzed using a Finnigan 4000 Gas Chromatograph/Mass Spectrometer coupled to a 6110 Data System. The following instrument parameters and operating conditions applied:

Column:	1.8 m x 2 mm i.d. glass, packed with 3% OV-17 on 80-100 mesh Chromosorb 750.
Temperatures:	oven from 100°C (0.1 min hold) to 225°C, (hold) at 3°C/min; injection port 225°C, separator 250°C and ion source 260°C.
Carrier gas:	helium flowing at 20 mL/min.

The mass spectra were scanned from 35 to 400 a m u every 2.1 s under control of the data system and the data were stored on magnetic disk. Individual PAH and O-PAH were identified and quantified by comparing the retention times and peak

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areas of characteristic ions (two ions per compound) in the field samples and a standard mixture of PAH and O-PAH, respectively. The lower limit of detection was ca 0.01 ng/L of each compound monitored in the original 200 L water sample.

RESULTS AND DISCUSSIONS

Results of the PAH and O-PAH analyses of the treated (plants A-F) and raw (plants E and F) waters are presented in Tables 1 and 2. Individual PAH concentrations ranged from 0.04 to 6.4 ng/L in the treated waters and from 0.1 to 34.4 ng/L in the raw waters (Table 1); individual O-PAH concentrations ranged from 0.1 to 2.1 ng/L in the treated waters and from 0.3 to 10.6 ng/L in the raw waters (Table 2). The results for the treated waters compare well with our previous results for Ottawa tap water (BENOIT et al., 1979). As a measure of the relative quality of the sampled waters, the aggregate PAH and O-PAH concentrations were computed by summing the individual PAH (Table 1) and O-PAH (Table 2) concentrations, respectively, for each water supply. The aggregate PAH levels (Table 1) at individual treatment plants for the two test periods do not show any discernable trend whereas the aggregate O-PAH levels (Table 2) show a marked increase in the October over the June sample for 5 of the treatment plants tested. This is possibly due to the accumulation of products from the oxidation of PAH during the summer when surface waters are exposed to higher levels of sunlight and atmospheric oxidants.

The water treatment plants (A-F) are located in three neighbouring water basins with two plants in each basin. Each basin has a different demography; basin 1 (plants A and B) drains a heavily populated urban area with an extensive industrial activity, basin 2 (plants C and D) drains a lightly populated rural area with little industrial activity and basin 3 (plants E and F) drains a moderately populated area with moderate industrial activity. The average aggregate PAH and O-PAH levels for each basin are presented in Table 3. For both test periods, basin 2, which has the lowest level of anthropogenic activity of the basins analysed, also has the lowest average aggregate PAH and O-PAH levels, although the difference in O-PAH levels for basins 1 and 2 is small (~ 10%). Apparently, the level of contamination of potable water is related to the population density within a basin. Similar results have been reported on PAH levels in the atmosphere (SUESS, M.J., 1976).

At the two water treatment plants (E and F) located in basin 3, samples of the raw and treated waters were taken simultaneously in the October sampling. Both of these plants draw raw water from the same river at locations ~ 5 miles apart. The two raw water supplies were sampled on different days with an interval of 15 days. The raw water at plant E (upstream from plant F) contained significantly higher aggregate levels of PAH (74.3 ng/L) and of O-PAH (28.5 ng/L) than at plant F (PAH, 13.1 ng/L; O-PAH, 3.4 ng/L) (Tables 1 and 2). Such a fluctuation in

Table 1. PAH concentrations (ng/L) in water[a] from water treatment plants A-F.

PLANT	A		B		C		D		E			F		
	JUN	OCT	JUN	OCT	JUN	OCT	JUN	OCT	JUN	OCT	RAW OCT	JUN	OCT	RAW OCT
Naphthalene	4.1	7.5	3.8	2.7	1.1	2.9	1.1	0.6	0.6	6.2	3.3	4.0	2.1	2.4
MeNaphthalene[b]	5.5	6.1	6.4	1.8	0.9	1.7	0.9	0.2	0.6	3.0	4.1	2.7	1.7	1.2
Dime-Naphthalene[c]	2.4	3.4	5.2	1.8	1.6	2.5	0.7	0.4	0.9	2.3	17.3	2.2	4.9	1.3
Biphenyl	0.4	0.5	1.7	0.6	0.2	0.3	0.2	0.1	0.1	0.6	0.7	0.5	0.2	0.3
Acenaphthylene	1.0	0.7	2.0	0.5	0.9	1.3	2.0	0.3	0.1	1.3	0.1	0.4	0.3	0.5
Bibenzyl	0.4	0.2	0.6	0.7	0.3	0.8	0.3	n.d.	0.1	0.1	1.0	0.1	0.1	0.3
Fluorene	0.2	0.6	0.5	0.3	0.3	1.0	0.7	0.2	0.1	1.8	0.4	1.1	0.04	0.9
Phenanthrene + Anthracene	1.0	1.4	0.6	1.0	0.9	2.8	0.4	0.1	0.5	4.8	9.8	4.1	1.8	5.3
1-Me-Phenanthrene	0.9	5.1	1.5	0.6	1.1	0.2	n.d.	1.1	1.3	4.5	34.4	2.4	n.d.	n.d.
Fluoranthene	0.6	0.9	0.8	0.5	0.9	1.3	0.4	0.2	0.5	3.9	1.4	2.6	0.7	0.7
Pyrene	0.3	0.4	0.4	0.4	0.3	0.5	0.04	0.1	0.3	1.8	1.7	2.0	0.5	0.2
Benz(a)anthracene + Triphenylene + Chrysene	0.2	0.2	0.4	n.d.	0.2	0.2	n.d.	n.d.	0.2	0.5	n.d.	2.6	0.4	0.05
Aggregate PAH	16.8	26.8	23.5	10.9	8.5	15.3	6.7	3.3	5.1	30.3	74.3	22.2	12.3	13.1

a - treated water unless otherwise stated.
b - sum of 1- and 2-methylnaphthalenes.
c - sum of 1,2-, 1,3-, 1,4-, 1,5-, 1,6-, 2,3-, 2,6, dimethylnaphthalenes and 2-ethylnaphthalene.

Table 2. O-PAH concentrations (ng/L) in water[a] from water treatment plants A-F.

PLANT	A		B		C		D		E			F		
	JUN	OCT	JUN	OCT	JUN	OCT	JUN	OCT	JUN	OCT	RAW OCT	JUN	OCT	RAW OCT
9-Fluorenone	0.5	1.3	0.7	1.0	1.2	1.3	n.d.	1.3	0.2	1.9	10.4	0.6	0.8	1.2
Perinaphthenone	0.3	1.1	n.d.	0.5	n.d.	0.5	n.d.	0.3	0.1	0.9	2.8	0.3	0.4	0.3
Acenaphthenequinone	n.d.	0.3	0.3	0.3	0.3	1.0	0.5	n.d.	1.1	n.d.	10.6	0.3	1.1	0.9
Anthraquinone	0.6	0.9	0.8	0.8	0.8	1.1	0.1	0.1	1.2	1.9	4.7	2.1	1.1	0.9
Aggregate O-PAH	1.4	3.6	2.0	2.6	2.3	3.9	0.6	1.7	2.6	4.7	28.5	3.3	3.4	3.3

[a] - treated water unless otherwise stated.

Table 3. Average aggregate PAH and O-PAH levels (ng/L) in treated waters from water basins 1, 2 and 3

	Basin 1 (Plants A and B)		Basin 2 (Plants C and D)		Basin 3 (Plants E and F)	
	PAH	O-PAH	PAH	O-PAH	PAH	O-PAH
June	20	1.7	7.7	1.5	15	2.9
October	19	3.1	9.4	2.8	21	4.0

the quality of the raw water may be caused by meteorological conditions. For example, it has been reported that rain accelerates the rate of deposition of suspended PAH from the atmosphere (SUESS 1976). It is difficult to correlate the fluctuations of PAH and O-PAH levels with atmospheric conditions because of the unknown lag time between deposition of the PAH on the earth's surface and introduction into the raw water supply. At plant E treatment of the water reduced the level of contamination considerably (PAH from 74.3 to 30.3 ng/L, O-PAH from 28.5 to 4.7 ng/L) whereas at plant F little improvement occurred (PAH from 13.1 to 12.3 ng/L, O-PAH from 3.4 to 3.3 ng/L) following treatment of the water. The effectiveness of the water treatment process for removal of organics from water has been reported (SMILLIE *et al*., 1978) to vary.

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