Chemosphere, Vol.27, No.10, pp 2017-2026, 1993
Printed in Great Britain

0045-6535/93 $6.00 + 0.00
Pergamon Press Ltd.

Toxaphene Contamination in Lake Baikal's Water and Food Web

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ABSTRACT

Water and biological samples were obtained from Lake Baikal in June 1991 and analyzed for toxaphene and other organochlorines. Dissolved toxaphene concentration ranged from 34 pg/L to 143 pg/L and were similar in magnitude to ΣDDT (47 pg/L; sum of 2,4'-DDT, 4,4'-DDT, and 4,4'-DDE) and Σchlordanes (28 pg/L; sum of cis- and trans-chlordane and cis- and trans-nonachlor). Toxaphene in biota was 1.9 mg/kg-lipid in the pelagic sculpin *Comephorus dybowskii*, 1.1 mg/kg-lipid in the omul (*Coregonus autumnalis migratorious*) and 2.3 mg/kg-lipid in Baikal seal *(Phoca siberica)* blubber. Toxaphene chromatographic patterns, determined by gas chromatography electron capture negative ion-mass spectrometry, were transformed in the seal relative to either of the fish, which is likely due to the seal's greater ability to metabolize some toxaphene congeners. The major peak in the Baikal seal toxaphene chromatogram was an 8-chlorinated bornane unlike that found by other investigators for narwhal or beluga whale blubber, but similar to ringed seals from the Canadian Arctic.

KEYWORDS: Toxaphene, Lake Baikal, Organochlorine, Bioaccumulation.

INTRODUCTION

Toxaphene is a complex mixture of chlorinated bornanes and bornenes containing up to 670 individual compounds (Stern *et al.*, 1992). From the late 1960's to 1975, this mixture was the most heavily used pesticide in the United States until its use was cancelled in 1982 (Voldner and Schroeder, 1989). Peak toxaphene usage occurred in 1974 when 55 x 10^6 tonnes were utilized as an insecticide primarily on cotton. Toxaphene application likely continues in many areas of the world including Central America, eastern Europe and the former Soviet Union (Bidleman *et al.*, 1988, Voldner and Schroeder, 1989). This combined with persistence of toxaphene in soils, will make this mixture a problem for some time to come.

Large past usage and environmental persistence has led to long-range transport of toxaphene *via* the atmosphere (Bidleman *et al.*, 1989; Hinckley *et al.*, 1991; Patton *et al.*, 1991; Bidleman *et al.*, 1992) and ecosystem-wide contamination with this mixture. Consequently, toxaphene has been found in biota from regions with little or no historical toxaphene application. Detectable levels of toxaphene have been measured in arctic invertebrates (Bidleman *et al.*, 1989; Hargrave *et al.*, 1993), the Great Lakes atmosphere (Rice *et al.*, 1986), Great Lakes, arctic and northern Canadian fishes (Swackhamer and Hites, 1988; Muir *et al.*, 1990a; Evans *et al.*, 1991; Hargrave *et al.*, 1992), Baltic and arctic seals (Andersson *et al.*, 1988; Bidleman *et al.*, 1988), and whales (Muir *et al.*, 1990b, 1991; Bidleman *et al.*, 1993). Unlike PCBs, toxaphene has not been as extensively studied in aquatic food webs or water. Recent investigations of organochlorine contamination in Canadian Arctic indicate that, like PCBs, toxaphene may impose a risk to natives who rely on marine mammals for food (Dewailly *et al.*, 1989; Kinloch *et al.*, 1992). Consequently, areas such as Lake Baikal, where native people also consume food from the lake, may be at similar risk.

The goal of this work was to measure toxaphene in water and three trophic levels of the Lake Baikal food web and compare this data to other areas, primarily the Canadian Arctic where this mixture has been more extensively studied. The primary open-water food web in Lake Baikal consists of a planktivorous sculpin (*Comephorus dybowskii*) which is fed on by the omul (*Coregonus autumnalis migratorious*) and a top predator (besides humans) the Baikal seal (*Phoca siberica*). An additional aim of this investigation was to compare levels of toxaphene and other organochlorines (PCBs, DDTs, chlordanes, and hexachlorocyclohexanes) from this data poor region to the Canadian Arctic, Western Europe and the Great Lakes.

MATERIALS AND METHODS

Collection. Seven 180 L surface water grab samples were collected from Lake Baikal (Figure 1) during June of 1991 while aboard the R.V. *G. Yu Verashchagin* by dropping 18 L stainless steel containers from the ship as it moved slowly forward to avoid contamination. Five water samples were obtained from the southern basin (site 3; Figure 1) and one each from the northern (site 1) and central basins (site 2). Biological samples were procured from various sources. Two omul (22 cm total length) were obtained from local fisherman. A total of 35 (2-10 cm total length) planktivorous sculpins were supplied by G.T. Chandler from a collecting trip in the summer of 1990. Seal blubber (~0.5 kg; age and sex unknown) was provided by the Limnological Institute in Irkutsk. All biological samples were immediately frozen after collection, shipped back to our laboratory on ice and frozen at -20 ^oC until analysis.

Water samples (180 L) were filtered using Gelman A/E glass fiber filters (GFFs; pre-treated by combustion at 450 ^oC for 24 h) enclosed in a high-pressure Millipore filter apparatus. Dissolved organochlorines were then extracted from water by passage through a 2 cm x 15 cm glass-enclosed column of XAD-2 resin (Mallinkrodt) at a flow rate of 250-350 mL/min. Details are given elsewhere (Capel and Eisenreich, 1985; Kucklick, 1992, Kucklick *et al.*, 1993). XAD-2 was refrigerated and GFFs frozen, shipped on ice then refrozen at -20 ^oC until analysis.

Extraction. XAD-2 resin was eluted with 150 mL methanol followed by 150 mL dichloromethane (DCM). NaCl saturated water was added to the methanol phase and then re-extracted three times with 25 mL DCM. The DCM fractions were then combined. GFFs were refluxed in 250 mL DCM for 24 hours. Fish samples were homogenized whole in a tissue blender; omul were homogenized separately and sculpins were pooled. 2-g fish subsamples were ground with 12 g Na_2SO_4, transferred to a soxhlet thimble and extracted for 24 h with DCM. Seal blubber (2-g) was refluxed in DCM for 24 h. The DCM in all sample extracts was reduced in volume by flash evaporation to 5-10 mL, then further evaporated to 1-2 mL in a gentle stream of purified nitrogen with a

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