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Polybrominated diphenyl ethers (PBDEs) in mussels from cultures and natural population

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ABSTRACT

Polybrominated diphenyl ether (PBDE) mass fractions were determined in mussel samples collected from 6 locations around Thermaikos Gulf in north Greece. PBDEs were present in all sampling sites and the average total (ΣPBDEs) ranged from 17.7 to 32.3 ng/g l.w., characterising Thermaikos as low polluted, a fact further supported by congener ratios and literature comparison. Distribution was even among stations with one exception. Congener profiles exhibited predominance of penta-/octa-BDEs as well as BDE-209. Statistical analysis showed significant difference in pollution levels between the two types of mussel cultures. No variations were observed for mussel bunch position or between cultures and natural population. Congener correlation analysis suggested different pollution sources between higher and lower brominated congeners as well as different metabolic/degradation processes. Bioaccumulation factors indicated that an increase in congener bromination degree leads to bioaccumulation capacity reduction. Consumption of mussels from Thermaikos gulf area poses no threat for public health concerning PBDEs.

1. Introduction

Polybrominated diphenyl ethers (PBDEs) are a group of chemical substances used mainly as additive flame retardants in a variety of commercial and household products such as polymer resins, plastics, textiles and paints, and electrical and building equipment, aiming at minimizing the ignition risk of these products or decelerating the burning process (Athanasiadou, 2003; Darnerud et al., 2001). The group consists of 209 congeners.

PBDE molecular structure is similar to those of persistent organic pollutants (PCBs, PCDDs, etc). Thus, they demonstrate environmental persistence, lipophilicity, bioaccumulation and resistance to degradation, which leads to their presence becoming ubiquitous in the environment and every level of the food web. The entry sources to the environment can be indirect (through air, soil or water transport) or direct from PBDE manufacturing and leaching/volatilization during the use of products or after their disposal (Watanabe and Sakai, 2003). Traces of these chemicals have been detected in numerous aquatic organisms regardless of topology (industrial, rural or remote areas) (Boon et al., 2002). The toxicological properties of PBDEs, although not as strong as these of other organic pollutants, are linked to the endocrine system and account for a considerable health risk in organisms through bioaccumulation and biomagnification (Tanabe, 2002). The immune and reproductive systems have been reported to present adverse effects (Rahman et al., 2001); one of human's major exposure route is through fish and shellfish consumption (Kiviranta et al., 2004).

Commercially the main PBDE products consist of penta-, octa- and deca-BDE mixtures (Table 1). North America and Asia produce and consume the lion's share of these mixtures (with USA on the lead, N. America uses more than 50% of the total PBDE production worldwide and 95% of penta-BDE mixtures) while in Europe penta- and octa-BDE mixtures in particular have been restricted (EC, 2003). Annual global demand of PBDEs has risen during the 90s especially for penta-BDE mixtures (Morf et al., 2007) although for the last decades deca-BDE represents over 80% of PBDE worldwide production (De Wit, 2002). There is still no directive in Europe against the production and use of deca-BDE; nevertheless, the European Court of Justice annulled the Commission Decision on the exemption of deca-BDE from the directive. The use of BDE-209 formulation is also prohibited in Europe since July 2008 (ECJ, 2008).

In the marine environment mussels are proven to be an excellent bioindicator among aquatic organisms for monitoring organic pollutants (Tanabe et al., 2008). The objectives of this study were to estimate PBDE levels, congener profile and spatial distribution in mussels (*Mytilus galloprovincialis*), both from cultures and natural population from Thermaikos Gulf, to compare them to worldwide reported data, to detect any differences that may exist between the two existing different types of mussel cultures in the area (modern long-line and pole/stake) or between the mussels' position in the

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Table 1
Global market of PBDEs and their commercial mixture synthesis.

Commercial mixture	Commercial mixture synthesis[a]	Global market in 2001 (metric tons)[b]				
		America	Europe	Asia	Rest of the world	Total
Penta-BDE (Bromkal 70-DE, DE-71)	38–42% tetra-BDE 45–49% penta-BDE 8–10% hexa-BDE 0–1% tri-BDE	7100	150	150	100	7500
Octa-BDE (Octabrom, DE-79)	0.5% penta-BDE 12% hexa-BDE 45% hepta-BDE 33% octa-BDE 10% nona-BDE 0.7% deca-BDE	1500	610	1500	180	3790
Deca-BDE (Saytex 102E, DE-83R)	0.3–3% nona-BDE 97–99% deca-BDE	24,500	7600	23,000	1050	56,100

[a] Source: WHO, 1994; ECB, 2001, 2002, 2003.
[b] Source: BSEF, 2003.

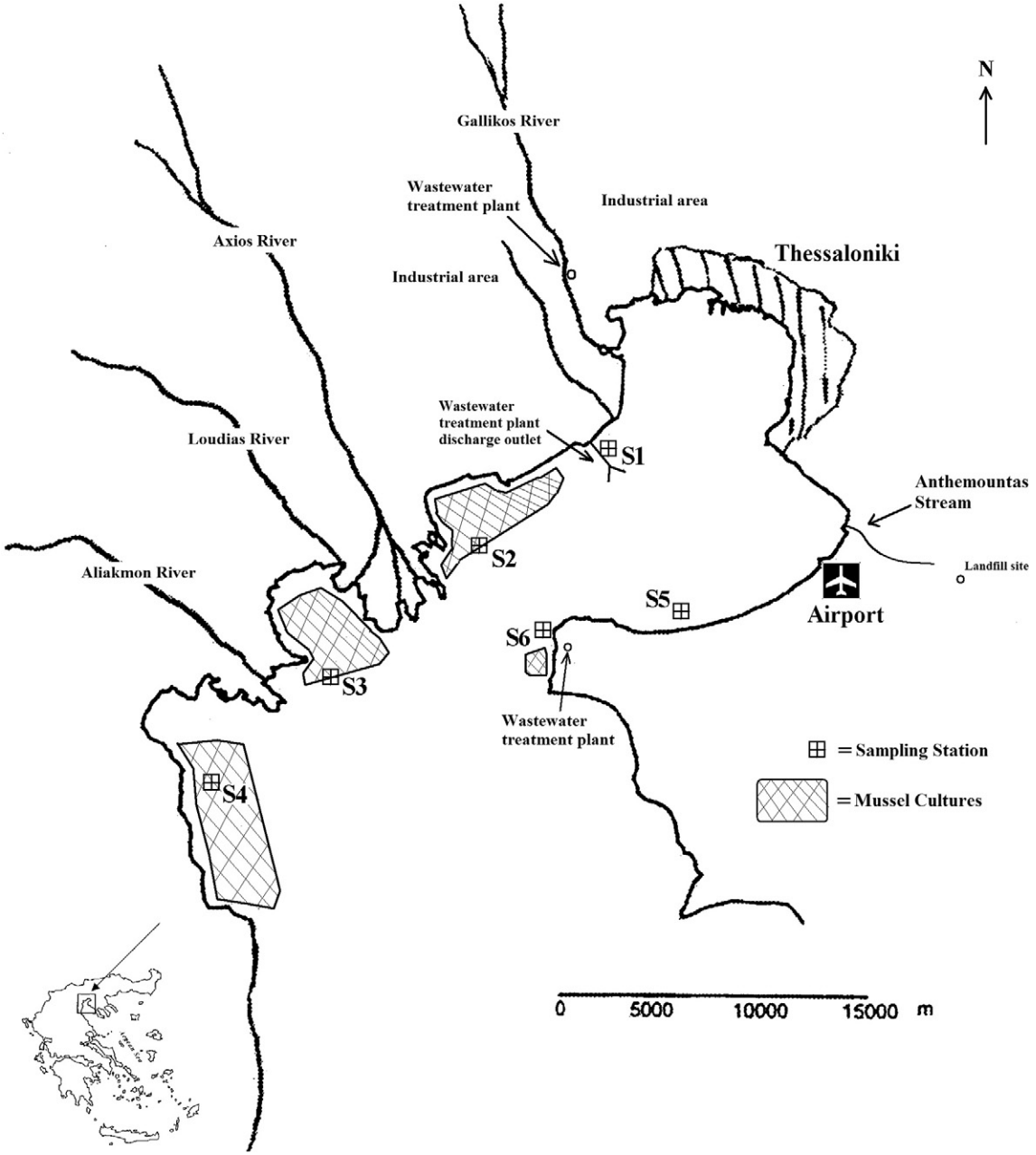

Fig. 1. Area map of Thermaikos Gulf with the sampling stations indicated S1–S6.

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