

Chapter 9

Intra lake spatial variations in pollution patterns of eel

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Summary

Variations in bioaccumulation load of polychlorinated biphenyls, organochlorine biocides and heavy metals in eel *Anguilla anguilla* L. from 4 areas of a 90 ha lake in central Flanders were studied. Although for most of individual pollutants no significant differences were found between eels of the different areas, there seems to be a slight shift in overall pollution pattern between the eels caught in the different areas of the lake. The study revealed significant differences in lindane concentrations in muscle tissue of eels from different areas. No evidence was found for potential causes of this pollution. This study illustrates the potential of using eel as monitoring organism for pollution by some persistent substances within lacustrine environments, even within rather small lakes.

Introduction

Spatial variations in pollution patterns in eels from different locations along a river system have been reported on several occasions (Castonguay *et al.*, 1989; de Boer and Brinkman, 1994; de Boer and Hagel, 1994; Belpaire *et al.*, 1999; Steinbacher *et al.*, 2000, ...), demonstrating the applicability of using eels as biomonitors of polychlorinated biphenyls, biocides and heavy metals in the environment (EIFAC, 1991; Knights, 1997; Geuzens *et al.*, 1999). Spatial variations in pollution patterns of eels within lacustrine environments, however, have seldom been studied. Within one lake, pollution loads might vary as a consequence of diverse causes like diffuse pollution through run off biocides from agricultural areas or accidental spills (e.g. in lake Balaton in 1991 and 1995 causing vast eel kill in certain parts of the lake (330 tons) (Bálint *et al.*, 1997). While concentrations found in water and sediment are low and even under detection limits, high concentrations can be measured in aquatic organisms. As sediment and water analyses may not always be able to detect these spatial differences in pollution within lakes (due to the hydrophobicity of these micropollutants and analytical restrictions), analysis of these pollutants bioaccumulated in eel might be a valuable method to detect these gradients.

Materials and methods

Lake Scholen is a small artificial eutrophic lake (90 ha) situated in Flanders (Belgium) and used occasionally in flood periods as a water retaining basin within the river systems of Dijle and Demer. The lake was excavated in 1974, overall depth is 4.5-5m. In the past years a water quality gradient (with respect to some physicochemical parameters) was reported with increasing quality from east to west, being the result of an influx of polluted water in the eastern part. In the west superfluous water can leave the lake at the outlet. Differences in fish assemblages and species abundances also seem to occur within the lake (Simoens *et al.*, 2002). In the east a part of the lake (Zone D) is distinct from the major part but is connected through a funnel. In order to study the variation in pollution load in the eels, 17 specimens from 4 different zones of the lake (Figure 9.1) were sampled by electrofishing or with fyke nets in september 1999. All eels were in the yellow eel phase and their length varied between 34.0 and 43.8 cm. Eels were analysed individually for a series of toxic substances (polychlorinated biphenyls, organochlorine biocides and heavy metals, see Table 9.1).

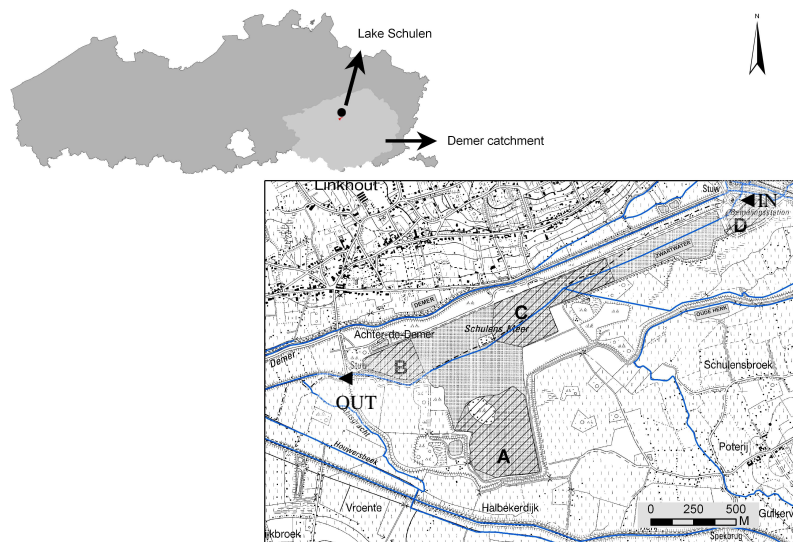


Figure 9.1. Position of Lake Schulen in Flanders with the indication of the different zones and in- and outlet of the lake.

From each eel a sample of ca 50 g of muscle tissue was removed, labeled and frozen before analysis. The analysis were performed by the Belgian Sea Fisheries Department in Ostend (PCBs and pesticides) and by the Veterinary and Agrochemical Research Centre in Tervuren (heavy metals).

Lipids were measured by total lipid extraction following Bligh & Dyer (1959). The techniques for analysis of PCBs and biocides are described in Roose *et al.* (1998). Analysis was performed on a Carlo Erba 8000 GC gas chromatograph with an electron capture detector and a 60m DB-17 and a DB-5 column, both with a film thickness of 0.25 μm and an internal diameter of 0.25 mm. The detection limit was 0.1 ng/g fat weight.

Quality assurance consisted of the analysis of procedural blanks, reproducibility and repeatability tests, injection of standard solutions as unknowns, and analysis of a certified reference material (BCR CRM 349). The lab routinely analyses sample in the framework of the international proficiency testing scheme QUASIMEME for organochlorines in biological samples.

Analysis less than detection limit was set on 0.05 ng.g^{-1} fat weight. Results were expressed as ng.g^{-1} fat weight. Results were also calculated and expressed for total PCB (Sum PCB) being the sum of the means of the 10 congeners measured and for total DDT (sum of the means of the isomers and breakdown products mentioned in Table 9.1). To enable comparison with the proposed Belgian standard for PCBs in fish and derived products, PCBs were also expressed in ng.g^{-1} body

weight for Sum 7 PCB (being the sum of the seven marker PCBs (PCB 28, 52, 101, 118, 138, 153 and 180).

Concentrations of heavy metals were measured by atomic absorption spectrometry and expressed as ng.g⁻¹ body weight.

Statistical analysis consisted in nonparametric analysis of variance with the Mann Whitney U test with the significance level set at 5% and factor analysis (biplot analysis) using Statistica version 5. The factor analysis was performed on the individual concentrations of the pollutants (for PCBs and pesticides expressed in ng/g fat weight and heavy metals in ng/g body weight). Some of the pollutants were left out of this analysis as all measurements were around the detection limit.

Table 9.1. List of pollutants measured

<u>Heavy metals</u>	cadmium, mercury and lead
<u>Polychlorinated biphenyls</u>	PCB 28/PCB 31, PCB 52, PCB 101, PCB 105, PCB 118, PCB138, PCB153, PCB 156, PCB 180
<u>Hexachlorine cyclohexanes</u>	α-HCH, γ-HCH (Lindane)
<u>Cyclodienes (drins)</u>	Dieldrin, Aldrin, Endrin
<u>Polychlorobenzenes</u>	Hexachlorobenzene (HCB)
<u>Chloroethanes</u>	<i>p,p'</i> -DDD (TDE), <i>p,p'</i> -DDT, <i>p,p'</i> -DDE, trans-nonachlor

Results and Discussion

For most of the contaminants analysed (Hg, Pb, PCBs, lindane, dieldrin, aldrin, endrin, HCB and Sum DDT), concentrations in eel from Lake Schulen are *not deviating* from reference values used in Flanders (Van Thuyne *et al.*, 2000; Belpaire *et al.*, 2000b), with the exception of cadmium which is *slightly deviating* in zones A, B and C and *deviating* from the reference value in zone D. In Belgium, consumption standards only exist for the heavy metals Hg, Cd and Pb. Two eels (zone D and C) exceed the 50 ng/g BW consumption standard for cadmium (58 and 62 ng/g BW). For PCBs a stringent consumption standard for fish products of 75 ng/g body weight (Sum 7 PCBs) has been proposed recently (BS, in prep). According to this decree proposal, fixing the maximal allowed concentrations of dioxines and PCBs in fish and derived products, 82% (n = 17) of the Lake Schulen eels should be considered as unfit for human consumption. Mean of Sum 7 PCBs is 175.1 ng/g BW (min 40.4, max 591.4), which in comparison to eels from most other waters in Flanders is relatively low, some of them being as high as 8500 ng/g BW (Belpaire *et al.*, 2000b).

Analysing the data of the individual contaminants in eel caught in the different zones, there seems to be no significant variation between zones (Figure 9.2), with the exception of the lindane concentrations which were significantly different between zones A and B, the latter being higher (Mann Whitney U test, $p < 0.05$). In many countries the legal use of lindane (gamma HCH) has been banned. In Belgium lindane is still being used, mainly in some agrocultures (mostly cultures of beet, corn and ornamental flowers), and it has been demonstrated to be present in eels, bioaccumulating in high concentrations, especially in the Demer and Dijle basins and in the IJzer catchment (western Flanders) (Belpaire *et al.*, 2000b). Presumably these patterns are related to land use activities. In Lake Schulen the origin of the higher lindane concentrations in eels of the zones B and C could not be traced.

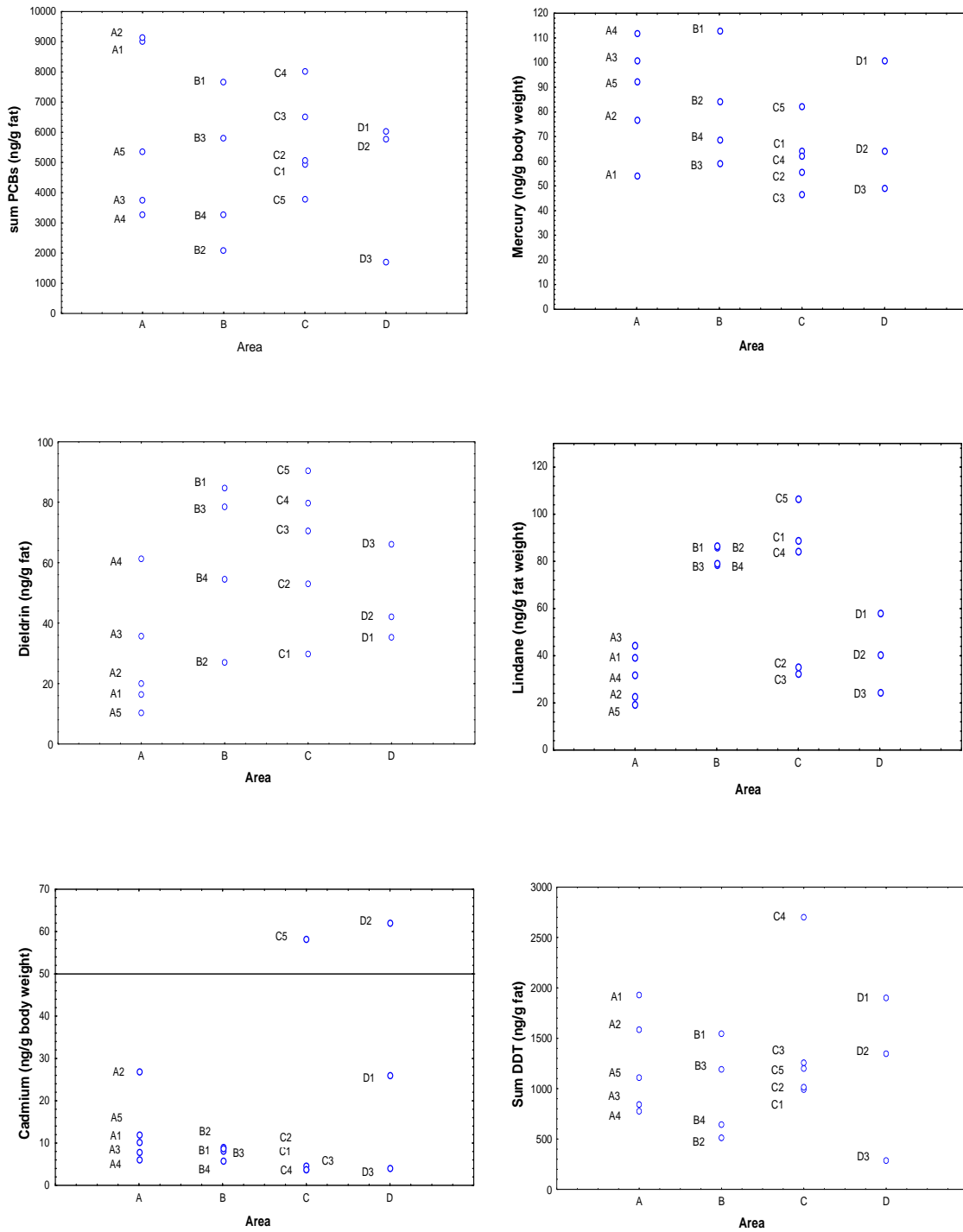


Figure 9.2. Concentrations of Sum PCBs, mercury, dieldrin, lindane, cadmium and Sum DDT in individual eels from the different zones. The concentrations are expressed in ng/g fat weight except for the heavy metals (in ng/g body weight). Horizontal line: Belgian consumption standard for cadmium.

The factor analysis of the combined data show that zone A is distinct from C, D and B (Figure 9.3). The distinct overall pollution pattern in the eels from zone A may be explained by the southern position of A, which has been less influenced by incoming (polluted) water from the eastern inlet point. The distinctive character of the A zone has been suggested earlier by Simoens *et al.* (2002) who found some significant differences in fish assemblages between some zones and calculated the flandrian Index of Biotic Integrity (Belpaire *et al.*, 2000a) of the different zones showing a gradual increase in the fish based ecological quality from the zones from east to west, with zone A having the best IBI score.

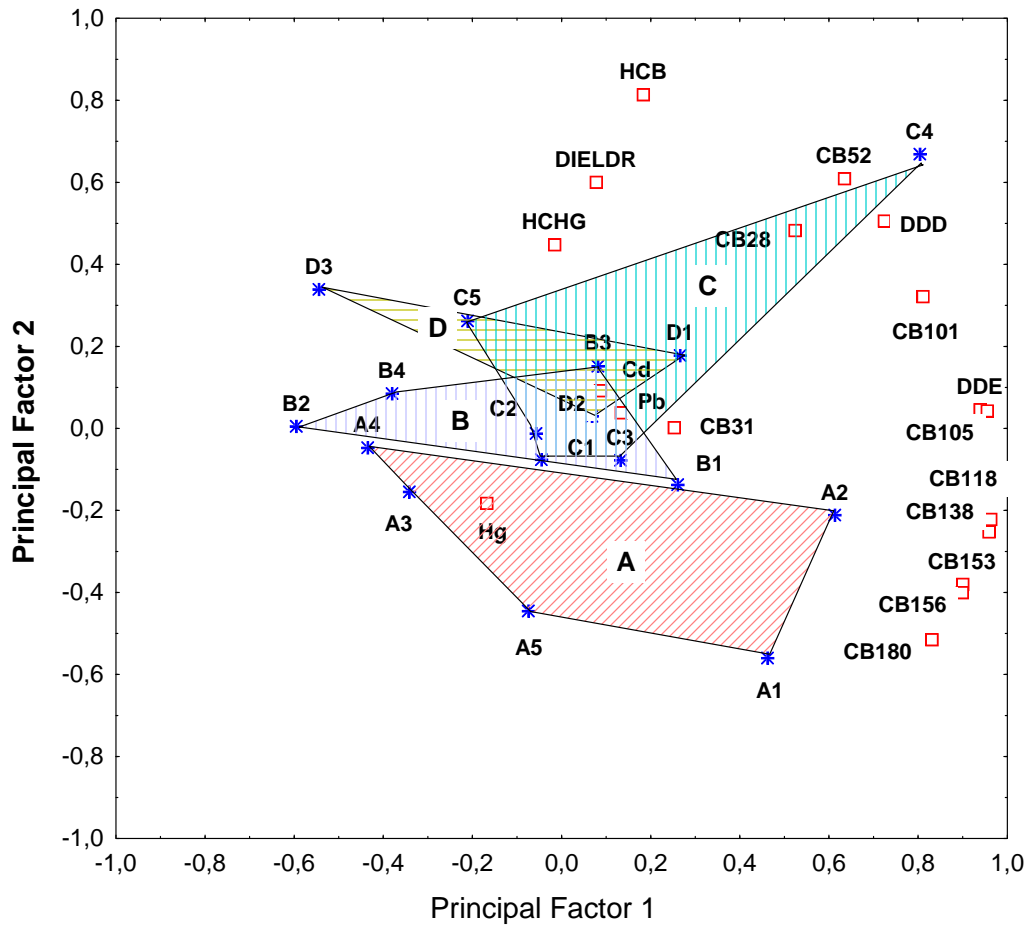


Figure 9.3. Factor analysis of contaminant concentrations in the eels of the different zones. Eels are numbered per zone (A1, A2, ...). HCHG is gamma - HCH (lindane).

In riverine systems eel is known as a good bioindicator to monitor the presence of contaminants. An essential element is the narrow home range of the species during its growing phase (yellow eel phase) (Tesch, 1977). Also in a lacustrine environment, the home range of eel seems to be restricted: in Lake Schulte during recapture experiments in a recent fish assessment survey (Simoens *et al.*, 2002), 92% of the eels (n = 48) were recaptured in the same zone. This strongly supports the usefulness of eels as a biomonitor for (variations of) pollution load within lakes. Even in relatively small lakes it might be useful to analyse concentrations of contaminants in eels in order to map the distribution of contaminants throughout the lake. Monitoring of contaminants in eel is a very accurate instrument to monitor the pollution load in aquatic ecosystems. Policy makers and water quality managers should consider the use of this indicator in their environmental reports. A comparative study of the efficiency of the various strategies for the measurement of pollutants in aquatic ecosystems is necessary in the perspective of a durable monitoring strategy.

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