Similar Decreasing Rate of OCs in Both Eutrophic and Oligotrophic Environments– A Result of Atmospheric Degradation? Part II.

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Introduction

The Swedish Environmental Monitoring Programme on Contaminants in Biota (SEMPC), based on annual sampling and analysis has been running since the late 1970s. Time series from this programme have recently shown that concentrations of various OCs have decreased at a similar rate either the time trends covered temporal trends from remote sub Arctic regions or polluted regions in the southern Baltic (1, 2). The results are unexpected since the models for Global transport of volatile and semi volatile compounds presented by Wania and Mackay (3, 4, 5) predict that concentrations will decrease more slowly in remote cold areas than in tempered southern areas after the discharges have ceased.

To investigate the relative importance of biological degradation in the past we will here study whether there are any significant differences in the rate at which concentrations have decreased if studied waters are eutrophic or oligotrophic. The degradation capability would be expected to be higher in eutrophic lakes than in oligotrophic lakes because of the larger biomass per volume water and consequently the higher degree of enzymatic degradation .

Material and Methods

We have used the Swedish time series from an oligotrophic lake, Lake Horsan, at the island Gotland in southern central Baltic, as well as a time serie from an eutrophic lake in the southernmost part of Sweden, Lake Krankesjön. From each location a sample of ten specimens of roach has been analysed individually per year and the geometric annual mean values have been calculated from which log-linear regression analysis has been applied describing the time trend. The annual change in concentration (%) has been calculated. For a description of methods for sampling, preparation, chemical analysis as well as statistical treatments used in the SEMPC see Bignert et al. (2). The two locations have been selected as uninfluenced by local discharges to the water describing the general background of the area. The study period covers 1981-1995. Both lakes are located in the southern Baltic region and the results is compared to earlier presented time trend series of Baltic herring and guillemot eggs from the

southern Baltic (2). Following compounds have been studied; ΣDDT, total PCB, HCB and α-HCH. See Table 1.

Table 1. Annual change in concentrations of various OCs in roach from the oligotrophic lake Horsan and the eutrophic lake Krankesjön expressed as % with the 95% confidence interval. Corresponding data from two time trend studies from the surrounding marine environment is also given.

Location/species	% 1980 –1995	%, 1980-1995	%, 1988-1995	%, 1988-1995
	ΣDDT	Total PCB	HCB	α-HCH
Horsan/roach/	**-9.8**	**-6.9**	**-12**	**-21**
Oligotrophic	-13 - -6.2	-9.5 - -4.3	-19 - -4.7	-26 - -15
Krankesjön/roach/	**-6.2**	**-5.8**	**-12**	**-16**
Eutrophic	-11 – -1.6	-8.7 - -2,8	-16 - -7.1	-36 - -9.4
Utlängan/herring	-6.2	-4.4	-18	-11
	-9 – - 3.3	-7.3 - -1.4	-23 - -13	-14 - -7.7
Stora Karlsö/	-12	-8.6	-9.2	-24
Guillemot egg	-13 - -2.7	-9.5 - 7.7	-13 - -5.6	-37 - -7.5

Table 2. Changes in concentrations of ΣDDT and Total PCB (%) in pike from various Swedish lakes comparing the measured concentrations in fish from the late 1960s and in fish collected in 1995. The various lakes are ordered from south to north and a rough nutritional status of the lakes is indicated as well as presence of local industry.

Location/species	Nutritional status	ΣDDT	Total PCB
1. Sövdesjön/pike	Eutrophic	-85	-74
2. Snogeholmssjön/pike	Eutrophic	-88	-80
3. Krageholmssjön/pike	Eutrophic	-82	-8
4. Krankesjön/pike	Eutrophic	-85	-50
5. Åsnen/pike	Mesotrophic, indust	-95	-69
6. Bolmen/pike	Mesotrophic, indust	-93	-78
7. Helgasjön/pike	Mesotrophic, indust	-81	-46
8. Hulingen/pike	Mesotrophic, indust	-88	-59
9. Ymsen/roach	Eutrophic	-54	-69
10. Roxen/roach	Eutrophic, indust	-86	-54
11. Bullaren/pike	Oligotrophic, indust	-94	-66
12. Siljan/whitefish	Oligotrophic, indust	-98	-94
13. Grundträsk/roach	Oligotrophic	-88	-67
14. Storvindeln/pike	Oligotrophic	-97	-70
15. Ladtjojaure/pike	Oligotrophic	-73	+54

Data from a study on past and present exposure of OCs to Swedish otters, studying the concentrations of DDT and PCB in fish from both eutrophic and oligotrophic waters in various parts of Sweden has also been included (6). This fish material was collected in the late 1960s and saved in the Swedish Environmental Specimen Bank. We collected new material of fish from these locations in 1995 and analysed both the old material and the material collected in 1995 with the same analytical method described in (2). Five to ten specimens of pike were analysed as a pool from each location and sampling occasion. This material just allows a rough estimate of the total decrease during late 1960s to 1995. For comparison we have used the

starting concentration in 1968 and 1967 respectively and the 1995 value from the long trend studies in Lake Storvindeln and Lake Bolmen within SEMPC. Sampling sites are reported in Table 2 and indicated in Figure 1.

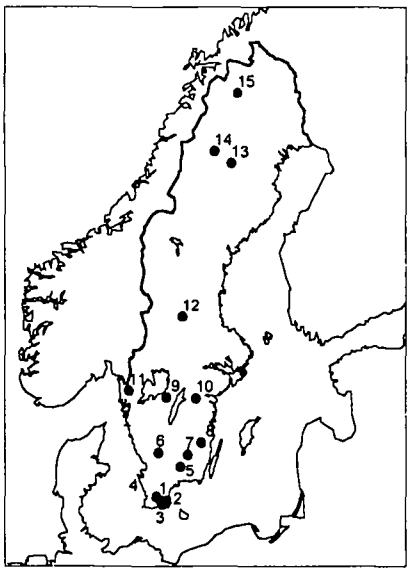

Figure 1. Sampling sites, see table 2.

Results and Discussion

The recorded changes over time do not indicate that concentrations would decrease more rapidly in the eutrophic Krankesjön than in the oligotrophic Horsan. See Table 1. The differences in changing rates are not significant. Neither do the results in Table 2 indicate a more rapid decrease in environments with a higher biological activity. Results, based on occasionally collected material is always risky to use for interpretations (7). However, for DDT compounds the changes over time seem similar. The change in PCB concentrations is more variable. This can be expected since a compound like PCB, used in various products, can be locally released to the environment at the disposal of the products. Of special interest is that also locally and industrially polluted and PCB contaminated waters like Lake Helgasjön, Lake Hulingen and Lake Roxen show a decrease similar to what can be found in locally unpolluted waters. The present results do not support that biological systems or enzymatic degradation are the major cause to explain the decreases of environmental contaminants found both in remote sub Arctic as well as tempered areas of the Globe.

The common decrease indicates a common environmental degradation process. Since our results do not support that higher biological activity implies a faster decrease, the similarities in observed temporal trends may indicate a major degradation process in a medium where the contaminants appear in a fairly equal distribution. This could be in the atmosphere.

There are several reports in the literature showing that both UV radiation and chemical reactions with various radicals may degrade various OCs (8, 9, 10, 11,). However, the present knowledge is still just pieces of information and we need more appropriate information on atmospheric degradation processes and their relative role to understand the environmental fate of environmental contaminants. It is not enough to show that things disappear, we also need to know which are the degradation products.

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References

1. Olsson, M., Bignert, A., Odsjö, T., Persson, W., Litzén, K., Eriksson, U., Häggberg, L. and Alsberg, T.; *Organohalogen Compounds* **1997**, 33, 99.
2. Bignert, A., Olsson, M., Persson, W., Jensen, S., Zakrisson, S., Litzén, K., Eriksson, U., Häggberg, L. and Alsberg, T.; *Environmental Pollution* **1998**, 99, 177.
3. Wania, F. and Mackay, D.; *Ambio* **1993**, 22, 10.
4. Wania, F. and Mackay, D.; *Environ. Sci. Technol.* **1996**, 30, 390.
5. Wania, F. and Mackay, D.; The global fractionation of persistent organic pollutants. NILU:TR 10/96, **1996** Norwegian Institute for Air Research, Kjeller-Norway.
6. Olsson, M., Roos, A. and Greyerz, E. Utveckling av PCB belastningen i svenska uttrar och i fisk under perioden 1965-1995. Report to Swedish WWF 1996-01-25.
7. Bignert, A., Olsson, M., de Wit, C., Litzén, K., Rappe, C. and Reutergårdh, L. *Fresenius J. Anal. Chem.* **1994**, 348, 76.
8. Atkinson, R. *Environ. Sci. Technol.* **1987**, 21,305.
9. Brubaker, W.W. Jr and Hites, R.A.; *J, Phys. Chem. A* **1998**, 102, 915.
10. Ballschmiter, K., *Angsw. Chem.* **1992**, 31, 487.
11. Parlar, H. Chapter 9, p. 245-276, in *Environmental Fate of Pesticides*, Eds. D.H. Hutson and T.R. Roberts, John Wiley & Sons, **1990**; ISBN 0 471 91711 7.