High Concentrations of Dioxins and other Contaminants outside Swedish Cellulose Industries Indicate Ongoing Pollution

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Introduction

Despite a number of regulatory measures at the coastal-bound industries the concentrations of dioxins are still high in the northern Baltic Sea. Recent results also indicate increasing concentrations after the bleaching process for the pulp industry was changed from chlorine gas to chlorine dioxide in the early 1990s (2). The high concentration in fatty fish from the Baltic has led to serious restriction on the marketing of fish products and thus the problem is of serious concern for countries around the Baltic (3).

A recent study on concentrations of dioxins in stationary fish outside industries related to the cellulose industry (one chipboard industry (c), 5 pulp industries with various bleaching processes as well as different water treatment procedures (e, f, h, i, k) and finally an industry treating the lipophilic tar products, tall oil (j) indicates ongoing pollution rather than leakage from previously deposited sediments. This presentation will focus on the relationship between contaminant concentrations (DDT, PCB, dioxins) and the presence of industrial activities and give some tentative hypothesis for the present pollution situation in the Baltic.

Material and methods

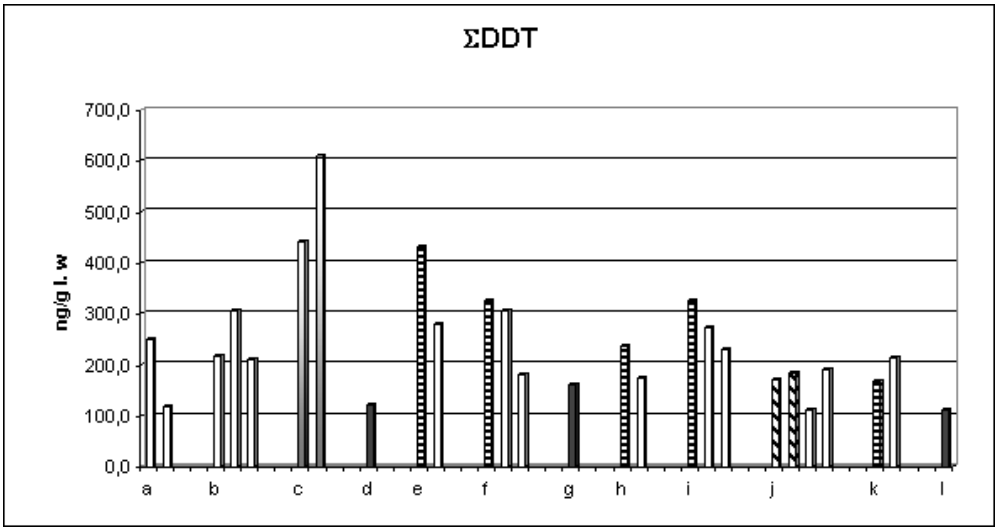
In autumn 2004 fish (Perch, *Perca fluviatilis* or Viviparian blenny, *Zoarces viviparous*) were collected outside the industries as well as in freshwaters in the vicinity of the industries and also at reference sites the Bothnian Sea. Muscle tissue was analysed for presence of a number of contaminants and pollutants including PCDD/Fs (dioxins), PCBs, DDT, PBDE, HBCD, HCB and HCHs. The lipids were extracted from the tissue using bipolar organic solvent mixtures, the lipid contents were determined gravimetrically, and the extracts were cleaned up using well-validated procedures. Finally, the pollutant levels were determined by gas chromatography with ECD (OCPs) or high-resolution mass spectrometry (dioxins).

Results

The results for SDDT and SPCB as well as the dioxins are presented in Figures 1-3. The results are ordered from south-west to north. The individual industrial locations are separated by space in the figures. All locations around an industry are presented after the innermost location and ordered according to distance from the industry. Results from the area most closest to the different pulp industries (e, f, h, i, k) are indicated by bars dashed by vertical lines. Results from the chipboard industry (c), the tall oil industry (j) and the reference sites in fresh waters (d, g, i) are indicated by shadowed bars, bars dashed by diagonal lines and black bars respectively. Remaining locations are indicated by unfilled bars.

Neither DDT or PCB is actively used in the process of the cellulose industry. Nevertheless both contaminants appear at highest concentrations outside the industries and for PCB the highest concentration appears outside the chipboard industry (Figures 1-2). However, there is no indication of increased concentrations outside the industry processing the tall oil and concentrations are fairly low in the freshwater locations as well.

The concentrations of dioxins are highest closest to most of the pulp industries. Outside the chipboard industry the result is higher than at the reference sites. Concentrations are low in the freshwater locations and there is no indication that the tall oil industry is a local source of dioxins.



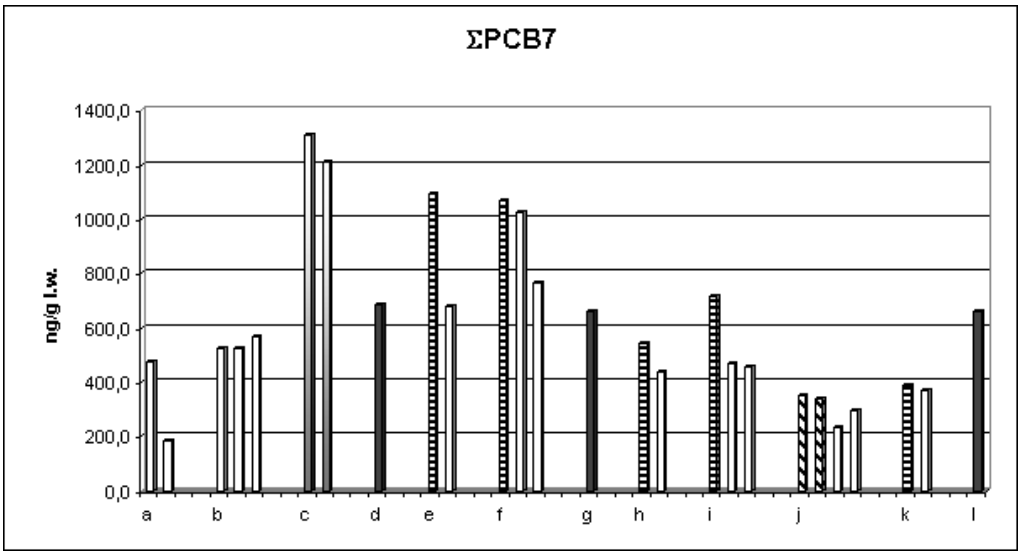


Figure 1. Concentrations of SDDT in fish muscle samples outside 7 industries in the Bothnian Sea. For explanation see Material and Methods

Figure 2. Concentrations of PCB in fish muscle samples outside 7 industries in the Bothnian Sea. For explanation see Material and Methods

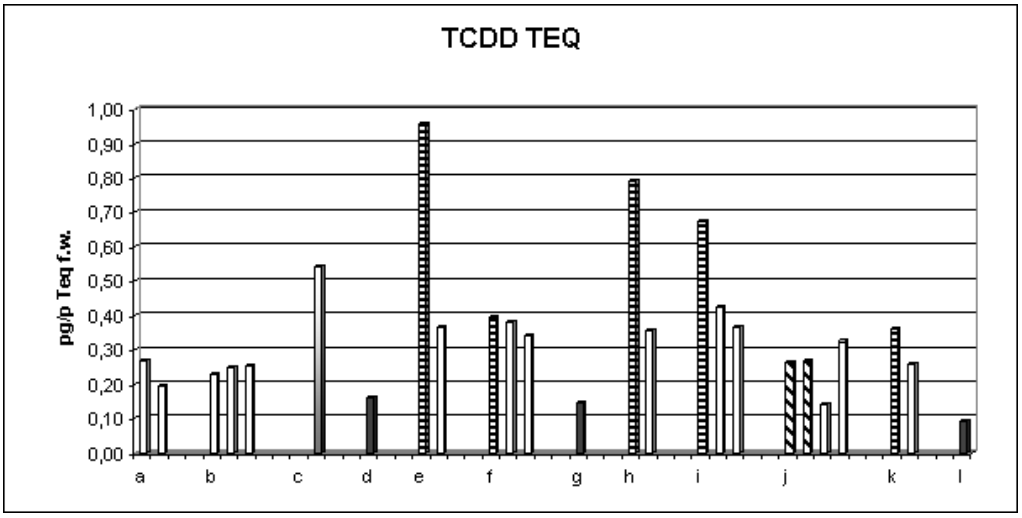


Figure 3. Concentrations of dioxins (TCDD TEQ) in fish muscle samples outside 7 industries in the Bothnian Sea. For explanation see Material and Methods

Discussion

The stabilized and even increasing concentrations of dioxins but not DDT and PCB in herring found at monitoring studies in the southern Bothnian Sea (B.S.), (2, 4) is difficult to explain as leakage from old sediments. If there was ongoing leakage, one would expect stabilized concentrations or a similar increase of DDT and PCB as for dioxins. To what extent a dredging of the harbour outside industry **e** can have had an impact on the conditions should, however, be further investigated. Another source of dioxins mentioned in recent studies is air borne pollution caused by increased burning of bio-fuel such as bark and firewood at the cellulose industry, heating industries or for heating of homes. However, the results present do not indicate burning activities as the source of high concentrations of dioxins in the B.S as the dioxin concentrations are low in the freshwater sites **(d, g, l).** These are also in the vicinity of both thermal power stations and cellulose industry, which both burn large amounts of the bio-fuel mentioned above.

Another hypothetical source could be the refinery and processing of tall oil. However, no indication of higher concentrations was found outside the industry **(j)** and there is no support for this hypothesis.

The findings that concentrations of DDT and PCB as well as dioxins increase with the proximity to the pulp industry **(e, f, h, i, k),** as well the chipboard industry **(c)** indicate that the treatment of large volumes of material (the timber) exposed to airborne fallout of contaminants (DDT, PCB and dioxins) over large areas might have an impact on the water quality outside the industries. The processing of timber at the chipboard industry is similar to the first steps in the pulp industry. That industrialized areas along contributing rivers of the area have little impact is indicated by low concentrations at location **(d)** located at the mouth of river Dalälven, the major river in the area.

The findings that the dioxin concentrations are highest in the vicinity of the pulp industries (**e, f, h, i** and **k**, however location **f** only slightly) indicate an impact from the pulp production. At all investigated industries producing pulp in the area, the pulp is bleached using chlorine dioxide. However, at industry **(f)** only half of the total production is bleached and the rest is unbleached.

In the table some data from the various industries are presented as well as approximate dioxin concentrations in fish from the industry sites. It should be noted that the water treatment facility at the chipboard industry **(c)** only has a sedimentation pond.

Industry	**Annual amount (tons in 2003) of bleached pulp**	**Dioxin conc. in fish. ppt TEQ fw**	**Amount bleached pulp (tons) / m^3 H_2O x 1000**	**Sludge treatment technique**
E	512 000	0.9	0.013	Activated sludge

				treatment
F	362 000	0.4	0.006	Areated stabilized basin
H	290 000	0.8	0.017	Activated sludge treatment
I	135 000	0.6	0.007	Sedimentation pond
K	329 000	0.3	0.011	Areated stabilized basin

Our preliminary results indicate that the bleaching process using chlorine dioxide as well as the sewage treatment technique used at the pulp mills might influence the degree of dioxin pollution outside the industries. The present results call for further research regarding the milling of large volumes of timber as well as the dredging of the harbour outside industry **(e)**.

The extremely large quantities of effluent water (almost 150 000 000 m^3/year) and the large quantities of timber processed imply certain dimensional problems since the concentration causing the dioxin pollution of the fish is fairly low. This calls for methodological challenges in future measurement campaigns.

References

1. The Swedish Environmental Protection Agency is acknowledged for financial support of the present study.

2 **Olsson M., Asplund L., de Wit C., Bignert A., Haglund P.** 2004. Report and Application for the current study to the Swedish Environmental Protection Agency.

3. **Olsson M., Bignert, A., de Wit C., Haglund P.** 2003. Dioxiner i Östersjöns fisk – ett hot mot svenskt fiske. Miljötillståndet i Egentliga Östersjön Rapport 2003. Stockholms Marina Forskningscentrum s. 3-8.

4. **Bignert, A., Olsson, M., Persson, W., Jensen, S., Zakrisson, S., Litzén, K., Eriksson, U.,Häggberg, L. And Alsberg, T.** 1998. Temporal trends of organochlorines in Northern Europe, 1967-1995. Relation to global fractionation, leakage from sediments and international measures. Environmental Pollution 99:177-198.