INDICATIONS OF RECOVERY FROM PCDD/F-CONTAMINATION OUTSIDE SWEDISH CELLULOSE INDUSTRIES

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Introduction

In the 1980s elevated levels of PCDD/Fs were discovered in sediments and biota from bodies of water receiving effluents from pulp mills in the Baltic Sea. The forest industry responded by eliminating elemental chlorine as a bleaching agent, which led to the virtual elimination of dioxins from the effluents, with concentrations falling below the detection level. Although, the levels of PCDD/Fs in biota from the Baltic have decreased considerably over time[1] there are still problems with high levels in, e.g. fatty fish from the northern Baltic Sea (the Bothnian Sea). Since the concentration of cellulose industries is high in this region, questions have been raised whether this situation can be explained by an unknown discharge of dioxins from this industrial sector or by leakage from historically contaminated sediments that may propagate through the aquatic food-webs[2].

A recent study[3] on levels of dioxins in sediments and biota outside industries of the Bothnian Sea was designed to investigate the role of contaminated sediments as a local source for dioxins in coastal ecosystems. This presentation will focus on comparisons of measured present PCDD/F-levels in sediments and fish with equivalent historical data and give a hypothesis for the present pollution in the Baltic Sea.

Materials and methods

In 2009-2011, non-migratory meagre fish (Perch, *Perca fluviatilis*) and sediments (cores and surface sediments) were collected outside industries and at reference sites (Fig. 1). Fish muscle and sediments were analysed for PCDD/F-content using standard analytical methods (Swedish standard SS-EN-1948)[4]. Levels of 17 PCDD/F congeners with 2378-substitution were determined and summed after adjusting the values by the appropriate toxic equivalency factors (WHO-TEFs[4]) to give 2,3,7,8-TCDD toxicity equivalents (TEQ).

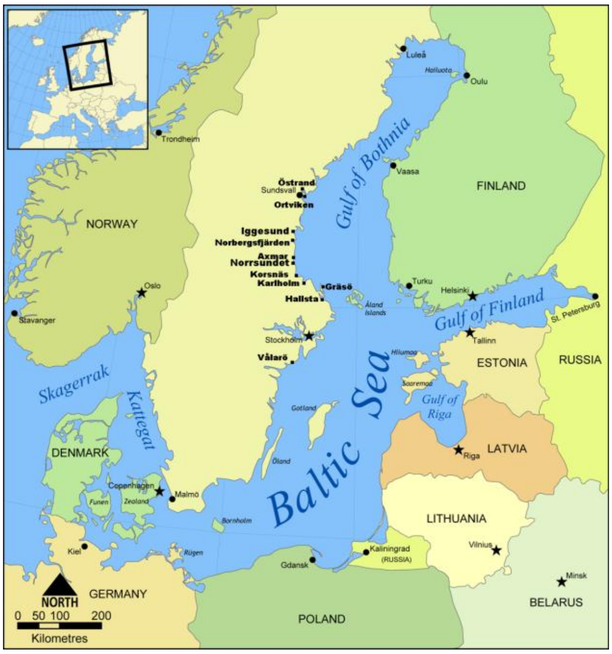


Figure 1. Study sites along the Swedish coast of the Baltic Sea.

Results and discussion
The content of PCDD/Fs at different layers in three sediment cores from areas with a continuous deposition of fine matter (accumulation areas) in three of the studied industrial sites is presented in Figure 2. A clear pattern with increasing PCDD/F levels, as the sediment depth increase, indicates that the deposition of dioxins has been decreasing over time. In the core from the Iggesund area, an estimate of sediment growth was available from sediment dating using radioactive isotopes and lamina counting[5]. The sediment depth 24-26 cm represents the conditions in the mid-1970s.

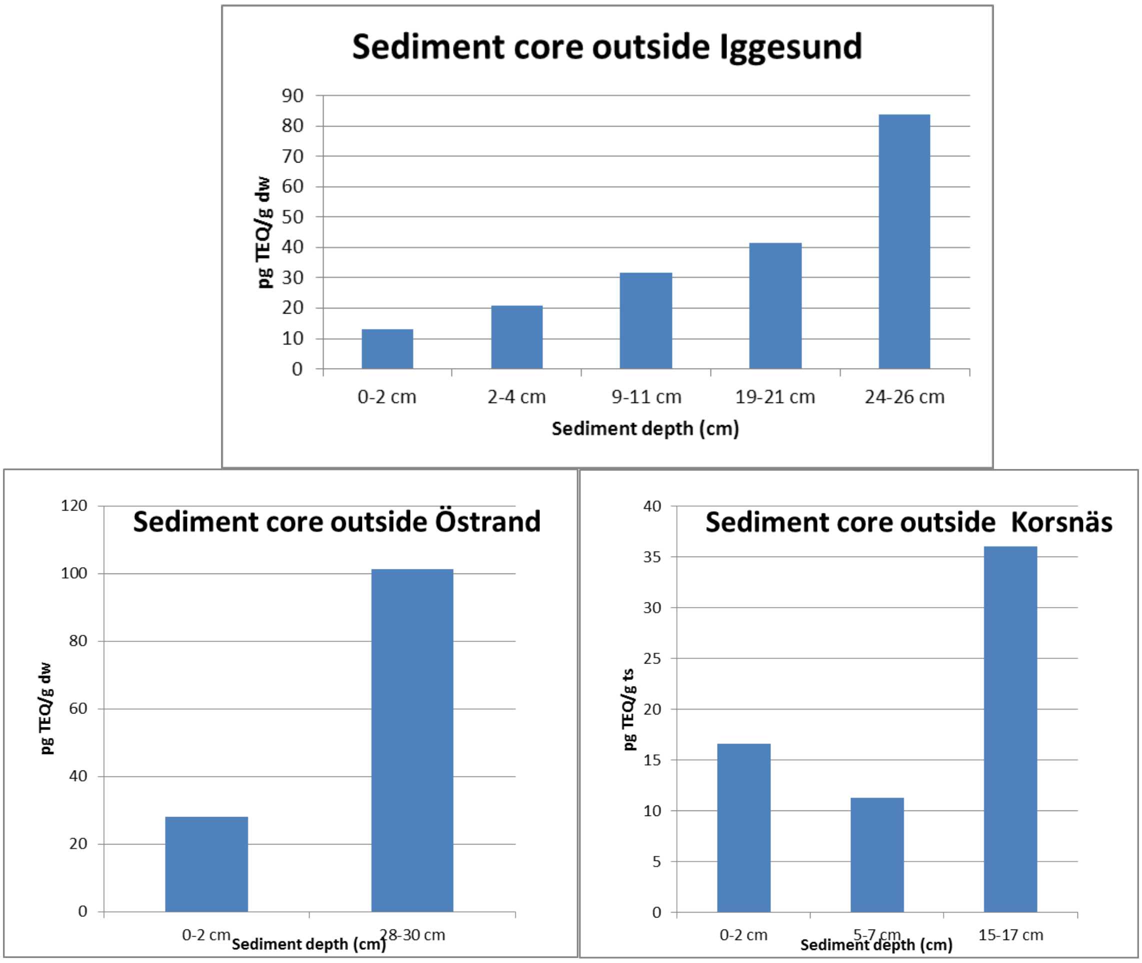


Figure 2. PCDD/F-content (pg TEQ/g dw) at various sediment depths in cores from three investigated industrial sites.

The spatial distribution of PCDD/Fs in surface sediments at various distances from the Iggesund area was studied in the mid 1980s[6]. The gradient study was repeated in 2009 and the results compared with the former (Fig. 3). The PCDD/F-content in the surface sediments has decreased considerably at all sampling stations when comparing the levels recorded in 1986 with present. In 2009, the sediment content of PCDD/F outside the mill from station 407 (4 km distance) and further out had dropped to background levels (< 5 pg TEQ/g dw).

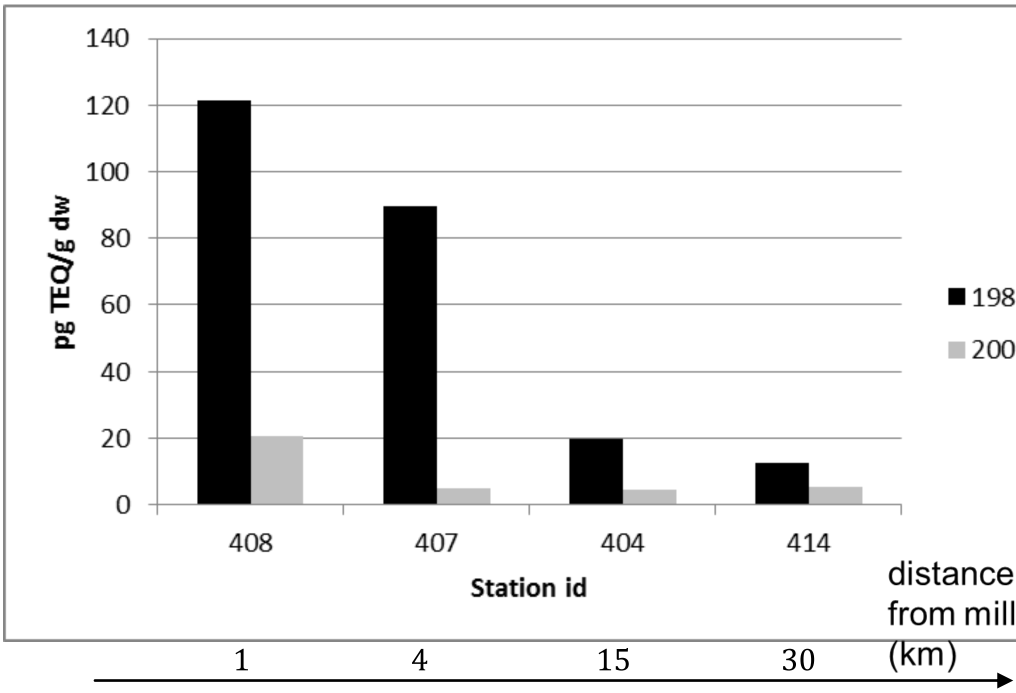
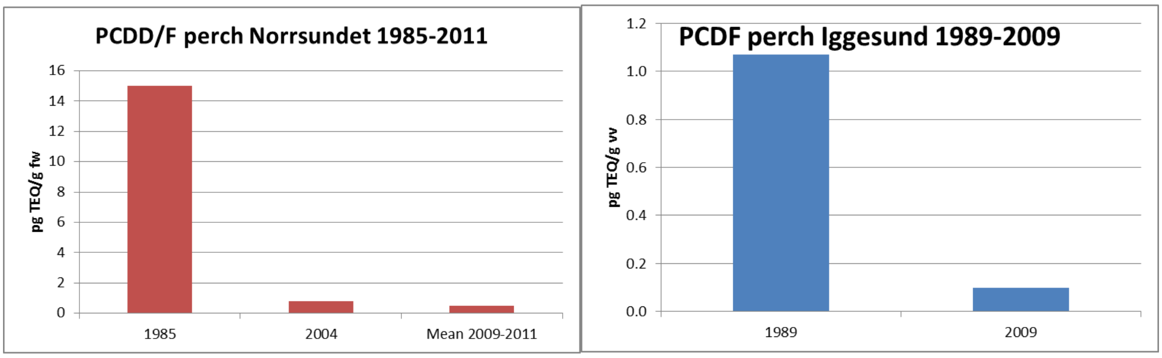


Figure 3. PCDD/F-content in surface sediments (0-2 cm, pg TEQ/g dw) at various distances from the Iggesund Mill. Comparison of levels measured in 1986 (dark[6]) with present study (light).

The recorded levels in fish muscle compared with historical data are presented in Figure 4. A steep decline in PCDD/F-content 3-5 year old fish from Norrsundet is seen when comparing measured levels of 1985[7] with present (Fig. 4a). The level measured in 1985 was extremely high taking into consideration that the sampled fish is relatively meagre compared to, e.g. Baltic herring. A slight but not significant decrease was also noted when comparing the level of 2004[2] (0.8) with the mean of six samples collected between 2009 and 2011 (0.5). However, the PCDD/F-content in fish from the Norrsundet area caught between 2009 and 2011 is still high compared to fish of equal size and age in reference areas (0.05-0.1 pg TEQ/g fw[3]).

From the Iggesund area, we only had historical data[8] on the PCDF-content (seven congeners of polychlorinated dibenzofurans) to compare with. Nevertheless, it was clear that the PCDF-level in fish has decreased between 1989 and 2009 (Fig. 4b) following the trend also observed in the sediments (Fig. 2-3).



a) b)

Figure 4. PCDD/F-content in fish muscle from perch comparing levels from present study with historical data[2,7,8].

The results from this study indicate that the solution to the large-scale problem of elevated PCDD/F-levels in Baltic fatty fish not is to be found in measures against previous or ongoing discharges from the cellulose industry. Elevated, although declining, levels of PCDD/Fs are still found near forest industries but it is unlikely that these amounts significantly contribute to the overall dioxin-contamination of the Baltic Sea. Especially as this problem to a large extent depends on the presence of the specific congener 23478-PeCDF, which did not appear to be elevated in any of our studied matrices (see further Malmaeus et al.[9]). Mitigating the atmospheric deposition of furans created during various combustion processes seems to be the only possible way to reduce the PCDD/F-content of the Baltic Sea ecosystem.

Acknowledgements

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