Distribution of toxic coplanar PCBs and PCDD/PCDFs in pine needles from the Swedish environment - evaluation of data and source identification

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Abstract

Environmental samples from different areas of Sweden indicate a widespread contamination of toxic coplanar PCBs. Uncontrolled combustion is a likely emission source.

Introduction

The pine needle have been shown to be useful as a monitor of atmospheric pollution (1). We have ourselves further developed the analytical techniques, to use the pine needle to measure environmental pollution by different chlorinated aromatics and to identify the sources (2).

Methods

Sampling and analysis of the pine needles was performed according to the previously described method (2). Each sample was analysed for 2,3,7,8-substituted isomers and groups of congeners of PCDD/PCDFs, PCBs according to DIN 51527 and the three toxic coplanar PCB-isomers (with 3,3',4,4'-, 3,3',4,4',5- and 3,3',4,4',5,5'-substitution).

The air dispersion modelling was done with a Gaussian model. The data analysis methods used were principal component analysis (PCA) and multivariate calibration with PLS. These methods and their application to chemistry have been extensively reviewed by others (3).

Results and discussion

37 samples of pine needles, of different age, from four different areas in Sweden were collected and analysed. These four areas represent different sources of environmental pollution, such as: Industrial park, municipal waste landfills (with and without fires) and urban environment. A PCA-model with two significant factors could explain 71% of the variance in the measurement data. Samples from the areas around the industrial park and the landfill with many accidental fires showed distinct influence from local sources. These samples were therefore evaluated as separated groups.

A two-factor PCA-model for the 12 samples of 3-year old pine needles collected inside and around the industrial park could explain 66% of the variance in the analytical data for PCDD/PCDFs and PCBs. The scores plot and loadings plot are shown in figure 1 and 2.

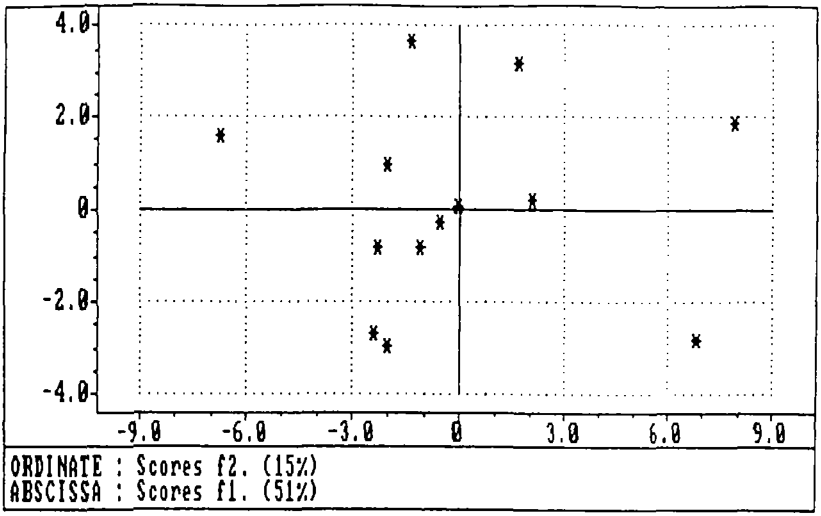

Figure 1
Scores plot, samples around industrial park

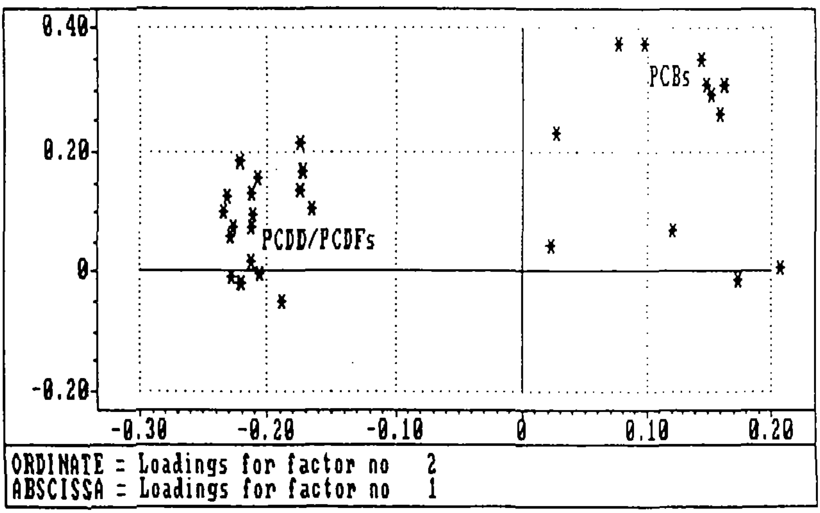

Figure 2
Loadings plot, samples around industrial park.

The pronounced variation between different samples and lack of correlation between PCDD/PCDFs on one hand and PCBs on the other can be interpreted as influence from two local sources. Therefore we have extended our evaluation with an air dispersion model to clarity the influence from one known emission source. The calculated annual average relative concentrations, from stack-emissions, in each sampling spot were compared with the measurement values. Relations between calulated and measured concentrations of PCDD/PCDFs and PCBs were evaluated by multivariate calibration with PLS. A weak correlation was found between stack-emissions and PCDD/PCDFs. The increased levels of PCBs showed no positive correlation with the calculated annual average concentrations, and can not be linked with continous stack-emissions.

Emissions of technical products are not a likely cause to the increased levels of PCBs around this industrial park. In these pine needle-samples PCBs according to DIN did not dominate in amount over the coplanar PCBs, with the same degree of chlorination, as would be expected for technical products. In the three samples with the highest concentrations, 3,3',4,4'-tetraCB was found at 640, 800 and 1500 pg/g (dry weight) compared to concentrations at or below 100-200 pg/g for 2,2',5,5,-tetraCB. Another possible local source was identified in a nearby sited landfill and it has been revealed that fires have taken place there during the growth period of the pine needles. We consider fires in this landfill as the most likely cause for the measured PCB contamination, since it has been shown that these fires emit significant amounts of both coplanar PCBs and PCDD/PCDFs (4).

Samples from another area, around a municipal waste landfill, showed increased levels of both PCDD/PCDFs and coplanar PCBs in samples from the most exposed spot. This landfill has experienced several fires during the last years. Figure 3 show the change in concentration of one coplanar PCB in pine needles of different age from two spots around this landfill.

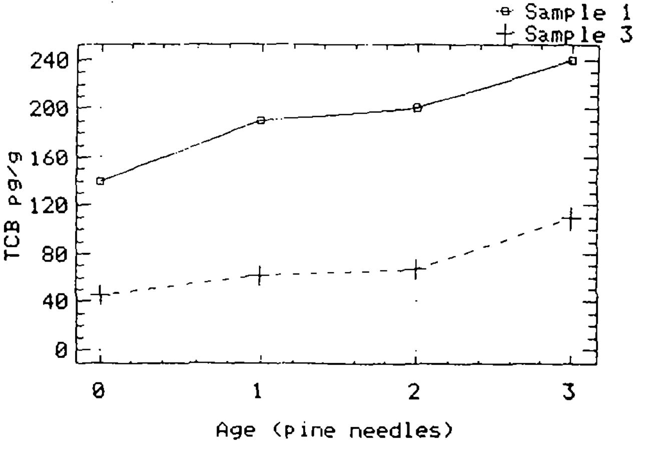

Figure 3
Concentration of 3,3',4,4'-tetraCB in pine needles of different age around waste landfill, pg/g (dry weight).

The variations for this PCB-isomer correlate well in the two sampling spots although the concentration differs. Obviously more than one fire in the landfill has caused the increased concentrations. This type of contamination was not seen around a comparable landfill without any fires in recent years.

We find the environmental pollution by coplanar PCBs especially intriguing. We have therefore compared the concentrations of two PCBs according to DIN (nos 52 and 101 or 2,2',5,5'-tetraCB and 2,2',4,5,5'-pentaCB) and two coplanar PCBs (nos 77 and 126 or 3,3',4,4'-tetraCB and 3,3',4,4',5-pentaCB) in pine needles from spots with a general background exposure and those with an increased local exposure, table 1.

Table 1
PCBs in 2-year pine needles, pg/g (dry weight).

Sample	PCB-52	PCB-77 Coplanar	PCB-101	PCB-126 Coplanar
General exposure:				
A	350	67	16	4.7
B	720	89	25	6.6
C	370	57	23	7.3
D	250	51	29	6.5
Local sources:				
E	350	200	21	15
F	<200	160	24	16
G	<200	150	30	16
H	210	140	20	14

From this table it is clear that concentrations of PCB-isomers dominating in technical products are relatively constant in all samples. In contrast, toxic coplanar PCBs increase strikingly in samples with influence from local sources.

Conclusions

The measurement data summarized in this paper show that:

- Analyses of pine needles can trace local sources to air-borne emissions of PCBs and PCDD/PCDFs.

- Fires in waste landfills cause increased levels of PCBs and PCDD/PCDFs in the surroundings that can be followed for several years.

- Uncontrolled combustion, e.g. fires, is a likely emission source of significance for coplanar PCBs.

References

1. ERIKSSON, G; JENSEN, S; KYLIN, H; STRACHAN, W
Nature 341, 42-44 (1989)

2. WARMAN, K
Chemosphere in press

3. MARTENS, H
NR-report no.: 786
Norwegian Computing Center 1986

4. ÖHRSTRÖM, T
Technical report MKS-89/96
Miljökonsulterna i Studsvik AB 1989