SELECTION OF SPECIFIC POLYCHLORINATED BIPHENYL CONGENERS: ANALYTICAL AND TOXICOLOGICAL ASPECTS

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ABSTRACT

Up to now, PCB are analytically and toxicologically characterized by a few selected congeners. In this study we report preliminary results in developing selection criteria for PCB congeners based on analyses of indoor air, food and human blood. Parallel with these analyses toxicological data are reviewed for criteria exhibited by the different PCB subgroups.

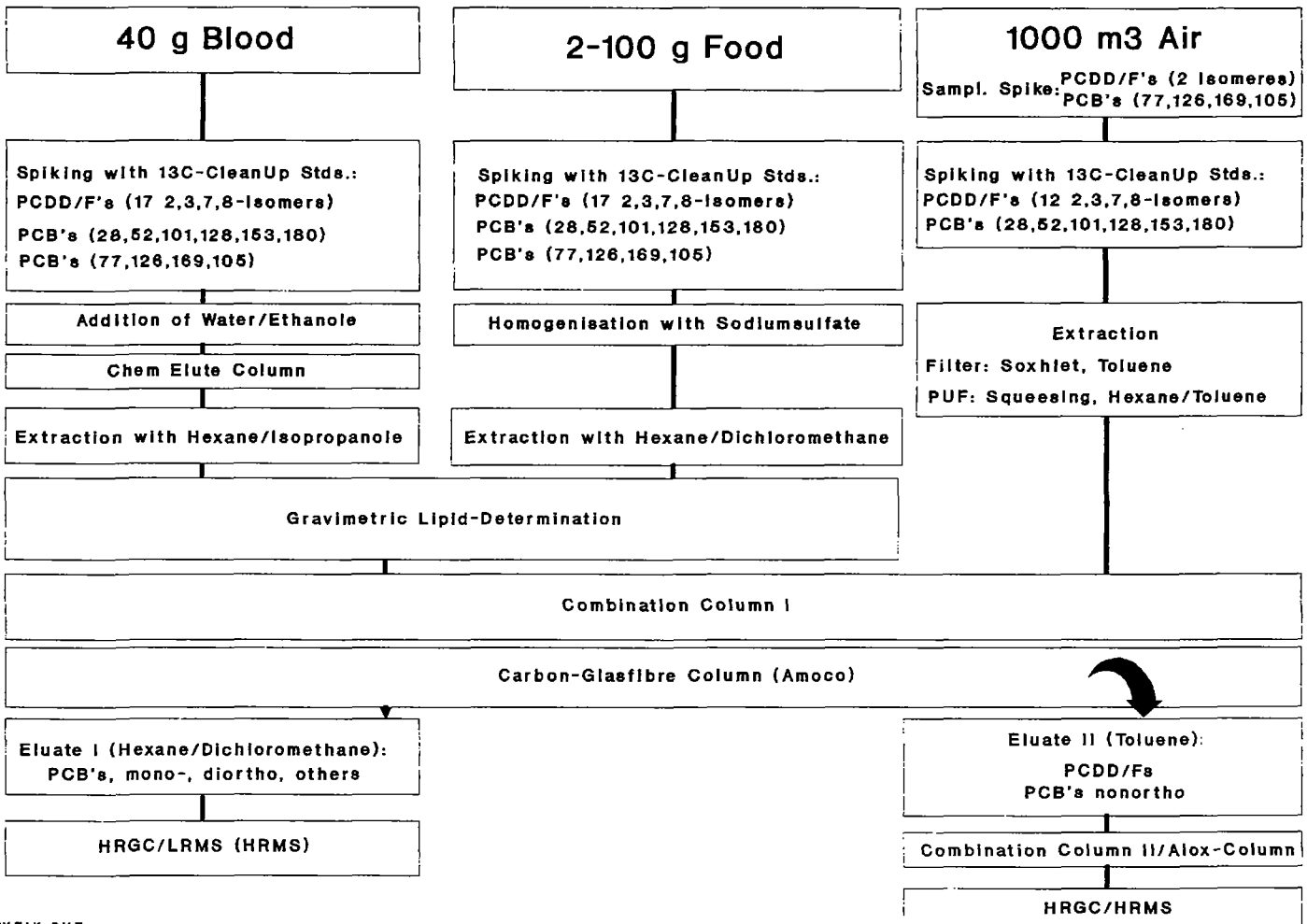
OBJECTIVES

Polychlorinated biphenyls (PCB) represent a mixture of various congeners showing a wide range and diversity of toxicity. During recent years, sensitive and effective sample clean-up and fractionation procedures for the isolation of individual PCB congeners have been developed[2,3,4]. Parallel with this progress, an emerging number of data on the toxicity of congeners of several PCB subclasses are available. According to the present data-base, especially the non-ortho and the mono-ortho substituted PCB are likely to exhibit the same order of magnitude of toxicity like the polychlorinated dibenzodioxins and dibenzofurans[1].

Currently, PCB mixtures are usually characterized by quantifying six selected congeners (IUPAC numbers 28, 52, 101, 138, 153, 180). Since the actual profiles of commercial PCB products are most often known not to be found in biological samples, it is generally accepted that the PCB concentration of a sample should preferably be determined by quantifying the individual congeners. Up to now, no consensus is reached on which congeners should be analysed routinely[1,3].

In order to establish analytical selection criteria, sample of indoor air, food and human blood were analyzed for their actual PCB profile. Furthermore, in a first attempt to review background data for a toxicological evaluation of individual PCB, 1. the congeners detected in the selected matrices were compiled to groups depending on the substitution in the ortho position and 2. the literature was searched for criteria exhibited by the different groups.

ANALYTICAL PROCEDURE FOR PCDD/F's AND PCB's



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Moreover, a single biological effect was chosen to demonstrate the animals' response to individual PCB.

MATERIAL AND METHODS

The analytical procedures for blood, food and air samples are shown as flow chart in Fig. 1.

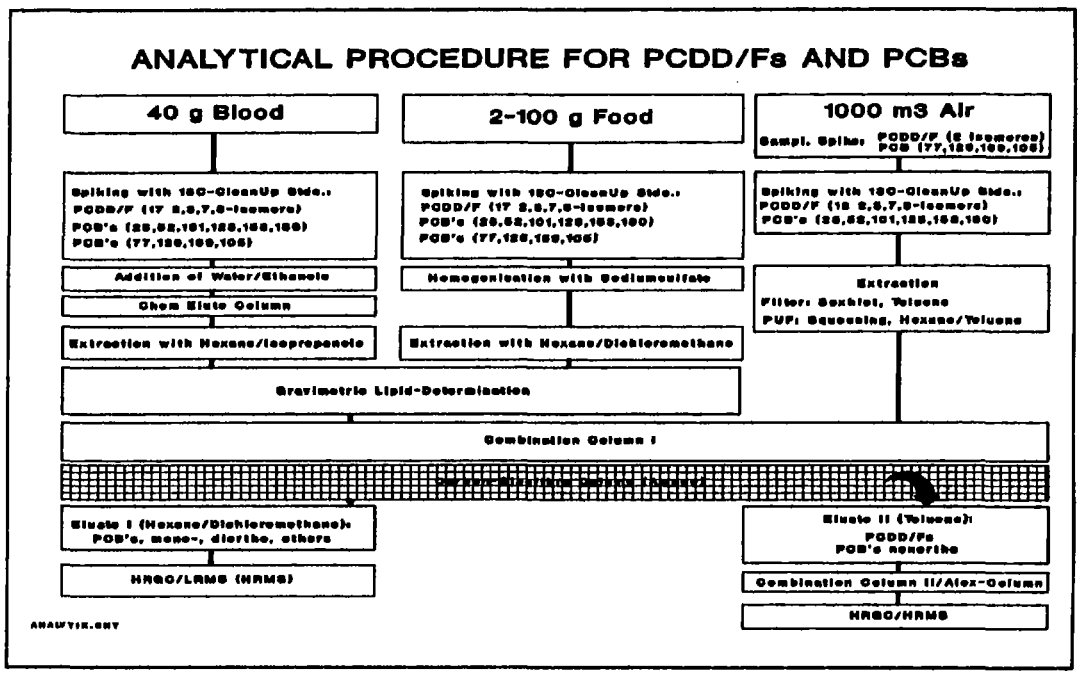


Figure 1: Analytical procedure for PCDD/PCDFs and PCBs in blood, food and air

The analytical method used for blood samples was nearly identical to that used for the successful participation in recent WHO interlaboratory validation studies on human blood[8,9,10] and will not be described here. Food samples were extracted with hexane/dichloromethane after homogenisation with sodium sulfate. Blood and food samples were spiked with ^{13}C labeled PCB and PCDD/PCDF congeners as shown in Figure 1 before extraction.

Airborne PCB were sampled on a combination of glassfibre filter and polyurethane foam (PUF)[5]. The upper PUF plug had been spiked with ^{13}C labeled PCB and PCDD/PCDF congeners before sampling. A total of 1000 m^3 of air was sampled over a period of 3 days.

The extracts of blood, food and air samples were subjected to a multicolumn system clean-up. Carbon/glass fibre chromatography was employed to separate the coplanar from the ortho-substituted PCB[7]. Analysis of non-ortho PCBs was performed by HRGC/HRMS (VG Autospec) using a 60 m column (DB5).

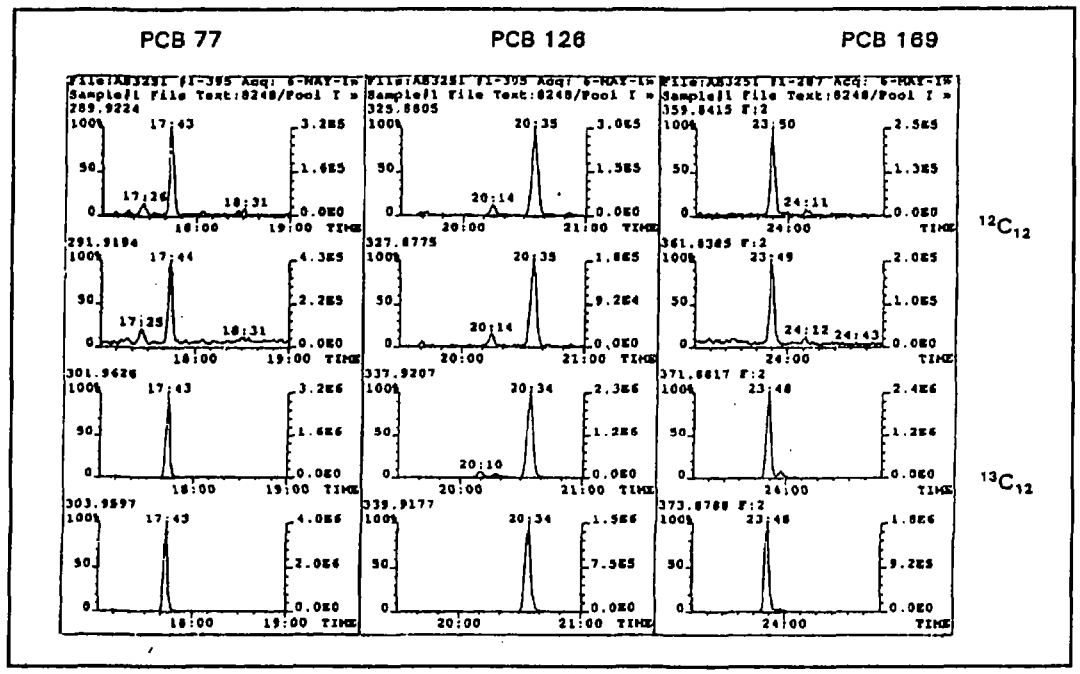


Figure 2: HRGC/HRMS traces of coplanar PCBs in blood

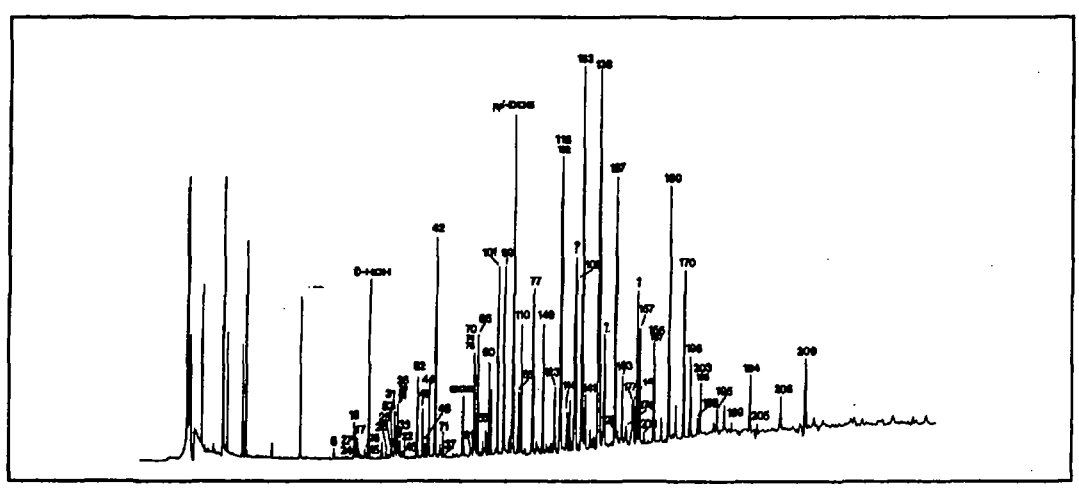


Figure 3: HRGG/ECD analysis of a lipidextract from the liver of dab (Limanda limanda (L.)) cought in the North Sea. ε-HCH was used as internal standard.

RESULTS

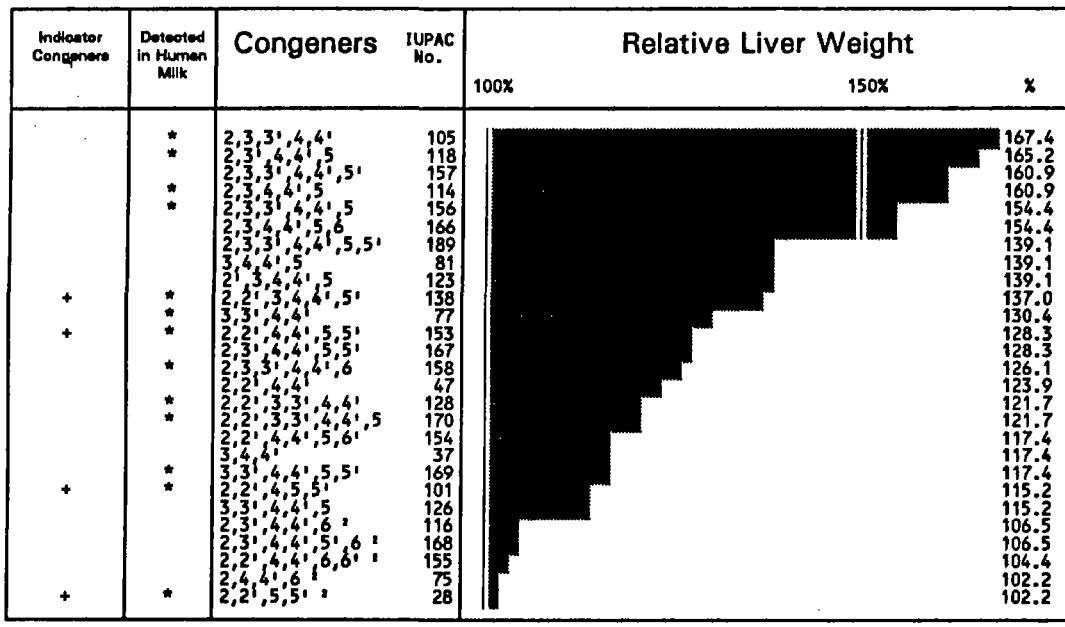
HRGC/HRMS traces for the coplanar PCBs 77, 126, 169 are shown in Figure 2 (blood sample). Low contamination of different sources cause difficulties in ultra trace analyses of PCB 77 at this time. Due to this minor blank contamination of PCB 77 the samples are going to be reanalysed with regard to this special problem. Detailed analytical data for blood, food and air will be presented in the final paper.

Figure 3 presents different PCB-congeners in fish (HRGC/ECD).

A short review on toxicological data of PCB congeners categorized in subgroups by ortho substitution is given in Table 1. Hepatotoxicity seems to be the most studied effect (Tab. 1).

Groups of PCB congeners characterized by ortho substitution	Shown to exibit the property of
non-ortho	hepatotoxicity (rat) promoting activity (rat) teratogenicity (mouse) embryotoxicity (chick embryo) dermal toxicity (rat) immunotoxicity (rat) genotoxicity (human lymphocytes) reproductive toxicity (rat)
mono-ortho	embryotoxicity (chick embryo) teratogenicity (mouse) immunotoxicity (chick embryo)
di-ortho	hepatotoxicity (chick) neurotoxicity (in vitro) promoting activity (rat) immunotoxicity (rat) genotoxicity (rat, mouse, human lymphocytes)
tri-ortho	hepatotoxicity (rat)
tetra-ortho	hepatotoxicity (chick) immunotoxicity (chick)

Table 1: Compilation of literature data on toxic effects of individual congeners of the above 5 groups



[1] 4 of the 6 indicator congeners for the quantitative residue analysis of food of animal origin (Recommended by the German Federal Health Office/Berlin). The other 2 congeners 52 and 180 are not shown.
[2] No significant difference between treated and control animals.

Figure 4: Detection of PCB congeners in human milk and the influence of several congeners on the liver growth in the experimental animals as an example of their biological effects. It shows an increase in relative liver weight of 3 week old male Long Evans rats within 4 days after a single i.p. dose of 500 μmol/kg of individual PCB (Parkinson et al., 1983).

DISCUSSION

From an analytical point of view, most of the PCB congeners can be expected to be identified and quantified in the near future, which leads to the question for their toxicological relevance. In a strict sense, therefore, data are necessary on the toxicokinetics, biotransformation and biochemical reactions underlying the organotoxicity, genotoxicity and cancerogenic potential as far as reports are available. In most of the reports viewed the PCB were tested in short term experiments (see for example Table 1 and Fig. 4). To enable the estimation of tolerable doses, however, long term experiments on animals are indispensable. Endpoints in these studies are listed in Table 1. As far as the initiating and promoting activity of individual congeners is concerned, detailed mechanistic studies may limit the extent of experiments. Because of the simultaneous occurrence of congeners (and other xenobiotics), interactions between individual PCB should be aimed at.

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