Multivariate data analysis of PCDD/PCDF patterns in human blood samples from workers in a magnesium production plant and a control group.

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Abstract

Blood samples from ten workers and a control group consisting of ten persons with no direct contact with the production of magnesium were studied. Isomer specific analyses of PCDD/PCDFs by means of HRGC/HRMS techniques were performed. Multivariate data analysis was used to study congener patterns of polychlorinated dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs) present in the samples and significant differences between the workers and the control group were found.

Introduction

Humans are continuously being exposed to PCDDs/PCDFs through the intake of food such as fish, meat and dairy products. In a recently published study it was shown that the blood plasma levels of several congeners of PCDDs/PCDFs were higher in men with a high intake of fish from the Baltic Sea than in men who consumed less or no fish[1]. Although ingestion is considered to be the most important exposure route for humans, inhalation and dermal contact may also represent significant routes in occupational environments where PCDDs/PCDFs are generated as unwanted contaminants.

Significant amounts of PCDDs/PCDFs are formed as undesired by-products in various high-temperature processes, including the production of metallic magnesium and have been detected in effluents and exhausts, as well as in fish and sediment samples collected in the vicinity of a magnesium plant[2].

Method

Subjects

Ten male workers, employed at the magnesium production plant between 10 and 36 years, and a control group, consisting of ten male persons with no direct contact with the production but living in the same area, were studied. The exact route of exposure is not known, but blood samples provide an index of past cumulative exposure to this kind of substances due to their stability and lipid solubility.

Analytical method

The analytical method for determining trace levels of PCDDs/PCDFs involves extraction with organic solvents and clean-up with various absorbents according to Nygren et.al.[3] The extracts were analysed by HRGC/HRMS techniques using a 60 m DB5 column and a VG-250S high resolution MS operating in the EI mode. This analytical method has recently been evaluated in a quality-control study organised by WHO[4] and our laboratory was regarded as qualified for this type of analysis.

Multivariate data analysis

Principal Component Analysis (PCA)[5] is a projection method where the included variables are combined into a few underlying descriptive dimensions, which makes it possible to study the systematic variation present in the data matrix. PCA results in an overview of the dominating patterns and major trends in the data. Interpretation of object (sample) grouping and variable correlation is made on score- (object) and loading- (variable) plots respectively.

Results

The results of the PCA using both the PCDDs and the PCDFs concentrations as variables clearly separated the control and the exposed individuals into two separate groups. All variables used in the PCA were log transformed. Two principal components were significant and together they explained 79 % of the variance in the data set. The loading plot revealed that all congeners were active to some extent, except HpCDD and OCDD that did not contribute to explaining any of the variation in the data set. PCDF congeners contributes most strongly to the separation of the two groups and to get a better picture of how the difference of PCDD and PCDF congener patterns influences the separation of the control and the exposed groups two separate PCA were performed. One using the levels of PCDFs as variables (fig 1.) and the other the PCDDs. The PCA using PCDF concentrations gives almost the same picture as the analysis involving all the variables, whereas the PCDD concentrations did not separate the two groups.

In addition to containing the common 2378-chlorine substituted congeners of PCDDs/PCDFs, 1234689-HpCDF was detected in the blood-serum from seven of the exposed men. Congeners that are not 2378-chlorine substituted are very rarely found in human samples.

The results of this study show that there is a significant difference between the congener pattern of PCDFs in blood samples from men working in the magnesium plant and the control group. It is also noteworthy that the congener pattern of this local control group differs from that of a regional control group from southern Sweden[1], with a normal fish consumption, mainly due to differences in the PCDF congener pattern.
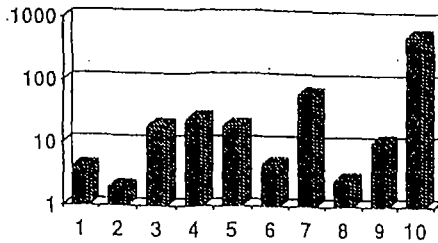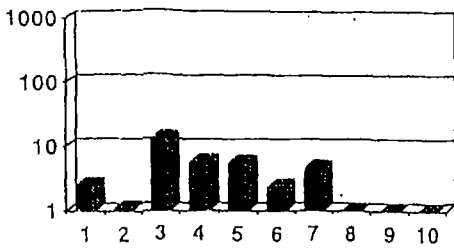
By determining the concentrations of PCDD/PCDF congeners and comparing patterns using multivariate data analysis it is possible to establish occupational exposure to these compounds.
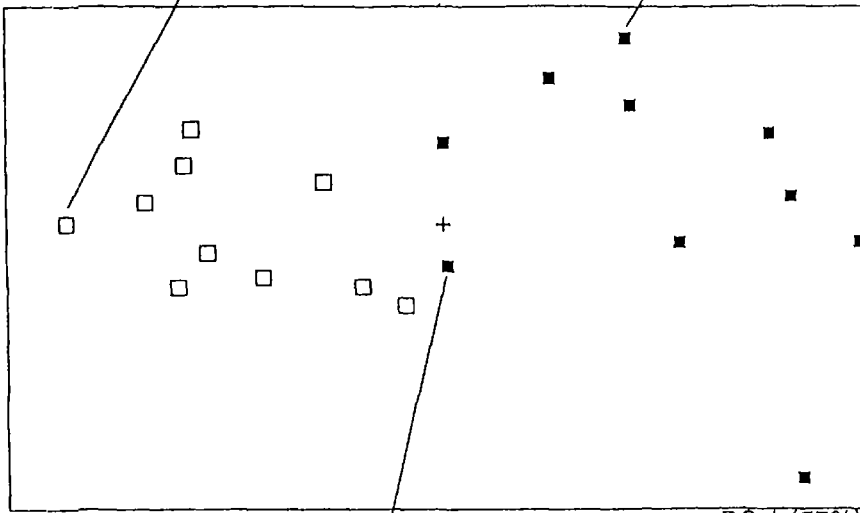
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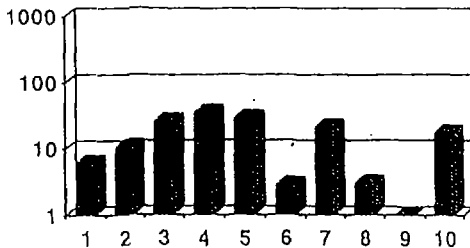
1. 2378 - TCDF
2. 12378 - PeCDF
3. 23478 - PeCDF
4. 123478 - HxCDF
5. 123678 - HxCDF
6. 234678 - HxCDF
7. 1234678 - HpCDF
8. 1234789 - HpCDF
9. 1234689 - HpCDF
10. OCDF

Score plot of all samples, showing PC1 vs PC2, calculated on PCDFs only. Open symbols represent the control group, filled symbols the exposed group. Numbers in the bar graphs refer to specific congeners of PCDFs of three individual samples (see table above)