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SOIL CONTAMINATION WITH PCDD/Fs AS A FUNCTION OF DIFFERENT TYPES OF LANDUSE IN A SEMI-RURAL REGION IN NORTHERN ITALY

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Introduction

Atmospheric deposition is the main factor for the vast majority of PCDD/Fs entering soils. Humans are exposed to PCDD/Fs in soils through agricultural products and subsequently, these compounds are incorporated in the human body[1-3]. Soils have a great capacity to act as reservoirs for organic pollutants such as PCDD/Fs, therefore assessment of pollutants in soil provide information on regional environmental quality.

There are only few studies that describe PCDD/Fs soil concentrations in Italy and they are mainly concerned on PCDD/Fs soil levels of contaminated sites near Seveso[4] or in the vicinity of solid waste incineration plants[5,6]. The objective of the present study is to assess the PCDD/Fs contamination in soils of the semi-rural Province of Pavia, located in Northern Italy (fig. 1). The sampling sites include rural (agriculture) and light-industrialized areas, to cover the whole extension of the Province of Pavia in relation to their actual land use.

Sampling

Pavia province was divided into 7 clusters for sampling (fig. 1), using the Land Use Cover Area from Statistical Survey (LUCAS EUROSTAT) network. Sampling method is reported elsewhere[7].Top soil pooled samples (from 0-30 cm) were collected from 41 rural and 19 industrial areas. Bottom soil pooled samples (from 70-100 cm) were simultaneously taken to assess background levels of the 7 mentioned clusters.

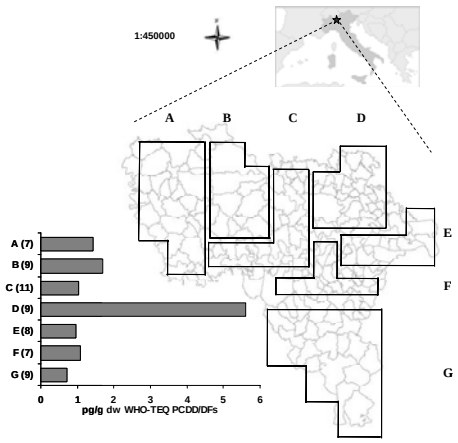

Figure 1: Soil sample clusters in the Province of Pavia and total PCDD/Fs concentrations in soil for the different clusters (pg / g dw WHO-TEQ). Between brackets, number of samples for each cluster.

Results and Discussion

OCDD/Fs dominated the 2,3,7,8 chlorine substituted congener pattern of all the soil samples (up to 80 % of the total concentration of 2,3,7,8 chlorine substituted PCDD/Fs), followed by the 1,2,3,4,6,7,8 hepta congener (fig. 2). In general, dioxin contribution was higher than furan contribution to the overall concentration. This profile has been described previously as results of long-range atmospheric transport[8]. Similar pattern was found in air, precipitation, settling matter and sediments at Lake Maggiore[9,10], about 200km North of Pavia.

Profiles of the congener fraction of total PCDD/Fs in soil can be used to identify the existence of different pollutant sources between sites. 2,3,7,8 chlorine-substituted PCDD/F congener patterns in soil do not differ among North (clusters A, B, C and D) and South (cluster G). In terms of land use, rural and industrial areas present similar 2,3,7,8 chlorine-substituted PCDD/F congener profile in soil, dominated in all cases by the high chlorinated congeners. Probable the pattern is a result of mixing diffuse regional sources followed by long range transport and relative atmospheric deposition[11]. These results implicate that all clusters have PCDD/F input from similar sources and no significant emission source is present in that zone.

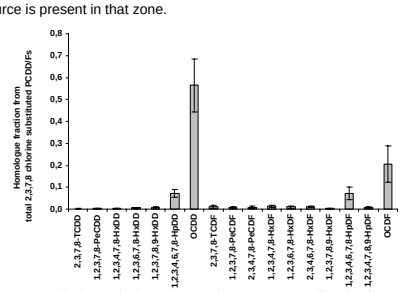

Figure 2: 2,3,7,8 chlorine-substituted PCDD/F congener profile of soil samples from Pavia Province.

Generally, the range from tetra- to octachlorinated 2,3,7,8 chlorine-substituted PCDD/Fs were detected in all the samples. Total concentrations of 2,3,7,8 chlorine-substituted PCDD/Fs in top soil samples from the Province of Pavia ranged from 0.48 to 11 pg/g dw I-TEQ (0.52-11 pg/g dw WHO-TEQ). The highest value corresponds to a site located at the North-East of the Province, up to 2 km South of one of the Milan´s airports. The clusters in the Northern part of the Province (clusters A, B, C and D) showed significantly higher mean levels ($p<0.001$) than the ones in the Southern part (cluster G). Arithmetic mean values for the Northern and Southern clusters were 1.6 and 0.62 pg/g dw I-TEQ, respectively (1.6 and 0.67 pg/g dw WHO-TEQ, respectively).

Top soil levels were significantly higher than bottom soil concentrations ($p<0.0005$). Total concentrations of PCDD/Fs in bottom soil samples from the Province of Pavia (Italy) ranged from 0.086 to 0.3 pg/g dw I-TEQ (0.088-0.41 pg/g dw WHO-TEQ). In most of the cases the bottom soil concentration levels are at around 8-30% of the top soil levels. No North/South differentiation is visible in the bottom soils.

There was a significant positive correlation between log TOC (Total Organic Carbon in soil sample) and log WHO-TEQ concentration of PCDD/Fs for the entire dataset of top soil values ($r2=0.56$, $p<0.0005$) (fig. 3). TOC and concentrations were log-transformed as a result of the Kolmogorow-Smirnov test. Bottom soil samples show a similar trend, although there is only small number of samples to prove its significance. Normalizing PCDD/Fs concentrations with total organic carbon did not change the differences between Northern and Southern top soils.

No significant differences of PCDD/Fs soil concentrations were found between areas with rural characteristics and light-industrialized sites (arithmetic means were 1.2 and 1.2 pg/g dw I-TEQ, respectively), indicating that these values represent the baseline pollution due to atmospheric deposition independently of land use. The obtained values are in the upper range of soil concentrations reported for agricultural soils[12-15] and in the lower range of urban/industrialized soil concentrations reported in the literature from other countries[16-19].

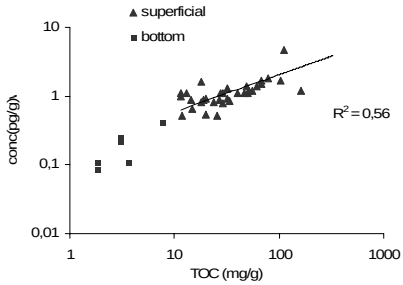

Figure 3: TOC (mg/g) vs. total PCDD/F concentrations (pg/g dw WHO-TEQ) in top and bottom soils.

At the present, in Europe there is no Directive that establishes PCDD/Fs concentrations in soil in order to regulate the possible uses of a soil. Italian law[20] on acceptable limit concentrations of PCDD/Fs in soil establishes a limit value of 10 pg/g dw TEQ for agriculture and residential use and of 100 pg/g dw TEQ for industrial uses. However, German guidelines for land use[21] recommend a more restricted limit of 5 pg/g dw I-TEQ for an unrestricted agricultural use. Only the soil concentration obtained for the North East of the Province exceeded the agriculture limits of both regulations, although it was not higher than the German guideline value of 40 pg/g dw I-TEQ for agriculture use without pasture.

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