POLYCHLORINATED DIBENZODIOXINS, DIBENZOFURANS, AND BIPHENYLS IN THE SOIL OF AN AREA NEIGHBORING A CONTAMINATED INDUSTRIAL SITE

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For approximately a century, the ACNA C.O. chemical plant at Cengio (Savona, northern Italy) utilized its own land to dispose of the chemical wastes it produced by dumping and burying them in the soil. Even the bed of the nearby Bormida River was moved aside to make more disposal area available. The river borders the site for ≈2.5 km, and to a large extent surrounds the area with higher contamination levels while the less contaminated northeastern side (≈1.2 km) is exposed. A few years ago, underground hydraulic barriers were set up between the site and the external environment to block the underground flux of contaminated fluids to the river.[1-3]

Because of the environmental hazard, a pilot study was financed in 1990 by the Ministry of the Environment to investigate polychlorinated dibenzodioxin (PCDD), dibenzofuran (PCDF), and biphenyl (PCB) contamination of the site soil, with the aim of providing a preliminary approximation of areas with different risk levels. Before beginning the study, the areas inside and outside the hydraulic barriers were divided into zones ranked according to different priorities of intervention. Maximum priority (Priority 01) was assigned to a stretch of land—between 50- and 100-m wide—alongside the outside of the hydraulic barriers, and incorporating the river bed for over 2.9 km.[2,3] In this report, the final outcomes are summarized from the assay of soil and sediment samples of this zone.

Several soil samples were available from previous sampling campaigns carried out in the periods of August-September of 1988 and 1989. Samples were collected by continuous coring (N = 14) from the surface level down to the upper horizon of the underlying low-permeability marl bed, and by dredging (N = 15) where the layer of soil was thinner. Additional topsoil (N = 9) and fluvial sediment (N = 8) samples were collected by

trowelling in June 1991. On the whole, samples were obtained from 22 sampling sites spread almost evenly along Priority 01 zone, and—in most cases—from more than one soil layer.[4]

For analyte quantitation, the 46 sample matrices available were subjected to a procedure previously described[1,2,4] entailing PCDD and PCDF congener- and PCB homolog-specific determinations, and then appropriate conversion to sample-specific cumulative data. The latter were statistically analyzed (outcomes summarized in Tables 1–3).

The mean cumulative PCDD and PCDF level, 1.65 ngTE/kg (Table 1; TE conversion by the US EPA TEF system of 1987[5,6]), is well below the conservative maximum tolerable limit (MTL) of

Table 1. Cumulative PCDD and PCDF data indicators for Priority 01 zone (N = 46) and general environment area (N = 8) sets. TCDD equivalents (Columns 3 and 5) by the US EPA TEF system.[5]

INDICATOR	LOGDATA	ngTE/kg	LOGDATA	ngTE/kg
N	46		8	
x_{max}	4.541	93.8	0.6098	1.84
x_{min}	-2.429	0.0881	-2.096	0.123
$\langle x \rangle$	0.5027	1.65	-0.8118	0.444
σ	1.654		0.8441	
95%UCL	0.9858	2.68	-0.1863	0.830
95%LCL	0.01980	1.02	-1.435	0.238
95th Percentile	3.223	25.1	0.5766	1.78
99th Percentile	4.357	78.0	1.154	3.17

Table 2. Cumulative PCDD and PCDF data indicators for Priority 01 zone (N = 46) and general environment area (N = 8) sets. TCDD equivalents (Columns 3 and 5) by the I-TEF system.[7]

INDICATOR	LOGDATA	ngTE/kg	LOGDATA	ngTE/kg
N	46		8	
x_{max}	4.868	130	1.461	4.31
x_{min}	-2.146	0.117	-1.094	0.335
$\langle x \rangle$	0.9002	2.46	0.1804	1.20
σ	1.630		0.7911	
95%UCL	1.374	3.95	0.7655	2.15
95%LCL	0.4187	1.52	-0.4050	0.667
95th Percentile	3.581	35.9	1.482	4.40
99th Percentile	4.700	110	2.024	7.57

Table 3. Cumulative PCB data indicators for Priority 01 zone (N = 46) and general environment area (N = 8) sets.

INDICATOR	LOGDATA	ng/kg	LOGDATA	ng/kg
N	46		8	
x_{max}	12.85	379,000	9.705	16,400
x_{min}	5.521	250	6.751	855
$\langle x \rangle$	9.043	8,460	8.172	3,540
σ	1.550		0.9647	
95%UCL	9.496	13,300	8.887	7,240
95%LCL	8.590	5,380	7.456	1,730
95th Percentile	11.59	108,000	9.758	17,300
99th Percentile	12.65	313,000	10.41	33,500

10 ngTE/kg for farming soil;[1,2,4,6] the same may be said for the 95%UCL value of 2.68 ngTE/kg. Even when findings are converted to TCDD equivalents by the more conservative I-TEF system,[7] the mean and its 95%UCL (2.46 and 3.95 ngTE/kg, respectively; Table 2) are still well within the aforementioned MTL.[4] The Priority 01 data sets have also been compared to the sets of measurements obtained from topsoil samples (P0 type; N = 8; Tables 1 and 2) from areas of the general environment not neighboring the plant site and with low anthropogenicity: despite the remarkable difference in the latter, the data sets—when statistically analyzed by TE-congruent pairs—exhibit a moderate degree of comparability which goes along fairly with what is stated above.[4]

Priority 01 cumulative PCB data appear to be spread over a wide concentration range (250–379,000 ng/kg; Table 3). However, the estimated contamination mean and its 95%UCL (8,460 and 13,300 ng/kg, respectively) are in agreement with PCB levels detected in domestic and foreign soils from the general environment or from farms.[4,8-10] As for PCDDs and PCDFs, the Priority 01 PCB data set has also been statistically compared to the parallel set of PCB measurements obtained from P0-type topsoil samples (N = 8; Table 3): in this case, despite the remarkable difference in area anthropogenicity, the two sets of data exhibit a good degree of comparability which supports the above observations very well.[4]

In light of the above and in terms of risk management, the zone investigated cannot be substantially differentiated from areas with low anthropogenicity. Therefore, no remedial actions appear to be necessary and there is no particular hazard for the neighboring human communities.[4]

Indeed, Priority 01 zone appears to be characterized by cumulative PCDD, PCDF, and PCB levels which, on average, are somewhat higher than the corresponding levels estimated for the general environment. However, these differences—much more evident when the upper extreme values are compared—cannot be detected, when statistically analyzed at a high significance level, due to the very widely spread values of the Priority 01 data sets. At any rate, it may be assumed that over the next few years the higher PCDD, PCDF, and PCB levels detected in a few soil layers will decrease by natural dissipation, thereby determining further decrease of the already low mean levels of these compounds in the zone.

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