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BIOMONITORING OF THE GENERAL POPULATION LIVING NEAR THE WASTE INCINERATOR OF TURIN: BASELINE LEVELS OF PCDDS, PCDFS, AND PCBs

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Introduction

In recent years incineration has become the most widely used treatment for waste management. Until a few years ago, waste incinerators were considered significant sources of environmental pollutants including polychlorinated dibenzodioxins (PCDDs), dibenzofurans (PCDFs), and polychlorobiphenyls (PCBs). Although the adoption of emission-abating technologies has resulted in a less likely occurrence of measurable health effects on population living near new generation incinerators [1], the potential health effects of exposure to emissions from waste incinerators are still of great concern to the population living around the plants.

In September 2013 a waste-to-energy (WTE) incinerator located in Turin area (Piedmont, Northern Italy) started to produce energy by the incineration of municipal solid wastes (421,000 tons per year burned). In order to evaluate the potential health effects on the population living near the plant, a health surveillance program (SPoTT) was implemented by the province of Turin [2]. This program included a biomonitoring study, carried out by Italian National Institute for Health in collaboration with two local health units (ASL TO3 and ASL TO1), aimed at assessing levels of metals, hydroxyl-polycyclic aromatic hydrocarbons (OH-PAHs), PCDDs, PCDFs, and PCBs on a cohort of subjects before the plant start-up and after some years of operation. The cohort was made by 400 individuals. Concentrations of metals and OH-PAHs were determined on the entire cohort while, according to the study design, levels of PCDDs, PCDFs, dioxin-like PCBs (DL-PCBs), and non-dioxin-like PCBs (NDL-PCB) were determined in a subgroup of 100 individuals.

The present paper describes the concentrations of PCDDs, PCDFs, and PCBs assessed in blood samples collected before the start-up of the WTE incinerator (“baseline” values of the biomonitoring study).

Materials and methods

Study design and sampling collection

A dispersion model was used to evaluate the emissions from the incinerator. On the basis of metal deposition, different exposure areas were defined [3]. People living in the area where metal deposition was predicted to be lower than 0.007 mg/m²/year (Area 1) were classified as “unexposed” subjects, while people living in the area with predicted metal deposition higher than 0.014 mg/m²/year (Area 2) were classified as “potentially exposed” subjects.

The study was approved by the local Ethics Committee.

A minimum of 50 subjects per area were randomly selected by the local health units ASL TO3 and ASL TO1 among individuals aged 36–50 years who had been living in the same area for at least five years. Prior to blood withdrawal, each subject signed an informed consent form. A questionnaire was administered to each subject on life environment and style, smoking and dietary habits, and work experiences. A total of 102 blood samples were obtained before the start-up of the incinerator in the period June–July 2013 from 50 “potentially exposed” and 52 “unexposed” subjects (Table 1).

Blood was drawn from donors and quickly centrifuged to obtain serum specimens, the latter were collected in FalconTM tubes and stored at -20 °C until analysis.

Chemical analysis

Individual samples were added with ¹³C-labeled PCDDs, PCDFs, and PCBs used as internal standards. Serum proteins were denatured by isopropanol/formic acid mixture and the lipidic fraction extracted with n-hexane. Clean-up was carried out by an automatic DEXTech™ System (LCTech GmbH, Dorfen Germany) equipped with three different pre-packed columns (acid silica, Florisil, and activated carbon). The quantification of analytes was performed by adapting US EPA Methods 1613-B (1994) and 1668-B (2008), using high-resolution gas chromatography coupled with high-resolution mass spectrometry (HRGC-HRMS, resolution 10,000; DFS, Thermo Fisher Scientific).

Statistical analysis

All statistical analysis were performed using the Statistica 8 software (StatSoft Inc.). The non-parametric Mann-Whitney U test was used to compare the differences in concentrations between two groups (differences for which $p < 0.05$ were considered statistically significant). Spearman test was used to evaluate the association strength between age and concentrations of the contaminants under study.

Results and discussion

Frequency distributions of concentrations of PCDDs+PCDFs, DL-PCBs, and TEQTOT (PCDDs+PCDFs+DL-PCBs) observed in the sampled population (N=102) before the WTE incinerator start-up are shown in Figure 1. TEQs are expressed as medium bound (UB) concentrations, and calculated by applying the dioxin toxicity equivalency factors (TEFs) adopted by the World Health Organization (WHO) in 1997 [4]. Cumulative concentrations of PCDDs+PCDFs ranged from 2.82 to 29.8 pgWHO-TE97/g lb, with median estimate of 9.62 pgWHO-TE97/g lb. DL-PCB concentrations were found to be in the ranges 2.96–33.3 pgWHO-TE97/g lb (median, 9.20 pgWHO-TE97/g lb). TEQTOT values varied from 5.78 to 53.5 pgWHO-TE97/g lb, with median estimate of 19.1 pgWHO-TE97/g lb. The total content of NDL-PCBs is given as the sum of 30 congeners (Σ 30NDL-PCBs) including the six “indicator” NDL-PCBs (Σ 6NDL-PCBs). Figure 2 presents the box-plots illustrating the distributions of NDLPCB data. Concentrations of Σ 30NDL-PCBs and Σ 6NDL-PCBs were found in the ranges 42.3–949 and 23.8–576 ng/g lb, respectively (median, 231 and 142 ng/g lb).

In agreement with other studies [5, 6, 7, 8, 9, 10] significant differences were observed in concentrations of the analyzed pollutants between genders ($p < 0.05$). Levels of PCDDs, PCDFs, and PCBs were in significantly higher in females than in males, possibly because of the higher body fat content in females. Fat content, indeed, has been hypothesized to influence the half-lives of PCDDs and PCDFs in humans [9 and 11].

The correlation between age and PCDD, PCDF, PCB levels in serum was studied by the Spearman rank correlation test. Significant positive associations were found between the age and the concentrations of all the contaminants ($p < 0.001$) in whole- and male datasets. In the female group a strong associations with age was observed for TEQTOT, DL-PCBs, and NDL-PCBs ($p < 0.02$), while for PCDDs+PCDFs the association resulted to be less significant ($p < 0.1$).

Figures 3 and 4 report the distribution of data observed for PCDDs+PCDFs, DL-PCBs, TEQTOT, and NDL-PCBs in the two exposure areas. The differences between Area 1 and Area 2 did not result significant ($p > 0.4$) for all the above-mentioned chemicals.

To our knowledge, this is the only human biomonitoring study on individual samples carried out in the last ten years on a wide group of subjects (general population, both sexes, different classes of age).

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Table 1 Sampling plan of the biomonitoring study on “potentially exposed” and “unexposed” subjects. Enrolment was carried out in June–July 2013.

Exposure area		Participants		
		Females	Males	Total
Area 1	”unexposed” subjects	25 (36–49)*	27 (36–50)*	52 (36–50)*
Area 2	“potentially exposed” subjects	25 (36–50)*	25 (36–49)*	50 (36–50)*
		50 (36–50)*	52 (36–50)*	102 (36–50)*

(*) Age range

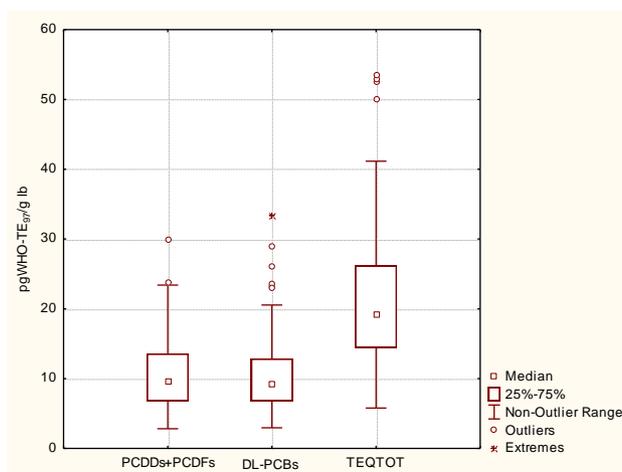


Figure 1. Box plots of PCDD+PCDF, DL-PCB, and TEQ_{TOT} levels in the general population of Turin (N=102). Blood samples obtained before the start-up of waste incinerator from June to July 2013.

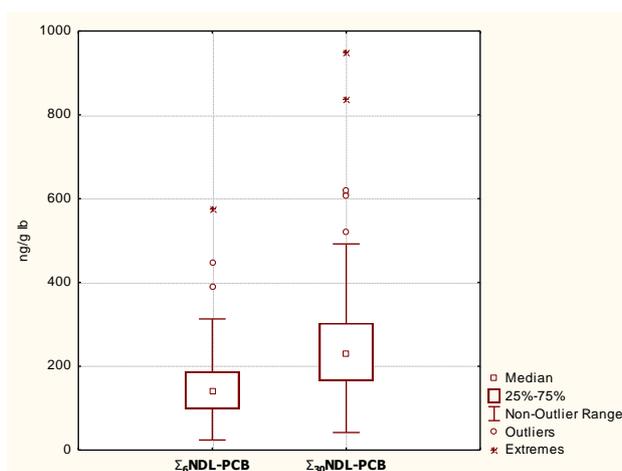


Figure 2. Box plots of NDL-PCB (Σ_{30} NDL-PCB and Σ_6 NDL-PCB) levels in the general population of Turin (N=102). Blood samples obtained before the start-up of waste incinerator from June to July 2013

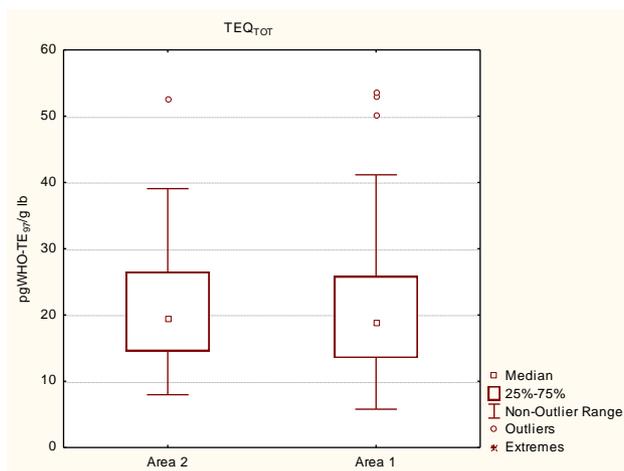


Figure 3. Box plots of TEQ_{TOT} levels in the two exposure areas. Blood samples obtained before the start-up of waste incinerator from June to July 2013.

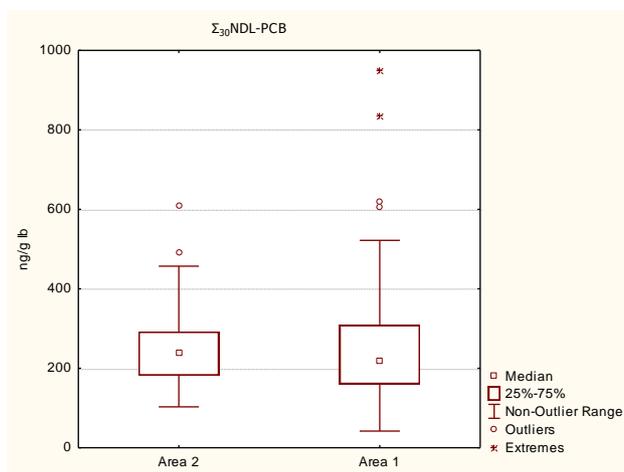


Figure 4. Box plots of NDL-PCB (Σ_{30} NDL-PCB) levels in the two exposure areas. Blood samples obtained before the start-up of waste incinerator from June to July 2013.