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# Occupational exposure to PCDDs, PCDFs, and PCBs of metallurgical workers in some industrial plants of the Brescia area, northern Italy

Annalisa Abballe[a,1], Pietro Gino Barbieri[b,1], Alessandro di Domenico[a], Siria Garattini[b], Nicola Iacovella[a], Anna Maria Ingelido[a,*], Valentina Marra[a], Roberto Miniero[a], Silvia Valentini[a], Elena De Felip[a]

[a] *Dipartimento Ambiente e connessa Prevenzione Primaria, Istituto Superiore di Sanità, Roma, Italy*
[b] *Servizio Prevenzione e Sicurezza Ambienti di Lavoro, ASL Provincia di Brescia, Italy*

## HIGHLIGHTS

- ▶ Dioxin/PCB haematic burdens of Brescia, Italy, metallurgical workers were investigated.
- ▶ Chemicals were measured in "professionally" (PE) and "not professionally" (NPE) exposed subjects.
- ▶ A significant difference was observed between PE data and a subgroup of NPE data (rural subjects).
- ▶ Increased haematic burdens of PE subjects were associated with certain workplace environments.

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## ABSTRACT

*Background:* The study was carried out in order to respond to public concern on the occupational exposure of metallurgical workers to highly toxic PCDDs, PCDFs, and PCBs in the area of the city of Brescia, northern Italy.
*Objectives:* The study investigated the effects on the haematic burden of occupational exposures to the aforesaid contaminants in different work environments, attempting to establish causal relationships and providing indications for occupational health preventive measures.
*Methods:* Chemical concentrations were measured in blood serum of "professionally exposed" (PE) and "not professionally exposed" (NPE) subjects. NPE subjects included industrial administrative employees, Brescia inhabitants, and remote rural people.
*Results:* The central tendency indexes of contaminant cumulative concentrations were higher in PE than in NPE samples (for the mean values: PCDDs + PCDFs, 22.9 vs. 19.5 pgWHO-$TEQ_{1997}$/g lb; DL-PCBs, 26.0 vs. 23.6 pgWHO-$TEQ_{1997}$/g lb; PCDDs + PCDFs + DL-PCBs ($TEQ_{TOT}$), 48.9 vs. 43.1 pgWHO-$TEQ_{1997}$/g lb; $\Sigma_6$[NDL-PCBs], 427 vs. 401 ng $g^{-1}$ lb); however, no statistical differences were detected at $P = 0.05$. A significant difference for PCDDs + PCDFs and $TEQ_{TOT}$ was observed as the NPE data were progressively reduced to those of the remote rural people. The existence of a differential occupational exposure due to different environments was detected by applying the factor analysis to congener-specific data (analytical profiles).
*Conclusions:* Findings indicate that metallurgical workers may be exposed to PCDD, PCDF, and PCB more than the general population, in particular due to non-negligible contributions to exposure from workplace ambient air. Findings also suggest that an improvement of preventive measures may be required to avoid chemical overexposure in certain metallurgical workplaces. To identify exposure groups, the DL- and NDL-PCB analytical profiles seemed to be more sensitive to environmental exposure sources/pathways than those of PCDDs and PCDFs.



## 1. Introduction

Polychlorinated dibenzodioxins (PCDDs), dibenzofurans (PCDFs) and biphenyls (PCBs) are toxic, bioaccumulative, and persistent chemicals whose health effects include dermal toxicity, immunotoxicity, reproductive and endocrine disrupting effects, teratogenicity, and carcinogenicity (EC, 2001). As known, PCBs are

* Corresponding author. Address: Toxicological Chemistry Unit, Department of the Environment and Primary Prevention, Italian National Institute for Health, Viale Regina Elena 299, 00161 Rome, Italy. Tel.: +39 06 4990 2322; fax: +39 06 4990 2836.
*E-mail address:* annamaria.ingelido@iss.it (A.M. Ingelido).
[1] These authors contributed equally to the work.

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industrial chemicals massively produced in many countries for over four decades (Fiedler, 2001; Holoubek, 2001; WHO, 2003). In fires and other thermal events, PCBs can be converted to PCDFs and other products (Erickson, 1989; De Felip et al., 1994). PCDDs and PCDFs—also collectively known as "dioxins"—are unintentional by-products released in a number of chemical processes as well as in other human activities, mainly including combustion processes (Bumb et al., 1980).

In the past three decades, the potential adverse effects of the aforesaid substances on human health prompted European Union (EU) regulatory authorities to define a wide range of measures to reduce their release into the environment and the food web. These measures have resulted in a substantial decrease of environmental and human levels of said compounds since the mid-1980s. However, PCDDs, PCDFs, and PCBs are still present in the environment, can be released from reservoir compartments (Fries, 1995; Holoubek, 2001; Fiedler, 2003; WHO, 2003), and continue to bioaccumulate in the food web (EC, 2001).

After the progressive abatement of emissions from non-hazardous waste incineration, once the largest source of PCDD and PCDF release into the atmosphere, other industrial processes—such as hazardous waste incineration and releases from the metallurgical industry—have likely become more important in the total inventory, providing relevant contributions of PCDDs, PCDFs, and possibly PCBs to their environmental burden (Li et al., 2010; Fang et al., 2011). The European Commission identified in iron ore sintering, electric-arc furnaces, and non-ferrous metal sintering important sources of PCDD and PCDF emissions to air (EC, 2001). In many countries, metallurgical processes were found to be the major contributors to the release of such compounds into the environment (Anderson and Fisher, 2002; Chen, 2004).

Relative to the general population, workers of the metallurgical industry can experience an increased exposure to PCDDs and PCDFs (Sweetman et al., 2004; Aries et al., 2008; Lee et al., 2009; Jackson et al., 2011). Though the diet accounts for more than 90% of the general population's total exposure to PCDDs, PCDFs, and PCBs, under specific circumstances contributions from environmental sources (including workplace) could play an important role in body burden building up (Bosch de Basea et al., 2011; Hsu et al., 2011). Indeed, the few occupational biomonitoring studies carried out on metallurgical workers revealed an overexposure to PCDDs and PCDFs (Chen et al., 2006a, 2006b; Lee et al., 2009).

The area of Brescia, a highly industrialized city in the Lombardy Region (northern Italy), is characterized by the presence of several metallurgical plants and by the highest number of secondary smelters in Italy. In the same area was the Caffaro Company, running the only Italian PCBs-producing plant, operative between 1930 and 1984. The prolonged and combined industrial activity has resulted in a widespread PCDD, PCDF, and PCB presence in the environment and local food produce, higher than current background (CTS, 2003; Turrio-Baldassarri et al., 2007) to such an extent that the area was declared "site of national interest for remediation" by the Italian authorities. In this exposure scenario, a possible overexposure deriving from work-related activities may be of high importance in assessing the health risks of exposed personnel.

The present study, supported by the local health agency—Azienda Sanitaria Locale (ASL) of the city of Brescia—was prompted by public concern on specific exposure situations in local metallurgical plants: indeed, in 1999 the Lombardy Region health authority had warned the regional health agencies about a relevant PCDD and PCDF presence detected in emission dusts from electrical iron smelters. The assessment of internal dose was carried out by measuring the serum concentrations of PCDDs, PCDFs, dioxin-like PCBs (DL-PCBs), and a selection of non-dioxin-like PCBs (NDL-PCBs). The aim of the study was to investigate in metallurgical workers the effects on the haematic burden of exposures to the aforesaid contaminants in different work environments, attempt to establish causal relationships between workplace activities and biomonitoring outcome, and provide indications for occupational health preventive measures.

**Table 1**
Participating subjects and panorama of the pooled samples showing the number of individual contributions (specimens) to each pooled sample. All recruited subjects were males.

| Sample classification (exposure environment and work department) | | | | Sample specimens (*N*) and mean age (years) | | Sample classification (exposure environment and work department) | | | | Sample specimens (*N*) and mean age (years) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Subjects professionally exposed (PE)* | | | | | | | | | | | |
| 01 | Steel 1 | Steel production | Fusion | 10 | 40.2 | 18 | Steel 3 | Steel production | Fusion | 10 | 47.6 |
| 02 | Steel 1 | Steel production | Fusion | 9 | 39.9 | 19 | Steel 3 | Steel production | Scrap handling | 9 | 45.1 |
| 03 | Steel 1 | Steel production | Casting | 10 | 43.2 | 20 | Steel 3 | Steel production | Casting | 14 | 46.3 |
| 04 | Steel 1 | Steel production | Casting | 10 | 42.8 | 21 | Steel 3 | Steel production | Maintenance | 7 | 42.7 |
| 05 | Steel 1 | Steel production | Casting | 10 | 44.0 | 22 | Aluminum 1 | Aluminum production | Fusion | 9 | 46.3 |
| 06 | Steel 1 | Steel production | Scrap handling | 12 | 47.7 | 23 | Aluminum 1 | Aluminum production | Casting | 10 | 42.0 |
| 07 | Steel 1 | Steel production | Maintenance | 8 | 42.0 | 24 | Aluminum 1 | Aluminum production | Scrap handling | 6 | 46.8 |
| 08 | Steel 1 | Steel production | Maintenance | 8 | 42.4 | 25 | Aluminum 1 | Aluminum production | Maintenance | 8 | 48.3 |
| 09 | Steel 2 | Steel production | Casting | 10 | 44.6 | 26 | Aluminum 1 | Aluminum production | Scrap handling | 5 | 41.2 |
| 10 | Steel 2 | Steel production | Casting | 10 | 43.3 | 27 | Aluminum 1 | Aluminum production | Maintenance | 6 | 47.3 |
| 11 | Steel 2 | Steel production | Casting | 10 | 43.0 | 28 | Aluminum 2 | Aluminum production | Mixed | 10 | 44.6 |
| 12 | Steel 2 | Steel production | Fusion | 10 | 41.3 | 29 | Brass 1 | Brass production | Fusion | 9 | 44.8 |
| 13 | Steel 2 | Steel production | Fusion | 10 | 36.2 | 30 | Brass 1 | Brass production | Fusion | 9 | 44.6 |
| 14 | Steel 2 | Steel production | Maintenance | 8 | 44.3 | 31 | Brass 3 | Brass production | Fusion | 9 | 46.8 |
| 15 | Steel 2 | Steel production | Maintenance | 7 | 36.6 | 32 | Cast iron 1 | Cast iron production | Fusion | 7 | 42.9 |
| 16 | Steel 2 | Steel production | Scrap handling | 6 | 46.3 | 33 | Cast iron 2 | Cast iron production | Mixed | 10 | 41.0 |
| 17 | Steel 2 | Steel production | Scrap handling | 6 | 44.3 | 34 | Cast iron 3 | Cast iron production | Mixed | 8 | 46.3 |
| *Subjects not professionally exposed (NPE)* | | | | | | | | | | | |
| 01 | Industrial environment (administrative employees) | | | 10 | 37.9 | 07 | Rural environment (remote subjects) | | | 9 | 35.3 |
| 02 | Industrial environment (administrative employees) | | | 10 | 39.3 | 08 | Rural environment (remote subjects) | | | 10 | 33.5 |
| 03 | Urban environment (Brescia inhabitants) | | | 13 | 38.9 | 09 | Rural environment (remote subjects) | | | 9 | 39.7 |
| 04 | Urban environment (Brescia inhabitants) | | | 11 | 46.7 | 10 | Rural environment (remote subjects) | | | 9 | 39.9 |
| 05 | Urban environment (Brescia inhabitants) | | | 11 | 46.7 | 11 | Rural environment (remote subjects) | | | 10 | 39.0 |
| 06 | Urban environment (Brescia inhabitants) | | | 11 | 47.1 | | | | | | |