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Preliminary study of possible relationships between exposure to PCDD/Fs and dl-PCBs in ambient air and the length of life of people

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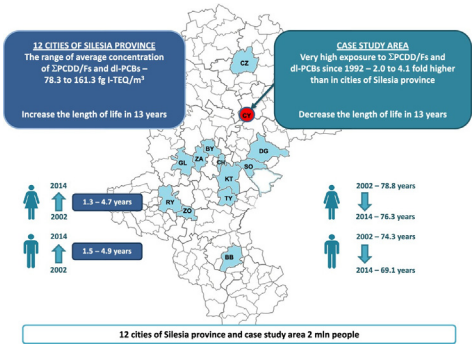
HIGHLIGHTS

- Impact of POPs air pollution on the length of life of 2 mln people were analyzed.
- Inhalation exposure to PCDD/Fs and dl-PCBs may shorten the life expectancy (LE).
- The mixture of POPs and PM_{10} showed strong correlation with the length of life.
- Reduction of POPs by 10 fg I-TEQ/m^3 could make LE of women longer by approx. 4 months.

GRAPHICAL ABSTRACT



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ABSTRACT

There is a lack of studies on the impact of very toxic and persistent organic compounds as polychlorinated dibenzodioxins (PCDDs), dibenzofurans (PCDFs) and polychlorinated biphenyls (PCBs) on the population life expectancy. Preliminary studies on the relations between exposure to PCDD/Fs and dl-PCBs in ambient air and the length of life of residents of 12 cities (2 million people) in the Silesia province has been undertaken. The average length of life of inhabitants in 12 cities of Silesia province was calculated on the basis of register of deaths after excluding deaths caused by external causes and the concentration of PCDD/Fs and dl-PCBs were measured. The studies have shown that inhalation exposure to dioxins, furans and dl-PCBs could be an important factor which may shorten the life expectancy of the population. The results of preliminary studies indicate a strong correlation between the concentration of PCDD/Fs and dl-PCBs in the ambient air and the length of life of women. The conducted analysis of the regression shows that reduction of chlorinated persistent organic compounds of 10 fg I-TEQ/m^3 could extend life expectancy of women by approximately 4 months (0.3 years).

1. Introduction

According to the results of scientific papers, population exposure to the air pollutants increases mortality caused by i.e. respiratory and cardiovascular diseases (Chen et al., 2016; Fang et al., 2016). It has also been shown, that reducing concentration of pollutants, such as particulate matter (PM_{10}), benzo(a)pyrene (BaP), nitrogen oxides (NOx),

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cadmium and lead, translates to a lower risk of death and as a result, elongation of life expectancy (Marchwinska-Wyrwał et al., 2010; César et al., 2015; Dominici et al., 2015; Madaniyazi et al., 2015; Dziubanek et al., 2017). In previous scientific elaborations there is a lack of studies on the impact of very toxic and persistent organic compounds as polychlorinated dibenzodioxins (PCDDs), dibenzofurans (PCDFs) and polychlorinated biphenyls (PCBs) on the population life expectancy. However, the significant effect of inhalation exposure to the PCDD/Fs, PCBs, and PCNs emitted from metallurgical plants in China on the elevated cancer risks in associated populations has been shown. The highest cancer risk was estimated for workers of aluminum and copper smelters (Yang et al., 2017). The increased cancer risks resulting from exposure to PCDD/Fs was found among workers of sinter plant located in southern Taiwan (Shih et al., 2008) and among melting and casting workers from automobile foundry factory in Hubei province in China (Wang et al., 2013). The increased mortality among men, in high dioxins exposure zones, from all cancers, rectal cancer and lung cancer, were found fifteen years after the uncontrolled emission of dioxins in Seveso (Bertazzi et al., 2001). As reported by Meneses et al. (2004) the reduction of PCDD/Fs emissions from a solid waste incinerator plant (MSWI), after installation of the air cleaning devices, was associated with decreased lifetime cancer risk of the population living in the vicinity.

Among the global sources of dioxin the industrial processes with combustion activities (mainly waste incineration and metal smelting) are the most significant contributors of atmospheric dioxin emissions (Booth et al., 2013). The biggest emitters of dioxin are industrialized countries in Europe, North America and South-East Asia. The G20 countries account for >80% of the emissions in the world. In the countries, where such practices as residential heating and residential waste combustion are frequent, nonindustrial sources plays also significant role in total emission of dioxins (Booth et al., 2013; Dopico and Gómez, 2015).

In Europe (EU-25), residential combustion in small combustion installations (>30%), open burning of waste and wood preservation (>16% each) are dominated sources of dioxins. The most important industrial sources are: iron and steel production, power production, non-ferrous metals and chemical industry. The major contributors of PCBs to the environment are emissions from power generation sources and road transport (>35% each), as well as iron and steel production (>10%) (BIPRO, 2006).

The PCDD/Fs emission levels generally have decreased in HELCOM countries, except those of them, where the emissions from nonindustrial sources are the major contributors, and where the social awareness is insufficient. In 2012, the largest contributions to total annual PCDD/F emission of HELCOM countries belong to Russia (65%) and Poland (20%) (Gusev, 2014). In the USA, the largest source of dioxins (35.1%) has been remained the open burning of residential rubbish and wood in backyard burn barrels (U.S. Environmental Protection Agency, 2006). In Asia, the main sources of dioxin emissions are combustion activities, metal industries, and waste incineration (Dopico and Gómez, 2015).

The highest concentration of PCDD/Fs in fly ash in China was indicated in samples from secondary cooper and zinc smelting but the most important source to dioxin emissions are the ferrous and nonferrous metal production (46%), heat and power generation (18%) and waste incineration (17%) (Liu et al., 2013a; Liu et al., 2015). As reported by Liu et al. (2013b) among industrial thermal processes the main source of PCBs emission are secondary zinc smelting and thermal wire reclamation, while the main source of polychlorinated naphthalenes (PCNs) emission are coking processes (Liu et al., 2010). Coke production is not only a source of PCNs, but also a source of PCDD/Fs, PCBs, hexachlorobenzene and pentachlorobenzene (Environ. Sci. Technol. 2009, 43: 9196–9201).

According to Polish inventory report (National Centre for Emissions Management, NCEM, 2016), the emissions from combustion of fuels in household boilers and furnaces are the most important contributors to emissions of dioxin and furans (57.5%). The second key source is stationary combustion in manufacturing of non-ferrous metals (9.2%). The main source of PCBs is also residential fuels combustion (66%) and next on line are combustion processes in energy and transformation industries (19%), road transport (6.6%) and iron and steel production (5%).

In the most industrialized part of Poland, Silesia (study area - 12,333 km^2), operate potential industrial sources of dioxin emissions as: 6 coking plants and 13 metallurgical plants, 17 processing plants of electrical and electronic waste, 5 medical and veterinary waste incinerators, 3 waste battery processing plants, 2 cement plants, 1 utilization plant of wastes containing PCBs, 1 utilization plant of waste containing pesticides (Internet System of Legal Acts, ISAP, 2010). In spite of such concentration of industry, the emission of PCDD/Fs and dl-PCBs from residential houses heated by coal remain the biggest problem presently, because the poor-quality coal is mixed with plastic wastes in combustion processes. Although officially banned, it happens especially in Silesia province, where many residential houses are heated by coal, the cheapest and easy available energy carriers in the region. To increase the heating power of poorer quality coal, plastic wastes are often co-incinerated, which results in the increased emission of both particulate matter and sulphur dioxide as well as PCDD/Fs and dl-PCBs from the low emission sources to the atmosphere (Dziubanek et al., 2016). In the earlier studies, conducted in a population of >3.5 million of Silesia province residents, a significant impact of chronic exposure to air pollutants on mortality and shortening the length of life of the local community has been shown (Marchwinska-Wyrwał et al., 2010; Dziubanek et al., 2017). In view of the existing problem of low emission in the Silesia province, preliminary studies on the relations between exposure to PCDD/Fs and dl-PCBs and the length of life of residents of selected cities from that region have been undertaken. Furthermore, the data on the length of life of Cynków inhabitants have been analyzed due to particularly high chronic exposure of them to the persistent organic compounds in ambient air, probably lasting since 1992 year, when residents started the production of PVC products.

The objective of this study was to assess the impact of the mixture of ΣPCDD/Fs and dl-PCBs and PM10 on the length of life of women and men in 12 cities of the Silesia province and case study area.

2. Material and methods

2.1. Study population

The study population consisted of people living in 12 cities of the Silesia province in Poland. This applies such cities as: Bielsko-Biała (BB), Bytom (BY), Chorzów (CH), Częstochowa (CZ), Dąbrowa Górnicza (DG), Gliwice (GL), Katowice (KT), Rybnik (RY), Sosnowiec (SO), Tychy (TY), Zabrze (ZA), Żory (ZO), which location was presented in the previous paper (Science of the Total Environment, Dziubanek et al., 2017, Fig. 1). These are the cities with a population from 62 (ZO) to over 300 thousand (KT) inhabitants, where up to 35% of houses are heated by coal.

In Cynków (CY), the case study area (50.563835″N and 19.088673″E), all houses are heated by coal. The inhabitants of CY have been involved, since 1992, in the production of the articles from the polyvinyl chloride (PVC) film, such as artificial Christmas trees, wreaths, flowers and other decorations. The PVC film imported from Thailand and China is mainly used for production. The inhabitants of CY generally possess the individual coal-based home heating systems, which increases the risk of co-incineration of the waste manufactured in the local production with coal. Post-production wastes are mixed with coal and incinerated in the household boiler rooms where the temperature of the incineration processes are about 500 °C, which constitutes the proper conditions for formation of dioxins and PCBs in the exhaust gases. The very high concentrations of PCDD/Fs and dl-PCBs in the air,