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Risk assessment of the common air pollutants in Teplice, Czech Republic

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Abstract

In the framework of the systematic investigation of the environment of the district of Teplice (Northern Bohemia), one of the most polluted regions in Europe, an attempt was made to estimate health risks to the inhabitants posed by the most common air contaminants (SO_2, NO_x, particulate matter). A meta-analysis of data published in recent papers dealing with health effects was performed. At first we weighed the number of positive and negative findings focusing on the following health indicators: prevalence of symptoms (coughing, wheezing), decreased respiratory function, prevalence of respiratory illness, and acute mortality. Only those categories in which the positive findings prevailed were taken into consideration and median values for LOAELs were calculated from the data referring to positive dose-response relationships. The exposure assessment was based upon a series of data on daily concentrations of the air contaminants in Teplice since 1975. Due to the somatic and respiration parameters, as well as to their habits, children between the ages of 8 and 10 appeared the most heavily exposed of all age groups. It was concluded that in real concentrations the risk is posed mainly from sulphur dioxide and, above all, from particulate matter.

Keywords: Environmental pollutants; Sulphur dioxide; Particulate matter; Risk assessment

1. Introduction

The Northern Bohemia brown coal basin comprises several districts characterised by a high concentration of industry, particularly brown coal mining and power engineering. This fact, together with the unfavourable geographical situation have resulted in some of the worst environmental pollution in Europe. The health consequences of environmental pollution in this region have been of major concern to the public. After the political changes in 1989 a new research program, the so called Teplice Program, was developed to evaluate

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the short-term and long-term health impact of air pollution on the population in the district of Teplice, designated as a model district for similarly polluted areas. Early studies provided evidence of a high incidence of cancer and reproductive and behavioural effects. The mortality in the district of Teplice has been found to be significantly higher than the average values for the Czech Republic. Higher respiratory morbidity and changes in respiratory functions have been found for children who were lifetime residents in Teplice. Nevertheless, the principal question—whether the recognised adverse health effects can be actually related to the air pollution levels—still remains to be answered. Therefore, an attempt was made to use health risk assessment approach for this purpose and to estimate health risks to the Teplice population from exposure to the most common air pollutants (SO_2, NO_x, particulate matter).

2. Methods

The whole procedure comprised several steps:

2.1. Data analysis

The recent published data of field epidemiological studies (in the last 5 years) dealing with health effects related to the concentrations of the three common air contaminants (SO_2, NO_x, PM [mostly PM10]) were used for the meta-analysis (Anderson et al., 1966; Braun et al., 1992; Kulstrunk and Bohni, 1992; Moseholm et al., 1993; Samet et al., 1993; Barnes, 1994; Devalia et al., 1994; Moseler et al., 1994; Castellsague et al., 1995; Guillen Perez et al., 1995; Herbath, 1995; Keiding et al., 1995; Linn et al., 1995; Moolgavkar et al., 1995; Pershagen et al., 1995; Raaschou Nielsen et al., 1995; Xu et al., 1995; Anonymous, 1996; Buchdahl et al., 1996; Dab et al., 1996; Ito and Thurston, 1996; Peters et al., 1996; Ponce de Leon et al., 1996; Pope, 1996; Saldiva et al., 1994; Schwartz, 1996; Spix and Wichmann, 1996; Sunyer et al., 1996; Touloumi et al., 1996; Zmirou et al., 1996). In the centre of our interest stand those studies that define minimum concentrations at which adverse health effects were recorded more often (mostly using odds ratios) at 0.05 level of significance. At first we weighed the number of positive and negative findings on the following health indicator: prevalence of symptoms (coughing, wheezing), decreased respiratory function, prevalence of respiratory illness, acute mortality, and prevalence of poor pregnancy outcome. Only the categories in which the positive findings prevailed (i.e. that the adverse health effects increased with the exposure) were taken into consideration, and median values were calculated from the data referring to the positive dose-response relationships. The values were used eventually used for calculating pragmatic LOAEL

Table 1
Somatic and respiratory parameters for different age groups

Age groups	Inhalation volume (m^3/day)	Body weight (kg)
Adults	20	70
Children 8–10-year-old	10	30
Children 1-year-old	3.8	10
New-borns	0.8	3

Table 2
Median values of the referred least effective concentrations of pollutants ($\mu g/m^3$ per day)

Pollutant	Mortality	Symptoms	Morbidity	Functions	Reprotox
SO_2	100	71	36[a]	100	100
PM10[b]	100	75	100	170	100

[a] Based on hospital admissions, includes the risk population with chronic illness.
[b] According to WHO update and revision of WHO Air Quality Guidelines available epidemiological data did not allow establishment of NOAEL.

Table 3
LOAELS calculated for the different age groups (μg/kg per day)

Pollutant	Age group	Symptoms	Mortality	Morbidity	Functions	Reprotox
SO_2	Adults	15.7	11.2	5.7	15.7	15.7
	8–10 Years	27.5	19.5	9.9	27.5	
	1 Year	20.9	14.8	7.5	20.9	
	New-borns	14.7	10.4	5.3	14.7	
PM10	Adult	15.7	11.8	15.7	26.7	15.7
	8–10 years	27.5	20.6	27.5	46.8	
	1 Year	20.9	15.7	20.9	35.5	
	New-borns	14.7	11.0	14.7	24.9	

estimates adjusted for different age groups (see further).

2.2. Exposure assessment

The exposure assessment was based upon a series of data on daily concentrations of the air contaminants in Teplice monitored since 1975 (SO_2), 1983 (NO_x) and 1989 (PM). The mean SO_2 concentrations have been generally decreasing in the past years, but with significant seasonal differences and high air pollution exposures during inversion episodes, where actual SO_2 and PM concentrations significantly exceeded the emission limits.

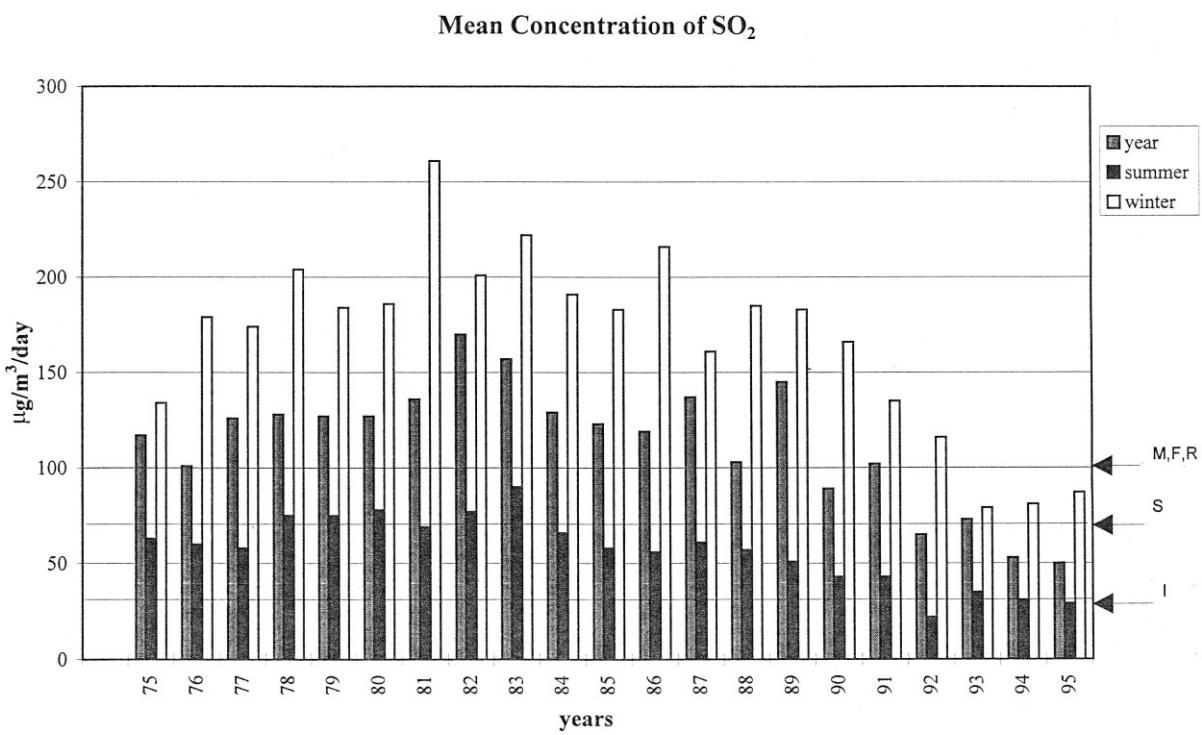

Fig. 1. Mean daily concentrations of sulphur dioxide (μg/m^3 per day) in the ambient air of Teplice between 1975 and 1995. Summer, winter, and whole-year averages. Pragmatic LOAELs for mortality (M), symptoms of respiratory distress (S), morbidity (I), impaired lung functions (F) and poor pregnancy outcome (R) derived from meta-analysis of data in the literature are depicted by arrows.

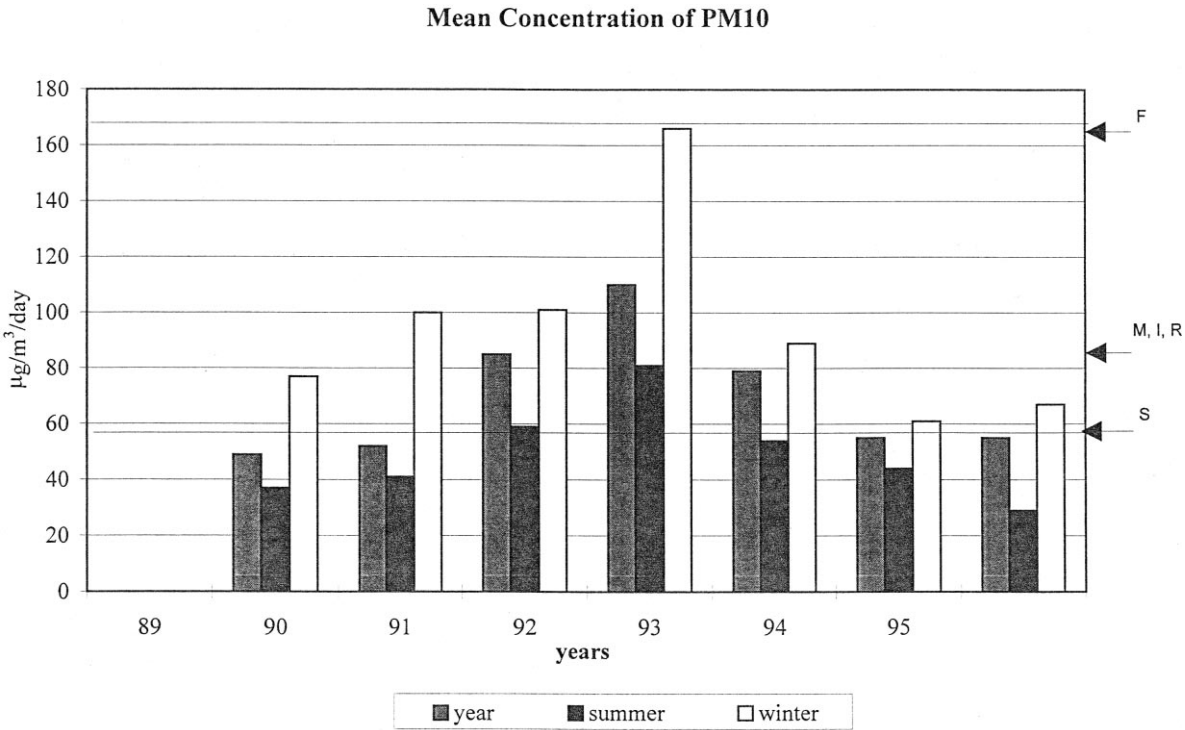

Fig. 2. Mean daily concentrations of particulate matter [PM10] ($\mu g/m^3$ per day) in the ambient air of Teplice between 1989 and 1995. Summer, winter, and whole year averages. Pragmatic LOAELs for mortality (M), symptoms of respiratory distress (S), morbidity (I), impaired lung functions (F) and poor pregnancy outcome (R) derived from meta-analysis of data in the literature are depicted by arrows. Remark: according to WHO update and revision of WHO Air Quality Guidelines available epidemiological data did not allow establishment of NOAEL.

The concentration data were used for the calculation of exposure dose for adults and children of different ages using conventionally employed somatic and respiration parameters (Table 1) for these population groups and taking into account their habits (prevalence indoor exposure, physical activity).

2.3. Risk characterization

The estimated exposure doses were compared with the pragmatic LOAEL values obtained in the meta-analysis.

3. Results

The results of meta-analysis confirmed the significance of SO_2 and particularly PM10 whereas, according to our criteria (> 50% positive reports), for NO_x the evidence for the health risk was found to be ambiguous. Consequently, we have focused our attention on the two former pollutants, calculating the median values included in Table 2. Pragmatic LOAELs adjusted for exposure of the different age groups are presented in Table 3.

According to these calculations, the individual burden appeared highest in the group of 8–10-year old children and that of the new-borns is comparable to the adults. A crude comparison with mean daily levels observed in Teplice (Figs. 1 and 2) that both air pollutants could have participated in the worsening of the health state of the inhabitants of Teplice until 1992 and it is highly probable that even in the present much lower

pollution may adversely influence the respiratory health status of school children.

In conclusion we may say that elevated levels of sulphur dioxide and particulate matter (or other attendant contaminants) found in the ambient air of Teplice contributed to the observed low quality of health of the inhabitants at least until the end of 1992. A further more detailed analysis will perhaps estimate the magnitude of this contribution and may lead to more precise conclusions regarding the mechanisms of health deterioration.

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