

MULTIPLE CORRELATION MODEL FOR ESTABLISHING THE ASSOCIATION BETWEEN ATMOSPHERIC AIR POLLUTION AND MORBIDITY

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A characteristics of atmospheric air pollution during the period from 1980 till 1992 in the town of Beloslav, a settlement located in the immediate proximity of Devnya industrial complex was prepared. The following parameters were examined: dust, sulphur dioxide, sulphuric acid, hydrogen sulphide, nitric oxides, ammonia, chlorine, and hydrogen fluoride. Annual indexes of pollution presented according to the Canadian Indexing System exceeded considerably the hygienic standards concerning most atmospheric air pollutants. During the whole period of observation the total index varied between 3,22 and 8,28 one unit being the standard. The morbidity rate of the population according to the registration files for children and adults was analyzed, too. Multiple correlation and step regression analyses were applied to follow-up the influence of the atmospheric air pollution on the morbidity. There were statistically reliable correlation dependences between the atmospheric air pollution and the diseases of the respiratory, nervous, alimentary and other systems.

Key-words: Atmospheric air pollution, indexes of pollution, morbidity, children, adults, multiple correlation analysis, step regression analysis

The effect of atmospheric pollution on the morbidity of exposed population is currently studied in the whole world. There exist numerous convincing data about the changed resistance of the organism under the influence of the atmospheric air pollution manifesting with a considerable reduction of both specific and

non-specific defense forces, the factors of cellular and humoral immunity, etc. (3,4,14,16). An increased morbidity rate of the population concerning the respiratory tract diseases such as acute bronchitis, asthma, and emphysema was registered and an association with the atmospheric air pollution with sulphur dioxide, nitric dioxide, fine-fraction dust, and aerosols of sulphuric acid was proved (7,8,12-15). An elevated morbidity rate of ischemic heart disease was also observed (11).

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The purpose of this study was to assess the atmospheric air pollution in the town of Beloslav located in the immediate proximity of a region with developed chemical industry and then to analyze the correlation with the morbidity of the population.

MATERIAL AND METHODS

A characteristics of the atmospheric air pollution in the town of Beloslav located 10 km far from the Devnya industrial complex presenting with well-developed chemical industry was prepared. The examination covered the period from 1980 till 1992. The following parameters were assessed: dust, sulphur dioxide, sulphuric acid, hydrogen sulphide, nitric oxides, ammonia, chlorine, and hydrogen fluoride. Canadian Indexing System was used to evaluate these parameters as the indexes of pollution were calculated in their independent and combined action (1,2,6,10). The morbidity rates of the population according to registration files in the town of Beloslav during the same period were analyzed as data were elaborated for both age groups - children and adults. A total of 34 nosological units according to the International Classification of Diseases were selected. In order to clarify the influence of atmospheric

air pollution on the morbidity of population multiple correlation and step regression analyses were applied.

RESULTS AND DISCUSSION

The results concerning the atmospheric air pollution with dust revealed that annual indexes remained within the limits of 1,33 to 4,84 one unit being the standard during the 13-year period and indicated a relatively constant level of dustiness in the settlement near to the industrial region (Fig. 1). Hydrogen fluoride values were rather variable. Annual indexes were very high in the beginning of the period - between 8,11 for 1981 and 5,39 for 1983. Then they decreased down to 2,77 and 3,47 for 1984 and for 1989, respectively, and even under the standard in the middle and the end of the period of observation - between 0,2 and 0,55 during 1986-1988 and between 0,4 and 0,64 during 1991-1992. Annual indexes of ammonia demonstrated a slightly elevated pollution over the standard in the early years (up to 1985) followed by gradual increase up to 2,24 in 1987 and reaching the maximum of 4,07 in 1990. The reduced values in the end of the period remained over the standard - between 2,43 for 1991 and 1,89 for 1992.

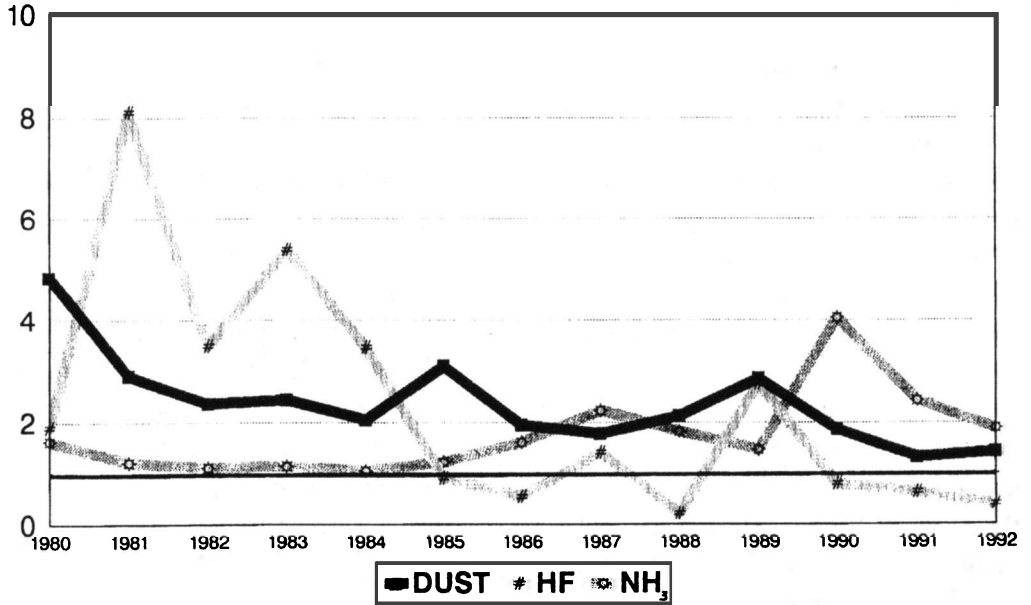


Fig. 1. Atmospheric air pollution indexes of dust, hydrogen fluoride and ammonia

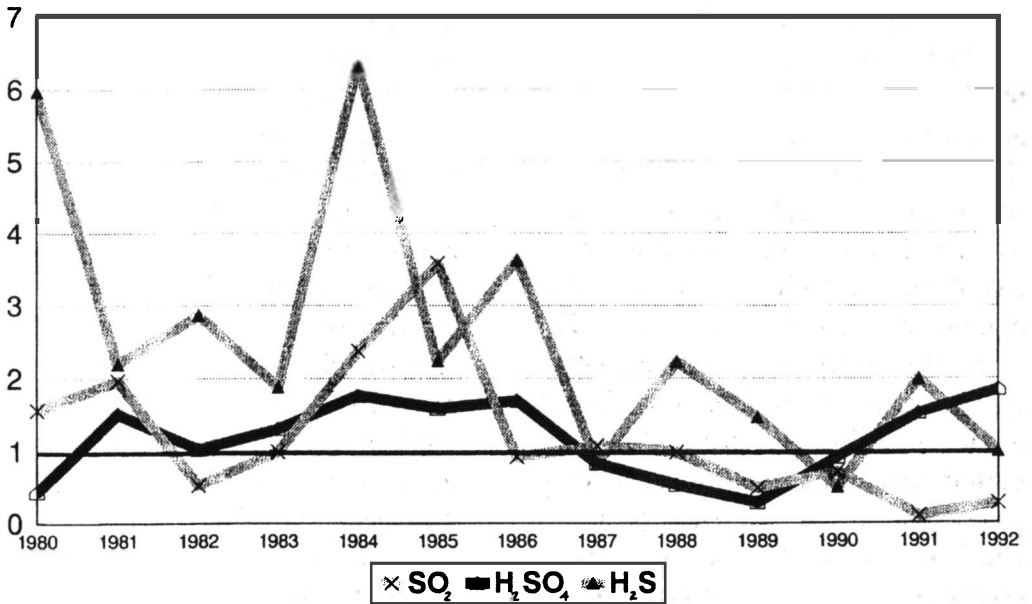


Fig. 2. Atmospheric air pollution indexes of sulphur dioxide, sulphuric acid, and hydrogen sulphide

Concerning the pollution with sulphur dioxide it was established that abnormally high indexes were found out during the first half of the period only - between 1,57 for 1980 and 3,58 for 1985 (Fig. 2). During the second half of the period the indexes varied about the standard or even considerably below it - down to 0,28 for 1992 and 0,10 for 1991. The pollution indexes of hydrogen sulphide were abnormally high for almost all the years - e. g., 1,77 for 1984 and 1,85 for 1985. In the early years and then in 1987-1990 these indexes were low - between 0,29 and 0,92. The indexes of hydrogen sulphide were considerably higher reaching their maximum in the beginning of the period (5,97 for 1980 and 6,31 for 1984). They decreased but remained abnormal in the rest years - up to 3,64 for 1986 but down to 0,50 and 0,83 for 1987 and 1990, respectively. Annual indexes of nitrogen oxides (nitric oxide and nitric dioxide) and chlorine were significantly lower than the standard and testified to a low pollution level. The simultaneous presence of different atmospheric air pollutants necessitated the elaboration of a complex assessment of the atmospheric air using a total pollution index (I_0). It was demonstrated that independently of the registered low concentrations of some atmospheric pollutants during the whole period of observation the total index

significantly exceeded the hygienic standard and varied between 3,22 and 8,28. It represented an important parameter providing a real idea of the atmospheric air pollution and thus it was currently used by numerous investigators (2,5).

These results testified to a rather high level of atmospheric air pollution in the town of Beloslav located in the immediate proximity of the region with intensively developed chemical industry. This location in a territory complicated by physico-geographic peculiarities contributed to this pollution level, too. The town of Beloslav is at sea-level and surrounded by plateaus high up to 300 m which is sufficient for the harmful emissions of the chemical works of Devnya industrial complex to hold at the ground layer. Prevailing breeze circulation and comparatively frequent Western and North-western winds exert their influence as they transport the chemical pollutants to the town of Beloslav. It was evident that there existed a tendency towards reduction of the atmospheric air pollution concerning the following indexes: sulphur dioxide, hydrogen sulphide, sulphuric acid, and hydrogen fluoride. The reasons could be looked for in the decreased exploitation of the production capacities of Devnya industrial complex and in the realized

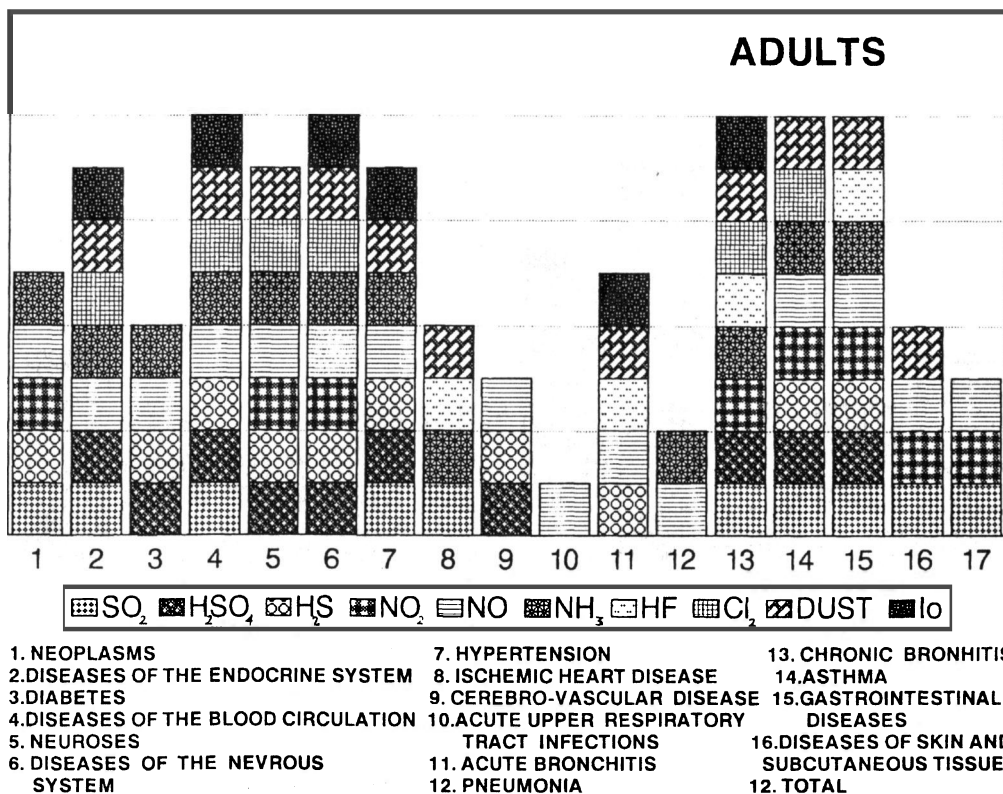


Fig. 3. Multiple correlation between atmospheric air pollution and morbidity rate in adults

reconstructions and improvements in the chemical works.

The results from the multiple correlation and regression models demonstrated that there existed statistically significant correlation dependences ($r = 0,7 \div 0,9$ at $0,001 \leq p < 0,01$) between the atmospheric air pollution with nitric oxides, sulphur dioxide, sulphuric acid, dust, chlorine, hydrogen fluoride, on the one hand, and the chronic bronchitis, asthma, pneumoniae, acute upper respiratory tract infections, diseases of the nervous and alimentary systems,

hypertension, ischemic heart disease, thyroid gland disease, skin diseases, and neoplasms (Figs. 3 and 4). These correlations were more outlined in the adult population than in the children. Some equations of regression in both age groups were presented.

1. Adults

Thyroid gland diseases:

$$Y = 27,7 - 1,48.X_{\text{dust}} - 1,11.X_{\text{NO}} + 1,34.X_{\text{I}_0} + 0,8.X_{\text{Cl}_2} + 0,68.X_{\text{SO}_2} - 0,92.X_{\text{H}_2\text{SO}_4} - 0,37.X_{\text{NH}_3}$$

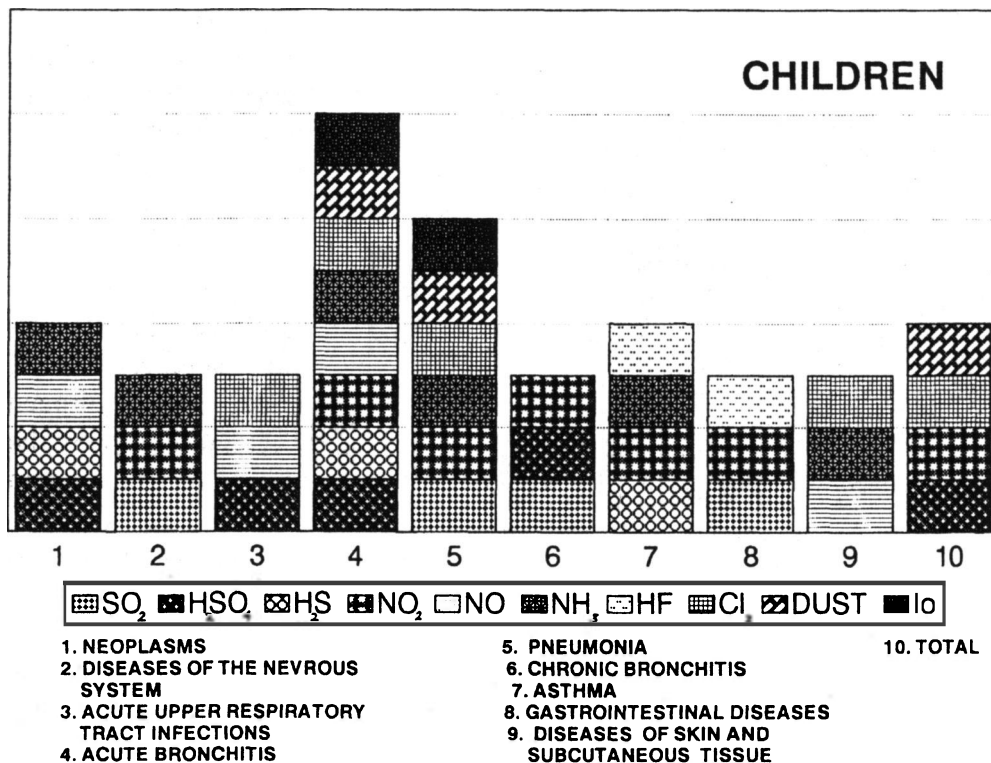


Fig. 4. Multiple correlation between atmospheric air pollution and morbidity rate in children

Hypertension:

$$Y = 438,31 - 1,13.X_{NO} + 0,42.X_{H_2SO_4} + 0,26.X_{H_2S} + 0,11.X_{I_0} + 2,94.X_{NH_3} - 3,19.X_{dust} - 2,16.X_{SO_2}$$

$$- 0,21.X_{NO} + 0,12.X_{H_2SO_4} - 0,36.X_{H_2S}$$

2. Children

Chronic bronchitis:

$$Y = 58,88 + 1,28.X_{H_2SO_4} - 0,69.X_{HF} - 1,2.X_{NO_2} - 0,37.X_{SO_2} + 0,82.X_{dust} + 0,38.X_{Cl_2} + 0,39.X_{NH_3} + 0,35.X_{I_0}$$

Acute bronchitis:

$$Y = 765,58 + 2,78.X_{NO_2} - 1,73.X_{dust} - 1,29.X_{NH_3} - 0,73.X_{NO} + 0,65.X_{H_2SO_4} - 0,71.X_{I_0}$$

Alimentary tract diseases:

$$Y = 537,64 - 0,9.X_{NO_2} + 0,32.X_{SO_2} + 0,41.X_{NH_3} - 0,23.X_{HF} + 0,44.X_{dust}$$

Pneumonia:

$$Y = 340,39 + 2,76.X_{NO_2} - 1,54.X_{NH_3} - 0,94.X_{Cl_2} - 0,59.X_{SO_2} - 1,05.X_{I_0} - 0,98.X_{dust}$$

Asthma:

$$Y = 56,02 - 1,14.X_{\text{NH}_3} - 1,02.X_{\text{H}_2\text{S}} + 0,85.X_{\text{NO}_2} - 0,92.X_{\text{HF}}$$

Single linear correlation (9) was used in order to clarify the effect of the atmospheric air pollution on the morbidity in some investigations. However, the method of multiple correlation and step regression analysis enabled the study of the combined action of the atmospheric pollutants on the morbidity rate of the population exposed. These results indicated the presence of an enhanced risk for the population in the town of Beloslav. There exists an obvious necessity for more profound investigations in this field. The awareness of the health status of single population groups could serve as a basis for the adequate organization of the medical aid, appropriate decision making and in the last reckoning for the achievement of a stable human health.

CONCLUSIONS

1. Annual pollution indexes for most pollutants exceeded significantly the hygienic standards in the town of Beloslav.

2. There was a tendency towards improvement of the atmospheric air pollution in the town of Beloslav of the following parameters: sulphur dioxide, sulphuric acid, hydrogen sulphide, and hydrogen fluoride. This was determined by the lower exploitation of the production capacities of Devnya industrial complex and by the already performed reconstructions and modernizations in the chemical works.

3. Multiple correlation and regression models revealed statistically significant correlation dependences between the atmospheric air pollution and the diseases of the respiratory, nervous, and alimentary systems, the haemopoietic organs, the skin and the neoplasms as well.

4. These correlations were more outlined for the adults than for the children.

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Множествен корелационен модел за установяване на връзката между замърсяването на атмосферния въздух и заболяемостта

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Резюме: Изготвена е характеристика на замърсяването на атмосферния въздух за периода от 1980 до 1992 г. в гр. Белослав - селище, разположено в непосредствена близост до Девненския промишлен комплекс. Изследвани са следните показатели: прах, серен двуокис, сярна киселина, сероводород, азотни окиси, амоняк, хлор и флуороводород. Годишните индекси на замърсяване, представени по канадската индексова система, значително превишават хигиенните хорми за по-голямата част от атмосферните замърсители. Сумарният индекс варира от 3,2 до 8,28 при норма единица за целия период на наблюдение. Проучена е и заболяемостта по обръщаемост на населението за медицинска помощ при деца и възрастни. За проследяване на влиянието на атмосферното замърсяване върху заболяемостта са използвани множествен корелационен и стъпков регресионен анализи. Установени са статистически достоверни корелационни зависимости между замърсяването на

атмосферния въздух и болестите на дихателната, нервната, храносмилателната и други системи.