EXAMINATIONS ON THE AIR QUALITY IN BEREHOVE (UKRAINE) BETWEEN 1997 AND 2007

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Abstract
First results of the examinations on the air quality in Beregszász (Ukraine) are presented in the present paper. Data sets of air quality monitoring network in Beregszász were provided by the Beregszász township office of National Health Service of Ukraine. Monitoring network consists of five stations in the industrial residential and recreational districts of the town. Measurements were carried out between 1995 and 2007 in the heating and in the non heating seasons. Spatial and seasonal distributions of SO_2, NO_2 and particulate matter were analyzed using the Student t-test.

Keywords: Beregszász, air pollutants, Student t-test.

1. Introduction

Human activities play an important role in the deterioration of the state of the environment, especially in air pollution. High concentrations of air pollutants occur mainly in the densely populated habituated (urban) spaces. Industrial activities, build-up and traffic are their main sources.

Environmental sciences have revealed the harmful effects of polluted urban air to human health. International organizations have been paying attention to the problem already. For instance the "Proposal for the EU Parliament and Council Directives on the Quality of Ambient Air and the Program Called Clear Air for Europe" of the Committee of the Regions of the EU declares that efforts must be taken in order to decrease the emission levels [1].

The main aim of the present paper is to survey the air pollution conditions for the three main pollutants (SO_2, NO_2, and PM – particulate matter that is, aerosol particles) compared to the Ukrainian guidelines in the town of Beregszász. Other objective is to trace seasonal differences via correlation heating season (from 1 October to 1 April) and non heating season (from 1 Aril to 1 October) concentrations.

2. Data base and methods

Emission monitoring is carried out by the Beregszász township branch of the Ukrainian Health Service on the base of the order of the Ukrainian Ministry of

Health in the town of Beregszász and in its township as well. Measurements are carried out four times (terminally) annually on the average at five sites in the town. Each terminal measurement takes three days (from 8 a.m. to noon). Monitoring sites are situated in three industrial (or ex industrial) one residential and one recreational zones. Their spatial pattern (Fig. 1) is the following:

a) industrial zone 1 – B. Hmelnicki street (the neighborhood of the tobacco factory)
b) industrial zone 2 – Széchenyi street (neighborhood of the Flextronic factory and the railway station)
c) industrial zone 2 – Gyár street (neighborhood of the Numinator factory)
d) residental zone – Muzsalyi street (a housing estate, along the road from Beregszász to Nagymuzsaly)
e) recreational zone –The park in the center of the town (at the crossing of the B. Hmelnicki and the Stefanik streets)

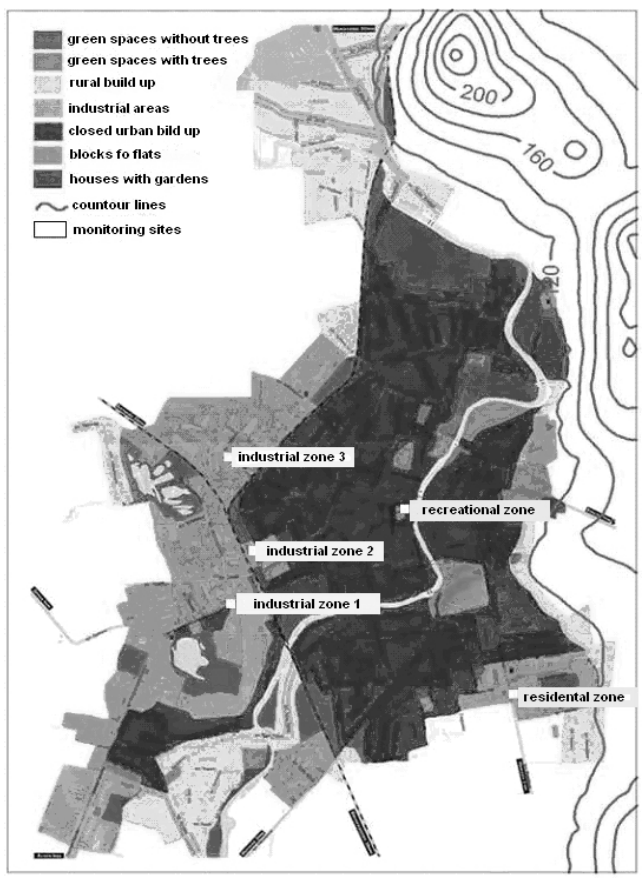

Fig. 1. the build-up map of Beregszász and the locations of the monitoring sites. (Source: Kakas et al. 2006)

Threshold limits of main air pollutants are regulated by the Ministry of Health of Ukraine as follows:

a) SO_2 - 0,5 mg/m^3
b) NO_2 - 0,085 mg/m^3
c) PM - 0,5 mg/m^3

The before mentioned values and the methods of monitoring are regulated in special orders, what are the following:

1. ОНД-1986 order on the measurement techniques;
2. ГОСТ-17.2.3.01.-1986 monitoring of pollutants in settlements;
3. ДБН-360-1992 order on the monitoring in towns and villages;
4. Ukrainian law – 1994. 02. 24. on the protection of human health in settlements (clause 19);
5. Governmental regulation on hygiene №207 – 1997 quality of air in settlements, chemical and biological pollutants (National Health Service, Beregszász).

Data from the monitoring records provided by the Beregszász township office of the National Health Service of Ukraine were processed using Microsoft Office Excel 2003, then the averages were calculated for each air pollutants for the whole studied period (1995–2007) and results have been presented on diagrams. Later statistical relationships among the air pollutants were analyzed using the Student t-test, what is used to compare the averages of different statistical samples, with the presumption that there are not any significant differences between the averages (x_1, x_2) of the two studied samples, therefore they can be considered as elements of the same statistical population. The equation for the calculation of the characteristic t-values (Péczely, 1979) is:

$$t = \frac{\bar{x}_1 - \bar{x}_2}{S\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$$

where S is the collective standard deviation of the two samples. It can be calculated in the following way, knowing the standard deviations (σ_1 and σ_2) and number of the elements (n_1 and $n_{2)}$ of the two samples:

$$S = \sqrt{\frac{(n_1 - 1)\sigma_1^2 + (n_2 - 1)\sigma_2^2}{n_1 + n_2 - 2}}$$

3. Results

In Fig. 2 Sulphur-dioxide concentrations are presented at the five sites in the studied period (1995–2007).

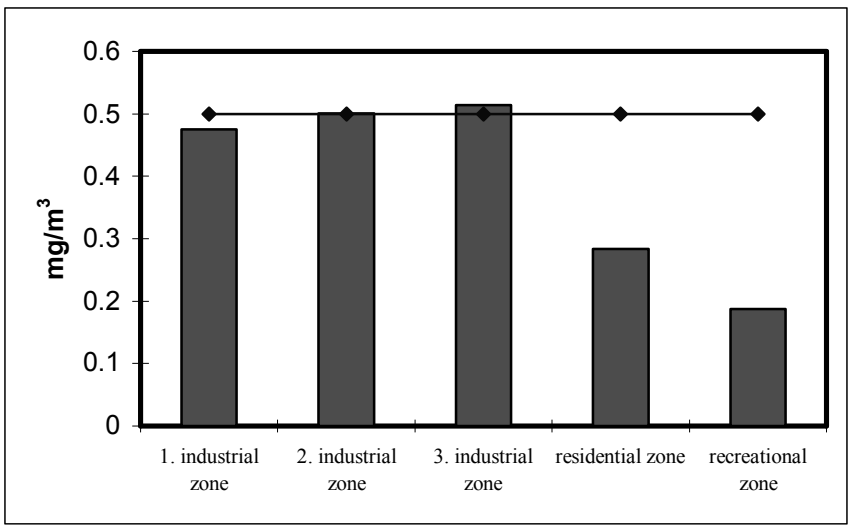

Fig. 2. Average sulphur-dioxide concentrations at the five monitoring sites in Beregszász for the period between 1995–2007 (The horizontal line shows the Ukrainian threshold)

Table 1. Comparison of the Sulphur-dioxide concentrations at the five monitoring sites in Beregszász on the base of the values of the Student t-test. Values printed in bold show significant relationships.

	1. industrial zone	2. industrial zone	3. industrial zone	residential zone	recreational zone
1. industrial zone	-	0.831	**2.406**	**9.104**	1.499
2. industrial zone		-	1.392	**9.681**	**11.551**
3. industrial zone			-	0.984	**11.794**
residential zone				-	1.115
recreational zone					-

It can be seen in the diagram that – according to our expectations – concentrations are the highest in the industrial zones. SO_2 concentrations are over the 0,5 mg/m^3 threshold limit in two cases and they are close to that in one, while concentrations are far below the threshold limits in the residential and recreational zones.

From the aspect of SO_2 concentrations there are remarkable differences between industrial zone 2-3 and 1. Significantly lower concentrations have been found in

residential and recreational zones. However, it is clear from table 1 that there are great differences between the residential and the recreational zones also.

Concentrations of Nitrogen-dioxide are presented in Fig. 3 at the five monitoring sites in the studied period (1995-2007).

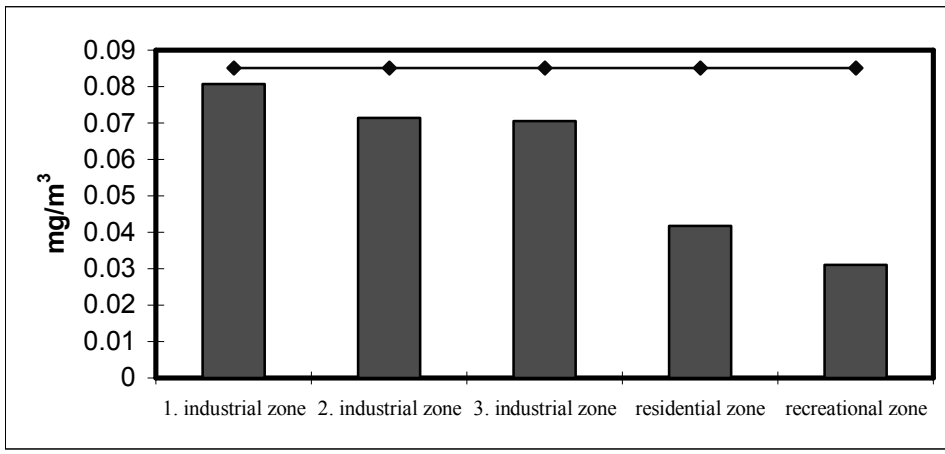

Fig. 3. Nitrogen-dioxide concentrations at the five monitoring sites in Beregszász for the period between 1995–2007 (The horizontal line shows the Ukrainian threshold)

Table 2. Comparison of the Nitrogen-dioxide concentrations at the five monitoring sites in Beregszász on the base of the values of the Student t-test. Values printed in bold show significant relationships

	1. industrial zone	2. industrial zone	3. industrial zone	residential zone	recreational zone
1. industrial zone	-	1.114	1.145	**2.844**	**3.398**
2. industrial zone		-	0.947	**12.643**	**11.028**
3. industrial zone			-	**11.413**	**11.604**
residential zone				-	**4.630**
recreational zone					-

Concentrations are under the threshold limit at each monitoring sites. According to the hypothesis they are closest to the threshold limit in the three industrial zones. Lowest concentrations occur in the residential and the recreational zones again.

There are not any meaningful differences between the industrial zones, but they differ significantly from the residential and the recreational zones. There are remarkable differences between these two zones again.

Particulate matter (aerosol particles) concentrations are presented in Fig. 4 at the five monitoring sites in the studied period (1995-2007).

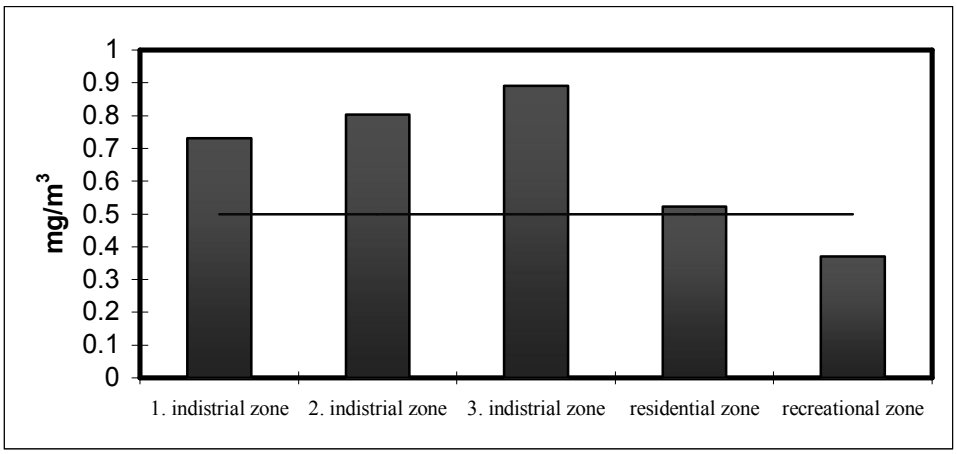

Fig. 4. PM concentrations at the five monitoring sites in Beregszász for the period between 1995–2007 (The horizontal line shows the Ukrainian threshold limit)

Table 3. Comparison of the PM concentrations at the five monitoring sites in Beregszász on the base of the values of the Student t-test. Values printed in bold show significant relationships

	1. industrial zone	2. industrial zone	3. industrial zone	residential zone	recreational zone
1. industrial zone	-	2.004	**3.420**	**3.201**	**4.973**
2. industrial zone		-	**2.170**	**4.962**	**6.595**
3. industrial zone			-	**4.880**	**6.242**
residential zone				-	**5.007**
recreational zone					-

PM concentrations reached the highest level from the studied pollutants. They exceed the Ukrainian threshold limits at all the monitoring sites with the exception of the recreational zone. The main source of PM is traffic. Unfortunately, the traffic network of the town is not a modern one; the ratio of good quality, blacktop roads is rather low, while there are a dynamically growing number of motor vehicles.

Concentrations of studied air pollutants in industrial zone 3 differ significantly from the two other industrial zones. The probability of correspondence of the values of industrial zone 1 and 2 is 95%. Concentrations in the residential and recreational zones are quite different; additionally they are characterized by different concentrations as well.

Measurement days were divided into a summer (from 1 April to 1 October) and a winter (from 1 October to 1 April) group. These two groups were compared also in order to trace seasonal courses.

In Fig. 5 seasonal course of SO_2 concentrations is presented. The horizontal line shows the Ukrainian threshold limit.

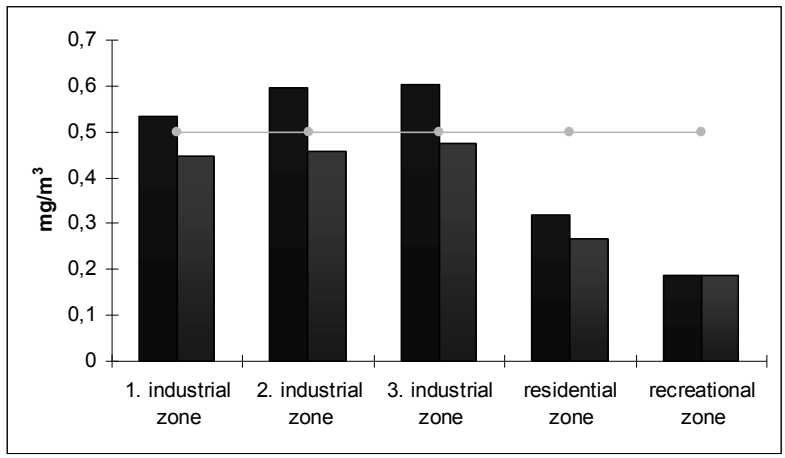

Fig. 5. Comparison of the seasonal average SO_2 concentrations at the five monitoring sites in Beregszász in the period between 1995–2007 (the horizontal line shows the Ukrainian threshold limit. left columns: winter, right columns: summer season)

Table 4. Comparison of the seasonal average SO_2 concentrations at the five monitoring sites in Beregszász on the base of the values of the Student t-test. Values printed in bold show significant relationships

	1. industrial zone	2. industrial zone	3. industrial zone	residential zone	recreational zone
SO_2	**2.482**	**3.145**	**2.608**	**1.999**	0.682
NO_2	0.944	1.158	1.905	0.762	1.604
Aerosol particles (PM)	1.039	0.983	1.522	**2.613**	1.140

It is clear from Fig. 5 that exceeding of the threshold limit occurs mainly in the winter. According to the Student t-test there are significant differences between the two seasons with the exception of the recreational zone. Higher winter concentrations can be explained by heating, since the main source of SO_2 in the atmosphere is the burning of fossil fuels with high Sulphur content like coal and oil

In Fig. 6 seasonal course of NO_2 concentrations is presented. The horizontal line shows the Ukrainian threshold limit.

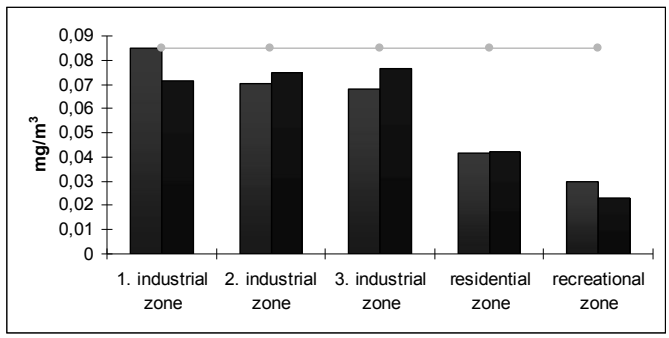

Fig. 6. Comparison of the seasonal average NO_2 concentrations at the five monitoring sites in Beregszász in the period between 1995–2007 (the horizontal line shows the Ukrainian threshold limit. left columns: winter, right columns: summer season)

According to Fig. 6, there is not any exceeding of the threshold limit in the case of NO_2. The significance analysis has showed not any significant seasonal differences. The diagram shows slightly higher winter concentrations of NO_2 what can be attributed to the heating season. Motor exhaust contains high amounts of NO_2, what can be the cause of the higher concentrations in industrial zone 1 in the summer, since it is situated near a road what is among the busiest roads in Beregszász *(Natiolnal Health Service, Beregszász, 2007)*.

In Fig. 7 seasonal course of particulate patter (Aerosol particles) concentrations is presented. The horizontal line shows the Ukrainian threshold limit. The diagram shows remarkable exceeding of the threshold limits in the industrial zones in both seasons. Additionally, there are high concentrations of particulate matter in the air in the residential zones in the summer as well. Seasonal differences what are significant according to the t-test, could only be found in the residential zone. Main sources of aerosol particles in ambient air beside natural processes are heating, waste incinerating, traffic and low quality roads.

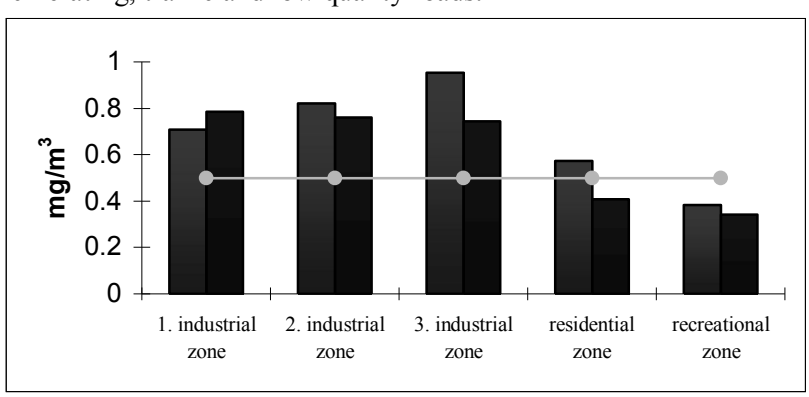

Fig. 7. Comparison of the seasonal average PM concentrations at the five monitoring sites in Beregszász in the period between 1995–2007 (the horizontal line shows the Ukrainian threshold limit. left columns: winter, right columns: summer season)

4. Conclusions

On the base of the average concentrations of the SO_2, NO_2 and particulate matter, it was found that according to the hypothesis, higher concentrations have been found in the three industrial zones. There are several exceeding of the threshold limits in the case of SO_2 particulate matter.

Seasonal courses have been traced on the summer (from 1 April to 1 October) and a winter (from 1 October to 1 April) data sets. In the case of SO_2 higher winter concentrations have been found, while the opposite situation has been found in the case of particulate matter concentrations. There have not been any significant seasonal differences in the case of NO_2. High concentrations of particulate matter (highly over threshold limits) pose the most serious problem, along with the winter averages of SO_2 concentration.

These are the first results of the research presented here. The next step is to analyze the relationships between concentrations of the air pollutants and the changes of meteorological conditions.

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[1} www.cor.eu.int - downloaded: 26th April 2006.