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Air pollution by nitrogen oxides in Sarajevo from 2005 to 2010

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ABSTRACT

Introduction: Air pollution occurs when the concentration of certain substances (pollutants) reaches a size which causes its toxicity, or in other words, begins to cause harm to human health, flora and wildlife.

Methods: Measurements were performed in the period from 2005 to 2010, at the measuring point Bjelave-Sarajevo by the method of Griess-Saltzmann. It encompasses the following parameters: NO, NO2, NOx, measured concentrations of pollutants in the atmosphere reduced to normal atmospheric conditions of 293 K (Kelvin) and pressure of 101.3 kPa (kilopascal).

Results: NO concentration in the period from 2005 to 2008 was above the permitted value, but the results of research in the period between 2009 and 2010, have shown that there was a decrease in NO concentration in the atmosphere. Measurements show that the concentration of this pollutant is currently declining, which is a positive result compared to the pollution of the atmosphere by nitrogen monoxide. Furthermore, the results of the research showed that the concentration of NO2 for the period of 2005 to 2010, is in the limited values, and that has a decreasing trend, which is also a positive result compared to the pollution of the atmosphere by nitrogen dioxide. Related to the total concentration of NOx in the atmosphere, the results of the research show that their representation corresponds to the limit values existing in the Rulebook on limit values for air quality.

Conclusion: The results of the research for the pollution of the atmosphere by nitrogen oxides in the investigated area show that the amount of nitrogen oxides in the atmosphere is in constant decline.

Keywords: atmosphere, pollution, nitrogen, nitrogen oxides.

INTRODUCTION

The environment is a specific medium in which easiest thing is recognizing negative human activities (1). Therefore, the increase in public interest in thematic areas of protecting the nature and improvement of environmental conditions is apparent. Development of awareness of the citizens is evident through increased interest in environmental activism with goal of solving general and specific problems. Most of the pollutants that pollute the atmosphere originate from industrial activities, but a significant part originates from the traffic (2). Before the war in our

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country, industry was the most significant air pollutant. Most industrial plants have stopped operating during the war and still have not reached pre-war level. As a result, it is expected that the pollution of the atmosphere is now much lower. Environmental sustainability implies that the degree of pollutants that are emitted, do not overcome the ability of air, water and land to absorb and process them (3). At the same time this implies a permanent conservation of biological diversity, human health, and the quality of air, water and land, according to the standards that are still sufficient for the life and well-being of people, and the preservation of flora and fauna (4). Air pollution is created by emissions of harmful gaseous and particulate matters, usually as a result of human activity, but also from the emissions from natural sources (5). During the burn of the fuel in all furnaces and engines, formation of nitrogen oxides at high temperatures occurs (6). In addition to the two basic components that make up the atmosphere: oxygen (circa 20%) and nitrogen (circa 78%), small amounts of gases, vapors and particles are naturally present in the atmosphere (7). If in the air, same or other components in concentrations which are higher than naturally present concentration occur, then we have the pollution of air appearance. This phenomenon came to the expression in the previous and current century due to the rapid development of industry, energetic and traffic. Allowed NOx emissions from power plants (fireboxes) depends on the fuel type and the capacity of the firebox, and that is prescribed by the legislation on permitted emissions into the environment, the Air Protection Act (Sl. Novine FBiH, No. 33/03) (8). Air pollution occurs when the concentration of certain substances (pollutants) reaches a size that affects its toxicity, or in other words, begins to cause harm to human health, flora and fauna (8). Nitrogen oxides are binary compounds of nitrogen and oxygen, which are: nitric oxide, NO, nitrogen dioxide, NO2; dinitrogen trioxide, N2O3; dinitrogen tetroxide, N2O4; dinitrogen pentoxide, N2O5 (9). Among them, there is the nitrous oxide N2O known as "laughing gas" or "heavenly gas." Although nitrogen oxides make up a large group, the expression NOX is commonly used for a mixture of NO and NO2, which are considered major polluters of the atmosphere. These two nitrogen oxides occur from fossil fuel combustion, especially at high temperatures over 1000 ° C (10). The aim of this study was to determine the pollution of the atmosphere caused by nitrogen oxides NO and NO2 in Sarajevo from 2005 to 2010, and based on the obtained results, suggest preventive measures that affect the reduction of atmospheric pollution by nitrogen oxides.

METHODS

Concentration of nitrogen oxides NO and NO2 and total nitrogen oxides NOx was determined by the Griess-Saltzmanna method, with the help of automatic station for measurement. Method by Griess-Saltzmanna is based on standard techniques of collecting samples in the absorbing solution, in which the nitrogen is determined spectrophotometrically. The air is vacuumed through the absorbing solution, which was consisted of sulfanilic acid. Nitrogen dioxide from the air first reacts with sulfanilic acid forming diazonium salt. That salt combines with the N-(l- naphthyl)-ethylene-diamine-dichloride giving an intense red-purple color, from which the concentration is directly proportional to the concentration of NO2 concentration. Due to the rapid formation of the color, sampling time is not more than 30 minutes. The method is suitable for determining the concentration of atmospheric NO2 - oxide from 40 to 1500 g/m^3. This method is adapted to the automatic analysis used by the automatic station Bjelave. Also, this method determines NOx, in other words; sum of NO + NO2, with condition that the sample was previously released through the KMnO4 solution which performs the oxidation of NO to NO2. Calculated concentrations of NO and NO2 in the atmosphere are reduced to normal atmospheric conditions of 293 K (Kelvin) and pressure of 101.3 kPa (kilopascal).

Displayed values for nitrogen oxides (24 - hour samples) obtained by this method are compared with the limit values prescribed by the Regulation on limit values for air quality (11). The study used the data from the Federal Hydrometeorological Institute BiH in the period from 2005 to 2010.

RESULTS

In accordance with the established dynamics and methodology of the research, measurement of atmo-

TABLE 1. Limit values (LV) of air quality in order to protect human health

Polluting substance	Sampling period	The average annual value (μg/m^3)	High value (μg/m^3)
SO_2	1 hour	90	500 [a]
SO_2	24 hours	90	240 [b]
NO_2	1 hour	60	300 [c]
NO_2	24 hours	60	140 [b]
LČ 10	24 hours	50	100 [b]
ULČ	24 hours	150	350 [b]
dim	24 hours	30	60 [b]
CO	8 hours		10.000
O_3	8 hours		150 [d]

[a] must not exceed more than 24 times in a calendar year.
[b] must not exceed more than 7 times in a calendar year (98th percentile).
[c] must not exceed more than 18 times in a calendar year.
[d] must not exceed more than 21 times in a calendar year (98th percentile)

TABLE 2. Limit values (LV) of air in order to protect the ecosystem are:

Polluting substance	Sampling period	The average annual value (μg/m^3)	High value (μg/m^3)
SO_2	calendar year and winter	20 [a]	-
NOx	calendar year	30	-
O_3	Five years	18000 [b]	-

[a] must not exceed more than 24 times in a calendar year.
[b] must not exceed more than 7 times in a calendar year (98th percentile).

TABLE 3. Statistical overview NO concentration μg / m³ (hourly samples) Sarajevo-automatic station Bjelave

CONCENTRATIONS	PARAMETAR NO (μg/m^3)					
	2005	2006	2007	2008	2009	2010
Csr	43	35	39	35	20	27
Cmax	692	526	434	523	258	180
C-50	24	17	21	19	10	21
C-95	146	143	139	125	72	56
C-98	249	226	207	189	120	77
C-99.9	506	415	396	392	212	153
% of valid samples	98,22	99,35	91,75	93,81	97,75	80,43
Number of samples taken	8604	8703	8037	8240	8563	7046

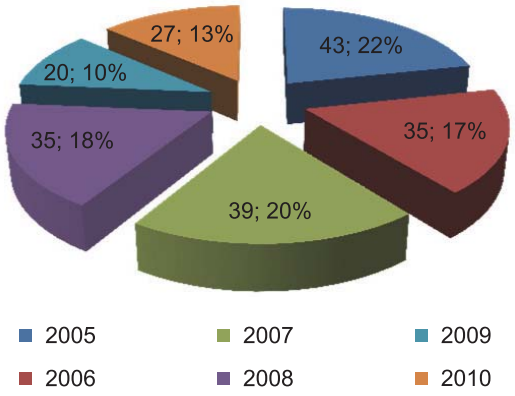

FIGURE 1. Average annual concentrations of NO automatic station Bjelave

spheric pollution by nitrogen oxides was conducted in Sarajevo at the measuring station Bjelave period from period of 2005th to 2010th year. All data are appropriately processed and presented in tables and graphs. The results are compared with the limit values prescribed by the Rulebook on air quality (GV) in aim to protect human health (Table 1) and the limit values of air (GV) in order to protect the ecosystem (Table 2).

By using automatic station Bjelave, concentrations of pollutants NOx, NO2, NO, are obtained, which are presented as the mean annual value-CSR maximum hourly value-Cmax and percentile values-C-50, C-95, C-98, C-99.9. Percentile values indicate the number of exceeding concentration of some pollutant in a specified number of hours in a year. In the course of one year is 8760 hours, and the C-50 = 4380 hours, C-95 = 438 hours, C-98 = 175 hours = 99.9 C-9 hours. In the stated tables, number of samples taken in the course of one year is given, as well as the percentage of valid samples (Source: Automated station Bjelave - Sarajevo).

In Table 3, the highest maximum concentration value is measured in year 2005 and amounted was 692 g/m^3 and the maximum measured mean value of nitric oxide was 43 g/m^3 and it was measured in year 2005. Shown values of NO concentration in Table 3 do not meet the limit values prescribed by the Rulebook on limit values for air quality.

In Table 4 we see that in 2005 the highest maximum concentration of nitrogen dioxide was measured and

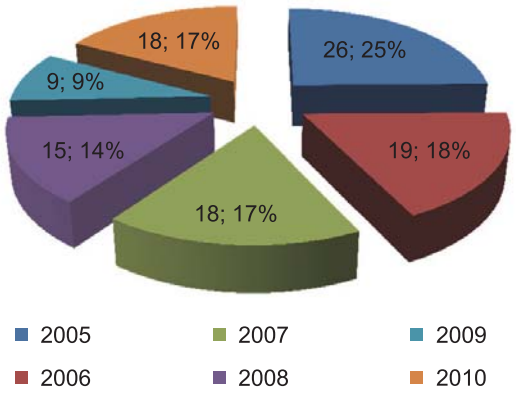

FIGURE 2. Annual average concentration of NO2 automatic station Bjelave

TABLE 4. Statistical overview of NO_2 concentrations µg / m³ (hourly samples) Sarajevo-automatic station Bjelave

CONCENTRATIONS	PARAMETAR NO_2 (µg/m³)					
	2005	2006	2007	2008	2009	2010
Csr	26	19	18	15	9	18
Cmax	299	187	165	137	168	119
C-50	17	12	14	12	7	16
C-95	81	63	47	38	25	30
C-98	122	93	63	53	33	37
C-99.9	250	145	129	122	66	59
% of valid samples	98,14	99,03	92,42	93,83	97,82	80,43
Number of samples taken	8597	8675	8096	8242	8569	7046

TABLE 5. Statistical overview of the concentration of total nitrogen oxides NOx (hourly samples) Sarajevo-automatic station Bjelave

CONCENTRATIONS	PARAMETAR NOx (µg/m³)					
	2005	2006	2007	2008	2009	2010
Csr	43	35	39	35	20	19
Cmax	692	526	434	523	258	255
C-50	24	17	21	19	10	10
C-95	146	143	139	125	72	65
C-98	249	226	207	189	120	115
C-99.9	506	415	396	392	212	210
% of valid samples	98.22	99.35	91.75	93,81	97,75	95,75
Number of samples taken	8604	8703	8037	8242	8563	8553

it was 299 g/m³, as well as the largest annual mean concentration which was 26 g/m³. The minimum values were measured in the 2010 year. Cmaxwas 119 g/m³, while in the year of 2009 Csr was 9 g/m³.

Shown concentrations of NO2 shown in the Table 4 correspond to limit values prescribed by the rulebook.

In the Table 5, we see that in the 2005, the highest concentrations of nitrogen oxides was measured, in the reporting period. The maximum concentration of NOx was 692 g/m³ and the average concentration was 43 g/m³.

Shown concentrations of total nitrogen oxides in Table 5 correspond with the values specified in the Rulebook on air quality values limit.

Chart 1 shows the average annual concentration of NOµg/m³ forthe period of 2005 to 2010. From the shown chart we can see that the highest concentration of NO was in 2005 and it was 43.22%, however, the lowest was measured in 2009 and it was 20.10%.

In the Figure 2, we can see that the average annual concentration of NO2µg/m³ for the period of 2005 to 2010. From the given chart we can see that the highest concentration of NO2 was in 2005, and it was 26.25% and the lowest in 2009 amounted to 9.9%.

DISCUSION

This paper presents the results of research of pollution of the atmosphere by nitrogen oxides in the Sarajevo area. Measurements included the period from 2005 to 2010 at the meteorological station at Bjelave. For grading the state of the pollution of the atmosphere by nitrogen oxides analysis of the following parameters were performed:

- Nitric oxide, NO
- Nitrogen dioxide, NO_2
- The total nitrogen oxides NOx

By analysis of the concentration for nitric oxide, we can see that the highest maximum and the highest average annual value of the concentration was measured in 2005. The highest measured value of nitrous oxide was 692µg/m³. Average annual nitrogen oxide value is 43µg/m³, which is more than the

limit value of 40 μg/m^3. Obtained concentrations of nitrous oxide did not meet the limit values that were prescribed by the Rulebook on limit values for air quality. Concentrations of nitrogen dioxide matched the limit values prescribed in the Rulebookon GV air quality. In 2005, the highest measured maximum concentration of nitrogen dioxide was 299 μg/m^3, and in 2005, the measured maximum annual mean concentration was 26 μg/m^3. The minimum values were measured in 2010. Cmax was to 119μg/m^3, and in 2009Csr was9 μg/m^3 in.

Concentrations of total nitrogen oxides did not exceed the prescribed GV Rulebook on air quality for the entire observed period. In the 2005, the highest concentrations in total nitrogen oxides were measured. Maximum NOx concentration was 692 μg/m^3, and the average concentration was 43 μg/m^3.

CONCLUSION

Based on the research results of pollution of the atmosphere by nitrogen oxides in the measuring station Bjelave area, we came up with the following conclusions:

Concentration of NO in the period from 2005 to 2008 was above the allowed value, but in the period since 2009 to 2010, there was a decline in the concentration below the limit value.

Concentration of NO2 in the period from 2005 to 2010 was in limit values and had a decreasing trend, which is also a positive result compared to the pollution of the atmosphere.

Given the above, conclusion is that the concentration of nitrogen oxides, in the atmosphere of the investigated area, is in the allowed value margins prescribed by the Rulebook on limit values for air quality, and the amount of nitrogen oxides in the atmosphere of the area is in a constant decline.

In order for conditions of living and working in Sarajevo, on the issue of pollution of the atmosphere by nitrogen oxides to be enhanced it is necessary to modernize and diversify monitoring atmospheric pollution by nitrogen oxides and to improve the quality of traffic in selection of vehicles on the roads, by checking the quality of fuel and the use of green fuels.

COMPETING INTERESTS

The authors declare no conflict of interest

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