Correlations on the Air Nitrogen Oxides Pollutant Concentration and Climatic Factors Variations in Bacau City

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Considering the air pollution actual issues, in special for the industrial cities, in the present paper were established some correlations between NOx concentration and some climatic factors. The data were obtained from Bacau air quality monitoring stations and are related to 2011. The climatic factors analyzed were air temperature, atmospheric pressure, atmospheric humidity, solar radiation, wind speed and direction. The data interpretations reveal some direct influence of the air NOx concentration dispersion and analyzed climatic factors variation.

Keywords: NOx pollutant concentration, air pollution, climatic factors

Air pollution is an actual and very important issue, evaluated from many points of view in natural and anthropic areas. In the cities, even we refer to large metropolis or small localities, the air pollution is put in the correlation with the human live quality, sustainable development, new concept of smart cities etc. At the bases of these aspects are the management of air pollution sources and monitoring infrastructure of the localities.

In urban area, air quality is directly influenced by the type and size of industrial activities, wastes management and all categories of traffic. In the cases of good cities air pollution management plans, the air pollution can be reduced by using strategies to corelate some important influenced factors as: green areas, buildings and population density, roads infrastructure, geographic and climatic conditions [1-11].

The diffusion of pollutants in the atmosphere are influenced by many factors and it is very important to establish the dependency of these and the locality particularities. The climatic factors variation may influence the air pollution dispersion in many cases and polluting categories (SO_2, NH_3, NOx etc.) [11-20].

From all categories of air pollutants compounds the nitrogen oxides (NOx) is very present in urban areas in general because of intense traffic. The nitrogen oxides can cause acid rain with direct influence on other pollution type. Nitrogen dioxide (as a gas) is very toxic both to humans and animals (the nitrogen dioxide toxicity degree is greater than four times in comparation with nitrogen monoxide. In some cases, the urban air quality is based on the NOx pollutants concentration variation [16-27].

Many studies analyzed the influence of some climatic factors and air pollution. In the most of these the air quality in urban area is continuously monitored by using different methods [4-25]. Also, the literature present correlations between some climatic factors, air pollution and human health. The synoptic climatologically conditions influences the NOx air concentration variation in special where the negative effects of traffic are obvious [6-11].

The most used methods for monitoring urban pollution are on-line sensors, positioned by using a specific plan for observing the variation of the concentration of pollutants in all cases of continuous and accidental pollution [6-20].

The present paper aims to establish some correlations between NOx air concentration variation and some climatic factors: temperature of the air, air pressure and humidity, solar radiation, the wind speed and direction. We use data recorded in 2011 by Bacau automatic air quality monitoring stations and regional meteorological station. The data interpretations evidenced some direct influence of the climatic factors to NOx air concentrations variation with Bacau City particularities (the city infrastructure and position).

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Experimental part

For the present study were used data performed by two automatically air quality monitoring stations placed into representative area of Bacau City: one in the City Center (BC1) and the second in the industrial part Bacau Station 2 (BC2) (Fig. 1).

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Fig. 1. Bacau City air quality monitoring stations [28]:
a. Bacau City center station (BC1);
b. Bacau industrial area Station 2 (BC2)

Both stations are part form the Romanian air quality monitoring plan (National Network for Automatic Air Quality Monitoring with 142 stations) a complex system with continuous monitoring of: sulfur dioxide (SO^2), nitrogen oxides (NO_2/NO_X), carbon monoxide (CO), ozone (O_3), powders in suspension (PM10 and PM2.5), benzene (C_6H_6) heavy metals (lead, cadmium, nickel, arsenic, mercury) and polycyclic aromatic hydrocarbons (Fig. 2) [8].

The data related to NO_X and 2011 were put into correlations with meteorological data obtained from the Bacau meteorological station (automatically station Vaisala MAWS 301 type). According to Romanian standard procedures the meteorological data were part of a global weather data [8].

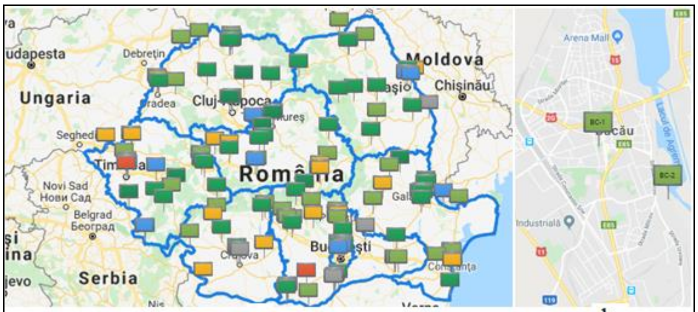

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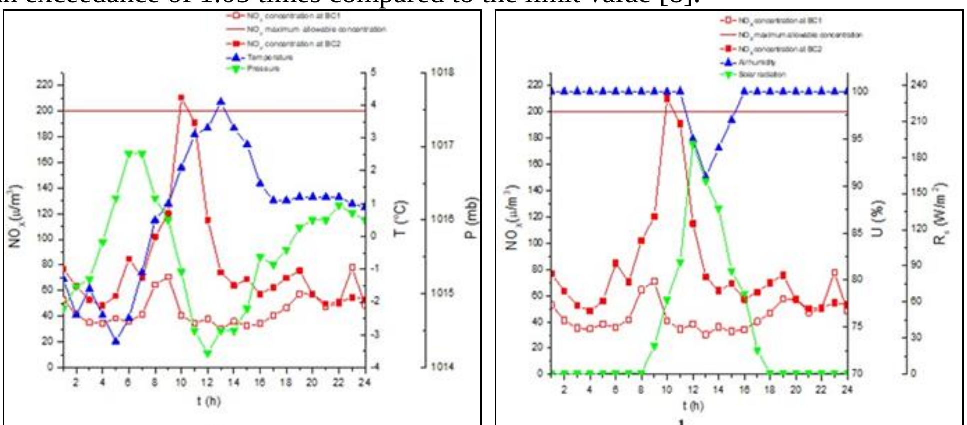
Fig. 2. Romanian air quality monitoring network: a. National air quality stations positions; b Bacau City air quality stations positions [28]

The analyzed climatic factors were air temperature, atmospheric pressure, atmospheric humidity, solar radiation, wind speed and direction. For data interpretation was considered the maximum allowable NOx concentrations related to 2010 (200 μg/m^3) according with Romanian Regulation.

The NOx concentrations and the climatic factors analyzed were correlated by considering some specific factors of influence, respectively: the NOx concentrations with air temperature and pressure; NOx concentrations correlated with air humidity and solar radiation; NOx concentrations corelated with wind speed and direction [8].

Results and discussions

During 2011 seven exceedances of the air nitrogen oxides maximum allowable limits concentration were recorded. The first exceedance was reported on 14.01.2011 (Fig. 3), at Bacau Station 2, respectively 210.36 μg/m^3, which corresponds to an exceedance of 1.05 times compared to the limit value [8].



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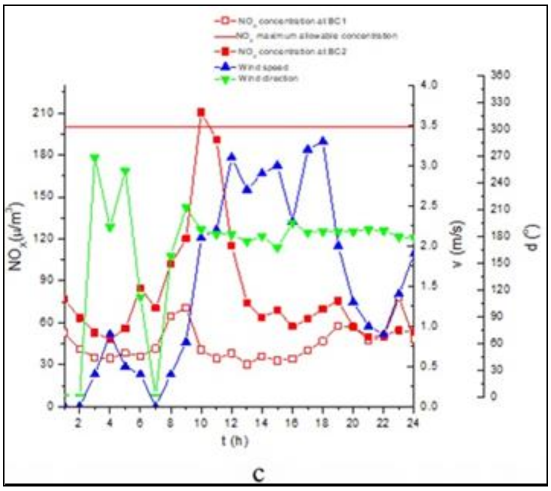
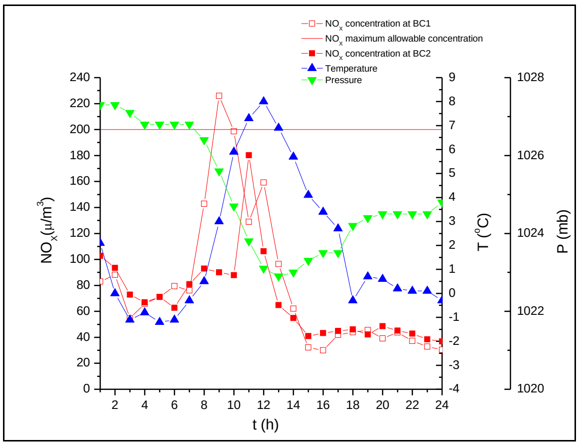


Fig. 3. NOx concentration over 24 h on 14/01/2011 at air quality monitoring stations BC1 and BC2 corelated with: a. air temperature and pressure; b. air humidity and solar radiation; c. wind speed and direction

At Bacau Station 1, the nitrogen oxides concentration was exceeded for three hours interval, from 09.00 to 11.00, presenting a maximum value of 273.9 µg/m^3, which corresponds to an exceedance of 1.36 times of the allowed limit. The pollutant dispersion was done in three hours at Bacau Station 2 and, during four hours at Bacau Station1 area.

The meteorological context was characterized by thermal values with 2°C higher than the climatological specific of January and the atmospheric pressure decreased by 2.8 mb, but it remained above the normal values. The wind was weak to moderate in the southern sector with values up to 3.1 m/s, humidity was high with values over 90%. This context of sky covering, high humidity and a pressure decrease, caused the high concentration of nitrogen oxides during the monitored intervals [8].

Another exceedance of the maximum allowable limit was registered on 18.01.2011, at Bacau Station 2 (Fig. 4). The maximum recorded value was 225.99 µg/m^3, (at 09.00), which corresponds to a 1.12 times exceedance of. At Bacau Station 1 the variations of the oxide concentrations were insignificant.



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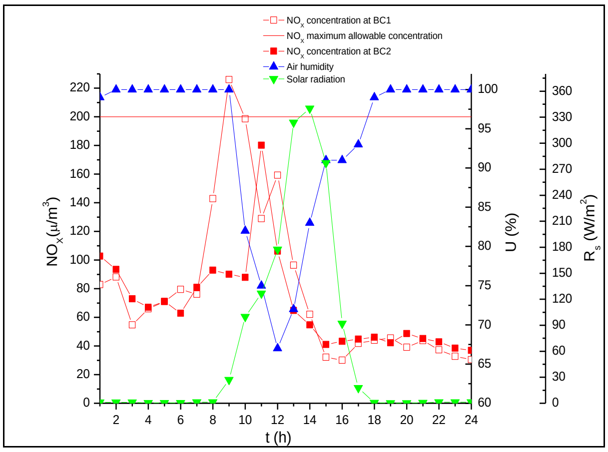

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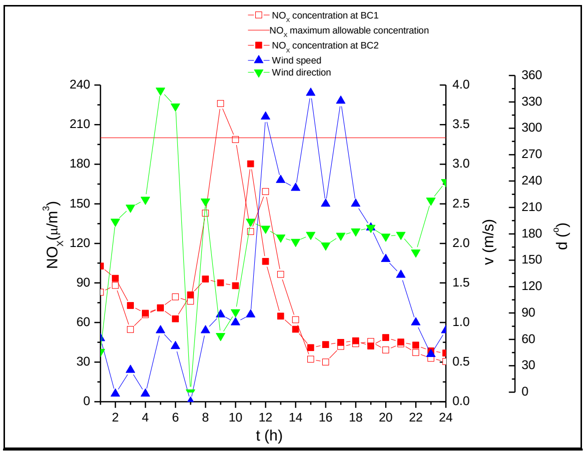

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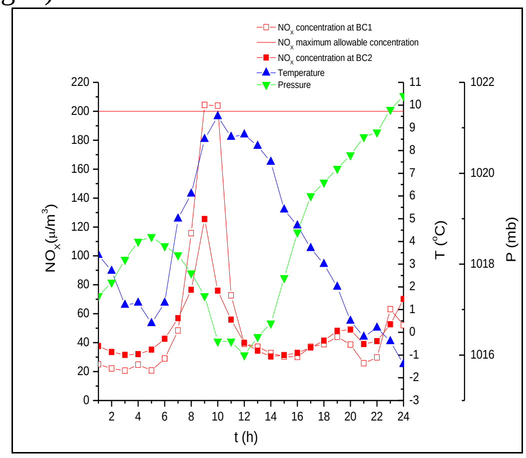
Fig. 4. NOx concentration over 24 h on 18/01/2011 at air quality monitoring stations BC1 and BC2 corelated with: a. air temperature and pressure; b. air humidity and solar radiation; c. wind speed and direction

The decrease of nitrogen oxides concentration at the initial value was achieved in five hours. During this time the air was supersaturated until 12:00 (the presence of fog), then the humidity dropped to 80%. The air temperature increased until 3 pm, when the maximum value of 8°C was recorded, then decreased from one hour to another. The atmospheric pressure had high values but decreased with 3 mb from 1026.8 mb to 1023.8 mb. The wind was generally weak until 9 am and then gradually increased in intensity from the southern sector, to average values of 3.6 m/s at 2 pm. These meteorological variations overlap with pollutant concentration decreasing.

On 09.02.2011 at the Bacau Station 1 monitoring the maximum allowable limit for nitrogen oxides was exceeded for two hours, with a maximum at 09.00, amounting to 204.33 µg/m^3, which corresponds to a 1.02 times exceedance (Fig. 5).



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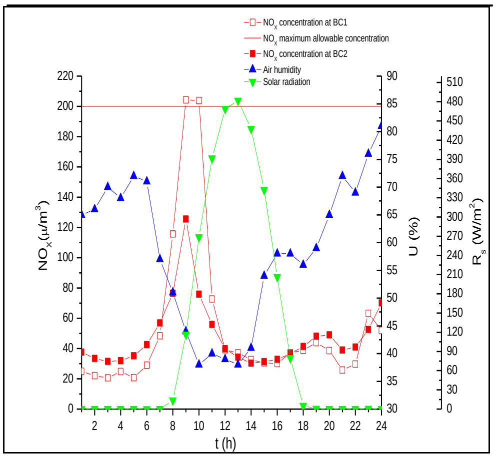

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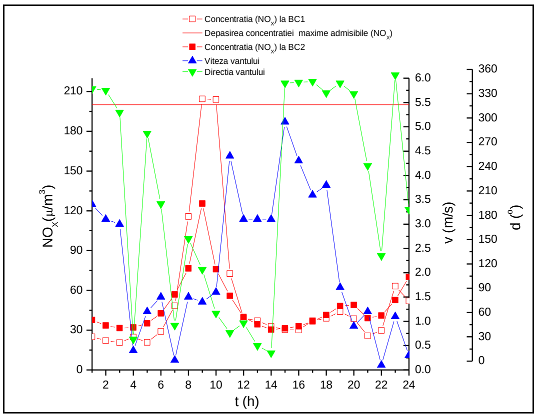

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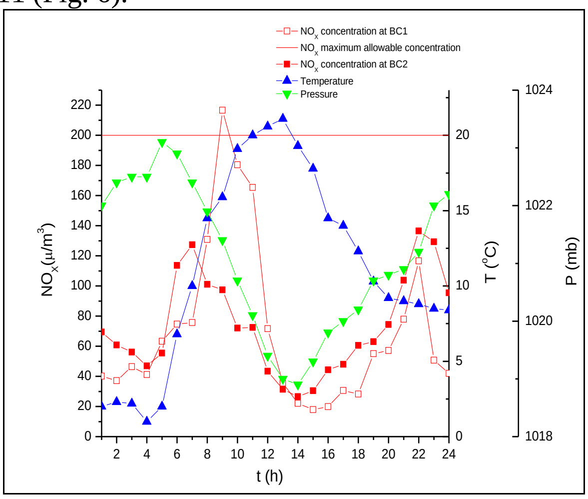
Fig. 5. NOx concentration over 24 h on 09/02/2011 at air quality monitoring stations BC1 and BC2 corelated with:
a. air temperature and pressure;
b. air humidity and solar radiation;
c. wind speed and direction

At the same time at Bacau Station 2 there was an increase in concentration, but that did not exceed the maximum allowable value. During this time the atmospheric pressure decreased by 2.4 mb but remained above the normal value (1016mb). The air temperature increased from one hour to another, to the maximum value of 9.5°C (at 13.00), then it went down. The sky was clear and, the atmospheric humidity dropped from 70% at sunrise to 30% at noon. The wind increased from one hour to another in the East-Nord-East sector, up to an hourly average of 4.4 m/s. In this meteorological context, clear sky, low humidity and air pressure variation, the pollutant concentration decreased in two hours [8].

Continuous measurements performed at the two air quality monitoring stations recorded only one maximum allowable limit overrun at Bacau Station 1, related to air nitrogen oxides, respectively 216.59 µg/m^3 at 09.00 in 15/03/2011 (Fig. 6).



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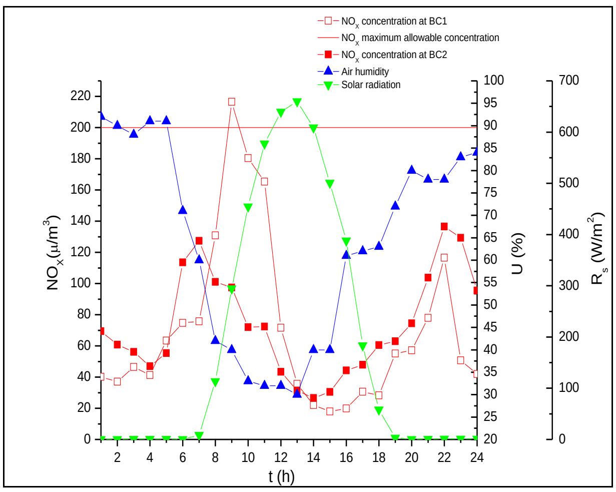

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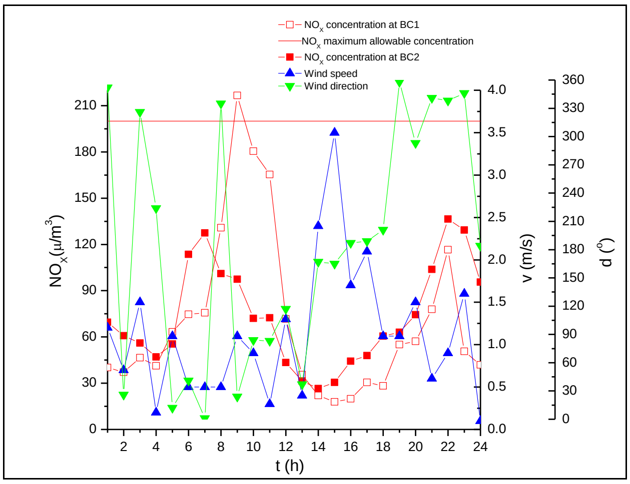

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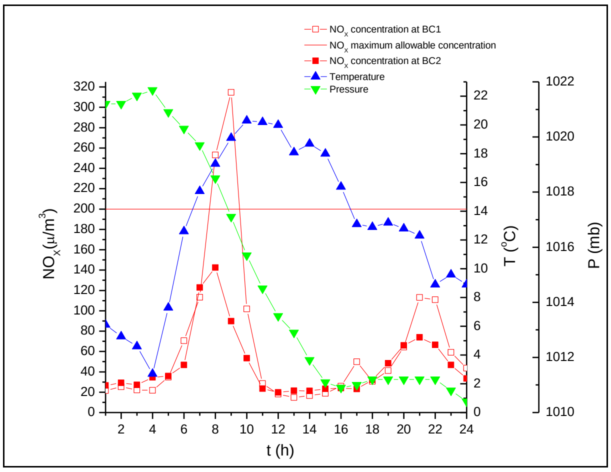
Also, we identified that the nitrogen oxides concentration decreases in four hours, under the following weather conditions: variable sky, high temperatures above 10°C (compared to the climatological norm), a low atmospheric humidity (30%), the wind increased from one hour to another in the South-Western sector, (an average values of 4.8 m/s) and atmospheric pressure values between 1020 ÷ 1018 mb.

The air nitrogen oxides concentration decrease was realized in two hours, under the following weather conditions: variable sky, high temperatures, above 8°C (compared to the climatological norms), a low atmospheric humidity of 20%, slow South-West direction wind, air pressure values between 1020.9 ÷ 1018.5 mb.

Another maximum allowable limit overload of the air nitrogen oxides was registered on 25.03.2011 at Bacau Station 1 (314.61 μg/m^3 value) (Fig. 7).



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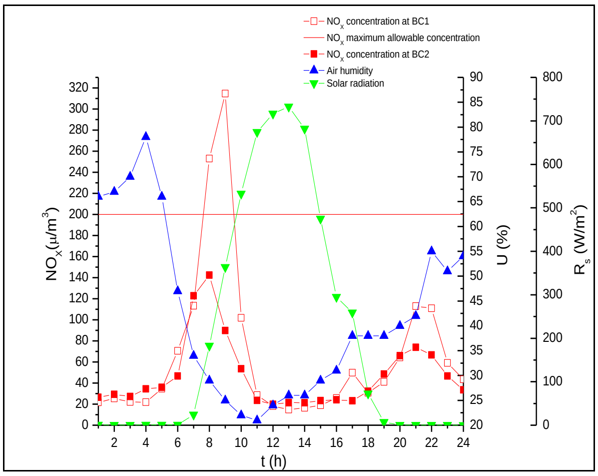

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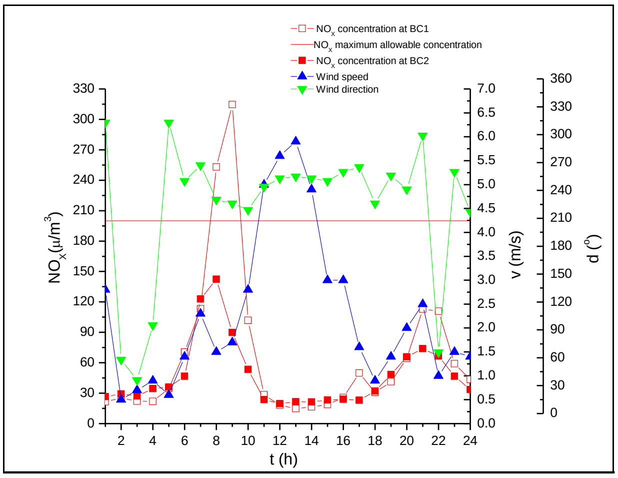

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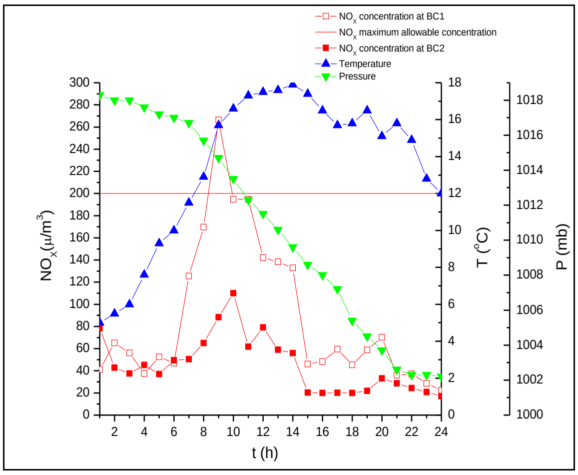
Fig. 7. NOx concentration over 24 hours on 25/03/2011 at air quality monitoring stations BC1 and BC2 corelated with:
a. air temperature and pressure;
b. air humidity and solar radiation;
c. wind speed and direction

The air nitrogen oxides concentration decrease was realized in two hours, under the following weather conditions: variable sky, high temperatures, above 8°C (compared to the climatological norms), a low atmospheric humidity of 20%, slow South-West direction wind, air pressure values between 1020.9÷1018.5 mb.

The last maximum allowable limit, related to nitrogen oxides, from 2011, was recorded on 07.04.2011 (Fig. 8), at Bacau 1 monitoring station, respectively 266.48 μg/m^3.

The nitrogen oxides concentration value decrease in five hours, under some specific meteorological conditions: covered sky, temperatures, above 8°C (a high value compared to the climatological norms of the period), a relatively high atmospheric humidity of 60%, slower wind and atmospheric pressure values between 1017.6 ÷ 1013.5 mb [8].



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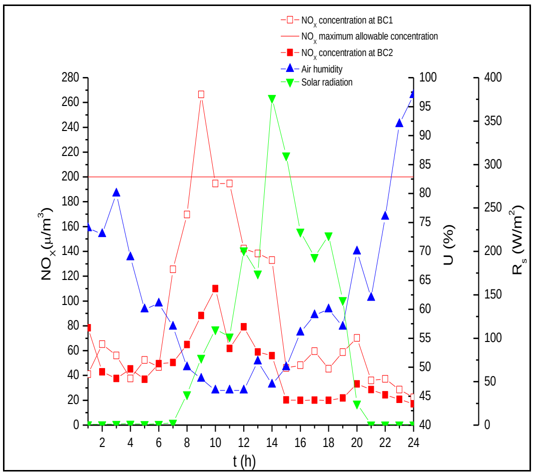

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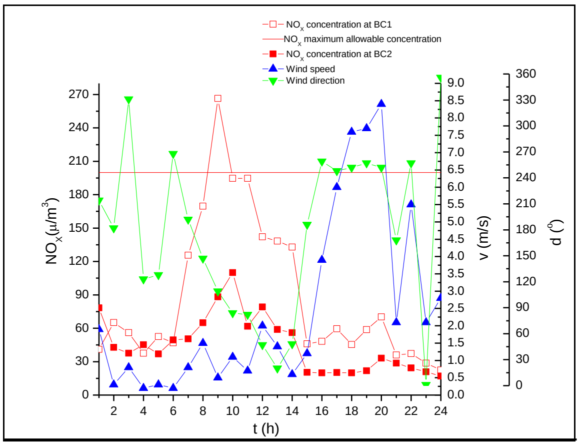

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Fig. 8. NOx concentration over 24 hours on 07/04/2011 at air quality monitoring stations BC1 and BC2 corelated with:
a. air temperature and pressure;
b. air humidity and solar radiation;
c. wind speed and direction

Conclusions

By analyzing air NOx concentrations variation from 2011 in Bacau City we can observe that the maximum allowable limit was exceeded during cold season.

For Bacau City, the fog is a frequent phenomenon during transitory and cold seasons with high air humidity in some day's intervals. Also, for the analyzed period it was observed that air quality and pollution dispersion can be influenced by atmospheric pressure variation.

The air relative humidity can influence the pollutant dispersion. In our cases, this aspect was evidenced during cold period, when the flog phenomenon is specific for Bacau City.

For the analyzed interval it was observed that NOx concentration overruns, at Bacau air quality monitoring stations, appear during interval 8 to 12 AM. These overruns can be the consequences of Bacau industrial hourly activities but also the road traffic intensity increasing can influence the recorded data.

Even if the NOx concentration overruns were recorded during cod season, it was observed that air temperature increasing determine the air pollutant dispersion.

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