

STATISTICAL STUDY OF THE ATMOSPHERIC DISPERSION OF SULPHUR AND NITROGEN OXIDES AT THE STACK OF A SPECIAL WASTE INCINERATION PLANT LOCATED IN THE SOUTHERN PART OF TIMISOARA

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Abstract

This paper presents the zone maps resulted from the statistical processing of NO_x and SO_x emissions varying with the weather conditions. This study uses data from the nitrogen and sulphur oxides emissions monitoring collected in 2013-2016 from the on-line gas analyser with the incineration plant evacuation system, as well as hourly weather records for four parameters (atmospheric pressure, temperature, rainfalls, wind speed and direction) recorded at our own weather station in the same period.

The statistical calculation and zone map drawing software was performed by our team members.

Keywords: NO_x, SO_x, weather conditions, air quality, zone maps, statistical processing

1. Introduction

Sulphur oxides are released in the atmosphere by fossil fuel heating systems, thermal power plants, the cars in the heavily industrialized areas and other industrial processes [1, 2].

Nitrogen oxides are also produced by the solid, liquid and gas fuel combustion in industrial plants, commercial, institutional and residential activities and road transport. Sulphur and nitrogen oxide monitoring is regulated at European level and it is required by the toxic effects the oxides have when their concentration exceeds the allowable values [2, 3, 4].

Based on the data recorded in the analyzer that monitors the stack emissions of the special waste incineration plant located in southern Timisoara, a mathematical model for SO₂ and NO_x dispersion has been developed. The model includes the basic dispersion parameters: SO₂ and NO_x concentrations, temperature, rainfall volume, and wind speed and direction.

The data were retrieved with the CloseView software [5] that generates a graphic representation under the form of a coloured cone whose intensity varies with the toxic concentration of a certain spot.

The results obtained with the monitoring and control equipment were used as input data for the NO_x dispersion simulation. The model should approximate the NO_x distribution as a pollutant plume and the distribution dynamics as accurately as possible (fig. 1).

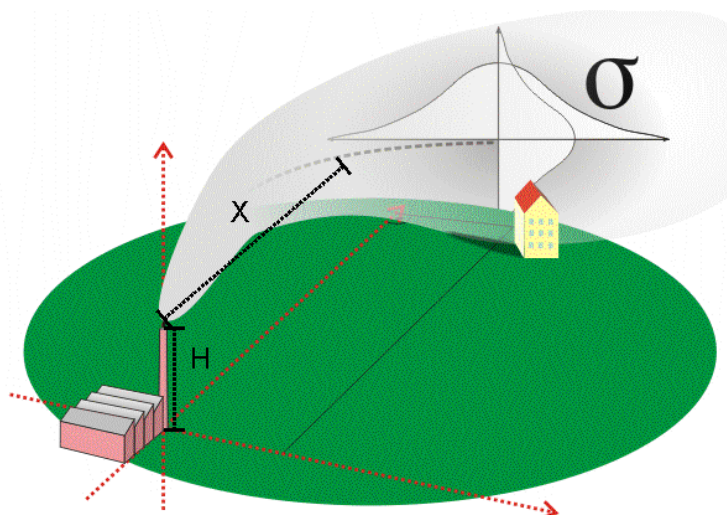


Figure 1. Gaussian distribution by wind direction

2. Material and methods

The data used for statistical processing were retrieved from the gas analyser mounted on the flue gas evacuation track. The automatic measurement equipment was calibrated on a daily basis.

The emission automatic monitoring equipment consists of the following:

I. **ENDA 600 Stationary Stack Gas Analyzer** - monitors the NO_x, SO₂, CO, CO₂, and O₂ emission concentrations in the flue gas released through the stack.

The calibrated measurement ranges are:

NO_x (0...200) mg/Nm³; NO_x (0...1000) mg/Nm³

SO₂ (0...200) mg/Nm³; SO₂ (0...1000) mg/Nm³

Table 1 summarizes the data of the measurement and control equipment of the incineration plant.

Table 1. Measurement and control equipment data

Parameter	Method	Analyzer
NO _x	NDIR	ENDA-600 CMA-680
SO ₂	NDIR	ENDA-600 CMA-680

The system takes measurements every two minutes and the data are sent to the central command and control unit. Based on the process programmes, this unit compares the received data with the acceptable values and adjusts the flow chart as required: increases/decreases the air flow rate in the combustion and post-combustion chamber ventilators; increases/decreases the lime and activated charcoal flow rate in the gas dry treatment phase and the water-air emulsion admission system in the flue gas conditioning phase during gas treatment; increases/decreases the gas exhauster flow rate of the stack; blocks/deblocks the waste feeding lock of the combustion chamber; opens the emergency stack at abnormal temperatures or increases the pressure of the gas evacuation track.

The measuring process continues at the stack. It is connected to the **automatic monitoring and control system of the plant**. This system acquires data continuously, every 15 seconds, and calculates average values every 2 minutes. The data are recorded both as the measured concentration and oxygen corrections. The averaging times for reports are 30 minutes, 1 hour, 24 hours, monthly and annually. Averaging at different intervals can be performed on request. The acquisition is redundant as it is performed in two different systems, with different data-collecting equipment. This ensures the continuous monitoring of the stack flue gas. At the same time, as the system is connected to the plant as control element, it provides automatic measures for preventing NO_x concentration increase in the flue gas.

3. Results and discussions

The NO_x and SO₂ measurements were taken at the stack of the incinerator located in the southern area of the city of Timisoara. The values recorded for three years, 2013 - 2016, were used to create the mathematical model for SO₂ and NO_x dispersion under the influence of weather factors. The major factors influencing the SO₂ and NO_x dispersion in the atmosphere are wind speed and direction, rainfall volume, atmospheric pressure and temperature. Although the analytical system records the data as momentary values at short intervals, this study required that the data should be processed statistically by daily and semester averaging.

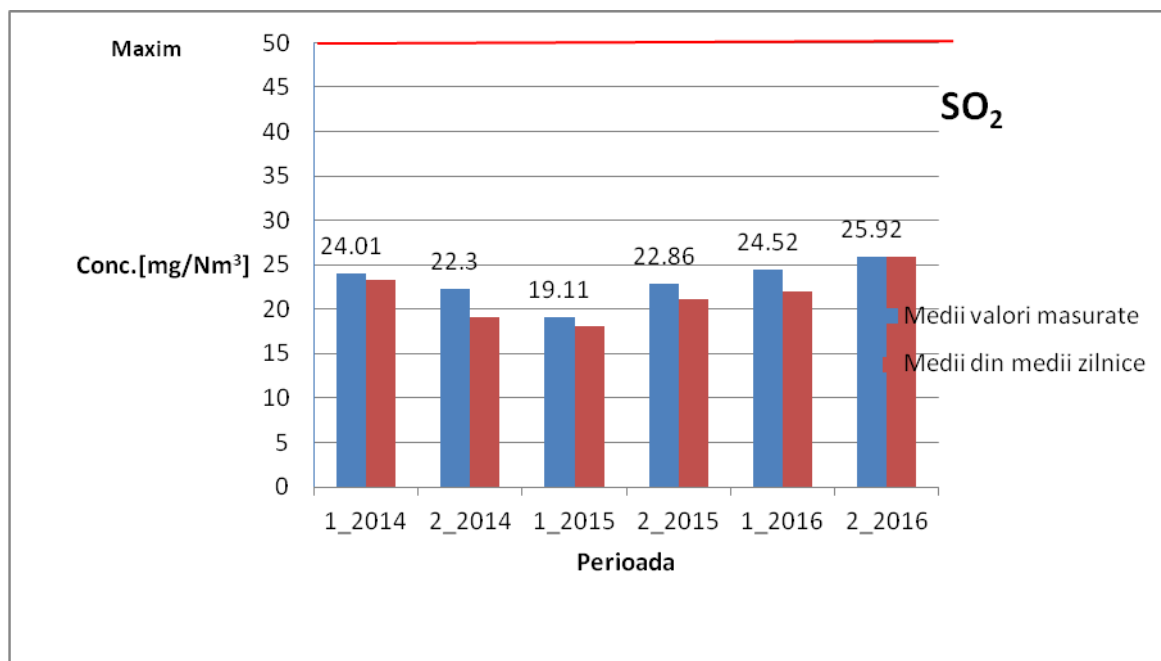


Figure 2. Graphic representation of SO₂ mean concentrations from mean values

As shown in figure 2, most concentration values in the monitored period are less than half the allowable maximum value for SO₂ emissions provided for in the current legal provisions.

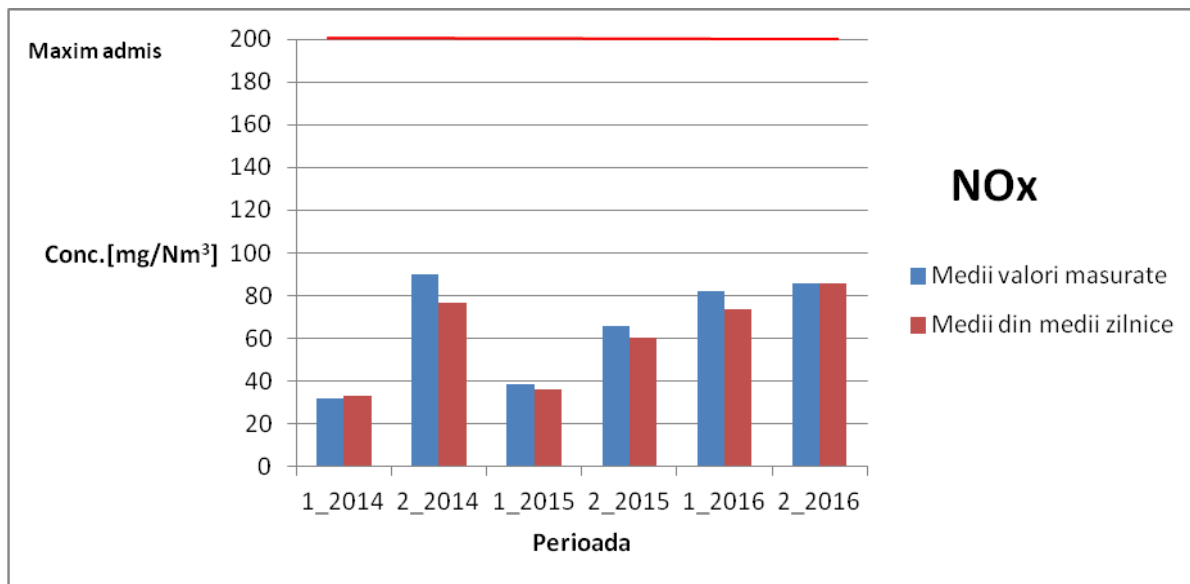


Figure 3. Graphic representation of NO_x mean concentration from mean values

The differences between the measured concentration means and the means calculated from the daily averages are caused by the variation in the composition of the waste menus, which differ from one day to another. The data on the nature of the incinerated waste in semester II/2014-2015 show that S-containing waste (inorganic compounds, acids) was incinerated in that period. Differences between the two means occur.

In the case of NO_x emissions in the atmosphere, the values are smaller than those calculated when the waste does not contain nitrogen compounds. Nitrogen comes from the combustion air which has a constant value even when no waste is incinerated. As with the SO₂ emissions, the differences between the measured values and the values calculated from the means are given by the nitrogen contained in the incinerated waste. The recorded data indicate that in 2013-2016 the nitrogen and sulphur emissions in the atmosphere do not exceed the maximum values provided for in the European emission standard [6] and by the National Environmental Protection Agency [7, 8, 9]. To determine an exact image of the affected area, CloseView software creates a projection of the dispersion of a chosen component in the graphic form overlapping the map zone.

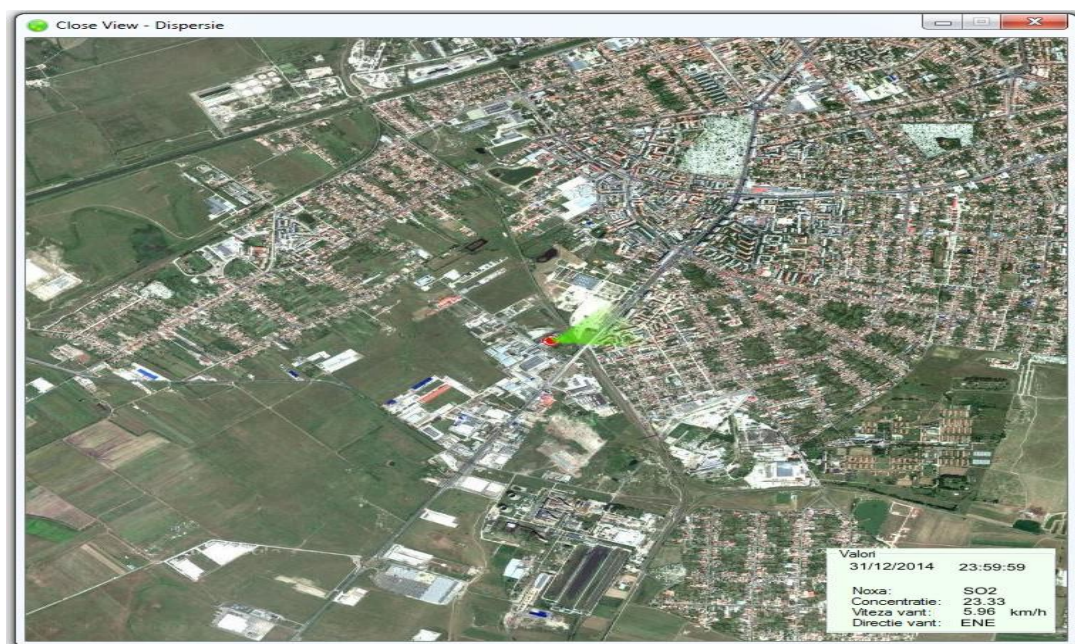


Fig. 4. SO₂ dispersion, 2014 average

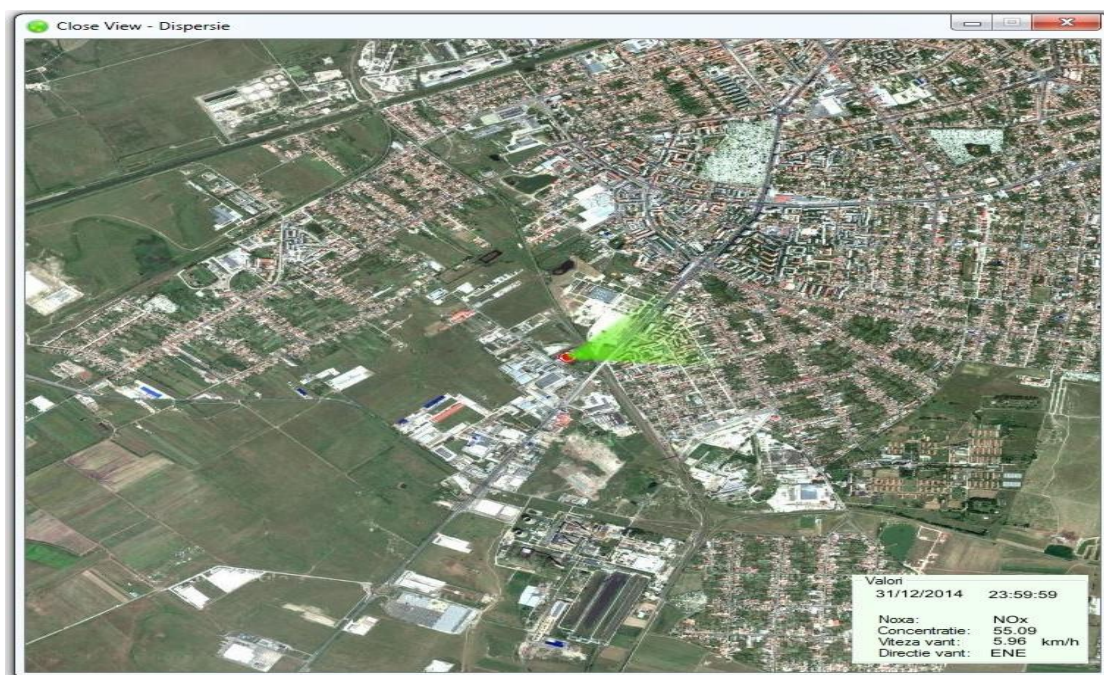


Fig. 5. NO_x dispersion, 2014 average

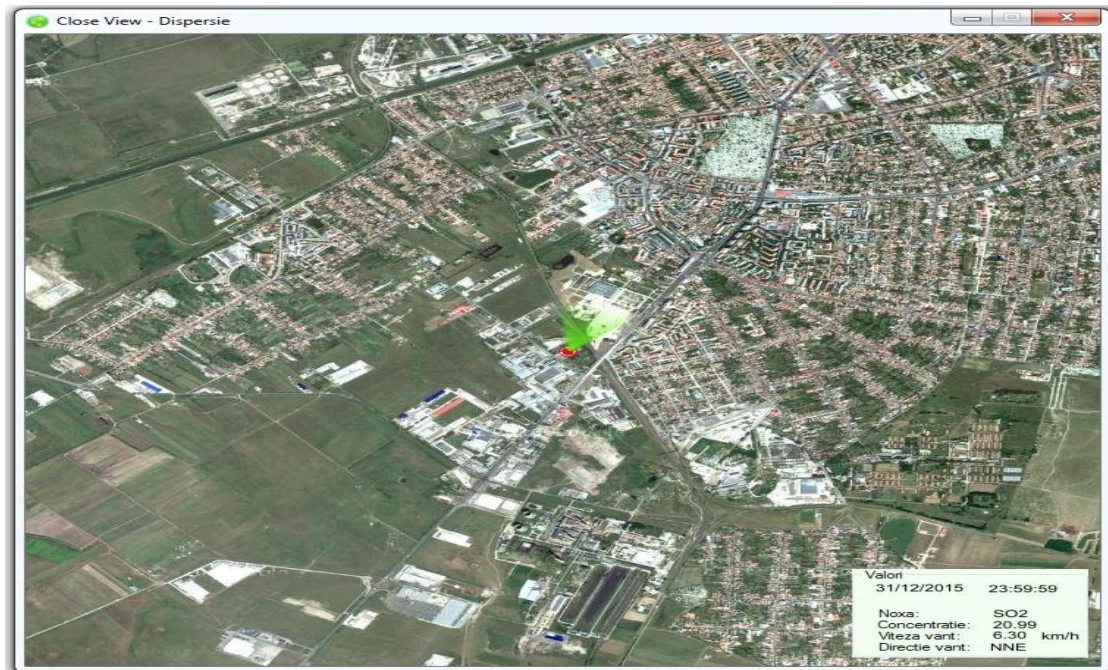


Fig. 6 SO₂ dispersion, 2015 average

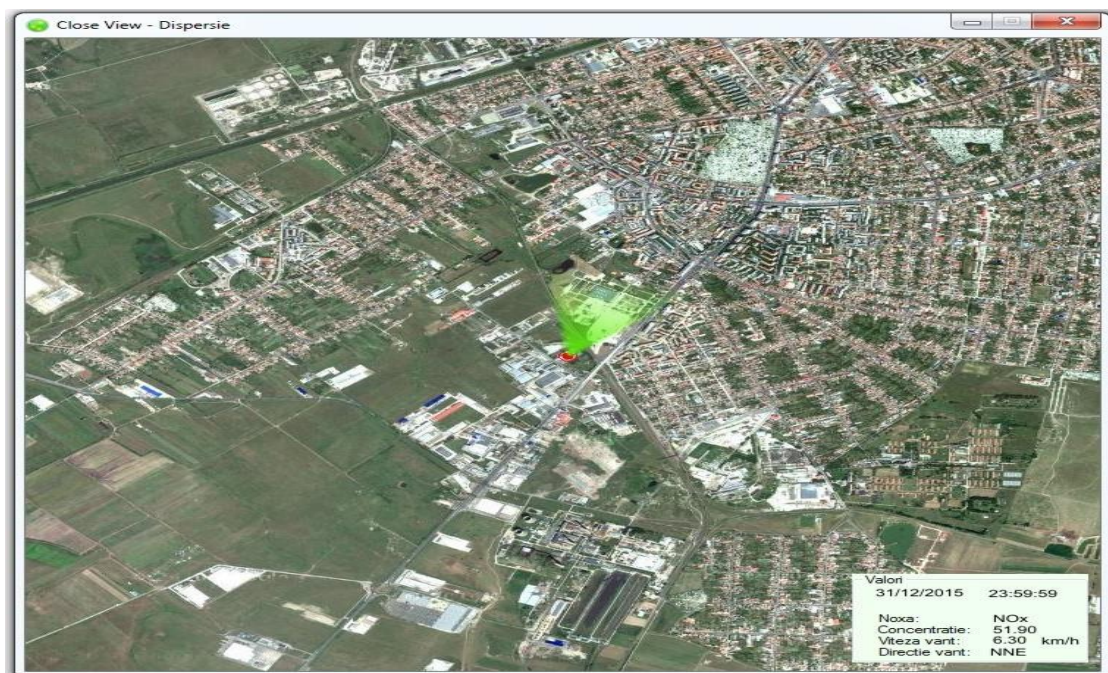


Fig. 7. NO_x dispersion, 2015 average

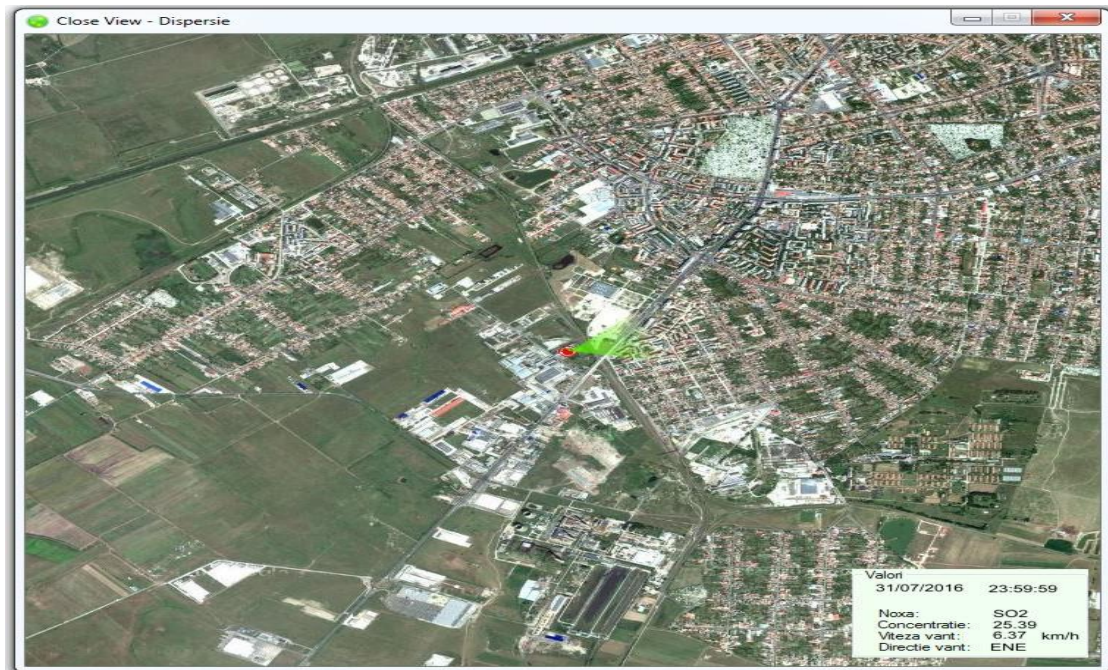


Fig. 8 SO₂ dispersion, 2016 average

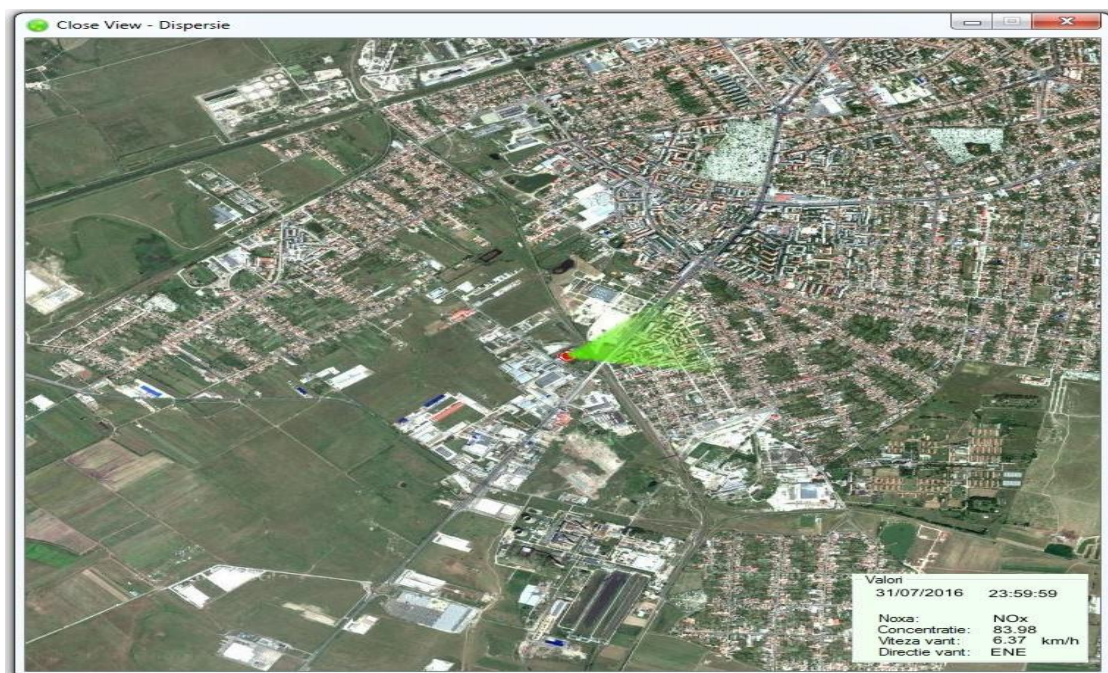


Fig. 9 NO_x dispersion, 2016 average

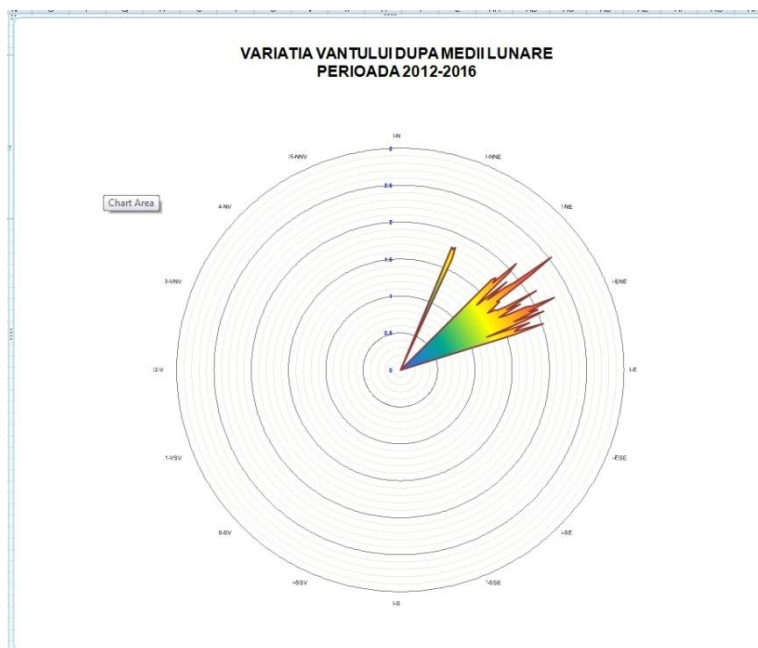


Fig. 10. Wind rose, 2012-2016

Conclusions

The projections of the NO_x and SO₂ emissions dispersion reveal the influence of wind speed on the smoke plume and, implicitly, dispersion. The visible differences between projections are caused by the speed of the dominant wind in that year.

Although the maps show visible projections, the dispersion is limited and the toxic concentrations are much lower than the admissible maximum limits. Nevertheless, for the identification of the affected zone, the calculations were related to the values of the released NO_x emissions, values that do not affect the population's health and the environment. Amplification was performed to identify the sulphur and nitrogen oxide dispersion in the atmosphere.

NO_x and SO₂ emissions produced during the incineration process make a small contribution to the pollution of the area where the study was conducted.

References

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