Pollution Impact of the Grozavesti Thermoelectric Power Plant on the Urban Agglomeration Bucharest

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The purpose of this paper is the experimental analysis of the thermoelectric power plant Grozavesti impact on Bucharest urban agglomeration for year 2015. Experimental research is done for the NOx and SO_2 pollutant for all seasons. The thermoelectric power plant Grozavesti is located near the Botanical Garden. Data provided by the industrial source are processed and constitute the input for the determination of the NOx and SO_2 concentrations by using the OML (Operational Local Model) air quality dispersion Gaussian model. The results from modelling shows that the highest NOx and SO_2 concentrations occur in the winter and autumn periods, due to unfavorable meteorological dispersion conditions and due to the operation of thermal power plant Grozavesti in the cold seasons. Thermoelectric power plants Grozavesti, operate on natural gas, because power plant have been refurbished. Generally, the results show that the industrial power plant represent the main contributions for pollution when the NOx and SO_2 are exceed the limit value, according to Law 104/2011- ambient air quality, and this affect vegetation and human health.

Keywords: pollutants, dispersion modes, air quality

Environmental pollution is one of the most debated issues of contemporary times and one of the first orders for today's societies. The quality of the atmospheric air influences directly the worldwide health [1]. Air pollution in urban areas is an important issue because of the effects it can have on the health of the population and on the vegetation [2,3]. There are many air pollution sources like transport, thermal power plant, domestic activities, etc [4]. Man and environment are inseparable entities: man's existence is environmentally dependent, and environmental factors (air, water, soil) can be changed by human action. Pollution occurs in the course of which some products resulting from physiological processes and from human and animal activity become residues that disturb good life by their nature and quantity. In the last decades, the process of degradation of environmental factors on our planet has been increasingly worrying [5].

Air pollution is mainly a wintertime and autumn problem related to stagnant meteorological conditions during synoptic high-pressure situations. Limit levels of NOx and SO_2 in Romania are also defined in the Law 104/2011 [6].

Nitrogen oxides (NOx) and sulphur dioxide (SO_2) are the main air pollutants. Both of them are mostly formed during the process of fossil fuels combustion, while some processes generate very high concentrations of NOx and SO_2. Measurement method for this pollutants are [7]:

- SO_2 measuring method (UV analyzer - excited fluorescence) – This method is very sensitive and it is a specific method for analyzing the SO_2 pollutant in ambientairandstac;
- NOx and O_3 measuring method - this method was developed for the measurement of NO and ozone using specific agents that react with ozone to produce NO or light (chemiluminescence).

The paper proposes to research a topic related to the pollution issue, of a European metropolis- Bucharest, suggesting new technical solutions to study and analysis air pollution.

Experimental part

Urban Bucharest area

In cities such as Bucharest, the main components of NOx and SO_2 will be derived from industrial measurement and from traffic. In areas of high traffic levels this contribution is usually in the range of 40 %. Bucharest is the capital and largest city of Romania, as well as its cultural, industrial, and financial center. It is located in the southeast of the country, at 44°252 573 N and 26°062 143 E, on the banks of the Dambovita River, less than 60 km north of the Danube River and the Bulgarian border.

The climate of Bucharest is moderate-continental, with an average annual temperature of 10-11°C; western and southern influences account for the presence of long, warm autumns, mild winter days or early spring. This moderate-continental climate has some air temperature differentials, specific to large cities, due to the additional heating of the street network, the combustion of fuel, and radiation from building walls. Generally, winters are cold, with heavy snow, often accompanied by blizzards. The lowest monthly average temperature is recorded in January, with an average of -3°C. The summer is very warm, in July the average temperature is 23°C, sometimes even at 35-40°C.

Precipitation is low, averaging 585 mm per year, but is higher in summer: the highest average monthly rainfall amounts in June (about 85 mm) and the lowest in March (15 mm) [7].

Thermoelectric power plants represent major sources of air pollution in the city of Bucharest through the operation of high-sulphur liquid fuels, releasing significant amounts of SO_2, NOx and dust into the atmosphere.

Description of data

Description of OML dispersion model

Air quality modelling is an essential tool for most air pollution studies. The air quality models are the means whereby pollutant emissions can be related to atmospheric pollutant concentrations. The uncertainties in assessment

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of air quality are related to both the quality of measured values of pollutant concentrations in local network and the input data for the models. The better estimation of air quality requests to combine the results of measurements with the results obtained by modelling.

The aim of our paper is to assess the industrial pollution from the thermoelectric power plants Grozavesti, using gaussian air quality dispersion model. The OML improves the methods for the simulation of dispersion processes in terms of certain physical parameters, with importance to boundary layer turbulence. The OML dispersion model is based on the Gaussian plume formulation. This is a gross simplification, as the Gaussian concept does not adequately describe the vertical structure of a plume, but it appears at present to be the only type of model capable of dealing satisfactorily with buoyant sources and with a wide range of stability conditions. This model was shown capable of simulating dispersion in extremely convective conditions. The main innovation in the OML model is the way in which the dispersion parameters σ_y and are determined [8].

In the OML model, the dispersion parameters are directly related to the basic physical parameters describing the turbulent state of the atmospheric boundary layer. As the turbulent properties may in general change with the height above the ground, the same is true for the dispersion parameters. In the OML model this dependence is expressed explicitly, making the model applicable for sources of any height [9].

As a main rule, either of the σ_y and σ_z is composed of the following three terms:

$$\sigma^2 = \sigma^2_{turb} + \sigma^2_{intern} + \sigma^2_{building} \quad (1)$$

where:

σ_{turb} - represents dispersion due to the atmospheric turbulence;

$\sigma_{int\ ern}$ - is a contribution due to entrainment of the ambient air into a rising plume;

$\sigma_{buillding}$ - is a contribution due to enhancement of dispersion in the wake of buildings near the source.

Output data

The OML-multi model generates average hourly concentrations, monthly averages, percentiles, and other important statistical values in air quality assessment across receptor network nodes [11].

Results and discussions

The Grozavesti Power Station is a large thermo-electrically power plant located in Bucharest, having 2 generation groups of 50 MW each having a total electricity generation capacity of 100 MW. The main equipment of the existing thermoelectrically power plant Grozavesti, belonging to ELCEN, was commissioned between 1965 and 1966 year, its life cycle is exceeded and, implicitly, they have an advanced degree of wear. As far as the use of primary resources concerns, the power plant has a relatively low overall efficiency.

For analysis the level of pollution the concentration of NOx and SO_2 was determinate in all four season.

Distribution of the concentration of NOx and SO2 at thermoelectric power plant Grozavesti using OML gaussian dispersion model are presented in the following figures.

Following the run of the Gaussian dispersion model OML, the values of the concentrations of the pollutants obtained are represented as isoconcentration for the 4 seasons. The predominant wind direction is north-southwest, and it is represented in figure 1.

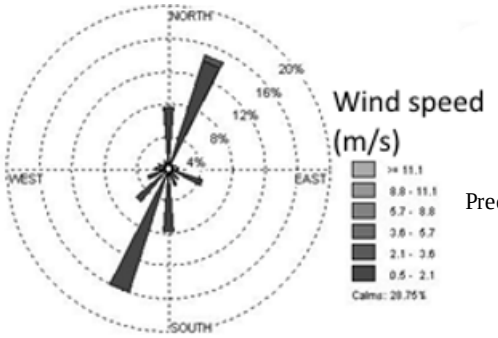

Fig.1. Predominant wind direction

Fig. 2.NOx winter concentration

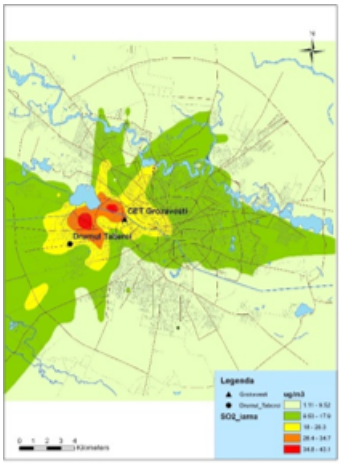

Fig 3. SO_2 winter concentration

The Grozavesti Thermal Power Plant as well as the Vest Thermal Power Plant are located near the industrial air quality monitoring station Drumul Taberei. The station records concentration values from those industrial sources and from traffic sources.

The variation of winter seasonal concentrations for NOx and SO_2 is shown in figures 2 and 3.

Analyzing the distribution of isoconcentration, we find the following:

- *For NOx pollutant* the concentration value approaches the limit value, but the emission limit value according to Law 104/2011 on air quality is slightly exceeded, the limit value being 30μg /m^3, because the boilers did not operate at their normal capacity. NOx concentrations are derived from traffic, and from the use of natural gas. Grozave°ti Power Plant no longer works at the existing facilities, because the equipment is over 40 years old and needs to be refurbished.

- *For SO_2 pollutant* the emission limit value according to Law 104/2011 on air quality is exceeded twice, the limit value being 20 μg/m^3. This overflow occurs from the operation of boilers in heavy fuel oil when it is very cold, but also because not all boilers are refurbished. The predominant wind direction is from east to west.

The variation of the spring season concentrations for NOx and SO_2 is shown in figures 4 and 5.

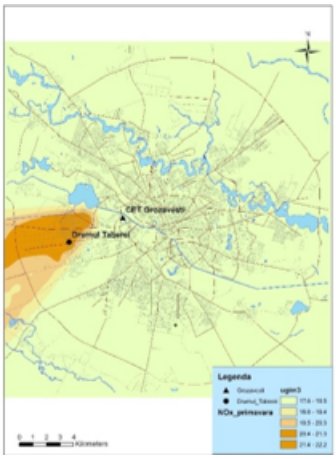

Fig. 4. NOx spring concentration

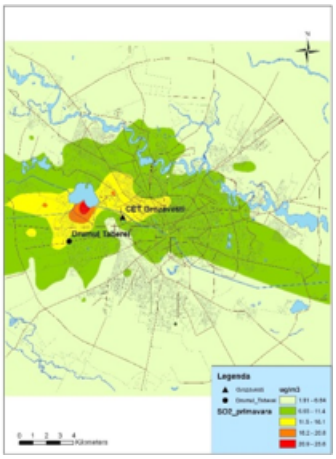

Fig. 5.SO_2 spring concentration

Fig. 6. NOx summer concentration

Analyzing the distribution of isoconcentration, we find the following:

- *For NOx pollutant,* the concentration value approaches the limit value, but the emission limit value according to Law 104/2011 on air quality is not exceeded, the limit value being 30 ìg/m^3, because the Power Plant Grozave°ti used more fuel and not all boilers at rated capacity were operating. The predominant direction of the wind is to the west, knocking out of the city.

- *For SO_2 pollutant* the emission limit value according to Law 104/2011 on air quality is slightly exceeded, the limit value being 20µg/m^3. This overflow comes from the operation of the fuel oil boilers and the fact that the cold season continued a little in March. The predominant wind direction is from east to west.

Variation of the summer seasonal concentrations for NOx and SO_2 is shown in figures 6 and 7.

Fig. 7. SO_2 summer concentration

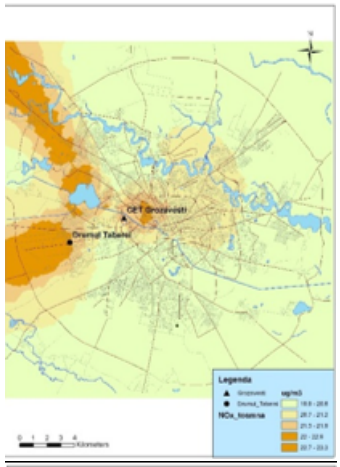

Fig. 8.NOx autumn concentration

Fig. 9. SO_2 autumn concentration

From the analysis of summer season maps it is noted that no exceedance of limit values is recorded, both NOx and SO_2 concentrations are below the limit value.

Variation of the autumn seasonal concentrations for NOx and SO2 is shown in figures 8 and 9.

Concentration limit values (30µg/m^3 for NOx and 20 ìg / m^3 for SO_2) were not exceeded, because during that period the Grozaveti power plant had a reduced operating regime, because the equipment was in the process of refurbishing and the most pollution came from traffic and from other industrial sources.

Conclusions

This paper presents an experimental study about the pollution generated by the industrial source – power plant Grozavesti. From the analysis of the isoconcentration maps, the NOx and SO_2 concentration is exceeded during the winter and spring season as the weather conditions play an important role, and the increase in natural gas consumption has led to higher emissions of pollutants. For

the analysis of pollutants a Gaussian dispersion model was used - OML (Local Operational Model) and important results were obtained regarding the sources of pollution represented by Grozavesti power plant.

The solution for reducing the pollution of power plant Grozavesti is a new high efficiency cogeneration unit (combined cycle gas-steam) to: improvement of the power plant's operation efficiency, cover the heat demand of the consumers connected to power plant Grozavesti in safety and continuity conditions throughout the entire year and reduction of the emissions and observance of environmental protection regulation in force.

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