Assessment and risk prevention of air pollution in urban sites

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Abstract. Atmospheric pollution limitation has evolved and evolves continuously, depending on the better knowledge of the harmful effects of the different atmospheric pollutants. The main elements that have led and lead to the continuous revision of the norms are the climatic changes and acid rain associated with atmospheric pollutants. In this context, the paper presents the following aspects: two monitoring regimes aims to evaluate and prevent air pollution in urban areas; was chosen as a monitoring location Constanta city, with strategic points exposed to the risk of pollution. For the monitoring of emissions in these locations, a self-employed emission analyzer was used. Where there are risk areas, exists a risk analisys with vulnerable locations and values of emissions's concentrations. There are monitoring CO, CO_2 , NO_2 , SO_2 emissions and PM2.5 and PM10 in air of urban sites which are exposed to the risk of pollution. Finally, the recorded values are below the maximum permissible limit. The conclusion is that pollution in urban sites can also be a danger to neighboring rural settlements, if there is no strict monitoring thereof.

1 Introduction

Air pollution is a well-defined element of European environmental policy, during the last decades the policies in this field have resulted in the reduction of emissions polluting substances and the marked improvement in air quality. Air quality is determined by air emissions from stationary sources and sources mobile (road traffic), mainly in the big cities, as well as by the long distance transport atmospheric pollutants. The current European legislation in the field of air pollution is supported by the Thematic Strategy on Air Pollution 2005 (TSAP) (EC,2005) which aims to improve quality of air in 2020 compared to the situation of 2000, defining concrete objectives in this regard the impact on

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human health and the environment. Many publications were developed on methods and tools for assessing the health risks of air pollution at local, national and international levels [1]. The strategy establishes European legislation and the measures necessary to reach the long-term target of the Sixth Action Program for the Environment (which took place between 2002 and 2012), reaching the "quality level of air that does not endanger and does not adversely affect human health and environment" [2], [3]. In Romania, the field of "*air quality*" [4], [5] is regulated by Law 104/15.06.2011 regarding ambient air quality [6] with subsequent modifications and completions (H.G. 336/2015 for amending the annexes 4 and 5 to Law 104/2011, respectively H.G. 806/2016 for amending the Annexes 4, 5, 6 and 7 to Law 104/2011) which transposes into national law the provisions of Directive 2008/50 / EC, [7] Directive 2004/107/EC [8] and EU Directive 2015/1480. For the implementation of the law of ambient air quality, the National Air System was established Integrated Air Quality Assessment and Management (NASIAQAM) which provides the organizational framework, institutional and legal cooperation of public authorities and institutions with competences in the field for the purpose of assessing and managing the ambient air quality, in a unitary way, throughout the territory Romania, as well as for informing the population and European and international bodies on ambient air quality [9]. The NASIAQAM ensures the monitoring of the ambient air quality through the National Network Air Quality Monitoring (NNAQM), and the National Emissions Inventory System Atmospheric pollutants (NEISAP), collect and manage the information and data received from the National Network. Currently, the NASIAQAM carries out continuous measurements of sulfur dioxide (SO_2), oxides of nitrogen (NOx), carbon monoxide (CO), ozone (O_3), particulate matter (PM10 and PM2.5), benzene (C_6H_6), lead (Pb), arsenic (As), cadmium (Cd), nickel (Ni), benzo (a) pyrene. Air quality in each station it is represented by suggestive quality indices, based on the concentration values of the main atmospheric pollutants measured. The NASIAQAM comprises 41 local centers (the local Environmental Protection Agencies) which collects and transmits to the public information panels the data provided by the stations and afterwards the primary validation is sent to the Air Quality Assessment Center (AQAC) for certification within the framework of the National Agency for Environmental Protection. The municipality of Constanta falls under the management regime I of the areas in the areas and agglomerations. In this regime I of management of areas in areas and agglomerations, the municipality Constanta is recorded with excess for nitrogen dioxide and nitrogen oxides [4].

To protect human health and the environment as a whole, studies have been conducted that highlight the impact of air emissions on air quality [1], [3], [4], [10], [11], [12].

The system procedure for validating air quality data from the National Air Quality Monitoring Network takes into account the fact that air quality is determined by air emissions from stationary and mobile sources [5], [9].

1.1 Area specific data analysed

1.1.1 General information

The city of Constanța is located in the county of the same name, in the southeastern part of Romania (Fig. 1) [2]. Constanta is divided into districts: Tăbăcăria, Brotăcei, North Faleza, Coiciu, Palas, Medeea, Brătianu, Center, Peninsula, Tomis I, II, III and North, Abbey, CET, Km 4, 4-5 and 5, South Faleza, at which added new neighborhoods such as Tomis Plus and Veterans (Gate 6) (Fig. 2) [2].

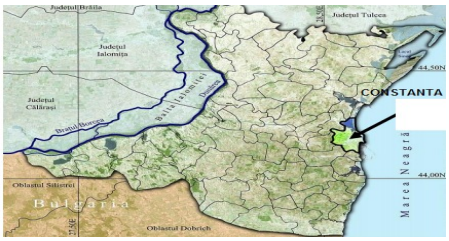

Fig. 1. Constanta city on Constanta county map.

Fig. 2. The districts of Constanta municipality

1.1.2 Description of the existing air quality situation

Since 2008, air quality monitoring in Constanta has been carried out through continuous measurements, through the automatic monitoring network, component of the network national monitoring. The air quality monitoring network in Constanta consists of 3 stations automatic: *Station CT 1* – Traffic station, located in Constanta municipality – area "Casa de Cultura", evaluates the influence of traffic emissions; *Station CT 2* – urban background station, located in Constanta municipality – park area Hall; *Station CT 3* – industrial type station, located in Constanta municipality – str.Extension of the Liliac no. 6, evaluates the influence of industrial sources on air quality, having the radius of the representational area of 10 – 100 m. The measurement at fixed points of the pollutants is done by applying the reference methods.

Background pollution represents the pollution existing in the areas where the influence does not directly manifest anthropogenic pollution sources. Background pollution monitoring is a global problem, important to be able to appreciate the effects of pollutants entering the fresh air of the sphere. The monitoring of regional pollution corresponds to the monitoring of the air located relatively far from urban or industrial centers, ie between background pollution and anthropogenic polluted air.

Impact pollution represents the pollution produced in the direct impact areas of the sources anthropogenic pollution. Continuous monitoring of (local) impact pollution is required because impact pollution directly and immediately affects trophic chains and human health.

The level of annual average concentrations of air pollutants in the surrounding air at the stations the automatic air quality monitoring network in Constanta municipality is presented as follows (table 1)[2], [5]:

Table 1. The level of average annual concentrations of atmospheric pollutants in ambient air in 2017

Station	NO_2 $\mu g/m^3$	SO_2 $\mu g/m^3$	CO $\mu g/m^3$	O_3 $\mu g/m^3$	Benzen $\mu g/m^3$	PM10 $\mu g/m^3$

CT1	38. 59	5.80	0.14	*	1.88	28.84
CT2	23.11	6.86	0.1	50.53	1.93	*
CT3	19.59	7.06	0.12	47.99	*	23.95

* The indicators in question were not measured at these types of stations

The annual limit value for health protection according to Law 104/2011 is 40 μg / m^3 [6]. According to Order 589/2018 in the period 2017 – April 2018, in Constanta municipality there were exceeded NO_X, NO_2, which leads to the inclusion in regime I. The annual limit value for SO_2 emissions protection of vegetation according to Law 104/2011 is 20 μg / m^3. Maximum daily value of 8-hour averages (sliding averages) for CO emissions for health protection according to law 104/2011 is 10 mg / m^3. Target value for ozone concentrations for the protection of human health, maximum daily average value per 8 hours, according to Law 104/2011 is 120 μg / m^3. The target value for benzene for the protection of human health, according to Law 104/2011 is 5 μg / m . The annual limit value for PM10 concentrations for the protection of human health according to Law 104/2011 is 40 mg / m^3. The target value for PM2.5 concentrations according to Law 104/2011 is 25 μg / m^3. The limit value for the protection of human health for Pb, according to the law 104/2011 is 0.5 μg / m^3. The target value for As, according to Law 104/2011 is 6 ng / m^3. The target value for Cd, according to Law 104/2011 is 5 ng / m^3. The target value for Ni, according to Law 104/2011 is 20 ng / m^3.

1.2 Monitored locations from Constanta urban site

In accordance with Art. 42, section 2, of Law no. 104/2011 regarding air quality "*in order to manage the ambient air quality in each area or agglomeration delimits areas that are classified in management regimes according to the result assessment of the ambient air quality* " [2], [6]. Two management regimes are defined: *management regime I* which represents the areas in the areas and the agglomerations in which the levels for sulfur dioxide, nitrogen dioxide, nitrogen oxides, particulate matter PM10 and PM2.5,lead, benzene, carbon monoxide are greater than or equal to the limit values plus the margin tolerance; *management regime II* which represents the areas in the areas and agglomerations in which the levels for sulfur dioxide, nitrogen dioxide, nitrogen oxides, particulate matter PM10 and PM2.5, lead, benzene, carbon monoxide are lower than the limit values, respectively for arsenic, cadmium, nickel, benzo (a) pyrene, PM2.5 suspended particles are smaller than the target values [6].

The classification of areas in urban areas and agglomerations into the management regime I or II was achieved taking into account both the previous classification in management regimes and the results obtained from the local air quality assessment, which used point measurements fixed, made between 2017 and 2018, with the help of a performance measuring station [5], [10].

2 Experimental research

The paper presents the following aspects: two monitoring regimes aims to evaluate and prevent air pollution in urban areas; was chosen as a monitoring location Constanta city, with strategic points exposed to the risk of pollution: the center of the city- the City Hall,

the port areas- Gate 5 – Port Constanta, the industrial area- Cora mall-Road police (Blv. I.C. Bratianu).

2.1 The center of the city- the State Theater and City Hall

- *Location: Constanta City Hall*
- *Period*: 10.10.2017 – 27.10.2017
- The values (limit, hourly, average) of parameters are presented in Table 2 (CO-Fig. 3; CO_2-Fig. 4; NO_2 –Fig. 5; Nox-Fig. 6; PM2.5-Fig. 7; PM10-Fig. 8; SO_2 – Fig. 9).

Table 2. The recorded values between in the center of city

Parameter/Unit	Limit value	Average daily value	Maximum value	Hourly Value
CO mg/m^3	< 0.10	0.11	0.919	10
CO_2 ppm	432.40	439.30	444.23	438.80
NO_2 $\mu g/m^3$/hour	60	44.7..... 57.7	< 200	193
Nox $\mu g/m^3$	> 30	80.17... 114.22	> 30	178.80....231.87
PM2.5 $\mu g/m^3$	25	25.67... 30.68	43	36.89....42.75
PM10 $\mu g/m^3$	50	57.01	50	92.11 ...111.10
SO_2 $\mu g/m^3$	350** 125 $\mu g/m^3$***	125	20*	350

* annual critical level for vegetation protection, calendar year and winter (September 1 - March 31)
** the hourly limit value for the protection of human health;
*** the daily limit value for the protection of human health.

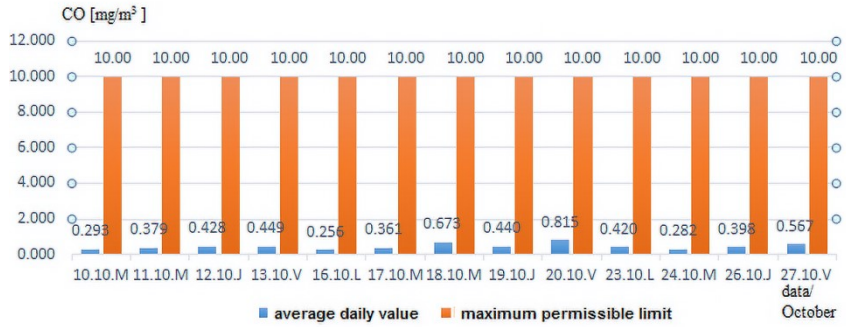

Fig. 3. CO-monitoring values in Constanta City Hall location.

CO - the values recorded are well below the allowed limit of 10 mg / m^3.

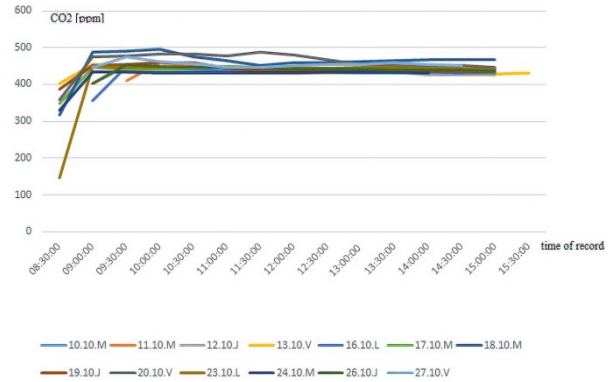

Fig. 4. CO_2-monitoring values in Constanta City Hall location.

Values are very close to all days and times. The average value per site is 439.30 ppm.

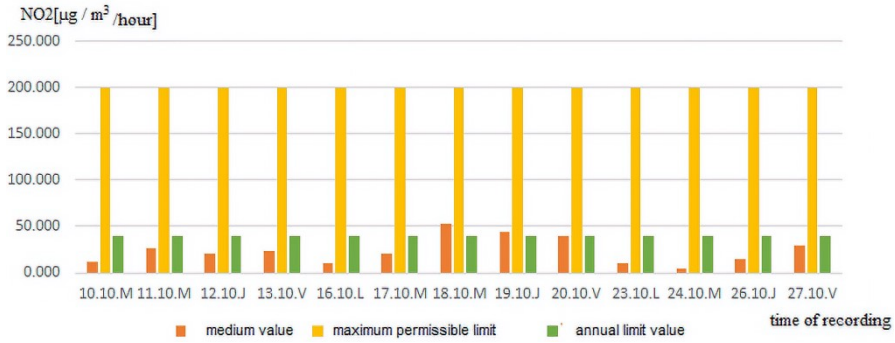

Fig. 5. NO_2-monitoring values in Constanta City Hall location-october 2017.

There were some small exceedances of 40 µg / m^3 (annual limit value for human health), respectively average daily values of 57.7 µg / m^3 and 44.7 µg / m^3.

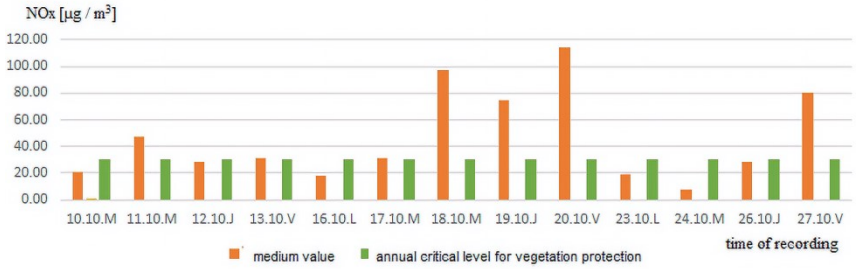

Fig. 6. NOx-monitoring values in Constanta City Hall location-october 2017.

Hourly and maximum hourly values were recorded frequently, as well as daily average values much higher than 30 µg / m^3. The maximum hours were recorded between 9.00 and 12.30.

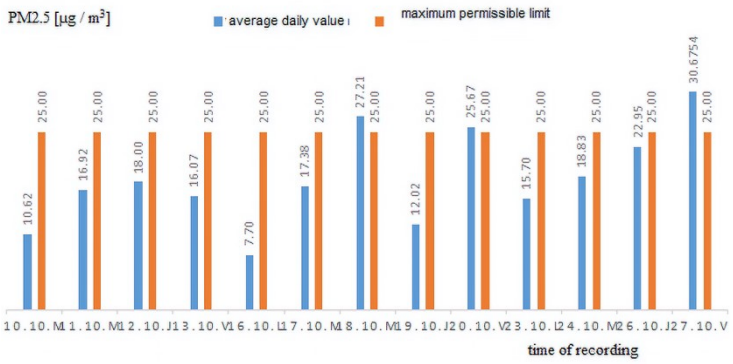

Fig. 7. PM2.5-monitoring values in Constanta City Hall location-october 2017.

Generally the hourly values and the daily average values are below the maximum allowed limit of 25 µg / m^3, however there are some exceedances to the hourly values. The maximum hours were recorded between 9.00 and 12.30.

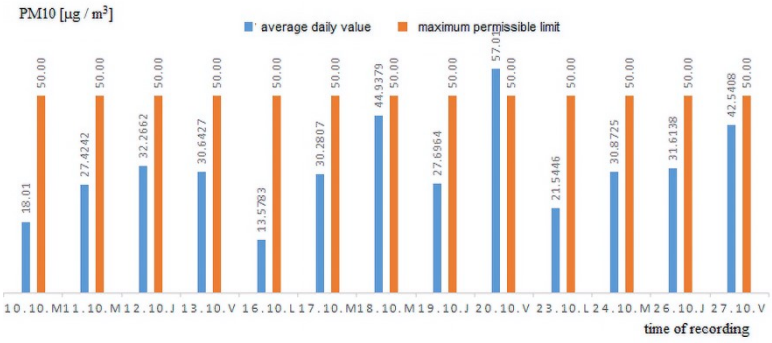

Fig. 8. PM10-monitoring values in Constanta City Hall location-october 2017.

Fig. 9. SO_2-monitoring values in Constanta City Hall location-october 2017.

All recorded hourly SO_2 values and daily average SO_2 values are well below the maximum permitted limit of 350 µg / m^3 / hour. For recorded values (from 0.2371µg / m^3 / hour to 0.38756 µg / m^3 / hour) there are support possibilities decreasing up to one hour with increase in concentration. For human health, these values may cause possible irritation of the nose and eyes

2.2 The port areas- Gate 5 – Harbour Constanța

- *Location*: the port areas- Gate 5 - Harbour Constanta
- *Period:* 14.03.2018 - 31.03.2018/ 01.04.2018 - 26.04.2018.
- The values of air parameters are presented in Table 3 (CO; CO_2; NO_2; NOx; PM2.5; PM10; SO_2).

Table 3. The recorded values of air parameters in the port areaa Gate 5-Harbour Constanta

Parameter/Unit	Limit value	Average daily value	Maximum value	Hourly Value
CO mg/m^3	< 0.10	0.11	1.40 (March) 2.53 (April)	10
CO_2 ppm	459.24	459.24	459.24	459.24
NO_2 $\mu g/m^3$/hour	60	45.60 47.04 52.09	< 200	82.78 84.39 85.07 85.84 103.29
NOx $\mu g/m^3$	> 30	63.16 73.60 77.83 88.35 96.80	> 30	204.18 208.95 232.26 236.65 249.45
PM2.5 $\mu g/m^3$	25	31.92 33.00 35.75 38.30	< 25	49.12 57.2 71.61 79.82 113.40
PM10 $\mu g/m^3$	50	52.77 53.19 61.74 61.92 69.11 99.16	< 50	155.70 207.30 244.80 247.70 287.40 323.90 406.90
SO_2 $\mu g/m^3$	< 350	125	20*	350

- critical level for vegetation protection, calendar year

The registered values are below the permitted limit of 10 mg / m^3 (maximum 1.40 mg / m^3 in March and 2.53 mg/m^3 in April). The values of CO_2 are constant for all-day measurement.

2.3 The industrial area- Cora mall-Road Police (Blv. I.C. Bratianu)

- *Location*: the industrial area- Cora mall-Road police (Blv. I.C. Bratianu)
- *Period*: 27.04.2018 - 25.05.2018.
- The values of air parameters are presented in Table 4 (CO; CO_2; NO_2; NOx; PM2.5; PM10; SO_2).

Table 4. The recorded values of air parameters in the industrial area Cora mall-Road Police

Parameter/Unit	Limit value	Average daily value	Maximum value	Hourly Value
CO mg/m^3	10	0.11	0.717	0.10
CO_2 ppm	464.04	464.04	464.04	464.04
NO_2 $\mu g/m^3$/hour	40*		< 200	70.41 71.01 71.27
NOx $\mu g/m^3$	> 30**	32.91 34.25 34.92 36.71 42.57	> 30	100.41 106.67 113.198 151.50 116.85
PM2.5 $\mu g/m^3$	< 25	26.47 (April) 26.62 (4May; 18.30-0.00) 33.18 (24May; 0.30-03.00)	206.80 380.60	49.12 57.2 71.61 79.82 113.40
PM10 $\mu g/m^3$	< 50	53.27 59.89 81.55 92.62 269.11	< 50	79.14 82.26 100.50 121.60 270.30
SO_2 $\mu g/m^3$	< 350	125	20*	350

* annual limit value for human health
** annual critical level for the protection of vegetation

CO - registered values are below the permitted limit of 10 mg / m^3 (max. 1.40 mg / m^3 in March and 2.53 in April); CO_2 - average value per site is 459.24 ppm. The values of CO are constant for all-day measurement. The recorded values of NO_2 are below the maximum permissible limit of 200 µg / m^3 / hour. There were some exceedances of the hourly values compared to 40 µg / m^3 .

2.4 The risk areas

In carrying out the Air Quality Plan for the city of Constanța have data on NOx and NO_2 emission sources located in the city were interrogated Constanța and structured on the following categories:1) *fixed sources* - represented by individual or common fixed sources represented in the most of the installations of the authorized economic operators from the point of view environmental protection;2) *Surface sources* - represented by diffuse (undirected) sources of emissions released in the surrounding air;3) *Linear sources* - represent the emission sources specific to the means of road transport, railway and air, as well as non-road mobile equipment equipped with engines with internal combustion. Emissions of nitrogen oxides, nitrogen dioxide are released on the territory of the municipality of Constanța in urban areas (inhabited areas) and on industrial platforms. Once released into the air, the pollutants, due to the scattering phenomenon, they can be transported to different areas depending on the conditions meteorological conditions

present. In order to manage the air quality, in each zone or agglomeration, the areas that are classified in the management regimes (I or II) were delimited according to the result of the evaluation of the ambient air quality. The management regimes are provided in art. 42 of Law no. 104/2011 [6]. Mathematical modeling of the dispersion of pollutants in the atmosphere consists in estimating concentrations of soil and height pollutants depending on the characteristics of the pollution sources, the meteorological and orographic, the processes of physical and chemical transformation that they may undergo pollutants in the atmosphere and their interaction with the soil surface [10]. Modeling the dispersion of pollutants into the atmosphere for emissions of pollutants generated by the emission sources within the municipality of Constanța were made with the AERMOD VIEW program, developed by the Canadian company Lakes Environmental [13]. The AERMOD model is a dispersion model, which allows long-term, medium and short calculation of emissions from point sources, traffic, surface sources and diffuse sources. For the municipality of Constanța, the dispersion model was run on network (13 x 13) km, with 500 m/ step. The data entered for the dispersion model are specific to 2017 [4]. The results obtained are: 1) wind rose and whether data series (Fig. 10); 2) graphic maps of the pollutant with the identification of average monthly or annual concentrations, hourly or daily concentrations, frequency of limit values according to legislative regulations; 3) data corresponding to maximum concentrations, concentrations in points network of receivers.

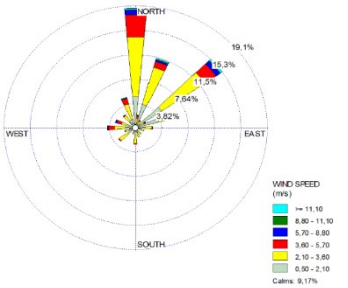

Fig. 10. Constanta wind rose and whather data series

Scenario:

-industrial sources- results of dispersion of average annual NOx concentrations in ambient air (Fig. 11, Fig. 12) and of average hourly NOx concentrations in ambient air (Fig. 13).

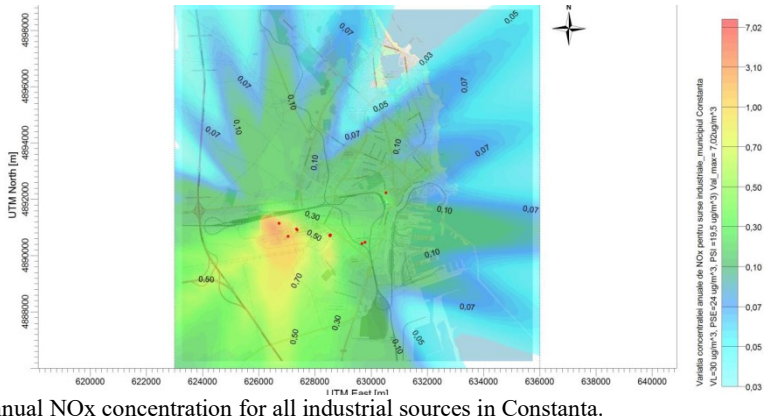

Fig. 11. Annual NOx concentration for all industrial sources in Constanta.

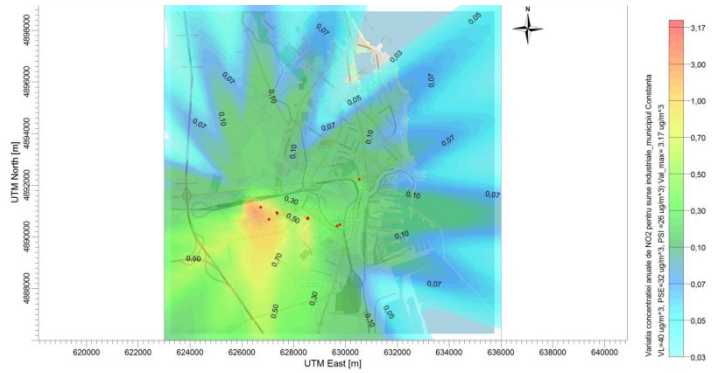

Fig. 12. Annual NO_2 concentration for industrial surface sources in Constanta.

The average annual concentration of NOx in the surrounding air for all sources, according to figure 11 is 7.02 μg / m^3, a value not exceeding the annual limit value, nor the upper threshold, but exceeds the lower threshold [2], [9].
The average annual NO_2 concentration in the surrounding air for the surface sources, according to figure 12, is 3.17 μg / m^3, a value that does not exceed the annual limit value and nor the lower and upper assessment threshold.

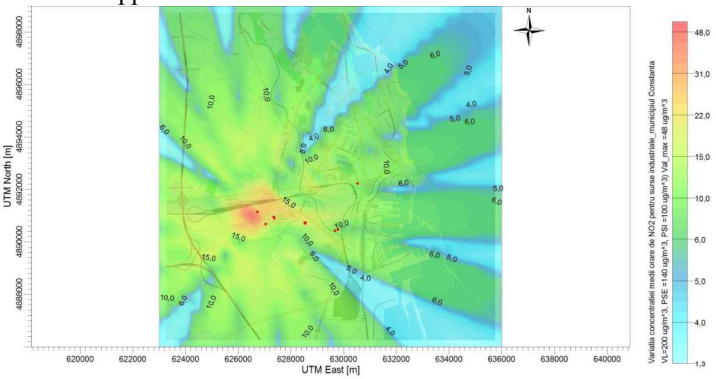

Fig. 13. Hourly NO_2 concentration for industrial sources in Constanta.

The average hourly NO_2 concentration in the ambient air for industrial sources, according to figure 13, is 48 μg / m^3, a value which does not exceed the annual limit value nor the threshold lower and upper evaluation.

- **liniar sources :**
- results of dispersion of average annual NOx concentration (Fig. 14), and of average hourly NO_2 concentrations in ambient air (Fig. 15).

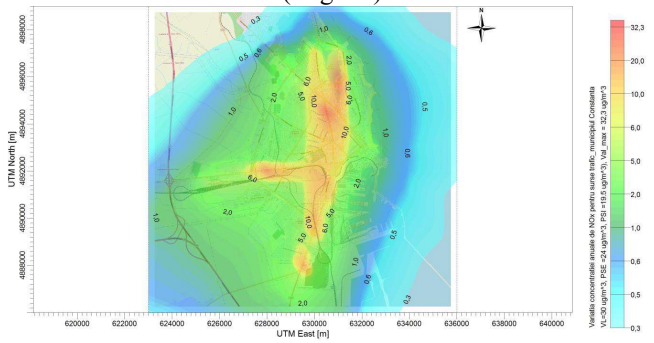

Fig. 14. Average annual NOx concentration for liniar sources in Constanta.

The average annual NOx concentration in the ambient air for linear sources, according to Figure 14, is 32.3 µg / m^3, a value that exceeds the annual limit value and the threshold. lower and upper evaluation.

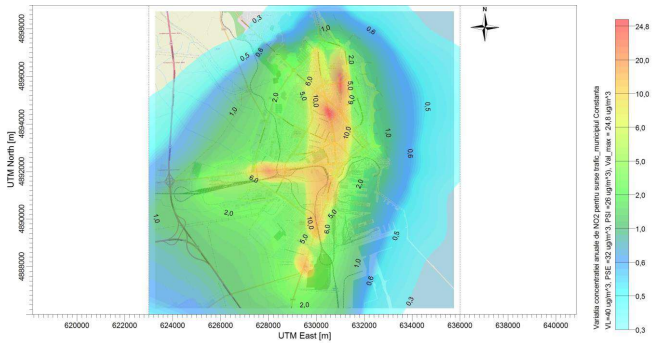

Fig. 15. Annual NO_2 concentration for linear sources in Constanta.

The average annual NO_2 concentration in the ambient air for linear sources, according to Figure 15, is 24.8 µg / $m^{3,}$ a value not exceeding the annual limit value and the upper assessment threshold, but exceeds the lower assessment threshold.

- results of average hourly NO_2 concentration (Fig. 16).

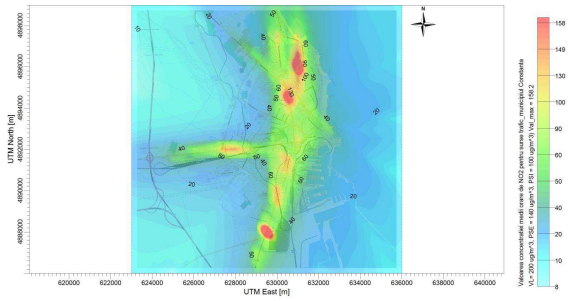

Fig. 16. Average hourly NO_2 concentration for linear sources in Constanta.

The average hourly NO_2 concentration in the ambient air for linear sources, according to Figure 16, is 158.2 µg / m^3, a value that does not exceed the annual limit value, but exceeds the lower and upper assessment threshold.

- **surface sources:**

- results of dispersion of average annual NOx concentrations in ambient air for sources of surface are presented in figure 17:

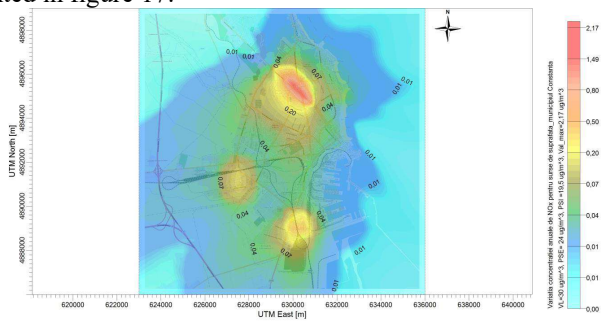

Fig. 17. Annual NOx concentration for surface sources in Constanta.

The average annual NOx concentration in the ambient air for the sources is surface, according to Figure 17, is 2.17 μg / m^3, a value that does not exceed the annual limit value and nor the lower and upper assessment threshold.

- The results of dispersion of average annual NO_2 concentrations in ambient air for sources surface are shown in Figure 18:

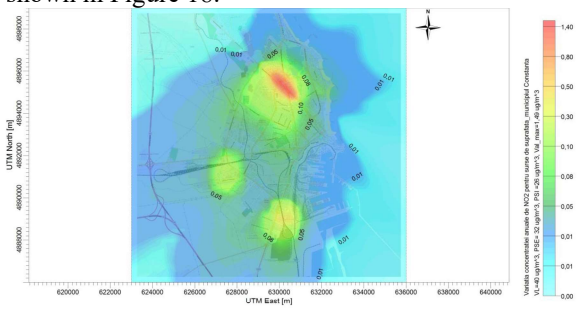

Fig. 18. Annual NO_2 concentration for surface sources in Constanta.

The average annual NO_2 concentration in the ambient air for the sources is surface, according to Figure 18, t is 1.49 μg / m^3, a value that does not exceed the annual limit value and nor the lower and upper assessment threshold.

- The results of the dispersion of the hourly average NO_2 concentrations in the ambient air for the sources of surface are shown in the Figure 19:

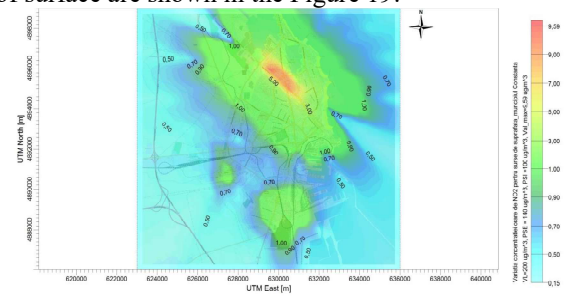

Fig. 19. Average hourly NO_2 concentration for surface sources in Constanta

The average hourly NO_2 concentration in the ambient air for the sources is surface, according to Figure 19, is 9.59 μg / m^3, a value that does not exceed the annual limit value and nor the lower and upper assessment threshold.

3 Conclusions

Air pollution has negative effects on materials and constructions, including those more representative constructions of cultural importance for Constanta. The air quality plan for the city of Constanța is drawn up taking into account the employment regime according to Order 598/2018 by which the city of Constanta is classified in regime I with exceedances of NOx, NO_2 in the period 2017 - April 2018. the air quality level was analyzed for the following indicators: powders in suspension (PM10 and PM2.5), benzene (C6H6), sulfur dioxide (SO_2), carbon monoxide (CO), lead (Pb), arsenic (As), cadmium (Cd) and nickel (Ni).

In the Constanta urban environment the presence of nitrogen oxides is due in particular to road traffic. Once released into the atmosphere *NO* and *NO_2*, which are aerosols, are dispersed by the wind and, in areas with low speeds of air currents, depending on the

density of the air, these gases will concentrate on the ground due to its higher density compared to air density. Acid rainfall on the ground can have effects different depending on the structure of the environment in which they fall, so that a calcareous land will be less affected compared to acidic soils composed mainly of silicon. Exposure of vegetation to nitrogen oxides causes plant damage through bleaching or death vegetal tissues, causing the fall of the leaves and reducing their growth rate. The short-term effects of P*M10* exposure on the respiratory tract are demonstrated, but from the point of view of mortality caused by long-term exposure, *PM2.5* presents a risk factor greater than PM10. The suspended particles accelerate the corrosion of metals, degrade paintings and sculptures and se deposit on buildings, contributing, sometimes even to the loss of heritage objects. The suspended particles negatively influence the development of flora and fauna. Above the flora acts by affecting the photosynthesis process, clogging the ostioles and disrupting the breathing, so that the plants do not grow sufficiently and the biological mass decreases. Suspended particles can absorb solar radiation by affecting or even reducing visibility. Another effect of particle pollution is to change the climate by forming clouds.

Following the modeling, it is found that for air quality implementation is necessary of measures at the emission sources that have the greatest contribution to air pollution, namely:

- for NO_2 and NOX - reduction of emissions from road transport, in particular by rehabilitation and modernization of transport infrastructure, ensuring mobility traffic, promoting the use of alternative means of transport (transport in common, bicycles, etc.);
- it is proposed to improve the bus fleet in order to reduce pollution, expand green spaces in Constanta.

This paper has financial support from the Constanta Maritime University under assistance project PN-III-P1-1.2-PCCDI-2017-0404 /31PCCDI/2018, *Holistic on the Impact of Renewable Energy Sources on Environment and Climate-HORESEC.*

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