ASPECTS CONCERNING THE MODELING OF THE AIR POLLUTANTS DISPERSION

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Abstract: *European directives on ambient air quality enter for the first time in Europe the concept of modeling in air quality assessment and management. Modeling of air quality management improves efficiency of the air quality management. By modeling, you can identify the contribution of various categories of sources to overcome the limits. Another major advantage of the use of modeling air pollutants in air quality management and evaluation is to improve capability to represent the spatial distribution of concentrations of pollutants, with effect from regional scale to local scale, even at the level of cities and streets. Furthermore, modeling will contribute to compliance or non-compliance to the quality objectives set by legislation while helping to identify areas where limits are exceeded. Impact assessment of air quality due the operation activities belonging to S.E. Craiova II was performed by mathematical modeling, the results reference to limits set by Order of the Minister of Water and Environmental Protection no. 592/2002 for approving the Norms on setting limits, the threshold values and criteria and methods of assessment of sulfur dioxide, nitrogen dioxide and nitrogen oxides, particulate matter, lead, benzene, carbon monoxide and ozone in ambient air, supplemented by the Order of the Minister of Environment and Water Management no. 27/2007. To calculate the dispersion of gaseous and particulate pollutants discharged into the atmosphere we used a specialized program called SIMGP v.4 developed under Visual Basic platform after the complete theory of the American model ISC3 (Sources Industrial Complex Models). The selection model is an important issue as there is no dispersion model recommended. Each model used should meet the needs of the particular analyzed case. Hundreds of models are available, and differences between their complexity and capacity to meet distinct physical or chemical processes in the atmosphere are evident. In this view, in this paper we will attempt a study of modeling the dispersion of pollutants at local level which will focus on assessing the impact on air quality resulting from emissions sources associated with the activities of the S.E. Craiova II, and quantify the impact that some air pollutants are having on the viticultural agroecosystems from the Dealurile Craiovei area by calculating the probabilities of exceeded maximum allowable concentrations for 30 minutes.*

Key words**:** *dispersion, modeling, NO_2, total powders*

INTRODUCTION

Air pollution has represented a big issue in the last decades, due to aggression on human health, on all environmental components (air, water, soil, vegetation), usually on the natural environment or built. Therefore, protection of the atmosphere becomes a matter of great importance in human health and environmental protection in the spirit of sustainable development concept.

The European directives on ambient air quality enter for the first time in Europe the concept of modeling in evaluation and management of air quality as a technique of measurement, calculation, prediction and estimation of levels of pollutants in ambient air.

Modeling the dispersion of pollutants in the air quality assessment has a very important role, while representing an important tool in developing action plans to improve air quality, which is the purpose and ultimate goal of environmental public authorities.

Modeling of air quality management improves its efficiency. By modeling, one can identify the contribution of various categories of sources to overcome the limits. Another major advantage of the use of modeling air pollutants in air quality management and evaluation is to improve the capability to represent the spatial distribution of concentrations of pollutants, with effect from regional scale to local scale, even at the level of cities and streets. Furthermore, modeling will contribute to compliance or non-compliance to the quality objectives set by legislation while helping to identify areas where limits are exceeded.

In this situation, there is also found Craiova Energy Complex which is being done and making major investments in clean-up equipment to reduce emissions of pollutants into the atmosphere in order to comply with obligations under the plans of action in integrated environmental permits.

In this view, in this paper we will try to complete a study of modeling the dispersion of pollutants at local level which will focus on assessing the impact on air quality resulting from emissions sources associated with the activities of the S.E. Craiova II, and quantify the impact that some air pollutants have or may have on the viticultural agro-ecosystems by calculating the probability of exceedance the maximum concentrations, allowable for 30 minutes.

MATERIAL AND METHODS

To calculate the dispersion of gaseous and particulate pollutants discharged into the atmosphere we used a specialized program called SIMGP v.4 developed under Visual Basic platform as a complete theory of the American model ISC3 (Sources Industrial Complex Models), computer algorithms presented in the guide of ISC3 model, Volume I and II, developed by the U.S. Environmental Protection Agency - Office of Air Quality-North Carolina, in September 1995.

Pollution dispersion simulation program SIMPG v.4 operating environment is compatible with Windows 9x, ME, 2000, XP, Vista or Windows 7. It is also compatible with all computer programs that use the ISC3 theory and the climatologic model. The program is particularly strong in calculating the likelihood of wind classes by classes of atmospheric stability on the 16 wind directions, also called triples, meteorological data for periods of up to 10 years. It can also calculate the average concentrations for time intervals from 30 minutes, hourly, daily, monthly, seasonal, annual or multiannual, the gaseous pollutants and particulate matter including PM10 discharged from a source or multiple sources (500 sources for gaseous emissions and 100 sources for particulate emissions).

The program also calculates the likelihood of exceeding the maximum allowable concentration for 30 minutes or one hour intervals of time considered for mediation of calculations, typically monthly average concentrations, seasonal, annual or multiannual. An important feature of the program is that is able to calculate the concentration for cases with thermal inversions or without thermal inversions.

Averaged concentrations are interpolated by a great performing graphic interpolator with presentation of spatial distributions of concentrations in two or three dimensions, color, or gray-scale, superimposed on maps or scale drawings constructed by the user using only a few points landmark.

Tested for 7 years to calculate average concentrations of 30 minutes, daily, monthly and annual in Bacău city as well as in cases of accidental pollution or due to strong thermal inversions (a well data from weather stations, automatic registration of 30 to 30 minutes and very accurate measurements of emission sources), resulted in a correlation coefficient between measured values and calculated field program of about 0.85. Design software SIMGP v.4 received feedback from specialists in the Netherlands after the simulations study the impact of major projects emissions of pollutants for different urban areas and protected areas (Bacău, Tulcea, Galați, Baia Mare, Suceava, Delta-Sulina branch, etc.).

To calculate hourly concentrations of NO_2 were used physical and technical data of the source presented in the following and hourly emission rate calculated in relation to gas flow zone of 1382822 Nm^3 /h is 194.1 g/s. To calculate the hourly emissions of NO_2 dispersion there were introduced the following input data in the calculation program:

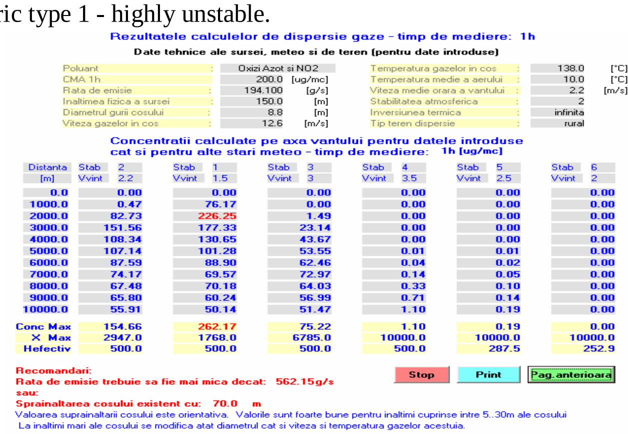
- physical characteristics of the stack no.1: stack height, 150 m, mouth diameter exhaust stack, 8.8 m, average rate of exhaust gas, 12.6 m, exhaust gas temperature, 138 °C;
- meteorological characteristics: average air temperature, 10 °C, class of atmospheric stability, b (unstable), ground wind speed, 2.2 m/s
- area of dispersion characteristics: rural area with varied vegetation and buildings with average heights of 4 m,
- allowable hourly limit established by Order 592/2002;

To calculate annual average concentrations of NO_2, data on physical characteristics of the source remain the same, the average annual temperature is 9 °C and annual emission rate is 172.7 g/s, relative to total annual gas volume discharged in 2008, by 10629994 thousands Nm^3/an.

RESULTS AND DISCUSSIONS

In the following figure, there are shown the NO_2 concentrations measured on wind axis (where concentrations are maximum), expressed in µg/mc. Concentration values thus calculated are valid for any wind direction considered, and hence, in the case when the wind blows from the direction of SSW-Source-S.C.D.A Şimnic but also for the case when it blows from the NW-Source-S.D. Banu Mărăcine.

From the analysis of hourly mean values calculated, one can observe that there is a possibility that at approximately 2000 m away from the source, in any direction of the wind, to go beyond the permissible limit of 200 mg/cm specified in the Order 592/2002 for the class of stability atmospheric type 1 - highly unstable.



Rezultatele calculelor de dispersie gaze - timp de mediere: 1h

Date tehnice ale sursei, meteo si de teren (pentru date introduse)

Poluant	Oxizi Azot si NO2		Temperatura gazelor in cos	138.0	[°C]
CMA 1h	200.0	[ug/mc]	Temperatura medie a aerului	10.0	[°C]
Rata de emisie	194.100	[g/s]	Viteza medie orara a vantului	2.2	[m/s]
Inaltimea fizica a sursei	150.0	[m]	Stabilitatea atmosferica	2	
Diametrul gurii cosului	8.8	[m]	Inversiunea termica	infinita	
Viteza gazelor in cos	12.6	[m/s]	Tip teren dispersie	rural	

Concentratii calculate pe axa vantului pentru datele introduse cat si pentru alte stari meteo - timp de mediere: 1h [ug/mc]

Distanta [m]	Stab 2 Vvint 2.2	Stab 1 Vvint 1.5	Stab 3 Vvint 3	Stab 4 Vvint 3.5	Stab 5 Vvint 2.5	Stab 6 Vvint 2
0.0	0.00	0.00	0.00	0.00	0.00	0.00
1000.0	0.47	76.17	0.00	0.00	0.00	0.00
2000.0	82.73	226.25	1.49	0.00	0.00	0.00
3000.0	151.56	177.33	23.14	0.00	0.00	0.00
4000.0	108.34	130.65	43.67	0.00	0.00	0.00
5000.0	107.14	101.28	53.55	0.01	0.01	0.00
6000.0	87.59	88.90	62.46	0.04	0.02	0.00
7000.0	74.17	69.57	72.97	0.14	0.05	0.00
8000.0	67.48	70.18	64.03	0.33	0.10	0.00
9000.0	65.80	60.24	56.99	0.71	0.14	0.00
10000.0	55.91	50.14	51.47	1.10	0.19	0.00
Conc Max	154.66	262.17	75.22	1.10	0.19	0.00
X Max	2947.0	1768.0	6785.0	10000.0	10000.0	10000.0
Hefectiv	500.0	500.0	500.0	500.0	287.5	252.9

Recomandari:
Rata de emisie trebuie sa fie mai mica decat: 562.15g/s
sau:
Sprainaltarea cosului existent cu: 70.0 m
Valoarea suprainaltarii cosului este orientativa. Valorile sunt foarte bune pentru inaltimi cuprinse intre 5..30m ale cosului
La inaltimi mari ale cosului se modifica atat diametrul cat si viteza si temperatura gazelor acestuia.

Figure 1: NO_2 concentrations calculated on the axis of the wind

The analysis of variance representation annual concentrations of NO_2 indicates that maximum values calculated are within 8 to 9 µg/m^3 significantly lower than the limit established in Order 592/2002 - 40µg/m^3 to human health and 30 µg/m^3 for the protection of vegetation. For the S.C.D.A. Şimnic area, maximum annual values for NO_2 is around 2-4 µg/m^3 and for S.D. Banu Mărăcine, between 4 and 6 µg/m^3.

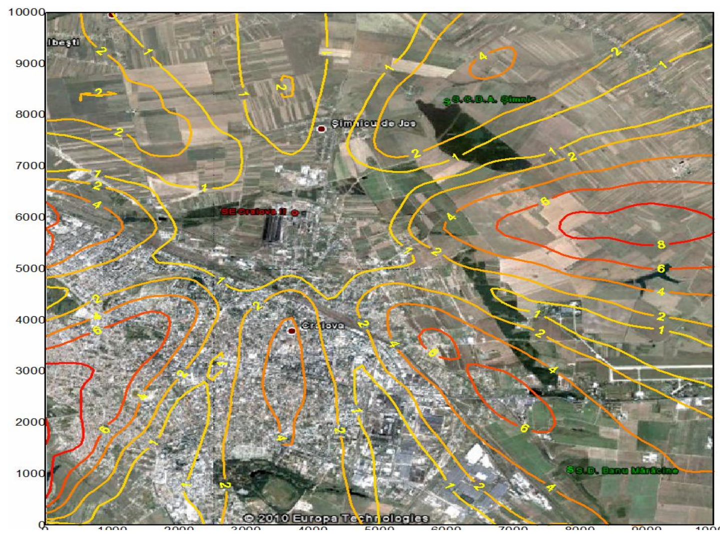


Figure 2: NO_2 annual concentrations from S.E. Craiova II

Regarding the situation of over-frequency allowable limits for NO_2 hourly during a year, it is shown in the figure below:

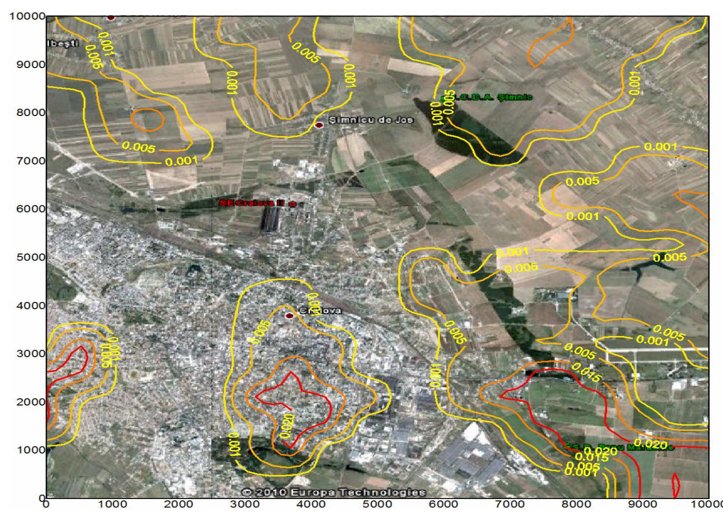


Figure 3: The situation of over-frequency allowable limits for NO_2 hourly during a year

It is noted that the S.C.D.A. Şimnic area is included within the curve of 0.005%, which means that the probability P of exceeding the allowable limit of 200 µg/m^3 hourly during a year will be:

$$P = \frac{8760 \cdot 0.005}{100} \approx 1$$ - exceeds the average hourly

S.D. Banu Mărăcine area is approximately inside curve of 0.02% resulting in a probability P of exceeding the allowable limit of 200 µg/m3 hourly during a year:

$$P = \frac{8760 \cdot 0.02}{100} \approx 2$$ - exceeded the average hourly

To calculate hourly concentrations of particulate total, the physical and technical details of the source remain the same and hourly emission rate calculated in relation to gas flow zone of 1382822 Nm^3/h is 12.1 g/s. The calculation of dispersion powders, as input data, we used the average density of dust discharged and mass fraction size; as for coal (lignite) we have 1.5g/cm^3 density, fraction 0..20µ = 0.35, 20..60µ fraction = 0.30, fraction 60..100µ= 0.25 and > 100µ = 0.1

In the following figure are presented the total powders concentrations measured on the axis wind (where concentrations are maximum), expressed in mg/cm. Concentration values thus calculated are valid for any wind direction considered, and hence the case when the wind blows from the direction of SSW-Source-S.C.D.A. Şimnic but also for the case when it blows from the NW -Source-S.D. Banu Mărăcine.

Rezultatele calculelor de dispersie pulberi - timp de mediere: 30'

Date tehnice ale sursei, meteo si de teren (pentru date introduse)

Poluant :	Pulberi Totale		Temperatura gazelor in cos :	138.0	[°C]
CMA 30'	500.0	[ug/mc]	Temperatura medie a aerului :	9.0	[°C]
Rata de emisie :	12.100	[g/s]	Viteza medie orara a vantului :	2.2	[m/s]
Inaltimea fizica a sursei :	150.0	[m]	Stabilitatea atmosferica :	2	
Diametrul gurii cosului :	8.8	[m]	Inversiunea termica :	infinita	
Viteza gazelor in cos :	12.6	[m/s]	Tip teren dispersie :	rural	

Concentratii calculate pe axa vantului pentru datele introduse cat si pentru alte stari meteo - timp de mediere: 30'[ug/mc]

Distanta [m]	Stab 2 Vvint 2.2	Stab 1 Vvint 1.5	Stab 3 Vvint 3	Stab 4 Vvint 3.5	Stab 5 Vvint 2.5	Stab 6 Vvint 2
0.0	0.00	0.00	0.00	0.00	0.00	0.00
1000.0	0.00	27.26	0.19	0.00	0.00	0.00
2000.0	55.14	17.13	15.29	5.09	45.94	55.14
3000.0	0.13	11.65	6.27	11.32	1.24	0.13
4000.0	0.36	9.48	5.86	0.62	9.80	0.36
5000.0	9.43	6.56	7.28	2.33	13.96	9.43
6000.0	22.59	5.00	6.04	4.39	8.23	22.59
7000.0	12.26	4.28	5.47	8.07	2.75	12.26
8000.0	2.23	3.35	4.82	8.42	0.71	2.23
9000.0	0.17	2.74	4.22	3.99	0.35	0.17
10000.0	0.01	2.26	3.69	1.64	0.43	0.01
Conc Max	122.75	33.20	17.09	22.98	68.16	102.95
X Max	1156.0	772.0	1763.0	2532.0	1791.0	2195.0
Hefectiv	--	--	--	--	--	--

Recomandari:
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Figure 4: The total powders concentrations measured on the axis wind

Analyzing the data calculated and presented in the figure above it can be concluded that there is no exceeding of the hourly limit allowable under 500µg/m^3 schedules STAS 12574/1987 for total suspended particulates. Total powders concentrations have a sinusoidal characteristic (peak followed by low) because the dust with different diameters is deposited along different feathers pollutant. Thus, powders with large diameters are deposited near the source, and then the other with smaller diameters (with lower specific gravity and low deposition rate) will be submitted at different distances.

To calculate annual average concentrations of particulate matter, data on physical characteristics of the source remain the same, the average annual temperature is 9 °C and annual emission rate is 10.8 g/s, relative to the total annual exhaust gas in 2008 by 10629994 Nm^3/an.

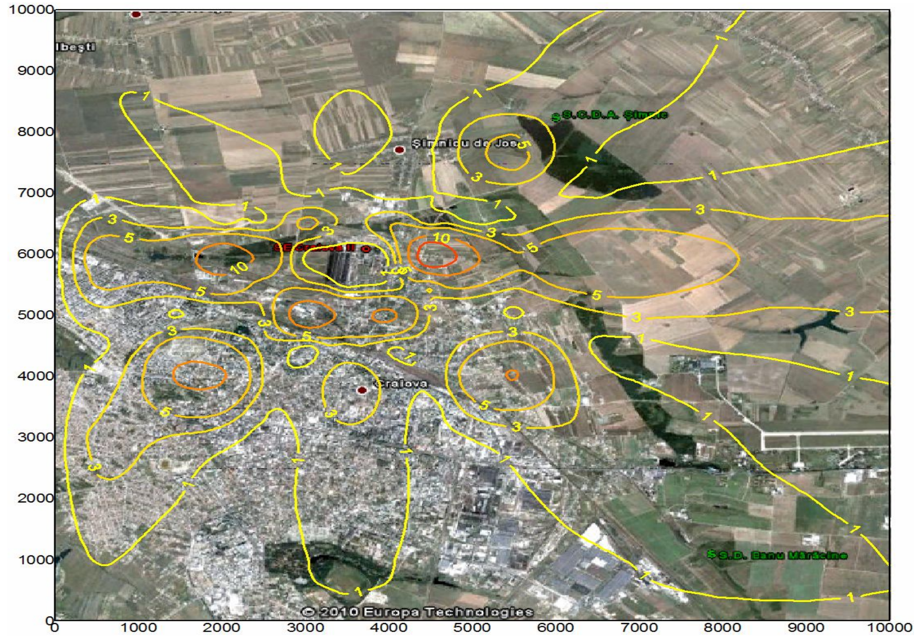

Figure 5: The dispersion of powders in suspension for long periods of time - annual

The above representation can be seen that the annual average values for particulate matter were maximum around 10 to 15 µg/m^3 in very restricted areas east and west of the source. S.C.D.A. areas feel and S.D. Banu Mărăcine annual concentrations of particulate matter have values ranging between 1 and 3 μm^3, is very small compared to annual limit of 75μm^3 specified in STAS 12574 in 1987.

In the figure below, one can see that inside the 0.005 and 0.008% curves there is a high probability to exceed the 30 minutes values limits (specified in STAS 12754/1987 as the 500µg/m^3) for total suspended particulates and the probability P for the curve of 0.005% is:

$$P = \frac{17520 \cdot 0.005}{100} \approx 0.88 \approx \text{ exceeds the average of 30 minutes}$$

and for the curve of 0008% the probability is:

$$P = \frac{17520 \cdot 0.008}{100} \approx 1.4 \approx \text{ exceeds the average of 30 minutes}$$

The situation regarding frequencies exceeded allowable limits zones for total suspended particulates over a year is shown in the figure below:

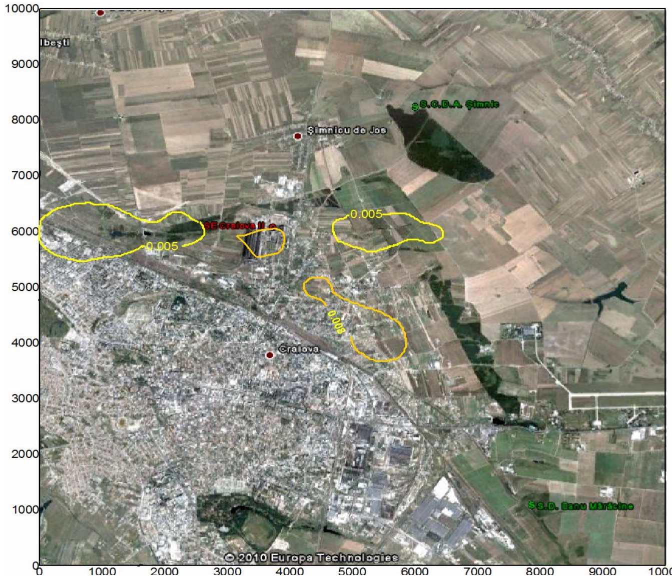

Figure 6: The situation of frequencies exceeded allowable limits zones for total suspended particulates over a year

CONCLUSIONS

After calculations of dispersion emissions of gaseous and particulate matter, one can draw the following conclusions:

Hourly average concentrations of NO_2 calculated are exceeded in a very restricted area with values above the permissible 200µg/m^3 least, may influence only the S.C.D.A. Şimnic area only when winds knock to the area, under conditions of stability of a class type highly unstable, characteristic of summer days with sky 1/3 covered with clouds and wind speeds of variables;

Annual concentrations of NO_2 are well below the annual permissible limit of 40 µg/m^3, and the frequency of exceeding of hourly limits are low, also expecting an over the limit allowable for the SCDA Şimnic 200 µg/m^3 schedules and feel about two times for the S.D. Banu Mărăcine;

Total suspended powders values are small compared with the allowable limits of 30 minutes 500µg/m^3 and annual 75 µg/m^3.

As a general conclusion, we can state that to achieve a more precise assessment of air quality and impact of different local sources of pollution for the area should be used efficiently and combined the two methods of investigation: monitoring and dispersion modeling of pollutants at different scales.

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