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AIR QUALITY MODELLING OF SO_2 EMISSIONS ASSOCIATED TO METALLURGICAL PROCESSES

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ABSTRACT. Metallurgical plants are one of the major industrial pollutants emitting mainly gases (SO_2, NO_x and CO_2) and particulate matters containing heavy metals. The objective of this study is to compare two situations, regarding the SO_2 emissions before and after the installation of the desulphurization system at a metallurgical plant. Two different sets of simulations were performed, considering a three days period for which meteorological data was available. The simulation results were compared to national SO_2 air quality limits. The results show a significant decrease of SO_2 concentrations after the installation of the desulphurization system, situated well within legal limits. Another objective of this study is to compare qualitatively the concentration data obtained from modelling with data measured on-site by a point-monitor.

Keywords: *air quality, metallurgical industry, SO_2 emissions, ISCST3 model*

INTRODUCTION

The magnitude of the effect humanity and its activities have on environmental change is one of the most pressing issues currently debated by all members of society. Air quality and climate change are issues that have complex socio-political implications. The potential impact of atmospheric processes and climate change on society is of crucial importance and therefore requires advanced scientific research into the causes, consequences and mitigation of such changes, in order to develop efficient strategies.

At European and global level there is a growing preoccupation on strategies and optimal actions for reduction of environmental pollution. The Directive 2008/1/EC of the European Parliament and of the Council of 15 January 2008 [1] concerning integrated pollution prevention and control (IPPC Directive) is the main Directive which create the legal framework for reduction of environmental pollution.

The IPPC Directive aims at a high level of protection for the environment as a whole. The Directive requires industrial activities with a high pollution potential to use 'best available techniques' (BAT). 'Best available techniques'

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are defined by the IPPC Directive as the most effective and advanced stage in the development of activities and their methods of operation which indicate the practical suitability of particular techniques for providing in principle the basis for emission limit values designed to prevent and, where that is not practicable, generally to reduce emissions and the impact on the environment as a whole.

In Romania, the IPPC Directive was transposed by G.E.O. no. 34/2002 on prevention, reduction and integrated pollution control, approved by Law no. 645/2002 [2].

For reduction of pollutant emissions, Best Available Techniques (BAT) are mainly considered: the use of fuel with a low polluting level; improvement of technology and combustion equipment according to fuel type, plant technical characteristics and local environmental conditions; the implementation of reduction techniques for sulphur dioxide (SO_2 < 350 mg/N^3) and particulate matter emissions (PM < 15 mg/N^3).

European policies have resulted in some decrease in SO_2 emissions levels. Still, metallurgical plants are one of the major industrial pollutants emitting mainly gases (SO_2, NO_x and CO_2) and particulate matters containing heavy metals.

These emissions also depend on the technology used in the metallurgical process. “In addition to the primary emissions, the gas to particle conversion processes, which depend on the meteorological conditions (mainly insolation and humidity), also give rise to considerable volumes of secondary particulate pollutants after the oxidation of sulphur and nitrogen oxides” [3].

The atmospheric pollutants emitted by metallurgical plants are then dispersed and carried over large distances (several to hundreds of kilometres) and finally deposited on the ground. The travel distances depend on a number of factors, such as stack height, grain size, and density of the individual particles [3]. Also, the deposition of pollutants is influenced by regional climatic conditions and physiographic features.

Atmospheric modelling is used to aid policy making on environmental issues and pollution control. Several models have been developed for the estimation of atmospheric impact, on a wide spectrum from easy to use regulatory models to more complex ones applicable to specific scenarios.[4].

The description of dispersion processes using models offers the possibility to study the atmosphere from mathematical and engineering point of view. Simulations offer the possibility to test the functionality and the dynamic behaviour of the model.

A complex modelling study requires various sets of data about source terms, emissions, imissions, vulnerability, local meteorology, terrain data etc.. Most of the air dispersion models have been developed for the prediction of downwind concentration of air pollutants and for the estimation of short-term and medium-term effects of these pollutants. The quality of results obtained using these modelling systems depend mostly on the versatility and quality of input data and the right choice of the model [5].

RESULTS AND DISCUSSION

The case study is built on a non-ferrous metallurgic plant which has zinc and lead as its main products. These products, indispensable to other economical sectors, are obtained in a pyro-metallurgical way, in a process that allows both zinc and lead to be obtained simultaneously form collective or selective sulphide concentrates.

In the first phase of the process these sulphides are oxidized, resulting in the zinc-lead agglomerate, which will be later processed in the furnace, and gases with high concentrations of SO_2 and PM containing heavy metals sent to a dry purification process using hose filters. In the past the gases cleaned of PM's were released into the atmosphere through the 250 m stack. This stack height assures a high level of dispersion.

The levels imposed by G.E.O. No. 34/2002 [2] were reached by running these gases through a desulphurization plant which uses the limestone-gypsum wet process [6]. This type of gas desulphurization has a series of advantages in comparison with desulphurization through a sulphuric acid producing process. By installing a desulphurization process the problems concerning the metallurgic plant's SO_2 pollution are solved.

For the comparison of the situations, regarding the SO_2 emissions before and after the installation of the desulphurization system, two different sets of simulations were performed, considering a three days period for which meteorological and point monitoring imission data was available.

The simulation results regarding to the SO_2 dispersion before the installation of the desulphurization system show maximum ground level imission concentrations much higher than the limits established in the G.E.O. No. 592/2002 [7] for the protection of human health for 1, 3 and 24 hr averages. The maximum concentrations are shown in table 1.

Table 1. Maximum imission concentrations obtained before desulphurization

	Maximum concentration [μg/m^3]	Limit value for protection of human health (G.E.O. No. 592/2002) [μg/m^3]
1 hr average	2880	350
3 hr average	1136	125
24 hr average	337	20

These maximum concentrations were obtained in stable (Pasquill class 6) atmospheric conditions in different imission points. Figure 1 shows the areas where concentrations are higher than the 1 hr average limit of concern established (C > 350 μg/m^3).

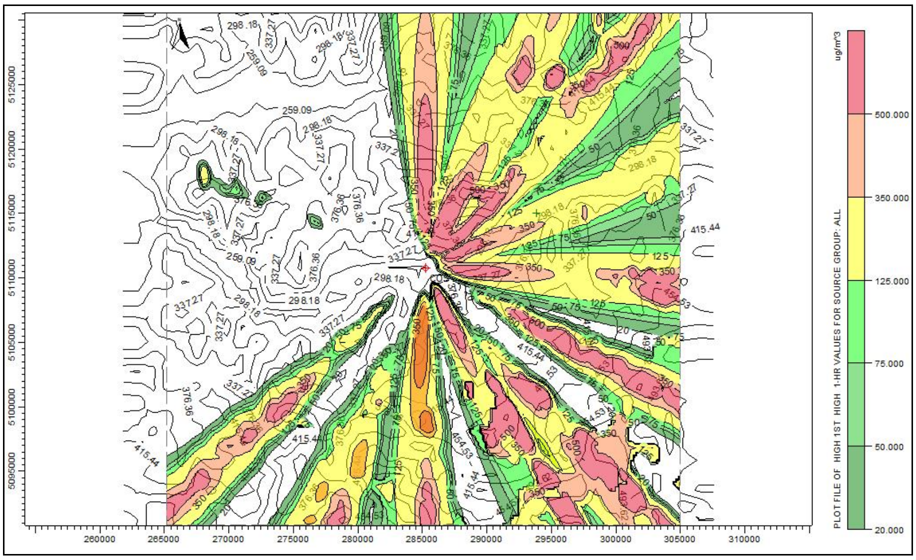

Figure 1. Maximum 1 hr average concentrations obtained before desulphurization

Figure 2 shows the areas where concentrations are higher than the 3 hr average limit of concern established (C > 125 μg/m^3).

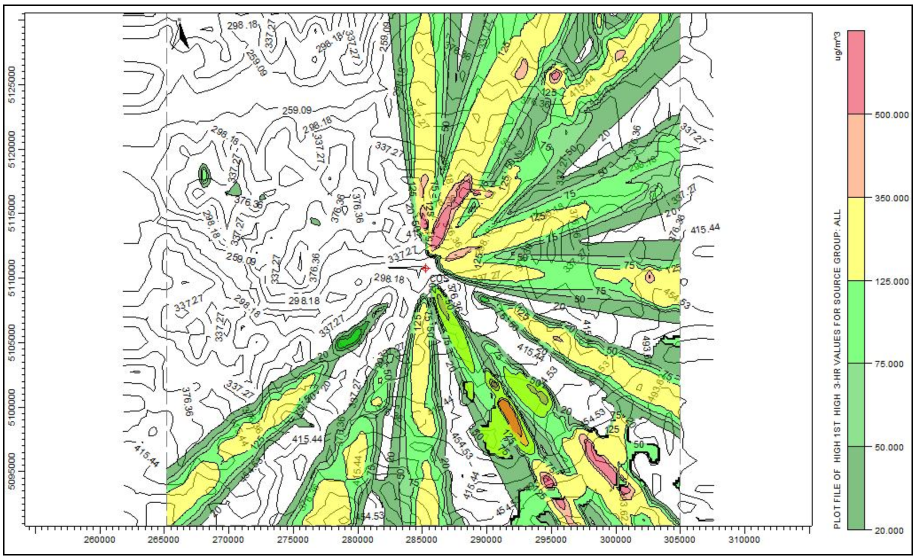

Figure 2. Maximum 3 hr average concentrations obtained before desulphurization

Figure 3 shows the areas where concentrations are higher than the 24 hr average limit of concern established (C > 20 μg/m^3).

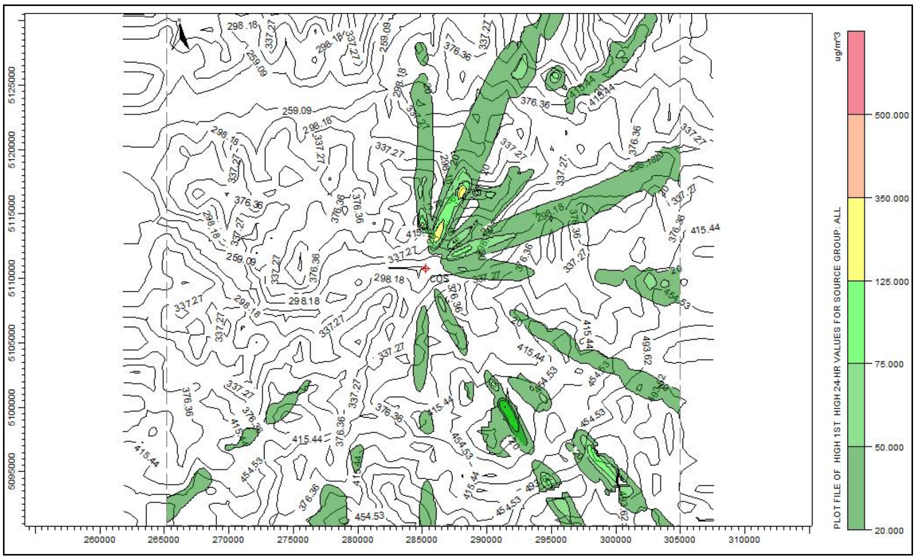

Figure 3. Maximum 24 hr average concentrations obtained before desulphurization

Simulation results were qualitatively correlated with imission concentration data measured at an automatic point monitor situated at 8 km from the emission source. The maximum 1hr average concentration obtained in simulation for the monitoring receptor point is 253 μg/m^3. It represents the maximum concentration that was reached using a 1 hour averaging period. The values of 1 hr concentrations are shown is figure 4.

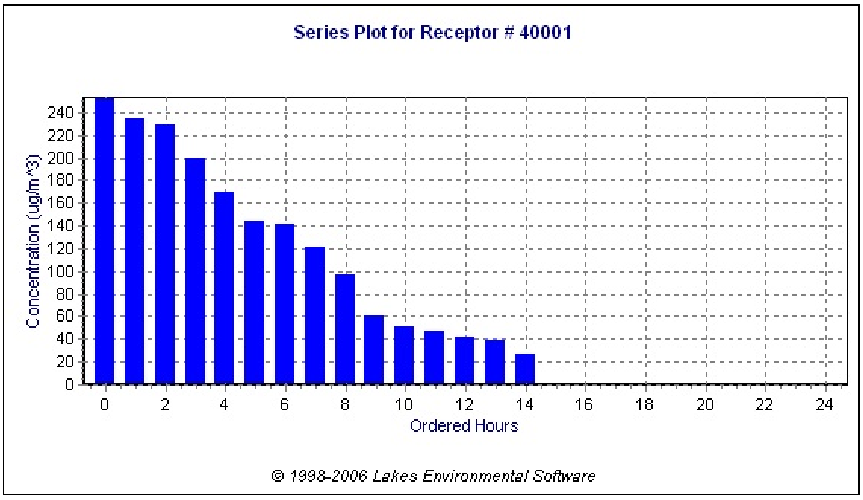

Figure 4. Maximum 1 hr average concentrations in monitoring receptor point

A qualitative comparison can be made between the concentration results obtained with simulations and the ones measured by the point monitor, presented in table 2.

Table 2. 1 hr average concentration measured at point monitor

1 hr average concentrations (μg/m³)			
Hour	**Day 1**	**Day 2**	**Day 3**
1:00	113.96	8.65	36.02
2:00	288.04	16.49	27.16
3:00	349.13	17.29	24.25
4:00	134.41	16.64	26.96
5:00	N/A	37.74	24.58
6:00	74.55	84.87	34.29
7:00	79.16	99.68	31.97
8:00	143.96	58.72	63.56
9:00	505.24	43.16	77.93
10:00	105.14	136.15	64.51
11:00	361.7	161.61	N/A
12:00	337.59	209.12	51.46
13:00	107.23	106.47	57.51
14:00	204.92	101.15	36.67
15:00	62.8	55.26	40.16
16:00	44.69	48.51	22.11
17:00	88.29	195.03	19.96
18:00	36.47	34.35	17.83
19:00	15.61	19.46	16
20:00	12.5	100.78	14.22
21:00	10.7	163.03	13.19
22:00	9.34	176.94	15.59
23:00	8.66	95.83	37.8
24:00	8.4	52.88	32.28
Daily average	***134.89***	***84.99***	***34.990***

Comparing the simulation results with the measured ones, it can be observed that the values have the same order of magnitude, but the simulation results show slightly lower values.

The simulation results regarding to the SO_2 dispersion after the installation of the desulphurization system show maximum ground level imission concentrations approx. 20 times lower than the limits established in the G.E.O. No. 592/2002 [7] for the protection of human health for 1, 3 and 24 hr averages. The maximum imission concentrations are shown in table 3.

Table 3. Maximum imission concentrations obtained after desulphurization process

	Maximum concentration [μg/m^3]	Limit value for protection of human health (G.E.O. No. 592/2002) [μg/m^3]
1 hr average	16	350
3 hr average	6	125
24 hr average	1	20

In figure 5 the situation of 1 hr average imission concentrations after the installation of the desulphurization system are represented.

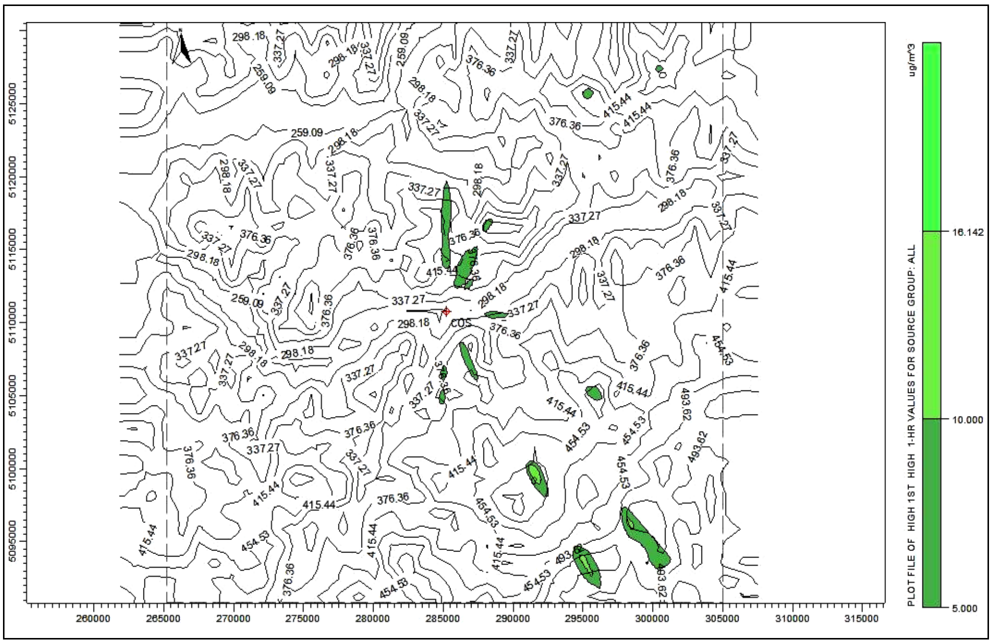

Figure 5. Maximum 1 hr average concentrations obtained after desulphurization process

It can be concluded that the installation of desulphurization system reduced the SO_2 emissions and imissions significantly and the obtained concentration values are well below the limits imposed by national and EU legislation.

CONCLUSIONS

The introduction of G.E.O. no. 34/2002 on prevention, reduction and integrated pollution control, approved by Law no. 645/2002, brought a significant contribution to the reduction of atmospheric pollutants such as SO_2, increasing air quality near industrial sites.

The objective of the case study was to determine the contribution of the desulphurization system in the reduction of the SO_2 emissions and imissions.

The simulation results, obtained for the situation before the installation of the desulphurization system, were compared with point monitoring data, showing a good qualitative correlation.

The simulations performed for the conditions after the installation of the desulphurization system show a significant reduction in the ground level concentrations of SO_2, well within the range imposed by national and European legislation.

In the future, imission monitoring measurements will be made and correlated with the simulations performed for the current process conditions.

EXPERIMENTAL SECTION

Air quality modelling of SO_2 emissions at a metallurgical plant

The case study focuses on the evolution of the air quality in the metallurgical plant area from the point of view of SO_2 emissions and imissions before and after the installation of the desulphurization system.

The dispersion simulations were performed using the ISC AERMOD View software package, using the Industrial Source Complex Short Term (ISCST3) model which is a Gaussian plume dispersion model that predicts air concentrations around point or area sources using emission rates (flux) and meteorological conditions as model inputs. ISCST3 is applicable for estimating short-term ambient impacts from point, area, and volume sources out to a distance of about 50 kilometres.

The meteorological data was obtained from the local station near the studied plant for a three days period and was processed using Rammet View, which is part of the ISC AERMOD View software package. Based on this data, Rammet View estimates the atmospheric stability class and mixing layer height for every hour taken into study.

The input data required by ISCST3 model includes: type of dispersion (dry/wet), data regarding the substance (type, dispersion coefficient), complex terrain data (computed by AERMAP, using GTOPO30 topographic data), source data (number of sources, location, height, release rate, release temperature and velocity), receptor data (defined grid).

ISC AERMOD View outputs results in the graphical form of dispersion maps superimposed on topographic maps. 10 maximum concentration scenarios can be computed simultaneously averaged on 1, 2, 3, 4, 6, 8, 12, 24 hours, one month, a specified period up to a year [8].

The in-situ monitoring data was collected by an automated device for the continuous monitoring of atmospheric SO_2 using UV fluorescence. The device employs a proprietary, internal dry-method sampling. The dry-method, due to its low maintenance requirements, continuous monitoring and instantaneous analysis of gas, is a preferred method for monitoring atmospheric SO_2 [9].

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