STUDIU PRIVIND EFICIENȚA UNUI SISTEM UMED DE DESULFURARE A GAZELOR DE ARDERE ASUPRA DISPERSIEI EMISILOR DE SO_2
STUDY REGARDING THE EFFICIENCY OF A WET FGD SYSTEM ON THE DISPERSION OF SO_2 EMISSIONS

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Coal-fired power plant represents the major source of sulphur dioxide emissions in Romania. This study presents the influence of a wet FGD system applied to an energetic block from Rovinari power plant in Gorj county over SO_2 dispersions regarding air quality. Sulphur dioxide emissions were modelled using AERMOD software considered a state-of-the-art dispersion model for industrial sources.

The results were plotted to Google Earth Pro showing a decrease of 95.6% for SO_2 hourly maximum concentrations and a decrease of 92.7% for SO_2 daily maximum concentrations.

Centralele termoenergetice care funcționează pe bază de cărbune reprezintă sursa majoră de emisii de dioxid de sulf din România. Acest studiu prezintă influența unui sistem umed de desulfurare al unui bloc energetic de la centrala electrică Rovinari din județul Gorj asupra dispersiilor SO_2 în ceea ce privește calitatea aerului. Emisiile de dioxid de sulf au fost modelate folosind software-ul AERMOD considerat un model de dispersie ultramodern pentru surse industriale.

Rezultatele au fost transpuse grafic în Google Earth Pro, arătând o scădere de 95,6% pentru concentrațiile maxime orare de SO_2 și o scădere de 92,7% pentru concentrațiile maxime zilnice de SO_2.

Keywords: *wet flue gas desulfurization, efficiency, SO_2, emission modeling, software dispersion model, AERMOD.*

1. Introduction

After 2007 when Romania became a member state of the European Union, all coal fired power plants in south-west Romania started installing flue gas desulfurization [1-3] (FGD) systems for their energetic blocks to meet emission standards. Sulphur dioxide, a gas released when burning coal, contributes to the formation of acid rain [4, 5] and particulate pollution, and represents a significant threat to human health [6, 7]. Overexposure to sulfur dioxide causes inflammation and irritation, leading to burning of the eyes, coughing, difficulty in breathing and chest tightness. People suffering from asthma and heart and lung diseases are at particular risk [8]. As well as sulfur dioxide, a FGD system will also reduce emissions of other harmful pollutants including dust, hydrogen fluoride, hydrogen chloride and mercury [9]. The purpose of the study is to compare SO_2 dispersions from one energetic block of a power plant from a year without FGD system (2009) with dispersions from the same energetic block from a year (2019) with FGD system already implemented, in order to evaluate the decrease of SO_2 concentrations and the quality of air.

2. Experimental

Breeze AERMOD was used for modeling the dispersion of SO_2 concentrations from Rovinari power plant, program based on the mathematical dispersion model AERMOD, developed, and used by the United States Environmental Protection Agency (US EPA) whose latest amendment and improvement is from July 10, 2019 (executable 19191r). Currently, AERMOD as the replacement to ISC is the preferred dispersion model by US EPA [10].

Breeze AERMOD is an enhanced version of the U.S. EPA-approved AERMOD that includes several modules [11] (a steady-state dispersion model, a preprocessor for meteorological data (AERMET) that accepts surface meteorological data and upper air soundings, and a preprocessor for terrain (AERMAP) whose main purpose is to provide a physical relationship between terrain features and the behavior of air pollution plumes.

The concentration distribution [12] is Gaussian in the stable boundary layer (SBL) in both the vertical and horizontal, while for the convective boundary layer (CBL), the vertical distribution is

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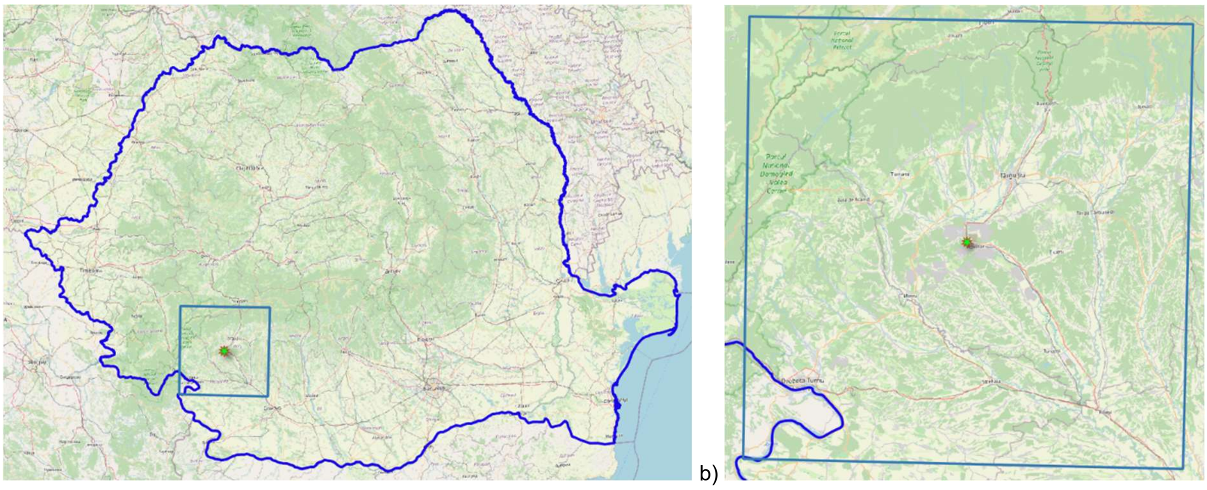
a) b)


Fig. 1 - Area of interest: a) inside country layer; b) close up / *Aria analizată: a) în interiorul României; b) imagine din apropiere*

described with a bi-Gaussian probability density function (p.d.f.). and the horizontal distribution is also assumed to be Gaussian.

The dispersion model can predict the concentrations of particulate pollutants like NOx, SOx, TSP, CO, and others from several types of pollutant emitting sources. Thus, this model considers topographic and climatic characteristics for each location (source of pollution) and can predict concentrations of pollutants from point sources, surfaces, or volumes [13].

The analyzed area (area of interest, Fig. 1) was set for a zone measuring 10,000 km^2 (100 x x100km) with the Rovinari power plant in the center.

The climatic data used in the preparatory stages of the dispersion model are of two types: surface hourly observations (ISHD) and radiosonde (able to capture the variability of weather conditions on the vertical profile). The surface data used were from the Craiova metrological station, while the upper air data were from Bucharest (Băneasa) metrological station.

These two types of data were entered in the AERMET module, going through steps of verification, QA (Quality Assurance) and merging. Both datasets were retrieved from The National Oceanic and Atmospheric Administration [14] (NOAA) of the United States of America, by accessing the online database. After processing of these, two types of files (.sfc and .pfl) resulted, containing the relevant information for area, spatio-temporal resolution and study period, both horizontally and horizontally vertical.

For the “without FGD” scenario, climatic data from 2009 (the last complete full year when the energetic block was functioning) was used, while for the “with FGD” scenario climatic data from 2019 (last complete year of metrological data available) was used.

The wind rose was generated containing details about calm periods and general wind directions, as well as the percentage for each on reference period. Wind roses (Figure 2, 3) were generated using the METVIEW feature within the AERMET module of AERMOD.

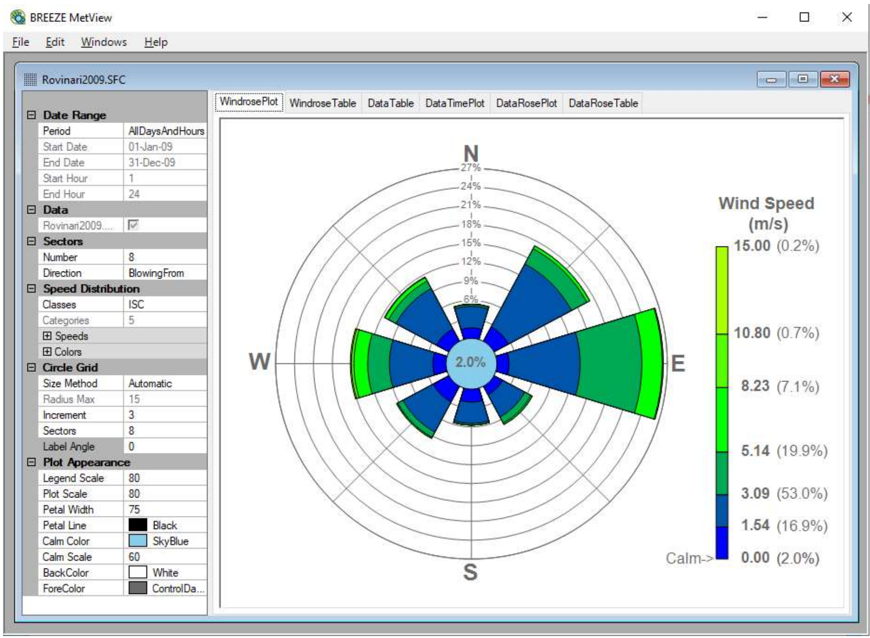


Fig. 2 - Wind rose and wind class frequency distribution – 2009 (year w/o FGD system) / *Roza vânturilor și distribuția frecvenței clasei vântului – 2009 (pentru anul fără desulfurare).*

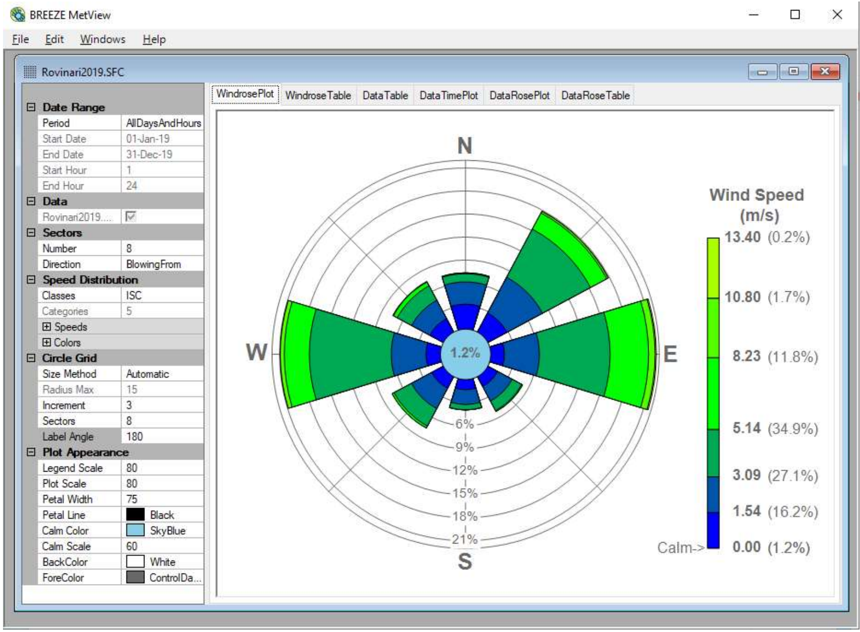


Fig. 3 - Wind rose and wind class frequency distribution – 2019 (year with FGD system) / *Roza vânturilor și distribuția frecvenței clasei vântului – 2019 (pentru anul cu desulfurare)*

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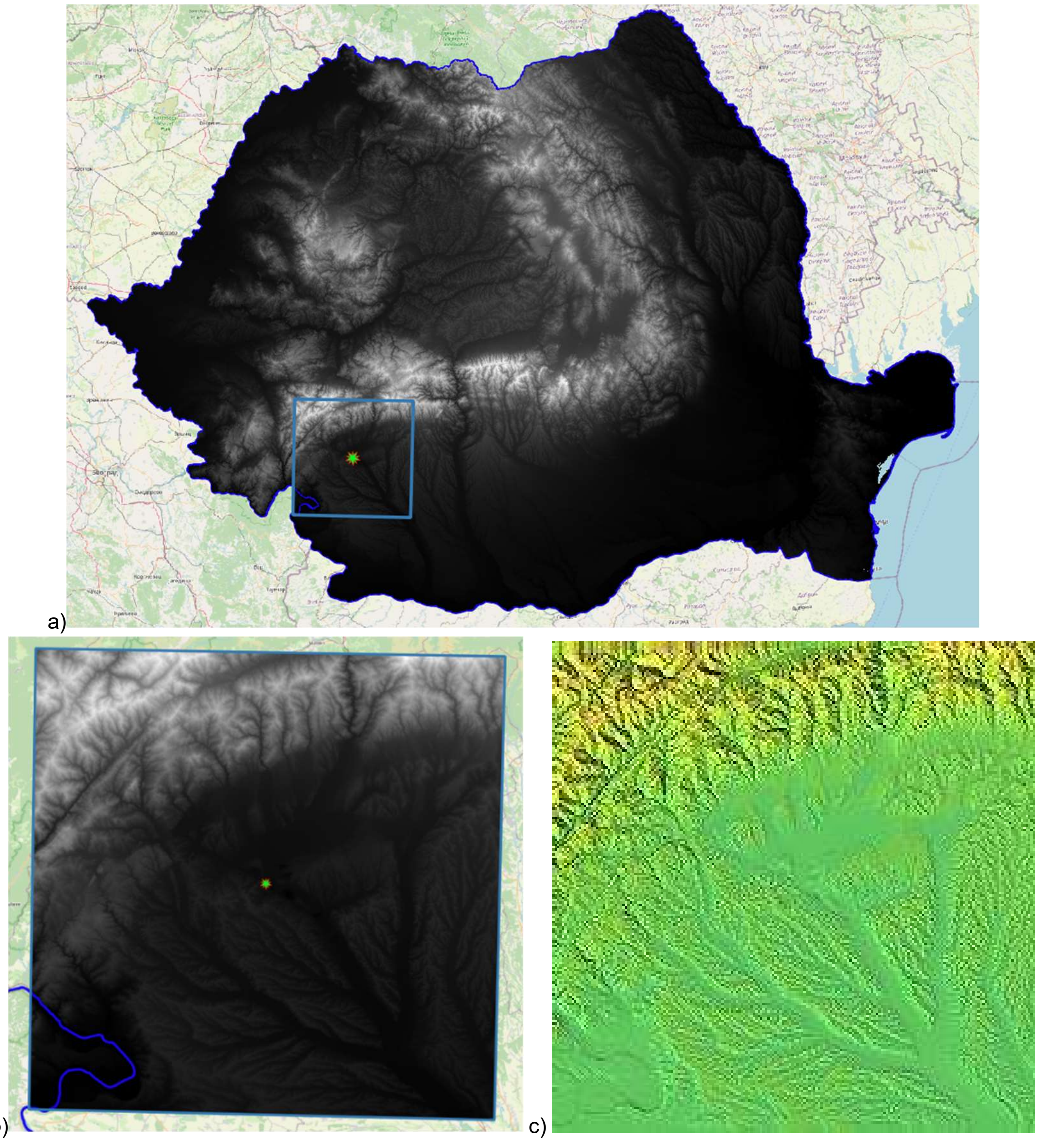


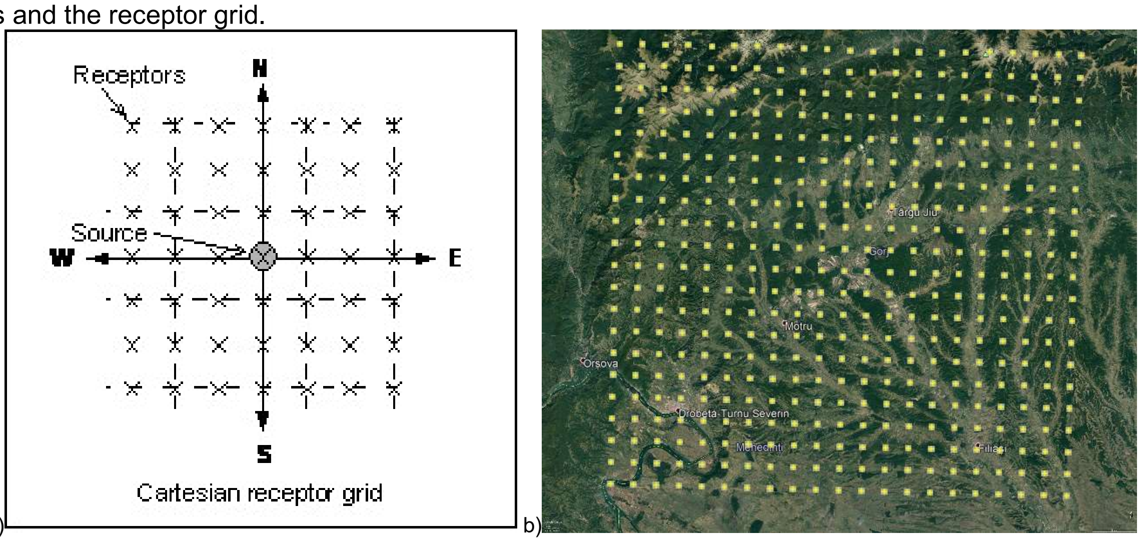
Fig. 4 - Digital elevation model: a) Romania; b) analyzed area; c) processed with AERMAP / *Modelul digital al terenului: a) pentru România; b) pentru aria analizată; c) harta ariei analizate procesată cu AERMAP*

Digital terrain modeling (DTM), also known as digital elevation model, is practical for creating a digital representation of topography and terrain.

The topographic data were obtained from Copernicus Land Monitoring [15] (Copernicus European Digital Elevation Model) processed through the QGIS software (Figure 4a and 4b) and integrated in the AERMOD software with AERMAP module (Figure 4c). The topographic data were correlated with those related to the emission sources and the receptor grid.

having as input data the technical parameters [16] from the integrated environmental permit and an environmental study for the National Agency for Environmental Protection. The input parameters are presented in the Table 1.

The implementation of the FGD system requires among other the construction of a new stack. The height of the new stack was designed to ensure a proper dispersion of SO_2 emissions.

a)


b)

Fig. 5. -The cartesian grid of receptors: a) example; b) plotted to Google Earth Pro
Grila carteziană de receptori: a) exemplu; b) suprapusă in Google Earth Pro

Table 1

Input Parameters for Aermod Software / *Date de intrare - Aermod*

	Without FGD system	With FGD system
Terrain elevation	164 m	164 m
X coordinates	668746.30 m E	668598.02 m E
Y coordinates	4974857.02 m N	4974725.41 m N
Emission rate	73,584 t/year	2,628 t/year
Stack height	220 m	120 m
Stack temperature	140 ^{0}C	55 ^{0}C
Stack velocity	10.96 m/s	15.15 m/s
Stack diameter	8.8 m	8.4 m

The uniform cartesian receptor grid represents how the receptors are placed in the space around the source (Figure 5a). The coordinates for the cartesian grid were adjusted for the southwest and northeast corner to match the analyzed area.

The cartesian receptor grid contains 441 receptors and can be seen below plotted to Google Earth Pro (Figure 5b).

The modeling of the dispersion of air pollutants was performed for years 2009 and 2019,

3. Results and discussion

The AERMOD output reports for both scenarios show the maximum, average, and minimum concentration for 1 hour and 24 hours. The data are presented in the Table 2 for both scenarios.

The first case analyzed was “without the FGD” system. In the figures below we can see the SO_2 dispersion (Figure 6) and distribution of concentration levels (Figure 7) for the 441 receptors

Table 2

Output Data from Aermod Software / *Date de ieşire - Aermod*

Scenario	SO_2 1h concentration, μg/m^3			SO_2 24h concentration, μg/m^3		
	Maximum	Average	Minimum	Maximum	Average	Minimum
w/o FGD	372.41	78.73	31.09	42.33	7.93	2.37
w FGD	16.16	3.81	1.38	3.06	0.34	0.11

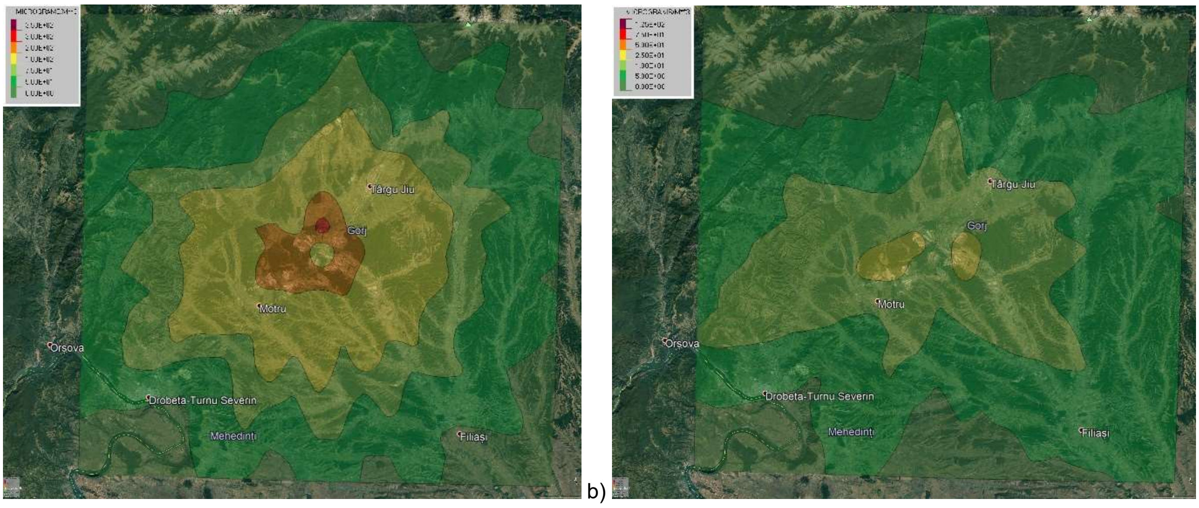


Fig. 6 - SO_2 dispersions (without FGD system) for: a) 1h; b) 24h
Dispersiile concentraţilor de SO_2 (fără desulfurare): a) 1 oră; b) 24 ore

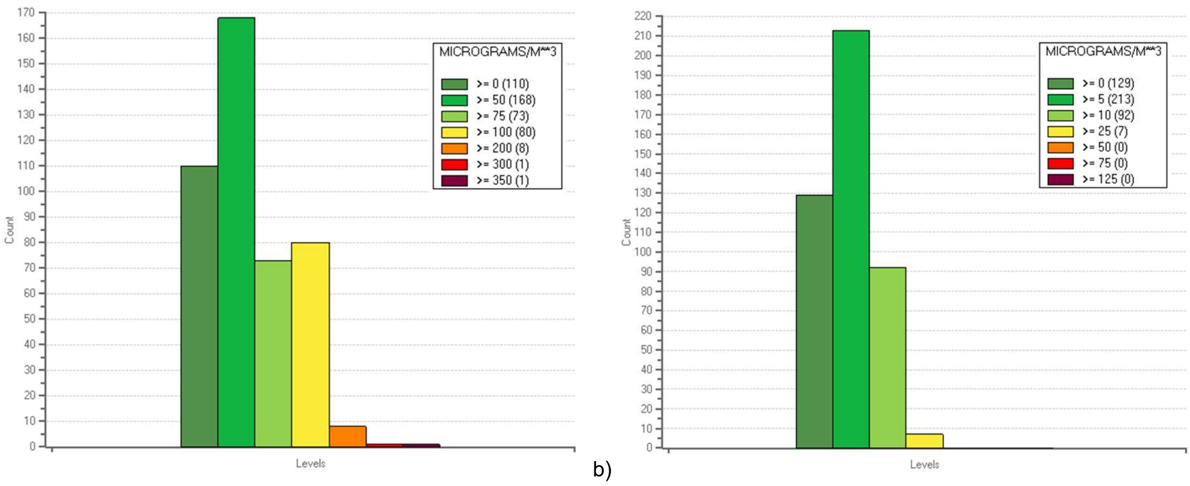


Fig. 7 - Distribution of SO_2 concentration levels (without FGD system) for: a) 1h; b) 24h
Distribuţia nivelurilor concentraţilor de SO_2 (fără desulfurare): a) 1 oră; b) 24 ore

for 1h and 24h. The limits for SO_2 concentrations in Romania are: 350 μg/m^3 for 1 hour and 125 μg/m^3 for 24 hours.

The dispersions modeled for the scenario "without FGD system" show us that the limit value for the SO_2 hourly concentration is slightly exceeded north of the emission source, while the SO_2 daily concentrations are under the limit value. The distribution of SO_2 concentration levels (without FGD system) reveals that most of the receptors from the analyzed area indicate hourly concentrations below 200 μg/m^3 and daily concentrations below 25 μg/m^3.

The second case analyzed was for the scenario "with FGD system". In the figures below we can see the SO_2 dispersion (Figure 8) and distribution of SO_2 concentration levels (Figure 9) for the 441 receptors for 1h and 24h. Given that the SO_2 concentrations were exceedingly small for both time periods the scale of the concentrations was considerably reduced.

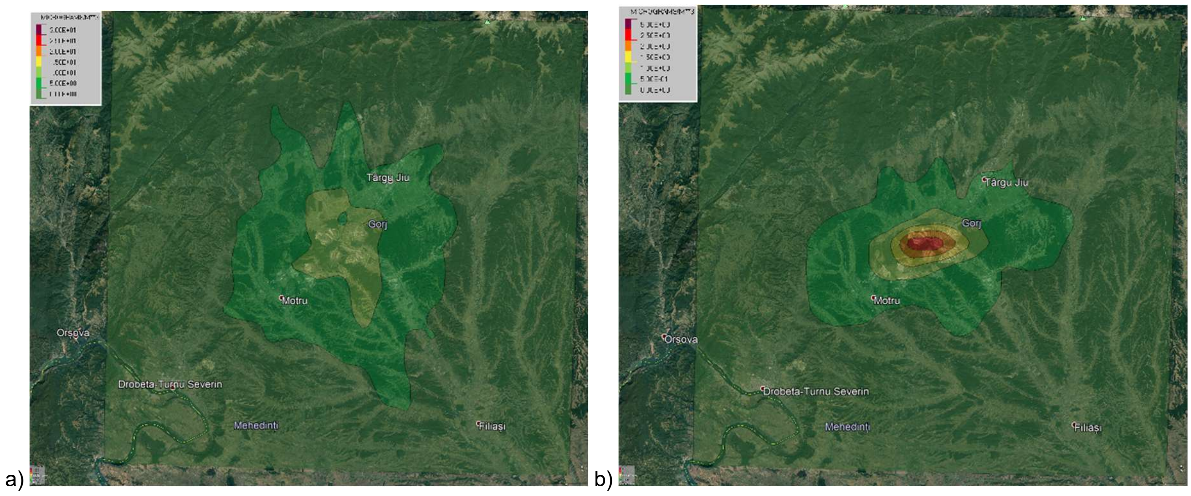


Fig. 8 - SO_2 dispersions (with FGD system) for: a) 1h; b) 24h

Dispersiile concentrațiilor de SO_2 (cu desulfurare): a) 1 oră; b) 24 ore

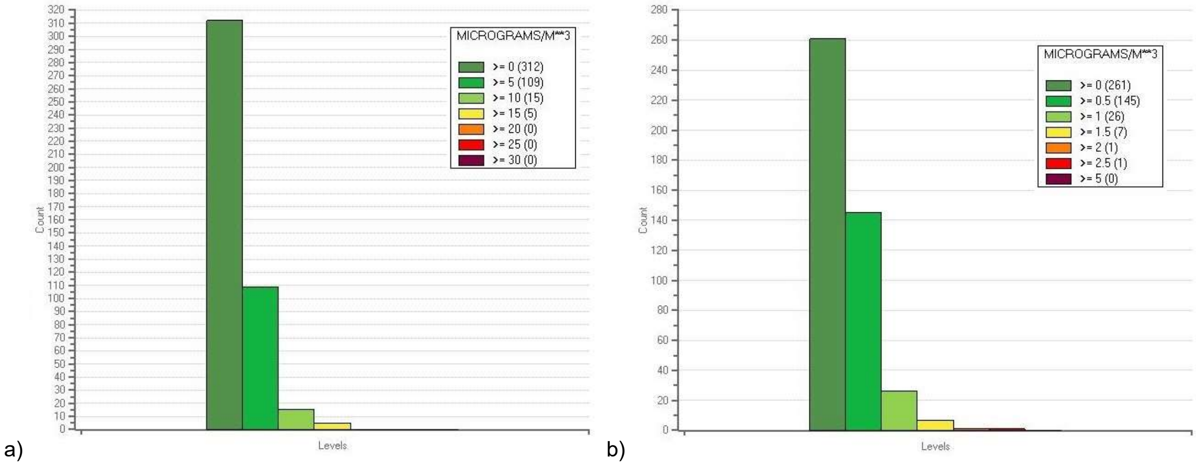


Fig. 9 - Distribution of SO_2 concentration levels (with FGD system) for: a) 1h; b) 24h

Distribuția nivelurilor concentrațiilor de SO_2 (cu desulfurare): a) 1 oră; b) 24 ore

This scenario shows hourly and daily concentrations with extremely low values. The dispersions indicate a maximum hourly concentration of 16.16 μg/m^3, and for the daily concentration a maximum of 3.06 μg/m^3. The distribution of SO_2 concentration levels (with FGD system) shows that most of the receptors from the analyzed area indicate hourly concentrations below 10 μg/m^3 and daily concentrations below 1 μg/m^3.

4.Conclusions

This study presents the efficiency of the implementation of a wet FGD system at Rovinari power plant regarding SO_2 emissions from coal burning. The emission modeling software used was Breeze Aermod.

The following conclusions can be drawn:

-the maximum hourly SO_2 concentration decrease by 95.6%.

-the average hourly SO_2 concentration decrease by 95.1%.

-the maximum daily SO_2 concentration decrease by 92.7%.

-the average daily SO_2 concentration decrease by 95.7%.

Even though the project is put on hold due to lack of funding, it was estimated that the commissioning year of the FGD system at energy block no. 5 from Rovinari power plant is 2021.

The evaluation for the global impact of the flue gas desulphurization installation on environmental factors (air, water, soil, biodiversity, socio-economic environment, etc.) is positive due to reduction of sulfur dioxide emission well below the maximum limits.

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