THE INFLUENCE OF THE SYNOPTIC CONDITIONS IN THE DISPERSION OF THE AIR POLLUTION INDICATOR – THE SULPHUR DIOXIDE (SO_2) IN THE SLATINA AREA

Dana Maria (OPREA) CONSTANTIN [1], Elena GRIGORE[1], Elena BOGAN[1], D. R. MANTA[2], R. ILEA[2]

ABSTRACT. The influence of the synoptic conditions in the dispersion of the air pollution indicator – the sulphur dioxide (SO_2) in the Slatina area. The sulphur oxides are among the most common pollutants, because the sulphur can be found in various forms in most of fuels and ores. The sulphur dioxide (SO_2) is a colorless, suffocating, irritating gas, which contributes significantly to the producing of the acid rains. The main objective of the study is to analyze the way of dispersion for the air pollution indicator – the sulphur dioxide (SO_2), in the Slatina town area, in relation to the climatic and topographic factors, but also to the nature of the pollution sources. The analysis will highlight the atmospheric conservation role of the pollutants through the thermic inversions, the atmospheric calm and the high air moisture. At the end of the study, there are presented the authors's conclusions formulated on the basis of the data from the German Meteorological Offenbach Service, the National Meteorological Administration and the Agency for Environmental Protection from the Olt County. The quantitative and qualitative analysis of an air pollution indicator constitutes a first step in ensuring the air quality management, which represents a component of the environmental management.

Keywords: air pollution, sulphur dioxide, dispersion, synoptic conditions, Slatina.

1. INTRODUCTION

Breaking the natural balance through human actions is made both by pollution and destructive actions for the ecological balance, such as deforestation and elimination of some species. The urban air, especially that of the industrialized regions, is loaded with solid and liquid particles, gases and vapors. Some of the natural constituents, such as methane, carbon monoxide, sulphur dioxide etc. are among the regular urban air pollutants, but whose proportion increases significantly under the influence of the various anthropogenic sources of pollution (Ionac and Ciulache, 2005). The atmospheric pollution has an historical character

[1] University of Bucharest, Faculty of Geography, 1 Nicolae Balcescu Avenue, 010041, district 1, Bucharest, Romania, danamartines@yahoo.com (corresponding author), elena.bogan@yahoo.com, ela_zigzag@hotmail.com

[2] University of Bucharest, Faculty of Geography, Climatology and Environmental Air Protection Scientific Students Circle, 1 Nicolae Balcescu Avenue, 010041, district 1, Bucharest, Romania, mantadaniel8@gmail.com, raul11.bv@gmail.com

so that the more the industrial activity has diversified and intensified, the more pollution rythm has accelerated, leading to the degradation of the atmospheric air quality (Bogdan and Câmpean, 2006). The release of the polluting gases into the atmosphere is the main cause of the anthropogenic climate change, which is the current global problem (Stehr and Hans, 2015). The air pollution with gases and vapors is more diverse, stronger and with greater unfavorable effects than the pollution with particules (Constantin, 2013). In 2013, the air pollution was the cause of 2.1 millions premature deaths worldwide, the most deaths being recorded in the Eastern Europe (including Romania) and Asia (Mănoiu et al., 2016).

The pollutants emitted into the atmosphere suffer the turbulent diffusion, followed by their dilution in cleaner air volumes, which is at greater distances from the source (Farcaş and Croitoru, 2003). The dispersion of pollutants in the atmosphere is determined by the characteristics of the emission or immission and by the geographical, meteorological and urban factors. The purpose of this study is to analyze the dispersion way of the air pollution indicator – the sulphur dioxide (SO_2) in the Slatina town area in terms of the meteorological factors which determine the pollution and self-purification. The analysis will be made at synoptic and air scale, being supplemented by the emissions sources, the describtion of the pollutant, the annual regime and its concentrations during 2014. The choice of the year 2014 is motivated by the annual concentration of SO_2, the lowest in the period 2008 – 2014. The analysis will be made for the Slatina town area due to the presence of one of the best performing large industrial companies in Romania, heavily engaged in the market economy, also being the largest aluminum producer in the Central and Eastern Europe (excluding Russia) – SC ALRO SA. This company is related to the economic and social development of Slatina since 1961 (Constantin, 2013). The town is located in the Southern Romania, on the high terraces on the left of the Olt river, having an altitudinal difference of 67 – 72 m and a maximum altitude of 175 m (Fig. 1).

Fig. 1. ***The study area*** (GIS processed open source, 2016)

2. MATERIALS AND METHODS

The sulphur dioxide (SO_2) or the sulphur anhydride is an inorganic pollutant compound of the sulphur, being a colorless, malodorous, suffocating, irritating gas, with a high frequency in the urban atmosphere (Rădulescu, 2008; Oprea, 2013). In the presence of the water vapors, the sulphur dioxide is converted to Sulphuric acid (H_2SO_4). The precipitations wash the atmosphere charged with this acid causing the acid rains, thus the sulphur dioxide is a gas with acidifying effect. The residence time of SO_2 in the atmosphere is 2 to 4 days (Popescu and Popescu, 2000).

For this analysis, there will be used: daily, monthly and annual average data, supplied by the Agency for Environmental Protection of the Olt County; the synoptic maps from the German Weather Service in Offenbach; the radio-surveys from the Bucharest-Afumaţi station; the climatological data from the National Meteorological Administration offered by statistical methods; the graphic and cartographic representations and facilities of the Microsoft Office software package. The data interpretation is done according to the STAS 12574/1987, 592/2002 MAPM Order and the Law no. 104/2011 on the quality of ambient air (APM Olt, 2015; ANPM, 2015). For the sulphur dioxide, the hourly maximum concentration for the protection of the human health is 350 µg/m^3, which must not be exceeded several 24 times/year, while the daily maximum concentration to protect the human health is 125 µg/m ^{3}, which must not be exceeded several 3 times/year.

In the Slatina town, the monitoring of the sulphur dioxide pollutant is achieved by: the automatic industrial-type station (OT-1), which is part of the national network of the air quality monitoring; the network of fixed sampling points per 24 hours at the industrial platform; the analysis laboratories and assessments of the noxes from the key industrial economic agents and the mobile stations located in the main intersections. The most representative pollutions sources with sulphur dioxide are the industrial agents: SC ALRO SA, SC ALTUR SA, SC TMZARTROM SA, SC ELECTROCARBON SA, SC PIRELLI TYRES, located in the industrial platform in the east of the town, being also added the burning sulphurous fossil fuels of the power electric and thermic plants and the burning of the liquid fuels in the combustion engines in the road traffic.

3. RESULTS AND DISCUSSIONS

The distribution in space and time of the pollution indicator – the sulphur dioxide, in the heart of the town is conditioned by the state of the atmosphere, the geographical factors, the quantity and type of emission/immission. The meteorological conditions are those which determine the conservation and pollutants vehicle role of the atmosphere. The conservation role of the emissions that is fulfilled by atmosphere is determined by the weather conditions such as the thermic inversion, the calm atmosphere and the high air moisture. The thermic convection, the wind and precipitation are the weather conditions which lead to exercise the atmosphere vehicle role of the pollutants (Bogdan and Câmpean, 2006).

The annual sulphur dioxide regime in the Slatina town area, for 2014, the highest monthly average value was recorded in February, of 16.92 µg/m^3. The maximum monthly average is determined by: a new source of temporary contamination, but a substantial one, represented by the installations for all kinds of heating buildings; the anticyclone regime prevalence and the higher air humidity of 85 – 87%. The lowest monthly average was recorded in August, of 6.22 µg/m^3, caused by an intense thermic convection, and the lack of the contamination sources (Table 1). The maximum allowable concentration (MPC) did not exceeded in any month. The annual average concentration of SO_2 was 10.90 µg/m^3, being the lowest annual average of the period 2008 – 2014. This value is 19.10 µg/m^3 lower than the highest yearly value recorded in 2008, of 30 µg/m ^{3} (Fig. 2).

Table 1. ***The annual regime of the pollution indicator – SO_2 in Slatina, in 2014***

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Monthly average (µg/m^3)	12.98	**16.92**	11.11	10.29	9.55	11.11	9.72	**6.22**	8.77	11.58	12.06	10.8
Allowable maximum concentration (µg/m^3)	125	125	125	125	125	125	125	125	125	125	125	125
Monthly data capture (%)	85	98.6	96.3	98.3	98.6	91.1	90	92	88.1	98.5	98.6	85.6

(Processed data after APM Olt – OT-1 station, 2016)

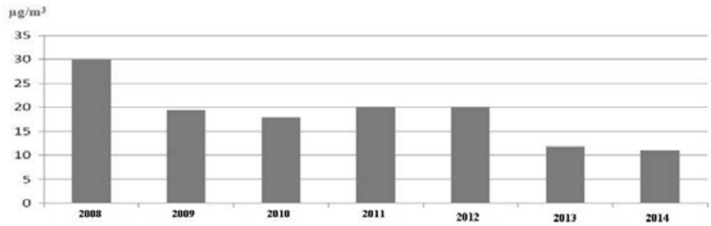


Fig. 2. ***The evolution of the annual average values (µg/m^3) of the SO_2 in Slatina, for the period 2008 – 2014*** (Processed data after APM Olt – OT-1 station, 2016)

In the evolution of the daily average concentrations values, there will be analyzed the highest daily averages for each season, highlighting the influence of the synoptic conditions in the dispersion of the sulphur dioxide, which determines the role of atmosphere of conservating the pollutants.

For the winter season, the highest daily average was 82.10 µg/m^3, recorded on January 1st 2014, without exceeding the daily maximum concentration (Fig. 3). During the night, the synoptic context of Romania was dominated by a large area of high pressure present in the entire South-East Europe (Fig. 4a). In this context, in the Slatina town area, as it can be seen on the graphic, during the night, there was present a thermic inversion between the ground layer and 980 hPa, of 8 – 9 °C intensity (Fig. 4b). In the evening, due to the rapid increase in atmospheric pressure and the blue sky, the air near the ground was cooled and again the phenomenon of thermic inversion manifested. During the day, no precipitations fell, and the average wind speed was 1 – 2 m/s. All these weather conditions favored the maintaining of the sulphur dioxide pollutant at the ground and the increasing of pollution.

In the spring of 2014, the highest daily average concentration was 89.16 µg/m^3, recorded on the day of April 5th 2014, without exceeding the daily maximum allowable concentration (Fig. 5). The daily average concentration is the result of Romania's proximity to an area of high pressure centered in Ukraine and the stationing of a Mediterranean Cyclone, weakly outlined in the Adriatic Sea, these both increasing the baric gradient (Fig. 6a). The wind presented intensification in the Eastern sector throughout the day, with gusts speeds between 13 – 20 m/s. But the presence of a moderate thermic inversion at an altitude of about 600 m has prevented the upward movements, channeling permanent the Eastern flow (Fig. 6b). Also, it should not be neglected the sulphur dioxide density of 2.73 kg/m^3, higher than the air density. During the day, no precipitations fell.

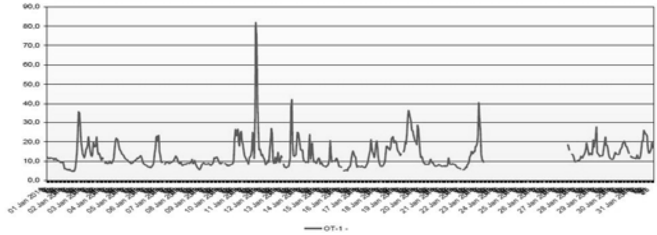
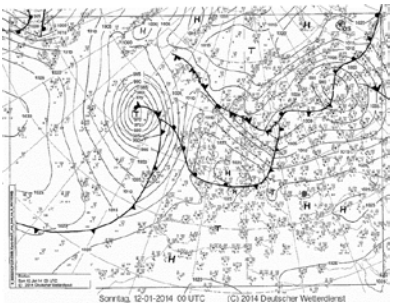
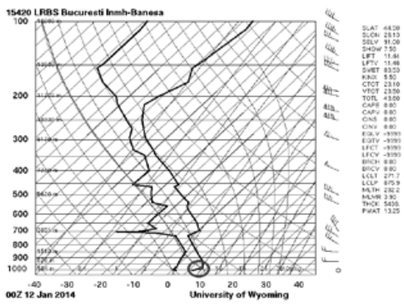


Fig. 3. ***The evolution of the daily average values (μg/m^3) of SO_2 in Slatina, for the month of January 2014*** (after APM Olt - OT-1 station, 2016)



a)



b)

Fig. 4. a) ***The synoptic map for Europe on January 12th 2014, at 00 UTC hour*** (source: www.wetter3.de/archiv); **b)** ***The aerological diagram from Bucharest station, on January 12th 2014, at 00 UTC hour*** (source: www.weather.uwyo.edu)

The highest daily average concentration was recorded in the summer of 2014, on the day of July 6th 2014, of 112.11 μg/m^3, without exceeding the daily maximum concentration (Fig. 7).

Keeping the sulphur dioxide pollutant at the ground, in the lower troposphere, the increased pollution was also implemented in the existing conditions in the South-Eastern Europe of a very low pressure field, so that the baric gradient had low values (Fig. 8a).

During the night, due to the lower wind speeds of 1 – 2 m/s and the radiative cooling, a thermic inversion was present, with an intensity above 5 °C (Fig. 8b).

During the day, the average wind speed was 1 – 3 m/s and no precipitations fell. During the day, between the ground and 1500 m layer, the atmosphere was in neutral bedding, a more rare situation.

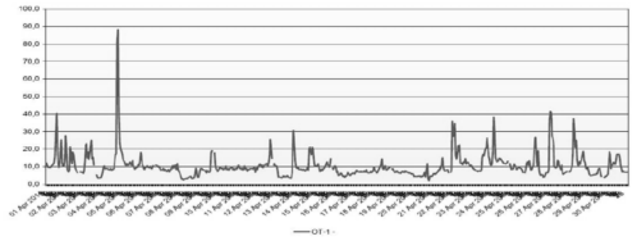
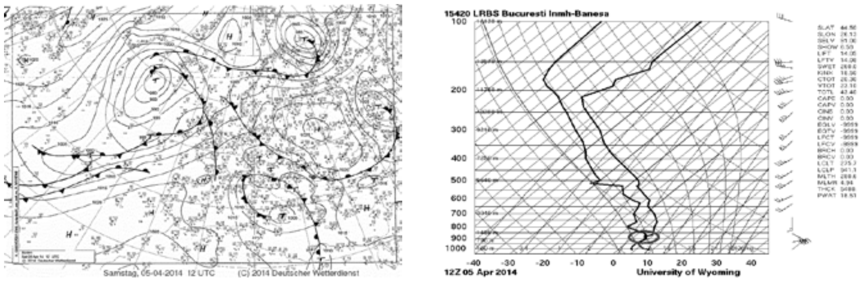


Fig. 5. ***The evolution of the daily average values (μg/m^3) of the SO_2 in Slatina, on April 2014*** (after APM Olt –OT-1 station, 2016)



a) **b)**

Fig. 6. a) ***The synoptic map for Europe on April 5th 2014, at 12 UTC hour*** (source: www.wetter3.de/archiv); **b)** ***The aerological diagram from Bucharest station on April 5th 2014, at 12 UTC hour*** (source: www.weather.uwyo.edu)

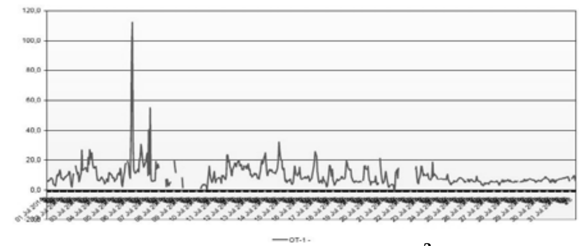
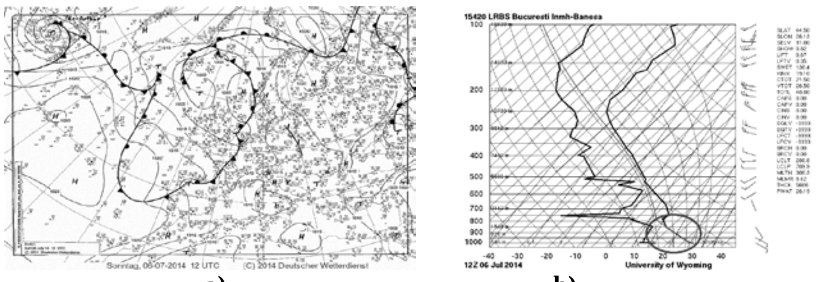


Fig. 7. ***The evolution of the daily average values (μg/m^3) of the SO_2 in Slatina, on July 2014*** (after APM Olt – OT-1 station, 2016)



a) **b)**

Fig. 8. a) ***The synoptic map for Europe on July 6th 2014, at 12 UTC hour*** (source: www.wetter3.de/archiv); **b)** ***The aerological diagram from Bucharest station, on July 6th 2014, at 12 UTC hour*** (source: www.weather.uwyo.edu)

In the autumn of 2014, the highest daily average concentration value of the sulphur dioxide pollutant was 144.09 µg/m^3, recorded on the day of November 5th 2014. *It is the only value of the year that exceeds the value of the allowable daily maximum concentation* of 125 µg/m^3 with 19.09 µg/m^3 (Fig. 9). This episode of pollution is the result of the presence of a high pressure field, established over the Eastern and South-Eastern Europe. At the same time, the country was located on the Eastern side of a thalweg extended over the Central Europe which led to the orientation of the atmospheric circulation in the southern sector in almost the entire troposphere and the advection of warm air masses from the North African origin (Fig. 10a). Following this synoptic context, in the area of the Slatina town, the average wind speed during the day was 1 m/s, while the thermic inversion with significant intensity of 7 °C within the first 98 m (about 1 °C/10 m) led to fog that has continued to thread the whole day (Fig. 10b). On November 5th 2014, no precipitations fell.

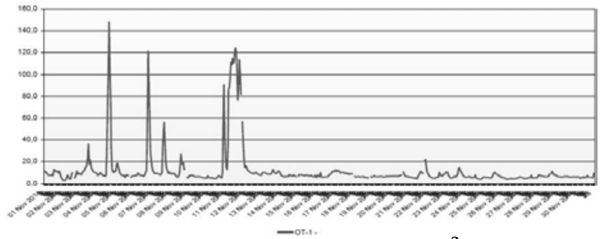
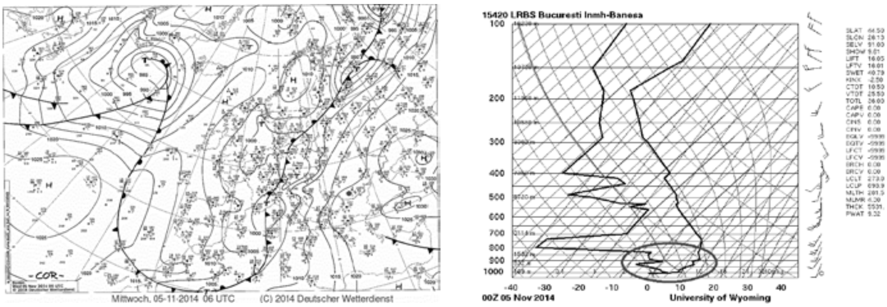


Fig. 9. ***The evolution of the daily average values (µg/m^3) of the SO_2 in Slatina, on November 2014*** (after APM Olt –OT-1 station, 2016)



a) **b)**

Fig. 10. a) ***The synoptic map for Europe on November 5th 2014, at 06 UTC hour*** (source: www.wetter3.de/archiv); **b)** ***The aerological diagram from Bucharest station, on November 5th 2014, at 00 UTC hour*** (source: www.weather.uwyo.edu)

4. CONCLUSIONS

Between the economic development and the environmental quality, there must be a balance relation in accordance with the principles and rules of the sustainable development. Therefore, in order to ensure the air quality management, the first step is the analysis of the quantitative and qualitative pollution indicators. And if episodes of pollution appear, it is effective to analyze the causes which led to these episodes in order to maintain the air quality. Sometimes, the atmosphere itself plays the role to accumulate and keep the pollutants resulting from the human activity, participating actively in the deteriorating of its own quality. This conservative role of atmosphere by keeping pollutants in the lower atmosphere and around the emission sources, has been evidenced by the most representative daily average concentrations recorded at Slatina, in 2014. During this year, the allowable daily maximum concentration exceeded only once, which must not be exceeded more than 3 times/year in order to ensure the human health. Furthermore, daily, monthly and annual avegares of the sulphur dioxide concentrations were lower than the ones recorded in the previous years, thus being followed the EU directive to reduce the concentrations of the air pollutants.

REFERENCES

1. ANPM (Agenţia Naţională pentru Protecţia Mediului) (2015), *Raportul anual privind starea mediului în România, anul 2014*. http://www.anpm.ro/web/guest/acasa accessed on November, 24, 2016.
2. APM Olt (Agenţia pentru Protecţia Mediului Olt) (2015), *Raportul privind starea mediului anul 2014 – Judeţul Olt*. http://www.anpm.ro/web/apm-olt/acasa accessed on November, 24, and December, 4, 2016.
3. Bogdan, O., Câmpean, I. (2006), *Bazele metodologice ale Meteorologiei*. Editura Universităţii "L. Blaga", Sibiu.
4. Constantin (Oprea), D. M. (2013), *Relaţia climă – poluarea mediului înconjurător în arealul municipiului Slatina*. Editura Universitară, Bucureşti.
5. Fărcaş, I., Croitoru, A. E. (2003), *Poluarea atmosferei şi schimbările climatice.* Casa Cărţii de Ştiinţă, Cluj-Napoca.
6. Ionac, N., Ciulache, S. (2005), *Ghid de cercetare environmental*. Editura Ars Docendi, Bucureşti.
7. Mănoiu, V. M., Gheorghe, Şt., Crăciun, Al. I. (2016), *The synoptic conditions and the critical levels of pollution for specific situations in Bucharest*. Volumul Conferinţei Aerul şi Apa Componente ale Mediului, 188-195.
8. Oprea, D. M. (2013), *The distribution over time and space of sulphur dioxide and influence on organic farming. Case study: the area of Slatina Town*. Scientific Papers Series „Management, Economic Engineering in Agriculture and Rural Development" 13, 1, 263-268.
9. Popescu, M., Popescu, M. (2000), *Ecologie aplicată.* Editura Matrix Rom, Bucureşti.
10. Rădulescu, C. (2008), *Emisii poluante. Metode pentru reducerea acestora*. Editura Bibliotheca, Târgovişte.
11. Stehr, N., Hans, S. (2015), *Clima şi societatea*. Editura Ars Docendi, Bucureşti.
12. http://www.wetter3.de accessed on November, 26, 2016.
13. http://weather.uwyo.edu/upperair/sounding. accessed on November, 26, 2016.