SPECTS OF THE FOG PHENOMENON IN BACAU CITY

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Keywords: the fog phenomenon, geographical positioning, atmospheric calm.

Abstract. The importance of knowing the fog phenomenon results from the fact that different industry, especially in transport, it can seriously disrupt this activity by reducing visibility. This paper analyses the recorded data as fog phenomenon varies according to the main meteorological factors in Bacau City.

Introduction

Bacau City, the capital of the district with the same name is located in the NE of Romania, in the lowland formed by the common valley of the Bistrita and Siret rivers.

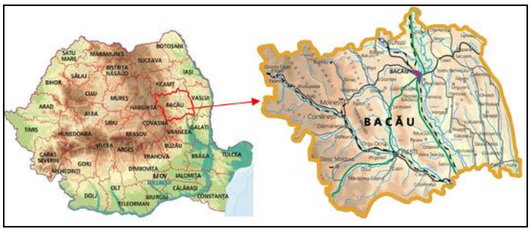

Fig. 1 - The cartographical representation of Bacau in the context of the geographical positioning at the national level (www.harta-romaniei.ro/; www.sportman.ro/).

Bacau City is the capital of the district Bacau and it is located in NE of Romania corresponding to the coordinates 46° 35’ N, 26° 55’ E. Its surroundings represent a vast and complex geographical area with many specific peculiarities. The slopes on the left of the Siret river are always steep and tall, they are

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accompanied by fragments of terraces and those on the right are slower and they have a wide unfolding of the terraces. (ANM 2008, www. arpmbc.anpm.ro).

The common valley of the two rivers looks like a depression corridor with north- south orientation with an opening to the west side, Bistrita valley and a narrowing to the south, " the Siret gate" , overlapping to the contact between the hills of the Tutova and the Carpathian peaks Pietricica- Barboiu.

The meadow steps and the flat or slightly sloping terraces stand as typical forms of the relief, with the eastern and south- east exhibition having a good drainage of groundwater (ANM 2008, www. arpmbc.anpm.ro).

The meadows and the terraces near the city are used for the practicing of the agriculture and high terraces are used for fruit growing and viticulture. The terraces favoured the construction of the ways of communication and they facilitated the spreading of the constructions (www. arpmbc.anpm.ro).

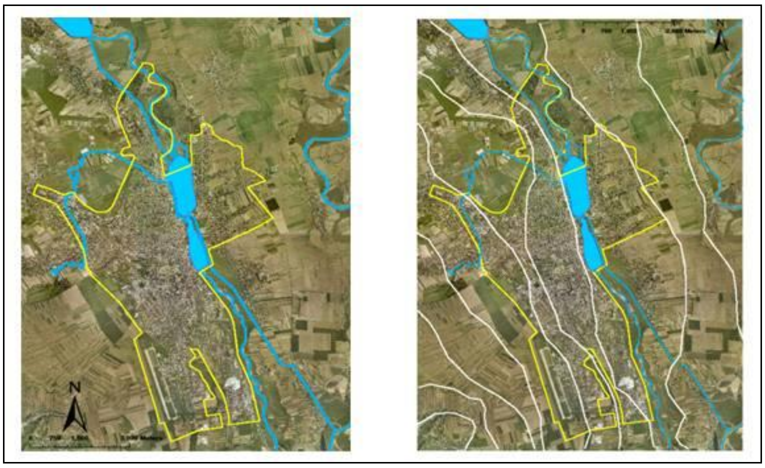

Fig. 2 - The cartographical representation of Bacau- the delimitation of the urban and peripheral areas.

Bacau City is located at just 9,6 km upstream of the confluence of Siret-Bistrita, at an altitude of 160,056 m

1. Climatic aspects in the city of Bacau

The climate of the city of Bacau is temperate - continental, with cold winters and hot dry summers, the result of the action of a complex of natural factors (general circulation of the atmosphere, the solar radiation, the landscape) and anthropogenic factors, the city itself having an essential role in creating its own mezoclime by a number of factors that constantly manifest (the materials of construction, the rugged profile, the green spaces) respectively through secondary factors (the artificial heating, the polluted atmosphere). The simultaneous action of these factors lead to the biogeochemical disturbance at the level of the system, the direct result being the urban discomfort (Gârţu 1991, ANM 2008).

This area of confluence and the Bistrita river corridor favor the channeling air masses over its weather conditions characterized by winds from the south and south- east, alternating with periods of atmospheric calm (average speeds of the wind (1,5m/s), the condition which characterizes the area most of the year and the frequent appearance of thermal inversion situations. These thermal inversions (the situation where a blanket of cold air is positioned under a blanket of warm air) can occur under a stationary atmospheric front of high pressure coupled with low wind speeds (Stefan 2004, Tasnea and Sarbu 1984).

In these conditions the atmospheric chemical mixtures between the atmospheric components and pollutants are slowed down, as well as reducing process, and the pollutants can be accumulated at low altitudes, close to the level of the ground (Dayan and Lamb 2005, Bogdan and Marinica 2007).

2. General aspects of the fog phenomenon

The importance of knowing the fog phenomenon results from the fact that in different economic branches, especially in transport (land, air and naval) it can seriously disrupt this activity by reducing visibility.

The provision of this phenomenon is a major difficulty, on the one hand because of the multitude of meteorological parameters which it depends on temperature, wind, pressure, humidity and on the other hand it depends on the local conditions (orographic). Because of this latter factor the general methods should have a strictly local application (ANM 2008, www. arpmbc. anpm. ro).

According to the international standards, the fog is a phenomenon that reduces the visibility to less than one kilometre. This phenomenon consists of small water drops suspended in the air.

The fog is formed when the moist air is cooled and it reaches to its point of dew, it becomes saturated and the vapours from the air are condensed forming tiny drops of water. The principle of the fog formation is the same as in cloud formation, except that this is a cloud which touches the ground (Bogdan and Marinică 2007, Gârţu 1991, Mureşan and Croitoru 2008).

The water drops which form the fog are very small, the diameter of the drop is about 2/100 mm and the distance between them is about 2 mm, so more than 100 diameters. The fog drops don't float in the air, as one might think, they fall like all the heavier bodies than the air, but the speed of fall is very small due to the very small volume. The forces that act on the drop are: the resistance force of the air and the closed sensitive weight, but they have opposite meanings, the fall of the fog drops is extremely slow, a fall on the lowest ascendant current it stops it or even it reverses it. The fall speed of a fog droplet with a diameter of 2/100 mm is about 1,3 cm/s. (Mureşan and Croitoru 2008, Tasnea and Sarbu 1984).

The total mass of the drops which constitutes the fog is 2g/m^3, lower to the water mass existing in the air in the vapour state. However the number of drops is very high, from 2 grams of water we can get a half billion of drops with the 2/100 mm diameter. When the drops that form the fog are quite big, the fog wets the objects which touches them, and if their size continues to grow up then it turns into drizzle.

The fog opacity is a remarkable fact, considering the total mass of the particles of the water extremely small. The maximal distance of visibility of the objects during the fog it is proportional to the radius of drops and it is inversely proportional with the mass of water from cubic meter and the fog intensity is characterized by the maximum distance where the objects can be seen and from where it comes the name of the fog: 100 m, 20 m, etc (Mureşan 2008, INMH 1986).

The fog has a whitish color due to air cooling, it is generally formed very quickly but it is dissipated very slowly. The general conditions of forming the fog are: a very high humidity and a wind that blows not too weak (if the temperature is below zero degrees, the drops freeze resulting the hoar frost), not too strong (in this case we can't talk about the fog formation).

2.1. The classification of the fog

2.1.1. The advection fog. For producing this type of fog it is required the presence of a warm and humid air mass and another cold and dry air. This is a very persistent fog because its superior surface is very important for the production of the condensation (fig.3.a). The thickness of this type of fog varies between 100 m and 1 km and it increases where there is a cooling at the top of the layer. The dissipation of this type of fog is very slow because it takes a reheating of the cold surface (it produces the disruption of the thermal equilibrium air- ground) (Stefan 2004, Meteorological Institution 1963).

2.1.2 The radiation fog. This fog is formed during the clear nights following after a warm day during which the evaporation was high, a situation where the moist air could cool long enough for forming the fog provided not to be wind. The conditions of formation of this type of fog there are also conditions of beautiful time (fig. 3.b).

The wind speed is almost zero (less than 10 km/h), the air is very moist and the clear sky will allow the production of the radiation fog. The air close to the soil surface is cooled by conduction in order to reach the dew point and the formed water drops produce a thin film of fog. The air continues to cool, increasing the number of water drops thickening the fog, it becomes opaque to infrared. The upper layer continues to cool, increasing the thickness of the fog. The dissipation is produced by heating from the sun or by the intensification of the wind. The radiation fog is generally formed in large spaces such as airports, highways, fields and it is the type of fog that disrupts the circulation of the planes and of the cars (Iordachescu 2011, ANM 2008).

2.1.3 The smog is a type of fog whose method of training can be represented schematically in Figure 4. a.

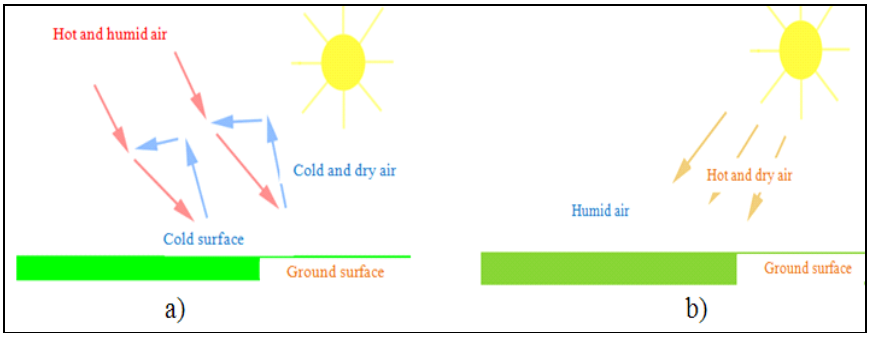

Fig. 3 - The graphical representation of the phenomenon of fog formation: a) the formation of the advection fog; b) the formation of the radiation fog (Iordachescu 2011).

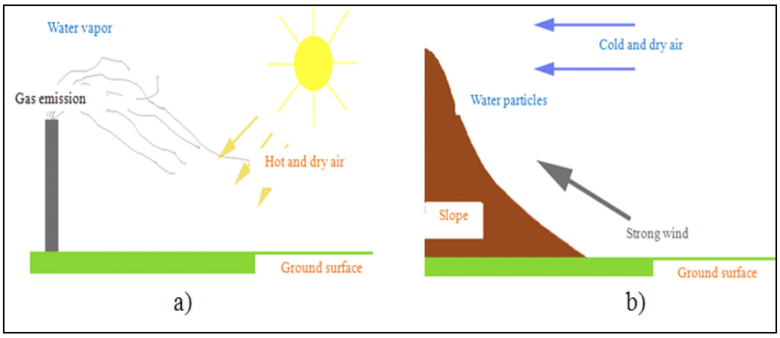

Fig. 4 - The graphical representation of the phenomenon of fog formation: a) the smog formation; b) the formation of the expansion fog (Iordachescu 2011).

The emission of the gases from the large cities may form an extended haze in the absence of the wind, where the gas tends to remain on the ground because of the water particles (the moisture), blocking the vertical displacement. The quantities of gas are accumulated in order to form a toxic fog, that it represents the smog. This fog phenomenon could be confused with the misty and dry air where there is dispersed dust (Mureşan and Croitoru 2008, Mureşan 2008).

2.1.4 The expansion fog is formed only in the mountains or in the hilly areas as it is illustrated in Figure 4 b). This type of fog is formed in the valleys due to high moisture, to a down wind and to a slope which are more or less stepped. The wind pushes the moist air on the slope, it meets the cold air from the altitude and thus creating fog expansion. The mode of the production of this type of fog can be explained by the fact that when a moist and a stable air mass cools adiabatically along a slope and the wind has speeds less than 5 km/h the fog is formed, and if the wind has speeds bigger than 5 km/h, the fog is broken forming Stratus type clouds (Iordăchescu 2011, Ştefan 2004).

2.1.5. The evaporative fog is a type of fog contrary to the mists of advection, it requires a warm surface and a very cold air mass (the difference of temperature between ground and air must be very big) and it can be represented schematically as in Figure 5 a). A mass of cold air reaches above a surface as the hot liquids and the temperature of the air is smaller than the temperature of the water, the air becomes saturated favoring a rapid condensation and resulting the formation of large amounts of water drops. Such a fog of reducing thickness it is formed on the lakes and on the rivers (Iordăchescu 2011, Tasnea and Sarbu 1984).

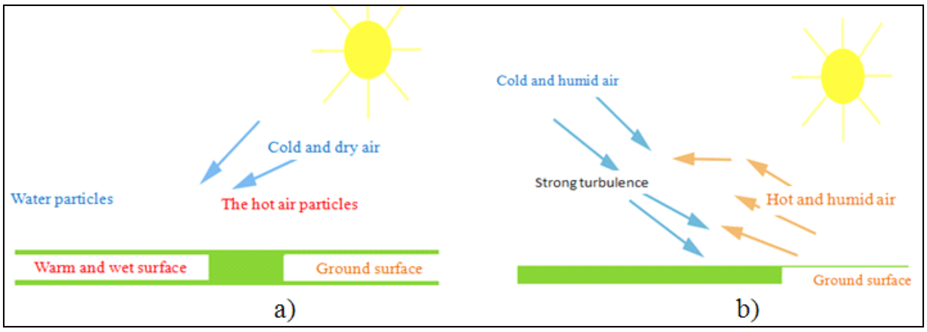

Fig. 5. The graphical representation of the phenomenon of fog formation: a) the formation of the evaporative fog; b) the formation of mixing fog (Iordăchescu (2011).

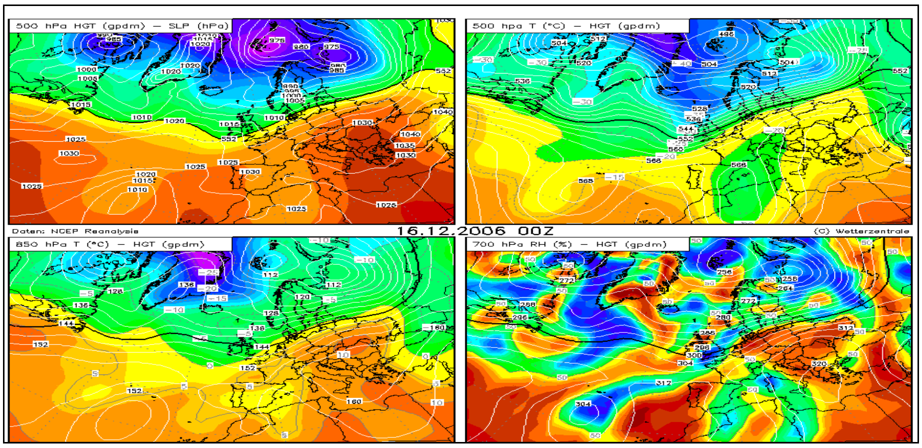

Fig. 6 - Synoptic conditions producing fog on the 16. 12. 2006 (www.wetterzentrale.de).

2.1.6. The mixing fog is a phenomenon that can be explained by the graphical representation in the Figure 5 b). The warm and moist air and the cold and humid air (with different densities) will mix producing the fog phenomenon on a small area, the visibility being bigger than 1 km.

In Figure 6 there are some cartographical examples with satellite view of the synoptic conditions producing fog (on the 16. 12. 2006).

3. Results and discussions

In order to achieve a more detailed analysis of the fog phenomenon in Bacau City, the main meteorological data were processed during 2005- 2010.

In Figure 7 the wind directions are presented in Bacau City.

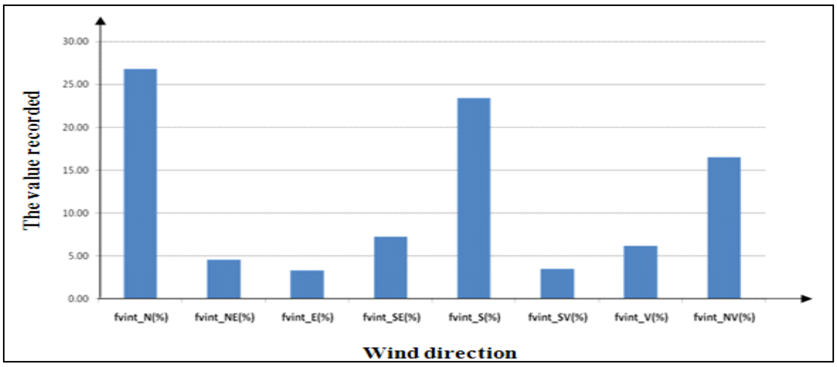

Fig. 7 - The wind direction in Bacau City.

Analyzing the chart above it can be noted that geographical position of Bacau causes airflow to be oriented on the North- South direction, the winds from the west and east being blocked by existing landforms, respectively by hills.

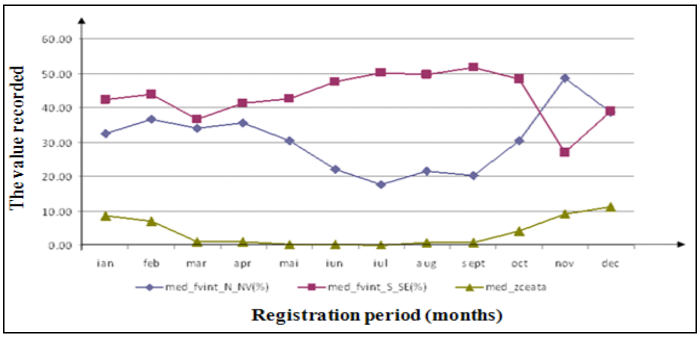

Fig. 8 - The graphical representation of mean values for the frequency of the winds on the S- SE and on the N- NV direction and the number of the days when the fog phenomenon was present between 2005- 2010.

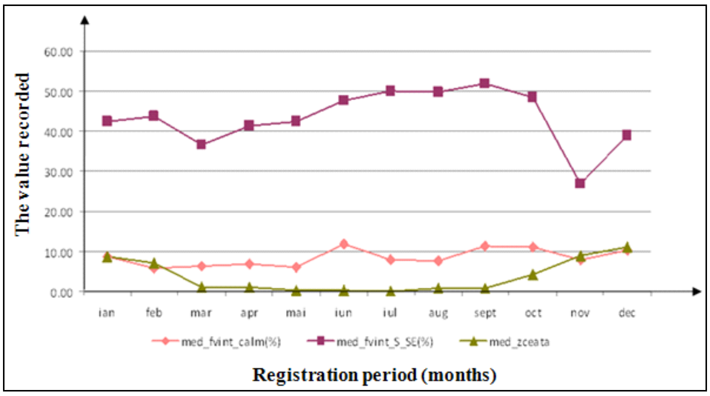

Fig. 9 - The graphical representation of the average values for the winds frequency on the S- SE direction and the graphical representation of the periods of atmospheric calm between 2005- 2010.

In Figure 8 the average values are presented for the winds frequency on the S- SE and N- NV direction and the number of the days when the fog phenomenon was present between 2005- 2010.

In Figure 9 the average values are presented for the winds frequency on the S-SE direction and the periods of atmospheric calm are also presented as well as the number of days when the fog phenomenon was present between 2005- 2010.

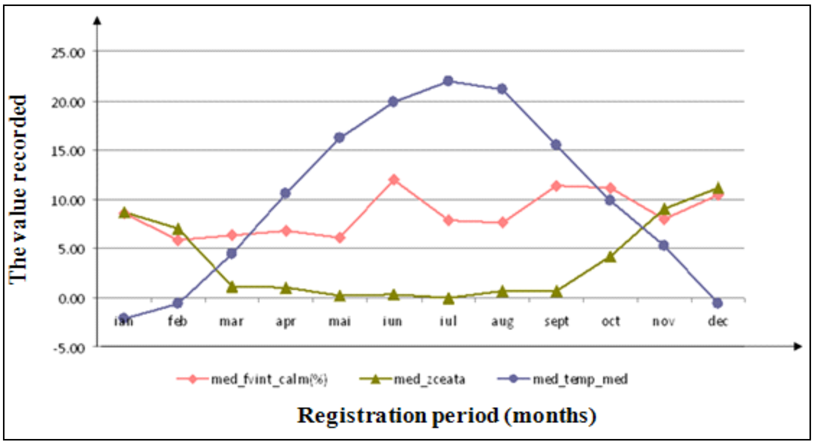

Fig. 10 - The graphical representation of the average values of the number of days when the fog phenomenon was present, the frequency of the atmospheric calm and the values of the monthly temperatures between 2005 - 2010.

In Figure 10 the average values of the number of days are presented when the fog phenomenon was present, there are also presented the monthly distribution of the average frequency of the periods of atmospheric calm as well as the values of the monthly temperatures from 2005 to 2010.

In Figure 11 the monthly distribution of the average of the number of days is represented when the fog phenomenon was present and the average of the monthly total precipitations it is also represented between 2005- 2010.

In Figure 12 a graph is presented where the weather phenomena were correlated to each other and they are presented in the graphs above, the intensity of the winds on the N- NV and S- SE direction, the number of days when the fog phenomenon was present as well as the average of the monthly total precipitations between 2005- 2010.

Analyzing the graphs above can appreciate the fact that this area of confluence and the Bistrita river corridor favor the channeling air masses over Bacau City. In the weather conditions characterized by winds from the south and south- eastern sector alternating with periods of atmospheric calm (the average speeds of the wind (1,5 m/s), it registers a specific situation of the Bacau area that causes frequent thermal inversion situations.

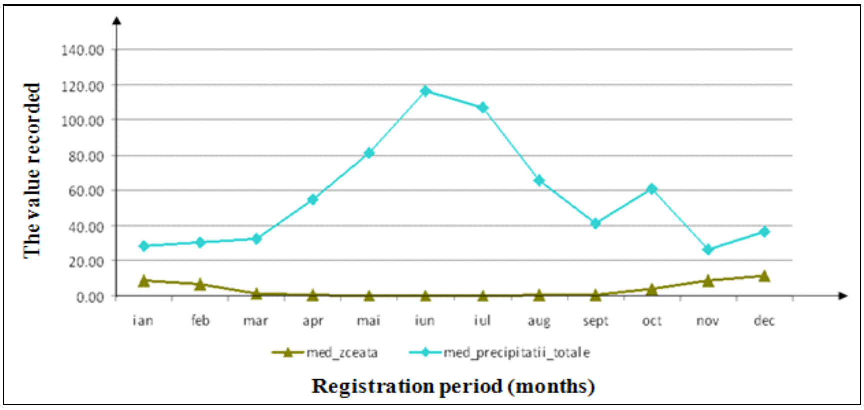

Fig. 11. Graphical representation of the average number of days of fog phenomenon and average monthly rainfall t in the period 2005-2010.

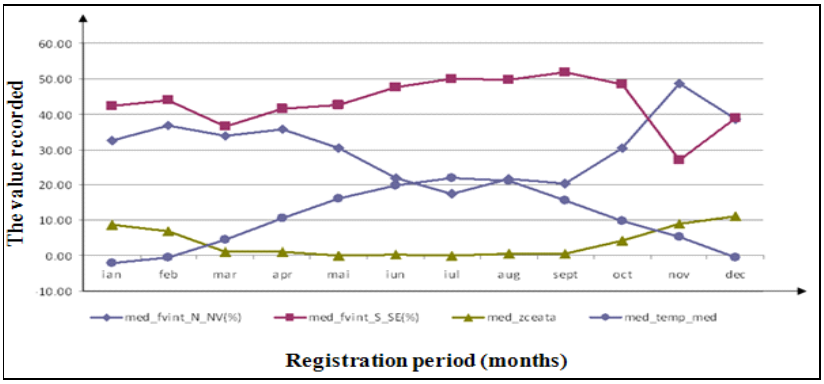

Fig. 12. The graphical representation of the winds frequency on the N- NV and S- SE direction, the number of days when the fog phenomenon was present and the average of the monthly total precipitations between 2005- 2010.

In order to analyse the fog phenomenon in Bacau for any time of year, there were made graphical representations for the entire analysed period, the phenomenon was analysed at the level of each calendar month (Figures 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23 and 24).

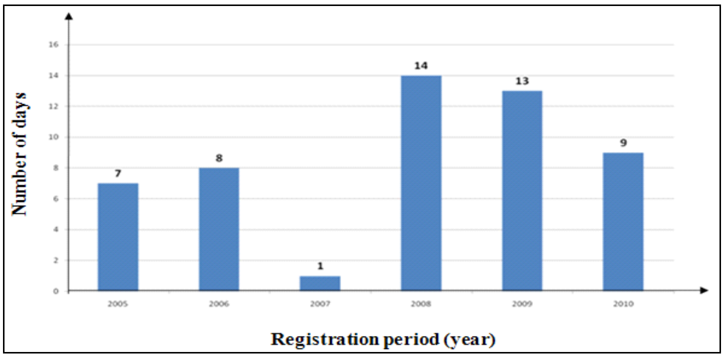

Fig. 13 - The graphical representation of the average number of foggy days in January between 2005- 2010

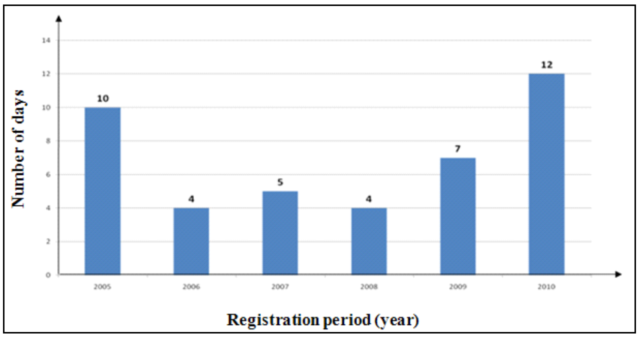

Fig. 14 - The graphical representation of the average number of foggy days in February between 2005- 2010.

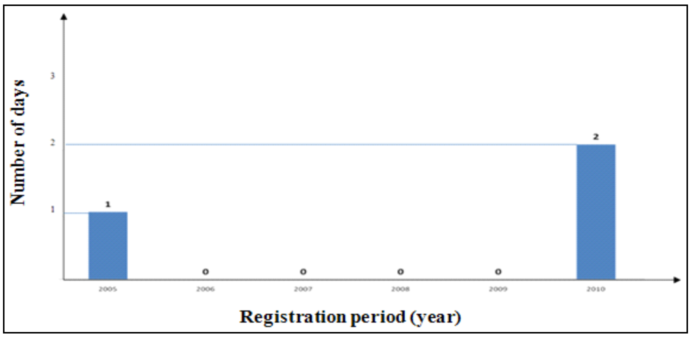

Fig. 15 - The graphical representation of the average number of foggy days in March between 2005- 2010.

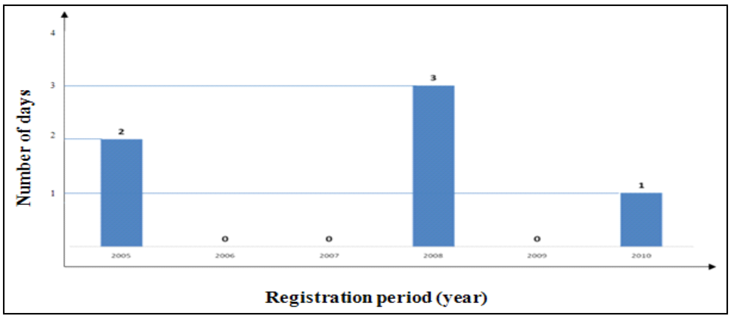

Fig. 16 - The graphical representation of the average number of foggy days in April between 2005- 2010.

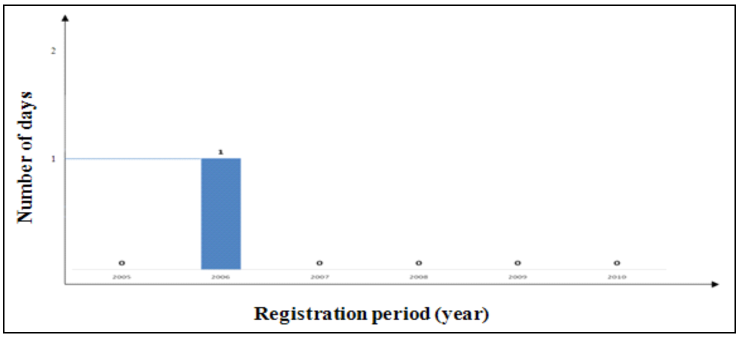

Fig. 17 - The graphical representation of the average number of foggy days in May between 2005- 2010.

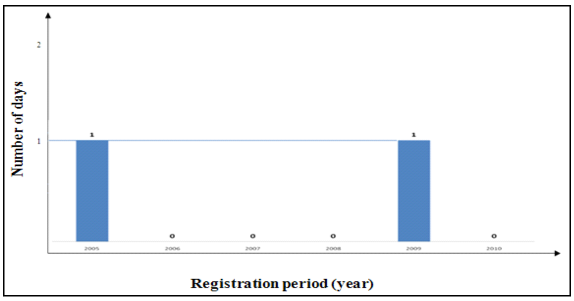

Fig. 18 - The graphical representation of the average number of foggy days in June between 2005- 2010.

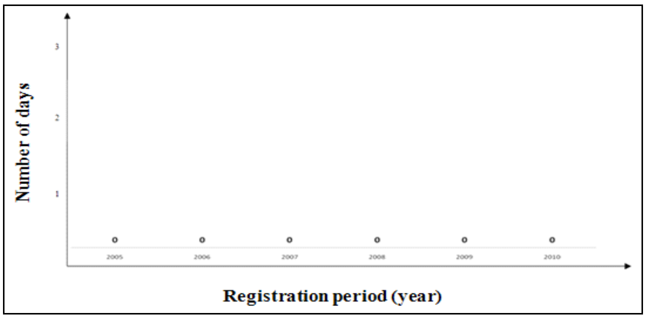

Fig. 19 - The graphical representation of the average number of foggy days in July between 2005- 2010

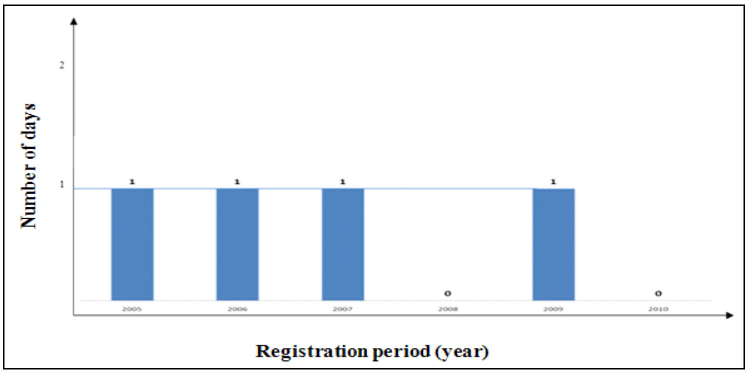

Fig. 20. The graphical representation of the average number of foggy days in August between 2005- 2010

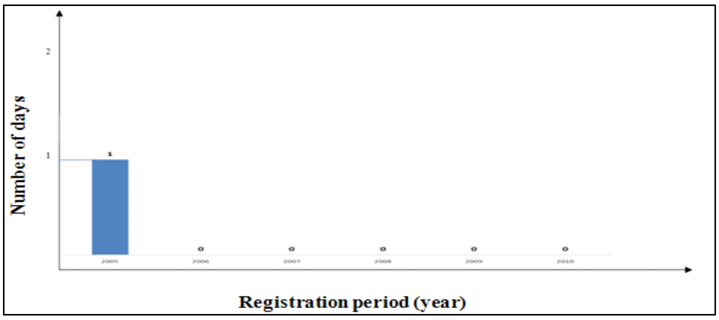

Fig. 21. The graphical representation of the average number of foggy days in September between 2005- 2010.

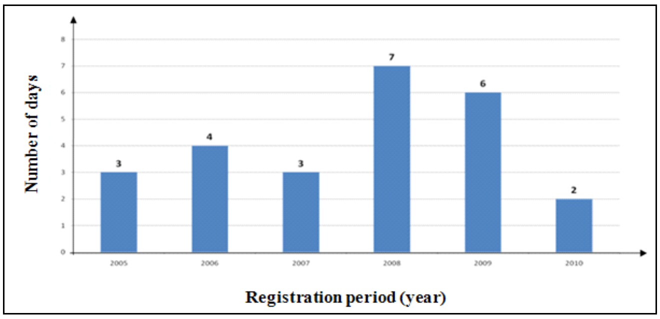

Fig. 22 - The graphical representation of the average number of foggy days in October between 2005- 2010

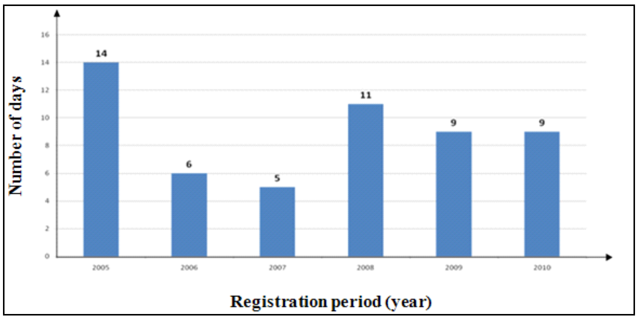

Fig. 23 - The graphical representation of the average number of foggy days in November between 2005- 2010

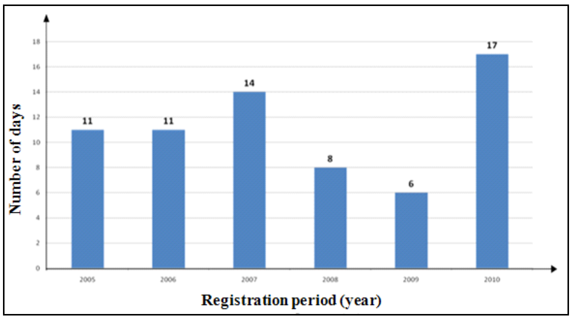

Fig. 24 - The graphical representation of the average number of foggy days in December between 2005- 2010.

Analyzing the graphs above we see that in January, February, November and December the meteorological conditions determined the increasing of the fog phenomenon in this period. In these months the maximum of days is recorded during the analyzed period where the fog phenomenon was produced respectively 17 days in December of 2010. This time of the year corresponds to the cold period of winter where the temperatures are low and the wind direction is primarily from N- NV but the precipitations are weak in quantity.

During the specific period of spring the fog phenomenon occurred mainly in April when in 2008 there have been three days with fog.

In the months of autumn the fog phenomenon was recorded in each of the analyzed six years respectively to a minimum of two days in 2010 and a maximum of 7 days in 2008.

Excluding June when the fog phenomenon didn't occur in summer, the fog phenomenon was recorded sporadically about one day per month throughout the analyzed period 2005- 2010.

Conclusions

The importance of knowing the fog phenomenon results from the fact that in different industries, especially in transport (land, air and naval), it can seriously disrupt this activity by reducing visibility.

The provision of this phenomenon is a matter of major difficulty, on the one hand because of the multitude of meteorological parameters that depend on temperature, wind, humidity and on the other hand because of the local conditions (orographic). According to this latter factor the general methods should have a strictly local application.

At the mesoscale, the fog is a short term phenomenon, therefore, it is difficult to analyzed and to predict.

As a main conclusion of the study, we noticed that the months with the most days where the fog had occurred there were those from the cold season respectively those of the transition from warm season to cold season- in autumn, at the transition from cold season to warm season- in spring, with a maximum in December followed by November, January and February.

In March, April, May, June, August and September, the number of recorded days is one to three days during a calendar month and the minimum is recorded in July when the fog phenomenon wasn't observed.

The altitude, the urban environment, the depression corridor which is characteristic to the area and the fact that warm masses of tropical home reach in Bacau City, they seem to be responsible for the large number of days with fog, it is bigger with 2 to 4 days than the average feature area east of the country.

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