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THE INFLUENCE OF METEOROLOGICAL AND TOPOGRAPHICAL PARAMETERS ON THE DISPERSION OF PM_{10} AND CO POLLUTANTS

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Abstract
At present, climate change is a global reality. One of its causes is the presence of pollutants in the atmosphere. Therefore, the purpose of this paper is to observe how the dispersion of pollutants is influenced by meteorological and topographic parameters. In order to carry out the study on the influence of synoptic conditions on the dispersion of air pollutants PM_{10} and CO, a continuous monitoring of the two pollutants was needed for one year (from March 2020 to February 2021) at all six air quality monitoring stations located in Argeș County. These data will be correlated with the climatological parameters obtained from the National Meteorological Administration. Using a numerical modeling program (SCREEN), it was performed a simulation of the dispersion of pollutants, determining the maximum concentration of the pollutant and the distance it reaches the ground, for several wind speeds, in all five classes of atmospheric stability.

Keywords: air quality, pollutants, simulation, wind

1. INTRODUCTION

Air pollution is one of the most dangerous forms of pollution, which can have disastrous effects on the environment or human health. Annually, there are about 400,000 premature deaths caused by the presence in the air of increasing concentrations of air pollutants (PM_{10}, carbon dioxide, sulfur dioxide, etc.) (Earth Observatory, NASA, 2013). The development of industry and transport, but also the increase of urbanization, causes the release into the atmosphere of emissions containing significant concentrations of pollutants. Burning fuel and desertifying the land lead to increased emissions of particulate matter and carbon dioxide - the main greenhouse gas (Fărcaș and Croitoru, 2003).

Carbon monoxide is one of the most important air pollutants, being lethal in high concentrations (approximately 100 mg/m^3), by reducing the ability to transport oxygen in the blood, with consequences on the respiratory and cardiovascular systems.

Particulate matter with diameters of up to 10 micrometers (PM_{10}) from the atmosphere are pollutants transported over long distances, caused by natural causes (such as entrainment of particles from the ground by the wind) or from anthropogenic sources (such as: combustion in the energy sector, road traffic, heating systems, burning fuels, etc.).

Meteorological factors, especially wind, significantly influence the levels of pollution and the spread of pollutants in the lower atmosphere (Chris, 2002). The transfer and dispersion of pollutants, which reach the atmosphere, take place according to the laws of turbulent diffusion, ie

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they are influenced by the direction and speed of the wind and the vertical gradient of temperature (Constantin et al., 2017, Strambeanu et al., 2016).
The main objective of the study on the influence of meteorological factors on the dispersion of PM_{10} and CO pollutants in Argeș County was to analyze how meteorological factors, especially direction and speed of wind, influence the phenomenon of air pollutant dispersion.

2. MATERIALS AND METHODS

In order to carry out the study on the influence of synoptic conditions on the dispersion of air pollutants – particulate matter (PM_{10}) and carbon monoxide (CO) in Argeș County, a continuous monitoring of the two pollutants was performed for one year (from March 2020 to February 2021) at all six air quality monitoring stations located in Argeș County.
The air quality monitoring network in Argeș County consists of six automatic stations, with a structure consisting of: two industrial stations, a road traffic station, a suburban station and two urban stations (figure 1).
The methods for measuring pollution indicators are as follows: the gravimetric method for particulate matter (PM_{10}) and the IR absorption method for carbon monoxide (calitatea aerului.ro). The data from the National Air Quality Monitoring Network (RNMCA) were analyzed, processed and correlated with the climatological ones from the National Meteorological Administration (http://www.meteoromania.ro).

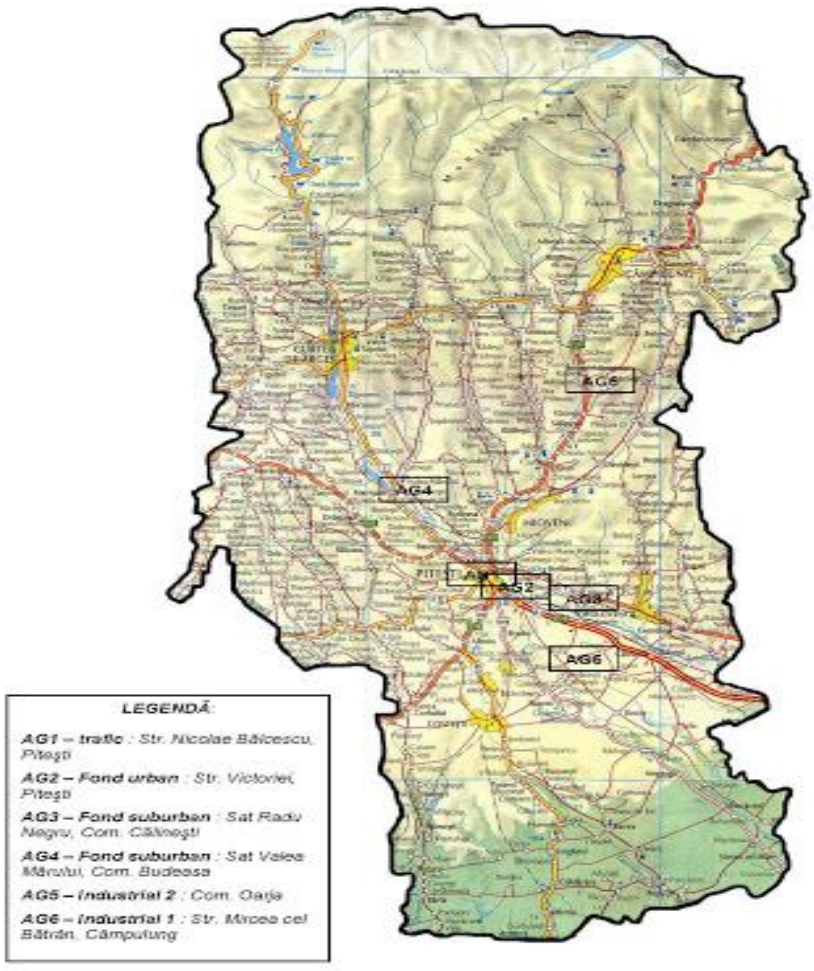

Figure 1. Location of air quality monitoring stations in Argeș County

In addition to this study, a numerical pollutant dispersion modeling program was used - SCREEN. It uses a Gaussian panel model that incorporates emission source-related factors, meteorological and topographic factors that influence dispersion, to estimate the concentration of pollutants from continuous sources. It is assumed that the pollutant does not undergo any chemical reaction and that

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no other removal process, such as wet or dry deposition, acts on the feather during its transport from the source.

3. RESULTS AND DISCUSSIONS

Analyzing the annual regime of suspended particles (PM_{10}) in Argeș County, for a period of twelve months, from March 2020 to February 2021, it is observed that the highest value of the average monthly concentration of particulate matter (PM_{10}) was recorded in November 2020, with the value of 41.59 µg/m³, at the monitoring station AG 1, station located in the road traffic monitoring area. The lowest value of the concentration of particulate matter was 11.05 µg/m³, recorded in July 2020, at AG 6 station, station that monitors pollutant concentrations in the industrial area of Pitești (fig 2). Annual average concentration of particulate matter (PM_{10}) in Argeș County was 22.80 µg/m³, a concentration that does not exceed the maximum allowed value (the maximum daily concentration for the protection of human health is 50 µ /m³, which must not be exceeded more than 35 times /year, while the maximum annual concentration for the protection of human health is 40 µg / m³) (www.calitateaer.ro).

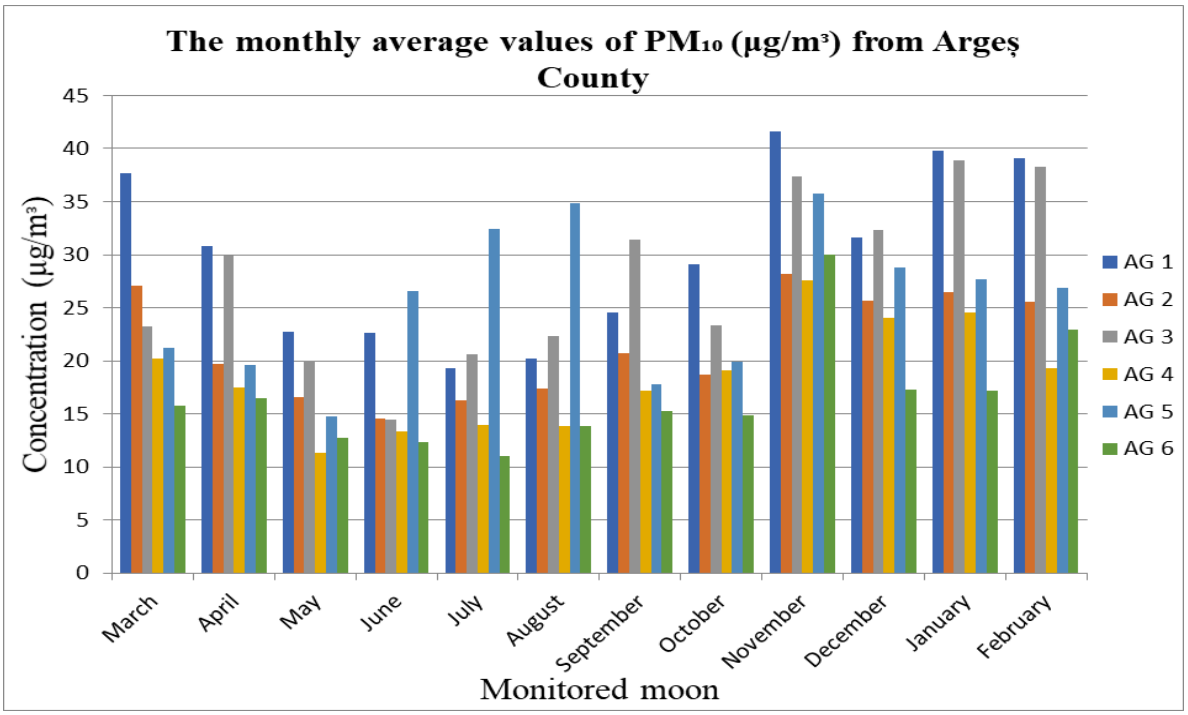

Figure 2. Evolution of the monthly average values (µg/m³) of PM_{10}, March 2020 - February 2021

The appearance of the maximum concentration of the pollution indicator - particulate matter (PM_{10}) in the road traffic monitoring area is determined by the appearance of a temporary source of contamination, represented by the intensification of road traffic in the area of the pollutant monitoring station, correlated with the operation at high capacity of district heating plants due to the cold period in which the maximum concentration was recorded.

The low concentration during July 2020 at the monitoring station AG 6, industrial area 1, is the result of low capacity operation of the main emission sources in the industrial area of Argeș County, due to the Covid-19 pandemic in our county, and with the onset of the pandemic, the program of

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operation of these polluting industrial spaces decreased and even the temporary closure of the activity of an important part of them.

The wind is a very important meteorological factor in the horizontal movement and dispersion of pollutants in the atmosphere. The movement of pollutants through the air is done in the wind direction and the pollutant concentration is inversely proportional to the wind speed. Thus, in addition to the fact that the wind speed accelerates the dispersion of pollutants, it also dilutes their concentration.

The maximum value of the concentration of particulate matter (PM_{10}), registered in November 2020, in Argeș County is the result of the presence on the territory of our country of a baric center of high pressure (Pit), as well as the appearance of a depression core fed by the Black Sea basin, rising the baric center positioned in the direction of ENE, NE of Romania. During the day the wind was quite calm, while at night the wind had intensifications of about 50-60 km/h.

Figure 3. Distribution of wind direction and wind speed in Argeș country for November 2020

Following the analysis of the annual carbon monoxide (CO) regime in Argeș County, we notice that the maximum value of the average monthly concentration of carbon monoxide was recorded in January 2021 - 0.66 mg/m^3, at the road traffic monitoring station AG 1. The lowest monthly average was observed in August (0.1 mg/m^3), recorded at the monitoring station AG 4, station located in the urban area of Argeș County (fig. 4). The average annual concentration of CO was 0.29 mg/m^3, a concentration not exceeding the maximum allowed value (the maximum allowed value for carbon monoxide being 10 mg/m^3, a limited value for the protection of human health (maximum daily value of averages per 8 hours).

The maximum concentration of the pollution indicator - carbon monoxide (CO) occurred in the winter season, respectively January 2021, is the result of excessive use, due to low temperatures, of home heaters around the location of the monitoring station.

The appearance of a minimum of carbon monoxide (CO) concentration in August, at the monitoring station AG 4, a station located in the urban area, in the yard of a school in Budeasa commune, is due to the lack of emission sources near the monitoring.

The maximum concentration of the pollution indicator - carbon monoxide (CO) is reached in the third decade of January as the synoptic configuration of Europe has changed, in the sense that the depression centers in the western Mediterranean basin have been replaced by Icelandic cyclones, which bring above our country a polar-oceanic air, but also consistent amounts of mixed precipitation. During the day, no precipitation fell, and the average wind speed was 1-2 m/s. All

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these meteorological conditions favored the maintenance of the carbon monoxide CO contaminant on the ground and the increase of the pollution.

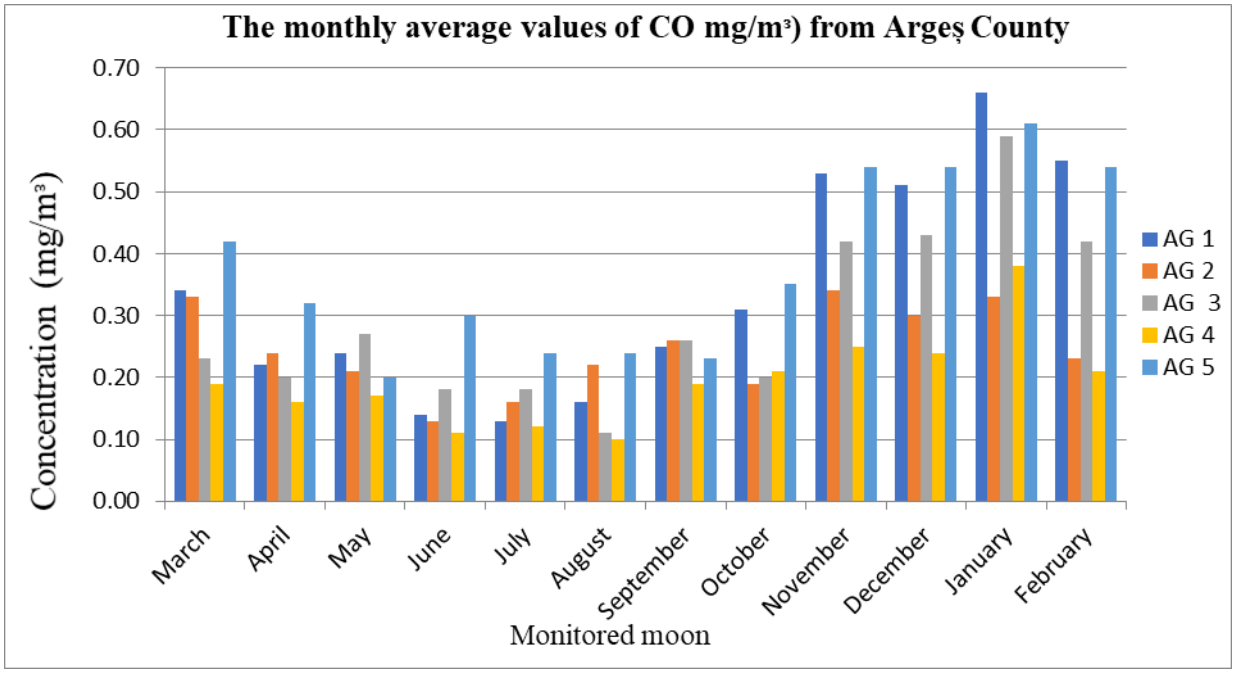

Figure 4. Evolution of the monthly average values (mg/m³) of the CO, March2020 - February 2021

Figure 5. CET Bradu location

In order to study the influence of wind on the dispersion of air pollutants, a simulation of the dispersion of pollutants emitted from a point source similar in size and location as that of CET Pitesti, with a height of 180 m and the inner dimension of the exhaust chimney of 5 m (figure 5).
From the data obtained by running the SCREEN program, for each of the five classes of atmospheric stability (1 high stability - 5 unstable), it was observed that the value of the maximum concentration of pollutants is the higher for the more stable the atmosphere (figure 6).

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The maximum distance at which the pollutant plume reaches the ground is inversely proportional to wind speed and is greatest where the atmosphere is unstable (stability class 5).

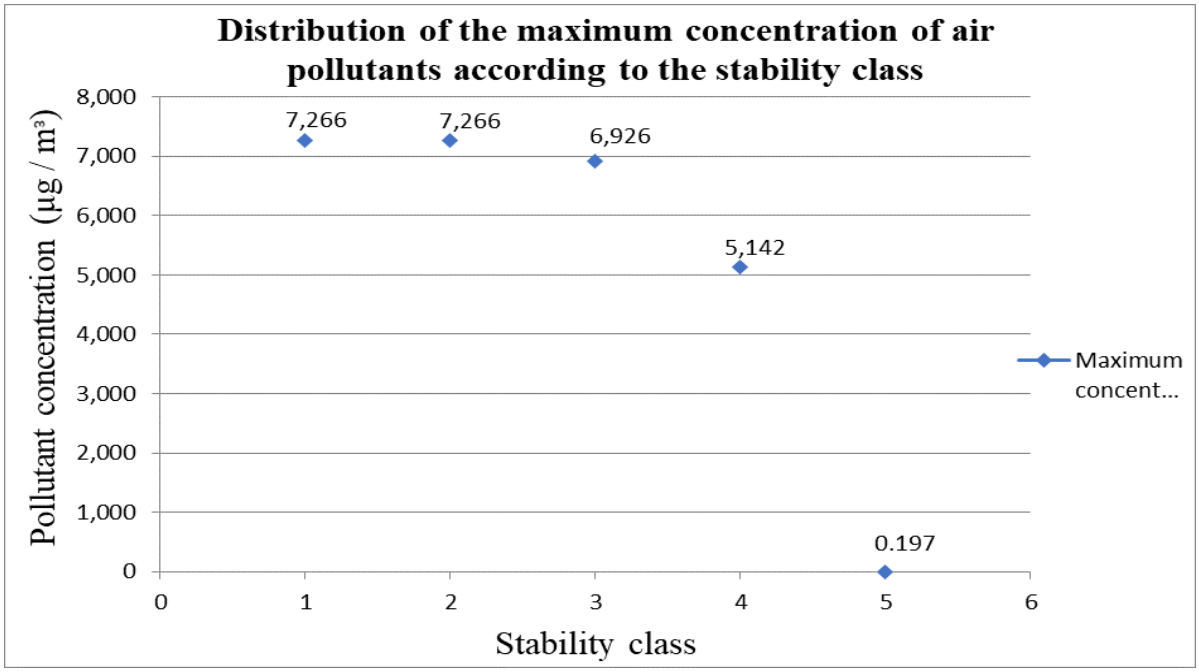

Figure 6. Maximum pollutant concentration depending on atmospheric stability

In addition, for no class of atmospheric stability and at none of the wind speeds did the Downwash effect manifest itself.

4. CONCLUSIONS

Quantitative and qualitative analysis of an air pollution indicator is a first step in ensuring air quality management, which is a component of environmental management. Particulate matter (PM_{10}) and carbon monoxide (CO) are two very dangerous pollutants for both human health and the environment, and for this reason the mitigation measures must be continuously monitored and applied when their concentrations exceed the permitted limit.

The air pollution meteorology helps to understand how pollutants are emitted and dispersed in the surrounding air. Wind speed is the meteorological parameter with the greatest impact on the process of dispersing pollutants into the air. When the wind speed has high values, the pollutant feather is transported over longer distances, and the high wind speed leads to the occurrence of internal turbulence of the effluent and improves the dispersion of pollutants. On the other hand, when the wind speed has low values, the lifting height of the pollutant feather is high and its dispersion is reduced, which leads to higher concentrations of pollutants near the emission source.

Dispersion models are important for the management and protection of ambient air quality, being necessary in the design of effective control strategies to reduce air pollutants. In our case, the restriction of traffic (depending on the degree of pollution of vehicles), the use of electric vehicles and the modernization of thermal power plants can lead to a decrease in PM_{10} and CO concentrations in Argeș County. The uplift of industrial pollutant evacuation chimneys helps a lot to

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reduce air pollution by placing of pollutant emission chimneys above the level of thermal inversions, avoiding the occurrence of high concentrations of pollutants in one place.

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