Analysis of air Quality in the Area of Coal-fired Power Plants

ADINA MILENA TATAR*
Constantin Brancusi University of Targu-Jiu, Faculty of Engineering, 30 Eroilor Str., 210135, Targu-Jiu, Romania

The purpose of this study was to carry out an air quality analysis in the town of Turceni by monitoring the concentration of pollutants nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO) and suspended particles with a diameter <10μm (PM_{10}) from the environment, given their impact on the health of the population. In this area the Gorj Environmental Protection Agency has a continuous air quality monitoring network, located northwest of Turceni Thermal Power Plant (GJ-3 - industrial station, which is part of the National Air Quality Monitoring Network). From the analysis of the data obtained during the monitoring it was found that 3 exceedences of the admissible limit value (L.V.) for the pollutant PM_{10} were recorded, representing 17.64% of the total values analyzed.

Keywords: air quality, NO_2, SO_2, CO and PM_{10}.

Environmental quality is defined as a set of properties, characteristics of the general or local environment that affect the lives of human beings and other organisms, and the state of the environment refers to those aspects of human health which include the quality of life, determined by physical, biological, socio-economic and psychosocial factors in the environment [1-4]. Air quality is determined by emissions to air from stationary and mobile sources, as well as long-distance pollutant transport [5-7]. The most known environmental threats are caused by ambient air pollution, poor water quality, insufficient hygiene, climate change, ozone depletion, biodiversity loss, soil degradation [8].

Pollution is the contamination of the environment with materials that can affect both human health and ecosystem functions [1]. Atmospheric pollution is of interest for monitoring and analysis when one or more substances or mixtures of pollutants are present in the atmosphere in quantities over a period of time that may be dangerous for humans, animals or plants and contribute to endangering activity and the well-being of population [9-11]. Pollutants are transported to the environment by atmospheric air, and the effects of pollution can also be manifested by changes in all major weather elements, reduction of solar radiation and temperature increase [1, 12, 13, 3]. Thus, atmospheric pollution is influenced by the following factors: geographic position, climatic factors, rainfall, atmospheric pressure, wind speed and direction, air humidity, atmospheric nebulosity, season [15]. At European level, the institution that coordinates air quality monitoring is the European Environment Agency (EMEA), which has the role of collecting air quality data from a total of 7 500 monitoring stations across Europe. This database called Air Base [14, 10] also includes the historical air quality database. One of the fundamental roles of A.E.M. is to support the European Union's environmental policy by monitoring and reporting the results of the implementation of European environmental legislation in all Member States of the EEA [6, 14, 10].

Experimental part

The purpose of this research is the measurement and comparative analysis of factors that affect air quality in the thermal power plant area. If the air quality index is maintained in optimal parameters then there is no risk of the thermal power plant being a source of pollution and a danger to the environment and the natural environment. In this respect, we have conducted a case study on air quality analysis in the Turceni area. The period affected by direct measurements on the ground was during the month of December 2017, this data being correlated with data analysis from different units and institutions linked to this monitoring. The town of Turceni is located in the southern part of Gorj County and has appeared around two industrial sites in the area: the Turceni Thermal Power Plant and the Turceni Hydro Power Plant. The quality of environmental factors in Turceni plays an important role in determining the health of the population, the main source of air pollution in the area being the Turceni thermal power plant. The Turceni thermal power plant is the largest thermal power plant in Romania, providing an installed capacity of 2 310 MW (about 10% of the annual electricity consumption of Romania) and has 6 energy blocks grouped in 4 large combustion plants (IMA) with the following equipment: Benson steam boiler of 1035 t/h, steam turbine 330MW, electric generator 330 MW/388 MVA, 400 MVA electric transformer, 24/400 kV. The solid fuel supply of the thermal plant is made by rail because the quarries that supply the coal-fired power station are at great distances. The slag discharge is carried out at the bottom of the steam boiler, and the solidified slag is crushed and stored in the hopper and hydraulically piped to the Bagger pump stations. The combustion gases are discharged through the boilers of the boiler 3, 4, 5 and 6 boiler desulphurization units, and two de-dusting devices of the electrophilter type are provided for the ashing of the resulting combustion gases. To reduce the formation of nitrogen oxides, the original burners have been replaced by modern tertiary air blowers. The slag and ash storage of the Turceni thermal power plant is not a source of air pollution in the area, located on the Ceplea Valley at a distance of 3.3 Km from the locality, and the main objective of the administration is to close this warehouse completely. At the same time, it should be noted that during the course of the event during the implementation of this application for air quality monitoring in the Turceni area, the thermal power plant operated with two energy blocks (rehabilitation and modernization works were done at the energy block no. 3 and block no. 4 was back-up block). From a climatic point of view, the locality is in the Southwest climate zone of the hills, with a continental hillside climate, with cold winters and hot and dry summers with sufficient rainfall but unevenness. The

* email: adddina.tatar@yahoo.com

Specific index	Range of concentrations				
	SO_2 (µg/m^3)	NO_2(µg/m^3)	O_3 (µg/m^3)	CO (mg/m^3)	Suspension particulate (µg/m^3)
1(excellent)	0 - 49,(9)	0 - 49,(9)	0 - 39,(9)	0 - 2,(9)	0 - 9,(9)
2(very good)	50 - 74,(9)	50 - 99,(9)	40 - 79,(9)	3 - 4,(9)	10 - 19,(9)
3(good)	75 - 124,(9)	100 - 139,(9)	80 - 119,(9)	5 - 6,(9)	20- 29,(9)
4(medium)	125 - 349,(9)	140 - 199,(9)	120 - 179,(9)	7 - 9,(9)	30 - 49,(9)
5(bad)	350 - 499,(9)	200 - 399,(9)	180 - 239,(9)	10 - 14,(9)	50 - 99,(9)
6(very bad)	> 500	> 400	> 240	> 15	> 100

Table 1
SPECIFIC INDICES CORRESPONDING TO CONCENTRATION RANGES FOR MONITORED POLLUTANTS [6]

temperature and precipitation regime is influenced by the ocean air masses in the west, combined with the Mediterranean climate in the S-V [16].

The analysis of the degree of air pollution in the area of the Turceni thermal power plant was carried out with the help of the air quality monitoring network, which includes an automatic station located in the northwest of the thermal power plant, monitoring the gaseous pollutants sulfur dioxide (SO_2) nitrogen (NO, NO_x and NO_2), carbon monoxide (CO), and particulate matter, PM_{10} fraction.

The continuous air quality monitoring station in the Turceni area (GJ-3) has the following equipment for the determination of atmospheric pollutants: SO2-monitor Europe ML 9850, NO/NO_2 /NO_x monitor Europe ML 9841, CO-monitor Europe analyzer ML 9830, respectively PM10 analyzer, LSPM10 UNITEC. A number of meteorological parameters can also be monitored with these equipments: temperature, precipitation, wind direction and speed, relative humidity, pressure, solar radiation [8]. The collected data was transmitted every hour, as an hourly average, to the local Environmental Protection Agency (APA) server where, after verification and validation, they were sent to the National Center for Verification, Reporting and Public Information. For the interpretation of the recorded concentrations for each pollutant, there were general and specific quality indices. The overall air quality index plays an important role in informing the public about the overall air quality status in the air monitoring station representativeness area, establishing for each of the automatic air quality monitoring stations within the National Air Quality Monitoring Network, (SO_2), nitrogen dioxide (NO_2), ozone (O_3), carbon monoxide (CO), suspended particulate matter (PM_{10}), and specific indices are a coding system for recorded concentrations of certain monitored pollutants. The general index is the largest of the specific indicators of the monitored pollutants, and at least three specific indices corresponding to the monitored pollutants have to be available [17]. Generic and specific indices are represented by numbers from 1 to 6, corresponding to excellent, very good, good, medium, bad, very bad grades. The norm for establishing air quality indicators to facilitate public information aims to interpret air quality data provided by automatic stations within the National Air Quality Monitoring Network to facilitate public information [18]. The specific indices corresponding to the concentration ranges for the monitored pollutants (SO_2, NO_2, O_3, CO, suspended particulates) are shown in table 1.

To determine the specific index corresponding to the concentration level of the monitored pollutants for sulfur dioxide, nitrogen dioxide and ozone was determined at each hourly arithmetic mean of the concentrations recorded in that hour and for carbon monoxide the arithmetic mean of the hourly values recorded over the last 8 hours, and the corresponding specific index was determined by fitting the arithmetic mean obtained in the concentration ranges of table 1. Analogously, the determination of the specific index corresponding to the particulate matter was determined by fitting the arithmetic average of the hourly values recorded over the past 24 hours in the concentration ranges specified in the table 1 [19].

Results and discussions

The analysis of the air quality in the Turceni area was made by measuring the average hourly, daily and monthly concentrations of the pollutants (NO_2, SO_2, CO, PM_{10}) and comparison with the limit values or, as the case may be, the maximum admissible concentrations provided by the normative acts in force [20, 17]. In order to carry out an analysis and objective situations regarding the level of pollution, the data recorded by the GJ-3 automatic station were centralized during December 2017, given the influence of several factors occurring during this period, and the interpretation of the results was performed according to Law no. 104/2011 on ambient air quality.

Nitrogen dioxide (NO_2)

Nitrogen dioxide is a yellow-orange-red-brown gas, depending on the temperature, heavier than air, generated by combustion of fuels in engines, furnaces, and is one of the compounds involved in the formation of oxidative smog. The reference method for the measurement of nitrogen dioxide and oxides of nitrogen is that laid down in SR EN 14211 and the standardized method for measuring concentrations is chemiluminescence. Following the centralization of the measured data for the NO_2 pollutant in December 2017 and their comparison with the hourly limit value (L.V.) in force from 1 January 2010, of 200 ìg/m^3, figure 1 shows the evolution of the NO_2 concentration in the ambient air in the Turceni area during the analyzed period.

From the analysis of the recorded data it was observed that the values of the concentrations of the NO_2 pollutant in the Turceni area were well below the allowed limit value, the result being very important for the protection of the environment. The highest recorded value for NO_2 pollutant during December 2017 was 25.03µg/m^3 on December 6 and the lowest value of 13.94 µg/m^3 on December 10.

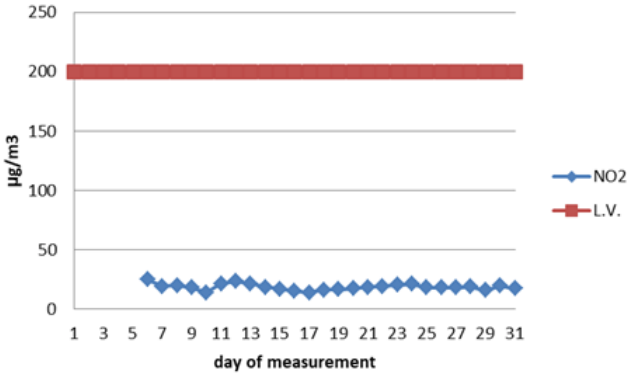

Fig. 1. Evolution of the NO_2 concentration in the ambient air in the Turceni area in December 2017

Sulfurdioxide (SO_2)

Sulfur dioxide (SO_2) is a colorless, non-flammable gas with a smelly odor generated mainly by fossil fuel combustion processes. The reference method for the

measurement of sulfur dioxide is that given in the SR EN 14212 standard and the standardized method for measuring the concentration is ultraviolet fluorescence. For SO_2 pollutant, Law no. 104/2011 on ambient air quality provides for the daily limit value (L.V.), in force from 1 January 2007 as 125 µg/m^3. In a first phase of SO_2 pollution monitoring the data recorded during December 2017 were centralized, resulting in figure 2 showing the evolution of sulfurdioxide concentrations in the town of Turceni, in relation to the daily limit value (L.V.).

At the next stage of the air quality assessment in the analysis of figure 2 it was observed that the values of the concentrations recorded for the sulfur dioxide pollutant during December 2017 did not exceed the daily limit value admitted, the highest value being registered on the 24th of December 2017, of 20.71µg/m^3.These low SO_2 concentrations were recorded as a result of the installation of the desulphurisation plants at the Turceni Thermal Power Plant in order to comply with the environmental norms and the legislation in force.

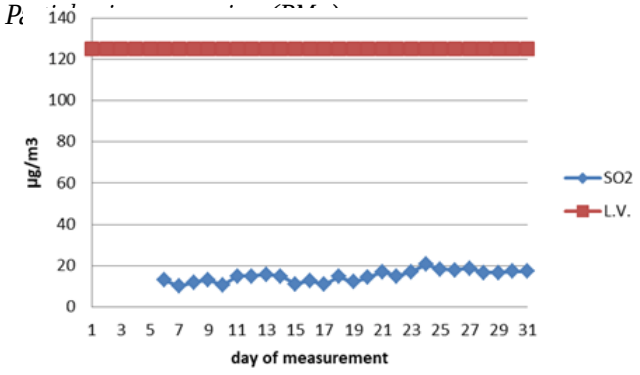

Fig. 2. Evolution of the concentration of SO_2 in the ambient air in the Turceni area, in December 2017

Suspended particles are a particle agglomerate of different sources, of different sizes, compositions and properties, representing a complex mixture of organic and inorganic substances, and their concentration varies depending on the season (summer and autumn PM_{10} is low in concentration) [21]. The reference method for the sampling and measurement of the PM_{10} fraction is described in European Standard EN 12341/1999 [22] and the measurement principle is based on the collection of PM_{10} fraction separated from the airborne particles on the filters and the laboratory gravimetric determination of the PM_{10} dust concentration and heavy metals (Pb, Cd, Ni, As) by atomic absorption spectrometry. During the year 2017 continuous monitoring of the PM_{10} fraction was performed both by the automatic method (nephelometric) and by the gravimetric method (reference method) according to SR EN 12341/2002 and by the analysis and centralization of the obtained data, it was observed that registered frequent exceedances of the daily limit values (50µg/m^3) and annual limit (40 ìg/m^3) for the protection of human health, provided by the legislation in force [9]. From the analysis of the data obtained during December 2017, it was observed that a number of 3 exceedances of the admissible limit value were recorded, representing 17.64% of the total measurements performed (between 1 and 14 December 2017 the PM_{10} analyzer did not work). By centralizing the data, the concentration of suspended particulate concentrations in the Turceni area was shown, shown in figure 3.

It is noted that during December the highest concentration of PM10 was registered on December 27, 2017, at 60.59 µg/m^3 and is due to the combined input of

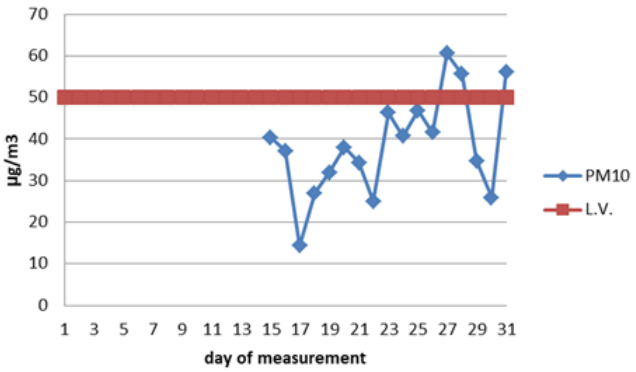

Fig. 3. Evolution of the concentration of PM_{10} to the immission in the Turceni area in December 2017

several sources: the thermoelectric power plant (the main source of pollution), slag and ash deposits, road traffic, residential heating.

The data analysis shows that the highest values are recorded during the cold season due to the weather-specific processes of this period, i.e. the maximum PM_{10} concentrations increase with the end of the cycle of vegetation marked by the fall of the leaves during October and even if traffic is not as intense in winter as in other seasons, the occurrence of other emission-related emissions associated with seasonal combustion generates, in combination with high atmospheric stability and high frequency of thermal and thermal inversions, dangerous increases in PM_{10} concentrations [23].

Carbon monoxide (CO)

Carbon monoxide is a major pollutant in urban air, with total emissions of this pollutant exceeding the sum of all other pollutants. The reference method for the measurement of carbon monoxide is that laid down in SR EN 14626 and the standardized method for measurement concentration is non-dispersive infrared spectroscopy [21]. The CO monitoring during December 2017 was carried out by the GJ-3 automatic station, and the interpretation of the obtained results was made by reference to the Law no. 104/2011, which provides for a maximum daily average of 8 hour (moving averages) of 10 mg/m^3 (this value was chosen after examining 8 h slides, calculated based on hourly and updated hourly / hourly data). Centralizing the maximum values of concentrations was achieved the evolution of the CO concentration in the ambient air in the Turceni area, shown in figure 4.

Analyzing the data obtained for the CO pollutant, it was ascertained that, as in the case of nitrogen dioxide, during December 2017 the concentration values (the maximum daily 8-hour average) were well below the permitted limit value, the highest value being recorded on December 13,

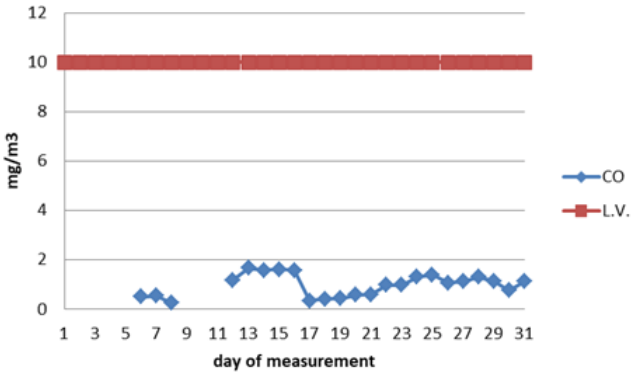

Fig. 4. Evolution of CO concentration (maximum daily average of 8 h) in the ambient air in the Turceni area in December 2017

2017, of 1.67 mg/m^3. It can also be seen observed that the CO pollutant does not pose a threat to the quality of the environment and human health.

Air quality indices

By fitting the concentration values obtained for the monitored pollutants (SO_2, NO_2, CO, PM_{10}) in the concentration ranges specified in Table 1, the specific air quality indexes in the area shown in figure 5 are obtained.

From the analysis of the data presented in figure 5 it was observed that during December 2017 CO and SO_2 pollutants had the specific index 1, corresponding to the excellent quality for the air quality. Pollutants PM_{10} (in 11 days) and NO_2 respectively (in 2 days) had the specific index 2, corresponding to the rating very well, and in the other days of December 2017 the specific index was 1.

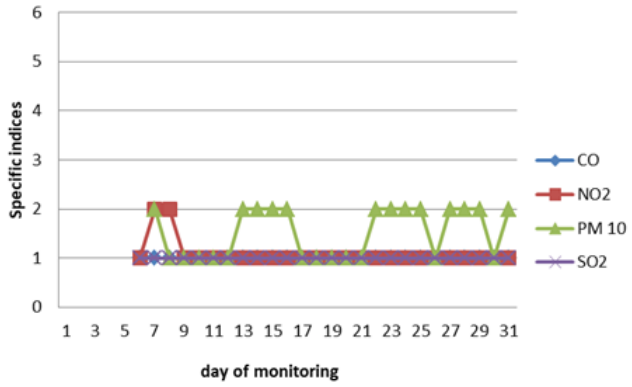

Fig. 5. Specific indices corresponding to the concentration level of monitored pollutants

Conclusions

From the analysis of the experimental results obtained during the air quality monitoring, in December 2017, in the Turceni area, it was found that the values of the pollutant concentrations (SO_2, NO_2, CO) were below the limit value and the particulate pollutant in PM_{10} fraction 3 overtaking of L.V. The highest recorded value for particulate pollutant in particulate matter, PM10 is 1.21 times higher than L.V., and the smallest is 50.1% of L.V. These exceedances were recorded mainly in the winter months and are mainly due to the fuels used in the production of electricity, the heating of individual dwellings and the scattering of anti-skidding material on the road, being favored by the unfavorable weather conditions (fog, weak wind, humidity). This study is a good practice model for quality control and identification of the causes that led to exceedances of PM_{10}, taking into account the effects of pollutants on the environment and the production of reports to be made available to stakeholders.

During the monitoring it was found that the specific pollutant indices had values corresponding to an excellent and very good air quality according to the norms. In situations where there have been alterations, these overshoots are generated by factors from the atmospheric particles originating from the Turceni Thermal Power Plant, coal deposits, traffic in the area, weather conditions, residential heating during the winter months, urban agglomerations. Under the optimal climate conditions specific to the Turceni area and the operation of the thermal power plant in normal conditions, the air quality index is in the quality parameters. The following must be emphasized, the quality of the air is influenced by other factors we have outlined, but we have not monitored them. The public opinion, due to a routine specific to a period of massive industrialization, considers that the only polluters are the thermoelectric power plants, forgetting other quantified factors may be more toxic and which should be another object of study that draws the attention of the environment agency and local agents.

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