Comparative Study Regarding Atmospheric SO_2 Content in Rovinari and Turceni Areas

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The goal of this research study is to compare the air quality of two urban locations from Targu-Jiu County namely Rovinari and Turceni. Measurements of SO_2 content with automatic analysers were used as a criterion to asssess the air quality. Rovinari and Turceni areas were chosen for this study due to the fact that there are located two thermal power plants considered high stationary sources with an important contribution to regional and global pollution by sulfur dioxide, nitrogen oxides and dust. Sustainable development of fossil fuel power plants cannot be done without the use of technology to limit or eliminate environmental pollution. Studies regarding determination of SO_2 content in the monitored areas were performed from January to December 2014. By interpreting the results obtained it can be concluded that the concentrations of sulfur dioxide in the ambient air are below the limit value set in legislation. This is mainly due to the developing of the programs for the progressive reduction of annual emissions of sulfur dioxide, nitrogen oxides and dust which was set up by operators of thermal power plants in order to comply with emission limit values. The high level of SO_2 concentration in cold season is attributed to intensifying the burning of fossil fuels for household activities.

Keywords: SO_2 air content, air pollutants monitoring, thermal power plant

Energy is one of the main attributes of human development. Energy converting from its primary sources in the forms directly usable by humans is almost accompanied by the release of substances with negative environmental effects. Although there are numerous national and international regulations regarding emissions from energy producing, often they are uncontrolled. Industrial pollutans emitted from stationary and mobile combustion plants are generated accidentally or continously, but they are always transported by air currents long distances and they contribute to disrupting the natural balance of the earth and they have important negative health effects [1-6]. Children and older people are considered to be the most vulnerable to the health negative effects of air pollution exposure [7].

For Romania, the energy sector has strategic importance. Sustainable development strategy of the energy sector includes long-term goals that reflect national economy demans related to providing resources, safety and energy efficiency, resource use and environmental preservation.

Transposition of EU environmental legislation involves special obligations for industry and thus for energy sector, obligations that cannot be achieved only through the use of advanced techniques, which have now reached at global level availability.

European Directive for large combustion plants - 2001/80/EC aims to improve air quality in E.U. countries and protection against health risks due to air pollution.

Large combustion plants contribute greatly to emissions of sulfur dioxide, nitrogen oxides and dust, so it is necessary to reduce these emissions to the requirements of the best available techniques [8-10].

Using the best available techniques makes the combustion of low grade coal possible, allowing operation of energy facilities in framing of European environmental regulations.

Numerous research papers reported worldwide in the last years present studies of the power plants impact on the environment and health [11, 12]. Thus, in a study of Popescu et al. (2011) on line air quality monitoring in the Romanian city of Timi°oara that included a power plant area was performed. From this study it was concluded that national and international air quality regulations are accomplished with some exceptions for NOx concentrations near city roads [12].

In our country, large combustion plants activity is regulated by a series of laws. Some of the most important of them are: Government Decision no. 440/2010 on establishing measures to limit air emissions of certain pollutants from large combustion plants; Law 271/2003 for the ratifying of the Protocols of the Convention on long range transboundary atmospheric pollution; Order no. 712/2003 of the Minister of Agriculture, Water and Environment, Order no. 199/2003 of the Ministry of Economy and Commerce, Order no. 126/2004 of the Ministry of Interior for approval of the *Handbook on developing proposals for programs for the progressive reduction of annual emissions of sulfur dioxide (SO_2), nitrogen oxides (NO_x) and dust from large combustion plants.* Other regulations are: Order of the Minister of Agriculture, Forests, Waters and Environment No. 818/2003; Law no. 104/June 2011 on ambient air quality); Government Decision no. 1879/2006 approving the national program for the progressive reduction of emissions of sulfur dioxide, nitrogen oxides, volatile organic compounds and ammonia.

The programs for the progressive reduction of annual emissions of sulfur dioxide, nitrogen oxides and dust were developed. These were negotiated and approved by local environmental authorities, becoming an integral part of the compliance programs. The measures proposed and undertaken by Progressive Reducing the Emissions Program are in accordance with the provisions of European Commission document *Integrated Pollution Control (IPPC)*

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- Reference document on best available techniques for large combustion plants - BREF.

Many sources of air pollution are in the Rovinari city. For this reason, Rovinary city is considered to be one of the most polluted areas in the county. The biggest source of pollution is the thermal power plant Rovinari situated on the right bank of the river Jiu, in the north-west of the village of the same name. The thermal power plant is using coal (lignite) from five perimeters: Garla, Rovinari East, Tismana I, Tismana II and Pinoasa.

Assessing of the impact of pollutants discharged into the atmosphere by Rovinari thermal power plant is achieved in two ways: as emissions related to the quantities or volume of pollutants in flue gases and as dispersion (immission) of pollutants in the surrounding area of pollution source. The recorded values have been reported to the permissible limit values.

Other sources of air pollution in the Rovinari area are specific to coal mining activity. Of all the potential areas of emissions, the most representative is the work of filing and storage in coal deposits. In addition to large quantities of dust reaching the atmosphere after technological storage and excavation expedition, in the coal deposits occurs very frequently the phenomenon of self-ignition.

Self-ignition of coal is a process of slow oxidation in contact with air, being an exothermic phenomenon that can affect coal deposits and outburst of coal pit. The observations made while on deposits of coal mining in Oltenia led to the conclusion that the time favorable for self-ignition is from 30 days to 90 days from the date of storage. In this time, the oxidation is a fast process, and thereafter the coal tends to stabilize its rate of oxidation at a low level.

As a result of the coal combustion, a series of gaseous chemical substances: sulfur dioxide, nitrogen dioxide, carbon monoxide, methane, ethene, polycyclic aromatic hydrocarbons and large amounts of dust are released [13].

A source of air pollution, especially in extreme weather conditions (strong winds) is the storage of ash and slag of Rovinari power plant, located in the south-east of the village. It can contribute to indoor air pollution with dust fly ash.

Motor vehicles have a big contribution to air pollution in the area with gaseous criteria pollutants (SO_2, NO_x, CO, CO_2) and particles given the fact that Rovinari is located near the national road DN66.

To all this, there are added domestic activities, especially in the cold time, such as: home heating that is accomplished by solid fuels (coal or wood) and gas combustion from which a series of specific pollutants are resulting.

Unlike Rovinari area where air pollution is due to several sources, in Turceni area, their number is much lower. It comes down mainly to thermal power plant in the area. This is because, unlike thermal power plant Rovinari, where coal careers are close and their supply with fuel it makes by using the conveyor belts directly from quarries in the area, for Turceni thermal power plant the supply with solid fuel is made by rail and pits which feeds the boiler with coal are at large distances.

Slag and ash deposits of the Turceni thermal power plant are not a source of air pollution in the area, because they are located in the valley Ceplea at a fairly large distance to the village.

Other sources that could contribute to ambient air pollution in the area are road transport and domestic human activities.

Experimental part

Air quality monitoring in the Rovinari is done using an automated station (code GJ-2) located in the south-east of the Rovinari city and thermal power plant (fig. 1).

Fig. 1. Location of the automatic monitoring station GJ-2 Rovinari

Sulfur dioxide analyzer is working based on the classical fluorescence spectroscopy. The sulfur dioxide presents a strong ultraviolet absorption peak between 200 and 240 nm. The amount of fluorescence emitted is directly proportional to the concentration of sulfur dioxide in the air sucked from the environment.

The results of the measurements made during the year 2014 will be analyzed to highlight the degree of ambient air pollution by sulfur dioxide. These were requested by the Environmental Protection Agency Gorj. Interpretation of the results of sulfur dioxide concentrations in the air was done in accordance with the provisions of Law 104/2011 on ambient air quality. Law 104/2011 provides a value limit of 125 mg/m^3, as the daily average for the protection of human health for sulfur dioxide concentrations in ambient air [14].

Values of average daily concentrations of sulfur dioxide obtained in 2014 in the Rovinari are shown in table 1.

During 2014 there were a total of 315 validated daily averages measurements which represents 86.3% of total measurements to be made.

A first remark and the most important is that all daily average concentrations of sulfur dioxide were below the limit value set by the laws in vigor.

However, by analyzing the average daily values on different times of the year, it appears that there are differences between them, sometimes quite significant.

Unlike Rovinari area where air pollution is due to several sources, the Turceni air pollution can be mainly due to thermal power plant.

Turceni Thermal Power Plant has 6 power units, grouped into 4 large combustion plants (LCPs). Under Directive 2001/80/EC that decided reducing or limiting emissions of sulfur dioxide, nitrogen oxides and dust from large combustion plants, transposed into national legislation by Government Decision 440/2010, large combustion plants (LCPs) means any technical equipment in which fuels are oxidized in order to use the thermal energy thus produced, whose rated thermal input is equal to or greater than 50MW.

The four large combustion plants of Turceni Thermal Power Plant are:

- 1 LCP consists of energy block no. 1 with a heat output power of 789MWt and which has been notified to operate 20,000 h between 2008 - 2015;

- 2 LCP consists of energy blocks no. 3 and 4, each of them with a heat output power of 789MWt;

- 3 LCP made up of energy blocks no. 5 and 6 (replaced energy block no. 7 until the modernization of energy block no. 6), each of them with a heat output power of 789MWt;

Table 1
SO_2 DAILY AVERAGE VALUES RECORDED ON 2014 IN ROVINARI

Month / Day	Jan. µg/m³	Feb. µg/m³	Mar. µg/m³	Apr. µg/m³	May µg/m³	June µg/m³	July µg/m³	Aug. µg/m³	Sep. µg/m³	Oct. µg/m³	Nov. µg/m³	Dec. µg/m³
1	35.87	26.13	25.48	40.28	14.68	21.4		12.51	26.9	18.13	23.61	12.23
2	101.32	26.08	24.53	20.27	14.62	20.53		11.86	26.8	21.53	40.4	12.61
3	76.43	26.22	17.59	25.8	14.16	14.49	15.42		25.2	10.36	48.83	13.33
4	119.51	30.51	14.29	25.76	14.37	16.21	62.55		24.38	25.98	67.56	14.47
5	46.48	32.77	15.56	21.5	16.54	17.41	17.73	29.5	25.72		30.94	13.37
6	41.47	39.35	15.36	14.2	16.83	17.89	14.93	17.02	25.03		23.09	13.44
7	23.56	53.29	15.48	28.89	13.54	30.75	20.66	18.69	26.1		23.12	12.1
8	23.43	45.17	22.84	17.58	28.37	25.68	14.62	20.67	31.82		24.74	12.8
9	27.42	47.64	25.12		22.81	18.55	13.01	33.03	26.87		24.42	13.24
10	26.13	32.91	25.83	16.96	21.34	31.99	13.19	28.88	27.89		108.58	13.43
11	35.35	30.8	29.54	16.14	16.57	16.82	13.45	22.73	30.18		111.4	13.58
12	30.32	35.53	35.78	14.29	15.96	21.88	17.17	24.47	27.06		38.25	16.06
13	36.27	23.08	24.61	20.33	15.68	47.13	15.55	24.45	27.71		22.27	14.85
14	32.44	30.66	37.97	17.77	13.44	24.36	17.09	24.25	27.53	26.65	14.87	13.41
15	25.54	26.73	33.11	22.85	12.98	15.48	14.37	25.11	24.9	11.95	14.04	17.26
16	23.56	32.11	21.23	13.04	12.7	14.56	19.65	34.46	25.03		13.09	15.09
17	25.82	38.41	28.84	13.84	28.57	21.69	24.16	27.84	25.51	8.58	12.87	17.82
18	26.77	39.8	20.07	15.68	16.38	42.24	16.51	28.67	27.01	9.58	13.64	14.14
19	29.03	36.08	24.79	12.73	21.95	15.83	13.1	31.5	25.38	11.95	13.13	15.38
20	24.41	29.95		14.21	21.12	14.59	16.43	34.93		13.35	15.07	18.11
21		25.99		18.23	24.02	14.18	12.93	31.83		26.83	16.48	29.62
22		19.6		17.13	28.12	17.75	12.35	33.3		13.73	21.03	20.39
23		17.64		19.79	16.24	21.96	13.66	29.07		11.66	20.65	23.6
24		15.84		15.49	28.12		11.85			12.85	15.26	27.21
25		14.5		14.66	19.61				26.54	12.53	33.49	19.87
26		26.2		14.74	34.96		16.19	35.37	21.85	12.23	19.9	17.21
27		56.65		14.85	40.49		13.5	25.61		57.36	34.01	14.91
28		34.88	11.47	14.22	19		10.78	20.97		40.85	18.59	14.58
29	42.15		24.39	15.01	26.05		12.01	23.71		22.55	16.77	13.75
30	53.71		18.24	13.34	18.25		11.24	24.51		41.42	13.55	16.34
31	26.9		18.79		14.35		10.66	32.44		28.2		20.73

- 4 LCP made up of energy block no. 7 with a heat output power of 789MWt and which has been notified to operate 20,000 h between 2008 – 2015.

Turceni Thermal Power Plant is a power plant with a flow sheet of electricity production unit type.

Energy blocks are each provided with the following equipments:
- a steam boiler 1035t/h, 192/48.5 bar, 540/540°C;
- a steam turbine 330MW, 180.4 bar, 535/535°C;
- an electric generator 330MW/388MVA, 24kV, 50Hz;
- an electric transformer 400MVA, 24/400kV.

Currently, the situation of these 330 MW power blocks is as follows:
- energy block no. 4 was rehabilitated and modernized through a special program conducted during 1995 ÷ 2005;
- energy block no. 5 was rehabilitated and modernized through and it was set up in April 2006;
- energy blocks no. 3 and 6 will be rehabilitated and modernized during 2012 ÷ 2016.

Residual flue gases are discharged through two fans flue gas axial type in vertical construction. Supply with air and exhausting of flue gases are designed on two parallel lines that can operate independently to 70% of the rated capacity of the boiler. Removal of the slag is made at the bottom of the boiler as a steam type by means of chain conveyors in a water bath. Slag solidified is then crushed and stored in bunkers, from where it is sent by pipeline to the hydraulic pump stations Bagger. Two cyclones type electrostatic precipitator are designed to retain the particulate ash from the flue gases resulted.

The flue gases are discharged to the atmosphere via four baskets of reinforced concrete, each being connected with two steam boilers of 1035t/h (power block no. 1 to the chimney no. 1, power blocks no. 3 and 4 to basket no. 2, power blocks no. 5 and 6 to the basket no. 3, and power block no. 7 to the basket no. 4).

Fig. 2. Location of the automatic monitoring station GJ-3 Turceni

After the installation of desulphurization facilities, flue gases are discharged for the blocks connected by new desulphurisation installations related to baskets boilers 3, 4, 5 and 6.

Slag and ash deposit of the thermal power plant Turceni is not a source of air pollution in the area, due to the fact that it is located in the valley Ceplea at a fairly large distance to the village.

Other sources that could contribute to ambient air pollution in the area are road transport and human activities.

For Turceni, ambient air quality monitoring is performed using an automated station (indicative GJ-3), located in the north-west of the thermal power plant, the main source of pollution in the area (fig. 2).

It will analyze and interpret the results of the measurements made during 2014. At this year's level was calculated and validated a number of average daily concentrations 353, which represents a 96.7% of data capture (table 2).

Table 2

SO_2 DAILY AVERAGE VALUES RECORDED ON 2014 IN TURCENI

Month / Day	Jan. µg/m³	Feb. µg/m³	Mar. µg/m³	Apr. µg/m³	May µg/m³	June µg/m³	July µg/m³	Aug. µg/m³	Sep. µg/m³	Oct. µg/m³	Nov. µg/m³	Dec. µg/m³
1	14.12	15.29	33.36	13.27	10.41		6.68	5.31	5.26	6.06	20.92	11.39
2	14.2	13.58	12.72	22.72	10.7		18.12	5.23	4.3	2.65	30.9	10.05
3	25.91	9.78	10.23	26.98	10.45	12.08	8.16	5.14	3.47	3.74	36.78	10.33
4	109.57	10.48	9.68	14.39	8.64	18.64	22.26	5.69	3.39	4.79	34.26	9.98
5	20	17.72	9.39	19.11	12.97	15.72	7.73	5.15	3.4	7.45	24.33	9.75
6	12.43	15.79	10.09	9.2	9.34	8.56	7.78	5.08	2.92	7.22	27.16	5.55
7	9.92	19.38	9.79	10.14	8.67	7.8	9.35	4.31	2.66	7.55	23.32	11.77
8	10.11	28.38	10.64	10.73	9.26	19.06	8.19	4.25	2.12	12.76	21.85	14.28
9	10.34	25.47	13.07	11.62	10.08	7.64	5.32	4.96	2.4	12.17	20.5	11.4
10	12.6	20.24	14.23	14.25	8.69	5.88	4.78	2.57	2.21	8.95	123.07	12.17
11	9.86	15.38	11.31	13.89	11.49	7.02	5.15	5.43	8.98	79.34	118.43	11.71
12	10.86	16.71	19.61	11.11	8.62	6.78	10.33	3.74	5.87	27.5	24.82	17.67
13	12.57	18.63	13.03	10.54	9.41	9.31	30.99		4.13	8.28	24.62	13
14	10.21	17.52	23.17	11.66	8.35	6.35	10.43		5.03	9.99	12.1	11.93
15	9.42	15.48	21.3	10.95	7.82	7.85	17.02		5.25	11.67	5.93	11.41
16	13.71	14.9	15.3	9.74	8.59	6.32	9.09		4.91	5.86	12.01	9.74
17	18.85	15.58	10.19	10.86	9.29	8.4	27.13	2.21	12.86	12.67	14.85	14.17
18	15.25	17.53	12.74	10.49	9.42	7.72	6.25	5.09	19.24	9.56	11.99	11.51
19	13.65	17.99	11.39	9.13	10.71	6.93	6.93	7.47	8.91	21.92	10.66	9.2
20	10.49	17.68	11.6	10.31	12.83	7.07	33.75	10.11	16.48	10.02	14.99	9.47
21	7.32	12.98	15.15	11.71	16.47	7.39	5.47	1.2	8.37	9.67	15.14	9.64
22	14.51	10.44	20.07	11.32	13.1	6.25	4.65	38.7	6.42	7.97	23.87	19.89
23	14.86	10.03	17.26	12.47	10.93	7.48	5.53	3.48	5.62	14.02	23.74	11.35
24	10.8	13.34	15.32	9.46	12.26	6.57	5.03	1.53	6.79	14.58	19.28	21.41
25	10.49	12.64	17.1	8.72	9.09	9.18	43.22	1.54	18.35	7.62	24.45	8.36
26	11.14	19.71	13.11	8.82	11.86	6.86	8.55	18.98	6.65	3.78	12.06	
27	20.86	32.05	14.29	10	34.41	45.31	5.25	2.13	6.92	26.52	12.87	
28	15.04	22.93	10.63	8.76	13.28	12.53	4.84	0.25	2.05	15.06	13.9	
29	18.28		13.37	12.91	10.98	19.98	4.87	3.87	19.41	9.26	15.11	
30	23.52		11.67	9.62	10.1	10.08	4.81	12.67	5.93	10.43	9.94	
31	12.7		13.61				5.17	10.04		12.36		10.59

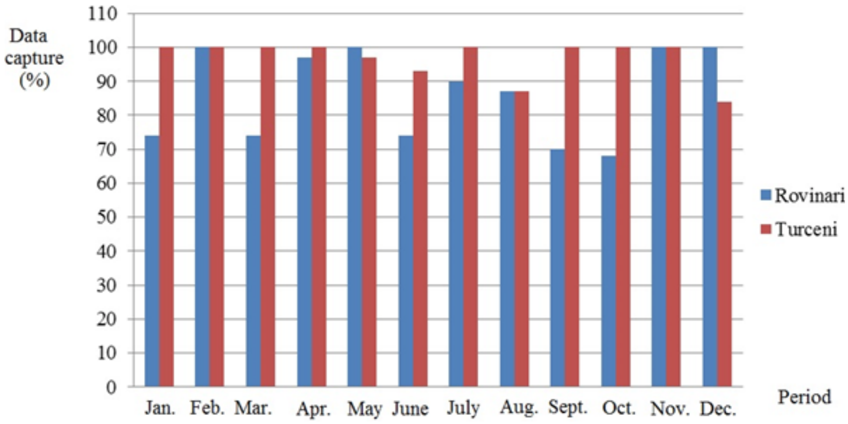

Fig. 3. Data capture for SO_2 in Rovinari and Turceni (2014)

An analysis of these data indicate that, in general, sulfur dioxide concentrations measured during 2014 varied quite broad, but without exceeding the limit value set by law.

Given the fact that the monitoring of ambient air quality in these two areas is performed using automated stations equipped with the same type of equipments, based on measurements made during 2014, there can be made some observations regarding pollution with sulfur dioxide.

Reporting the actual number of days in which measurements of concentrations of sulfur dioxide were made to the total number of days, it appears that for the Rovinari to capture a data rate of 86.3% and the area Turceni 96.7%.

Data capture for the two areas studied, for each month of 2014 is shown in figure 3.

Differences in data capture are due to technical failures experienced by the two automatic stations, primarily at its climate control system. It should be noted that none of the areas studied showed any values for concentrations of sulfur dioxide above the permissible limit value.

An analysis of average daily concentrations highlights that their higher values were recorded in the Rovinari area.

Figure 4 highlights the variation of monthly average concentrations calculated using daily values obtained for sulfur dioxide.

If for the Rovinari the highest concentrations of sulfur dioxide were recorded during January, February and November, the monthly averages of them representing between 24% and 32% of the permissible limit value. For Turceni the highest concentrations of sulfur dioxide values were recorded in November, representing 21% of the monthly average limit value.

The biggest differences in terms of sulfur dioxide concentrations in ambient air of the two areas have been reported in August and September (fig. 5).

By comparing the monthly average concentrations of sulfur dioxide of the two areas, it is found that for Rovinari area, the values of SO_2 concentrations were higher than those recorded in Turceni for 4.3 times in August and 3.8 times in September.

During August, the differences appear more evident if, for example, we compare the minimum daily concentrations of sulfur dioxide recorded between the two areas, for Rovinari area being higher than Turceni for 47 times. In September, the daily minimum concentration was higher in Rovinari area of approx. 11 times higher than in the Turceni. The only exception was the maximum daily concentration of August, which is higher in Turceni than Rovinari.

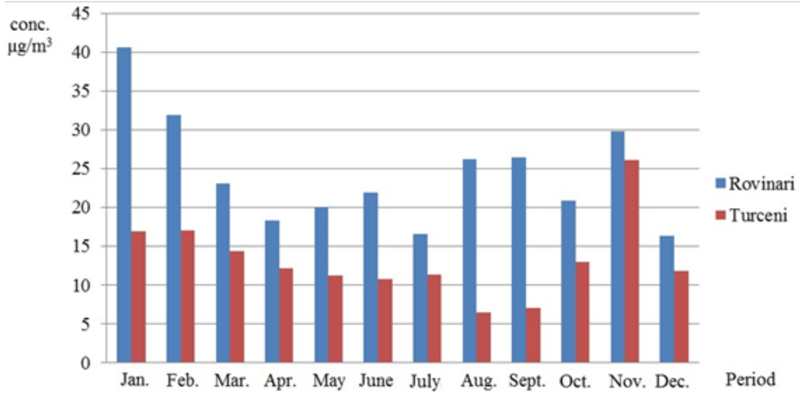

Fig. 4. Variations of monthly average concentrations of SO_2 in Rovinari and Turceni areas

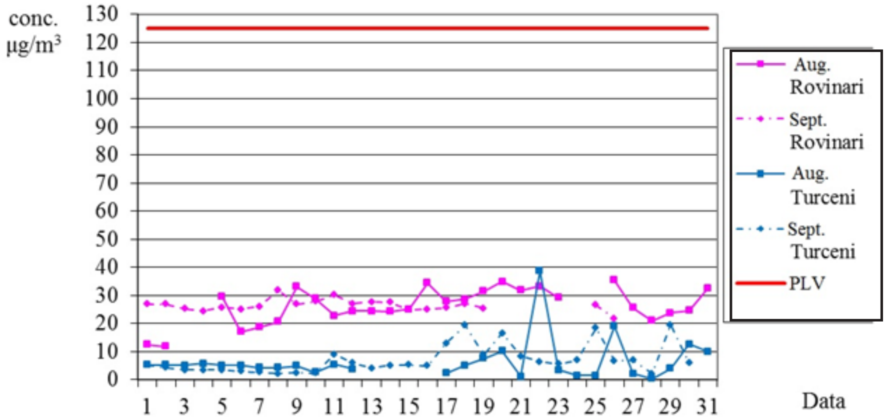

Fig. 5. Variation of concentrations of SO_2 Rovinari and Turceni areas during August-September 2014 (PLV – permissible limit value)

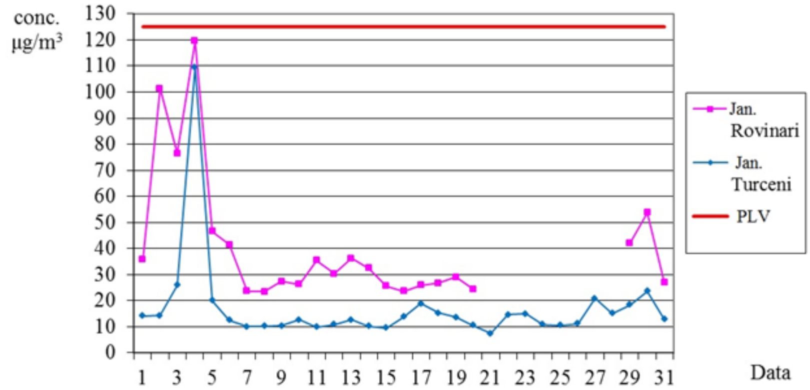

Fig. 6. Variation of concentrations of SO_2 in Rovinari and Turceni areas during January 2014

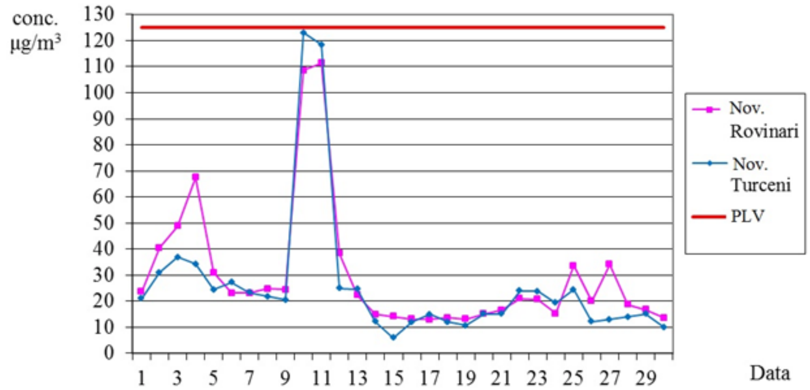

Fig. 7. Variation of concentrations of SO_2 in Rovinari and Turceni areas during November 2014

Obvious differences were seen between concentrations of sulfur dioxide in January, the monthly average of the Rovinari area being over the area Turceni with 2.4 times (fig. 6).

At the opposite pole, it can be considered November, when there were recorded the smallest differences between the concentrations of sulfur dioxide of the two areas. In this period, monthly average concentration of Rovinari area is 1.1 times higher (fig. 7). Between the daily concentrations with the lowest values of the two areas the difference was 2.2 times higher in the Rovinari. For daily maximum concentrations, the higher value was recorded in the Turceni. In other periods of the year the monthly average concentrations were 1.4 – 1.9 times higher in the area Rovinari than Turceni.

Another aspect to be analyzed in the two areas under study is related to the specific indications corresponding to sulfur dioxide concentration. The values of measurements made during 2014 revealed that sulfur dioxide can contribute to the overall index setting the air quality in the area. General air quality index can be classified on a scale of values, marked from 1 (excellent) to 6 (very bad). The basic condition for determining the general air quality index is the existence of at least three monitoring indicators. The general air quality index is given by the indicator monitored that presents specific index with the highest value.

In this regard, the hourly sulfur dioxide concentrations, depending on the value obtained, can be fitted within one of the areas of concentration which correspond to a specific index, from excellent (1) to very bad (6) (table 3).

Table 3

SPECIFIC INDEX FOR SO_2 LEVEL

SO_2 concentrations (μg /m³)	Specific index
0 – 49.9	1(excellent)
50 – 74.9	2 (very good)
75 – 124.9	3 (good)
125 – 349.9	4 (medium)
350 – 499.9	5 (bad)
>500	6 (very bad)

Analyzing the average daily concentrations of sulfur dioxide for each area and comparing them with the concentration range of each specific index, it has been found that they belong to three areas of concentration, causing as many specific indexes.

Thus, in the Rovinari, out of a total of 315 daily averages of sulfur dioxide, 304 namely 96.5% were within the range of concentrations from 0 to 49.9 μg SO_2/m^3, representing specific quality index air characteristic to excellent (1), 6 (1.9%) are in the concentration range of 50 to 74.9 μg SO_2/m^3, representing very good (2) specific index and 5 (1.6%) were in concentrations range 75- 124.9 ∝g SO_2/m^3, representing good (3) specific index (fig. 8).

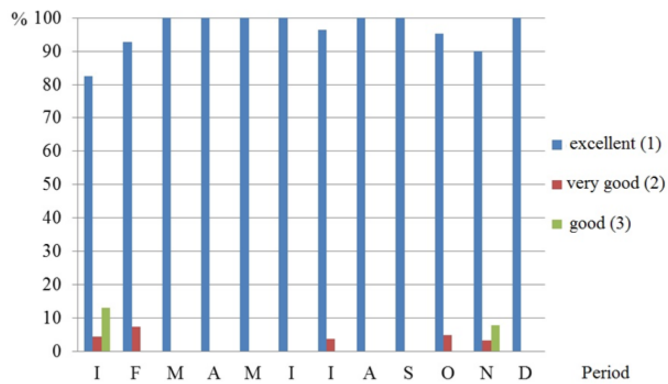

Fig. 8. Specific quality indicators for SO_2 in the Rovinari area

January and November were the only times when the average daily concentrations of sulfur dioxide belonged to the three specific air quality indices, but each time was predominantly the excellent specific quality index (1), representing 92.6% for January and 90% for November.

The characteristic values of specific index of very good quality (2) were present in 5 of the 12 months of the year. The presence of the highest (7.2%) reported the number of average daily concentrations of the month of February.

Good specific index (3) was registered in only two periods of 2014 (January and November), representing 13.1% and 6.7% of the average daily concentrations of each month.

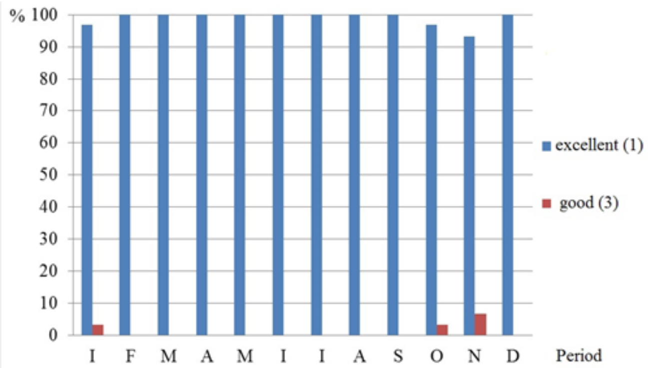

Fig. 9. Specific quality indicators for SO_2 in the Turceni area

In other periods of the year, the daily average concentrations ranged from 0 to 49.9 µg SO_2/m^3, corresponding to a specific index of excellent quality (1).

Looking at the Turceni, it was observed that from 353 out of a total average daily concentrations of sulfur dioxide 89.9% or 349 of them were within the range of concentrations corresponding to the excellent index specific quality (1) and 1.1% namely 4 were characteristics to the good specific index (3) (fig. 9).

Unlike the Rovinari, in Turceni the daily averages of sulfur dioxide belong to only two ranges of concentration corresponding to specific indices of excellent quality (1) and good quality (3).

January, October and November were the months of 2014 whose average daily concentrations of SO_2 were within the range of concentrations corresponding to the specific index characteristic for good quality (3). The remaining periods of the year had only values for concentrations of sulfur dioxide corresponding to specific index characteristic for excellent quality (1).

In the case of Turceni area, the number of months in which all average daily concentrations of sulfur dioxide have shown the value of specific index characteristic for excellent quality (1) accounted 75%. For Rovinari, this number accounted 58% of the total number of months.

Both, for Rovinari and Turceni the prevailing wind directions were north-northwest to south-southeast and north-northeast to south-southwest.

The higher concentrations of sulfur dioxide in the Rovinari, without exceeding the permissible limit value can be attributed to the fact that in this case the automatic station for air quality monitoring is located south-east of the power thermal plant, one of prevailing wind directions.

The fact that in the two areas analyzed the average daily concentrations of sulfur dioxide were below the permissible limit value, demonstrates that the two power plants operated by energy groups have been upgraded and equipped with desulphurisation plant flue gas.

Excepting December, both in the Rovinari and in the Turceni, the highest concentrations of sulfur dioxide were recorded in the period between January and February, and in November, which could be attributed to the contribution and other sources of pollution, especially residential heating during the cold season.

By comparing these results with the results obtained by other authors, it can be concluded that SO_2 concentrations do not put serious problems relative to its limit [15]. Over the years, it significant negative trends were observed in our country for all gaseous pollutants at majority of sites and a general compliance with EU regulations in this field indicating that the control measures that were taken started to have desired effects [15].

Starting from the finding that 70% of sulfur dioxide in the atmosphere comes from thermal power industry, it is considered that in this field measures to reduce emissions must be a priority.

Reducing and control emissions of sulfur oxides from combustion and industrial processes can be achieved by applying several measures such as use of fuel with a low sulfur content, replacement of burning sulfur fuels with other energy sources, removing sulfur from fuels prior to burning and removing sulfur oxides from the flue gases [16, 17].

Replacing fossil-fuel sources with nuclear power plants would solve the problem of SO2 pollution, but the quantities of nuclear fuels are limited.

Removing sulfur from fuels before burning requires a number of processing depending on the type of fuel and the form of sulfur in fuel. Sulphur in fuel is in the form of organic and inorganic compounds - sulphides and sulphates. During sulphate combustion sulfur is transformed in ash and organic sulfur and that from sulphide sulfur is converted mostly in sulfur dioxide.

Currently, there are numerous methods to reduce sulfur dioxide generated by burning fossil fuels. One of the most important methods is the fluidized bed. A fluidized bed is a system in which a gas is partitioned by a grid of distribution (grid or nozzle of the jet) being ejected from the bottom to upwards through a bed of solid particles so that the particles floating in the gas stream are in a permanent agitation. In principle, the process is the combustion of carbon particles suspended in an oxidant stream. Depending on the speed of air injection, there are fluidized bed combustion in stationary and circulating fluidized bed.

The most used technology to reduce sulfur dioxide is the flue gas desulphurization. This can be done in several ways: dry process, semi-dry processes and wet processes.

In the case of dry desulfurization process, sulfur dioxide is retained by physical, or chemical adsorption, absorption and chemical reaction.

A method of flue gas desulphurisation processes based on physical adsorption is that uses as an additive activated coke. Another possibility of dry desulphurisation of sulfur dioxide is chemical absorption by addition of chemical additives, based on calcium or magnesium. Various additives may be added to the different point of combustion, or at different points on the route of combustion gases.

Semi-dry processes are based on the use of a suspension of alkali or alkaline-earth which is brought into contact with the flue gas containing sulfur dioxide. It was used as the active agent a concentrated solution of ammonia or calcium hydroxide. Thus, a dry reaction product will be obtained in the hot combustion gases which are then collected in the particulate filter.

Dry and semi-dry desulphurisation plants are used less, especially for small power plants.

Wet processes have the wider industrial uses. The advantages of these processes are the high retention level of sulfur dioxide from flue gases and the low cost of the materials used.

Wet flue gas desulfurization takes place in the injection guns called scrubbers. In this case, a solution or suspension of an alkaline or alkaline earth metal is dispersed in the flue gas desulfurization or it is brought into homogeneously contact with it, so that the sulfur dioxide is removed by absorption.

Wet desulfurization flue gas method is used by the two power plants Rovinari and Turceni.

The main feature of the wet desulfurization is simultaneous reduction of sulfur dioxide, gypsum producing and the control of limestone supply as essential to overcome fluctuations in fuel sulfur content.

Each power unit has been/will be installed a desulphurisation unit that uses limestone as absorbent substance and a by-product of the process of sulfur dioxide retaining, gypsum. Use of calcium carbonate ($CaCO_3$-limestone) as the absorbent is justified by its high availability and low cost price.

Conclusions

In connection with those presented regarding sulfur dioxide content in air from Rovinari and Turceni areas can be set several conclusions.

Use of fossil fuels (coal) as the main source of producing electricity also constitutes a major source of environmental pollution.

Pollutants resulting from burning coal for energy production, which are of special importance in terms of environmental protection are: SO_2, NOx, CO_2 and particulate matter. Once in the atmosphere, pollutants can act directly or indirectly through their involvement in various processes and phenomena occurring in the atmosphere, such as intensifying the greenhouse effect or the formation of acid rain.

In addition to the effects that they produce on the atmosphere by modifying the natural composition and generation of new harmful chemicals substrates, when pollutants reach land or water, they produce negative effects in the destruction of flora and fauna, land, water pollution with all the consequences of these [18-20].

The content of sulfur dioxide in the flue gas varies depending on the amount of sulfur present in fuels and the presence of sulfur of them varies from one geographical area to another.

Both in Rovinari and Turceni the concentrations of sulfur dioxide in the ambient air are below the limit value set in legislation.

The higher concentrations of sulfur dioxide from Rovinari area can be attributed to the contribution and other sources of air pollution, given that supply coal power plant is done directly from quarries in the area.

Higher concentrations of sulfur dioxide for these two zones were recorded in the cold season, which is attributed to the contribution of residential heating sources in those areas.

Reducing sulfur dioxide concentrations in ambient air of the two areas analyzed became possible thanks to the measures undertaken by the two power plants by applying wet desulphurization technology of combustion gases.

Given the physical volumes and value of the modernization works, in order to comply with the emission limits of some pollutants, these works were phased realized for periods of several years, based on negotiations and implementation deadlines agreed with the European forums.

By accomplishing the modernization works, both technical and economic performance of each power unit were increased, resulting in prolonging life, reducing specific fuel consumption and, most importantly, reduce environmental pollution.

References

1. SELMI, W., WEBER, C., RIVIERE, E., BLOND, N., MEHDI, L., NOWAK, D., Urban Forestry & Urban Greening, **17**, 2016, p. 192.
2. SZEP, R., MATYAS, L., KERESZTES, R., GHIMPUSAN, M., Rev Chim. (Bucharest), 67, no. **2**, 2016, p. 205
3. SZEP, R., KERESZTES, R., CONSTANTIN, L., Rev Chim. (Bucharest), **67**, no. 3, 2016, p. 408
4. SZEP, R., KERESZTES, R., DEAK, G., TOBA, F., GHIMPUSAN, M., Rev Chim. (Bucharest), **67**, no. 4, 2016, p. 639
5. CAPATINA, C., LAZAR, G., PASCU, L.F., SIMONESCU, C.M., Rev Chim. (Bucharest), **65**, no. 12, 2014, p. 1426
6. KANADA, M., DONG, L., FUJITA, T., FUJII, M., INOUE, T., HIRANO, Y., TOGAWA, T., GENG, Y., Energy Policy **61**, 2013, p. 1322
7. CAKMAK, S., HEBBERN, C., CAKMAK, J.D., VANOS, J., Journal of Environmental Management **177**, 2016, p. 1
8. LAZAR, G., CAPATINA C., SIMONESCU, C.M., Rev Chim. (Bucharest), **65**, no. 10, 2014, p. 1215
9. CAPATINA, C., SIMONESCU, C.M., Rev. Chim. (Bucharest), **64**, no. 12, 2013, p. 1471
10. CAPATINA, C., SIMONESCU, C.M., Rev. Chim. (Bucharest), **63** no. 12, 2012, p. 1289
11.DRAGOMIR, E.G., OPREA, M., 2nd IFAC Workshop on Convergence of Information Technologies and Control Methods with Power Systems May 22-24, 2013. Cluj-Napoca, Romania, p. 89
12. POPESCU, F., IONEL, I., LONTIS, N., CALIN, L., DUNGAN, I.L. Romanian Journal of Physics, **56**(3-4), 2011, p. 495
13. MATEOS, A.C., GONZALEZ, C.M., Microchemical Journal **125**, 2016, p. 116
14. ***Law 104/2011 on ambient air quality
15. IORGA, G., BALACEANU RAICU, C., STEFAN, S., Atmospheric Pollution Research, **6**, 2015, p. 824
16. CAPATINA, C., SIMONESCU, C.M., Environmental Engineering and Management Journal, **7**(6), 2008, p. 717.
17. LAZAR, G., CAPATINA, C., SIMONESCU, C.M., Rev Chim. (Bucharest), **59**, no. 8, 2008, p. 939
18. CAPATINA, C., SIMONESCU, C.M., DADALAU, N., CIRTINA, D., Rev. Chim. (Bucharest), **67**, no. 7, 2016, p. 1247
19. WEI, J., GUO, X., MARINOVA, D., FAN, J., Journal of Cleaner Production **64**, 2014, 404
20.TAJ, T., JAKOBSSON, K., STROH, E., OUDIN, A., Spatial and Spatio-temporal Epidemiology **17**, 2016, p. 37

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