Stations for monitoring of the air quality in the cross border area Bulgaria-Romania

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Stations for monitoring of the air quality in the cross border area Bulgaria-Romania: In the present work are considered stations for monitoring of air quality, located near the banks of Danube river. An analysis of their work is caried out considering their ability to measure various air pollutants. The results from pollution by fine particles with a size of 10 μm (FPS 10) in both sections are presented and compared.
Key words: air quality, pollution, monitoring of the air

INTRODUCTION

Ambient air quality is assessed by monitoring the concentrations of major air pollutants. They sign up for a certain period of time (eg 1 hour, 8 hours, 24 hours, one month or one year) at the points for monitoring air quality. Registering of the appropriate levels is necessary to avoid, prevent or reduce harmful effects on human health and environmental damages.

When the level and type of contaminants are under control, it is possible to look for the sources of contamination, and thus to take appropriate measures for reducing or eliminating pollutants. So the knowledge of the stations in the border region and their ability to record various pollutants is very important.

EXPOSITION

According to the accepted European Operational Cross-Border Cooperation Programme Romania-Bulgaria for the period 2007-2013 [1] the border areas of both countries are included. This program creates a connection between the two countries and aims to promote and support the development of the regions situated on both banks of the Danube River. Programme is financed by EU funding to Romania and Bulgaria. It covers nine regions of Bulgaria: Vidin, Vratsa, Montana, Pleven, Veliko Tarnovo, Ruse, Silistra, Dobrich, Razgrad and seven counties of Romania: Mehedinti (with center-city Drobeta Turnu Severin), Dolj (centered Craiova), Olt (with center Slatina) Teleorman (centered Alexandria), Giurgiu with center Giurgiu) Calarasi with center Calarasi) and Constanta with Constanta city center).

As an exception to this program as a neighboring regions of Rousse and Silistra Razgrad region is included, although it is not in the border area, but 10 km. distance from the border - the Danube River.

The population of this border area is approximately 5 million inhabitants of which about 64% are allocated in Romania and in Bulgaria 36%, which represents 17.34% of the population of both countries.

An air quality condition is an important indicator for the successful development of the region, for human health and the natural resources protection. "Air Quality" means the condition of the ground layer of the atmosphere, determined by the composition and ratio of natural ingredients and additives of natural or anthropogenic origin.

During the past years, the efforts of local authorities and the governments of the two countries aim to improve the quality of air we breathe. It is not enough to achieve and ensure good air quality in all regions. A significant part of the population still lives in areas where air quality significantly deviates from the specified by the European Union (EU) limits provided for the protection of human health. Ambient air quality in the air basin of the crossborder region is dependent on the impact of climatic factors and the emission of

pollutants, mainly from local sources - from the industrial business, construction, different fuel systems, transport and households.

A main document for assessment and management of air quality in the European Union is Directive 1996/62 [2]. It makes the basic principles of a common strategy in the EU for air cleanness and measures to be implemented to prevent or reduce harmful effects on the human health and the environment. Since this Directive subsequent directives are initiated regulating the standards of the respective air pollutants. First is the Directive 1999/30/EC [3], which sets rates for sulfur dioxide, nitrogen dioxide, particulate matter and lead in the air and puts standards that must be met by 2005 and 2010.

The next up is 2000/69/ES Directive [5], which sets standards for carbon monoxide and benzene. The standards for polycyclic and aromatic hydrocarbons are established in the Directive [6], and for volatile organic compounds (VOCs) in [7]. Directive 2001/81/EC [7] introduces national limits for key atmosphere pollutants. In response to these directives, Law on air quality passed in Romania [17], and the relevant ordinance OM nr. 1095/2011 establishing indicators of air quality and information of the inhabitants [18], and in Bulgaria - Clean Air Act [19] and Ordinance № 12 on limit values for sulfur dioxide, nitrogen dioxide, particulate matter, lead , benzene, carbon monoxide and ozone in ambient air [20].

Control of the main parameters characterizing the quality of the ground layer of air in the Bulgarian section of the region is provided by the Regional Inspectorates of Environment and Water (REIW): in Montana, Vratsa, Pleven, Veliko Tarnovo, Ruse and Varna. The observation of air quality and its control is carried out by the National Ecological Monitoring System (NEMS) [21]. It is operated by the Executive Agency of Environment (EAE) under the Ministry of Environment and Water (MEW). The control of air quality in the Romanian part of the region is carried out by the Regional Environmental Agencies (ARPM): in Mehedinţi, Craiova, Olt, Teleorman, Giurgiu, Călăraşi and Constanţa. After initial validation and certification the results of these agencies are sent to the National Reference Laboratory for Air Quality - Laboratorului Naţional de Referinţă pentru Calitatea Aerului (LNRCA) and included in the national network for monitoring of air quality - Reteaua Nationala de Monitorizare a Calitatii Aerului (RNMCA) [9] in real time.

As in the Bulgarian as well as the Romanian areas main controlled pollutants are: sulfur dioxide (SO_2), nitrogen oxides (NO_2) and (NO_x), carbon monoxide (CO), ozone (O_3), volatile organic compounds (VOCs) and benzene and particulate matter (PM10 and PM2, 5).

Bulgarian system for air quality monitoring includes 54 points of which - 34 automatic measuring stations (AMS), 10 DOAS (Differential Optical Absorption Spectroscopy) stations, and 10 stations with manually collected samples. The system for air quality has six mobile automatic stations (MAC) connected to the regional laboratories in Sofia, Plovdiv, Pleven, Stara Zagora, Varna and Rousse. MAC are used for further measurements in areas where stations miss or are limited, as well as in case of emergency situations,if reasonably requested by state and local organizations to study the effect of the implementation of the municipal programs for reducing the level of atmospheric pollutants.

Currently in Romania 142 points for monitoring air quality are available, which are equipped for automatic measurement of key air pollutants. 41 of those points are included within RNMCA network for monitoring air quality in real time.

The following stations are in use for the assessment of air quality:

Traffic stations - they are used to assess the impact of motor vehicles movement traffic on the air quality. They have a range of action of 10-100m. They supervise the following pollutants: sulfur dioxide (SO_2), nitrogen oxides (NO_x), carbon monoxide (CO), ozone (O_3), volatile organic compounds (VOCs) and particulate matter (PM10 and PM2, 5);

Industrial type stations - they are intended to assess the impact of industrial activities on air quality. They have a range of action between 100 m to 1 km. In addition to

the above listed indicators, they also measure meteorological parameters - wind speed and direction, temperature, humidity and rainfall.

Urban and suburban background stations - they are used to assess air quality for certain urban areas and have a range of 1-5 km. They measure the same indicators as the stations of the industrial type.

Regional stations - they serve to assess air quality and have a representative area of 200 to 500 km. They measure the same indicators as urban background stations.

In Bulgarian crossborder section, the following monitoring stations operate:

- *Town of Vidin* - AMS - urban background station installed in "St. Petka" Hospital. It measures sulfur dioxide (SO_2) and PM10,.
- *Town of Montana* - are manually installed in RIEW. It measures SO_2, NO_2 and PM10;
- *Town of Vratsa*

a) AMS - urban background station installed near the railway station. It measures SO_2, NO_2, NO_x, CO, PM10, and benzene;

-b) station with manually collected samples installed in RIEW. It measures SO_2 and PM10;

- *Town of Pleven* - AMS - traffic station, installed on "Doyran" Street behind the NRA. Measured SO_2, NO_2, NO_x, CO, PM10, and benzene;
- *Town of Nikopol* - DOAS - urban background station installed in the building of the Municipality of Nikopol. Measured SO_2, NO_2, NO_x, CO, O, and PM10;
- *Veliko Tarnovo City*- station with manually collected samples installed in RIEW. Measured PM2.5 and PM10;
- *Town of Gorna Oryahovitsa* - urban background station located at the crossing of "Ivan Vazov" Street "and Feb. 19th" Street Measured SO_2, NO_2, NO_x, O_3 and PM10;
- *Town of Svishtov* - urban background station installed in the building of Svishtov municipality. Measured SO_2, NO_2, NO_x, CO, O_3, H_2S, and PM10;
- *City of Ruse*

a) AMS - urban background station installed at the Russian Consulate. Measured SO_2, NO_2, NO_x, CO, benzene, PM10 and PM2.5;

b) DOAS R2 - urban background and industrial station installed in the building of "JITI - PS". Measured SO_2, NO_2, NO_x, CO, PM10, and benzene;

c) DOAS R3 - urban background and industrial station installed in the building of "HLEBNA MAYA yeast - AD". Measured SO_2, NO_2, NO_x, CO, PM10, and benzene;

d) RIEW (Regional Inspectorate for Environment and Water) - station with manually collected samples installed in the building of RIEW. Measured PM10, but by Order of the Minister of MEW dd. 01. 01.2012 the station is closed;

- *Town of Silistra* –

a) DOAS S1 - urban background station installed in the building of Trade-unions. Measured SO_2, NO_x, O_3 and PM10;

b) DOAS S2 - industrial station installed in the building of "LESILMACH - PS". Measured SO_2, NO_x, O_3, and PM10;

- *Town of Dobrich* - AMS - urban background station, installed on "Father Paisius' school. Measured SO_2, NO_2 and PM10,.

In the Romanian cross border section the following monitoring stations are located:

- *County Mehedinţi.*

MH-1 - Industrial station installed in the town of Drobeta Turnu Severin, 3, "Baile Romane" Street. Measured SO_2, NO_2, NO_x, NO, H_2S, benzene, PM10 and PM2.5;

- *Dolj County*

- DJ-1-traffic station installed in the town of Craiova, "Calea Bucuresti" Street and "Plata Mare" Street. Measured SO_2, NO_2, NO_x, CO, PM10, and benzene;

- DJ-2 - urban background station installed on "A.I. Cuza" Street in the municipality of Craiova. Measured SO_2, NO_2, NO_x, CO, benzene and PM2.5;

- DJ-3 - industrial station installed in town of Craiova, crossing of "Maria Tanase" Street and "N. Titulescu " Boulevard. Measured SO_2, NO_2, NO_x, O_3 and PM10;

- DJ-4 - Industrial station installed at the entrance of the village of Insalnita - Craiova. Measured SO_2, O_3;

- DJ-5 - suburban background station installed at the entrance of the suburbs Breasta of Craiova. Measured SO_2, CO and O_3;

- *County Olt.*

- OT-1 - Industrial station installed in the town of Slatina "Dealul Gradiste" Street. Measured SO_2, NOx, SO, O_3 and PM10;

- *County Teleorman.*

-TR - 1 - urban background station installed in the town of Alexandria 1,"Dunarii" Street. Measured SO2, NO2, NOx, NO, CO, O3, benzene and PM10;

-TR - 2 - traffic station installed in the town of Turnu Magurele. Measured SO2, NO2, NOx, NO, CO and O_3;

- *County Giurgiu.*

- GR-1 - traffic station installed in town of Giurgiu, 2,"Calea Bucuresti" Street. Measured SO2, NO2, NOx, NO, CO, PM10, and benzene;

- GR-2 - urban background station installed in town of Giurgiu 2,"1 Decembrie 1918" Street. Measured SO2, NO2, NOx, NO, CO, O3, benzene and PM10;

- GR-3 - industrial station installed in the industrial zone of the town of Giurgiu on the road to the village of Slobozia. Measured SO2, NO, NO2, NOx, CO and PM10;

- GR-4 - suburban background station installed between Oinacu village and Branistea village near Giurgiu. Measured SO_2, NO_2, NO_x, NO, CO and PM10

- *County Călăraşi.*

- CL-1 - traffic station installed in the city of Calarasi, "Prelunyirea Bucuresti" Street. Measured SO2, NO2, NOx, NO, CO, PM10, and benzene;

- CL-2 - urban background station installed in the city of Calarasi, 69,"Tudor Vladimirescu" Street. Measured SO_2, NO_2, NO_x, NO, CO, O_3, benzene and PM10

- *County Constanţa.*

- CT-1 - traffic station installed in the town of Constanta, "1 Decembrie 1918" Blvd. within the area of bloc 56. Measured SO2, NO2, CO, PM10, and benzene;

- CT-2 - urban background station installed in Constanta, "Nihal Viteazu"Street, in the area of the Primarie park. Measured SO2, NO2, NOx, CO, benzene and PM2.5;

- CT-3 - suburban background station installed in the town of Navodari, "Tabara Victoria" Street. Measured SO2, NOx, NO, CO, O3, benzene and PM10

- CT-4 - traffic station installed in the town of Mangalia on the road to Constanta whithin the area of the Archaeological Park. Measured SO2, NO2, NOx, CO, PM10, and benzene;

- CT-5 - Industrial station installed in the industrial zone of the town of Constanta, 5, "Prelungirea Liliacului" Street. Measured SO2, NO2, NOx, O3, CO and PM10;

- CT-6 - industrial station installed in Navodari town, "Sanatatul"Street, "Lazar Edelianu" School. Measured SO2, NO2, NOx, O3, CO and PM10;

- CT-7 - Industrial station installed in the town of Medjidia,35,"Decebal" Street. Measured SO_2, NO_2, NO_x, O_3, CO and PM10.

In order to faster giving of information to the population, the National Monitoring Network for Air Quality - (RNMCA) of Romania allows of quick access to all regions of the country, each county and stations. For clearly inform the public about air quality it is accepted assessment in this system to be carried out by "a specific index." This index is given numerically or by color for the following pollutants: sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), ozone (O_3), and particulate matter (PM10).

The value of the specific index depends on concentration of the relevant pollutant-Table 1. The larger concentration of pollution leads to higher specific indices. To calculate the total index it should be included at least three indicators of predominant monitored pollutants which are different for different stations. Indices are represented by integers between 1 and 6. A certain color correspond to each figure -Fig. 1.

Табл. 1

Specific index	Sulphur dioxide SO_2	Nitrogen dioxide NO_2	Ozone O_3	Carbon monoxide CO	Particulate matter PM10
	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$
1	0 - 49.9	0 - 49.9	0 – 39.9	0 – 2.9	0 – 9.9
2	50 – 74.9	50 – 99.9	40 – 79.9	3 – 4.9	10 – 19.9
3	75 – 124.5	100 – 139.9	80 – 119.9	5 – 6.9	20 – 29.9
4	125 – 349.9	140 – 199.9	120 – 179.9	7 – 9.9	30 – 49.9
5	350 – 499.9	200 – 399.9	180 – 239.9	10 – 14.9	50 – 99.9
6	> 500	> 400	> 240	> 15	> 100

Fig. 1. Color performance of specific indexes
1 - excellent, 2 - very good, 3 - good, 4 - on average, 5 - poor, 6 - very bad

The analysis of data from the annual reports of the regional environmental agencies (ARPM) of Romania shows that some of the stations have low percent of validity of the measured data. For example the validity of data for PM10 for year 2010 for station GR-1 was - 77.1% for GR-2 - 48.3% for GR-4 14.3%. For year 20011 validity of the measured data for all the 4 stations in Giurgiu county is less than 50% and therefore, statistics for PM10 are not processed. It is noteworthy that in some other stations there is low percent of validity of the other controlled indexes.

Table. 2

	SO_2	NO_2	NO_x	CO	ФПЧ10	O_3
GR-2	9.1	7.2	7.2	-	-	11.8
GR-4	65.7	61.4	61.4	22.8	-	69.8
CL-1	92.2	14.7	14.7	69.5	17.8	-
CL-2	89.6	0	0	67.8	0	79.6
TR-2	96.5	92.1	-	-	27.6	92.4
DJ-1	-	-	-	-	38	-
DJ-2	-	-	-	-	58	-

These low rates of validity for some of the monitored pollutants lead to incorrect assessment of air quality in the Romanian area.

As it was mentioned at the beginning, quality control of the ambient air for Bulgaria is carried out by the National Monitoring System. Through that system the concentrations of key indicators are daily monitored, according to the Clean Air Act, i.e.: total dust, particulate matter (PM10, PM2.5), sulfur dioxide, nitrogen dioxide / nitrogen oxides, carbon monoxide, ozone, benzene lead, cadmium, nickel, arsenic, polycyclic aromatic hydrocarbons (PAHs). In addition, according to the nature and sources of emissions, in different regions of the country specific parameters are controlled: ammonia, aerosols of sulfuric acid, toluene, xylene, styrene, hydrogen sulfide, methane and non-methane hydrocarbons as well as some other specific pollutants.

The following meteorological parameters are under control: wind speed and direction, barometric pressure, total solar radiation, humidity and air temperature.

All the automatic stations (AMS and DOAS) work in permanent operation (24 hours) and air quality data come in real time in the respective regional dispatch offices (regional databases in REIW) and in the central control center in Sofia EEA - national air quality database, but the data are preliminary. After checking and verifying their authenticity final data are published in the quarterly bulletin and in the National report on the state of the environment.

Manual air monitoring stations only operate in daylight hours and carry four samplings per day, working 5 days a week.

Daily newsletter contains information about the levels of some basic indicators characterizing the air quality in accordance with national and European legislation: fine particulate matter (PM10), sulfur dioxide, nitrogen dioxide, carbon monoxide and ozone.

Information on standards for harmful substances in the air, in accordance with national and European legislation, as well as an information on the health effects of air pollution are published on the website of EAE. This bulletin provides only exceedings of the threshold values of the following pollutants: SO2 - average hourly and average day and night (24 hours) norm; NO2 - average hourly rate, average PM10-clock; CO - maximum 8-hour average in one day; O_3 - threshold for informing the population. Unfortunately specific values are not indicate, but the overruns only. Values of these indicators are given in the quarterly bulletins and PM10 – by days in the monthly newsletters of each RIEW.

One of the main and most large-scaled air pollutants and the determinant of the quality are PM10. Fine particulate matter are particles with a size smaller than 10 μg / m and two types of PM 10 and 2.5 CDF are under control.

"PM10" means particulate matters which pass through a size-selective separator as defined in the reference method for the sampling and measurement of PM10, EN 12341, with a 50 percent retention effectiveness in aerodynamic diameter of 10 μm;

"PM2,5" means particulate matters which pass through a size-selective separator as defined in the reference method for the sampling and measurement of PM2,5, EN 14907, with a 50 percent retention effectiveness in aerodynamic diameter 2,5 μm;

Fine particulate matters are a major air pollutant in urban areas because of the wide variety of sources emitting PM. Main sources are solid fuels for heating with high ash content, which exceed 50% in some cases, combustion installations, transport, domestic heating, etc.. PM10 levels are a key indicator of air pollution from combustion (industrial and residential) installations and road transport. Unorganized pollution as a result of combined climatic has an effect on concentration turns and diffuse pollution due to a combination of climatic characteristics - power and direction of the wind and not cleaned roadways, construction activities etc.

To find out what is the situation in the cross border region Bulgaria-Romania, the results of the annual reports of regional agencies in Romania [10-16] and Bulgaria [22-27] are analyzed.

In Fig. 2 the annual average PM10 concentrations are presented recorded in stations for the period 2010-2011 in various monitoring stations in the area of Bulgaria.

It is noteworthy that pollution from the dust are significant. Under the annual limit of 40 μg/m3 in 2010 are stations in the cities of: Silistra DOAS "LESILMACH" - 33.52 μg/m^3; AMS Vratsa - with annual average - 35.07 μg/m^3; DOAS Ruse "Yeast" and Silistra DOAS "Trade unions" with values of 37.4 μg/m^3 each. The highest averages are in Vidin - 76.44 μg/m3, Montana - 59.18 μg/m^3, Vratsa RIOSV - 56.17 μg/m^3 and Dobrich - 51.09 μg/m^3. In 2011 the lowest content is again in Silistra DOAS "LESILMACH" with 33.9 μg/m^3, Silistra DOAS "Trade unions" - 36.6 μg/m^3 and AMS-Vratsa 39.1 μg/m^3., and with the highest level are Vidin again -76.86 μg/m^3. Montana, Gorna Oryahovitsa and Dobrich had an increase in pollution, respectively Montana from 59.18 μg/m^3 increase to 65.97 μg/m^3 in 2010; respectively Gorna Oryahovitsa from 51.87 μg/m^3 to 69.94 μg/m^3 and Dobrich from 51.09 μg/m^3 of 58.78 μg/m^3. Increase was reported in the three stations in Ruse and in Svishtov. A reduction is reported only in Veliko Tarnovo from 51.6 μg/m^3 to 49.7 μg/m^3.

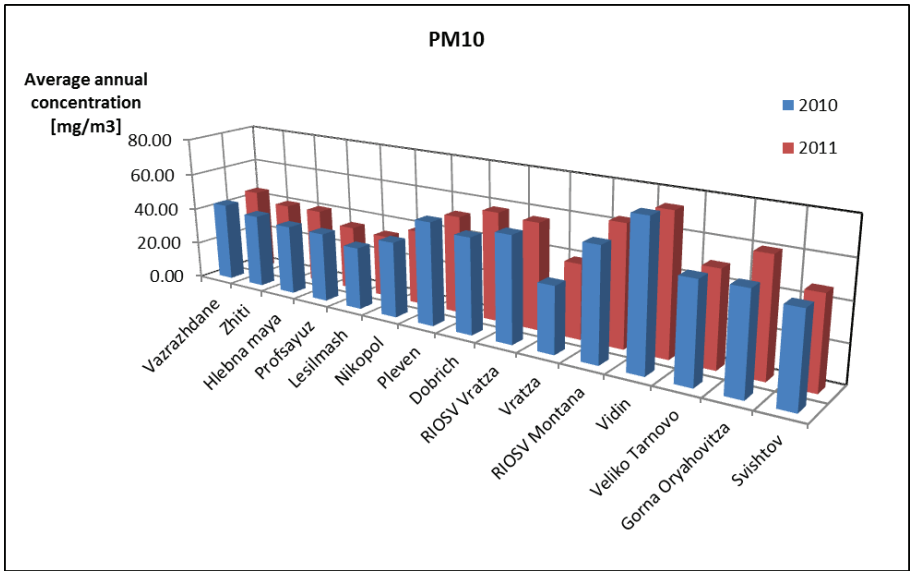

Fig. 2. Average annual concentration of PM10 measured in 2010 and 2011 in the Bulgarian section

Fig. 3 shows the average annual concentration in 2011 recorded by stations in the cross border area of Romania. It is noteworthy that none of the stations exceed the average annual rate of 40 μg/m^3. The highest average annual concentration - 36,8 μg/m^3 was recorded in Station MH -1 in Drobeta Turnu Severin. As noted above, because of the low validity of the measurements the results of the 4 stations in Giurgiu, CL -2 station in Calarasi and CT - 6 in Constanta are not reported. Data from station CL-1 in Calarasi covers the period from April to the end of July, which does not show the actual average annual level.

A question of Interest is to determine the number of exceedances of the average day maximum rate (50 μg/m^3) of PM10. The permissible maximum number of these exceedances is 35 times per calendar year. Fig. 4 shows the number of days that was recorded exceeding the PM10 levels for 2010 and 2011 years per each monitoring stations. Obviously the highest number of days whit the exceeding of levels are recorded

in Vidin and the lowest levels are in Silistra. In 2010, in Vidin, 214 days are recorded (365 measurements) with levels above 50 μg/m^3, and in 2011 these exceedances were 183 (331 measurements). More than 8 times exceedances of the average day level of 50 μg/m^3, is recorded in Vidin, as on 24.12.2010 a concentration of 412.9 μg/m^3 is registered.

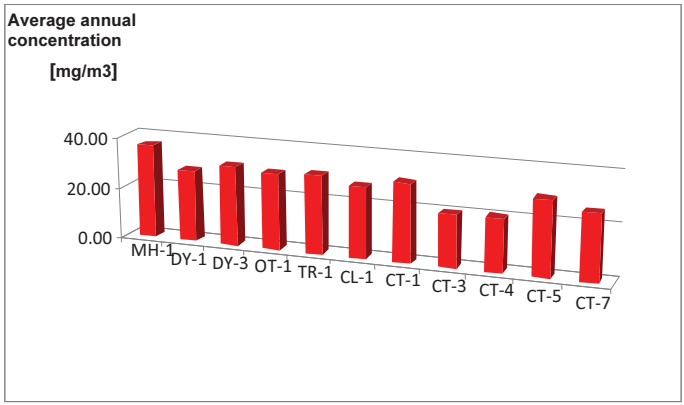

Fig. 3. Average annual concentration of PM10 measured in 2011 in the Romanian section.

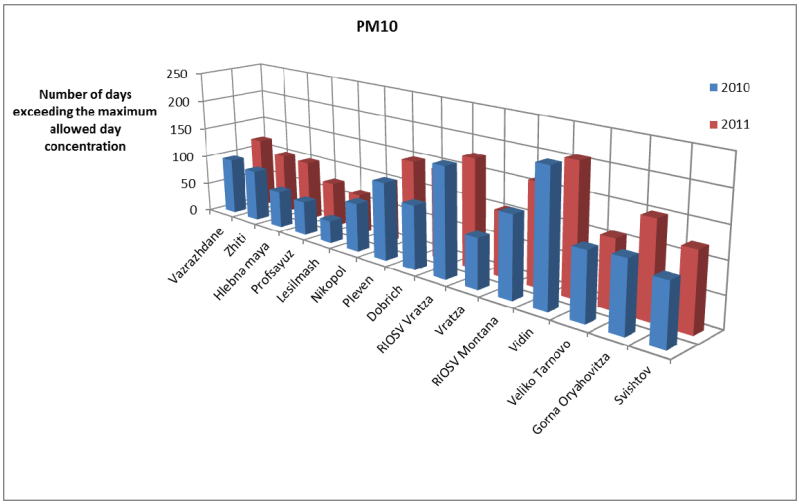

Fig. 4. Number of days exceeding the maximum average day value (50 μg/m^3) in the Bulgarian section.

A large number of exceedances were recorded and in the points of: RIEW Vratsa, RIEW Montana, Veliko Tarnovo. Gorna Oryahovitsa, Svishtov and Ruse. The number of

days exceeding the norm of 35 days ranges from 2 to 6 times. The biggest value of the PM10 for the entire Danube basin was recorded on 21.12.2010 at the station in Svishtov with 478.4 μg/m^3, which exceeds the average day rate 9.57 times and at a station in Gorna Oryahovitsa-424.96 μg/m^3, exceeding average day rate of PM10 - 8.5 times. It should be mentioned that despite the measures taken to reduce pollution, in 2011 a decrease of PM10 was not observed, but contrariwise there is a certain increase.

The lowest number of days exceeding the maximum day limit of 50 μg/m^3 was recorded at the point DOAS "LESILMACH" Silistra - 38 days, i.e. excess is three days more. Compared to other points the lower number of exceeding are in the points: DOAS "Trade unions" Silistra - 57 days (1.63 times excesses) and DOAS "Hlebna maya" (Yeast) Rouse - 64 days exceedings of the maximum day rate.

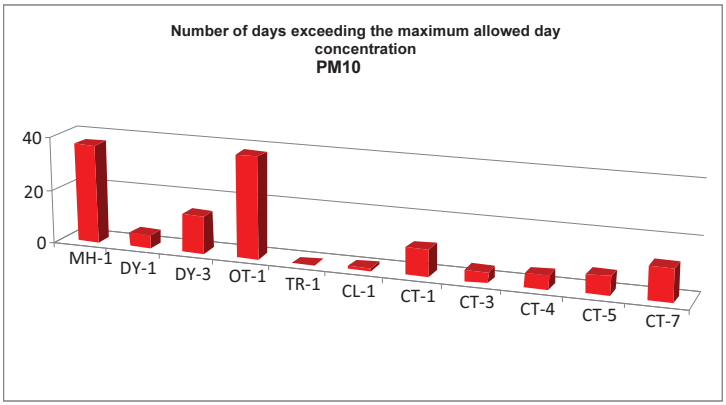

Fig. 5. Number of days exceeding the maximum allowed day value (50 μg/m^3) in the Romanian section.

Fig. 5 shows the number of excesses in the cross border area of Romania. The largest number of exceeding in it is registered in the monitoring stations OT -1 in the town of Slatina - 38 exceedances and MH -1 in Drobeta Turnu Severin - 37 numers. At the rest points, the number of exceedances is significantly smaller. The highest value of PM10 - 199.6 μg/m^3 was recorded on 2.12. 2011. in the town of Drobeta Turnu Severin.

CONCLUSION

1. Whit few exceptions, in the Bulgaria-Romania cross-border region, comparatively good monitoring system is build, of which all stations are automated excepting the 4 in the Bulgarian part whit manually collected samples. There are no built stations in major towns such as: Razgrad, Calafat, Zimnitsa, Oltenitsa, Kozloduy and others.;

2. Despite the well-developed monitoring system in the Romanian area, a significant number of stations have very low validity of the measured data, making the assessment of the actual air quality difficult.

3. National Network for Monitoring Air Quality - (RNMCA) Romania gives at any time the possibility to see "specific indices" of individual pollutants, but does not provide their quantitative values.

4. Only exceedances of the maximum level are published in the daily bulletin of the National System for monitoring of the air quality in Bulgaria, without specifying the corresponding concentrations Thus presentation of the data does not allow to make a

realistic assessment of air quality.

5. The analysis of pollution with fine particles of dust PM10 found out that the Bulgarian section has significantly higher levels of pollution than the Romanian, and the number of exceedances of the average day concentration is many times bigger.

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The paper is reviewed.