Pavle N. ĐURAŠKOVIĆ*, Aleksandar KOJOVIĆ*

DEPOSITION OF SULFUR AT PODGORICA AREA

Sažetak: Oksidovane forme sumpora su glavni nosioci kisjelosti prizemnog sloja atmosfere. Emisija ovih materija, koje se u gasnoj fazi nalaze u obliku sumpor-dioksida – SO2, a u tečnoj fazi (padavine), u obliku sulfatnog jona – SO_4^{2-}, velika je i iz prirodnih izvora (morska maglica, vulkani), i iz antropogenih izvora (sagorijevanje goriva, saobraćaj, industrija). Zbog toga je prisustvo oksidovanog sumpora u atmosferi indikator njenog globalnog zagađenja.

Sadržaj sumpora u prizemnoj atmosferi na području Crne Gore je bio promjenljiv, u saglasnosti sa promjenom intenziteta i vrste privrednih djelatnosti tokom posljednjih decenija. 80-ih godina prošlog vijeka dominantni izvor emisije sumpora su bili industrijski izvori, čija emisija je na području Podgorice bila značajnog intenziteta. 90-ih godina dolazi do privredne recesije, koja je imala za posljedicu veoma nizak sadržaj sumpora u atmosferi. U prvoj deceniji ovog vijeka dominantni izvor emisije sumpora u atmosferu je drumski saobraćaj.

Sumpor je prisutan u vazduhu Podgorice, bez obzira na to da li je lokalnog ili regionalnog porijekla, o čemu svjedoči postojana učestalost kisjelih padavina. Katastar emisije sumpora iz lokalnih izvora na području Podgorice je urađen 80-ih godina prošlog vijeka. Od tada nema pouzdanih podataka o veličini emisije i njenoj promjeni u proteklom periodu, za čim svakako postoji realna potreba.

U okviru Programa monitoringa kvaliteta vazduha u mreži stanica Hidrometeorološkog zavoda, vrši se kontinuirano mjerenje sadržaja SO_2 u vazduhu i sulfata padavinama, u 24-časovnim uzorcima. Na stanici u Podgorici vrši se odvajanje mokre od suve depozicije padavina.

U ovom radu je izvršena procjena veličine depozicije sumpora na području Podgorice, korišćenjem podataka iz redovnog monitoringa. Obrađeni su podaci sadržaja SO 2 u vazduhu i sulfata u suvoj i mokroj depoziciji. Za proračun depozicije usvojena je brzina depozicije 0.6 m/s. Veličina depozicije je bila vremenski promjenljiva, u zavisnosti od veličine emisije i konkretnih meteouslova. Korišćeni 5-godišnji period analize, 20052009, dozvoljava identifikovanje vremenskog trenda ove pojave. Rezultati o veličini depozicije su značajni u sagledavanju stanja u predmetnoj problematici, u vremenu intenziviranja privrednih djelatnosti u Crnoj Gori. S druge strane, oni mogu poslužiti kao pouzdana osnova za upoznavanje i razgraničenje lokalnog od regionalnog uticaja, zatim za procjenu efekata ovih jedinjenja na ekosisteme, bilo direktno, ili preko doprinosa zakišeljavanju prizemne atmosfere, a značajni su kao element upravljanja kvalitetom vazduha.

Ključne riječi: *kvalitet vazduha, sumpor, kisjelost vazduha, depozicija, Podgorica*

---

* Pavle N. Đurašković, Aleksandar Kojović, Hidrometeorološki zavod Crne Gore, Podgorica

Abstract: Oxidizing forms of sulphur are the main carrier of the ground atmosphere acidity. Emission of these substances, which exists as sulphur-dioxide SO 2, in gaseous phase, and as sulphate ions – SO 42-, in liquid phase (rain), have been relatively big, both from natural (sea mist, volcano) and antropogenic (fuel combustion, traffic, industry) sources. For this reasons, the presence of the oxidizing sulphur in the atmosphere is an indicator of its global pollution.

The content of sulphur have been variable in the ground air, at Montenegro area, in acordance with emission intensity. Important air emission from industrial sources, along 80-es of the last century, was drastically reduced, due to economic sanction of UN. In the beginning of this century, following the economic development increase the quantity of air emission. Characteristic of this new situation is that the dominant emission source of air sulphur is roud traffic.

The presence of sulphur in the air of Podgorica area is evident, on the basis of regular air quality monitoring. The acid rains are more frequent phenomenon. Cadastre of sulphur emission from local sources at Podgorica area, was done in 80-ies. Since then it has not any reliable data on the emission level.

Hydrometeorological Institute has carried out the air quality monitoring of this area. In the frame of this programme, it was done the permanent measuring of SO 2 in 24 h air samples, as well as sulphates in the 24 h samples. The „wet" deposition is separated from" dry" deposition, at Podgorica station.

In this paper, the estimation of the sulphur deposition amount at Podgorica area is done. The data of SO_2 content in the air and sulphates content in the precipitations (dry and wet deposition) are included. For the calculation matter, it is accepted the deposition velocity of 0.6 m/s. The level of deposition was temporary variable, what depends of emission quantity and current meteorological conditions. It is processed the 5-years period, 2005–2009, which allows identification of the temporal trend of this phenomenon. Results on deposition level are important for better understanding of the state of this issue in light of contemporary economic and pollution situation. On the other side, data obtained can be useful as a valid base for cognition and separation of the local from the regional influence of emission, then for estimation of the pollution effects to the ecosystems, directly or by acid precipitations, then as element of air quality management, etc.

Key words: *Air quality, sulphur, precipitation acidity, deposition, Podgorica area*

INTRODUCTION

The state in the economy and production was wery varying in Montenegro, in the recent decades. After the period of increase of industrial productions and development, in the 90th of last century came to the overall recession of economy.

On the begin of this century, it is started the reconstruction, but with new its strustural characteristics. Because that, this period is very interesting for assessment of antropogenic factor to overall quality of environment.

The sulphur compounds (sulphates in rain water, sulphur oxides in air) are main carrier of atmospheric acidity [1]. Sources of sulphur emmission to the air are natural and industrial, which are dominant.

Measuring the oxidized forms of sulphur, as global ground atmosphere pollution indicators, have been integral part of air quality monitoring, which has Hydro-

meteorological Institute – Environment Department carried out on its air quality network, every year.

Data from regular emmission Cadastre/Inventory are missing for correctly management on sulphur emmission/imission. Last data exists from 1985. y. when had been done Cadastre of sulphur emmission at Titograd city (now named Podgorica) [2]. Ever since it has not any such data, and it exists need for them, because: control and eventualy reduction of emmission, assessment of balans of sulphur, import-export aspects etc.

The task of this paper was the evaluation of available data of sulphur imission, and possible assessment of sulphur deposition at Podgorica area.

MATERIAL AND METHOD

Analysis of data of sulphur concentration in rain-sulphates and air-sulphurdioxide was done. It was included data for measuring station of HMI in Podgorica, in the period 2005/2009 [6]. Content of sulphur has measured every 24 hours.

Precipitation collecting was done by „bulk" method. Roughly separation of „Wet" from „Dry" deposition was done. If was not rain under 0,1 mm, in last 24 h, funnel was washed with 0,5 ml of dest. water, and such sample was treated as „dry" deposition. Concentration of sulphates was measured spectrophotometricaly, by the barium-perchlorate-Thorin method.

Sampling of SO_2 in air was made by the pararozanylin (West-Gaek) method, and it was determined spectrophotometricaly, on 560 nm.

Deposition in liquid and gaseous phases of air are calculated. „Dry" deposition was calculated as sum of deposition of S-SO_2 in air and S-SO_4 in the dry deposition of precipitions. For this deposition, 0,6 m/s deposition velocity has been used.

RESULTS AND DISCUSSION

Calculated results of „dry", „wet" and total sulphur deposition are shown in tables 1,2 and 3. Theese results are presented in the diagrams 1 and 2.

Results was shown that the „dry" sulphate-sulphur deposition was lower about for 10 time then in the „wet" deposition. This is probably consequence of bigger regional transport and „import" of sulpates [4,5]. Local emmission is more connected with S-SO_2. Concentration of S-SO 2 has increased during the period, what is consequence of contemporary building activity near the station, as well as increase of traffic frequency. In the recent years it was came to change of emmission source's structure [2]. Emmission from Aluminium Plant, which was dominant with 98% in total sulphur emmission, drastically decreased in recent 20 years, and it was increased emmission from traffic, in the same time.

Generally, total sulphur emmission was considerably smaller, than in industrial period before 1990. y.

Comparing this amount of sulphur deposition at Podgorica area with one on EMEP station at Zabljak [3]., it can be shown that the" dry" deposition at Podgorica was similar or a little bit smaller than at Zabljak, but the „wet" deposition was sim-

ilar like Zabljak station. This means that the sulphur deposition at Podgorica is relativly low, and that main contribution to total deposition givs regional transport of sulphur compounds, coming by precipitations.

Table 1: „Dry" deposition of sulphur at station HMI in Podgorica

Godine	DD S-SO 4 g/m2	DD S-SO 2 g/m2	Total
2005	0,097	3,40	3.50
2006	0.129	0,78	0.91
2007	0.127	0,86	0.99
2008	0.118	31,75	31.87
2009	0.062	7,37	7.43
2005–2009	0.107	8.83	

Table 2: „Wet" deposition of sulphur at station HMI in Podgorica

Godine	WD S-SO 4 g/m2
2005	2.41
2006	1,71
2007	1,45
2008	1,99
2009	2,13
2005–2009	1.93

Table 3: Total deposition of sulphur at station HMI in Podgorica

Godine	TD S-SO 4 g/m2
2005	2.41
2006	1,71
2007	1,45
2008	1,99
2009	2,13
2005–2009	1.93

CONCLUSION

The deposition of oxidized forms of sulphur (SO 4 in the rain and SO 2 in the air) was calculated at Podgorica area. Velocity of deposition 0.6 m/s has been used.

In this aim the data of concentration of sulphur in 24 h samples of air and precipitations on station HMI in Podgorica, in the period 2005–2009, has been analysed.

It was observed a decreasing of linear temporal trend of „wet" deposition, and increasing trend of „" dry"" deposition.

„Wet" deposition was higher than „Dry". Total deposition at Podgorica was relativly low, at the background level (like EMEP).

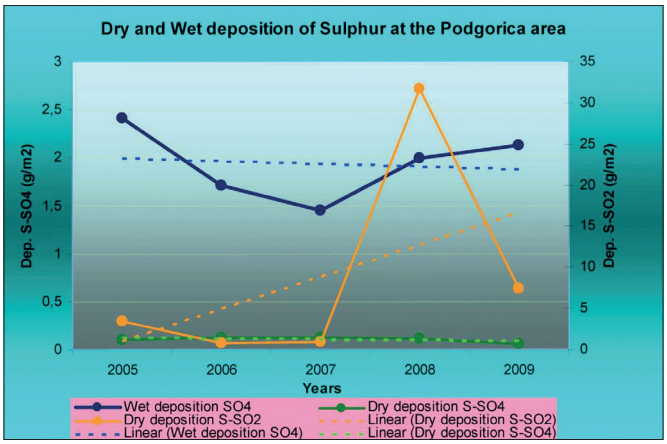

Fig. 1.

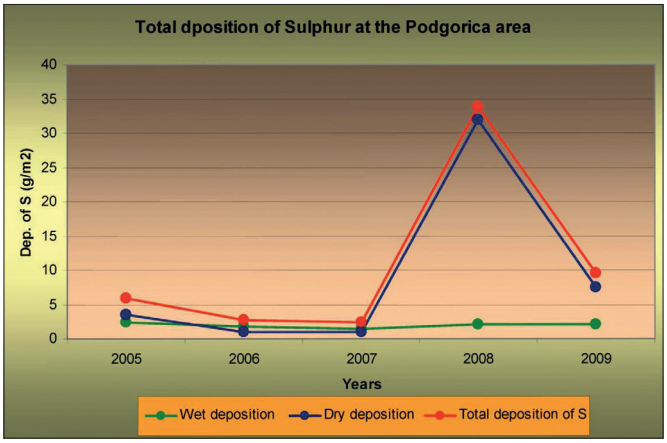

Fig. 2.

The main influence to the amount of „wet" deposition have regional transport and the related meteo conditions, because it warying from year to year, and the trend is not so representative. The bigest influence to the „dry" deposition have local emmission sources, the first of all traffic, because the increasing trend is logic consequence of the present state.

REFERENCES

[1] Markovic, D., at all.: *Stanje i procesi u životnoj sredini*, knjiga 1, Fakultet za fizičku hemiju, Beograd, 1995.

[2] *Katastar emisije sumpora na teritoriji grada Titograda,* RHMZ Srbije, Beograd, 1985.

[3] Vukovic, T., Djordjevic, D.: *Transport and Deposition of Sulfur in/from FR Yugoslavia,* FHMI, Belgrade, 1997.
[4] Djordjevic, D., Djuraskovic, P., Tosic, I., Unkasevic, M.: *Wet deposition of water-soluble main ions in precipitation over the south-eastern Adriatic region*, Atmospheric research (in press), 2010.
[5] Djordjevic, D., Tosic, I., Unkasevic, M., Djuraskovic, P.: *Water-soluble main ions in precipitation over the south-eastern Adriatic region: chemical composition and long-range transport,* Environ Sci Pollut Res, 2010.
[6] Data base, HMI, Podgorica.