University of Belgrade, Technical Faculty in Bor

29th International Conference Ecological Truth & Environmental Research

EcoTER'22

Proceedings

Editor
Prof. Dr Snežana Šerbula

21-24 June 2022, Hotel Sunce, Sokobanja, Serbia

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PREFACE

In today's world, the environment has been endangered by the use of outdated technology, fossil fuels and environmental law violations. Therefore, environmental and many other scientists all over the world have been concerned about finding sustainable technology in resolving these issues. That is why environmental research and ecological truth are at the focus of the 29th International Conference Ecological Truth & Environmental Research 2022 (EcoTER'22), which will be held in Sokobanja, Serbia, 21–24 June 2022. On behalf of the Organizing Committee, it is a great honor and pleasure to wish all the participants a warm welcome to the Conference.

We hope to convey the message of the conference, which is that a transformation of attitudes and behavior would bring the necessary changes. This is also an opportunity for the participants who are experts in this field to exchange their experiences, expertise and ideas, and also to consider the possibilities for their collaborative research.

The 29th International Conference Ecological Truth & Environmental Research 2022 is organized by the University of Belgrade, Technical Faculty in Bor, and co-organized by the University of Banja Luka, Faculty of Technology, the University of Montenegro, Faculty of Metallurgy and Technology – Podgorica, the University of Zagreb, Faculty of Metallurgy – Sisak, the University of Pristina, Faculty of Technical Sciences – Kosovska Mitrovica and the Association of Young Researchers, Bor.

These proceedings include 85 papers from the authors coming from the universities, research institutes and industries in 6 countries: Bulgaria, Italia, Albania, Bosnia and Herzegovina, Montenegro and Serbia.

As a part of this year's conference, the 4th Student section – EcoTERS'22 is being held. We appreciate the contribution of the students and their mentors who have also participated in the Conference.

Financial assistance provided by the Ministry of Education, Science and Technological Development of the Republic of Serbia is gratefully acknowledged by the Organizing Committee of the EcoTER'22 conference.

The support of the Platinum donor and their willingness and ability to cooperate have been of great importance for the success of EcoTER'22. The Organizing Committee would like to extend their appreciation and gratitude to the Platinum donor of the Conference for their donation and support.

We appreciate the effort of all the authors who have contributed to these Proceedings. We would also like to express our gratitude to the members of the scientific and organizing committees, reviewers, speakers, chairpersons and all the Conference participants for their support to EcoTER'22. Sincere thanks go to all the people who have contributed to the successful organization of EcoTER'22.

Prof. Snežana Šerbula,

President of the Organizing Committee

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THE ASSOCIATION BETWEEN SHORT-TERM EXPOSURE TO SO_2 AND EMERGENCY ROOM ADMISSIONS IN URBAN AREA. CASE STUDY SERBIA

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Abstract
The aim of this study was to explore the risk effect of air pollution caused by SO_2 on the emergency room admissions for cardiovascular, respiratory diseases, schizophrenia, and pregnancy-related problems in Bor, Serbia. We collected data on some patients for each of these outcomes, including daily mean concentrations of SO_2 and daily mean temperature and relative humidity for 2014-2018. The generalized-additive model (GAM) was utilized to evaluate the associations between daily SO_2 and emergency room visits for each outcome. The results have shown that short-term exposure to high SO_2 concentration has a significant effect on citizens' health, especially vascular diseases, inflammation, schizophrenia, and pregnancy problems.

Keywords: SO_2, Generalized-Additive Model, health impact, urban area

INTRODUCTION

Air pollution is considered a great ecological problem [1] in urban areas, especially in developing countries. Monitoring of air quality [2] and the impact of local pollution sources [1] aim to improve overall environmental quality [3].

Besides PM particles, a high concentration of sulfur dioxide SO_2 is still the main air pollution source in urban and industrial areas of developing countries [4]. Sulfur dioxide SO_2 is a sharp-smell colorless gas that is heavier than air and water-soluble [5]. Sulfur is a component of oil derivates, coal, gas, and metal ores, whose processing results in significant emission of this gas into the atmosphere [6]. Also, the gas is being emitted during the refining of crude oil in refineries and cement production. Cars as a by-product and factory chimneys emit sulfur dioxide SO_2 into the air [1,4]. Air pollution has become a leading risk [7] for the global mortality and morbidity rate. In the last decades, the yearly level of sulfur dioxide concentration has been reduced under the limits. However, developing countries are still dealing with the problem of sulfur dioxide emission [4,8].

There are limited epidemiological studies whose aim was to investigate the correlations between mortality, morbidity, and air pollution [9], especially in areas with a high level of sulfur dioxide SO_2 concentration [4,7,10,11]. Air pollution from sulfur dioxide SO_2 causes disorders, health problems, hospitalization, and lower average life expectancy [9]. Sulfur dioxide SO_2 is a strong respiratory irritant [12] and bronch-opstructure [4], which irritates the mucous membranes and upper respiratory tract. People's reactions are different because the sensitivity to sulfur dioxide SO_2 is not the same. During normal breathing, a larger amount of inhaled sulfur dioxide SO_2 is retained in the nose and throat [4], while a smaller amount reaches the lungs [7]. In serious cases, inhalation of higher concentrations [3] causes excess fluid in the lungs, blood oxygen reduction, and death in a few minutes [4,13]. Symptoms of excess fluid in the lungs are coughing and shortness of breath which may occur several hours after exposure. It causes systemic inflammation and oxidative stress. [14,15] Short-term exposure to a higher concentration of SO_2 [16] correlates with the increases in mortality and morbidity rates [17].

Therefore, this time-series analysis aims to explore the impacts of short-term exposure to SO_2 on hospital admissions for respiratory, cardiovascular, mental diseases, and pregnancy-related problems and to point out how increased pollution impacts the population's health.

MATERIALS AND METHODS

Study area

Bor is a small city (44°05′N, 22°06′E, 350–400 m above sea level) of 45,000 inhabitants, located in the Eastern part of the Republic of Serbia. The city of Bor (Serbia) is a mining and industrial city with developed non-ferrous extractive metallurgy. The copper smelter is located near the city, and for decades the local population has been exposed to pollutants such as SO_2 and PM_{10} with a high percentage of heavy metals [18].

Data collection

Data on the number of patients were collected between April 2014 and December 2018 from the local emergency room in Bor, Serbia, and used to examine the risk of copper smelter pollution to human health in order to make recommendations on how the local population's quality of life could be improved. The daily average SO_2 concentrations were collected from the Bor Municipality's website. The daily mean temperature and relative humidity were collected from the Serbian Agency for Environmental Protection and the Mining and Metallurgy Institute in Bor. Patients with cardiovascular, respiratory, mental, and pregnancy-related disorders who sought care from the emergency room during the day were included in the study. The diagnoses are primary, classified according to the International Classification of Diseases (ICD-10).

Statistical analysis

Generalized Additive Model (GAM) was used to assess the relationship between the SO_2 variation (Lags 0, 1, 2 and 3) and the daily number of patients for each particular diagnosis. At lag 0, GAM was used to detect the connection between air pollution and disease on a given day. Similarly, the mean concentration of air pollution at lag 1, 2 and 3 refer to one, two or three days before and the number of patients on the current day. Overall cumulative exposure to SO_2 on the current day and the previous three days (lag 0:3) was also estimated.

GAM was used in this study with the quasi-Poisson distribution. Several covariates were adjusted with the penalized spline function. The generalized cross-validation (GCV) score was used to find the optimum degrees of freedom (df) [19]. For the calendar time, the optimal df was 7 per year. For the mean temperature, the optimal df was 3, and for the relative humidity, the optimal df was 3. Besides the single lag model, the distributed lag model, where the multiple lags (lag 0:3) of air pollution are simultaneously included in the model, was applied. So, the model can be expressed as follows:

$$\log(\mu_t) = \alpha + \beta_{t-l}(SO2_{t-l}) + s(\text{Time}, df = 7) + s(T, df = 3) + s(RH, df = 3) \quad (1)$$

where the $\log(\mu_t)$ referred to the daily number of the diseases, t was the first day, and l was the lag days. β_{t-l} was the regression coefficient and $SO_{2_{t-l}}$ was the mean concentration of SO_2 at different lag days. The time was the calendar time. T stood for temperature, and RH was relative humidity. α was an intercept, and s was the penalized cubic spline function.

The results were expressed as the percentage changes (PC (%)) in the daily subject visits for each outcome for a 10 μg/m^3 increment of the SO_2 concentrations and its 95% confidential intervals. Statistical analysis was performed using the R software (https://www.r-project.org). To fit the GAM model, the 'mgcv' package was used. $p<0.05$ was considered statistically significant.

RESULTS AND DISCUSSION

The distribution of the average daily SO_2 concentrations from 2014 to 2018 is presented in Figure 1 . Mean daily concentrations of SO_2 were exceeded 66 times during the observed period, with maximum daily average values above 2000 μg/m^3.

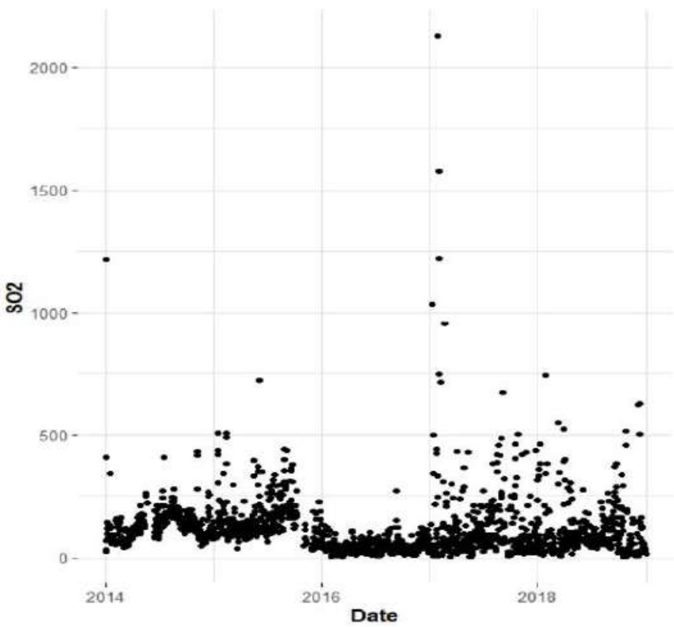

Figure 1 *Time-series plots of SO_2 concentrations between 2014 and 2018*

The estimates from the single pollution model are presented in Table 1.

According to the single pollutant model (Table 1), each 10 μg/m^3 increase in SO_2 (lag 3 and lag 0:3) is associated with the 0.78% (95% CI: (0.15, 1.35)) and 0.88% (95% CI: (0.32, 0.1.34)) increase in the output visits for the subjects with cerebrovascular diseases, respectively. Also, the increase in SO_2 (lag 0:3 - accumulative) is associated with the 0.29%

(95% CI: (0.12, 0.48)) increase in admission for upper respiratory tract infection. Besides, the increase in SO_2 (lag 3 and lag 0:3 - accumulative) is associated with the 0.19% (95% CI: (0.03, 0.36)) and 0.44% (95% CI: (0.11, 0.78)) increase in the subjects with psychotic disorders. The largest increase in the number of the subjects with pregnancy-related problems found for SO_2 on day 4 (Accumulative) was 0.25% (95% CI: (0.07, 0.38)).

Table 1 *The air pollution model*

	PC (%)	95CI (%)	P value
Model I: SO_2			
Vascular deseases, lag 3	0.78	(0.15; 1.35)	0.05
Vascular deseases, lag 0:3	0.88	(0.32, 1.34)	0.05
Upper respiratory tract infection, lag 2	0.53	(0.16; 0.91)	0.05
Upper respiratory tract infection, lag 3	0.78	(0.22; 1.36)	0.01
Upper respiratory tract infection, lag 0:3	0.29	(0.12; 0.48)	0.05
Chronic lung obstruction, lag 2	0.23	(0.04; 0.44)	0.03
Chronic lung obstruction, lag 3	0.41	(0.19; 0.62)	0.04
Chronic lung obstruction, lag 0:3	0.63	(0.13; 1.01)	0.05
Psychotic disorders, lag 3	0.19	(0.03; 0.36)	0.03
Psychotic disorders, lag 0:3	0.44	(0.11;0.78)	0.02
Pregnancy problems, lag 3	0.17	(0.01; 0.32)	0.03
Pregnancy problems, lag 0:3	0.25	(0.07; 0.38)	0.03

To assess the robustness of the main results obtained in this research study, a sensitivity analysis was performed. The df of the calendar time (5–8 df), the temperature (T) (3–5 df), and the relativity humidity (RH) (3–5 df) were changed. The results showed that when varying the degrees of freedom for time (5–8 df) no significant change in the effect was noticed, in the association between the SO_2 pollutant and the variables, as for the Temperature (T) (3–5 df) and the Relativity Humidity (RH) (3–5 df).

Similar results have been obtained in other studies. Increased oxidative stress and inflammation in the nervous system may be crucial biochemical mechanisms underlying the relationship between SO_2 and mental health [20]. Changes in synaptic plasticity in the hippocampus have been linked to SO_2 exposure [21]. Regarding the impact on pregnancy, in their study, Zhou *et al*. [22] found that SO_2 was one the largest contributor to an increased risk of preterm birth.

However, there has been a long debate on whether SO_2 has an independent effect on human health or serves as a proxy for combustion mixture [23]. Either way, further experimental or observational studies based on personal measurements and modeled residential concentrations are required to evaluate whether SO_2 has a causative health impact.

CONCLUSIONS

The present study confirmed that the daily emergency room admissions for vascular, respiratory, mental, and pregnancy diseases were significantly associated with exposure to

SO_2 in the city of Bor (Serbia). The study also revealed that risks of hospital admissions increased with the cumulative days of exposure to air pollution (lag 2, 3, and 0:3). Based on our findings, we would recommend certain categories of population, like pregnant women and chronic patients, to reduce their outdoor activities during elevated concentrations of pollutants. This study once again highlights the importance of monitoring and controlling the emission sources.

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