University of Belgrade
Technical Faculty in Bor

31st International conference

Ecological Truth & Environmental Research

Editor
Prof. Dr Snežana Šerbula

PROCEEDINGS

Hotel Sunce, Sokobanja, Serbia
18–21 June 2024

PROCEEDINGS

31st INTERNATIONAL CONFERENCE

ECOLOGICAL TRUTH & ENVIRONMENTAL RESEARCH – EcoTER'24

Editor:

Prof. Dr Snežana Šerbula, University of Belgrade, Technical Faculty in Bor

Technical editors of the Proceedings:

Dr Tanja Kalinović, University of Belgrade, Technical Faculty in Bor

Dr Jelena Kalinović, University of Belgrade, Technical Faculty in Bor

Prof. Dr Ana Radojević, University of Belgrade, Technical Faculty in Bor

Dr Jelena Jordanović, University of Belgrade, Technical Faculty in Bor

Sonja Stanković, MSc, University of Belgrade, Technical Faculty in Bor

Editor of the 6th Student Section:

Prof. Dr Maja Nujkić, University of Belgrade, Technical Faculty in Bor

Technical editor of the 6th Student Section:

Vladan Nedelkovski, MSc, University of Belgrade, Technical Faculty in Bor

Cover design:

Aleksandar Cvetković, BSc, University of Belgrade, Technical Faculty in Bor

Publisher: University of Belgrade, Technical Faculty in Bor

For the publisher: Prof. Dr Dejan Tanikić, Dean

Printed: University of Belgrade, Technical Faculty in Bor, 100 copies, electronic edition

Year of publication: 2024

CIP - Каталогизација у публикацији
Народна библиотека Србије, Београд

502/504(082)(0.034.2)
574(082)(0.034.2)

INTERNATIONAL Conference Ecological Truth & Environmental Research (31 ; 2024 ; Sokobanja)

Proceedings [Elektronski izvor] / 31st International conference Ecological Truth & Environmental Research - EcoTER'24, Sokobanja, Serbia, 18-21 June 2024 ; [organized by] University of Belgrade, Technical faculty in Bor (Serbia) ; [co-organizers University of Banja Luka, Faculty of Technology – Banja Luka (B&H) ... [et al.]] ; [editor Snežana Šerbula]. - Bor : University of Belgrade, Technical faculty, 2024 (Bor : University of Belgrade, Technical faculty). - 1 elektronski optički disk (CD-ROM) ; 12 cm

Sistemski zahtevi: Nisu navedeni. - Nasl. sa naslovne strane dokumenta. - Preface / Snežana Šerbula. - Tiraž 100. - Bibliografija uz svaki rad.

ISBN 978-86-6305-152-2

а) Животна средина -- Зборници б) Екологија – Зборници

COBISS.SR-ID 147002889

The 31st International Conference
Ecological Truth & Environmental Research – EcoTER'24

is organized by:

UNIVERSITY OF BELGRADE
TECHNICAL FACULTY IN BOR (SERBIA)

Co-organizers of the conference:

University of Banja Luka, Faculty of Technology,
Banja Luka (B&H)

University of Montenegro, Faculty of Metallurgy and Technology, Podgorica (Montenegro)

University of Zagreb, Faculty of Metallurgy, Sisak (Croatia)

University of Pristina, Faculty of Technical Sciences, Kosovska Mitrovica (Serbia)

Society of Young Researchers – Bor (Serbia)

The EcoTER'24 conference is financially supported
by
the Ministry of Science, Technological Development and Innovation
of the Republic of Serbia

Republic of Serbia
MINISTRY OF SCIENCE,
TECHNOLOGICAL DEVELOPMENT AND INNOVATION

Platinum donor of the EcoTER'24 conference

Platinum donor of the EcoTER'24 conference

Gold donor of the EcoTER'24 conference

Silver donor of the EcoTER'24 conference

SCIENTIFIC COMMITTEE

Prof. Dr Snežana Šerbula, *President*

Prof. Dr Alok Mittal (India)
Prof. Dr Jan Bogaert (Belgium)
Prof. Dr A. Nadgórska-Socha (Poland)
Prof. Dr Luis A. Cisternas (Chile)
Prof. Dr Wenhong Fan (China)
Prof. Dr Martin Brtnický (Czech Republic)
Prof. Dr I.M. De Oliveira Abrantes (Portugal)
Prof. Dr Shengguo Xue (China)
Prof. Dr Tomáš Lošák (Czech Republic)
Prof. Dr Maurice Millet (France)
Prof. Dr Murray T. Brown (New Zealand)
Prof. Dr Xiaosan Luo (China)
Prof. Dr Daniel J. Bain (USA)
Prof. Dr Che Fauziah Binti Ishak (Malaysia)
Prof. Dr Richard Thornton Baker (UK)
Prof. Dr Mohamed Damak (Tunisia)
Prof. Dr Jyoti Mittal (India)
Prof. Dr Miriam Balaban (USA)
Prof. Dr Fernando Carrillo-Navarrete (Spain)
Prof. Dr Pablo L. Higueras (Spain)
Prof. Dr Mustafa Cetin (Turkey)
Prof. Dr Mauro Masiol (Italy)
Prof. Dr George Z. Kyzas (Greece)
Prof. Dr Mustafa Imamoğlu (Turkey)
Prof. Dr Petr Solzhenkin (Russia)
Prof. Dr Yeomin Yoon (USA)
Prof. Dr Chang-min Park (South Korea)
Prof. Dr Faramarz Doulati Ardejani (Iran)
Prof. Dr Natalija Dolić (Croatia)
Prof. Dr Milutin Milosavljević (Serbia)
Prof. Dr Nenad Stavretović (Serbia)
Prof. Dr Ivan Mihajlović (Serbia)
Prof. Dr Milovan Vuković (Serbia)
Prof. Dr Nada Blagojević (Montenegro)
Prof. Dr Darko Vuksanović (Montenegro)
Prof. Dr Irena Nikolić (Montenegro)
Prof. Dr Šefket Goletić (B&H)
Prof. Dr Džafer Dautbegović (B&H)
Prof. Dr Borislav Malinović (B&H)
Prof. Dr Slavica Sladojević (B&H)
Prof. Dr Nada Šumatić (B&H)
Prof. Dr Snežana Milić (Serbia)
Prof. Dr Dejan Tanikić (Serbia)
Prof. Dr Milan Trumić (Serbia)
Dr Jasmina Stevanović (Serbia)
Dr Dragana Ranđelović (Serbia)
Dr Viša Tasić (Serbia)
Dr Ljiljana Avramović (Serbia)
Dr Stefan Đorđievski (Serbia)
Prof. Dr Branimir Jovančićević (Serbia)
Dr Mirjana Marković (Serbia)
Dr Lidija Mančić (Serbia)
Dr Tanja Brdarić (Serbia)
Prof. Dr Tatjana Anđelković (Serbia)
Prof. Dr Milan D. Antonijević (UK)
Prof. Dr Jelena Mitrović (Serbia)
Prof. Dr Polonca Trebše (Slovenia)
Prof. Dr Popescu Francisc (Romania)
Prof. Dr Adrian Eugen Cioablă (Romania)

HONORARY COMMITTEE

Dr. Petar Paunović
(Zaječar, Serbia)

Prof. Dr Zvonimir Stanković
(Bor, Serbia)

Prof. Dr Velizar Stanković
(Bor, Serbia)

Prof. Dr Milan M. Antonijević
(Bor, Serbia)

Prof. Dr Ladislav Lazić
(Sisak, Croatia)

Dragan Ranđelović, Society of Young Researchers – Bor
(Bor, Serbia)

Toplica Marjanović, Society of Young Researchers – Bor
(Bor, Serbia)

Mihajlo Stanković, Special Nature Reserve of Zasavica
(Sremska Mitrovica, Serbia)

ORGANIZING COMMITTEE

Prof. Dr Snežana Šerbula, *President*

Prof. Dr Snežana Milić, *Vice President*

Prof. Dr Đorđe Nikolić, *Vice President*

Prof. Dr Ana Radojević, *Vice President*

Dr Tanja Kalinović, *Vice President*

Prof. Dr Marija Petrović Mihajlović

Prof. Dr Milan Radovanović

Prof. Dr Milica Veličković

Prof. Dr Danijela Voza

Prof. Dr Maja Nujkić

Prof. Dr Ana Simonović

Dr Jelena Kalinović

Dr Jelena Jordanović

Dr Dragana Medić

Sonja Stanković, MSc

Vladan Nedelkovski, MSc

Aleksandar Cvetković, BSc

Dragan Milenković, IT service

PREFACE

The 31st international conference Ecological Truth & Environmental Research – EcoTER'24 focuses on showing the latest research findings and innovations in the field of ecology, environmental protection and sustainable development. The conference will be held in Sokobanja (Serbia) in hotel Sunce in the period of 18–21 June 2024.

The aim of the conference is to connect the experts in various fields in order to transform attitudes and behaviors in everyday practices, as well as in the industry and economy sector which is essential for achieving the desired changes that our society must undergo.

The 31st international conference Ecological Truth & Environmental Research – EcoTER'24 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 Society of Young Researchers – Bor.

These Proceedings encompass 119 papers from the authors coming from the universities, research institutes and industries in 15 countries: Brazil, Norway, USA, Spain, Austria, Libya, Italy, Israel, Slovenia, Croatia, Romania, Bulgaria, Montenegro, Bosnia and Herzegovina, North Macedonia, and Serbia. It is a great honor and pleasure to cordially wish a warm welcome to all the participants of the conference.

As a part of this year's conference, the 6th Student Section – EcoTERS'24 will be held. We appreciate the contribution of the students and their mentors who have also participated in the conference and hope that students will continue to explore and to be curious, since education is a never-ending process, and knowledge is continuously growing.

The organization of the EcoTER'24 conference has been financially supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia.

The support of the Donors and their willingness and ability to cooperate has been of great importance for the success of the EcoTER'24 conference. The organizing committee would like to extend their appreciation and gratitude to the Platinum donors of the conference – Serbia ZiJin Copper doo Bor and HBIS SERBIA, to the Gold donor of the conference – Elixir Group, as well as to the Silver donor of the conference – Serbian Chamber of Engineers.

We would like to express our sincere appreciation to all the authors who have contributed to the Proceedings. We would also like to express our gratitude to the members of the scientific, organizing and honorary committees, reviewers, speakers, chairpersons and all the conference participants for their support of the EcoTER'24. Sincere thanks go to all the people who have contributed to the successful organization of the EcoTER'24.

Prof. Snežana Šerbula,

President of the scientific and organizing committee

TABLE OF CONTENTS

Plenary Lectures

Invited Lectures

Conference Papers

Environmental monitoring and impact assessment

Ecotoxicology and environmental safety

Hazardous materials and green technologies

Environmental biology

Environmental and material flow management

Student Section – EcoTERS'24

EcoTER'24
31st International Conference Ecological Truth & Environmental Research
18–21 June 2024, Hotel Sunce, Sokobanja, Serbia
www.eco.tfbor.bg.ac.rs

THE RELATIONSHIP BETWEEN PM_{10} AND METEOROLOGICAL PARAMETERS CLOSE TO THE MINING AREA

Milica Veličković[1*], Danijela Voza[1]

[1]University of Belgrade, Technical Faculty in Bor, V.J. 12, 19210 Bor, SERBIA

[*]*mvelickovic@tfbor.bg.ac.rs*

Abstract

PM_{10} is one of the most dangerous air pollutants and represents a serious environmental and health problem. Its concentration is influenced by many factors, among which meteorological parameters stand out as the most important. In this sense, this study aimed at exploring the relationship between PM_{10} and meteorological variables (atmospheric temperature (AT), barometric pressure (BPR) and relative humidity (RH)) in rural area near copper mine. The data about meteorological parameters and PM_{10} concentrations were collected for 2019–2022. The dataset was divided into two periods (cold and warm) to analyze potential seasonal variations. The correlation analysis was employed in order to investigate the relationship between the observed variables. The results have shown that coefficient of correlation is positive and statistically significant, but very low between PM_{10} and AT and BPR, and negative between PM_{10} and RH, for both periods.

Keywords: PM_{10}, meteorological parameters, correlation analysis.

INTRODUCTION

Particulate matter (PM) presents a complex mixture of organic and inorganic substances and can have a different composition, depending on the emission. Sources of PM particles can be both natural and anthropogenic. Anthropogenic sources include industry, domestic fuel burning and traffic. On the other hand, natural sources include volcanoes, fires, dust storms, and aerosolized sea salt [1]. Previous studies have confirmed that fossil fuel combustion and industrial metallurgical processes are the most common anthropogenic sources of PM_{10} [2]. PM particles in the air represent a serious environmental problem, primarily due to the content of toxic substances and heavy metals in them [3]. High concentrations of heavy metals in PM particles can cause serious respiratory and cardiovascular diseases [4]. Based on these facts, WHO recommended that the mean annual level of PM_{10} should not exceed 15 $\mu g/m^3$ and mean 24-hour should not exceed 45 $\mu g/m^3$ [5] due to the protection of human health.

Apart from the pollution sources themselves, the level of particles in the air is influenced by other factors, among which meteorological parameters stand out as the most important. Meteorological conditions, such as wind speed, wind direction, temperature, relative humidity and atmospheric pressure, play an important role in the dispersion of suspended particles [6,7]. Research has shown that concentrations of suspended particles (PM_{10}) correlate negatively with air temperature and wind speed but positively with air pressure and relative air humidity [8]. However, the relationship between the concentration of suspended particles

(PM_{10}) and meteorological factors varies during different seasons. The study conducted by Chen et al., [9] found that the correlation between suspended particulate matter (PM_{10}) and air temperature is negative during summer and autumn but positive during winter and spring. By observing the seasonal variation of PM_{10}, it can be better understood, explained and predicted its future concentrations.

A large number of studies has proven that huge quantities of PM_{10} are generated during mining operations, which include excavating machines, shovels, drilling machines and transportation by heavy-duty dumpers in the mining areas [10–12]. In general, when it comes to open pit mines the dispersion of PM depends on local meteorology. Wind flow is the prime mover of the PM from one place to the other [13], but other meteorological parameters also have their role. Hence, the main aim of this study was to analyse the relationship between meteorological factors and PM_{10} near open pit mining area.

MATERIALS AND METHODS

Study area

For this study, the public datasets of PM_{10} concentrations and meteorological conditions in Bor from January 2019 to December 2022 were obtained from the official website of Bor municipality. The concentration of suspended particles PM_{10} is measured using the SRPS EN 12341 reference method and it was done by Institute for Mining and Metallurgy in Bor. The data were collected from the measuring station Krivelj, located in a rural area, at 425 m above sea level. The measuring point is positioned in the direction of the dominant southeast wind in the village of Krivelj. At this location, a large influence of the Velik Krivelj tailings pond was observed, and when the southeast wind blows, dust particles are blown in the direction of the village. In addition, due to very intensive industrial activities, there is also an increase in traffic in this area, which contributes to an increase in pollution.

The climate of study area is moderate to medium continental, with a transition to mild mountain in the higher mountain zones. The characteristics of this climate are warm and sunny summers and cold winters with a lot of snow. The seasons are recognizable, with autumn sometimes being warmer than spring, with more sunny days and less rainfall. Summers are characterized by stable weather conditions, with long sunny and shorter rainy periods. In winter, the weather is characterized by low temperatures and intense snowfall.

RESULTS AND DISCUSSION

Data for study period were divided into cold (October–April) and warm (May–September) periods. The average daily content of PM_{10} in the air in the period of 2019–2022 was measured at the measuring point Krivelj, and the obtained values (cold period, warm period, and an average values on annual level) are shown in Table 1.

Table 1 *Average concentration of PM_{10} particles in ambient air in the village Krivelj for period 2019–2022*

Location		2019	2020	2021	2022
Measuring station Krivelj	Cold period	36.9	28.7	28.3	38.2
	Warm period	27.2	24.8	26.2	28
	Avg. Value	31.9	27.1	27.5	30.7
	Days above limit	29	10	3	24

Based on the results shown in Table 1, it can be concluded that somewhat higher values of PM_{10} were registered during the cold period over the entire study period, which is logical since this is also the heating period. The good thing is that the average daily limit was not exceeded more than 35 times [5], which confirms that air pollution in this area, very well known for high pollution [14], is improved.

In addition, correlation analysis was performed to investigate relationship between PM_{10} and meteorological parameters in different periods. For strong correlation, the value of the correlation coefficients must be near ±0.5, with the statistical significance of ($p \leq 0.05$). The obtained results (Table 2) reveal that the coefficient of correlation is positive and statistically significant, but very low between PM_{10} and AT (atmospheric temperature) and BPR (barometric pressure), and negative between PM_{10} and RH (relative humidity), for both periods.

Table 2 *Correlation between PM_{10} and meteorological factors in different periods*

	AT	RH	BPR
Cold	0.143**	-0.228**	0.095*
Warm	0.234**	-0.158**	0.105*

** p<0.000, *p<0.05

The evaluation of the Pearson correlation coefficient between PM_{10} concentration and meteorological factors such as temperature, humidity and barometric pressure (Table 2) has indicated that PM_{10} is inversely correlated with relative humidity, both for warm and cold periods. Thus, when the humidity increases, the average PM_{10} concentration decreases and vice versa. It has been proven that humidity has different influences on particle size distribution, for small-size particles, the moisture content is usually negatively correlated, as shown by the evidence of the washing effect [15,16].

Atmospheric pressure and particulate matter concentrations were significantly positively correlated, but the correlation coefficient is about 0.1, which is very low. The same situation is regarding the correlation between PM_{10} and AT, which could be unexpected, since the obtained results (Table 1) have shown that the concentration of PM_{10} was higher during the cold period compared to the warm period.

Two important processes, atmospheric dispersion, which removes dust particles from air pollution through the process of dry and wet deposition by rain, and the second, aerosolization diffusion from the surface, which accounts for the air emission of particulate matter from street vehicles, industrial dust, and soil dust, can both explain the very low coefficients of

correlation. These linear connections have made it clear that human activity is the primary source of PM_{10} in the study area [17].

CONCLUSION

In this study, average concentrations of PM_{10} for a four-year period are presented. Data were divided into cold and warm periods in order to analyse their possible seasonal variations. The results have shown that PM_{10} concentrations were slightly higher during cold period. The correlation analysis revealed that PM_{10} have positive correlation with AT and BPR but a negative with RH. However, although statistically significant, the coefficients of correlation are very low.

For future research, it is important to conduct further investigation on the influence of other meteorological factors (wind speed, precipitation) on PM_{10} concentration in order to have more accurate assessments of the major causes of air pollution in this area.

ACKNOWLEDGEMENT

The authors are grateful to the Ministry of Science, Technological development and Innovation of the Republic of Serbia for financial support according to the contract with the registration number 451-03-65/2024-03/200131.

REFERENCES

[1] Seinfeld J.H., Pandis S.N., Atmospheric Chemistry and Physics: From Air Pollution to Climate Change, 2nd ed., John Wiley and Sons, Inc, Hoboken, New Jersey (2006), ISBN: 978-0-471-72018-8.

[2] Duan J., Tan J. Atmos Environ. 74 (2013).

[3] Šerbula S.M., Antonijević M.M., Milosević N.M., *et al.*, J. Hazard. Mater. 181 (1–3) (2010) 43.

[4] Ristić N., Veličković M., Živković Ž., *et al.*, Pol. J. Environ. Stud. 31(4) (2022) 3287–3296.

[5] WHO. WHO global air quality guidelines. Particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide. Geneva: World Health Organization; (2021).

[6] Kermani M., Jafari A.J., Gholami M., *et al.*, Environ. Sci. Pollut. Res. 28 (2021) 16434–16446.

[7] Xu J., Yan F., Xie Y., *et al.*, Particuology 20 (2015) 69–79.

[8] Liu F., Tan Q. W. Jiang X., *et al.*, (2018). Huanjing Kexue, 39(4) (2018) 1466–1472.

[9] Chen T., He J., Lu X., *et al.*, (2016). Int. J. Env. Res. Pu. 13(9) (2016) 921.

[10] Pandey B., Agrawal M., Singh S. Atmos. Pollut. Res. 5 (2014) 79–86.

[11] Yadav, S.K., Jain, M.K. Int. J. Environ. Sci. Technol. 17 (2020) 695–708.

[12] Yadav S.K, Jain M.K, Patel D.K. Monitoring of air pollution in different region along road network, Jharia Coalfield, Dhanbad, India *in* Water Science and Technology Library.

Editor: Singh V., Yadav S., Yadava, R., Springer, Singapore (2018), ISBN: 978-981-10-5792-2.

[13] Patra A.K., Gautam S., Majumdar S. *et al.*, Air Qual Atmos Health 9 (2016) 697–711.

[14] Šerbula S.M., Milosavljević J.S., Kalinović J.V., *et al.*, Sci Total Environ. 777 (2021) 145981.

[15] Kozakova J., Pokorna P., Cernikova A., *et al.*, Aerosol Air. Qual. Res. 17 (2017) 1234–1243.

[16] Dung N., Son D., Hanh, N., *et al.*, Geosci. Environ. Protect. 7 (2019) 138–150.

[17] Giri D., Krishna M.V., Adhikary, P.R., Int. J. Environ. Res. 2 (2008) 49–60.

ISBN 978-86-6305-152-2