8th International Conference

MINING AND ENVIRONMENTAL PROTECTION

22 – 25th September 2021, SERBIA

MINING AND ENVIRONMENTAL PROTECTION

PROCEEDINGS

Editor
Prof. dr Ivica Ristović

Sokobanja
22 – 25th September 2021

FOREWORD

After the consultations with business entities in the field of mining and environmental protection, faculties and scientific institutes, an initiative for organizing a scientific meeting on mining and environmental protection was taken in 1996. The Faculty of Mining and Geology in Belgrade, CENTER FOR ENVIRONMENTAL ENGINEERING, have organized the First Yugoslav Conference with International participants held from 25th to 27th April 1996 in Belgrade, Serbia. 2nd International Symposium was held in Belgrade from 25th to 27th 1998. 3th Symposium was held in Vrdnik from 21st to 23rd May 2001, 4th International Symposium was held in Vrdnik from 23rd to 25th June 2003, 5th International Symposium was held in Vrdnik from 10 to 13 June 2015, 6th International Symposium was held in Vrdnik from 21st to 24th June 2017, and 7th International Symposium was held in Vrdnik from 25th to 28th September 2019.

Due to the large number of subjective and objective reasons organization of the symposium was discontinued in 2003. On the basis of the conclusions made at the 7th Symposium MEP 2019 and great interest of domestic and foreign scientific and professional public, the Faculty of Mining and Geology in Belgrade, in cooperation with co-organizers (National University of Science and Technology "MISIS", Moscow, Russia Berg Faculty TU Košice, Slovakia, University of Ljubljana, Faculty of Natural Sciences and Engineering, Slovenia, Goce Delčev University in Štip, N. Macedonia and University in Banja Luka, Faculty of Mining, Prijedor, Republic of Srpska, Bosnia & Herzegovina, Association of Mining and Geology Engineers), shall organize the 8th International Conference Mining and Environmental Protection – MEP 2021.

Considering the overall work of the conference from 1996 until today, we are proud to celebrate this year the 25 years of work and existence of the International Conference on Mining and Environmental Protection - MEP For all these years, about 700 scientific and professional papers in this field have been published in the Proceedings of the International MEP Conference, and about 1500 participants from the country and abroad have attended the conferences.

Unfortunately, the situation with the Covid 19 pandemic has changed a lot, including the number of participants who will be present at the Symposium. On the other hand, this year a large number of participants from the country and abroad are expected to attend the conference online.

The previous Symposium, were very successful and scientist and companies from many countries gathered to exchange information and research results. The objective of this Conference is to bring together engineers, scientists and managers working in mining industry, research organizations and government organizations, on development and application of best practice in mining industry in the respect of environment protection.

At the Book of Proceedings of 8th International Conference on Mining and Environmental Protection are 38 Papers. Almost half is from abroad, or their authors is from different countries. At least 100 authors and co-authors took part in the preparation of these papers. The papers were reviewed by Reviewers and Scientific Committee. Only high-quality papers were selected, from two side, one from the scientific basis and the second from point of view of applicability in resolving problems at the development of mining.

We are very grateful to the authors of the papers, who contributed to a great extent to the success of this meeting by having sent enough number of high quality papers, and thereby made the work of the reviewers a pleasant one in respect of selecting the best quality papers. Also, we would like to thank all of the participants in the Conference, as well as the sponsors who helped and enabled us to hold such a great meeting.

The Organizing Committee of the Conference made the decision to dedicate this Conference and this Proceedings to prof. dr Milivoje Vulić from the Faculty of Natural Sciences and Engineering, University of Ljubljana, longtime Vice President of the International Conference Mining and Environmental Protection, a great professor and scientist, a good man, who passed away between the last and this Symposium.

Editor

PROCEEDINGS

8th International Conference **MINING AND ENVIRONMENTAL PROTECTION**

***Editor*:** prof. dr Ivica Ristović, Faculty of Mining and Geology, Belgrade

Publisher: University of Belgrade, Faculty of Mining and Geology, Belgrade, Serbia

For publisher: Prof. dr Zoran Gligorić, Dean

Technical desing: M.Sc. Milena Lekić

***Printed by**:* SaTCIP, Vrnjacka Banja, 2021

Copies: 150

ISBN 978-86-7352-372-9

The publication of this Proceedings approved by the Council of Faculty of Mining and Geology, University of Belgrade

All Papers in Proceedings are reviewed.

This Proceedings was published with the financial assistance of the Ministry of Education, Science and Technological Development of Republic of Serbia

ORGANIZER

UNIVERSITY OF BELGRADE, FACULTY OF MINING AND GEOLOGY, Belgrade
CENTER FOR ENVIRONMENTAL ENGINEERING, Mining Department
www.rgf.bg.ac.rs

COORGANIZERS

NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY "MISIS", MOSCOW, RUSSIA
www.en.misis.ru

BERG FACULTY TU KOŠICE, SLOVAKIA
www.fberg.tuke.sk

UNIVERSITY OF LJUBLJANA, FACULTY OF NATURAL SCIENCES AND ENGINEERING, SLOVENIA
www.ntf.uni-lj.si

GOCE DELČEV UNIVERSITY IN ŠTIP, MACEDONIA
www.ugd.edu.mk

UNIVERSITY OF BANJA LUKA, FACULTY OF MINING ENGINEERING, PRIJEDOR, REPUBLIC OF SRPSKA, BOSNIA AND HERZEGOVINA
www.rf.unibl.org

ASSOCIATION OF MINING AND GEOLOGY ENGINEERS

https://sirgs.org.rs

SCIENTIFIC COMMITTEE

Geology, Serbia, dr Predrag Lazić, University of Belgrade, Faculty of Mining and Geology, Serbia, dr Vladimir Milisavljević, University of Belgrade, Faculty of Mining and Geology, Serbia, dr Aleksandar Cvjetić, University of Belgrade, Faculty of Mining and Geology, Serbia, dr Dejan Stevanović, University of Belgrade, Faculty of Mining and Geology, Serbia, dr Marija Ilić, University of Belgrade, Faculty of Mining and Geology, Serbia, dr Suzana Lutovac, University of Belgrade, Faculty of Mining and Geology, Serbia, dr Lidija Beko, University of Belgrade, Faculty of Mining and Geology, Serbia, dr Ivica Ristović, University of Belgrade, Faculty of Mining and Geology, Serbia, dr Slaviša Stanković, University of Belgrade, Faculty of Biology, Serbia, dr Snežana Pašalić, Institute of Nuclear Sciences, Vinca, Belgrade, Serbia, dr Marija Stojmenović, Institute of Nuclear Sciences, Vinca, Belgrade, Serbia, dr Milan Kragović, Institute of Nuclear Sciences, Vinca, Belgrade, Serbia, dr Zoran Nikić, Faculty of Forestry, Belgrade, Serbia, dr Aleksandra Milutinović-Nikolić, ICTM, Belgrade, Serbia, dr Predrag Banković, ICTM, Belgrade, Serbia, dr Gordana Gajić, IBISS, Belgrade, Serbia, dr Gordana Stefanović, University of Niš, Faculty of Mechanical Engineering, Niš, Serbia, dr Nebojša Arsić, Faculty of Technical Sciences, Kosovska Mitrovica, Serbia, Dean, dr Srđan Jović, Faculty of Technical Sciences, Kosovska Mitrovica, Serbia, Vice dean, dr Duško Minić, Faculty of Technical Sciences, Kosovska Mitrovica, Serbia, Vice dean, dr Gordana Milentijević, Faculty of Technical Sciences, Kosovska Mitrovica, Serbia, dr Nataša Elezović, Faculty of Technical Sciences, Kosovska Mitrovica, Serbia.

ORGANIZING COMMITTEE

President of the organising committee:, *dr. Ivica Ristovic, Belgrade, Serbia,* ***Vice presidents of the organising committee:*** *dr Alexander V. Myaskov, Moscow, Russia, dr Gabriel Fedorko, Košice, Slovakia, dr Goran Vižintin, Ljubljana, Slovenia, dr Robert Šajn, Ljubljana, Slovenia, dr Zoran Despodov, Štip, Republic of Macedonia, dr Vladimir Malbašić, Prijedor, RS, Bosnia and Herzegovina, dr Tomislav Šubaranović, Belgrade, Serbia,* ***Organizing committee****:, dr Nikoleta Husakova, Košice, Slovakia, dr Jozef Cambal, Slovakia, dr Jan Feher, Slovakia, dr Olga O. Sheshko, Moscow, Russia, dr Drago Potočnik, Ljubljana, Slovenia, dr Aleksandra Trenčovska, Ljubljana, Slovenia, dr Jiri Fries, Ostrava, Czech Republic, dr Zoran Despodov, Štip, Republic of Macedonia, dr Dejan Mirakovski, Štip, Republic of Macedonia, dr Nataša Elezović, Kosovska Mitrovica, Serbia, dr Vladimir Milisavljević, Belgrade, Serbia, dr Aleksandar Cvjetić, Belgrade, Serbia, dr Suzana Lutovac, Belgrade, Serbia, dr Dragana Nišić, Belgrade, Serbia, MSc Milena Lekić, Belgrade, Serbia, MSc Andrijana Nedeljković, Belgrade, Serbia, MSc Uroš Pantelić, Belgrade, Serbia, MSc Luka Crnogorac, Belgrade, Serbia, MSc Emilija Širadović, Belgrade, Serbia, BSc Nadežda Petrović, Lazarevac, Serbia, BSc Nina Milojević, Belgrade, Serbia, Isidora Vulić, Faculty of Criminal Justice and Security, Maribor, Slovenia.*

C O N T E N T S:

8th International Conference
MINING AND ENVIRONMENTAL PROTECTION
22 – 25th September 2021, Serbia

COPPER REMOVAL BY PELLETIZED FLY ASH

Sonja Milićević[1], Sanja Martinović[2], Milica Vlahović[2], Vladimir Jovanović[1], Sanja Šešlija[2], Aleksandar Savić[3], Milan Kragović[4]

[1] Institute for technology of nuclear and other mineral raw materials, SERBIA, s.milicevic@itnms.ac.rs
[2] University of Belgrade, Institute of Chemistry, Technology and Metallurgy, SERBIA
[3] University of Belgrade, Faculty of Civil Engineering, SERBIA
[4] University of Belgrade, Institute of Nuclear Sciences, Vinča, SERBIA

Abstract: *The increasing levels of industrial wastewater that are released to the environment present a serious threat to human health, living resources, and ecological systems. Fly ash was tested for removal of Cu2+ from contaminated water in in a micronized and pelletized form. Experiments were performed for wide range of initial concentration of Cu 25-600 mg dm-3. Pellets fraction size was 2.0-3.5 mm, while the content of cement, as a binder was 10%. Under applied experimental conditions pellets manifested exceptional adsorption capacity (25.64 mg/g) that was three times higher compared to the micronized fly ash (8.85 mg/g).*

Keywords: *adsorption, copper, fly ash, pelletization*

1. INTRODUCTION

Within the last few decades, world population growth more rapidly than ever before and severe industrial expansion resulted in serious environmental problems. Water, air, and soil contamination present not only the threat to the plant and animal life but also highly influence the quality of human life. Thus, the sustainability of all ecosystems and life on the Earth is seriously threatened. Anthropogenic sources of all kind of contamination are introduced into the environment through intensive industrial development.

Recent investigations are focused on possibility of waste utilization as potential adsorbents in wastewater treatments. Industrial by-products and wastes are almost zero-cost materials and at the same time their utilization could contribute to the solution of their management problem improving the material efficiency within the several industrial activities.

Fly ash has potential application in wastewater treatment because of its major chemical components (alumina, silica, ferric oxide, calcium oxide, magnesium oxide and carbon), and its physical properties such as porosity, particle size distribution and surface area. Besides, the alkaline nature of fly ash makes it a good neutralizing agent [1, 2]. Namely, fly ash as a potential hazardous solid waste produced like a by-product in power plants worldwide in million tons has attracted researches interest for years. Fly ash material solidifies while suspended in the exhaust gases and is collected by electrostatic precipitators or filter bags. Since the particles solidify rapidly while suspended in the exhaust gases, fly ash particles are generally spherical in shape and range in size from 0.5 µm to 300 µm. Therefore, the hydraulic properties of fly ash are the one that present major obstacle for its application in wastewater treatments.

The problem of micronized fly ash particles that are not useful in wastewater treatments can be overcome through the agglomeration process such as pelletization. Pelletization is a form of tumble growth agglomeration, whereby material fines are “grown” through a tumbling motion and the addition of water or a binding agent [3]. This process is a non-pressure method of agglomeration that allows production of new materials and use of waste resources with significant environmental and economic impact.

This paper is focused on usage of pelletized fly ash as a new adsorption material that is more suitable for the application in the wastewater treatments than the parenting one (micronized fly ash).

2. EXPERIMENTAL

Fly ash originates from power plant Nikola Tesla (Tent B). The chemical composition was determined by atomic absorption spectrophotometry (AAS) using the Perkin Elmer PinAAcle 900T and is presented in Table 1.

Table 1 *Chemical composition of the fly ash*

Content (%)							
SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	TiO_2
47.80	30.53	5.47	8.69	2.29	1.49	0.25	1.02
Cd	Pb	Zn	Cu	Cr	Ni	Mn	IL*
0.005	0.04	0.021	0.005	0.022	0.03	0.045	1.45

IL* Ignition lost

Chemical composition places the investigated fly ash to the class F that is characterized with pozzolanic properties.

The mineralogical composition of fly ash was primarily quartz with small amounts of mullite and plagioclase as determined by X-ray powder diffraction analysis (Philips, PW-1710).

Particle size distribution (Figure 1), determined using laser diffraction method (Helos (H1597) & Sucell R4, Sympatec GmbH) show the major size fraction mass content (60 %) of the class below 100 µm.

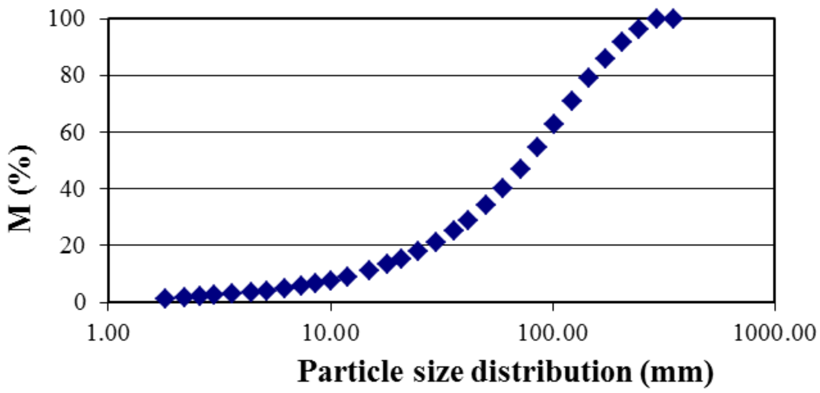

Figure 1 *Particle size distribution of the fly ash*

Fly ash pelletizing was conducted on ’’Ünal’’ disc pelletizer with vibratory feeder, (plate diameter 40 cm, edge height 10 cm, plate inclination angle of 50°, rotary speed 15 rpm). The detailed procedure is reported previously [4]. Obtained pellets have to meet certain quality standards which provide stability during transport, handling and storage and resistance to disintegration in water, thus ensuring its adsorbents properties suitable for column system. This mean that pellet mechanical properties must satisfied defined values and tests for pellet mechanical properties include; impact resistance, compressive strength, abrasion resistance and the time required for the pellet to disintegrate in water [5]. The results pointed out the pellets with addition of 10 % cement as the best one from the mechanical properties point of view.

The additional dose of the plasticizer (Cementol Hiperplast 463), up to 3 % in relation to the amount of the cement, additionally improves the mechanical properties, especially impact resistance. Under the investigated pelletizing conditions, more than 80 % of the obtained pellets are suitable for the application in continuous systems, from the particle size distribution point of view [4].

The examination of copper uptake was carried out by shaking (in Heidolph shaker Unimax 1010) 1g of pelletized fly ash with 100 mL of aqueous solution of CuSO4•5H2O p.a. ("Lach:ner") containing various initial copper concentrations 25 – 600 mg dm-3). Experiments were performed at room temperature using the batch technique for 24 h. After equilibration all suspensions were centrifuged at 10000 rpm for 10 min and the concentration of remaining copper was determined in supernatants by atomic absorption spectrophotometry using the Perkin Elmer PinAAcle 900T instrument.

3. RESULTS

Copper adsorption by micronized (P) and pelletized fly ash (P_{10} and P_{10P}) was examined by using extent range of Cu initial concentration (Figure 2). Index 10 in subscript indicates the presences of 10% of cement as a binder in a pellets and the index 10P in subscript point to presence of 10% of cement and the plasticizer. The pellets fraction size used in experiments was 2.0-3.5 mm.

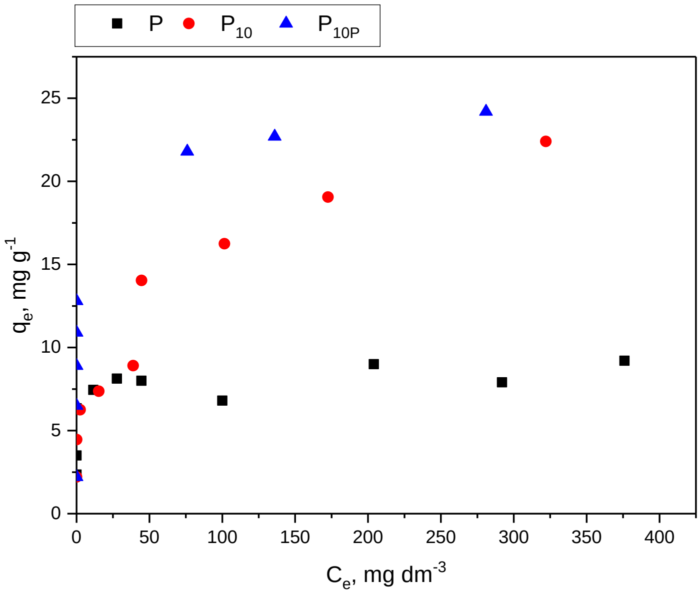

Figure 2 *Sorption isotherms of copper uptake on micronized and pelletized fly ash*

Based on the achieved results, it is noticed that the obtained fly ash pellets efficiently adsorb copper ions. The adsorption isotherms for fly ash and pellets show an increase in the adsorbed amount of Cu^{2+} ions with increasing initial concentration, they are similar in shape, and the only difference is in the maximum adsorption capacity. The maximum value of the adsorption capacity decreases in the range P_{10P}> P_{10}> P. This indicates that the presence of cement has a positive effect on the adsorption capacity. Namely, it was noticed that the pH value of solutions in which fly ash pellets are used as adsorbents (5.5 - 6.3), is higher in relation to the value in solutions where only fly ash is used (4.5 - 5.2). The increased pH value of the solution is a consequence of the hydration of the present cement and has a positive effect on the adsorption process. Adsorption by fly ash takes place by the mechanism of binding of heavy metal ions to the functional groups present in the fly ash. Most likely, a slightly elevated pH value favors the protonation of functional groups, in a way that increases the possibility of adsorption of divalent cations on their surface.

The experimental data from the equilibrium studies were analyzed using Langmuir sorption model. This model showed exceptional agreement with the experimental data.

The linear form of the adsorption isotherm for the copper removal by micronized and pelletized fly ash, obtained using the Langmuir model, is given in Figure 3.

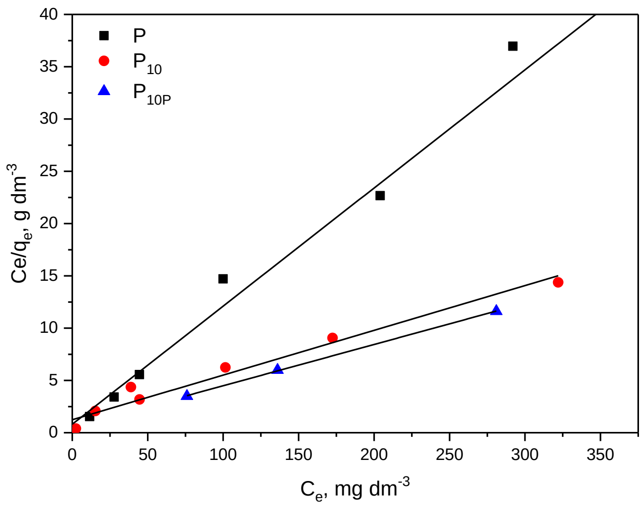

Figure 3 *Linear form of the Langmuir adsorption model*

The sorption capacity q_m, which is a measure of the maximum sorption capacity corresponding to complete monolayer coverage, showed that a mass capacity for the Cu^{2+} uptake by P_{10P} pellets is three times higher than the micronized fly ash (P) and that value is correctly 25.64 mg Cu^{2+} per gram of adsorbent (Table 2).

3. CONCLUSION

The obtained pellets were used in batch systems as an adsorbent for heavy metal ions, i.e. copper ions. The achieved results are above expectations. Pellets have three times higher adsorption capacity (25.64 mg/g) compared to the micronized fly ash (8.85 mg/g). Following the pH value of the solution, the presence of cement increases this value and this increase has positive effects on the binding of copper ions to the functional groups of ash. This means that the mobility of hydrated copper ions from the solution to the available sites inside and on the surface of the fly ash particles and pellets depends on the initial concentration but it is also highly influenced by the presence of cement.

Acknowledgment: This research has been part of the investigations on the bilateral project N° 40808RM (project registration number: 451-03-01963/2017-09/08) between the France and Serbia (Pavle Savic program). It has been financed by the Ministry of Education, Science, and Technological Development of Republic of Serbia Part of the investigations were financially supported through the ‘’Green fond’’ financed by the Ministry of Environmental Protection of Republic of Serbia. The authors would like to express their gratitude for this support.

REFERENCES

1. Milićević, S., Boljanac, T., Martinović, S., Vlahović, M., Milošević, V., Babić, B., (2012), Removal of copper from aqueous solutions by low cost adsorbent-Kolubara lignite, Fuel Proc. Techn. 95 1-7.
2. Papandreou, A., Stournars, C. J., Panias, D., (2007), Copper and cadmium adsorption on pellets made from fired coal fly ash, J. Hazard. Mater. 148 (3), 538-547.
3. Mehos, G., Kozicki, C.M., (2017) Choosing agglomeration equipment, Chemical Engineering, 124 (10), 51-57.
4. Milićević S., Martinović S., Jovanović V., Vlahović M., Kanari N., Popović A., Kojić M., Development and mechanical properties of the pelletized fly ash, XIII IMPRC, 08-10 May 2019, Belgrade, Serbia, 38-44.
5. Albert, K.B., Langford, D., (1998) Pelletizing limestone fines, Mars Mineral, Mars, PA, 12–29.