



University of Belgrade
Technical Faculty in Bor,
Mining and Metallurgy
Institute Bor

**54th International
October Conference
on Mining and Metallurgy**

PROCEEDINGS

Editors:

Ljubiša Balanović

Dejan Tanikić



18-21 October 2023, Bor Lake, Serbia

**PROCEEDINGS,
54th INTERNATIONAL OCTOBER CONFERENCE
on Mining and Metallurgy**

Editors:

Prof. dr Ljubiša Balanović

Prof. dr Dejan Tanikić

University of Belgrade, Technical Faculty in Bor

Technical Editor:

M. Sc. Miljan Marković

University of Belgrade, Technical Faculty in Bor

Publisher: University of Belgrade, Technical Faculty in Bor

For the publisher: Dean Prof. dr Dejan Tanikić

Circulation: 200 copies

CIP - Каталогизacija у публикацији Народна библиотека Србије, Београд

622(082)(0.034.2)

669(082)(0.034.2)

INTERNATIONAL October Conference on Mining and Metallurgy (54 ; 2023
; Borsko jezero)

Proceedings [Elektronski izvor] / 54th International October Conference on Mining
and Metallurgy - IOC 2023, 18-21 October 2023, Bor Lake, Serbia ; [organized by]
University of Belgrade, Technical Faculty in Bor and Mining and Metallurgy Institute
Bor ; editors Ljubiša Balanović, Dejan Tanikić. - Bor : University of Belgrade,
Technical Faculty, 2023 (Niš : Grafika Galeb). - 1 USB fleš memorija ; 1 x 1 x 5 cm

Sistemska zahtevi: Nisu navedeni. - Nasl. sa naslovne strane dokumenta. - Tiraž 200. -
Preface / Ljubiša Balanović. - Bibliografija uz svaki rad.

ISBN 978-86-6305-140-9

a) Рударство -- Зборници b) Металургија -- Зборници

COBISS.SR-ID 126659849

Bor Lake, Serbia, October 18-21, 2023



Conference is financially supported by
The Ministry of Science, Technological
Development and Innovation
of the Republic of Serbia

Platinum Donors



Gold Donors



Silver Donor



Exhibitions



REFRATEC

Friends of the Conference



LOLA INSTITUT

THE FOUNDATION 'B.SC. ENG. BOŠKO INJAC'

SCIENTIFIC COMMITTEE

Prof. Dr Dejan Tanikić (Serbia) - president
Prof. Dr Nada Štrbac (Serbia) - vice-president
Prof. Dr Radoje Pantović (Serbia) - vice-president

Dr Ana Kostov (Serbia)
Prof. Dr Adam Grajcar (Poland)
Prof. Dr Adina Negrea (Romania)
Dr Andrei Rotaru (Romania)
Prof. Dr Batrić Pešić (USA)
Dr Biserka Trumić (Serbia)
Prof. Dr Boštjan Markoli (Slovenia)
Dr Branislav Marković (Serbia)
Prof. Dr Cornelia Muntean (Romania)
Prof. Dr Daniela Grigorova (Bulgaria)
Prof. Dr Dejan Ivezić (Serbia)
Prof. Dr Desimir Marković (Serbia)
Prof. Dr Dimitris Pnias (Greece)
Prof. Dr Dimitriu Sorin (Romania)
Prof. Dr Dmitry Vasilyev (Russia)
Dr Dragan Komljenović (Canada)
Prof. Dr Dragan Manasijević (Serbia)
Dr Dragan Milanović (Serbia)
Prof. Dr Dragan Milovanović (Serbia)
Prof. Dr Dragoslav Gusković (Serbia)
Prof. Dr Dušan Orać (Slovakia)
Prof. Dr Duško Minić (Serbia)
Prof. Dr Endre Romhanji (Serbia)
Prof. Dr Essen Suleimenov (Kazakhstan)
Prof. Dr Farzet Bikić (Bosnia and Herzegovina)
Prof. Emeritus Fathi Habashi (Canada)
Prof. Dr Grozdanka Bogdanović (Serbia)
Prof. Dr György Kaptay (Hungary)
Prof. Dr Ivan Mihajlović (Serbia)
Prof. Dr Iveta Vaskova (Slovakia)
Prof. Dr Jakob Lamut (Slovenia)
Prof. Dr Jasmin Suljagić (Bosnia and Herzegovina)
Dr Jasmina Stevanović (Serbia)
Dr Jasna Stajić Trošić (Serbia)
Prof. Dr Jovica Sokolović (Serbia)
Prof. Dr Jožef Medved (Slovenia)
Prof. Dr Kaikun Wang (China)
Prof. Dr Karl Heinz Spitzer (Germany)
Prof. Emeritus Karlo Raić (Serbia)
Prof. Dr Kemal Delijić (Montenegro)
Prof. Dr Komnitsas Konstantinos (Greece)
Prof. Dr Kostas Matis (Greece)
Prof. Dr Krzysztof Fitzner (Poland)
Prof. Dr Luis Filipe Malheiros (Portugal)
Prof. Dr Milan Antonijević (Serbia)
Prof. Dr Milan Trumić (Serbia)
Dr Mile Bugarin (Serbia)

Dr Milenko Ljubojev (Serbia)
Prof. Dr Milovan Vuković (Serbia)
Prof. Dr Mira Cocić (Serbia)
Mirjam Jan-Blažič (Slovenia)
Prof. Dr Mirjana Rajčić Vujasinović (Serbia)
Prof. Dr Mirko Gojić (Croatia)
Dr Miroslav Sokić (Serbia)
Prof. Dr Mirsada Oruč (Bosnia and Herzegovina)
Dr Nadežda Talijan (Serbia)
Prof. Dr Natalija Dolić (Croatia)
Prof. Dr Nedeljko Magdalinović (Serbia)
Prof. Dr Nenad Radović (Serbia)
Prof. Dr Nenad Vušović (Serbia)
Prof. Dr Nicanor Cimpoesu (Romania)
Prof. Dr Nobuyuki Masuda (Japan)
Prof. Dr Onuralp Yucel (Turkey)
Prof. Dr Pavel Broz (Czech Republic)
Prof. Dr Petr Solozhenkin (Russia)
Prof. Dr Petrica Vizureanu (Romania)
Dr Sun Zhongmei (China)
Prof. Dr Ridvan Yamanoglu (Turkey)
Prof. Dr Rodoljub Stanojlović (Serbia)
Prof. Dr Rositsa Paunova (Bulgaria)
Prof. Dr Sead Čatić (Bosnia and Herzegovina)
Prof. Dr Sergey Krasikov (Russia)
Dr Slavomír Hredzák (Slovakia)
Prof. Dr Snežana Milić (Serbia)
Prof. Dr Snežana Šerbula (Serbia)
Prof. Dr Srba Mladenović (Serbia)
Dr Srećko Stopić (Germany)
Prof. Dr Stojan Groudev (Bulgaria)
Prof. Dr Sulejman Muhamedagić (Bosnia and Herzegovina)
Prof. Dr Svetlana Ivanov (Serbia)
Prof. Dr Tatjana Volkov-Husović (Serbia)
Prof. Dr Tomáš Havlik (Slovakia)
Prof. Dr Velimir Radmilović (Serbia)
Prof. Dr Velizar Stanković (Serbia)
Prof. Dr Vesna Grekulović (Serbia)
Dr Vladan Čosović (Serbia)
Vladan Mihailović (Serbia)
Dr Vladan Kašić (Serbia)
Prof. Dr Vladimir Krstić (Canada)
Prof. Dr Vladislav Kecojević (USA)
Dr Walter Valery (Australia)
Prof. Dr Xuewei Lv (China)
Prof. Dr Yong Du (China)
Prof. Dr Žarko Radović (Montenegro)
Prof. Dr Zdenka Zovko Brodarac (Croatia)
Dr Zoran Stevanović (Serbia)
Prof. Dr Željko Kamberović (Serbia)

ORGANIZING COMMITTEE

Prof. dr Ljubiša Balanović, Full Professor (UB TF Bor) - president
Prof. dr Saša Stojadinović, Full Professor (UB TF Bor) - vice-president
Prof. dr Srba Mladenović, Full Professor (UB TF Bor) - vice-president
Dr Ana Kostov, Principal Research Fellow (MMI Bor) - vice-president

Prof. dr Nada Štrbac, Full Professor (UB TF Bor)
Prof. dr Dragan Manasijević, Full Professor (UB TF Bor)
Prof. dr Vesna Grekulović, Full Professor (UB TF Bor)
Prof. dr Đorđe Nikolić, Full Professor (UB TF Bor)
Prof. dr Milan Radovanović, Full Professor (UB TF Bor)
Prof. dr Marija Petrović Mihajlović, Full Professor (UB TF Bor)
Prof. dr Zoran Štirbanović, Associate Professor (UB TF Bor)
Prof. dr Milan Gorgievski, Associate Professor (UB TF Bor)
Prof. dr Saša Marjanović, Associate Professor (UB TF Bor)
Prof. dr Ivana Marković, Associate Professor (UB TF Bor)
Prof. dr Žaklina Tasić, Associate Professor (UB TF Bor)
Doc. dr Dejan Petrović, Assistant Professor (UB TF Bor)
Doc. dr Anđelka Stojanović, Assistant Professor (UB TF Bor)
Doc. dr Uroš Stamenković, Assistant Professor (UB TF Bor)
Dr Jasmina Petrović, Assistant with PhD (UB TF Bor)
Vladimir Nikolić, Assistant (UB TF Bor)
Milica Zdravković, Assistant (UB TF Bor)
Miljan Marković, Assistant (UB TF Bor)
Milijana Mitrović, Assistant (UB TF Bor)
Milan Nedeljković, Assistant (UB TF Bor)
Avram Kovačević, Teaching Assistant (UB TF Bor)
Sandra Vasković, English Lecturer (UB TF Bor)
Oliver Marković, IT service (UB TF Bor)
Violeta Aleksić, Liquidator (UB TF Bor)

TABLE OF CONTENTS

Plenary Lectures

Velimir R. Radmilović (SERBIA)

Energy: One of the biggest challenges in 21st century 3-3

Jing Yu, Mingshui Luo, Junyi Xiang, Yang You, Zhixiong You, Xuewei Ly (CHINA)

Efficient extraction of vanadium from vanadium slag 4-8

Invited Lectures

Batrić Pešić (UNITED STATES)

The ongoing restructuring of universities to adopt the sophistication offered by internet 11-19

Yaima Filiberto, Alberto Montenegro, Eugenio Alvarez (SPAIN)

Machine learning applied to improving the scrap recycling and melting process in all types of ferrous alloys and steel 20-22

Slobodan Kostić, Qi Fenglai, Savo Pirgić, Nenad Botić, Dobrica Milovanović, Čedomir Sušić, Igor Zlatković (SERBIA)

Construction of a new sintering plant 180 m² within the HBIS Group Serbia Iron & Steel 23-26

Satyananda Patra (INDIA)

Acid activation of bentonite: Physico-Chemical characterization and application in goethitic iron ore green pelletization 27-35

Ridvan Yamanoglu (TURKEY)

Production of metal-based powders by atomization techniques 36-45

Yong Du, Rainer Schmid-Fetzer, Jincheng Wang, Shuhong Liu, Jianchuan Wang, Qiang Lu, Yuhui Zhang, Kai Li (CHINA, GERMANY)

Computational design of engineering materials: case studies for a cemented carbide and a heat resistant Al alloy 46-46

Conference Papers

Ordinartsev Denis, Nadezhda Pechischeva, Svetlana Estemirova, Andrey Rempel (RUSSIA)

Cr(VI) photosorption on composite sorbent of montmorillonite with amorphous TiO₂ 49-52

Mikhail Korovkin, Ludmila Ananyeva, Andrey Zherlitsyn, Sergey Kondratyev, Olesya Savinova (RUSSIA)

Electro-pulse crushing in high-purity quartz production 53-55

Žarko Radović, Nebojša Tadić (MONTENEGRO)

Analytical simulation of EAF dust enrichment 56-59

<u>Nebojša Tadić, Žarko Radović</u> (MONTENEGRO) <i>Thermal and mechanical relaxation of residual stresses in cold rolled aluminium alloy strips</i>	60-63
Dragan Šabaz, Miloš Stojanović, Dejan Petrović (SERBIA) <i>Selection of anchor type using AHP method</i>	64-67
<u>Miloš Stojanović, Veljko Lapčević, Ivica Vojinović</u> (SERBIA) <i>Blast fragmentation analysis in Jama Bor by using WipFrag software</i>	68-71
<u>Veljko Lapčević, Toma Jovičić, Slavko Torbica</u> (SERBIA) <i>Mine ventilation model validation by PQ survey</i>	72-75
<u>Jelena Đorđević, Jelena Stefanović, Sandra Guševac, Ivan Jelić, Stefan Trujić</u> (SERBIA) <i>Life cycle analysis (LCA) of asphalt layers containing recycled asphalt pavement</i>	76-79
<u>Jelena Ivaz, Dejan Petrović, Predrag Stolić, Mladen Radovanović, Dragan Zlatanović, Saša Stojadinović, Pavle Stojković</u> (SERBIA) <i>Occupational injuries in underground coal mining: statistical analysis of data</i>	80-83
<u>Jelena Ivaz, Dejan Petrović, Mladen Radovanović, Dragan Zlatanović, Saša Stojadinović, Pavle Stojković</u> (SERBIA) <i>Prediction of methane emissions in coalmine - Soko</i>	84-87
<u>C. Prochaska, E. Kokkinos, D. Merachtsaki, A. Lampou, E. Peleka, K. Simeonidis, G. Vourlias, A. Zouboulis</u> (GREECE) <i>Recovery of metallic fractions from medical products labelled for single use</i>	88-91
<u>Nataša Sarap, Marija Janković, Vojislav Stanić, Ivana Jelić, Marija Šljivić-Ivanović</u> (SERBIA) <i>Analysis of gross alpha and gross beta activity in samples around former uranium mine Gabrovnica</i>	92-95
<u>Dragan Manasijević, Ljubiša Balanović, Ivana Marković, Uroš Stamenković</u> (SERBIA) <i>Latent heat of some aluminium based phase change alloys for thermal energy storage</i>	96-99
<u>Anđelka Stojanović, Ivica Nikolić, Isidora Milošević</u> (SERBIA) <i>Position of European countries in sustainable resource management</i>	100-103
<u>Aleksandar Đorđević, Duško Minić, Milena Zečević, Dragan Manasijević</u> (SERBIA) <i>Mechanical and electrical properties of the ternary Ag-Ge-Sn alloys</i>	104-107
<u>Milena Zečević, Duško Minić, Aleksandar Đorđević, Dragan Manasijević</u> (SERBIA) <i>Effect of chemical composition on the corrosion resistance of the ternary Ag-Ge-Sn alloys</i>	108-111
<u>Tatiana Aleksandrova, Nadezhda Nikolaeva</u> (RUSSIA) <i>Extraction of low-dimensional structures of nonferrous and noble metals from refractory raw materials</i>	112-115
<u>Viša Tasić, Tatjana Apostolovski-Trujić, Bojan Radović, Nevena Ristić, Tamara Urošević, Vladan Kamenović, Zvonko Damjanović</u> (SERBIA) <i>Air quality measurements in the Bor city during the reconstruction of the copper smelter Bor in 2022</i>	116-119

<u>Slavica Miletić, Biserka Trumić, Suzana Stanković</u> (SERBIA) <i>Application of control charts in the laboratory for testing the metallic materials</i>	120-123
<u>Alexey M. Amdur, Sergei A. Fedorov, Andrey A. Forshev, Nikolay V. Grevtsev, Vera V. Yurak</u> (RUSSIA) <i>Technological aspects of the use of peat as a component of pulverated coal fuel for blast furnaces</i>	124-127
<u>Ljiljana Avramović, Zoran Stevanović, Vanja Trifunović, Radmila Marković, Dragana Božić, Daniela Urošević, Silvana Dimitrijević</u> (SERBIA) <i>Hydrometallurgical treatment of mining waste from Bor - Serbia in aim of copper recovery</i>	128-131
<u>Daniel Kržanović, Radmilo Rajković, Ivana Jovanović, Milenko Jovanović, Miomir Mikić</u> (SERBIA) <i>Determination the final contour of the open pit Veliki Krivelj for the mining capacity 23.1 million tons of ore</i>	132-135
<u>Vladan Marinković, Miroslava Maksimović, Milenko Jovanović, Goran Pačkovski</u> (SERBIA) <i>The use of unmanned aerial vehicles for making the precise 3D topo models and orthophoto images</i>	136-140
<u>Dejan Tanikić, Anđela Stojić, Jelena Đoković, Miloš Stoljiljković</u> (SERBIA) <i>Mechanical characteristics of the shape memory alloy Cu-Zn-Al</i>	141-144
<u>Ljiljana Avramović, Vanja Trifunović, Zoran Stevanović, Radmila Marković, Dragana Božić, Dejan Bugarin, Silvana Dimitrijević</u> (SERBIA) <i>Copper recovery from RE-flotation tailings by combined process</i>	145-148
<u>Milenko Jovanović, Daniel Kržanović, Radmilo Rajković, Vladan Marinković, Miroslava Maksimović, Miomir Mikić</u> (SERBIA) <i>Application of hybrid geogrids in mining</i>	149-153
<u>Stefan Trujić, Miroslava Maksimović, Vladan Marinković, Ljiljana Avramović, Vanja Trifunović, Dragana Božić</u> (SERBIA) <i>Geological exploration of the technogenic deposit - old flotation tailing pit - Bor with the possibility of leaching</i>	154-157
<u>Zoran Stevanović, Radmila Marković, Ljiljana Avramović, Vojka Gardić, Jelena Petrović, Dragana Božić</u> (SERBIA) <i>Sustainable and smart mining</i>	158-161
<u>Snežana Ignjatović, Ivana Vasiljević, Branisav Sretković, Milanka Negovanović</u> (SERBIA) <i>Using gravity data to define structural correlation affecting the formation of Neogene basins</i>	162-165
<u>Deniz Eylül Akpınar, Batuhan Turgut, Ugur Gurol, Savas Dilibal</u> (TURKEY) <i>Characterization of wire arc additively manufactured wear-resistant bimetallic component</i>	166-169
<u>Mistreanu Sebastian, Ramona Cimpoesu, Dragoş Achiţei, Mihai Popa, Daniela Lucia Chicet, Vasile Manole, Ana-Maria Scripcariu, Nicanor Cimpoesu</u> (ROMANIA) <i>Sandblasting process influence on stainless steel cutting element properties</i>	170-174

<u>Dorđe Petrović, Katarina Stanković, Latinka Slavković Beškoski, Ksenija Kumrić</u> (SERBIA) <i>Removal of Cu(II) from aqueous solutions using adsorbent based on chitosan hydrogel beads</i>	175-178
Jovan P. Šetrajčić, Siniša M. Vučenović (BOSNIA AND HERZEGOVINA) <i>Modified basic properties of electrons in layered nanocrystals with a complex lattice</i>	179-182
Irena Nikolić, Milena Tadić, Dijana Đurović, Nevena Cupara, Ivana Milašević (MONTENEGRO) <i>Kinetic and thermodynamic aspects of strontium adsorption by steelmaking slag</i>	183-186
Miomir Mikić, Milenko Jovanović, Sandra Milutinović, Daniel Kržanović, Radmilo Rajković (SERBIA) <i>New flotation plant Veliki Krivelj monitoring plan</i>	187-190
Miomir Mikić, Radmilo Rajković, Daniel Kržanović, Sandra Milutinović (SERBIA) <i>Recultivation of open pit Veliki Krivelj</i>	191-194
Farzet Bikić, Khaola Awad, Halim Prčanović, Mirnes Duraković (BOSNIA AND HERZEGOVINA) <i>Analysis of influenced factors on tropospheric ozone content in the city of Zenica during 2020</i>	195-198
Sandra Milutinović, Ljubiša Obradović, Daniel Kržanović, Miomir Mikić, Radmilo Rajković (SERBIA) <i>Flotation tail storage methods</i>	199-202
Sandra Milutinović, Milena Kostović, Ljubiša Obradović, Srđana Magdalinović, Sanja Petrović (SERBIA) <i>Methods of transportation and discharge of tails to flotation tailings pond</i>	203-206
Uğur Gürol, Ceren Çelik, Müesser Göçmen, Mustafa Koçak (TURKEY) <i>Microstructural and mechanical characterization of armor steel joint welded with sandwich design</i>	207-210
Branka Pešovski, Milan Radovanović, Vesna Krstić, Danijela Simonović, Silvana Dimitrijević (SERBIA) <i>Electrochemical characteristics of the anodized titanium oxide films in sulfuric acid</i>	211-215
Duško Đukanović, Nemanja Đokić, Zoran Aksentijević, Daniel Radivojević, Branisl Stakić (SERBIA) <i>Methane as an untapped energy potential of the "Soko" brown coal mine</i>	216-220
Žaklina Tasić, Marija Petrović Mihajlović, Ana Simonović, Milan Radovanović, Maja Nujkić, Milan Antonijević (SERBIA) <i>Electrochemical methods for the determination of tryptophan and caffeine</i>	221-224
Isidora Milošević, Anđelka Stojanović, Sanela Arsić, Ivica Nikolić, Ana Rakić (SERBIA) <i>Circular economy in the era of Industry 5.0</i>	225-228

<u>Almaida Gigović-Gekić, Elvis Agović, Belma Fakić, Hasan Avdušinović</u> (BOSNIA AND HERZEGOVINA) <i>Effect of delta ferrite on microstructure and hardness welded joints of steel S21800</i>	229-232
<u>Radmila Marković, Dragana Bozić, Zoran Stevanović, Tatjana Apostolovski Trujić, Vojka Gardić, Ljiljana Avramović, Vesna Marjanović</u> (SERBIA) <i>Combining neutralization and adsorption methods for metals removal from Saraka stream</i>	233-236
<u>Ana Petrović, Radmila Marković, Emina Požega</u> (SERBIA) <i>CNTs as potential material for wastewater purification: a review</i>	237-240
<u>Zdenka Stanojević Šimšić, Ana Kostov, Aleksandra Milosavljević, Slavica Miletić</u> (SERBIA) <i>Experimental investigations of cunalag alloys with 70 at%Cu</i>	241-244
<u>Ana Kostov, Aleksandra Milosavljević, Zdenka Stanojević Šimšić, Ivan Jovanović</u> (SERBIA) <i>Determination of melt properties in Cu-Fe alloys</i>	245-248
<u>Vladimir Nikolić, Milan Trumić</u> (SERBIA) <i>A simple method of determining of bond work index for finer samples</i>	249-252
<u>Ivan Jovanović, Novica Staletović</u> (SERBIA) <i>Management of risk assessment in environmental protection in surface copper mine</i>	253-256
<u>Jovan P. Šetrajić, Stevo K. Jaćimovski, Siniša M. Vučenović</u> (BOSNIA AND HERZEGOVINA) <i>Possibility of localized electron states appearance in ultrathin layered crystalline structures</i>	257-260
<u>Jovica Sokolović, Ivana Ilić, Dragiša Stanujkić, Zoran Štirbanović</u> (SERBIA) <i>Application of VIKOR method for comparison of the washability of coals</i>	261-264
<u>Vladimir Jovanović, Dejan Todorović, Branislav Ivošević, Dragan Radulović, Sonja Milićević, Marija Ercegović, Slavica Mihajlović</u> (SERBIA) <i>The process of obtaining biochar and the development of the products thus obtained</i>	265-269
<u>Jelena Petrović, Marija Ercegović, Marija Simić, Marija Koprivica, Jelena Dimitrijević, Marija Marković</u> (SERBIA) <i>Mg/Fe-modified hydrochar with promoted adsorption performances</i>	270-273
<u>Esra Dokumaci Alkan, Nurdan Ari, Murat Alkan</u> (TURKEY) <i>A coating application of IN718 via self-propagating high-temperature synthesis method</i>	274-277
<u>Murat Alkan, Esra Dokumaci Alkan, Dilan Ugurluer, Aslihan Karakanat</u> (TURKEY) <i>Production of AlCoCrCuXFeNi alloys via self-propagating high-temperature synthesis method</i>	278-281
<u>Jarmila Trpčevská, Iveta Vasková, Katarína Pauerová, Martina Laubertová, Dušan Oráč</u> (SLOVAKIA) <i>Zinc volatilization in the primary and the secondary zinc production</i>	282-286

<u>Dragan Ignjatović, Lidija Đurđevac Ignjatović, Vanja Đurđevac, Katarina Milivojević, Ivan Jovanović (SERBIA)</u> <i>Application of the numerical method in the definition of a substrate of circular cross section</i>	287-291
<u>Dragan Ignjatović, Lidija Đurđevac Ignjatović, Vanja Đurđevac, Mladen Supić, Dušan Tašić (SERBIA)</u> <i>Influence of the subsoil bearing capacity during formation of high landfills</i>	292-296
<u>Bojana Živković, Jelisaveta Marjanović, Jelena Đokić, Maja Petrović (SERBIA)</u> <i>Soil and rock properties as a basis for the sanitary landfill settings</i>	297-300
<u>Milan Gorgievski, Miljan Marković, Nada Štrbac, Vesna Grekulović, Kristina Božinović, Milica Zdravković, Marina Marković (SERBIA)</u> <i>Adsorption kinetics for copper ions adsorption onto onion peels</i>	301-304
<u>Saba Nourozi, Fatemeh Pourasgharian, Ahmad Khodadadi Darban (IRAN)</u> <i>Recovery of copper from low-grade copper ore using organic acid</i>	305-308
<u>Maria Krasteva (BULGARIA)</u> <i>Methodology and equipment for researching corrosion cracking processes in steel 3H14L (BDS 3692-78)</i>	309-312
<u>Jasmina Nešković, Pavle Stjepanović, Nenad Milojković, Dejan Lazić, Klara Konc Janković, Svetlana Polavder, Ivana Jovanović (SERBIA)</u> <i>Testing the Bond work index on limestone from flue gas desulphurization plant in TPP Ugljevik</i>	313-317
<u>Biljana Zlatičanin, Sandra Kovačević (MONTENEGRO)</u> <i>Impact of titanium addition on microstructure and properties of as-cast Al-Cu15 alloys</i>	318-321
<u>Biljana Zlatičanin, Sandra Kovačević (MONTENEGRO)</u> <i>Effect of cooling rate on mechanical properties of binary Al-Cu23 alloys</i>	322-324
<u>Desislav Ivanov, Irena Peytcheva, Marko Holma (BULGARIA)</u> <i>Horizon Europe AGEMERA project - Agile Exploration and Geo-modelling for European Critical Raw Materials: The potential of Assarel porphyry copper deposit for critical raw materials</i>	325-328
<u>Shehret Tilvaldyev, Uzziel Caldiño Herrera, Jose Omar Davalos, Manuel Alejandro Lira Martinez, Marlenne Alejandra Hernandez Lira, Diego Adan Villordo Melendez (CANADA)</u> <i>Problems of anthropogenic pollution of space</i>	329-334
<u>Mohammed Derqaoui, Abdelmoughit Abidi, Abdelrani Yaacoubi, Khalid El Amari, Omar Oabi, Abdelaziz Bacaoui (MOROCCO)</u> <i>Apatite flotation from low-grade sedimentary phosphate ore</i>	335-338
<u>Nadezhda Kazakova, Alexandar Popov, Georgi Chernev (BULGARIA)</u> <i>Influence of the distribution and content of limestone particles on the properties of blended cements</i>	339-342

<u>Daniel Ogochukwu Okanigbe, Shade Rouxzeta Van Der Merwe</u> (SOUTH AFRICA) <i>Rocks of Obafemi Awolowo University and Environ, Nigeria: structural analysis of geological contact</i>	343-347
<u>Vladan Kašić, Ana Radosavljević Mihajlović, Jovica Stojanović, Slavica Mihajlović, Melina Vukadinović, Nataša Đorđević, Ivana Jelić</u> (SERBIA) <i>Study of thermally treated zeolitic tuffs of Serbia, deposits "Zlatokop" and "Općište"-Beočin</i>	348-352
<u>Vesna Grekulović, Aleksandra Mitovski, Milica Zdravković, Nada Štrbac, Milan Gorgievski, Milovan Vuković, Miljan Marković</u> (SERBIA) <i>Electrochemical behavior of copper in chloride medium in the presence of nettle extract</i>	353-356
<u>Marko Pavlović, Marina Dojčinović, Muhamed Harbinja, Atif Hodić, Dragan Radulović, Mirjana Stojanović, Zagorka Aćimović</u> (SERBIA, BOSNIA AND HERZEGOVINA) <i>Effects of the application of pyrophyllite in the composition of protective coatings</i>	357-360
<u>Tamara Ristić, Nenad Milosavljević, Dobrica Milovanović</u> (SERBIA) <i>Measures for the processing of iron with a higher incoming phosphorus content at the steel shop</i>	361-365
<u>Ivana Mikavica, Dragana Randelović, Milena Obradović, Jovica Stojanović, Jelena Mutić</u> (SERBIA) <i>Microplastic textile fibers in urban soils of Serbia</i>	366-369
<u>Jianbo Zhao, Xinnan Zhao, Donglai Ma, Yang You, Zhixiong You, Xuewei Lv</u> (CHINA) <i>Preparation of ferronickel by semi-molten smelting a mixture of two types of laterite ore</i>	370-374
<u>Mladen Radovanović, Dejan Petrović, Jelena Ivaz, Dragan Zlatanović</u> (SERBIA) <i>Possibility of copper ores exploitation using in situ leaching method</i>	375-378
<u>Ivan Jelić, Nikola Lekić, Nikola Stanić, Miomir Mikić</u> (SERBIA) <i>Selection of an optimal route for relocation of the Čehotina river bed</i>	379-382
<u>Milica Zdravković, Vesna Grekulović, Bojan Zdravković, Nada Štrbac, Milan Gorgievski, Miljan Marković</u> (SERBIA) <i>Electrochemical behavior of steel in 0.1 mol/dm³ HCl in the presence of potato peel juice</i>	383-386
<u>Ivana Marković, Dalibor Jović, Uroš Stamenković, Dragan Manasijević, Ljubiša Balanović, Milan Gorgievski</u> (SERBIA) <i>Microstructure and thermal properties of leaded brass after quenching</i>	387-390
<u>Mehmet Ali Yildiz</u> (SERBIA) <i>Hot strip mill walking beam slab reheating project</i>	391-394
<u>Peter Polyak</u> (SERBIA) <i>Finishing mill automation upgrade at hot strip mill</i>	395-400
<u>Branislav Potić, Ana Arifović</u> (SERBIA) <i>The metallurgical testing results of the boron mineralized material from Valjevo-Mionica basin</i>	401-406

<u>Uroš Stamenković, Ivana Marković, Srba Mladenović, Saša Marjanović, Avram Kovačević, Milijana Mitrović, Filip Basarabić (SERBIA)</u> <i>The influence of quenching media on different properties of C45 carbon steel</i>	407-413
<u>Yang You, Jiabao Guo, Zhixiong You, Xuewei Lv (CHINA)</u> <i>Investigation of the mixing and granulation behavior of iron ore fines in horizontal high-shear granulator</i>	414-417
<u>Jovica Sokolović, Grozdanka Bogdanović, Velizar Stanković, Gracijan Strainović, Ivana Ilić, Milan Gorgievski, Miljan Marković (SERBIA)</u> <i>Investigation on beneficiation of iron from copper ore of Mauritania Copper Mine (MCM) by magnetic separation</i>	418-421
<u>Essen Suleimenov, Rustam Sharipov, Galymzhan Maldybayev, Zhibek Orazaliyeva (KAZAKHSTAN)</u> <i>Investigation of the influence of pulsed electric current on the efficiency of decomposition of aluminate solution</i>	422-423
<u>Lovro Liverić, Tamara Holjevac Grgurić, Sunčana Smokvina Hanza, Wojciech Sitek, Vedrana Špada, Marko Kršulja (CROATIA)</u> <i>Influence of silver content on martensitic transformation of Cu-Al-Ag alloy</i>	424-427
<u>Hasan Ali Taner, Vildan Onen (TURKEY)</u> <i>Evaluation of the efficiency of different collectors in the chalcopyrite flotation</i>	428-434
<u>Vesna Conić, Dragana Božić, Miloš Janošević, Ljiljana Avramović, Vanja Trifunović, Dejan Bugarin, Ivana Jovanović (SERBIA)</u> <i>A pyro-hydrometallurgical process for the recovery of zinc from jarosite waste</i>	435-438
<u>Maria Krasteva, Rumen Petkov (BULGARIA)</u> <i>Research the rate of chemical corrosion of steel 3X14H2 (BDS 3692-78)</i>	439-442
<u>Srba Mladenović, Bojan Novaković, Ivana Marković, Uroš Stamenković (SERBIA)</u> <i>Effect of casting speed and water flow on tensile strength, elongation and microstructure of continuous cast copper wire</i>	443-447
<u>Nadira Bušatlić, Ilhan Bušatlić, Dženana Smajić-Terzić (BOSNIA AND HERZEGOVINA)</u> <i>Dependence of compressive strength of geopolymer based on fly ash and alkaline activator ratio</i>	448-451
<u>Gergana Meracheva, Efrosima Zaneva-Dobranova, Nikolay Hristov (BULGARIA)</u> <i>Hydrocarbon potential of the Lower Paleozoic sediments in NE Bulgaria by geochemistry and well-logging</i>	452-455
<u>Dragana Marilović, Grozdanka Bogdanović, Sanja Petrović (SERBIA)</u> <i>Leaching of flotation tailings with a solution of sulfuric acid and ionic liquid</i>	456-459
<u>Ivana Jovanović, Vesna Conić, Dragan Milanović, Daniel Kržanović, Tanja Stanković, Daniela Urošević, Miloš Janošević (SERBIA)</u> <i>Determination of Bond rod mill work index of a very low-grade copper ore</i>	460-463

<u>Hasan Ali Taner, Ali Aras, Muhammad Hashim Rasa</u> (TURKEY) <i>Investigation of the effect of depressant and collector conditioning times on cobalt recovery by flotation</i>	464-467
<u>Aleksandar Cvetković, Žaklina Tasić, Marija Petrović Mihajlović, Maja Nujkić, Milan Radovanović, Ana Simonović</u> (SERBIA) <i>Microplastics</i>	468-471
<u>Sanja Petrović, Srđana Magdalinović, Ljubiša Obradović, Sandra Milutinović, Bojan Drobnjaković, Slađana Krstić</u> (SERBIA) <i>Tailing management: tailings filtering equipment</i>	472-475
<u>Jelena Stefanović, Jelena Đorđević, Sandra Guševac</u> (SERBIA) <i>XRD analysis of corrosion product formed in industrial aggressive environment</i>	476-480
Muhamad Ghulam Isaq Khan, Filip Rajković, Miljana Popović, Dejan Prelević, Aleksandar Ćitić, Tamara Radetić (SERBIA) <i>Initiation of abnormal grain growth in cold-rolled sheet of AA5182 Al-Mg alloy: role of texture</i>	481-484
<u>Danijela Voza, Hesam Dehghani, Milica Veličković</u> (SERBIA) <i>The dissolved oxygen prediction based on the machine learning techniques</i>	485-488
<u>Hasan Acan, Hasan Ergin</u> (TURKEY) <i>A novel model for minimizing mine closure costs and the optimum final quarry boundry</i>	489-492
<u>Ivana Jovanović, Dragan Milanović, Oliver Dimitrijević, Vesna Conić, Igor Svrkota</u> (SERBIA) <i>Role of wing tank in DMS process. Suspension velocity through the seal leg orifice – case study</i>	493-496
<u>Dejan Petrović, Jelena Ivaz, Saša Stojadinović, Predrag Stolić, Dragan Zlatanović</u> (SERBIA) <i>Risk management and mining machines maintenance – a brief review</i>	497-500
<u>Stefan Đorđievski, Dragana Adamović</u> (SERBIA) <i>History of surface water pollution by mining and metallurgical activities in Bor, Serbia</i>	501-504
<u>Olivera Dragutinović, Vaso Manojlović, Đorđe Veljović, Stefan Dikić, Marko Simić</u> (SERBIA) <i>Investigation of the properties of Co-Cr-W and Co-Cr-Mo alloys coated with hydroxyapatite for use in dental implants</i>	505-509
<u>Zoran Karastojković, Dragoslav Gusković, Ognjen Ristić, Zorica Kovačević</u> (SERBIA) <i>About the “relative plasticity” between steel matrix and non-metallic inclusions</i>	510-513
<u>Aleksandar Jovanović, Mladen Bugarčić, Milena Milošević, Marija Vuksanović, Muna Abdualatif Abdurahman, Miroslav Sokić, Aleksandar Marinković</u> (SERBIA, LIBYA) <i>Modified hybrid cellulose membrane for Nickel(II) ions removal from industrial wastewater</i>	514-517
<u>Elena Todorova, Nadezhda Kazakova, Georgi Chernev</u> (BULGARIA) <i>Structural investigation via SEM analysis of silica hybrid materials</i>	518-521

<u>Tanja Kalinović, Jelena Kalinović, Jelena Milosavljević, Ana Radojević, Snežana Šerbula (SERBIA)</u> <i>Atmospheric bulk deposition as environmental quality indicator</i>	522-526
<u>Gordana Marković, Vaso Manojlović, Miroslav Sokić, Jovana Ružić, Dušan Milojkov (SERBIA)</u> <i>Designing biocompatible high entropy alloys using Monte Carlo simulations</i>	527-530
<u>Tatjana Volkov-Husović, Sanja Martinović, Ana Alil, Milica Vlahović (SERBIA)</u> <i>Application of image analysis for cavitation erosion resistance monitoring of some engineering materials</i>	531-534
<u>Milan Nedeljković, Srba Mladenović, Jasmina Petrović, Milijana Mitrović (SERBIA)</u> <i>Changes in the structure and density of copper during the refining smelting process</i>	535-538
<u>Jasmina Petrović, Srba Mladenović, Ivana Marković, Milan Nedeljković, Milijana Mitrović (SERBIA)</u> <i>Microstructure analysis of EN AW 6061 alloy using a SEM microscope after artificial aging</i>	539-542
<u>Milijana Mitrović, Saša Marjanović, Biserka Trumić, Jasmina Petrović, Milan Nedeljković (SERBIA)</u> <i>Effects of cold rolling and annealing processes on the microstructure and properties of micro-alloyed copper</i>	543-546
<u>Makedonka Dimitrova, Jasminka Dimitrova Kapac (NORTH MACEDONIA)</u> <i>Unlocking energy efficiency: financing preferences for SMEs in the Republic of North Macedonia</i>	547-555
<u>Zoran Štirbanović, Vesna Vojinović, Jovica Sokolović, Maja Trumić (SERBIA)</u> <i>Analysis of the effectiveness of different methods for cutting samples</i>	556-559
<u>Ivica Nikolić, Isidola Milošević, Anđelka Stojanović (SERBIA)</u> <i>Land turnover increases due to mining: An empirical analysis of Bor, Serbia, 2013-2022.</i>	560-563
DONORS	565-590
AUTHOR INDEX	591-596

...

Mg/Fe-MODIFIED HYDROCHAR WITH PROMOTED ADSORPTION PERFORMANCES

Jelena Petrović, Marija Ercegović, Marija Simić,
Marija Koprivica, Jelena Dimitrijević, Marija Marković

Institute for Technology of Nuclear and Other Mineral Raw Materials, Belgrade, Serbia

Abstract

This study examined Mg/Fe-pyro-hydrochar produced from grape pomace as potential sorbent for Cu²⁺ ions. Obtained results show that the Mg/Fe-modification increases the adsorption capacity for five times. To evaluate the effectiveness of produced sorbent, Langmuir, Freundlich, Sips and Redlich-Peterson isotherm models were applied to batch adsorption results. According to applied models Cu²⁺ adsorption at equilibrium fitted the Sips isotherm model, with a maximum achieved capacity of 75 mg/g. Spectroscopic analysis reveal that oxygenated active sites and aromatic groups on pyro-hydrochar surface participate in Cu²⁺ ions binding. In general, preliminary findings from this paper offers perspective to effective utilization of waste biomass as an efficient adsorbents for Cu²⁺ ions removal.

Keywords: waste biomass, pyro-hydrochar, heavy metal removal, adsorption mechanism.

1. INTRODUCTION

Over the years, rapid development of industrial activities caused accelerated production of industrial effluents contaminated with heavy metals. The inadequate management of polluted wastewater and its release into water bodies poses a serious threat to the environment and human health [1,2]. Besides other heavy metals, copper (Cu²⁺) is classified as an essential micronutrient, however numerous anthropogenic activities are the significant contributors to the detrimental levels of Cu²⁺ in the environment, thus its concentration exceeds the permissible limits [3]. For this reason, removal or reduction of Cu²⁺ ions to standards defined acceptable quantity from the various industrial effluents become essential. Until now, various physical and chemical strategies (chemical precipitation, ion exchange, coagulation, oxidation, membrane filtration, adsorption, etc.) have been widely used for this purpose [4]. Among aforementioned techniques, adsorption is currently considered as a simple, efficient, low energy demand, and cost-effective method for wastewater purification. Along with adsorption, the development of novel adsorbents is on the rise. A movement toward greener methods proposes utilization of waste agricultural biomass as a chip, renewable and highly available as adsorbent material in adsorption technique. Furthermore, conversion of agricultural waste to carbonaceous materials has made their practical application even more attractive. Carbon-rich adsorbents can be produced from various waste biomasses by gasification, pyrolysis or hydrothermal carbonization (HTC).

The latter conversion process offers significant advantages over dry pyrolysis, such as milder reaction conditions (180-260°C) and high conversion efficiency of wet waste biomass into a carbon-rich product, hydrochar [2]. Although produced material exhibit smaller active surface and porosity compared to activated carbon, hydrochars shows significant potential for application in wastewater treatment due to a large number of functional groups on their surface [5]. Regarding improvement of adsorption potential, numerous studies have examined various physical and chemical modifications or functionalization of hydrochars. Previous experiences have shown that the treatment with hydrogen peroxide, different alkalis or metal salts can significantly increase their adsorption efficiency [2,5].

Within this study, the potential application of Mg/Fe doped grape pomace hydrochar as a potential adsorbent of Cu²⁺ ions from aqueous solutions will be investigated for the first time. In order to detail examine the binding mechanism and the metal adsorption process, characterization of hydrochar before and after Cu²⁺ removal, as well as isothermal study was performed.

2. EXPERIMENTAL

2.1 Preparation and modification of hydrochar

Waste pomace was collected from an open landfill site after processing of grapes into confectionery products. Pomace was air-dried, ground, and hydrothermally carbonized in an autoclave (Carl Roth, model II), in water as a reaction medium (1:15 m/v ratio) at 220°C, for one hour. The resulting hydrochar (GPHC) was filtered and dried at 105°C. The impregnation of the obtained hydrochar with MgO and FeO was carried out by a two-step co-precipitation procedure during which 1g of the HC-GP was stirred with Mg and Fe salts for 4 h at 60°C. Thereafter, the material was subjected to pyrolysis (Nabertherm 30-3000°C, Germany) at 300°C, within 1h, in an inert atmosphere. Obtained Mg/Fe-activated pyro-hydrochar was labeled as Mg/FeGPHC.

2.2 Characterization of obtained Mg/Fe-pyro-hydrochar and adsorption test

To gain insight into the influence of modification process onto adsorbent surface, and to reveal participation of functional groups in the binding of Cu²⁺ ions, the spectroscopic analyses using Thermo Scientific Nicolet iS50 FT-IR spectrometer were performed. The KBr pastilles that include 0.8 mg of powdered Mg/Fe-HC and 80 mg of KBr have been recorded in transmission mode under spectral range from 4000 to 400 cm⁻¹.

The influence of the initial Cu²⁺ concentration on the removal efficiency and the evaluation of the equilibrium adsorption capacity were examined under batch adsorption test. For this reason, 25 mL of Cu²⁺ solutions (pH 5.0) of different concentrations (100-500 mg/L) were stirred with 0.5 g/L of the Mg/FeGPHC during 24 h at room temperature (298±0.5 K), and 250 rpm. The content of Cu²⁺ in the resultant filtrates was measured using Atomic Absorption Spectrophotometer (AAS) (Analytic Jena Spekol 900T). The amounts of Cu²⁺ removed by tested Mg/FeGPHC were calculated by following equation:

$$q_{eq} = \left(\frac{C_0 - C_{eq}}{m} \right) \times V \quad (1)$$

where C₀ and C_{eq} are the initial and equilibrium concentrations of the Cu²⁺ solution (mg/L); V represents the volume of the Cu²⁺ solution (L), m is the amount of adsorbent (Mg/FeGPHC) (g), respectively.

3. RESULTS AND DISCUSSION

3.1 Spectroscopic assay

In order to gain insight into the involvement of functional groups on the Mg/FeGPHC surface, and therefore the reveal potential mechanism of Cu²⁺ ion removal, a spectroscopic analysis of the adsorbent material before and after adsorption was performed. The obtained results (Figure 1a.) reveal that Mg/FeGPHC showed the peaks common to hydrochars, which indicate an aromatic structure rich in oxygen functional groups. Thus, the FTIR diagrams of modified GP hydrochar display a broad peak at around 3300 cm⁻¹, attributed to stretching vibrations of hydroxyl and carboxyl groups, aromatic C=C at around 1590 cm⁻¹, band at around 1380 cm⁻¹ corresponding to stretching vibrations of carboxylate -CH₂ or C-O, as well as correlated bands (1200 to 1000 cm⁻¹) attributed to stretching vibrations of aromatic and aliphatic C-O groups [2]. The peaks notable in spectral range from 750 to 500 cm⁻¹ indicating the presence of MgO and FeO incorporated onto

the hydrochar surface during the modification process [6]. Obtained findings suggest that the Mg/FeGPHC display surface abundant with functional groups, which contribute to heavy metal removal.

As a result of Cu²⁺ ions adsorption, certain changes are notable through all spectral range. A broad intense peak that occurs at about 3300 cm⁻¹ after adsorption shows a significant decrease in intensity. Similarly, the other bands notable on the FTIR spectrum become less pronounced and shifted to lower wavenumbers after the adsorption of Cu²⁺ ions. This observation indicates that the potential mechanisms responsible for metal ions binding include Cu- π reaction between aromatic groups of Mg/FeGPHC (C=C) and Cu²⁺ ions, surface complexation with oxygen-containing functional groups (-OH, C-O), as well as exchange with Mg and Fe ions.

3.2 Preliminary adsorption test

3.3 Isothermal study

Preliminary adsorption test reveal that modified hydrochar exhibited significantly higher adsorption capacity (71 mg/g) towards Cu²⁺ ions in comparison to unmodified (14 mg/g). In order to gain insight into the nature of the interaction between Cu²⁺ ions and modified Mg/FeGPHC surface, and to determine a theoretical maximum adsorption capacity, four isotherm models were applied to the experimental results [2,7].

The Langmuir isotherm model:

$$q_e = \frac{q_m K_L C_e}{1 + K_L C_e} \quad (2)$$

The Freundlich isotherm model:

$$q_e = K_F C_e^{1/n} \quad (3)$$

The Sips isotherm model:

$$q_e = q_m \frac{K_S C_e^{n_s}}{1 + K_S C_e^{n_s}} \quad (4)$$

and Redlich-Peterson (R-P) isotherm model:

$$q_e = \frac{K_{RP} C_e}{1 + a_{RP} C_e^\beta} \quad (5)$$

Where C_e represents the equilibrium concentration (mg/L), q_m is the maximum quantity of adsorbed Cu²⁺ ions (mg/g), K_L, K_F, K_S, and K_{RP} are model constants, 1/n adsorption intensity, n_s is the Sips model exponent, and a_{RP} (L/mg) represents the R-P equilibrium constant.

The obtained results are presented and summarized in Figure 1b, and Table 1.

Table 1- Parameters and determination coefficients of the isotherm models for Cu²⁺ removal

Models	Parameters	Value	Models	Parameters	Value
Langmuir	q _m (mg g ⁻¹)	83.28	Freundlich	K _F (mg g ⁻¹)(L mg ⁻¹) ^{1/n}	17.95
	K _L (L mg ⁻¹)	0.14		1/n	0.41
	R ²	0.9755		R ²	0.9828
Sips	q _m (mg g ⁻¹)	75.0	R-P	K _{RP} (L g ⁻¹)	35.54
	K _S (L mg ⁻¹)	0.14		a _{RP} (L mg ⁻¹)	1.23
	n _s	0.62		β	0.72
	R ²	0.9930		R ²	0.9900

Based on results of correlation coefficients (R^2) displayed in Table 1 can be concluded that the Sips isotherm model best described nature of the interaction. Thus, adsorption occurs as multi-layered adsorption on a heterogeneous surface. Furthermore, according to Sips isotherm model the maximum adsorption capacity (q_m) was 75 mg/g. In addition, summarized parameters from applied isothermal models ($K_L < 1$, $K_F > 1$, the $1/n$, and n_s values are in range from 0 to 1, and $\beta < 1$) suggesting that the removal of Cu^{2+} ions onto investigated material are favorable.

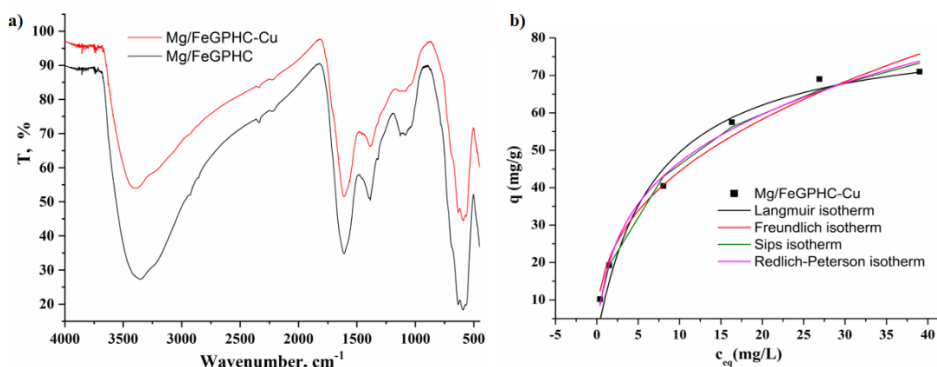


Figure 1- FTIR spectra (a) before and after adsorption onto Mg/FeGPHC, and applied isotherm models (b)

4. CONCLUSION

In this study, Mg/Fe doped grape pomace hydrochar was investigated as potential adsorbent of Cu^{2+} ions from aqueous solution. The prepared Mg/FeGPHC was subjected to spectroscopic analysis before and after adsorption, as well as isothermal study tests. Based on the results, oxygen-containing functional groups and aromatic functional groups from Mg/FeGPHC surface participate in the binding of Cu^{2+} ions from aqueous solutions, with maximum adsorption capacity of 75 mg/g. Moreover, removal of Cu^{2+} ions onto investigated material is favorable process.

Acknowledgement

The authors are grateful to the Ministry of Science, Technological Development and Innovation of the Republic of Serbia for the financial support (contract no. 451-03-47/2023-01/200023).

REFERENCES

- [1] X. Hu, L. Dai, Q. Ma, J. Xu, J. Ma, X. Liu., *Ind. Crops Prod*, 187 (2022) 115396.
- [2] J. Petrović, M. Ercegović, M. Simić, D. Kalderis, M. Koprivica, J. Milojković, D. Radulović *J. Mol. Liq.* 376 (2023) 121424.
- [3] W-C. Chen, H-M. Saad, K-S. Sim, V-S. Lee, K-W. Tan., *J. Mol. Struct.* 1254 (2022) 132337.
- [4] K. Majhi, M. Let, U. Halder, A. Chitikineni, R-K. Varshney, R. Bandyopadhyay., *Environ. Res.* 223 (2023) 1185431.
- [5] B. Li, J-Q. Lv, J-Z. Guo, S-Y. Fu, M. Guo, P. Yang., *Bioresour. Technol.* 275 (2019) 360-367.
- [6] S-W. Hwang, A. Umar, G-N. Dar, S-H. Kim, R-I. Badran., *Sensor Letters*, 12 (2014) 1-5.
- [7] M. Simić, J. Petrović, T. Šoštarić, M. Ercegović, J. Milojković, Z. Lopičić, M. Kojić., *Processes*,10 (2022) 1957.