



MINING AND METALLURGY INSTITUTE BOR

and



TECHNICAL FACULTY BOR, UNIVERSITY OF BELGRADE

IOOC 2018
**International October
Conference**

**50th International October Conference
on Mining and Metallurgy**

PROCEEDINGS

Editors:

**Ana Kostov
Milenko Ljubojev**

30th September – 3rd October 2018

Hotel "Jezero" Bor Lake, Serbia



MINING AND METALLURGY INSTITUTE BOR

and



TEHNICAL FACULTY BOR, UNIVERSITY OF BELGRADE



**50th International October Conference
on Mining and Metallurgy**

PROCEEDINGS

Editors:

**Ana Kostov
Milenko Ljubojev**

30th September – 3rd October 2018

Hotel "Jezero" Bor Lake, Serbia

50th International October Conference on Mining and Metallurgy

Editors: Ana Kostov, Milenko Ljubojev

Publisher: Mining and Metallurgy Institute Bor

Printed in: "GRAFOMED-TRADE" Bor

Text printing preparation: Vesna Simić

Disclaimer: Authors are responsible for the content, translation and accuracy.

Circulation: 200 copies

CIP- Каталогизација у публикацији
Народна библиотека Србије, Београд

622(082)
669(082)

INTERNATIONAL October Conference on Mining and Metallurgy (50 ; 2018 ; Borsko jezero)

Proceedings / 50th International October Conference on Mining and Metallurgy - IOC 2018, 30th September - 3rd October 2018 Bor Lake, Serbia ; [organized by] Mining and Metallurgy Institute Bor and Technical Faculty Bor, University of Belgrade ; editors Ana Kostov, Milenko Ljubojev. - Bor : Mining and Metallurgy Institute, 2018 (Bor : Grafomed-trade). - XXV, 519 str. : ilustr. ; 25 cm

Tiraž 200. - Bibliografija uz svaki rad. - Registar.

ISBN 978-86-7827-050-5

1. Institut za rudarstvo i metalurgiju (Bor) 2. Tehnički fakultet (Bor)

a) Рударство - Зборници
b) Металургија - Зборници

COBISS.SR-ID 267792140

Bor, October 2018



TABLE OF CONTENTS

PLENARY LECTURES

- Daizo Ishiyama, Nobuyuki Masuda, Atsushi Shibayama, Zoran Stevanović, Ljubiša Obradović, Vladan Marinković, Radmila Marković, Ljiljana Avramović, Vojka Gardić*
AN APPROACH TO FIND THE ADVANCED METHODS FOR SOLUTION OF PROBLEMS RELATED TO THE MINING ACTIVITIES IN THE BOR MINING AREA, SERBIA 3
- Aca Jovanović, Mile Bugarin*
APPLICATION OF THE SENSOR SORTING TECHNIQUE IN PROCESSING THE PRIMARY AND SECONDARY RAW MATERIALS 9
- Victor Verbičchi, Octavian-Victor Oancă, Aurel-Valentin Birdeanu*
THE NEW MANUFACTURING TECHNOLOGIES BY WELDING 15
- Mihaela Ciopec, Adina Negrea, Cornelia Muntean, Petru Negrea, Narcis Duțeanu, Oana Grad*
CELLULOSE FUNCTIONALIZED WITH CROWN ETHER AND Fe (III) USED FOR ARSENIC REMOVAL FROM WATER 23
- Miodrag Žikić, Milan Živković, Saša Stojadinović, Goran Ćosić*
TECHNO- ECONOMICAL ANALYSIS OF THE CUTOFF Cu CONTENT IN THE CORRECTED SOUTH-EAST PUSHBACK AT THE OPEN PIT VELIKI KRIVELJ 29

GEOLOGY, MINING AND MINERAL PROCESSING

- Kemal Gutić, Muhidin Brčaninović, Emir Sejranović*
MONITORING OF WELL CONSTRUCTION BY MINING FOR THE PILLAR SITE "S2" FOR THE VIADUCT AT ZENICA – CORRIDOR VC 35
- Dejan Bugarin, Nikola Stanić*
EXAMPLES AND EXPERIENCES OF THE MINING TOURISM AND POSSIBILITY OF THEIR APPLICATION IN SERBIA 39
- Daniel Kržanović, Miroslav Grujić, Dejan Stevanović, Nenad Vušović, Milenko Ljubojev*
STRATEGIC MINE PLANNING PHASES OF THE COPPER ORE OPEN PITS - A CASE STUDY: THE OPEN PIT VELIKI KRIVELJ, SERBIA 43
- Daniel Kržanović, Ivana Jovanović, Sanja Petrović, Sladjana Krstić, Radmilo Rajković*
ASSESSMENT THE FLEET PRODUCTIVITIES IN A LONG-TERM PLANNING OF THE OPEN PITS 47
- Igor Svrkota, Miloš Stojanović, Ivan Svrkota, Zoran Stojanović, Duško Djukanović*
ANALYSIS OF THE GROUND STABILITY IN THE ORE BODY T3 OF THE JAMA BOR UNDERGROUND MINE 51



<i>Vladimir Nikolić, Milan Trumić, Ljubiša Andrić, Maja Trumić</i> MICRONIZATION OF ZEOLITE IN A VIBRATING MILL WITH RINGS	55
<i>Maja Trumić, Nevena Munčan, Milan Trumić, Dragan Radulović</i> SEPARATION OF THE PS/ABS PLASTICS USING THE FROTH FLOTATION	59
<i>Nikola Stanić, Saša Stepanović, Aleksandar Doderović, Željana Sekulić, Miljan Gomilanović</i> CALCULATION ANALYSIS OF THE CONSTRUCTIVE PARAMETERS OF THE INTERNAL LANDFILL KUTLOVAČA AND INCLUDED IN THE DESIGN STATE	63
<i>Miljan Gomilanović, Saša Stepanović, Dejan Stevanović, Aleksandar Doderović, Nikola Stanić</i> ANALYSIS OF THE OPTIMIZATION CONTOURS OF THE OPEN PIT IN THE ZONE OF ROOF COAL SERIES GACKO-CENTRAL FIELD WITH THE WHITTLE SOFTWARE PACKAGE IN THE FUNCTION SIZE OF A BLOCK	67
<i>Markus Wilke, Thomas Silber-Hasslacher, Vladan Čanović</i> EFFICIENT AND SUSTAINABLE TAILING DEWATERING AND STORAGE BY THE GEOSYNTHETIC DEWATERING TUBES: WORKING PRINCIPLES AND TALVIVAARA CASE STUDY	71
<i>Aleksandar Doderović, Saša Stepanović, Nikola Stanić, Miljan Gomilanović</i> ANALYSIS OF THE TANDEM WORK OF SPREADER AND DRAGLINE ON THE LANDFILL OF THE OPEN PIT	77
<i>Srdana Magdalinović, Dragiša Stanujkić, Dragan Milanović, Vesna Marjanović, Miomir Mikić, Branislav Rajković</i> POSSIBILITY OF COMMON PROCESSING THE MINERALIZATION FROM THE SITE KRIVELJSKI KAMEN AND ORE DEPOSIT VELIKI KRIVELJ	81
<i>Jelena Ivaz, Dejan Petrović, Saša Kalinović, Dejan Tanikić, Pavle Stojković</i> ANALYSIS OF THE WORKERS AGE INFLUENCE ON THE INJURY RATES IN THE UNDERGROUND COAL MINING IN SERBIA	87
<i>Ivana Jovanović, Sanja Petrović, Daniel Kržanović, Sladana Krstić, Dejan Petrović</i> NRMSE OF PREDICTION THE COPPER FLOTATION INDICATORS OBTAINED BY THE SOFT COMPUTING BASED MODELS	91
<i>Saša Stepanović, Nikola Stanić, Aleksandar Doderović, Miljan Gomilanović, Željana Sekulić</i> ANALYSIS OF LOSSES IN A FUNCTION OF SELECTION THE LEVEL OF ROOF COAL SERIES - COAL DEPOSIT GACKO	95
<i>Lidija Đurđević Ignjatović, Dragan Ignjatović, Milenko Ljubojev, Dušan Tašić, Daniela Urošević</i> APPLICATION OF CEMENTED PASTE BACKFILL IN THE SUBLEVEL STOPPING METHOD	101
<i>Dragan Ignjatović, Lidija Đurđević Ignjatović, Milenko Ljubojev, Daniela Urošević, Dušan Tašić</i> SUBLEVEL STOPPING METHOD MODELING USING THE CEMENT PASTE BACKFILL FOR AFTERWARD EXCAVATION OF THE MAIN PILLARS	105



<i>Vladimir Nikolić, Milan Trumić, Ljubiša Andrić, Maja Trumić</i> MICRONIZATION OF ZEOLITE IN A VIBRATING MILL WITH RINGS	55
<i>Maja Trumić, Nevena Munčan, Milan Trumić, Dragan Radulović</i> SEPARATION OF THE PS/ABS PLASTICS USING THE FROTH FLOTATION	59
<i>Nikola Stanić, Saša Stepanović, Aleksandar Doderović, Željana Sekulić, Miljan Gomilanović</i> CALCULATION ANALYSIS OF THE CONSTRUCTIVE PARAMETERS OF THE INTERNAL LANDFILL KUTLOVAČA AND INCLUDED IN THE DESIGN STATE	63
<i>Miljan Gomilanović, Saša Stepanović, Dejan Stevanović, Aleksandar Doderović, Nikola Stanić</i> ANALYSIS OF THE OPTIMIZATION CONTOURS OF THE OPEN PIT IN THE ZONE OF ROOF COAL SERIES GACKO-CENTRAL FIELD WITH THE WHITTLE SOFTWARE PACKAGE IN THE FUNCTION SIZE OF A BLOCK	67
<i>Markus Wilke, Thomas Silber-Hasslacher, Vladan Čanović</i> EFFICIENT AND SUSTAINABLE TAILING DEWATERING AND STORAGE BY THE GEOSYNTHETIC DEWATERING TUBES: WORKING PRINCIPLES AND TALVIVAARA CASE STUDY	71
<i>Aleksandar Doderović, Saša Stepanović, Nikola Stanić, Miljan Gomilanović</i> ANALYSIS OF THE TANDEM WORK OF SPREADER AND DRAGLINE ON THE LANDFILL OF THE OPEN PIT	77
<i>Srdana Magdalinović, Dragiša Stanujkić, Dragan Milanović, Vesna Marjanović, Miomir Mikić, Branislav Rajković</i> POSSIBILITY OF COMMON PROCESSING THE MINERALIZATION FROM THE SITE KRIVELJSKI KAMEN AND ORE DEPOSIT VELIKI KRIVELJ	81
<i>Jelena Ivaz, Dejan Petrović, Saša Kalinović, Dejan Tanikić, Pavle Stojković</i> ANALYSIS OF THE WORKERS AGE INFLUENCE ON THE INJURY RATES IN THE UNDERGROUND COAL MINING IN SERBIA	87
<i>Ivana Jovanović, Sanja Petrović, Daniel Kržanović, Sladana Krstić, Dejan Petrović</i> NRMSE OF PREDICTION THE COPPER FLOTATION INDICATORS OBTAINED BY THE SOFT COMPUTING BASED MODELS	91
<i>Saša Stepanović, Nikola Stanić, Aleksandar Doderović, Miljan Gomilanović, Željana Sekulić</i> ANALYSIS OF LOSSES IN A FUNCTION OF SELECTION THE LEVEL OF ROOF COAL SERIES - COAL DEPOSIT GACKO	95
<i>Lidija Đurđevac Ignjatović, Dragan Ignjatović, Milenko Ljubojev, Dušan Tašić, Daniela Urošević</i> APPLICATION OF CEMENTED PASTE BACKFILL IN THE SUBLEVEL STOPPING METHOD	101
<i>Dragan Ignjatović, Lidija Đurđevac Ignjatović, Milenko Ljubojev, Daniela Urošević, Dušan Tašić</i> SUBLEVEL STOPPING METHOD MODELING USING THE CEMENT PASTE BACKFILL FOR AFTERWARD EXCAVATION OF THE MAIN PILLARS	105



55	<i>Jovica Sokolović, Zoran Štirbanović, Ivana Strainović, Novka Živadinović, Dragan Perić</i>	
59	VALORIZATION OF MAGNETITE FROM THE COPPER SLAG IN RTB BOR AND ITS APPLICATION AS A SUSPENSOID	111
	<i>Sladana Krstić, Ivana Jovanović, Milenko Ljubojev, Sanja Petrović, Milan Jovanović, Dušan Tašić, Srdana Magdalinović</i>	
	THE CARBONATE DEPOSIT "KRIVELJ"	115
63	<i>Zoran Štirbanović, Jovica Sokolović, Dragiša Stanujkić, Dragan Milanović, Miloš Kirov</i>	
	THE EFFECT OF LIBERATION OF THE COPPER MINERALS ON TECHNOLOGICAL INDICATORS OF THE FLOTATION PROCESS	119
67	<i>Tatjana Petrović Čačić, Aleksandra Vuković, Vladimir Bačanac, Veselin Bakić</i>	
	STATISTICAL ANALYSIS OF THE QUALITY DATA OF THE DEPOSIT "RADLJEVO NORTH", KOLUBARA COAL MINE, SERBIA	125
	<i>Jovan Blagojević, Radmila Generalović, Dragan Radojković, Marijana Petrović</i>	
	EXPLORATION WORKS ON REGULATION THE RIVERBED OF PESTAN	129
71	<i>Dušan Tašić, Lidija Đurđevac Ignjatović, Dragan Ignjatović</i>	
	DETERMINING THE POINT LOAD STRENGTH INDEX OF THE OVERLYING ZONE AT THE OP GACKO	133
77	<i>Sanja Petrović, Grozdanka Bogdanović</i>	
	DISSOLUTION OF CHALCOPYRITE IN ACIDIC HYDROGEN PEROXIDE SOLUTION	137
	<i>Pavle Stojković, Dejan Petrović, Miodrag Žikić, Saša Stojadinović</i>	
	DEVELOPMENT OF THE PROGRAM FOR DIMENSIONING AND SELECTION THE DEWATERING OBJECTS AND EQUIPMENT FOR THE OPEN PIT DEWATERING	141
81	<i>Pavle Stojković, Jelena Ivaz, Nenad Vušović</i>	
	GIS SOLUTION FOR THE "STRMOSTEN" PIT IN THE COAL MINE "VODNA"	145
87	<i>Vitomir Milić, Mladen Radovanović, Stefan Tasić</i>	
	ANALYSIS OF THE POSSIBILITY FOR APPLICATION THE SHORTWALL METHOD IN THE RAVNA REKA COAL DEPOSIT OF THE REMBAS MINE	151
91	<i>Marko Pavlović, Marina Dojčinović, Ljubiša Andrić, Jovica Stojanović, Dragan Radulović, Milan Petrov, Marina Blagojev</i>	
	INFLUENCE OF THE BASALT STRUCTURE AND PROPERTIES ON DEVELOPMENT THE CAVITATION DAMAGE	155
95	<i>Daniela Urošević, Dragan Milanović, Daniel Kržanović, Branislav Rajković, Miomir Mikić, Ivana Jovanović, Sladana Krstić</i>	
	POSSIBILITY OF ACHIEVING A CAPACITY OF 11×10^6 TONS OF ORE IN THE CRUSHING AND SCREENING PLANT OF RBM	159
101	<i>Dejan Petrović, Vitomir Milić, Jelena Ivaz, Ivana Jovanović, Pavle Stojković</i>	
	ANALYSIS OF APPLICATION A SUBLEVEL STOPPING METHOD WITH THE PASTA BACKFILL IN THE BOR MINE	165
105	<i>Sanja Petrović, Ivana Jovanović, Srdana Magdalinović, Daniel Kržanović, Sladana Krstić</i>	
	DETERMINATION THE THICKENING PARAMETERS OF THE FINAL FLOTATION TAILINGS FROM THE ORE DEPOSIT BORSKA REKA	169



METALLURGY AND MATERIALS SCIENCE

<i>Nebojša Tadić, Nikola Šibalić, Milan Vukčević, Mitar Mišović</i> CHARACTERISTICS OF THE FSW WELDED COPPER SHEET JOINTS	175
<i>Aleksandra Ivanović, Vesna Cvetković - Stamenković, Biserka Trumić, Saša Marjanović, Vesna Marjanović, Silvana Dimitrijević</i> PdNi5 ALLOY: THE EFFECT OF THERMOMECHANICAL PROCESSING REGIME ON MECHANICAL PROPERTIES AND ELECTRICAL CONDUCTIVITY	181
<i>Silvana Dimitrijević, Mirjana Rajčić-Vujasinović, Stevan Dimitrijević, Zoran Stević, Aleksandra Ivanović</i> STABILITY OF THE GOLD MERCAPTOTRIAZOLE COMPLEX AT pH=4	185
<i>Guillermo Reyes, Alejandro Cruz, Nicolás Cayetano, Ricardo Sánchez, Víctor Gutiérrez</i> THE EFFECT OF DIFFERENT INOCULANTS AND COOLING CONDITIONS ON THE GRAPHITE FLAKE FORMATION	191
<i>Ana Kostov, Aleksandra Milosavljević, Zdenka Stanojević Šimšić</i> PHASE TRANSFORMATIONS IN THE SHAPE MEMORY Ti - Al - V ALLOY	197
<i>Ewa Rudnik, Karolina Chat, Leszek Szatan</i> HOT-DIP GALVANIZING WASTE AS A VALUABLE SOURCE OF THE SECONDARY ZINC	201
<i>Žarko Radović, Nebojša Tadić, Nada Štrbac, Dragan Manasijević</i> THERMAL CONDUCTIVITY OF STEEL AS A FUNCTION OF THE ALLOYING ELEMENTS CONTENT	207
<i>Zdenka Stanojević Šimšić, Ana Kostov, Aleksandra Milosavljević</i> HARDNESS AND MICROHARDNESS OF THE SELECTED ALLOYS IN A VERTICAL Cu _{0.5} Ag _{0.5} -Al SECTION IN THE TERNARY Cu-Al-Ag SYSTEM	211
<i>Eduardo Colin-García, Alejandro Cruz-Ramírez, Ricardo Sanchez-Alvarado, Macaria Hernández-Chávez</i> MODULUS CASTING EFFECT ON THE MICROSTRUCTURE OF DUCTILE ALLOYED IRON WITH NICKEL	215
<i>Veljko Savić, Srđan Matijašević, Vladimir Topalović, Snežana Zildžović, Sonja Smiljanić, Snežana Grujić</i> NON-ISOTHERMAL ANALYSIS OF NUCLEATION THE Li ₂ O-GeO ₂ -Al ₂ O ₃ -P ₂ O ₅ GLASS	219
<i>Vladimir Topalović, Srđan Matijašević, Jelena Nikolić, Veljko Savić, Sonja Smiljanić, Snežana Grujić</i> LANTHANUM-DOPED PHOSPHATE GLASS FOR BIOMEDICAL APPLICATION	223
<i>Lidija Gomidželović, Ana Kostov, Dragan Manasijević, Ljubiša Balanović</i> THERMODYNAMICS OF DIFFERENT MULTICOMPONENT SHAPE MEMORY ALLOYS	227
<i>Lidija Gomidželović, Ana Kostov, Ljubiša Balanović, Dragan Manasijević, Vesna Krstić</i> CALCULATION THE THERMODYNAMIC PROPERTIES OF THE Cu-In-Sb ALLOYS FROM A COPPER CORNER BY THE RKM MODEL	233



<i>Lidija Gomidželović, Ana Kostov, Dragan Manasijević, Ljubiša Balanović, Hesam Pouraliakbar</i> GENERAL SOLUTION MODEL: THERMODYNAMIC PROPERTIES OF THE ALLOYS FROM A GALLIUM CORNER OF THE Au-Ga-In-Sb SYSTEM	237
<i>Lidija Gomidželović, Ana Kostov, Emina Požega, Ljubiša Balanović</i> INVESTIGATION THE HARDNESS AND ELECTRICAL CONDUCTIVITY OF THE SELECTED Cu-Al-Zn SHAPE MEMORY ALLOYS	241
<i>Christof Lanzerstorfer</i> DUST FROM THE SECONDURY COPPER SMELTER: APPLICATION OF THE AIR CLASSIFICATION FOR IMPROVED DUST RECYCLING	245
<i>Christof Lanzerstorfer</i> ZINC CYCLES CAUSED DUE TO THE IN-PLANT DUST RECYCLING IN THE INTEGRATED STEEL MILLS: OPTIMIZATION USING THE AIR CLASSIFICATION	249
<i>Karolina Chat, Ewa Rudnik</i> WETTABILITY OF THE ELECTROPLATED METALLIC COATINGS	253
<i>Aleksandra Milosavljević, Ana Kostov, Zdenka Stanojević-Šimšić</i> ELEMENTAL MAPPING IN THE SEM-EDS AS AN ADDITIONAL METHOD FOR MICROSTRUCTURE CHARACTERIZATION	257
<i>Borislava Vurdelja, Filip Veljković, Boris Rajčić, Silvana Dimitrijević, Stevan Dimitrijević, Željko J. Kamberović, Suzana Veličković</i> CHARACTERIZATION OF THE ANODIC FILMS FORMED ON THE Ag ₆₀ Cu ₂₆ Zn ₁₄ ALLOY BY THE LDI MASS SPECTROMETRY	261
<i>Biserka Trumić, Lidija Gomidželović, Vesna Krstić, Ljubiša Balanović, Saša Marjanović</i> MICROSTRUCTURE INVESTIGATION OF THE MULTICOMPONENT Au-Ag-Cu-Pd ALLOYS	265
<i>Iwona Dobosz, Dawid Kutyla, Malgorzata Kac, Grzegorz Wloch, Piotr Żabiński</i> SYNTHESIS AND MAGNETIC PROPERTIES OF THE Co-Ru ALLOY NANOWIRES	269
<i>Stevan Dimitrijević, Željko Kamberović, Milisav Ranitović, Silvana Dimitrijević, Marija Korać</i> SILVER MICRO-SIZED POWDER OBTAINED BY THE CHEMICAL REDUCTION	273
<i>Biljana Zlatičanin, Sandra Kovačević</i> STRENGTHENING RESPONSE OF THE HEAT-TREATABLE Al-Cu ₅ -Mg ₃ ALLOYS TO THE AGEING PROCESS	279
<i>Emina Požega, Pantelija Nikolić, Slavko Bernik, Saša Marjanović, Lidija Gomidželović, Stevan Vujatović, Milan Radovanović</i> INVESTIGATION OF THE BiSbTeSe SINGLE CRYSTAL DOPED WITH Zr	283
<i>Biljana Zlatičanin, Sandra Kovačević</i> STRUCTURE DETERMINATION OF THE EUTECTIC Al ₂ Cu AND Al ₂ CuMg BY THE ELECTRON MICROSCOPY	287



<i>Aleksandar Savić, Ivana Jelić, Dimitrije Zakić, Dragi Antonijević, Ivana Šekler, Aleksandar Kostić</i> THE NEW THERMAL INSULATION MATERIAL BASED ON THE MISCANTHUS X GIGANTEUS AND FLY ASH	291
<i>Vasily Lutsyk, Vera Vorob'eva, Anna Zelenaya</i> INFLUENCE OF COBTHEALT TO THE COPPER-SULFIDE INTERACTION: 3D COMPUTER MODEL OF THE Co-Cu-CoS-Cu ₂ S T-x-y DIAGRAM	295
<i>Matej Drobne, Urška Klančnik, Milan Terčelj, Peter Fajfar</i> MICROSTRUCTURAL CONSTITUENTS – IMPACT ON THERMAL FATIGUE CRACK GROWTH IN THE CAST IRON	299
<i>Zoran Karastojković, Zoran Janjušević</i> TEMPERATURE MEASURING DURING HEATING IN THE SALT BATHS BEFORE HIGH SPEED STEEL QUENCHING	303
<i>Nikola Bajić, Darko Veljić, Mihailo Mrdak, Jasmina Pekez, Zoran Radosavljević, Zoran Karastojković</i> STRUCTURE CHANGES IN THE WELD METAL AS AFUNCTION OF FILLER METAL COMPOSITION AND WELDING REGIME OF THE MICROALLOYED STEEL	307
<i>Miroslav Sokić, Srđan Stanković, Branislav Marković, Jovica Stojanović, Nela Petronijević</i> ACID LEACHING OF COPPER FROM FLOTATION TAILINGS OF THE COPPER MINE MAJDANPEK, SERBIA	311
<i>Biserka Trumić, Ljubica Radović, Vesna Krstić, Lidija Gomidželović, Aleksandra Ivanović, Saša Marjanović</i> HIGH TEMPERATURE RESISTANCE OF PLATINUM AND ITS ALLOYS IN A FUNCTION OF IMPURITIES	315
TECHNOLOGY AND CHEMISTRY	
<i>Branka Pešovski, Vesna Krstić, Danijela Simonović, Suzana Dragulović, Vesna Marjanović</i> PHYTOREMEDIATION AS A METHOD FOR WASTEWATER TREATMENT	321
<i>Vesna Krstić, Branka Pešovski, Tamara Urošević, Danijela Simonović, Lidija Gomidželović, Biserka Trumić</i> FTIR AND XPS TECHNICS FOR THE Cu ₂ + ADSORPTION AND CATALYSIS	325
<i>Dana Stanković, Milenko Ljubojev, Zlatko Ječmenica</i> REDUCTION OF SULFUR IN THE WASTE FLUE GASES OF THE POWER PLANTS USING THE LIMESTONE COMPOSITE AS THE SULFUR ABSORBENT	329
<i>Marija Petrović, Tatjana Šoštarić, Jelena Petrović, Jelena Milojković, Marija Koprivica, Mirjana Stojanović</i> CORN SILK AS A BIOSORBENT FOR THE METAL IONS REMOVAL FROM THE MINING, SMELTING AND ELECTROPLATING WASTEWATER	335
<i>Jelena Petrović, Marija Mihajlović, Marija Petrović, Mirjana Stojanović, Marija Kojić, Zorica Lopičić</i> GRAPE POMACE HYDROCHAR AS AN EFFICIENT ADSORBENT FOR CADMIUM REMOVAL	339



<i>Dragana Božić, Milan Gorgievski, Velizar Stanković, Nada Štrbac</i> PHYSICO-CHEMICAL CHARACTERIZATION OF THE BEECH SAWDUST AND WHEAT STRAW	345
<i>Vanja Trifunović, Marija Petrović Mihajlović</i> 5-CHLORO-BENZOTRIAZOLE AS A COPPER CORROSION INHIBITOR IN 3% NaCl SOLUTION	351
<i>Vladimir V. Panić, Velizar Stanković, Čedomir Dumitrašković, Silvana Dimitrijević, Aleksandar B. Dekanski, Vesna Ž. Panić, Jasmina S. Stevanović</i> DECAY OF DIMENSIONALLY STABLE ANODES IN THE COPPER POWDER PRODUCTION – EXPERIENCE FROM THE "POMETON" TIR, BOR, SERBIA	357
ENVIRONMENTAL PROTECTION	
<i>Vesna Krstić, Marko Radotić, Jane Paunković, Violeta Jovanović</i> ANALYSIS OF THE PROBLEM OF ILLEGAL DUMPS, ACASE OF THE KRAGUJEVAC MUNICIPALITY, THE REPUBLIC OF SERBIA	363
<i>Jelena V. Petrović, Sladana Alagić, Mile Dimitrijević, Mile Bugarin, Mirjana Šteharnik, Marija Milivojević</i> THE CONTENT OF HEAVY METALS IN THE SHOOTS OF COMMON REED DIFFERENTLY SUBMERGED IN LAKE ROBULE	367
<i>Tatjana Apostolovski - Trujić, Viša Tasić, Aleksandra Ivanović, Renata Kovačević, Mirjana Šteharnik</i> CORRELATIONS BETWEEN THE HEAVY METALS AND ARSENIC DETERMINED IN PM10 NEAR THE COPPER SMELTER IN BOR	371
<i>Stefan Djordjievski, Daizo Ishiyama, Yasumasa Ogawa, Zoran Stevanović, Ljubiša Obradović, Milan Jovanović</i> MOBILITY AND WEATHERING OF THE FLOTATION TAILINGS IN THE RIVER BED AND FLOODPLAIN SEDIMENTS OF THE TIMOK RIVER	377
<i>Vesna Marjanović, Radmila Marković</i> CHEMICAL METHODS FOR TESTING THE EFFICIENCY OF STABILIZATION/SOLIDIFICATION PROCESS OF MATERIAL CONTAINING THE HAZARDOUS SUBSTANCES	383
<i>Viša Tasić, Tatjana Apostolovski - Trujić, Marijana Pavlov-Kagadejev, Danilo Spalović, Vladan Miljković</i> COMPARATIVE MEASUREMENTS OF THE SUSPENDED PARTICLES (PM2.5) IN THE INDOOR AIR USING THE LOW-COST SENSORS	387
<i>Dragan Vasalić, Ivan Lazović, Sanja Petronić, Zoran Masoničić, Viša Tasić</i> ECOLOGICAL AND ECONOMIC ASPECTS OF DIESEL FUEL USE IN THE ROAD TRANSPORT BY THE HEAVY-DUTY VEHICLES IN SERBIA	393
<i>Vesna Marjanović, Radmila Marković</i> PHYSICAL METHODS FOR TESTING THE EFFICIENCY OF STABILIZATION/SOLIDIFICATION PROCESS OF MATERIAL CONTAINING THE HAZARDOUS SUBSTANCES	399



<i>Ivana Jelić, Milena Rikalović, Biljana Martinović</i> AMBIENAL AIRPOLLUTION DURING THE INFECTIOUS MEDICAL WASTE TREATMENT BY STERILIZATION	405
<i>Maja Nujkić, Mile Dimitrijević, Snežana Milić, Ana Radojević, Boban Spalović, Slađana Alagić, Jelena Kalinović</i> COPPER AND ARSENIC ACCUMULATION AND PHYTOREMEDIATION BY SOAPWORT AND YARROW GROWING IN THE VICINITY OF THE COPPER SMELTER IN BOR	409
<i>Vesna Cvetanovski, Milana Popović, Marina Birovljev</i> DATA BASE ON THE CHEMICAL ACCIDENTS - FACTS AND eMARS	413
<i>Snežana Šerbula, Jelena Milosavljević, Ana Radojević, Tanja Kalinović, Jelena Kalinović, Maja Nujkić</i> AIRBORNE METALS/METALLOIDS CONCENTRATIONS IN BOR	417
<i>Dragana Adamović, Tamara Urošević, Bojan Radović, Marija Milivojević, Ivona Bezeg-Romić</i> PHYTOREMEDIATION METHODS OF SOIL CONTAMINATED WITH HEAVY METALS	421
<i>Radmila Marković, Marina Janjušević, Aca Jovanović, Suzana Stanković, Ivan Svrkota, Ivona Bezeg Romić, Jelena Erceg</i> CHARACTERISTICS OF THE FILTER WASHING WASTE WATER IN THE DRINKING WATER TREATMENT PLANT "BELE VODE"	425
<i>Rabab Almabrouk Alhadi Salih, Dunja Antonijević, Teodora Nedić, Igor Čeliković, Boris Lončar</i> RADON CONCENTRATION IN THE SHALLOW LAYERS OF SOIL	429
<i>Teodora Nedić, Luka Rubinjoni, Rabab Alamabrouk Alhadi Salih, Igor Čeliković, Boris Lončar</i> MEASURING THE RADON EXHALATION FROM THE CENTRAL AND SOUTH-WESTERN SERBIA SOIL SAMPLES	433
<i>Cosmin Vancea, Giannin Moșoarcă, Marius Gheju, Petru Negrea</i> THE NEW ALTERNATIVES FOR INERTIZATION THE EXHAUSTED REACTIVE MIXTURES RESULTED FROM REMOVAL OF Cr(VI) WITH Fe ₀ IN A CONTINUOUS-FLOW SYSTEM	437

RELATED FIELDS:

**MECHANICAL ENGINEERING,
CIVIL ENGINEERING, ARCHITECTURE, ELECTRONICS,
INFORMATION, MANAGEMENT, ETC.**

<i>Branislav Rajković, Dejan Tanikić, Zoran Ilić</i> DETERMINATION THE OPERATING REGIMES OF A BOILER SHUNT PUMP	441
<i>Marijana Pavlov-Kagadejev, Visa Tasić, Vladan Miljković, Danilo Spalović</i> THERMAL IMAGING CAMERAS FOR INDUSTRIAL APPLICATIONS	447
<i>Milan Radivojević, Miša Stević, Zoran Stević</i> REALIZATION OF THE COMPUTER CONTROLLED SYSTEM FOR THE THERMAL ANALYSIS OF MATERIAL	453



05	<i>Milan Radivojević, Miša Stević, Marko Tanasković</i> APPLICATION OF THE LabVIEW PROGRAM PACKAGE FOR CONTROL AND MONITORING THE PROCESS OF REBALLING BGA CHIPS457
09	<i>Slavica Miletić, Dejan Bogdanović, Miodrag Manić, Dragan Mihajlović</i> IDENTIFICATION THE EFFECT OF FACTORS ON PREJUDICES IN THE ENTREPRENEURIAL DECISION MAKING IN MINING461
13	<i>Slavica Miletić, Dejan Bogdanović, Valentina Velinov, Bojan Stojčetočić, Miladin Đurić</i> ANALYSIS OF THE EXTERNAL ENVIRONMENT OF THE ORGANIZATION465
17	<i>Jelena Đorđević, Sandra Filipović, Jelena Stanković</i> ALLOWABLE STRESS AND PLASTIC ANALYSIS CARRIED OUT ON A STEEL TRUSS469
21	<i>Sandra Filipović, Jelena Đorđević, Jelena Stanković</i> ANALYTICAL SOLUTION FOR THE ANGLE-PLY PLATES USING THE FIRST ORDER SHEAR DEFORMATION PLATE THEORY473
25	<i>Vitaly Solodovnikov</i> DEVELOPING THE SUPPLY CHAIN PLANNING METHODOLOGY FOR METALS477
29	<i>Ghassan S. El-Masry, Benur Maatug, Mustafa El-Musbahi</i> ELECTRICAL DISCHARGE MACHINING (CUTTING METAL TO PRECISE SHAPES USING THE ELECTRICITY)481
33	<i>Gabrijela Popović, Bojan Djordjević, Dragan Milanović</i> THE MCDM APPROACH IN A CRITERIA PRIORITIZATION IMPORTANT FOR THE COPPER ORE MINING METHOD SELECTION487
37	<i>Predrag Stolić, Danijela Milošević, Aleksandra Milosavljević</i> E-LEARNING AND LOG ANALYSIS IN INTRODUCTION THE NEW TECHNOLOGIES AND TECHNOLOGICAL SOLUTIONS491
41	DONORS497
43	AUTHOR INDEX 513



GRAPE POMACE HYDROCHAR AS AN EFFICIENT ADSORBENT FOR CADMIUM REMOVAL

Jelena Petrović, Marija Mihajlović, Marija Petrović, Mirjana Stojanović,
Marija Kojić, Zorica Lopičić

Institute for Technology of Nuclear and Other Mineral Raw Materials,
86 Franchet d'Esperey St., 11000 Belgrade, Serbia,
E-mail: j.petrovic@itnms.ac.rs

Abstract

Hydrochar prepared from the hydrothermal carbonization of the grape pomace was investigated as potential adsorbent for the Cd^{2+} from aqueous solution. To increase the sorption efficiency, the hydrochar was modified using the different chemical treatments (citric acid (CA), H_2O_2 and KOH) and characterized by a FTIR spectroscopy. The preliminary adsorption tests showed that the adsorption capacity of hydrochars was 3.8 before and 5.0, 14.5 and 49.34 mg/g upon modification by CA, H_2O_2 and KOH, respectively. It was observed that the KOH activation enhances the surface functionality of hydrochar, and thus significantly improves the Cd^{2+} adsorption capacity. Therefore, the KOH-modified hydrochar should be considered as an efficient adsorbent for Cd^{2+} removal.

Keywords: Grape pomace, cadmium removal, hydrothermal carbonization, material modification

1 INTRODUCTION

Extensive utilization of fossil fuels and rapid expansion and development of industrial activities in the last decades, caused increased emission and discharge of heavy metals into the environment [1]. Due to its cumulative effects and toxicity even in low concentrations, heavy metals are potential threat to the environment, humans and other living organisms [2]. Cadmium (Cd) has been considered as one of the most harmful heavy metals for humans since it easily seriously endangers our liver, kidney and skeleton even in trace amounts [3]. This metal can be found in high concentration in liquid industrial waste, especially in wastewaters from metal smelting, battery manufacturing and chemical production [1]. Therefore, it is necessary to find a solution for the Cd pollution problem, and prevent discharge of industrial wastewater into the watercourses without prior purification.

Until now, a numerous physical, chemical, and biological removal techniques have been applied for the adsorption of heavy metals from wastewaters before its releasing into the environment [2]. However, conventional techniques usually exhibited certain limitation, and adsorption became prominent and preferred method for remediation of heavy metals from waters [1,2]. This technology has numerous advantages that include regeneration of adsorbent, easy operation, low cost and high efficiency [4]. So far a numerous materials have been investigated as potential adsorbents of Cd^{2+} , such as waste biomass, polymers, zeolites and activated carbons [1,4].

Along with the adsorption, development of novel adsorbent materials is on the increase. One of such material is hydrochars, produced by hydrothermal carbonization of different waste biomasses [5]. Many literatures have suggested hydrochars as a



promising alternative agent for the treatment of heavy metals. This material have more advantageous compared to activated carbons and biochar, such as mild reaction conditions, high conversion efficiency of wet biomass load and abundance of reactive oxygen functional groups (OFGs) (e.g., hydroxyl and carboxylic) on its surface [2,6]. In order to further increase of the adsorption capacity, various modification methods have been developed [2,7,8]. Previous publication showed that alkali modification (KOH or NaOH) and modification with hydrogen peroxide (H_2O_2), have a significantly improved hydrochar sorption ability [7,8,9].

The specific objectives of this study was to investigate the ability of grape pomace hydrochar (GPHC) as adsorbent of Cd^{2+} ions from aqueous solution and to determine the impact of different modification on hydrochar adsorption properties. Particular interest of this study was to explore the suitability of GP as a precursor for preparation of adsorbent, since this type of biomass is largely available in Serbia. In order to improve the adsorption capacity, the produced hydrochar was modified using the KOH and for the first time with H_2O_2 and CA solutions. The present work shows the feasibility of novel utilization the waste GP into a value-added hydrochar (HC) with a high adsorption ability for removal of heavy metals like Cd^{2+} .

2 EXPERIMENTAL

2.1 Biomass

The used GP was left behind after the wine processing at open landfill sites at a test plot Radmilovac, from witch was randomly collected. To obtain homogeneity of the sample, biomass was air-dried to constant weight and grinded. Sieved fraction of 0.5 mm was used in further hydrothermal carbonization experiments.

2.2 Hydrochar Preparation and Activation

Preparation of the GPHC was carried out in a laboratory autoclave (Carl Roth, Model II), equipped with temperature controller and thermocouple. Total volume of autoclave was 250 mL, and reaction loads included 10 g of biomass and 150 mL of ultrapure water (1:15 ratio), and was carbonized at 220°C within 1 h at reaction temperature. After that period, the HC and process water were filtered. Obtained GP-HC was rinsed with water and dried to constant weight. To make the modified GP-HC tree different techniques were performed. KOH modification of HC (HCGP-KOH) was described at our previous work [2]. For H_2O_2 modification (HCGP- H_2O_2) 3 g of HC was stirred with 40 ml H_2O_2 (10 %) during 2 hours [10]. Additionally, inspired by previous work of Sun et al. (2015) HC was modified using citric acid [11]. In this modification, 2 g of HC was mixed with 0.6 M citric acid solution at ratios of 1:8 (w:v) for 30 min (HCGP-CA). All modification processes were obtained at room temperature and produced HCs were filtered, rinsed with distilled water and dried overnight in an oven at 105°C.



2.3 Chemical

Cadmium nitrate salt ($Cd(NO_3)_2$) was

2.4 Prelimin

Removal adsorption test flasks containing temperature were measured (Spekol 300).

The adsorption using the following

$$q = \frac{C_0 - C_e}{R}$$

$$R = \frac{C_0 - C_e}{V}$$

where V, C_0 and C_e respectively

2.5 FTIR S

The FTIR mode using range of 4000

3 RESULT

3.1 Prelim

The GPHC exhibited 3.8 mg/g significant adsorption. GPHC-KOH that most KOH mo



2.3 Chemicals

Cadmium solutions and standards were prepared using analytical grade cadmium nitrate salt ($\text{Cd}(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$, Sigma-Aldrich). A stock cadmium nitrate solution (56 mg/L $\text{Cd}(\text{NO}_3)_2$) was prepared with deionized water.

2.4 Preliminary Adsorption Test

Removal of Cd^{2+} ions using GPHC and modified HCs were performed at batch adsorption test. Adsorbent mass of 0.025 g of each HC was added to 100 mL volumetric flasks containing 25 mL of standard Cd^{2+} solution (56 mg/L), and shaken at room temperature for 120 min at 250 rpm. The content of Cd^{2+} ions in the resultant filtrates were measured using Atomic Absorption Spectrophotometer (AAS) (Analytic Jena Spekol 300).

The adsorption capacity and removal percentage at equilibrium q were calculated using the following equation (1) and (2) respectively:

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

$$R = \frac{C_0 - C_{eq}}{C_0} \times 100\% \quad (2)$$

where V , is the volume of the Cd^{2+} solution (L), m is the amount of adsorbent (g); C_0 and C_{eq} are the initial and equilibrium concentrations of the Cd^{2+} ions (mg/L) respectively.

2.5 FTIR Spectroscopy

The FTIR analysis of modified HC was performed in the Attenuated total reflection mode using Thermo Scientific Nicolet iS50. The spectra were obtained in the spectral range of 4000-400 cm^{-1} .

3 RESULTS AND DISCUSSION

3.1 Preliminary Adsorption Test

The preliminary adsorption results showed (Figure 1) that the HCGP-KOH exhibited the best ability for Cd^{2+} removal. The adsorption capacity was increased from 3.8 mg/g in GPHC, to 49.34 mg/g in GPHC-KOH. Besides, the same HC showed a significant increase in the removal percentage. At applied adsorption conditions the GPHC-KOH remove up to 95.62 % of Cd^{2+} ions from the solution. This study has shown that most suitable technique for production the efficient GPHC-based adsorbents was KOH modification. Obtained results are in agreement with literature data stating that the

alkali modification of HCs may increase the porosity, surface area and cause the change of surface functional groups of HC [2,6,8].

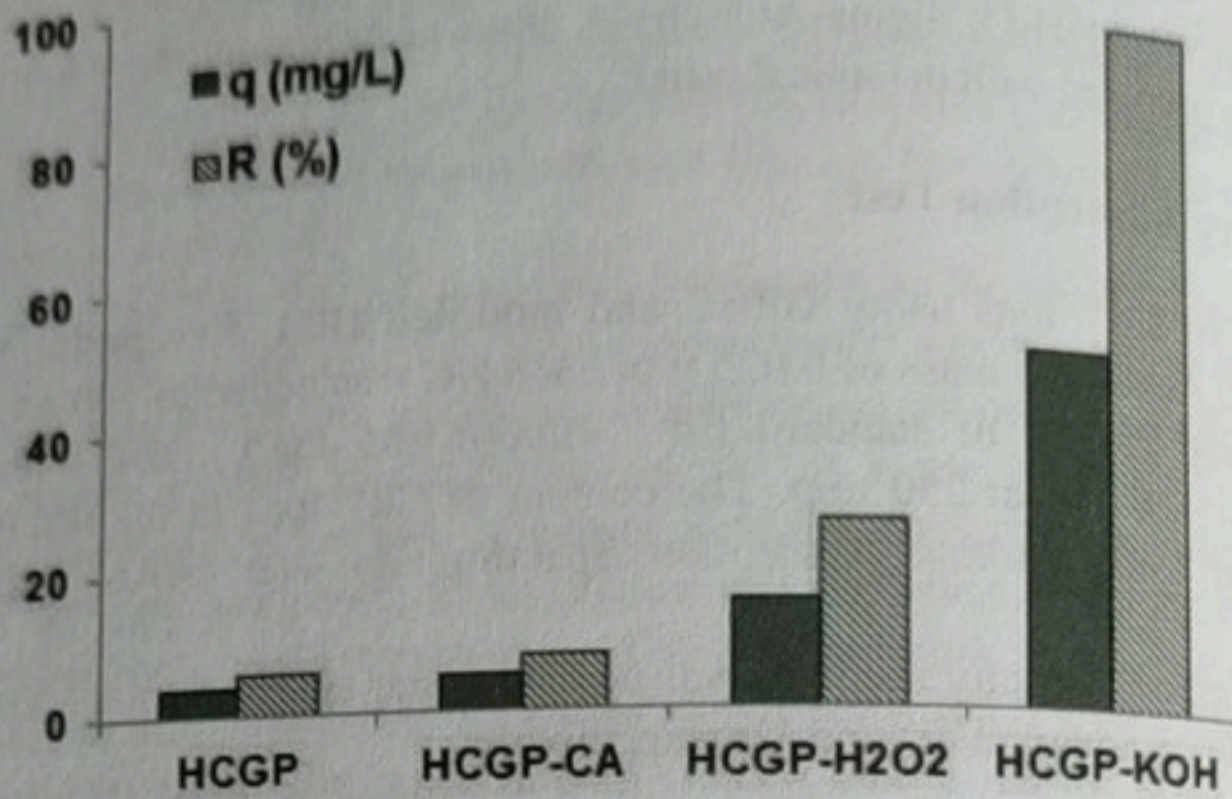


Figure 1 Cd²⁺ removal using HC and modified HCs

3.2 FTIR Spectroscopy

FTIR spectrums of modified HCs are presented in Figure 2.

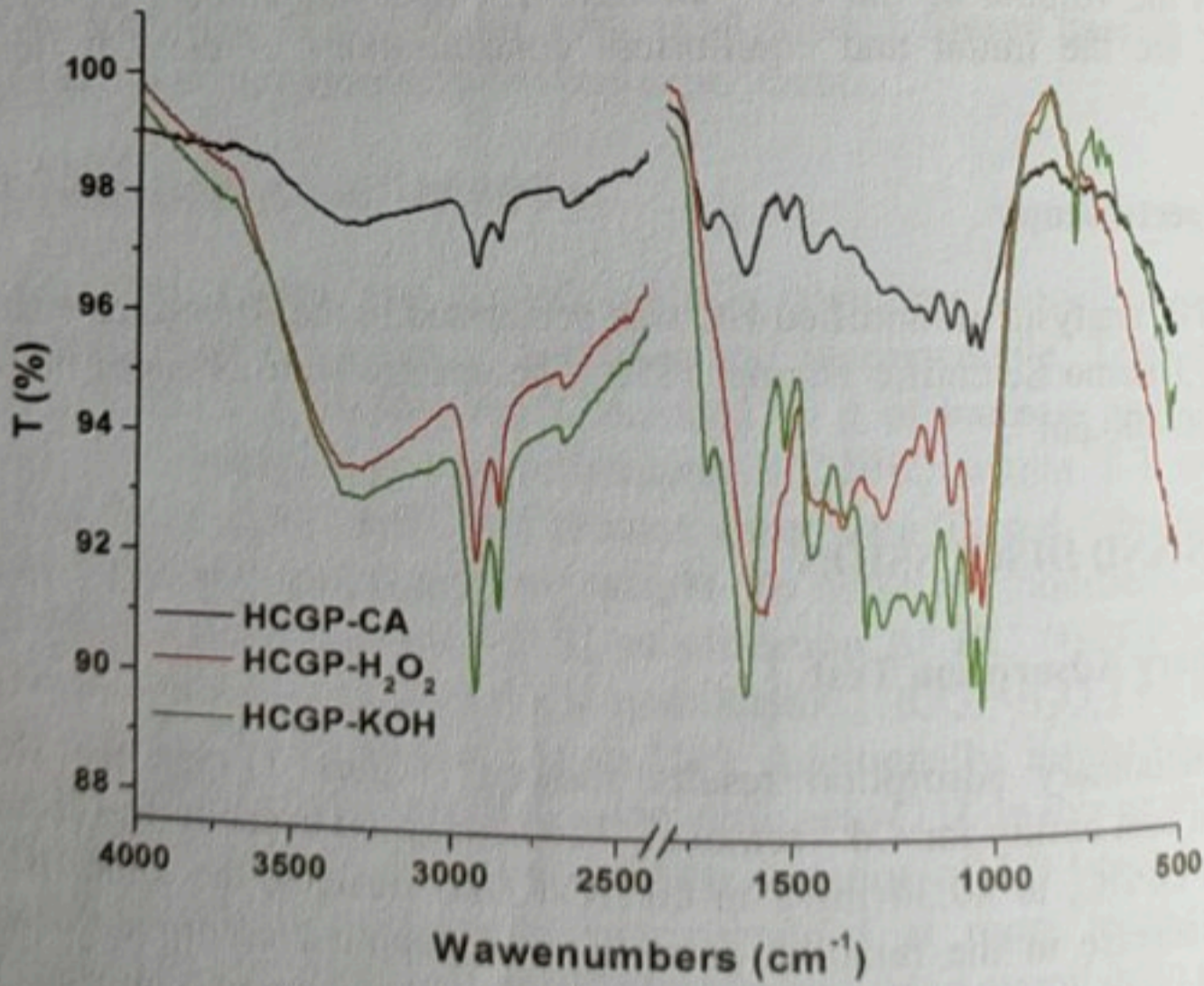


Figure 2 FTIR spectra of modified HCs

As can be seen from the structure. After 1617, 1058 and 1017 cm⁻¹ to an oxidation [1,10]. However, it is more pronounced. This is accordingly more adsorption ability relative to the previous studies.

4 CONCLUSIONS

The results show that the higher adsorption capacity of GPHC-CA. This is due to which might be the effect of alkali modification. This is a promising method for removal from wastewater.

ACKNOWLEDGMENTS

The authors thank the Development of the project included in the project.

REFERENCES

- [1] H. Zhang, J. Pei, L. Miha, (2017) 795-800
- [2] J. Pei, L. Miha, (2017) 266-271
- [3] L. Miha, (2017) 266-271
- [4] N. K. S. T. (2017) 266-271
- [5] M. N. S. T. (2017) 266-271



As can be seen from Figure 2, all three modifications caused changes in the GPHC structure. After treatments the peaks attributed to O-H and C-O vibrations (3385 cm^{-1} , 1617 , 1058 and 1033 cm^{-1}) become more apparent. The reason for that may be ascribed to an oxidation of certain groups to carboxyl group of organic acid during modification [1,10]. However, subsequent to alkaline modification these peaks become the most pronounced. This suggests that GPHC-KOH have more OFGs than other HCs, and accordingly more electron donating sites for Cd^{2+} adsorption. This may explain the better adsorption ability of the produced material and the advantage of alkaline modification relative to modification using H_2O_2 and CA. The obtained result is in agreement with previous studies that investigated alkali modification of different hydrochars [2,6,8].

4 CONCLUSION

The results from this study showed that the GPHC-KOH exhibited significantly higher adsorption capacity and percentage of Cu^{2+} removal than the GPHC- H_2O_2 and GPHC-CA. The differences in FTIR spectra of HCs samples showed structural changes which might affect the increase of the Cd^{2+} sorption ability, and provide an explanation of alkali modification influence onto HC surface. Our findings suggest that the waste GP is a promising precursor for production the quality and efficient adsorbents for Cd^{2+} removal from the industrial wastewater using the hydrothermal carbonization.

ACKNOWLEDGEMENTS

The authors are grateful to the Ministry of Education, Science and Technological Development of the Republic Serbia for the financial support of this investigation included in the Project TR 31003.

REFERENCES

- [1] H. Zhang, X. Yue, F. Li, R. Xiao, Y. Zhang, D. Gu., *Sci. Total Environ.* 631-632 (2018) 795-802.
- [2] J. Petrović, M. Stojanović, J. Milojković, M. Petrović, T. Šoštarić, M. Laušević, M. Mihajlović., *J. Environ. Manage.*, 182 (2016) 292-300.
- [3] L. Han, H. Sun, K. S. Ro, K. Sun, J. A. Libra, B. Xing., *Bioresour. Technol.*, 234 (2017) 77-85.
- [4] N. K. Koju, X. Song, Q. Wang, Z. Hu, C. Colombo, *Environ. Pollut.*, 240 (2018) 255-266.
- [5] M. Mihajlović, J. Petrović, S. Maletić, M. Kragulj Isakovski, M. Stojanović, Z. Lopičić, S. Trifunović., *Energy Convers. Manag.* 159 (2018) 254-263.



- [6] S.E. Elaigwu, V. Rocher, G. Kyriakou, G.M. Greenway., *J. Ind. Eng. Chem.*, 20 (2015) 3467-3473.
- [7] P. Regmi, J. Moscoso, S. Kumar, X. Cao, J. Mao, G. Schafran., *J. Environ. Manage.*, 109 (2012) 61-69.
- [8] X.J. Zuo, Z. Liu, M.D. Chen., *Bioresour. Technol.*, 207 (2016) 262-267.
- [9] K. Sun, J. Tang, Y. Gong, H. Zhang., *Environ. Sci. Pollut. Res.*, 22 (2015) 16640-16651.
- [10] A. Cibati, B. Foereid, A. Bissessur, S. Hapca, *J. Clean. Prtod.*, 162 (2017) 1285-1296.
- [11] L. Sun, D. Chen, S. Wanb, Z. Yu., *Bioresour. Technol.*, 198 (2015) 300-308.



Abstract

This wheat straw charge of sawdust revealed the beech

Key
zero char

1 INTR

De addition and land Release accelera metals metallic process macy, v from ac [1]. The Zn, Hg several water [proper ultim "surplu biomasa sawdu energy adsorp

2 EXI