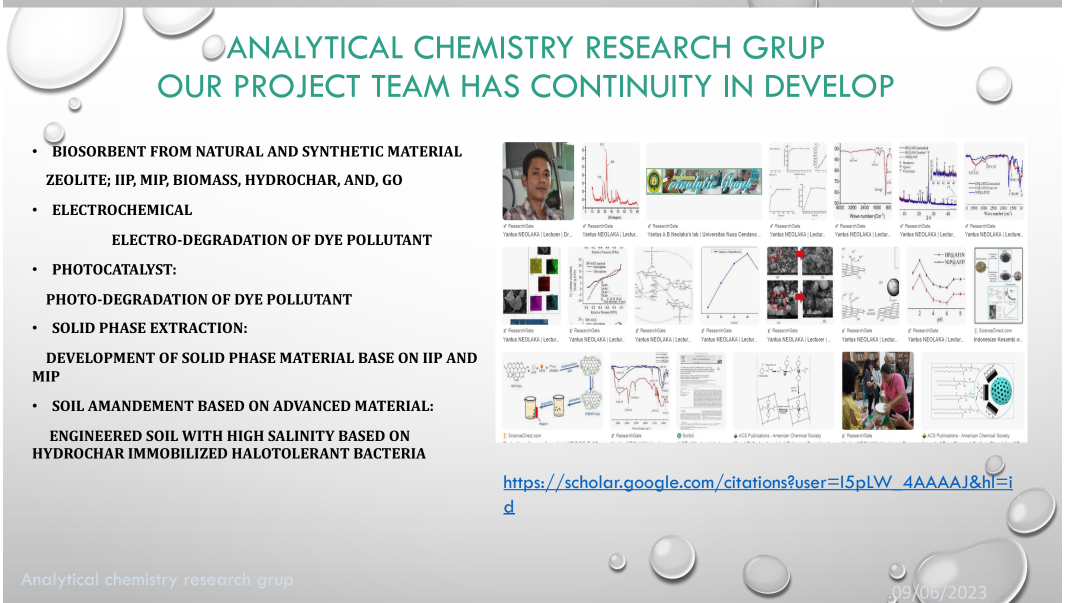

SEMINAR NASIONAL PENDIDIKAN DAN SAINS KIMIA VI TAHUN 2023
CHEMICAL EDUCATION DEPARTMENT-FKIP UNDANA
UNIVERSITAS NUSA CENDANA
HYDROTHERMAL CARBONIZATION MATERIAL FROM COW-BONES
DEVELOPMENT OF BIOSORBENT FOR DYE REMOVAL
Yantus A.B Neolaka
09/06/2023
Analytical chemistry research grup


ANALYTICAL CHEMISTRY RESEARCH GRUP
OUR PROJECT TEAM HAS CONTINUITY IN DEVELOP
• BIOSORBENT FROM NATURAL AND SYNTHETIC MATERIAL
ZEOLITE; IIP, MIP, BIOMASS, HYDROCHAR, AND, GO
• ELECTROCHEMICAL
ELECTRO-DEGRADATION OF DYE POLLUTANT
• PHOTOCATALYST:
PHOTO-DEGRADATION OF DYE POLLUTANT
• SOLID PHASE EXTRACTION:
DEVELOPMENT OF SOLID PHASE MATERIAL BASE ON IIP AND MIP
• SOIL AMANDEMENT BASED ON ADVANCED MATERIAL:
ENGINEERED SOIL WITH HIGH SALINITY BASED ON HYDROCHAR IMMOBILIZED HALOTOLERANT BACTERIA
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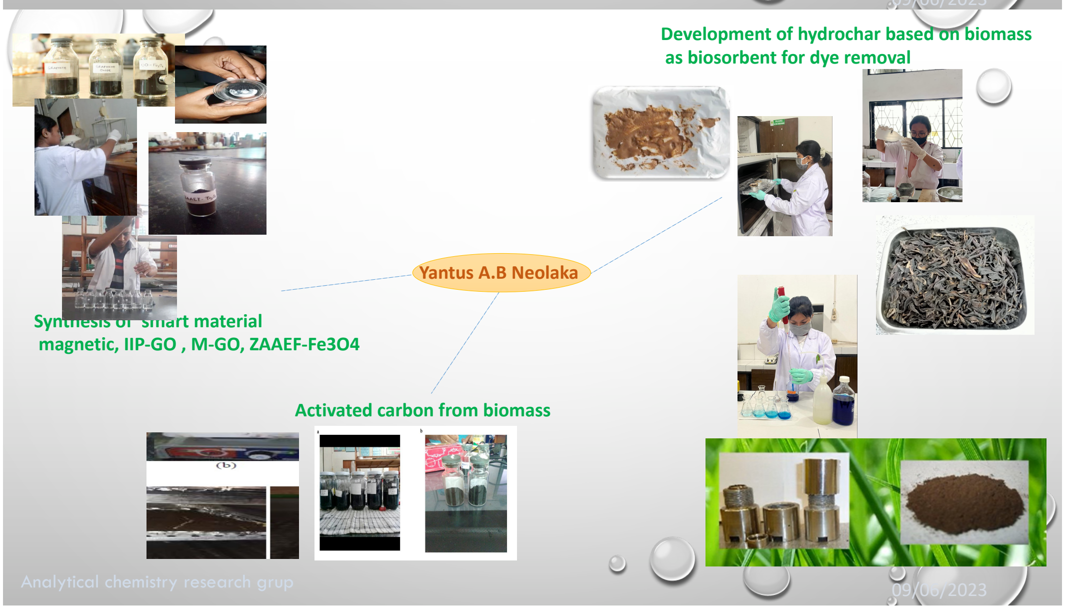
Development of hydrochar based on biomass
as biosorbent for dye removal
Yantus A.B Neolaka
smart material
magnetic, IIP-GO , M-GO, ZAAEF-Fe3O4
Activated carbon from biomass
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CONTENT

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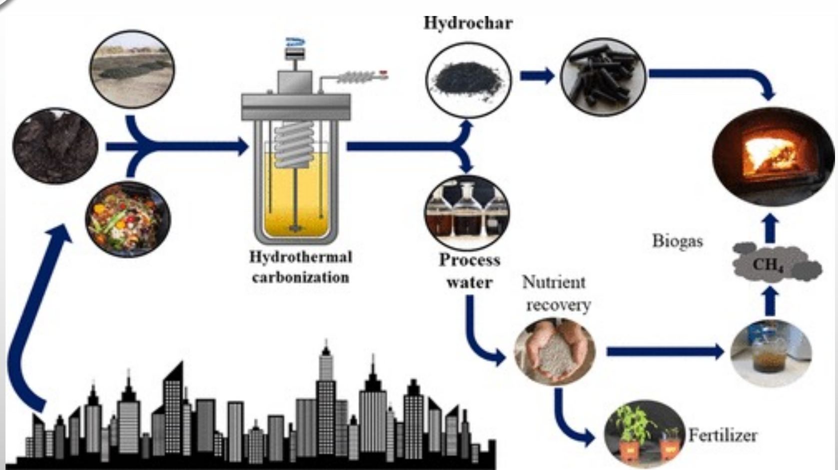
BACKGROUND OF RESEARCH OF BIOSORBENT

- THE RESEARCH ON BIOSORBENTS FOCUSES ON THE DEVELOPMENT AND APPLICATION OF NATURAL OR MODIFIED MATERIALS FOR THE REMOVAL OF POLLUTANTS FROM VARIOUS ENVIRONMENTAL MATRICES, SUCH AS WATER, AIR, AND SOIL. BIOSORBENTS ARE MATERIALS DERIVED FROM LIVING OR ORGANIC SOURCES THAT HAVE THE ABILITY TO BIND OR ADSORB CONTAMINANTS ONTO THEIR SURFACE OR WITHIN THEIR STRUCTURE.
- THE BACKGROUND OF BIOSORBENT RESEARCH CAN BE TRACED BACK SEVERAL DECADES WHEN SCIENTISTS BEGAN EXPLORING ALTERNATIVE AND SUSTAINABLE METHODS FOR TREATING AND REMEDIATING CONTAMINATED ENVIRONMENTS. TRADITIONAL METHODS, SUCH AS CHEMICAL PRECIPITATION AND ACTIVATED CARBON ADSORPTION, HAVE LIMITATIONS IN TERMS OF COST, EFFICIENCY, AND ENVIRONMENTAL IMPACT. BIOSORBENTS OFFER A PROMISING ALTERNATIVE DUE TO THEIR ABUNDANT AVAILABILITY, LOW COST, BIODEGRADABILITY, AND POTENTIAL FOR HIGH POLLUTANT REMOVAL EFFICIENCY.
- THE RESEARCH ON BIOSORBENTS INVOLVES STUDYING DIFFERENT TYPES OF BIOMASS, INCLUDING AGRICULTURAL WASTE, PLANT MATERIALS, ALGAE, FUNGI, BACTERIA, AND VARIOUS BYPRODUCTS FROM INDUSTRIES. THESE BIOMATERIALS POSSESS NATURAL SORPTION PROPERTIES, SUCH AS SURFACE FUNCTIONAL GROUPS (E.G., HYDROXYL, CARBOXYL, AMINO GROUPS), COMPLEX POLYSACCHARIDES, PROTEINS, AND OTHER ORGANIC COMPOUNDS, WHICH ENABLE THEM TO INTERACT WITH AND CAPTURE CONTAMINANTS.

Principles of hydrochar Production



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PRINCIPLES FACTOR OF HYDROCHAR

The principles of hydrothermal carbonization include:

Temperature and Pressure: HTC requires elevated temperatures typically ranging from 180 to 250 degrees Celsius and pressures between 10 and 25 bar. These conditions facilitate the breakdown of complex organic compounds and promote carbonization.

Residence Time: The biomass or organic waste materials are exposed to the elevated temperature and pressure for a specific duration known as the residence time. Residence time can vary from a few minutes to several hours, depending on the desired characteristics of the hydrochar.

Water as a Reaction Medium: Water plays a crucial role in HTC. It acts as both a reaction medium and a source of hydrogen for the carbonization process. Water also helps maintain the required pressure and temperature conditions for the reaction.

Carbonization Reactions: During hydrothermal carbonization, complex organic molecules in the biomass undergo several chemical reactions. These reactions include dehydration, decarboxylation, depolymerization, and condensation. These processes lead to the breakdown of the biomass into simpler carbon compounds, resulting in the formation of hydrochar.

Carbon-rich Product: The end product of hydrothermal carbonization is hydrochar, which is a carbon-rich material resembling coal or charcoal. Hydrochar has a high carbon content and can be used as a solid fuel or as a precursor for the production of activated carbon, biochar, or carbon-based materials.

Nutrient Retention: One of the advantages of hydrothermal carbonization is that it can retain a significant portion of the nutrients present in the biomass or organic waste materials. The hydrochar produced contains residual nutrients such as nitrogen, phosphorus, and potassium, which can be beneficial for agricultural applications when used as a soil amendment.

Environmental Benefits: Hydrothermal carbonization offers several environmental benefits. It can effectively convert various types of biomass and organic waste into a stable and energy-dense carbon product, reducing the volume of waste and mitigating greenhouse gas emissions. The process also helps in the recycling of nutrients and can contribute to the development of a circular economy.

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Some of the commonly used hydrochar synthesis methods:

Hydrothermal Carbonization (HTC): HTC is a widely employed method for hydrochar synthesis. It involves subjecting biomass or organic waste to high temperature (180-250 degrees Celsius) and pressure (10-25 bar) in the presence of water. The biomass undergoes carbonization, resulting in the formation of hydrochar.

Pyrolysis: Pyrolysis is a thermochemical process that involves the decomposition of biomass or organic waste in the absence of oxygen. The biomass is heated at high temperatures (typically 300-800 degrees Celsius) to induce the breakdown of complex organic compounds into simpler carbonaceous materials, including hydrochar.

Torrefaction: Torrefaction is a mild thermal treatment process conducted at temperatures typically between 200 and 300 degrees Celsius in an inert atmosphere. Biomass is heated under controlled conditions to remove moisture and volatile components, resulting in the production of hydrochar.

Slow Pyrolysis: Slow pyrolysis involves the gradual heating of biomass at relatively low temperatures (around 400-600 degrees Celsius) in the absence of oxygen. This method allows for the production of a higher proportion of solid hydrochar compared to other volatile products.

Hydrothermal Liquefaction (HTL): HTL is a process that utilizes elevated temperature and pressure in the presence of a solvent (typically water) to convert biomass or organic waste into a liquid product known as bio-oil. During the HTL process, a solid residue called hydrochar is also formed.

Microwave-Assisted Carbonization: This method involves the application of microwave energy to biomass or organic waste in the presence of water. The microwaves rapidly heat the biomass, promoting the carbonization process and resulting in the formation of hydrochar.

Co-pyrolysis: Co-pyrolysis involves the simultaneous or sequential pyrolysis of two or more feedstocks. It can be conducted with different combinations of biomass, waste materials, or coals. Co-pyrolysis can enhance the production of hydrochar with desired properties by combining different precursor materials.

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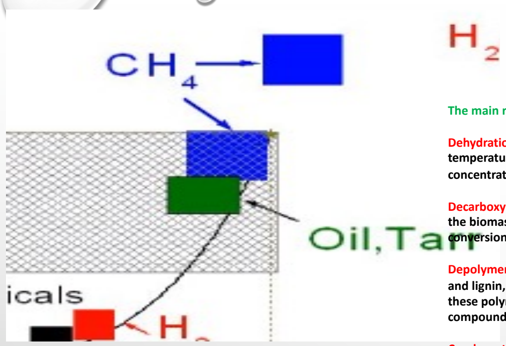

The main reaction principles of HTC include:

Dehydration: During HTC, the water present in the biomass or organic waste undergoes dehydration. High temperature and pressure conditions cause the removal of water molecules from the biomass, leading to the concentration of carbonaceous materials.

Decarboxylation: Decarboxylation is a key reaction in HTC where carboxylic acid groups (-COOH) present in the biomass are eliminated, resulting in the release of carbon dioxide (CO2). This reaction contributes to the conversion of complex organic compounds into simpler carbonaceous structures.

Depolymerization: The complex organic polymers present in the biomass, such as cellulose, hemicellulose, and lignin, undergo depolymerization during HTC. High temperature and pressure conditions break down these polymers into smaller molecular fragments, including sugars, aromatic compounds, and other organic compounds.

Condensation: Condensation reactions occur in HTC, leading to the formation of new carbon-carbon bonds. The smaller molecular fragments resulting from depolymerization can react with each other or with other reactive species present in the system, forming larger carbonaceous structures. This process contributes to the carbonization and densification of the biomass.

Hydrogenation and Hydrogen Transfer: HTC also involves hydrogenation reactions where hydrogen atoms are incorporated into the carbonaceous structures. Water acts as a source of hydrogen during these reactions. Hydrogen transfer reactions can also occur, facilitating the redistribution of hydrogen within the reactants.

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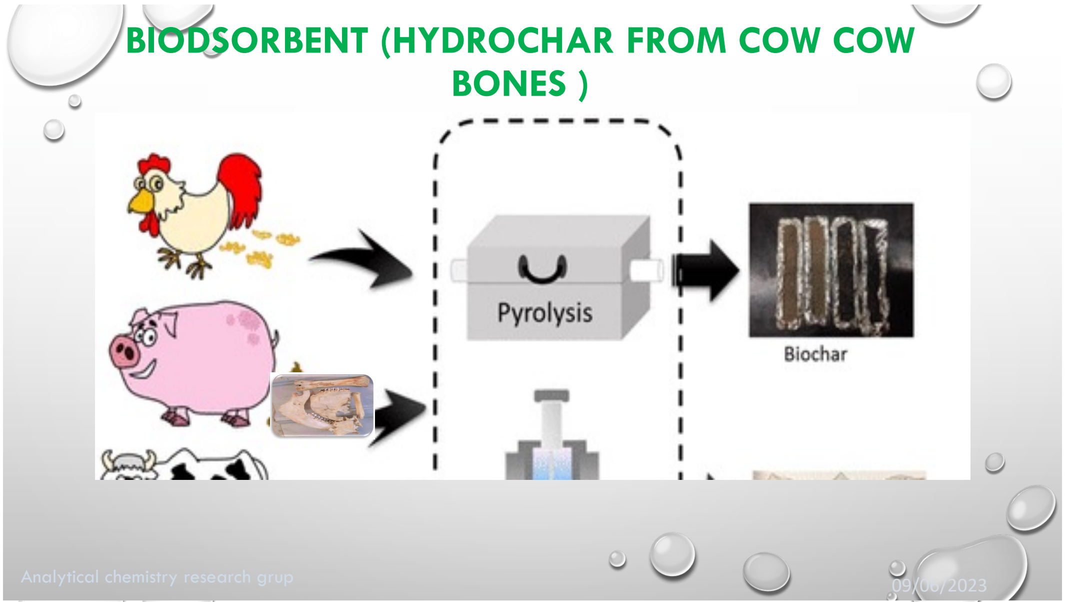
BIODSORBENT (HYDROCHAR FROM COW COW BONES)
Pyrolysis
Biochar
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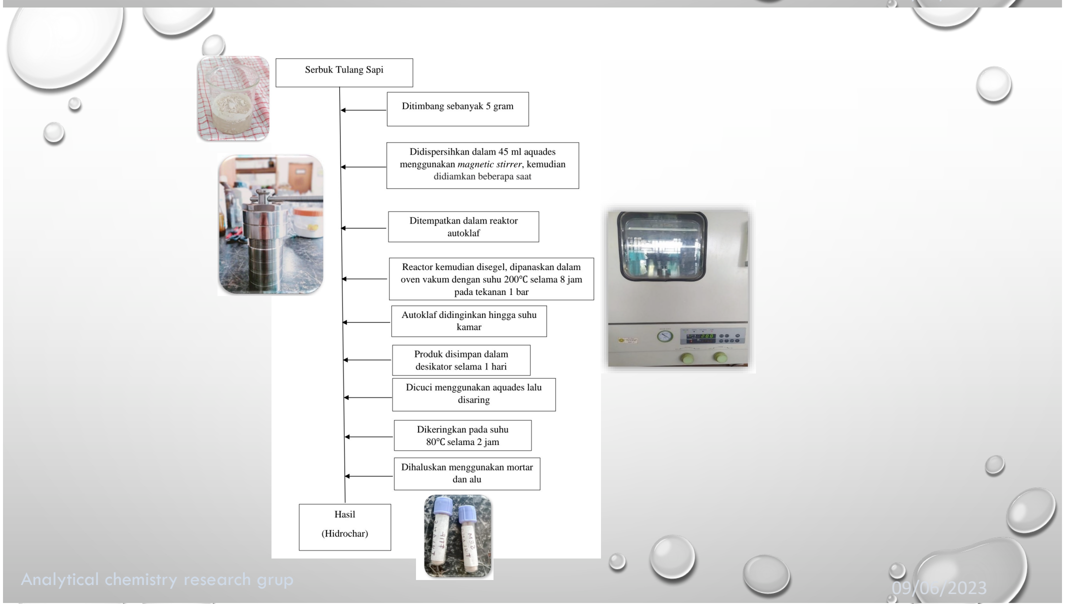
Serbuk Tulang Sapi
Ditimbang sebanyak 5 gram
Didispersihkan dalam 45 ml aquades menggunakan magnetic stirrer, kemudian didiamkan beberapa saat
Ditempatkan dalam reaktor autoklaf
Reactor kemudian disegel, dipanaskan dalam oven vakum dengan suhu 200°C selama 8 jam pada tekanan 1 bar
Autoklaf didinginkan hingga suhu kamar
Produk disimpan dalam desikator selama 1 hari
Dicuci menggunakan aquades lalu disaring
Dikeringkan pada suhu 80°C selama 2 jam
Dihaluskan menggunakan mortar dan alu
Hasil (Hidrochar)
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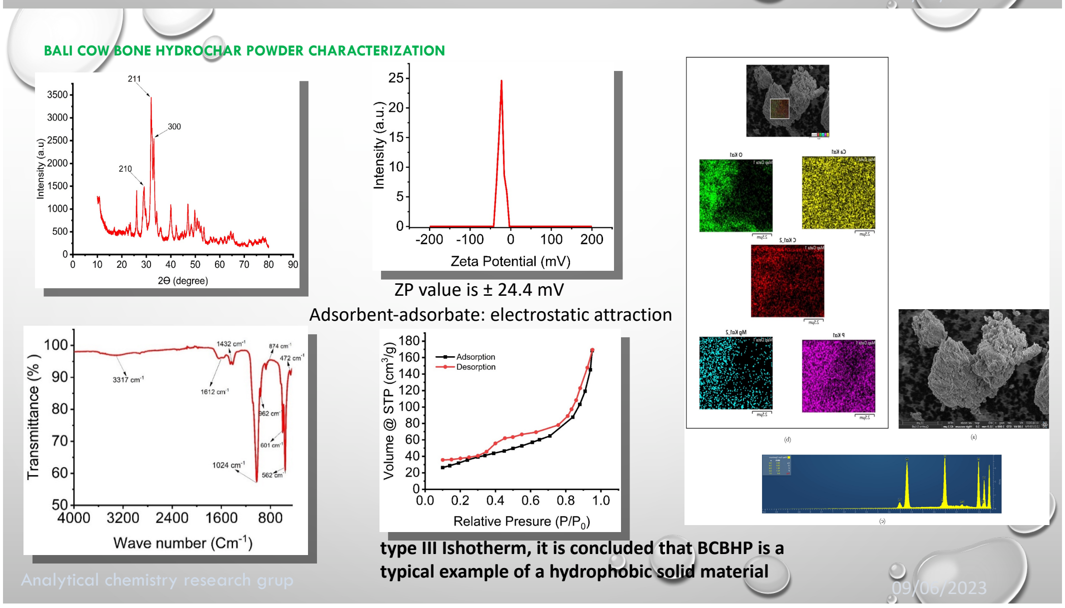
BALI COW BONE HYDROCHAR POWDER CHARACTERIZATION
Intensity (a.u.)
2θ (degree)
Intensity (a.u.)
Zeta Potential (mV)
ZP value is ± 24.4 mV
Adsorbent-adsorbate: electrostatic attraction
Transmittance (%)
Wave number (Cm-1)
Adsorption
Desorption
Volume @ STP (cm3/g)
Relative Presure (P/P0)
type III Ishotherm, it is concluded that BCBHP is a typical example of a hydrophobic solid material
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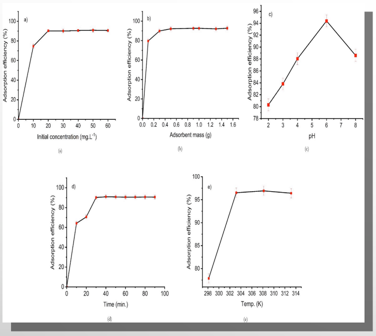
OPTIMIZATION ADSORPTION PARAMETER OF MR



Optimization parameter of adsorption methyl red on BCBHP.

No	Adsorption parameters	Optimum conditions	qe ($mg.g^{-1}$)
1	Mass adsorbent (g)	0.5	2.52
2	Initial concentration $mg.L^{-1}$	20	3.61
4	Contact time (min.)	30	3.60
3	pH	6	3.77
5	Temperature (K)	303.15	3.86

When BCBHP is spread in water, its hydrophobic characteristic allows the surface to absorb hydrogen ions (H+) and become positively charged

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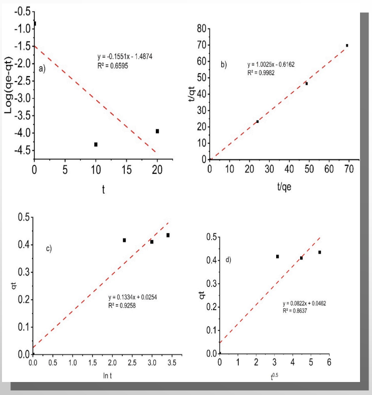
KINETICS MODELING



Kinetics modeling data of adsorption methyl red on BCBHP.

Kinetics model	Parameters
PFO	$R^2 = 0.659$
	$K_1 = 0.005\ L\ min^{-1}$
	$q_e = 6.502\ mg\ g^{-1}$
PSO	$R^2 = 0.998$
	$K_2 = 1.614\ g\ mg^{-1}.min^{-1}$
	$q_e = 0.997\ mg\ g^{-1}$
Elovich	$R^2 = 0.925$
	$\alpha = 9.068\ mg\ g^{-1}.min^{-1}$
	$\beta = 7.496\ mg\ g^{-1}$
Intraparticle diffusion	$R^2 = 0.863$
	$K_{dif} = 0.008\ mg\ g^{-1}.min^{-0.5}$
	$C = 0.046\ mg\ g^{-1}$

kinetic model of methyl red adsorption on BCBHP follows a pseudo-second-order model. This result is indicated by the value of the linear regression coefficient (R2) is 0.998, where the value of this coefficient is very linear. It can be assumed that the adsorption rate of methyl red dye on the BCBHP adsorbent occurs at a specific active site. In addition, it was determined that chemical adsorption was the primary regulating mechanism for adsorption. One possible mechanism is electron exchange between the adsorbent and the Methyl Red dye analytedominated by the chemisorption process with relatively large surface heterogeneity of the adsorbent

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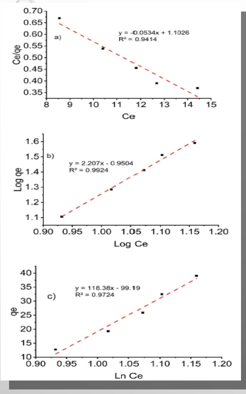
ISOTHERM MODELLINGS

Values of various thermodynamic parameters of methyl red adsorption on BHP.

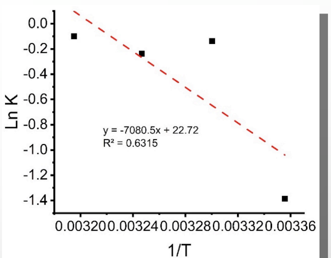
Temperatures (K)	ΔG° ($kJ.mol^{-1}$)	ΔH° ($kJ.mol^{-1}$)	ΔS° ($kJ.mol^{-1}$)
298	−115.158	−58.867	0.188
303	−116.102		
308	−117.047		
313	−117.991		

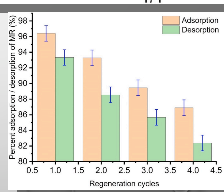


Parameter values of several isotherm models of methyl red on BCBHP.

Isotherm models	Parameters	
Langmuir	R^2	0.941
	q_m ($mg.g^{-1}$)	0.906
	K_L ($L.mg^{-1}$)	−1.171
Freundlich	R^2	0.992
	N	2.207
	K_F ($mg.g^{-1}$)	8.920
Temkin	R^2	0.972
	b_T (kJ/mol)	−25.411
	K_T ($L.mg^{-1}$)	2.311

value of n ≥ 1 indicates a homogeneous system and n ≤ 1 indicates a heterogeneous system. Here, it can be concluded that methyl red adsorption on BCBHP occurs with a homogeneous system. The value of bT of the Temkin isotherm was used to know the methyl red adsorption is controlled by chemisorption or physisorption. Indication of adsorption would occur through ion exchange if the Temkin isotherm obtained b values between 8 and 16 kJ mol^{-1}, while less than −40 kJ mol^{-1} adsorption follows the physisorption process [48]. Table 3 shows that the b value for BCBHP is confirmed to follow the chemisorption process because the b value is not less than −40 kJ mol^{-1}. This Isotherm data supports the obtained kinetic modeling data.





the adsorption of methyl red dye on BCBHP occurs by chemisorption, exothermically, and spontaneous

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CONCLUSION

- Hydrochar (BCBHP) made from Bali cattle bone has been prepared, characterized, and used to adsorb methyl sorbate from water samples.
- XRD, FTIR, FESEM-EDX, and BET-BJH characterizations show that BCBHP has the main elemental composition, $CaCO_3$, with a rhombohedral crystal structure of 61.59%.
- Methyl red adsorption on the adsorbent BCBHP lasted optimally for 30 min at a temperature of 303.15 K, using an adsorbent mass of 0.5 g at pH 6.
- Zeta potential measurement obtained a value of ± 24.4 mV. Lower BCBHP zeta values suggest a higher electrostatic attraction between methyl red and BCBHP surface.
- Kinetic modeling showed that the adsorption of methyl red on BCBHP followed pseudo-second-order.
- Isotherm modeling shows that methyl red adsorption followed the Freundlich model.
- The thermodynamic study also indicates that chemisorption, endothermic and spontaneous reactions follow methyl red adsorption on BCBHP.
- Furthermore, the reusability study of using BCBHP in the adsorption of methyl red also shows that this adsorbent can be applied to remove dyes in waste management systems.

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ACKNOWLEDGEMENT

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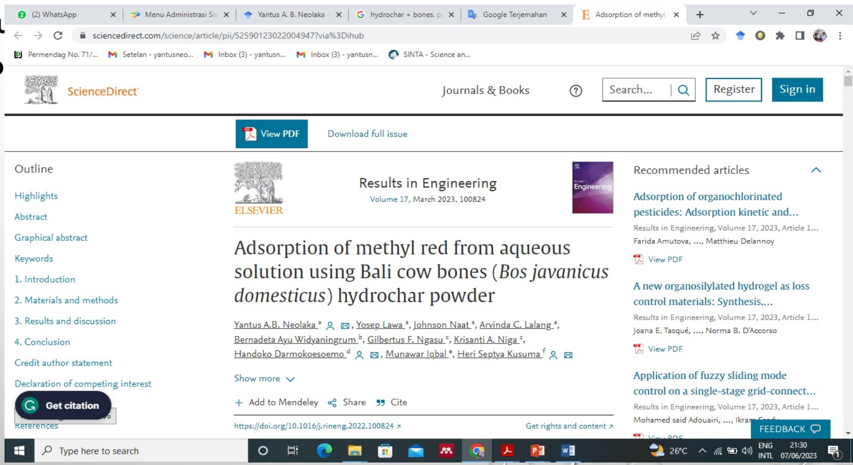

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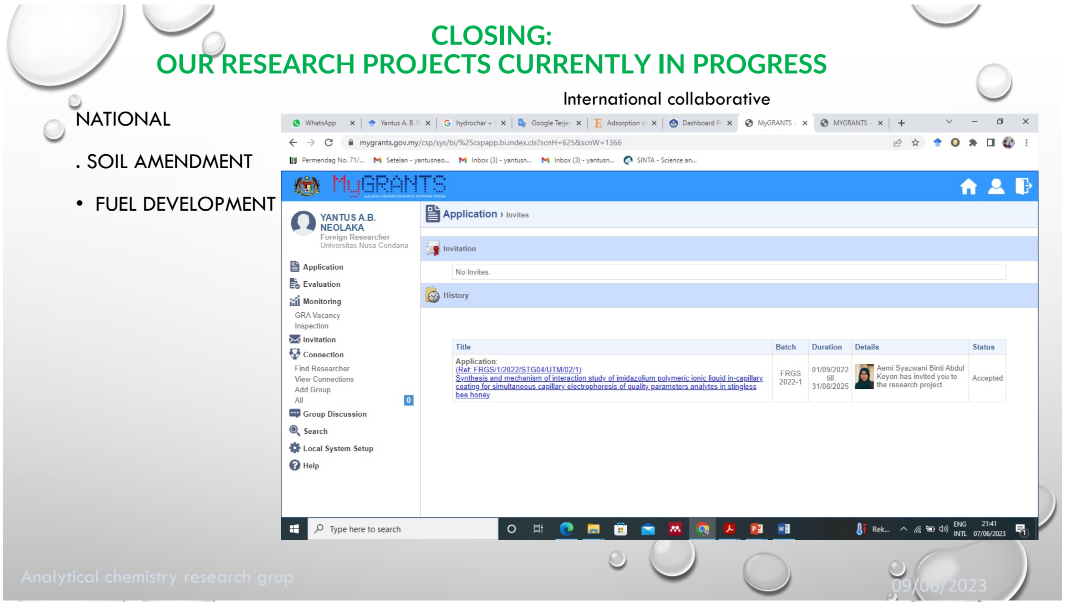
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Application › Invites
Invitation
No Invites.
History
Title
Batch
Duration
Details
Status
Application:
(Ref. FRGS/1/2022/STG04/UTM/02/1)
Synthesis and mechanism of interaction study of imidazolium polymeric ionic liquid in-capillary coating for simultaneous capillary electrophoresis of quality parameters analytes in stingless bee honey
FRGS 2022-1
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Aemi Syazwani Binti Abdul Keyon has invited you to the research project.
Accepted
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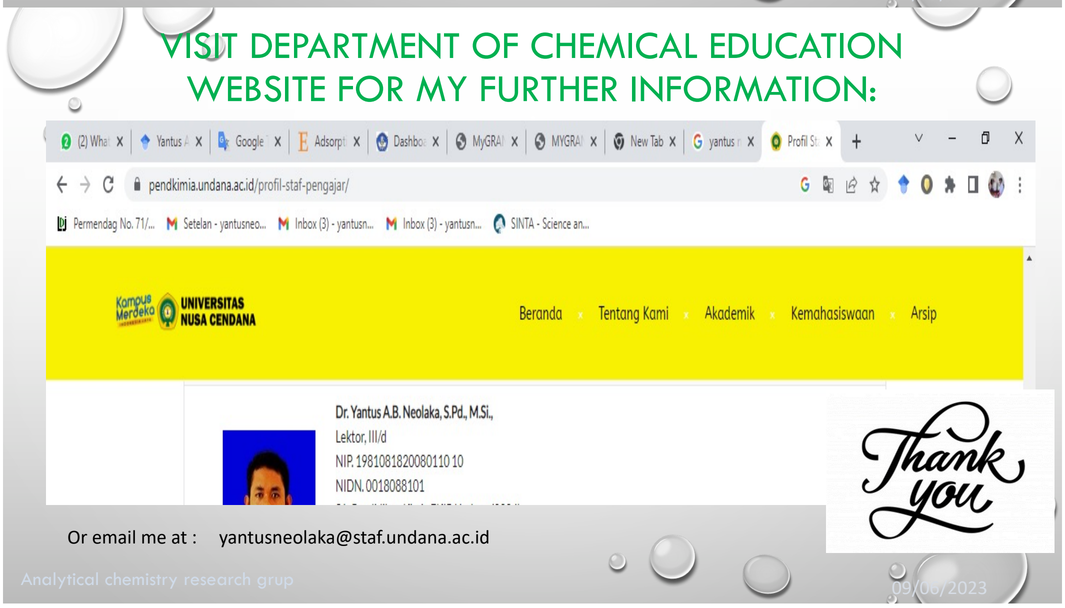
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