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SKEMA KOLABORASI PEMERINTAH

FILTER AIR GAMBUT BERBASIS ZEOLIT ALAM PAHAE DAN KARBON AKTIF CANGKANG KEMIRI UNTUK PENGOLAHAN AIR GAMBUT MENJADI AIR BERSIH

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RINGKASAN

Penelitian ini bertujuan untuk menganalisa keefektifan filter air gambut berbasis zeolit alam Pahae dan karbon aktif cangkang kemiri untuk pengolahan limbah air gambut menjadi air bersih. Air gambut adalah salah satu sumber air yang dapat dijadikan sebagai sumber air baku untuk air bersih bila dilakukan penyulingan atau filtrasi. Karakteristik air gambut mempunyai intensitas warna merah kecoklatan, derajat keasaman tinggi (nilai pH rendah), kandungan zat organik tinggi, dan konsentrasi partikel tersuspensi dan ion rendah. Masalah air gambut dapat menimbulkan masalah kesehatan karena air gambut memiliki intensitas warna kecoklatan, nilai pH rendah, kandungan zat organik yang tinggi dan ion yang rendah. Air gambut bisa menimbulkan penyakit seperti kolera, hepatitis, disentri, penyakit kulit dan mata serta penyakit pencernaan. Masyarakat yang menggunakan air gambut sebagai keperluan sehari-hari rentan mengalami gangguan kesehatan karena air gambut tergolong air yang tidak memenuhi persyaratan air bersih yang ditetapkan oleh Permenkes RI Nomor: 416/Menkes/Per/IX/1990 Tentang Syarat-syarat dan Pengawasan Kualitas Air. Derajat keasaman (pH) yang rendah, tingginya kadar Besi (Fe) dan Mangan (Mn) dapat menyebabkan kerusakan gigi, sakit perut, keracunan dan berbagai penyakit seperti kanker, sirosis ginjal, diare bahkan terjadi kematian mendadak (Eprie et al., 2021). Oleh karena itu dilakukan upaya pengolahan air gambut agar dapat dimanfaatkan sebagai sumber air bersih dan nantinya memenuhi persyaratan kualitas air yang diberlakukan oleh PERMENKES RI Nomor: 416/Menkes/Per/IX/1990 Tentang Syarat-syarat dan Pengawasan Kualitas Air. Salah satu bahan alam yang dapat dimanfaatkan sebagai bahan adsorbsi adalah zeolit alam. Karena itu, tujuan utama dari penelitian ini adalah meningkatkan daya serap filter air gambut berbasis zeolit alam Pahae dan karbon aktif cangkang kemiri untuk pengolahan limbah air gambut menjadi air bersih. Zeolit yang digunakan pada penelitian ini adalah zeolit alam Pahae yang berlokasi di Tapanuli Utara, Sumatera Utara. Untuk mencapai tujuan tersebut, beberapa tahapan kerja akan dilakukan, yaitu mulai dari membersihkan zeolit alam pahae dari pengotor lainnya dengan menggunakan aquadest dan dikeringkan pada suhu 100 derajat Celcius selama 24 Jam. Kemudian zeolit diaktivasi secara basa menggunakan KOH dan dikomposit dengan karbon aktif yang berasal dari cangkang kemiri. Pada tahapan ini, sifat struktural dari penggunaan komposit zeolit dan arang aktif dianalisa untuk mengetahui pengaruh komposisi zeolit dan arang aktif dalam pengolahan air gambut menjadi air bersih. Selanjutnya optimalisasi pengolahan air gambut menjadi air bersih diukur dengan menentukan waktu kontak, komposisi zeolit dan arang aktif, konsentrasi anion awal, pH dan suhu. Dari penelitian ini ditargetkan menghasilkan luaran wajib dan luaran tambahan. Luaran wajib berupa artikel ilmiah di jurnal Q1 yaitu jurnal Materials Science for Energy Technologies dan luaran tambahan sebagai pemakalah di International Conference on Chemical Science and Technology Innovation (ICOCSTI).

BAB 1
PENDAHULUAN

1.1 Latar Belakang

Pertambahan jumlah penduduk menyebabkan kebutuhan akan air bersih meningkat. Air bersih merupakan salah satu kebutuhan pokok manusia yang dapat diperoleh dari berbagai sumber, tergantung pada kondisi daerah setempat. Keadaan sumber air di setiap daerah berbeda-beda, tergantung kondisi alam dan aktivitas manusia. Daerah yang bergambut atau rawa biasanya mengandung air berwarna coklat, berkadar asam humus, zat organik, dan besi yang tinggi. Untuk sumur yang dangkal sedangkan sumur yang agak dalam air berwarna jernih dan memiliki kandungan besi dan mangan yang tinggi (Oktaviani et al., 2022).

Air gambut adalah salah satu sumber air yang dapat dijadikan sebagai sumber air baku untuk air bersih bila dilakukan penyulingan atau filtrasi. Karakteristik air gambut mempunyai intensitas warna merah kecoklatan, derajat keasaman tinggi (nilai pH rendah), kandungan zat organik tinggi, dan konsentrasi partikel tersuspensi dan ion rendah. Masalah air gambut dapat menimbulkan masalah kesehatan karena air gambut memiliki intensitas warna kecoklatan, nilai pH rendah, kandungan zat organik yang tinggi dan ion yang rendah. Air gambut bisa menimbulkan penyakit seperti kolera, hepatitis, disentri, penyakit kulit dan mata serta penyakit pencernaan (Sari dan Mashuri, 2020). Masyarakat yang menggunakan air gambut sebagai keperluan sehari-hari rentan mengalami gangguan kesehatan karena air gambut tergolong air yang tidak memenuhi persyaratan air bersih yang ditetapkan oleh Permenkes RI Nomor: 416/Menkes/Per/IX/1990 Tentang Syarat-syarat dan Pengawasan Kualitas Air. Derajat keasaman (pH) yang rendah, tingginya kadar Besi (Fe) dan Mangan (Mn) dapat menyebabkan kerusakan gigi, sakit perut, keracunan dan berbagai penyakit seperti kanker, sirosis ginjal, diare bahkan terjadi kematian mendadak (Eprie et al., 2021). Oleh karena itu dilakukan upaya pengolahan air gambut agar dapat dimanfaatkan sebagai sumber air bersih dan nantinya memenuhi persyaratan kualitas air yang diberlakukan oleh PERMENKES RI Nomor: 416/Menkes/Per/IX/1990 Tentang Syarat-syarat dan Pengawasan Kualitas Air. Salah satu bahan alam yang dapat dimanfaatkan sebagai bahan adsorbsi adalah zeolit alam.

Zeolit alam merupakan bahan mineral yang cukup banyak ditemukan di Indonesia. Zeolit merupakan kristal berpori yang paling utama tersusun oleh mineral silika dan alumina yang membentuk struktur tetrahedral. Adanya rongga yang terbentuk dari susunan tetrahedral silika dan alumina menjadi ciri khas dari zeolit. Tiap struktur tetrahedral memiliki 4 anion oksigen dengan kation alumina atau silika ditengahnya. Zeolit memiliki pori-pori berukuran molekular sehingga mampu menyaring dan memisahkan molekul dengan ukuran tertentu. Zeolit secala alami terbentuk dari batuan vulkanik yang mengandung banyak mineral dan bahan organik lainnya. Oleh sebab itu, dilakukan aktivasi terhadap zeolit sebelum digunakan sebagai adsorben. Metode aktivasi zeolit terdapat dua jenis yaitu secara bahan kimia dan secara fisik atau pemanasan. Aktivasi secara kimiawi dilakukan dengan menggunakan larutan asam atau basa. Hal ini bertujuan untuk melarutkan pengotor organik yang mana pengotor asam akan larut dan hilang dengan basa dan sebaliknya pengotor yang besifat basa akan larut dan hilang dengan larutan asam. Metode aktivasi secara fisik atau pemanasan dilakukan dengan memanaskan zeolit. Hal ini bertujuan untuk menghilangkan molekul air dan mendegradasikan pengotor senyawa organik yang terjerat di dalam pori-pori zeolit sehingga pori-pori zeolit akan lebih terbuka (Muttaqii et al., 2019).

Dalam meningkatkan kinerja zeolit alam dalam proses pengolahan air gambut, maka pada penelitian ini dilakukan penambahan karbon aktif atau arang aktif dari cangkang kemiri. Adapun cangkang kemiri dipilih pada penelitian ini karena cangkang kemiri merupakan limbah organik yang dapat diuraikan secara alamiah namun membutuhkan waktu yang lama oleh karena teksturnya yang cukup keras dengan permukaan yang kasar dan beralur sehingga dapat dimanfaatkan menjadi produk arang aktif atau karbon aktif. cangkang kemiri sangat cocok untuk dijadikan bahan baku karbon aktif karena memiliki kandungan selulose, hemiselulose, dan lignin. Kadar holoselulosa cangkang kemiri sebesar 49,22%, (Eso et al., 2021).

Dengan mempertimbangkan besarnya kebutuhan masyarakat akan air bersih, maka tujuan khusus penelitian ini adalah menghasilkan sebuah filter air gambut berbasis zeolit alam Pahae dan karbon aktif cangkang kemiri untuk pengolahan limbah air gambut menjadi air bersih. Zeolit alam yang digunakan dalam filter ini merupakan zeolit alam yang sudah di aktivasi secara basa menggunakan KOH dan dikomposit dengan karbon aktif yang berasal dari cangkang kemiri. Pada tahapan ini, sifat struktural dari penggunaan komposit zeolit dan arang aktif dianalisa untuk mengetahui pengaruh komposisi zeolit dan arang aktif dalam pengolahan air gambut menjadi air bersih. Selanjutnya optimalisasi pengolahan air gambut menjadi air bersih diukur dengan menentukan waktu kontak, komposisi zeolit dan arang aktif, konsentrasi anion awal, pH dan suhu. Adapun zeolit yang digunakan pada penelitian ini adalah zeolit alam Pahae yang berasal dari Tapanuli Utara, Sumatera Utara. Adapun pemilihan material zeolite alam sumatera utara yang digunakan pada filter ini sejalan dengan renstra Universitas Sumatera Utara yaitu untuk mengembangkan potensi wilayah Sumatera Utara dan USU yang tertuang dalam kompetitif TALENTA khususnya pada poin natural resources.

1.2 Rumusan Permasalahan

Berdasarkan latar belakang masalah yang telah dikemukakan, maka dapat dirumuskan beberapa rumusan masalah sebagai berikut:

1. Apakah Zeolit Alam Pahae dan karbon aktif cangkang kemiri bisa digunakan sebagai filter untuk pengolahan air gambut?
2. Bagaimana karakteristik filter untuk pengolahan air gambut berbasis Zeolit Alam Pahae dan karbon aktif cangkang kemiri?
3. Bagaimana pengaruh variasi komposisi filter untuk pengolahan air gambut berbasis Zeolit Alam Pahae dan karbon aktif cangkang kemiri?
4. Apakah filter berbasis Zeolit Alam Pahae dan karbon aktif cangkang kemiri optimal digunakan sebagai filter untuk pengolahan air gambut?

1.3 Tujuan Khusus

Tujuan khusus dari penelitian ini, yaitu:

1. Membuat filter untuk pengolahan air gambut yang berbasis zeolit alam Pahae dan karbon aktif cangkang kemiri.
2. Mengetahui karakteristik filter untuk pengolahan air gambut berbasis zeolit alam Pahae dan karbon aktif cangkang kemiri.
3. Mengetahui pengaruh variasi komposisi filter untuk pengolahan air gambut berbasis zeolit alam Pahae dan karbon aktif cangkang kemiri.
4. Mengaplikasikan filter untuk pengolahan air gambut berbasis zeolit alam Pahae dan karbon aktif cangkang kemiri.

1.4 Urgensi Penelitian

1. Melimpahnya potensi zeolit sebagai sumber daya alam di indonesia, khususnya di Sumatera Utara.
2. Perlu dilakukan penelitian tentang perluasan aplikasi zeolit sebagai filter air gambut, sehingga dapat meningkatkan nilai ekonomis zeolit.

3. Dengan adanya filter air gambut ini, pemurnian air gambut dapat dilakukan dengan praktis, relatif murah, cepat dan ramah lingkungan

1.5 Rencana Target Luaran

Luaran penelitian yang ditargetkan, dihasilkannya produk adsorber filter berbasis zeolit alam Pahae dan arang aktif dari cangkang kemiri, draf artikel ilmiah internasional, dan sebagai pemakalah di prosiding internasional. Tabel 1.1 adalah rencana target capaian penelitian.

Tabel 1.1 Rencana Target Luaran

No.	Jenis Luaran*	Jumlah	Nama Jurnal, Nama Konferensi, Jenis KI, Nama Produk, Judul Buku Ajar
	Luaran Wajib		
1	Artikel di jurnal internasional	1	Materials Science for Energy Technologies
2	Artikel di junal nasional		-
3	Hak Kekayaan Intelektual		-
4	Artikel di prosiding internasional terindeks bereputasi		
	Luaran tambahan		
1	Artikel di prosiding internasional	1	International Conference on Chemical Science and Technology Innovation (ICOCSTI)
2	Artikel di jurnal nasional		-
3	Hak Kekayaan Intelektual		-
4	Produk/TTG/model/karya seni		-
5	Buku ajar		-
6	MoU/MoA		

*****Catatan: sesuaikan dengan luaran untuk masing-masing skema

BAB 2

TINJAUAN PUSTAKA

2.1 Zeolit

Zeolit merupakan batuan mineral anorganik yang banyak terdapat di Indonesia. Zeolit adalah bahan berpori dengan sifat fisikokimia yang baik, seperti kapasitas tukar kation yang tinggi, selektivitas kation dan volume pori besar (Atikah, 2017). Kegunaan zeolit didasarkan atas kemampuannya melakukan pertukaran kation adsorpsi dan katalisator. Zeolit memiliki bentuk kristal yang sangat teratur dengan rongga yang saling berhubungan ke segala arah yang menyebabkan luas permukaan zeolit sangat besar sehingga sangat baik digunakan sebagai adsorben (Millar et al, 2016). Karakteristiknya yang unik, termasuk sangat stabil dengan sangat tinggi kapasitas adsorpsi dan selektivitas dan memiliki struktur pori aktif besar (mikropori) dan memiliki luas permukaan spesifik yang tinggi. Zeolit memiliki potensi untuk diproses lebih lanjut menjadi produk yang dapat digunakan untuk aplikasi luas, antara lain sebagai mendukung katalis. Zeolit adalah struktur kristal alumina silikat terhidrasi berbentuk kerangka tiga dimensi, yang memiliki rongga dan saluran serta mengandung ion logam seperti Na, K, Mg, Ca dan Fe serta molekul air (Gultom et al, 2016). Pemanfaatan zeolit sebagai adsorben sudah banyak digunakan pada industri, pertanian, dan lingkungan. Tabel 2.1 menunjukkan selektivitas adsorbat terhadap beberapa jenis zeolit.

Tabel 2.1 Selektivitas Adsorbat Terhadap Jenis Zeolit (Ackley, Rege, and Saxena 2003)

Jenis Zeolit	Aplikasi	Gas Sedikit Diadsorpsi	Gas Banyak Diadsorpsi	Peneliti
Chabazite	Prapurifikasi udara	Udara (N_2 dan O_2)	CO_2	Tomoki (1988)
Clinoptilolite	Prapurifikasi udara	Udara (N_2 dan O_2)	CO_2, CO, NO	Tezel (1995)
Erionite	Separasi Udara	O_2	N_2	Honan (1974)
Ferrierite	Purifikasi gas alam, batubara, biogas	CH_4, C_2S, C_3S	NH_3	Hayhurst (1978)
Mordenite	Purifikasi gas	H_2, He, Ne, Kr, Xe	H_2O, CO, CO_2, CH_4	Nishizawa (1984)
Phillipsite	Purifikasi gas alam, batubara, biogas	CH_4, C_2S, C_3S	NH_3	Kirov (1992)

2.2 Cangkang Kemiri

Pohon kemiri adalah jenis pohon yang sangat serbaguna, hampir seluruh bagian dari pohon ini dapat dimanfaatkan, dengan produk utama berupa isi biji kemiri. Kemiri (Aleurites mollucana L, Willd) adalah jenis pohon yang mudah untuk ditanam, cepat tumbuh, dan tidak memerlukan persyaratan tempat tumbuh yang khusus. Saat ini, limbah yang dihasilkan dari proses pemecahan biji kemiri berupa tempurung kemiri belum dimanfaatkan secara optimal. Tempurung kemiri ini memiliki berat hampir dua per tiga dari berat biji kemiri utuh, sedangkan sepertiganya adalah inti atau karnel dari buah kemiri. Limbah ini memiliki potensi yang sangat besar jika dimanfaatkan untuk menghasilkan produk bernilai, salah satunya adalah sebagai bahan baku arang aktif (Hendra, 2017). Cangkang kemiri adalah limbah organik yang dapat terurai secara alami, meskipun memerlukan waktu yang cukup lama karena teksturnya yang keras dan permukaannya yang kasar serta beralur. Oleh karena itu, cangkang kemiri dapat dimanfaatkan sebagai bahan baku untuk produk arang aktif atau karbon aktif. Tempurung kemiri sangat sesuai untuk digunakan sebagai bahan baku karbon aktif karena mengandung selulosa, hemiselulosa, dan lignin. Kandungan holoselulosa dalam tempurung kemiri sebesar 49,22%, yang lebih rendah dibandingkan dengan holoselulosa dalam kayu yang berkisar antara 65%-75% (Eso et all., 2021).

Cangkang kemiri adalah limbah organik yang memang dapat diuraikan secara alami, namun proses penguraian membutuhkan waktu karena teksturnya yang keras. Mengingat faktor lingkungan tersebut, cangkang kemiri dapat dijadikan sebagai bahan baku untuk pembuatan karbon aktif. Dengan memanfaatkan limbah cangkang kemiri ini, tidak hanya dapat mengatasi masalah penumpukan limbah, tetapi juga diharapkan dapat menghasilkan produk yang aman dan ramah lingkungan. Perkembangan teknologi yang semakin maju saat ini mendorong permintaan akan bahan baku yang lebih ekonomis, tahan lama, dan berkelanjutan. Dengan menggunakan cangkang kemiri sebagai bahan baku untuk karbon aktif, kita dapat memenuhi kebutuhan ini dan sekaligus berkontribusi dalam upaya pelestarian lingkungan (Simamora et al., 2020).

2.3 Air gambut

Air gambut adalah salah satu sumber air yang dapat dijadikan sebagai sumber air baku untuk air bersih melalui proses penyulingan atau filtrasi. Air gambut merupakan air permukaan yang dapat ditemukan di wilayah Kalimantan dan Sumatra. Air ini memiliki ciri khas dengan intensitas warna merah kecoklatan, tingkat keasaman yang tinggi (nilai pH rendah), kandungan zat organik yang tinggi, serta konsentrasi partikel tersuspensi dan ion yang rendah (Sari et al., 2020). Zat-zat organik ini terutama berbentuk asam humus yang berasal dari dekomposisi bahan organik seperti daun, pohon, atau kayu (Dzulkhairi, 2015).

Berdasarkan kajian Pusat Sumber Daya Geologi Departemen Energi dan Sumber Daya Mineral, lahan gambut di Indonesia tersebar dengan sekitar 50% berada di pulau Kalimantan, 40% di pulau Sumatera, dan sisanya tersebar di Papua dan pulau-pulau lainnya. Luasnya lahan gambut yang tersebar di beberapa wilayah ini menunjukkan potensi kuantitatif yang sangat besar untuk dikelola sebagai sumber daya air yang dapat diolah menjadi air bersih atau air minum. Di beberapa daerah, masyarakat menggunakan air sumur galian, air sungai, dan sumber air lainnya yang diambil dari daerah gambut, namun air tersebut belum selalu memenuhi standar air bersih. (Yuliana et al., 2022).

Air gambut pada umumnya tidak memenuhi standar kualitas air bersih yang telah ditetapkan. Namun, melalui pengolahan yang tepat, air gambut dapat diubah menjadi air yang layak dikonsumsi. Untuk menilai kualitas air gambut, beberapa parameter yang mempengaruhinya harus diperhatikan sesuai dengan Peraturan Menteri Kesehatan Republik Indonesia No. 416/ Menkes/ PER/ IX/ 1990 tentang Syarat-Syarat dan Pengawasan Kualitas Air. Parameter tersebut meliputi derajat keasaman (pH) yang harus berada dalam rentang 6,5 hingga 9,0, warna dengan batas maksimal 50 skala TCU, kekeruhan dengan batas maksimal 25 NTU, serta kandungan organik ($KMnO_4$) dengan batas maksimal 10 mg/liter (Debby et al., 2014).

Gambut terbentuk dari timbunan sisa-sisa tanaman yang mati dan mengalami proses pembusukan (materi organik), baik secara perlahan atau tidak perlahan selama jangka waktu yang lama. Pertumbuhan terus-menerus dari timbunan materi organik ini terjadi karena proses dekomposisi yang terhambat oleh kondisi anaerob atau kondisi lingkungan lainnya yang menghambat perkembangan biota pengurai. Pembentukan gambut dimulai dengan adanya perairan dangkal seperti danau yang lambat laun ditumbuhi oleh tanaman air dan vegetasi lahan basah. Tanaman yang mati dan mengalami dekomposisi bertahap membentuk lapisan yang menjadi transisi antara lapisan gambut dan substratum (lapisan di bawahnya) yang berupa tanah mineral. (Prasetyo, 2021).

2.4 Teori Adsorpsi

Adsorpsi merupakan salah satu metode yang digunakan dalam proses pemisahan, seperti halnya dengan metode proses absorbsi, distilasi, dan ekstraksi. Adsorpsi adalah proses penjerapan *solute* dari fluida ke permukaan aktif padatan. Fenomena ini terjadi karena terdapat gaya-gaya yang tidak seimbang pada batas antar permukaan. Adanya gaya ini menyebabkan padatan cenderung menarik molekul-molekul yang lain yang bersentuhan dengan permukaan padatan. Adsorpsi berkaitan dengan proses akumulasi atau pemusatan substansi adsorbat pada permukaan adsorben. Hal ini dapat terjadi melalui antar muka dua fasa, misal fasa cair dengan cair, fasa gas dengan cair, fasa gas dengan padat atau fasa cair dengan padat (Udyani dan Wulandari, 2014). *Adsorbent* adalah zat yang dapat menyerap fluida, baik cair maupun gas sehingga nantinya akan membentuk lapisan tipis pada permukaan zat tersebut. Salah satu jenis *adsorbent* yang dapat digunakan adalah zeolit. Zeolit dipilih karena selain mudah didapat, harganya pun juga cukup murah (Hamidi dkk, 2011).

Bahan padat yang mempunyai kemampuan mengikat (menyerap) molekul tertentu disebut adsorben, sedangkan zat yang dijerap disebut adsorbat. Proses adsorpsi biasanya dilakukan dengan cara mengontakkan larutan/gas dengan padatan, sehingga komponen larutan/gas dijerap pada permukaan padatan. Waktu kontak berpengaruh terhadap proses penyerapan. Waktu kontak merupakan lamanya zat yang akan diadsorpsi bercampur dengan adsorben.

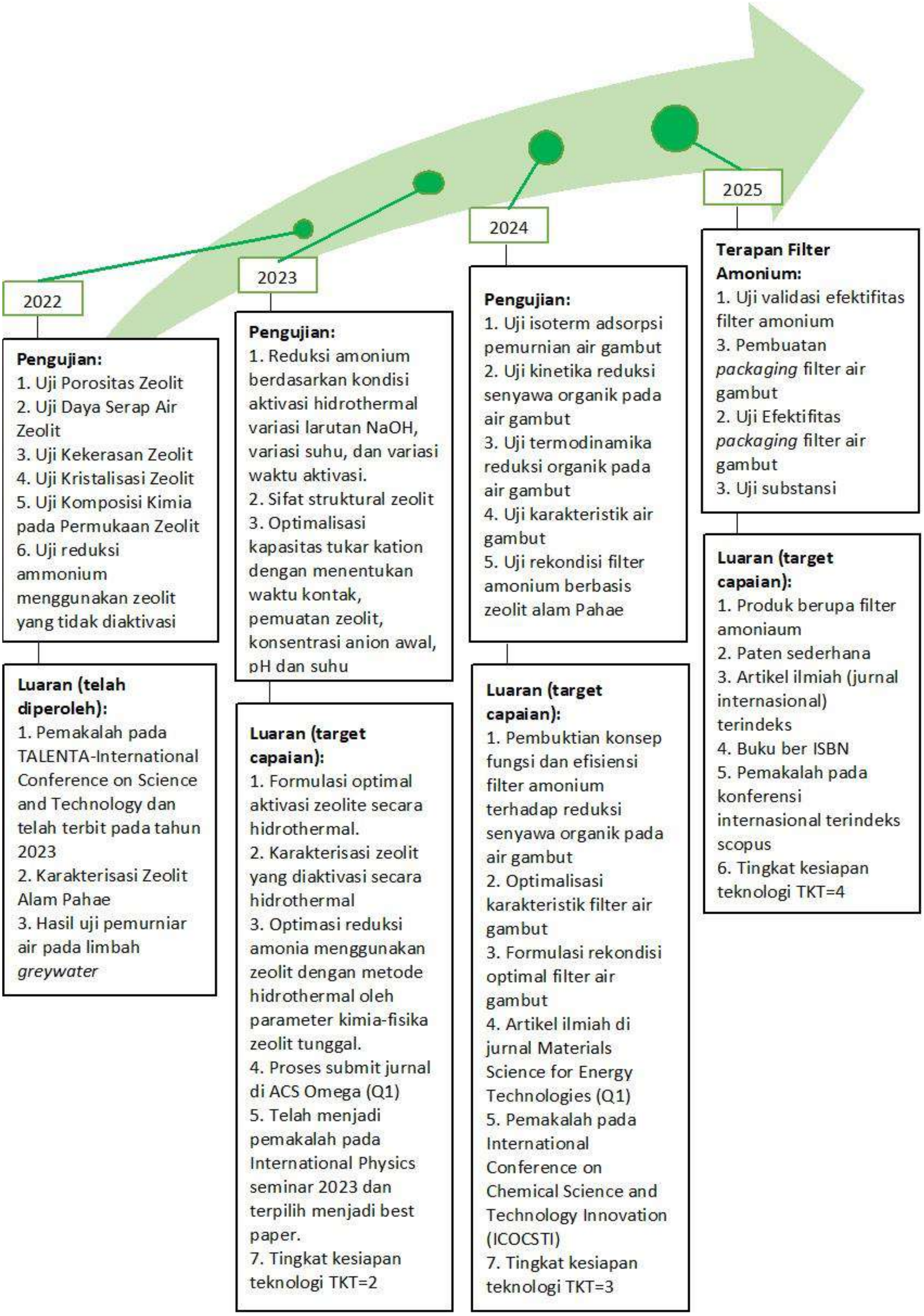
2.5 Karbon Aktif

Karbon aktif adalah padatan berpori yang dihasilkan dari bahan baku mengandung karbon melalui proses khusus sehingga memiliki permukaan yang aktif dan selektif. Struktur pori menyebabkan karbon aktif memiliki luas permukaan yang sangat besar, sekitar 300 - 2000 m^2/gr. Proses pembuatan karbon aktif melibatkan dua tahap, yaitu karbonisasi dan aktivasi. Karbonisasi adalah proses pengarangan dalam ruangan tanpa oksigen dan bahan kimia lainnya, sementara aktivasi dilakukan untuk meningkatkan luas permukaan karbon hasil karbonisasi. Aktivasi melibatkan pemecahan ikatan hidrokarbon atau oksidasi molekul permukaan karbon, sehingga sifat fisika dan kimianya berubah dan luas permukaannya bertambah besar, yang berpengaruh pada kemampuan adsorpsi.

Kemampuan adsorpsi karbon aktif merupakan akumulasi komponen di antarmuka dalam dua fasa. Gaya tarik-menarik antara molekul, ion, atau atom dalam dua fasa tersebut, yang dikenal sebagai gaya Van der Waals, menyebabkan terbentuknya suatu fasa baru yang berbeda dengan masing-masing fasa sebelumnya. Atom, ion, atau molekul dalam daerah antarmuka dapat mengalami ketidakseimbangan gaya pada kondisi tertentu, sehingga dapat menarik molekul lain sampai tercapai keseimbangan gaya. Daya serap karbon aktif dipengaruhi oleh sifat karbon aktif itu sendiri, sifat komponen yang diserap, sifat larutan, dan sistem kontak. Kemampuan adsorpsi karbon aktif terhadap komponen dalam larutan atau gas terjadi karena kondisi permukaan dan struktur porinya (Laos et al., 2016).

2.6 Peta Jalan Penelitian

Hasil penelitian Noryoto *et al.*, 2020, dan Khairani dan Amilia, 2022 menunjukkan bahwa zeolite dan arang aktif dapat digunakan sebagai filter air gambut. Hal ini ditunjukkan dengan kemampuan zeolite dalam menyerap warna dan reduksi pH pada air gambut. Kemampuan zeolit dan arang aktif sebagai adsorben ini akan dimanfaat untuk meningkatkan kualitas air bersih. *Roadmap* penelitian ditunjukkan pada Gambar 2.2.

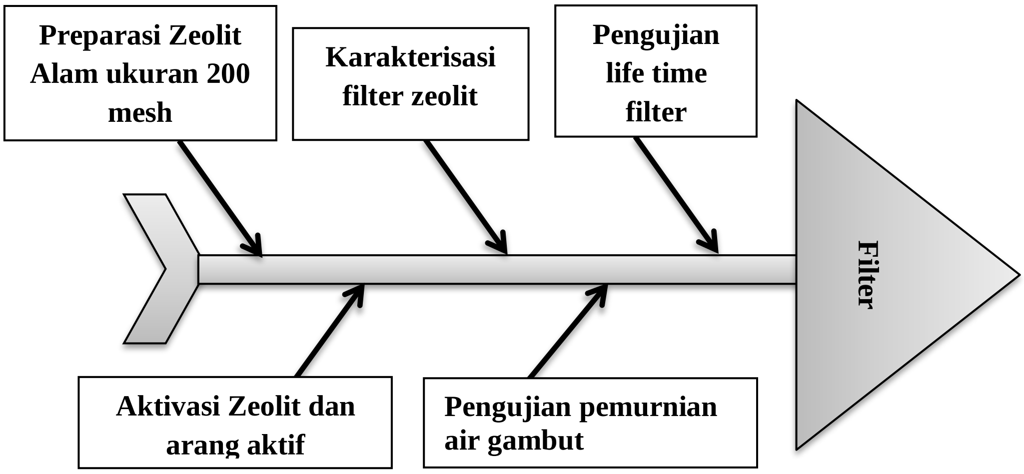


Gambar 2.2 Peta Jalan Penelitian

BAB 3
METODE PENELITIAN

3.1 Tulang Ikan Penelitian

Penelitian dilakukan dalam beberapa tahapan, seperti yang digambarkan dalam tulang ikan penelitian Gambar 3.1, dan diagram alir pabrikasi, karakterisasi, dan proses pemurnian air gambut, Gambar 3.2.



Gambar 3.1 Tulang Ikan Penelitian

3.2 Alat dan Bahan Penelitian

Bahan yang digunakan dibagi menjadi dua bahan, yaitu bahan material dan bahan kimia. Adapun bahan material yang digunakan adalah zeolit alam Pahae yang berasal dari Tapanuli Utara dan cangkang kemiri yang berasal dari sidikalang, Dairi. Bongkahan zeolite dihancurkan menggunakan martil untuk menghasilkan zeolit ukuran 200 mesh. Bahan kimia yang digunakan adalah KOH, dan Aquabidest.

Alat yang digunakan dalam penelitian ini adalah X-Ray Diffraction (XRD), X-ray fluorescence (XRF), Scanning Electron Microscopy-Energy Dispersive X-ray Spectrometer (SEM-EDX), Ultra Violet – Visible (UV-Vis) Spectrophotometer, ayakan 10 dan 20 mesh, Hydrothermal Autoclave Reactor Chamber, tanur vakum, oven, neraca analitik, beaker glass berbagai ukuran, gelas ukur, spatula, corong Bunche, Labu Ukur 2000 mL, pH meter, pipet volume, pipet mohr, labu ukur, shaking waterbath, Autoclave, Magnetic Bar, mortal, dan hot plate magnetic stirrer.

3.3 Metode

3.3.1 Preparasi Zeolit Alam Simangumban Ukuran 200 Mesh

Zeolit yang digunakan pada penelitian ini adalah zeolit yang berasal dari Tapanuli Utara tepatnya daerah Simangumban dimana, zeolit tersebut masih dalam bentuk bongkahan. Zeolit yang masih dalam bentuk bongkahan terlebih dahulu di hancurkan, kemudian digerus atau diremukkan dengan menggunakan mortal dan lumpang. Zeolit Alam Simangumban yang sudah digerus diayak dengan ayakan ukuran 200 mesh. Lalu zeolit yang lolos ayakan 200 mesh dicuci dengan aquadest sebanyak 3 kali untuk menghilangkan zat pengotor lainnya. Kemudian dikeringkan di dalam oven suhu 100^0C selama 24 jam. Kemudian diuji zeolit sebelum aktivasi kimia dengan XRF untuk melihat tingkat kemurnian unsur dalam zeolit. Kemudian dicuci dengan aquadest sebanyak 3 kali untuk menghilangkan pengotor-pengotor yang terikut didalam zeolit. Diaktivasi kimia dengan larutan KOH 10%. Dikeringkan zeolit Pahae yang sudah diaktivasi secara kimia di dalam oven selama 1 jam dengan suhu 100°C. Zeolit Pahae yang sudah kering siap digunakan. Kemudian diuji zeolit dengan XRF untuk melihat tingkat kemurnian unsur dalam zeolit sesudah diaktivasi kimia. Aktivasi merupakan proses yang dilakukan agar dapat diperoleh luas permukaan pori serta membuang senyawa pengotor dari zeolit (Rais et al., 2017).

3.3.2 Proses pengolahan cangkang kemiri menjadi karbon aktif

Cangkang kemiri yang digunakan berasal dari Sidikalang, Kabupaten Dairi. Cangkang kemiri di bersihkan dari daging buah yang melekat lalu cangkang kemiri di cuci bersih kemudian dikeringkan dalam oven dengan suhu 100 °C. Setelah mengering cangkang kemiri dibuat menjadi arang aktif dengan cara dikarbonisasi menggunakan *furnance* pada suhu 300 °C selama 2 jam. Hasil karbonisasi kemudian di haluskan menggunakan mortar dan diayak menggunakan ayakan ukuran 200 mesh.

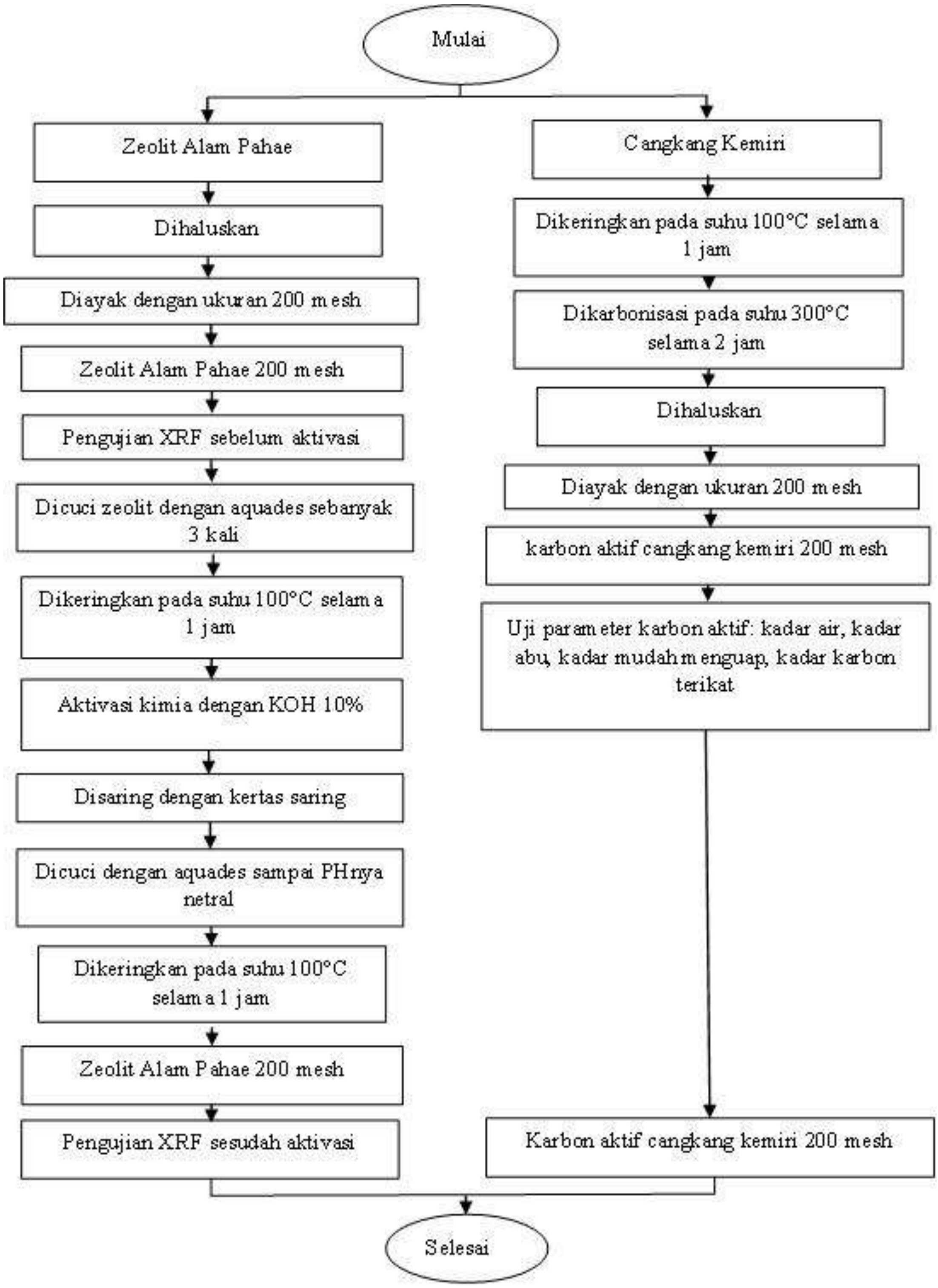
3.3.3 Pembuatan filter berbasis zeolit alam Pahae dan karbon aktif cangkang kemiri

Hasil pencampuran komposisi dimasukkan kedalam alat cetakan dengan ketebalan plat 1 cm, panjang 3 cm, lebar 3 cm dengan volume cetakan 10 gram. Selanjutnya dilakukan pencetakan dengan Hydraulic Press selama 10 menit dengan massa beban yang diberikan sebesar 5 ton. Hasil sampel Hidraulic Press berupa padatan yang selanjutnya sampel dibiarkan dalam ruang terbuka selama 1 minggu, hal ini bertujuan untuk menghindari sampel yang retak pada saat pemanasan. Sampel yang sudah dibiarkan selama 1 minggu, selanjutnya diaktivasi pada suhu 600 °C selama 2 jam. Adapun tujuan dari aktivasi fisika filter berbentuk padatan adalah untuk mendapatkan sifat mekanik (kekerasan). Sampel yang telah diaktivasi dibiarkan selama 1 hari didalam oven dalam kondisi off. Dari aktivasi tersebut dihasilkan filter yang siap untuk diuji sifat fisis (porositas, daya serap air), sifat mekanik (kekerasan), SEM, XRD dan pengaplikasian pada air gambut.

3.3.4 Proses pengolahan air gambut

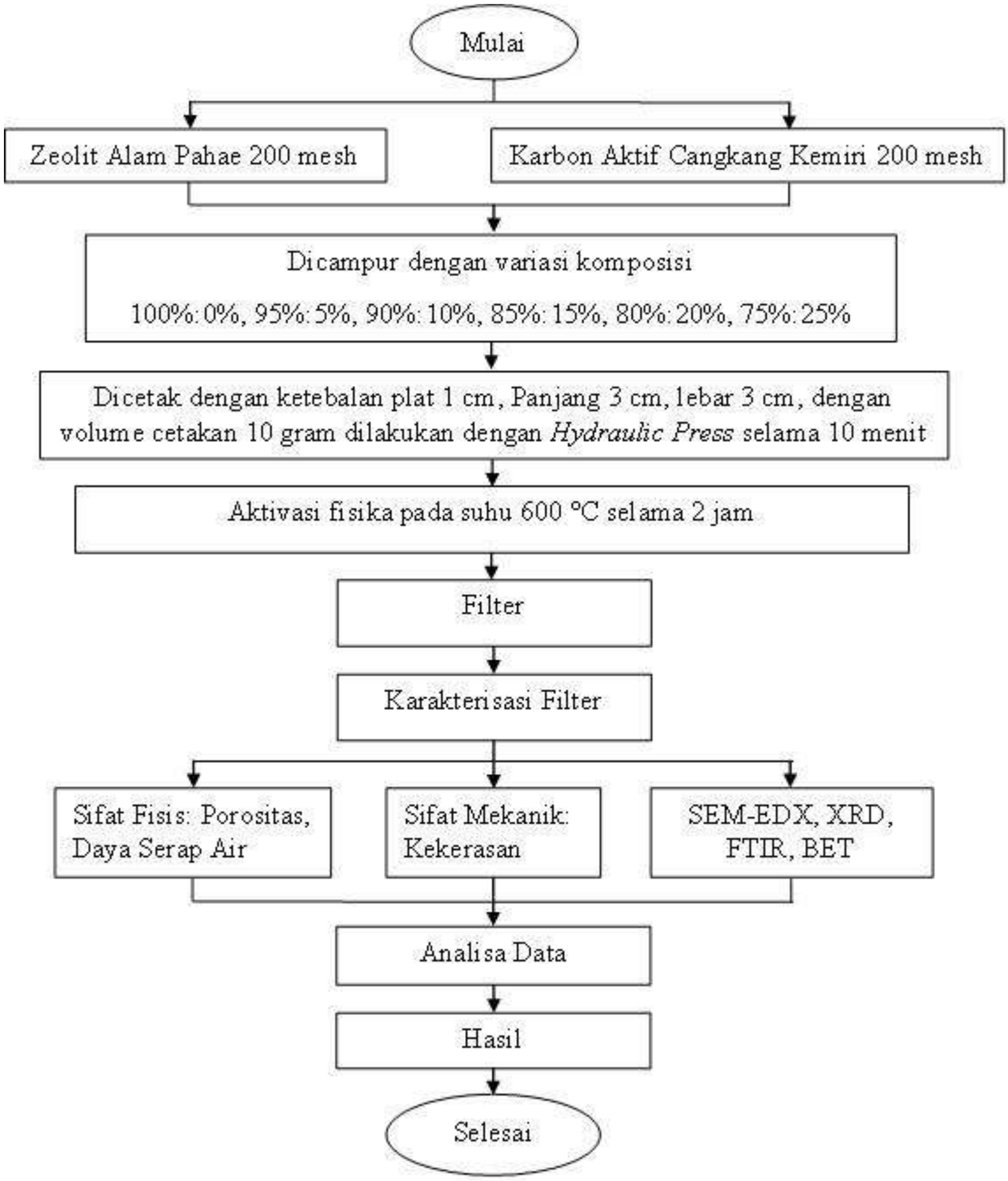
Pengolahan air gambut dilakukan dengan mengkarakterisasi air gambut sebelum diolah (uji warna, kekeruhan, PH, kandungan logam Fe dan Mn). Lalu filter yang sudah tercetak dengan ketebalan plat 1 cm, panjang 3 cm, lebar 3 cm dengan volume cetakan 10 gram diletakkan pada beaker glass. Air gambut dituang ke dalam beaker glass sebanyak 100 ml. Dimasukkan filter dan air gambut pada elenmeyer kemudian diaduk menggunakan hot plate magnetik stirer dengan kecepatan 8 rpm pada suhu 60°C selama 1 jam. Lalu hasil pengolahan air gambut diuji (uji warna, kekeruhan, PH, kandungan logam Fe dan Mn).

Diagram Alir Preparasi Sampel Zeolit Alam Pahae dan Cangkang Kemiri



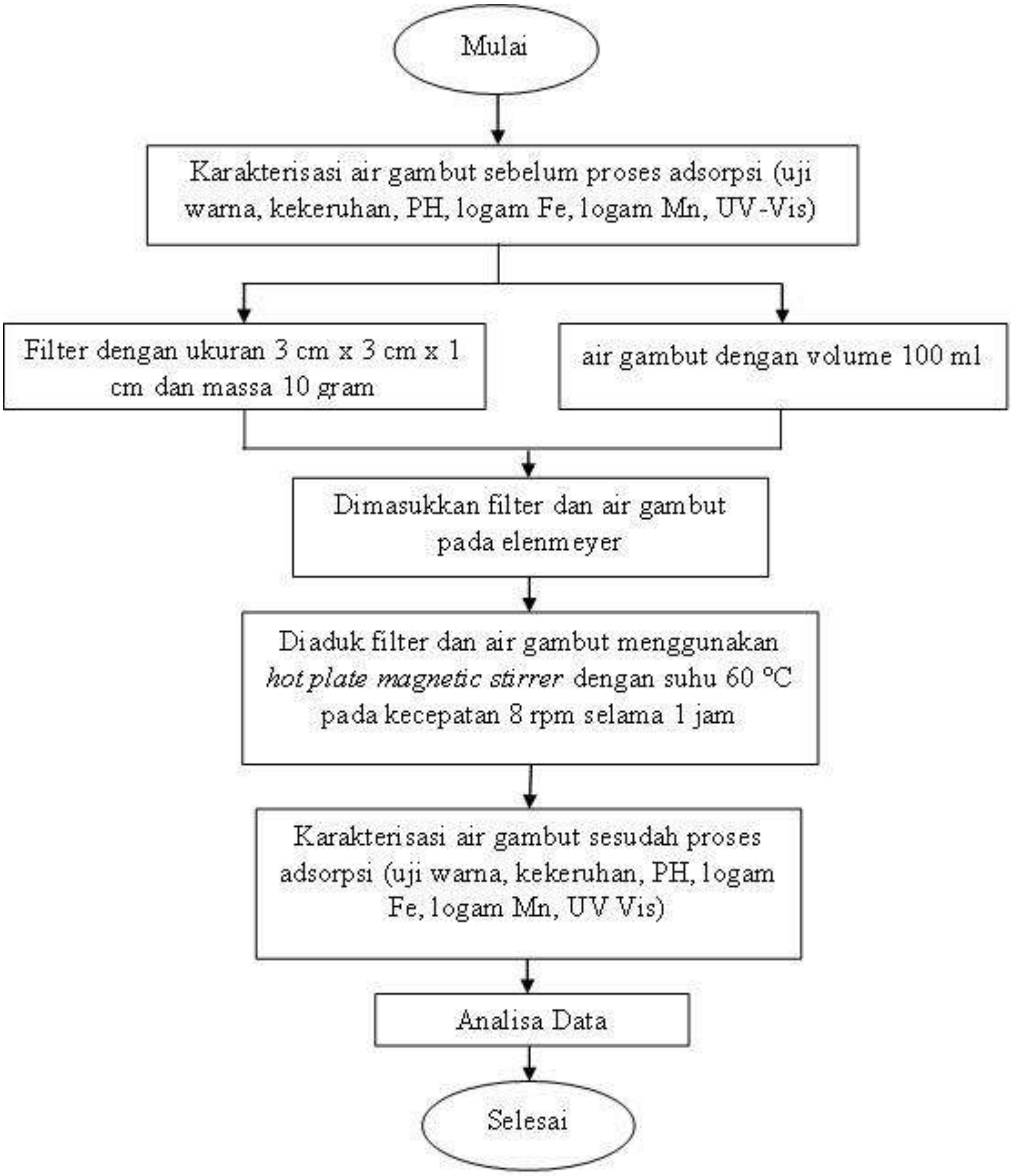
Gambar 3.2 Diagram Alir Preparasi Sampel Zeolit Alam Pahae dan Cangkang Kemiri

Diagram Alir Pembuatan Sampel dan Karakterisasi Sampel



Gambar 3.3 Diagram Alir Pembuatan Sampel dan Karakterisasi Sampel

Diagram Alir Aplikasi Sampel



Gambar 3.4 Diagram Alir Aplikasi Sampel

3.4. Susunan Organisasi Tim Pengusul dan Pembagian Tugas

No	Nama/NIDN/NIP	Fakultas/Unit	Bidang Ilmu	Uraian Tugas
1.	Dr. Susilawati, S.Si., M.Si./0007127402/ 197412072000122001	FMIPA/Fisika	Fisika Material	• Merancang secara detail prosedur penelitian dan membagi tugas kepada tim peneliti. • Mengkordinir dan mengarahkan anggota penelitian dalam menyelesaikan tugas masing-masing. • Menganalisis data hasil penelitian secara menyeluruh. • Mengevaluasi keseluruhan hasil penelitian beserta luarannya. • Mengkordinir mahasiswa sebagai anggota pembantu penelitian dalam preparasi sampel dan aktivasi zeolite & arang aktif.
2.	Prof. Dr. Dra Erna Frida M.Si/0023016402/ 196401231991022001	FMIPA/Fisika	Fisika Material	• Mengkordinir mahasiswa sebagai anggota pembantu penelitian dalam preparasi sampel dan karakterisasi air gambut • Mengkordinir mahasiswa dalam melakukan proses adsoprsi air gambut • Menganalisis hasil uji pemurnian air gambut. • Membuat draf publikasi ke jurnal internasional. • Membuat laporan akhir dan laporan penggunaan dana 100%.
3.	Dr. Andriayani S.Pd., M.Si./ 0005036903/ 196903051999032001	FMIPA/Kimia	Kimia Anorganik	• Mengkordinir mahasiswa sebagai anggota pembantu penelitian dalam preparasi sampel dan aktivasi zeolit & arang aktif. • Mengkarakterisasi komposit zeolit dan arang aktif. • Menganalisis hasil uji SEM EDS, XRF dan XRD. • Membuat draf publikasi untuk international conference.

4.	Prof. Dr. Perdinan Sinuhaji MS/ 0010035905/ 195903101987031002	FMIPA/Fisika	Fisika Material	• Mengkordinir mahasiswa sebagai anggota pembantu penelitian dalam preparasi sampel dan pembuatan simulasi air gambut • Mengkordinir mahasiswa dalam melakukan proses pemurnian air gambut. • Mengkordinir mahasiswa sebagai anggota pembantu penelitian dalam proses pemurnian air gambut. • Membuat Laporan Kemajuan hasil Penelitian dan laporan penggunaan dana 70%.
5.	Prof. Drs. Perdamean Sebayang, M.Si	Pusat Riset Material Maju	Material Maju	• Menganalisis hasil karakterisasi komposit zeolit dan arang aktif. • Menganalisis hasil uji SEM EDS, XRF dan XRD.

BAB 4
BIAYA DAN JADWAL PENELITIAN

4.1 Biaya Penelitian

No.	Jenis Pengeluaran	Biaya Yang Diusulkan (Rp)	
		LP USU	**Mitra (*in kind*)**
1.	Honorarium untuk petugas laboratorium, pengolahan data dan honor operator	Rp.4.512.000,-	-
2.	Pembelian bahan habis pakai, biaya pengujian, biaya fotocopy, ATK, penjilidan dan publikasi jurnal.	Rp.49.608.000,-	Rp. 20.000.000,-
3.	Biaya Perjalanan dan akomodasi pengambilan sampel zeolite ke Tapanuli Utara (Pahae)	Rp. 2.400.000,-	-
4.	Sewa untuk peralatan/mesin/ruang laboratorium, dan peralatan penunjang penelitian lainnya.	Rp. 3.480.000,-	-
Sub Total		**Rp.60.000.000,-**	**Rp. 20.000.000,-**

4.2 Jadwal Penelitian

No.	Jenis Kegiatan	Tahun I										Indikator Kinerja
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
1.	Studi Literatur											Penerapan metode penelitian
2.	Persiapan Alat dan Bahan											Alat dan Bahan siap digunakan
3.	Preparasi zeolite ukuran 200 mesh											Zeolite lolos ayakan 200 mesh
4.	Aktivasi Zeolite dan arang aktif											Zeolit dan arang aktif Teraktivasi
5.	Pengambilan sampel air gambut											pH air gambut asam
6.	Karakterisasi XRF Zeolit dan arang aktif											Memastikan material yang digunakan adalah benar zeolit dan arang aktif
7.	Karakterisasi Filter dengan porositas, daya serap air, kekerasan, SEM EDX, XRD, FTIR dan XRD.											Data morfologi permukaan, kandungan unsur, luas permukaan, dan struktur kristal.
8.	Analisis Data Hasil karakterisasi dengan SEM EDX, XRF, FTIR.											Data yang dihasilkan memiliki kualitas yang baik secara saintifik.
9.	Pengujian Kinerja filter air gambut (uji warna, kekeruhan, PH, logam Fe, logam Mn, UV Vis)											Berkurangnya kadar senyawa organik pada air gambut dan warnanya jernih
11.	Penulisan Laporan Akhir											Laporan Akhir
12.	Penulisan Draft Artikel Ilmiah Dan Draft Paten											Draft Artikel Ilmiah Dan Draft Paten
13	Publikasi Jurnal											Submit ke Jurnal materials science for energy technologies

DAFTAR PUSTAKA

Akmal, Y., Saifuddin, F., & Zulfahmi, I. 2019. "Karakteristik Morfometrik Dan Studi Osteologi Ikan Keureling". Prosiding Biotik, 5(1).

Atikah, Wulan Safrihatini. 2017. "Potensi Zeolit Alam Gunung Kidul Teraktivasi Sebagai Media Adsorben Pewarna Tekstil." Arena Tekstil. 32 (1): 17-24.

Bingol, O. R., dan C. Durucan. 2012. "*Hydrothermal Synthesis of Hydroxyapatite from Kalsium Sulfate Hemihydrate*". Am. J. Biomed. Sci. 4(1). 50-59.

Dyah A, Vera I S, Yusriani D I S. 2013. *"Method Assessment for Ammonia Analysis in Water using Sakicylate Test Kit"*. Ecolab. 7: 49-108.

Gultom, Golfrid., Wirjosentono, Basuki., Sebayang, Kerista and Ginting, Masno. 2016. "*Preparation and Characterization of Microwave-absorption of Sarulla North Sumatra Zeolite and Ferric Oxide-filled Polyurethane Nanocomposites.*" Procedia Chemistry. 19: 441 – 446.

Hamidi, Nurkholis., Wardana, Ing dan Widhiyanuriyawan, Denny. 2011. "Peningkatan Kualitas Bahan Bakar Biogas Melalui Proses Pemurnian Dengan Zeolit Alam." Jurnal Rekayasa Mesin. 2 (3): 227-231.

Hermawan, J. R. 2015. "Perbedaan zeolit alam tak teraktivasi dan Teraktivasi sebagai adsorben dalam Menurunkan kadar amoniak (NH_3) Pada limbah cair rumah sakitUmum daerah ungaran". Junal Skripsi. FKM UNNES. 11-20

Hien, V. D., D. Q. Huong, dan P. T. N. Bich. 2010. "*Study of the Formation of Porous Hydroxyapatite Ceramics from Corals via Hydrothermal Process*. Journal of Chemistry. Vol. 48 (5). P. 591 – 596

Hui, P., S. L. Meena, G. Singh , R. D. Agarawal, dan S. Prakash. 2010. "*Synthesis of Hydroxyapatite Bio-Ceramic Powder by Hydrothermal Method*". Journal of Minerals and Materials Characterization and Engineering, 9(8): 683-692.

Manafi AM, Joughehdoust S. 2009. "*Synthesis of Hydroxyapatite Nanostructure by Hydrothermal Condition for Biomedical Application*". Iranian J Pharmaceutechal Science 5(2):89-94.

Megawati, I. A. 2015. "Uji Toksisitas Deterjen Terhadap Ikan Nila (Orechromis niloticus). Jurnal Skripsi. FKIP UMRAH. 1 – 10.

Millar, G. J., Winnet, A., Thompson,T., Couperthwaite, S.J. 2016. "*Equilibrium Studies of Ammonium Exchange with Australian Natural Zeolites*." *Journal of Water Process Engineering*. 9: 47-57.

Ngapa, Y. D., Sugiarti, S., & Abidin, Z. 2016. "*Hydrothermal Transformation of Natural Zeolite from Ende-NTT and Its Application as Adsorbent of Cationic Dye*". Indones. J. Chem. 16 (2). 138 – 143.

Norjanna, F., Efendi, E., & Hasani, Q. 2015. "Reduksi Amonia Pada Sistem Resirkulasi Dengan Penggunaan Filter Yang Berbeda". E-Journal Rekayasa dan Teknologi Budidaya Perairan. 4 (1). ISSN : 2302-3600

Nuryoto, G. N., Nurmuhammad R., & Kuniawan, T. 2020. "Studi Penyerapa Amoni Menggunakan Zeolit Alam Bayah Tanpa Aktivasi Pada Tambak Ikan". Jurnal Integrasi Proses. 9 (2) :21-26

Oye, G., Sjoblon J. dan Stoker M. 2011. "*Synthesis and Characterization of Siliceous and Aluminum-Containing Mesoporous Materials from Different Surfactant Solution*". Micropor Mesopor Mater. 27, 171- 180

Saputra, D. S., Haeruddin., & Widyarini, N. 2016. "Efektivitas Kombinasi Mikroorganisme Dan Tumbuhan Air Lemna Minor Sebagai Bioremediator Dalam Mereduksi Senyawa Amoniak, Nitrit, Dan Nitrat Pada Limbah Pencucian Ikan". Diponegoro Journal of Maquares. 5 (3) : 80-90.

Sucofndo. 1999. "Laporan Kandungan Amonia dalam Limbah". PT. Sucofndo, Jakarta

Susilawati, *et al*. 2023. *Zeolite Filter-Activated Charcoal Cocoa Bark As Ammonium Absorbing Material in Greywater Waste*. AIP Conference Proceedings. 2626 (040012).

Susilawati, *et al*. 2023. *Characterization of Physical of Filters Based on Pahae Natural Zeolite and Active Charcoal of Cocoa Rind*. AIP Conference Proceedings. 2626 (040024).

Susilawati, *et al*. 2023. *Filter material based on zeolite-activated charcoal from cocoa shells as ammonium adsorbent in greywater treatment*. South African Journal of Chemical Engineering. 43: 266 – 272

Susilawati, *et al*. 2022. *The Effectiveness of Pahae Natural Zeolite-Cocoa Shell Activated Charcoal Nanofilter as a Water Adsorber in Bioethanol Purification*. ACS Omega. 7 (43): 38417 - 38425

Radojevic, M. & V.N. Bashkin. 1999. "*Practical Environmental Analysis*". RoyalSociety of Chemistry, USA

Udyani, Kartika dan Wulandari, Yustia. 2014. "Aktivasi Zeolit Alam Untuk Peningkatan Kemampuan Sebagai Adsorben Pada Pemurnian Biodiesel." Seminar Nasional Sains dan Teknologi Terapan II Institut Teknologi Adhi Tama Surabaya. ISBN : 978-602-98569-1-0.

LAMPIRAN – LAMPIRAN

Lampiran 1. Justifikasi Anggaran Penelitian

Anggaran Penelitian Dana LP USU

1. Honorarium				
Honor	**Honor/Jam (Rp)**	**Waktu (Jam/Minggu)**	**Minggu**	**Besaran Honor (Rp)**
Jasa Preparasi sampel zeolit	4.800,-	20	16	1.536.000
Jasa Preparasi sampel simulasi air limbah greywater	4.800,-	20	16	1.536.000
Honor Tenaga Pembantu Penelitian	3.000,-	20	24	1.440.000
			Sub total (Rp)	**4.512.000**

2. Pembelian Bahan Habis Pakai				
Material	**Justifikasi Pembelian**	**Kuantitas**	**Harga Satuan (Rp)**	**Besaran Harga Bahan Habis Pakai (Rp)**
Kertas A4	ATK	3 rim	50,000	150,000
Pulpen	ATK	2 kotak	36,000	72,000
Spidol	ATK	2 Kotak	66,000	132,000
Penggandaan dan jilid laporan	ATK	1 unit	300,000	300,000
Kertas Label	ATK	2 pack	18,000	36,000
Aquadest	Air pencuci zeolite	33 jerigen	36,000	1,188,000
Sample cup	Wadah sampel	30 pcs	10,000	300,000

Kertas whatman no. 1	Kertas saring	3 box	390,000	1,170,000
Aquabidest	Pelarut bahan kimia	30 botol	40,000	1,200,000
KOH	Bahan kimia untuk aktivasi zeolit	2 botol	849,000	1,698,000
HCl	Bahan kimia untuk pengatur PH dan pengawet air gambut	1 botol	606,000	606,000
NaOH	Bahan kimia untuk pengatur PH	1 botol	720,000	720,000
pH universal	Bahan pengujian	2 kotak	597,000	1,194,000
Sarung Tangan Kerja Safety PVC Merah Tahan Asam / Kimia	APD	3 pcs	30,000	90,000
Alkalin Sitrat	Bahan kimia untuk analisa amonia	1 botol	1,008,000	1,008,000
NaOCl	Bahan kimia untuk analisa senyawa organic air gambut	10 botol	121,800	1,218,000
Kertas Whatman 42	Kertas saring	3 pack	420,000	1,260,000
Sarung Tangan	APD	2 pack	90,000	180,000
Masker Respirator Krisbow	APD	3 pcs	60,000	180,000
RC Masker Kimia 203 KRISBOW Respirator double Filter	APD	10 pcs	119,700	1,197,000
Tissue	ATK	12 pack	9,000	108,000
Hydrothermal Autoclave Reactor	Alat untuk aktivasi zeolit	3 pcs	1,800,000	5,400,000
Magnetic stirrer	Pengaduk larutan	3 pcs	70,000	210,000
Masker	APD	2 pack	60,000	120,000
Buffer pH 2	Larutan buffer pH	1 botol	538,200	538,200
Buffer pH 5	Larutan buffer pH	1 botol	538,200	538,200
Buffer pH 7	Larutan buffer pH	1 botol	538,200	538,200
Buffer pH 9	Larutan buffer pH	1 botol	538,200	538,200

Buffer pH 11	Larutan buffer pH	1 botol	538,200	538,200
Plastik Klip 1 Kg	Wadah zeolite	2 pack	45,000	90,000
Plastik Klip 250 gram	Wadah zeolite	3 pack	30,000	90,000
Biaya seminar Internasional	Biaya seminar Internasional	1 paket	3,000,000	3,000,000
Biaya proof reading jurnal	Biaya proof reading jurnal	1 paket	4,200,000	4,200,000
Biaya publikasi jurnal internasional	Biaya publikasi jurnal internasional	1 paket	19,800,000	19,800,000
			Sub total (Rp)	**49.608.000**

3. Perjalanan

Material	Justifikasi Perjalanan	Kuantitas	Harga Satuan (Rp)	Besaran Biaya Perjalanan (Rp)
Pengambilan Sampel Zeolit ke Tapanuli Utara (Pahae).	Pengambilan sampel zeolit	1 Kali	2.400.000,-	2.400.000,-
			Sub total (Rp)	**2.400.000,-**

4. Sewa

Material	Justifikasi Sewa	Kuantitas	Harga Satuan (Rp)	Besaran Biaya Sewa (Rp)
Oven	Sewa	4	142.500,-	570.000,-
Hot Plate Stirer	Sewa	4	90.000,-	370.000,-
Sewa UV-Vis Spectrophotometer	Sewa	4	300.000,-	1.200.000,-
Sewa Furnace	Sewa	4	90.000,-	370.000,-
Sewa Desikator	Sewa	4	90.000,-	370.000,-
Sewa Timbangan Analitik	Sewa	4	150.000,-	600.000,-
			Sub Total (Rp)	**3.480.000,-**
TOTAL ANGGARAN YANG DIPERLUKAN (Rp)				**60.000.000,-**

Anggaran Peneltian Dana *in kind* Mitra

Biaya Pengujian				
Material	**Justifikasi Anggaran**	**Kuantitas**	**Harga Satuan (Rp)**	**Besaran Biaya (Rp)**
Uji Karakterisasi SEM-EDX	Karakterisasi sampel	6	850.000,-	5.100.000,-
Uji Karakterisasi XRD	Karakterisasi sampel	6	450.000,-	2.700.000,-
Uji Karakterisasi XRF	Karakterisasi sampel	6	430.000,-	2.580.000,-
Uji Karakterisasi BET	Karakterisasi sampel	6	1.200.000,-	7.200.000,-
FTIR	Uji organik air gambut	10	242.000,-	2.420.000,-
TOTAL ANGGARAN YANG DIPERLUKAN (Rp)				**20.000.000,-**

Lampiran 2: Biodata Tim Peneliti

1. Ketua Pengusul

Nama	: Dr. Susilawati, S.Si., M.Si.
NIDN//NIP	: 007127402/197412072000122001
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ID Sinta	: 6089224
SISTER	ada (sudah diperbaharui)
H index Scopus	: 4

Publikasi di Jurnal Internasional Terindeks

No.	Judul Artikel	Peran	Nama Jurnal, Tahun Terbit, Volume, Nomor, P-ISSN/E-ISSN	URL Artikel (jika ada)
1	The Effectiveness of Pahae Natural Zeolite-Cocoa Shell Activated Charcoal Nanofilter as a Water Adsorber in Bioethanol Purification	Penulis Pertama/ Penulis Koresponden	ACS Omega, 2023, 7, 43, 24701343	https://doi.org/10.1021/acsomega.2c03614
2	Filter material based on zeolite-activated charcoal from cocoa shells as ammonium adsorbent in greywater treatment	Penulis Pertama/ Penulis Koresponden	South African Journal of Chemical Engineering, 2023, 43, 266 – 272, 10269185	https://doi.org/10.1016/j.sajce.2022.11.006
3	Performance optimization of CuO-ZnO ceramic electrode on the electrocoagulation of wastewater	Penulis kedua/Penulis Koresponden	Materials Science for Energy Technologies, 2023, 6, 7-14, 25892991	https://doi.org/10.1016/j.mset.2022.11.001
4	Effect of reduced graphene oxide (rGO) in chitosan/Pahae natural zeolite-based polymer electrolyte membranes for direct methanol fuel cell (DMFC) applications	Penulis kedua	Materials Science for Energy Technologies, 2023, 6, 252 – 259, 25892991	https://doi.org/10.1016/j.mset.2023.01.002

5	Synthesis of magnetic activated carbon-supported cobalt (II) chloride derived from pecan shell (Aleurites moluccana) with co-precipitation method as the electrode in supercapacitors	Penulis kedua	Materials Science for Energy Technologies, 2023, 6, 429-436, 25892991	https://doi.org/10.1016/j.mset.2023.04.004
6	Preparation, characterization, and desalination study of polystyrene membrane integrated with zeolite using the electrospinning method	Penulis keempat	Heliyon, 2023, 8, 8, 24058440	https://doi.org/10.1016/j.heliyon.2022.e10113
7	Fabrication And Modification Of Chitosan/Pahae Natural Zeolite/Reduced Graphene Oxide (Cs/Pnz/Rgo)–Based Polymer Electrolyte Membranes	Penulis kedua	Rasayan Journal of Chemistry, 2022, 15, 3, 09741496	https://rasayanjournal.co.in/admin/php/upload/3651_pdf.pdf
8	Preparing Nanoparticle of Pahae natural Zeolite Using High Energy Milling and Its Potential for Bioethanol Purification	Penulis Pertama/ Penulis Koresponden	Rasayan Journal Chemistry, 2021,14, 2, 0974-1496/0976-0083	http://www.rasayanjournal.com
9	Fabrication of chitosan/natural zeolite composite-based polymer electrolyte membranes.	Penulis Kedua	Rasayan Journal Chemistry, 2020,13, 4, 0974-1496/0976-0083	http://www.rasayanjournal.com
10	The improvement of mechanical properties of hydrogen filter based on natural zeolite from pahae and clay addition	Penulis Pertama/ Penulis Koresponden	Rasayan Journal Chemistry, 2020,13, 3, 0974-1496/0976-0083	http://www.rasayanjournal.com
11	The effect of molybdenum disulfide nanoparticles and sodium dodecyl sulfate addition towards wear protection properties from the sae 10W-30 standard. Lubricants.	Penulis Pertama/ Penulis Koresponden	Rasayan Journal Chemistry, 2020,13, 2, 0974-1496/0976-0083	http://www.rasayanjournal.com

12	The effect of tungsten disulfide additives and sodium dodecyl sulfate on base oils combinations compared to lubricants 10W-40 to reduce friction.	Penulis Pertama/ Penulis Koresponden	Rasayan Journal Chemistry, 2019,12, 3, 0974-1496/0976-0083	http://www.rasayanjournal.com
13	Hydrogen Purification Using Natural Pahae Zeolit And Cocoa Rind Based Filter.	Penulis Pertama / Penulis Koresponden	International Journal of Applied Engineering Research, 2017, 12, 13, 0973-4562	http://www.ripublication.com
14	Manufacture of Water Vapour Filter Based on Natural Pahae Zeolite Used for Hydrogen Fueled	Penulis kedua	Applied Mechanics and Material, 2015, 754-755 / 754-755.789	www.scientific.net

Publikasi di Jurnal Nasional Terakreditasi

No.	Judul Artikel	Peran	Nama Jurnal, Tahun Terbit, Volume, Nomor, P-ISSN/E-ISSN	URL Artikel (jika ada)
1	Processing of Palm Midrib Waste into Animal Feed with a Fermentation Process that is integrated with a chopper in Sialang Village Deli Serdang	Penulis Pertama	ABDIMAS TALENTA Vol. 7, No. 1, 2022 211-221 p-ISSN: 2549-4341 e-ISSN: 2549-418X	https://talenta.usu.ac.id/abdimas/article/view/6509
2	Fruit Fly Pest Control with Ultrasonic Waves and Modified Steiner Trap in Orange Orchard in Narigunung 1 Village, Karo Regency	Penulis Kedua	ABDIMAS TALENTA Vol. 6 (2) 2021: 485-491 p-ISSN: 2549-4341 e-ISSN: 2549-418X	https://talenta.usu.ac.id/abdimas/article/view/6097
3	Introduction of verticulture technique for utilization of spring land in Madrasah Tsanawiyah (MTS) Ibnu Sina City of	Penulis Kedua	ABDIMAS TALENTA Vol. 4 (1) 2019: 872 – 876 p-ISSN: 2549-4341 e-ISSN: 2549-418X	https://talenta.usu.ac.id/abdimas/article/view/4246

Proseding Seminar/Konferensi Internasional Terindeks

No.	Judul Artikel	Peran	Nama Jurnal, Tahun Terbit, Volume, Nomor, P-ISSN/E-ISSN	URL Artikel (jika ada)
1	Characterization of Physical of Filters Based on Pahae Natural Zeolite and Active Charcoal of Cocoa Rind	Penulis Pertama/ Penulis Koresponden	AIP Conference Proceedings, 2023, 2626, 040024, 0094243X	https://doi.org/10.1063/5.0136201
2	Zeolite Filter-Activated Charcoal Cocoa Bark As Ammonium Absorbing Material in Greywater Waste	Penulis Pertama/ Penulis Koresponden	AIP Conference Proceedings, 2023, 2626, 040012, 0094243X	https://doi.org/10.1063/5.0136201
3	The Influence of Sulfuric Acid Crosslinked on Mechanical and Chemical Properties of	Penulis kedua	AIP Conference Proceedings, 2023, 2626, 040022, 0094243X	https://doi.org/10.1063/5.0135937
4	Effect of storage time of biodegradable plastic porang starch with glycerol plasticizer on mechanical and thermal	Penulis kedua	AIP Conference Proceedings, 2023, 2595, 030002, 0094243X	https://doi.org/10.1063/5.0123884
5	Utilization of porang starch (Amorphophallus oncophyllus Prain) and chitosan in the production and	Penulis kedua	AIP Conference Proceedings, 2023, 2595, 030006, 0094243X	https://doi.org/10.1063/5.0123883
6	Construction of Ultrasonic Fruit Fly Repellent Device in Orange Orchard	Penulis ketiga	Journal of Physics: Conference Series, 2023, 2421, 012030, 17426588	https://iopscience.iop.org/article/10.1088/1742-6596/2421/1
7	Anatomical properties of branches and twigs mangrove woods	Penulis keempat	IOP Conference Series: Earth and Environmental Science, 2022, 1115, 1, 17551307	https://iopscience.iop.org/article/10.1088/1755-1315/1115/1/012066
8	Synthesis and characterization of natural zeolite-clay as resistive humidity detection	Penulis Pertama/ Penulis Koresponden	Journal of Physics: Conference Series, 2021, 012040, -, 17426588	https://doi.org/10.1088/1742-6596/1811/1/012040

9	A new of colorimetric sensor based on azo-hydrazone compound for recognition of CN-ion	Penulis ketiga	AIP Conference Proceedings, 2021, 2342, 030004, 0094243X	https://doi.org/10.1063/5.0045550
10	The utilization of cocoa rind waste and clay as filter materials in purifying well water	Penulis Pertama/ Penulis Koresponden	AIP Conference Proceedings, 2020, 2221, 1100101,	https://doi.org/10.1063/5.0003177
11	Fabrication and characterization of physical and mechanical properties based on clay and cacao rind porous ceramics	Penulis Pertama/ Penulis Koresponden	AIP Conference Proceedings, 2020, 2221, 1100091	https://doi.org/10.1063/5.0003174
12	Effect of dopant on superconductor $Bi_{1.6}Pb_{0.4}Sr_2Ca_{2-x}M_xCu_3O_y$ (M = Ce, Na, Mg) phase 2223 by solid method	Penulis Kelima	AIP Conference Proceedings, 2020, 2221, 1100111	https://doi.org/10.1063/5.0003934
13	The effect of Mg, Na, and Ce addition on the superconducting properties of $Bi_{1.6}Pb_{0.4}Sr_2Ca_{2-x}M_xCu_3O_y$ prepared sol-gel method	Penulis Ketujuh	AIP Conference Proceedings, 2020, 2221, 1100061	https://doi.org/10.1063/5.0004299
14	Improving zeolite power of pahae natural adsorption as the hydrogen filter with the addition of blood clams (Anadara Granosa) as the filler	Penulis keempat	Journal of Physics: Conference Series, 2019, 1185(1), 012005, 1742 - 6596	https://iopscience.iop.org/issue/1742-6596/1185/1
15	Ethanol Purification Using Active Natural Pahae Zeolite By Adsorption Distillation Method	Penulis Pertama / Penulis Koresponden	Journal of Physics Conf. Series, 2018, 1116, 032037, 1742 - 6596	https://iopscience.iop.org/issue/1742-6596/1116/3
16	Fabrication of Ceramic Composites Based on CuO - ZnO	Penulis Pertama / Penulis Koresponden	Journal of Physics Conf. Series, 2018, 1116, 032038, 1742 - 6596	https://iopscience.iop.org/issue/1742-6596/1116/3

17	Characterization of Low-Density Polyethylene (LDPE) / Carbon Black (CB) Nanocomposite-Based Packaging Material	Penulis Kelima	Journal of Physics Conf. Series, 2018, 1120, 012066, 1742 - 6596	https://iopscience.iop.org/issue/1742-6596/1120/1

Penerbitan Buku

No.	Judul Buku	Tahun Penerbitan	ISBN	Penerbit	URL (jika ada)
1	Pengolahan Limbah Cair Industri Perkebunan dan Air Gambut Menjadi Air Bersih	2011	979 458 541 6	USU Pers	
2	Penuntun Praktikum Fisika	2011	200	-	
3	Elektroda Tembaga Pada Proses Elektrokoagulasi Dalam Penjernihan Air Sungai	2021	57	QIARA MEDIA	
4	Inovasi Material Komposit untuk Pengolahan Air Limbah menggunakan Metode Elektrokoagulasi	2021	79	CV. Pena Persada	
5	Penerapan Metode Elektrokoagulasi Dalam Peningkatan Kulaitas Air	2021	82	NEM	

Perolehan Kekayaan Intelektual (KI)

No.	Judul KI	Tahun Perolehan	Jenis KI	Nomor	Status KI	URL (jika ada)
1	KIT Filter Hidrogen Yang Mengandung Zeolit Untuk Pemurnian Gas Hidrogen Hasil Pemisahan Molekul	2018	Paten Sederhana	IDS000001981	Granted	https://pdki-indonesia.dgip.go.id/index.php/paten/ekk1QU9rR09vTzVlS1VMRG83VXV1dz09?q=Filter+Zeolit+Untuk+Pemurnian+Gas+Hidrogen+Hasil+Pe

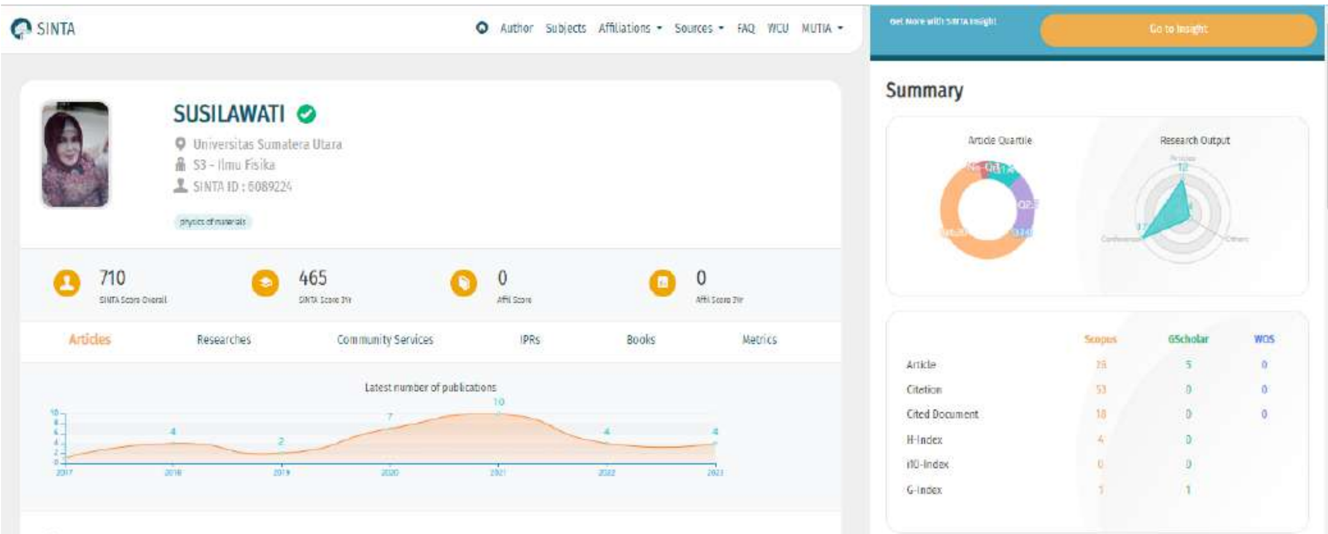
2	Bahan Pengisi dari kulit kerang darah (anadara granosa) untuk pemurnian gas hidrogen hasil pemisahan molekul air dengan metode elektrolisa	2023	Paten Sederhana	IDS000006210	Granted	

Semua data yang saya isikan dan tercantum dalam biodata ini adalah benar dan dapat dipertanggungjawabkan secara hukum. Apabila di kemudian hari ternyata dijumpai ketidak-sesuaian dengan kenyataan, saya sanggup menerima sanksi.

Demikian biodata ini saya buat dengan sebenarnya untuk memenuhi salah satu persyaratan dalam pengajuan proposal Penelitian Dasar.

Medan, 31-07-2023
Ketua Pengusul,

(Dr. Susilawati, S.Si., M.Si.)



2. Anggota

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NIDN//NIP	0023016402/ 196401231991022001
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ID Sinta	6024055
SISTER	ada (sudah diperbaharui)
H index Scopus	8

Publikasi di Jurnal Internasional Terindeks

No.	Judul Artikel	Peran	Nama Jurnal, Tahun Terbit, Volume, Nomor, P-ISSN/E-ISSN	URL Artikel (jika ada)
1	New Material Nanocomposite Thermoplastic Elastomer with Low Cost Hybrid Filler Oil Palm Boiler Ash/Carbon Black	Penulis Kedua/ Penulis Koresponden	J. Ecol. Eng., 2023, 24, 2, 2299-8993	https://doi.org/10.12911/22998993/156903
2	Effect of Hybrid Filler Oil Palm Boiler Ash – Bentonite on Thermal Characteristics of Natural Rubber Compounds	Penulis Pertama/ Penulis Koresponden	Ecol. Eng. Environ. Technol., 2023, 2, 205–213, 2719-7050	https://doi.org/10.12912/27197050/156961
3	Carboxymethyl Cellulose Nanoadsorbent for Remediation of Polluted Water	Penulis Kedua/ Penulis Koresponden	J. Ecol. Eng. 2023, 24, 1, 2299-8993	https://doi.org/10.12911/22998993/156150
4	Selfcleaning and antibacterial activities of textiles using nanocomposite oil palm boiler ash (OPBA), TiO2 and chitosan as coating	Penulis Kedua/ Penulis Koresponden	South African Journal of Chemical Engineering, 41, -, 105-110, 10269185	https://www.scopus.com/record/display.uri?eid=2-s2.0-85131644679&origin=resultslist&sort=plf-f
5	Preparation of Environmentally Friendly Adsorbent using Oil Palm Boiler Ash, Bentonite and Titanium Dioxide Nanocomposite Materials	Penulis Ketiga/ Penulis Koresponden	J. Ecol. Eng., 2022, 23, 12, 2299-8993	https://doi.org/10.12911/22998993/155020
6	Optimization of Palm Oil Boiler Ash Biomass Waste as a Source of Silica with Various Preparation Methods	Penulis Kedua/ Penulis Koresponden	J. Ecol. Eng., 2022, 23, 8, 2299=8993	https://doi.org/10.12911/22998993/150694
7	The Effect Of Size And Crumb Rubber Composition As A Filler With Compatibilizer Pp-G-MA In Polypropylene Blends And Sir-20 Compound	Penulis Kedua/ Penulis Koresponden	Jurnal Makara Seri Teknologi Universitas	http://journal.ui.ac.id/technology/journal/article/view/1517

	On Mechanical And Thermal Properties		Indonesia/2012, Vol 16 No 2 Desember 2012 Akreditasi Dikti No 56/Dikti/Kep/2012	
8	The Effect Zeolite Addition In Natural Rubber Polypropylene Composite On Mechanical, Structure, And Thermal Characteristics	Penulis Kedua/ Penulis Koresponden	Jurnal Makara Seri Teknologi Universitas Indonesia/2012 Vol 17 No 3 Desember 2013 Akreditasi Dikti No 56/Dikti/Kep/2012	http://journal.ui.ac.id/technology/journal/article/view/2926
9	Preparation Natural Bentonit in Nano Particle Material as Filler nanocomposite High Density Poliethylene (Hdpe)	Penulis Kedua/ Penulis Koresponden	IISTE, Chemistry ang Materials Research united states/2013 Vol 3, No. 13, 2013 ISSN 2224-3224(Print) ISSN 2225-0956 (online)	https://www.iiste.org/Journals/index.php/CMR/article/view/9382
10	Analyses Mechanic And Thermal Composite Thermoplastic High Density Polyethylene With Filler Zeolite Modification	Penulis Kedua/ Penulis Koresponden	Journal International IISTE ,Chemistry ang Materials Research united states/2014, Vol 6 No 3 2014 ISSN 2224-3224(Print) ISSN 2225-0956 (online)	https://www.iiste.org/Journals/index.php/CMR/article/view/11723
11	Natural Zeolite Modification With A Surfactant Cetyl Trimethyl Ammonium Bromide (Ctab) As Material To Filler In Polypropylene	Penulis Kedua/ Penulis Koresponden	Journal International IISTE ,Chemistry ang Materials Research united states/2014 Vol 6 No 6 -2014 ISSN 2224-3224(Print) ISSN 2225-0956 (online)	https://www.semanticscholar.org/paper/Natural-Zeolite-Modification8 With-A-Surfactant-As-Frida-Bukit/8af569aa5bf4b8d623adc6015e8b91b14cfea554
12	Synthesis Of Fe3O4 Nanoparticles Of Iron Sand	Jurnal Chemistry and	07 /(07). /2015 pp. 110-115. ISSN	http://iiste.org/Journals/

	Coprecipitation Method With Polyethylene Glycol 6000	Materials Research/2015,	2225-3224	index.php/CMR /article/ view/24399/249 73
13	Characterization of Nanoparticles Fe3O4 Nanocomposite Blend with Thermoplastic HDPE	Journal International IISTE, Chemistry and Materials Research/2016	Vol.8/No 8/2016 ISSN 2224-3224 (Print) ISSN 2225-0956 (Online)	http://iiste.org/J ournals/ index.php/CMR /article/ view/32336/332 24
	Morphology And Conductivity Film In Polyaniline Doped ZnO	The Third Annual International Seminar on Trends in Science and Science Education 2016, 7-8 Oct 2016, Medan.	The Third Annual International Seminar on Trends in Science and Science Education 2016, 7-8 Oct 2016, Medan.	http://digilib.uni med.ac .id/22512/ Tahun 2016 http://sitsefmipa. unime d.ac.id/proceedi ng2016 /sitse2016/45%2 0Eva% 20Marlina%20G inting1 ,%20Sri%20Wa hyuni% 20Batubara1,%2 0Nurdi n%20Bukit1,%2 0Erna %20Frida2.pdf
	Analysis Thermal of Thermoplastic Elastomer With Filler Powder Waste Tire	Agrium/2016 Vol.20/ No.2/Oktober 2016 ISSN 0852-1077 (Print) ISSN 2442-7306	Vol.20/ No.2/Oktober 2016 ISSN 0852-1077 (Print) ISSN 2442-7306 (Online)	http://jurnal.ums u.ac.id/ index.php/agriu m/articl e/view/629/560

Publikasi di Jurnal Nasional Terakreditasi

No.	Judul Artikel	Peran	Nama Jurnal, Tahun Terbit, Volume, Nomor, P-ISSN/E-ISSN	URL Artikel (jika ada)
	Pengolahan Ban Bekas Berwawasan Lingkungan Menjadi Bahan Bamper Pada	Penulis Kedua/ Penulis Korespon den	Teknologi Indonesia Jurnal LIPI/2011 34/Edisi Khusus 2011	

	Outomotif			
	Sifat Mekanis Nano Komposit Termoplastik High Density Poliethylene Dengan Filler Nano Partikel Fe3O4		Semirata Bidang MIPA BKS-PTN Barat 2016, 22-24 May 2016, Palembang.	http://digilib.unimed.ac.id/22516/
	Struktur dan Morfologi Nano Komposit Campuran Zeolit Abu Sekam Padi		Jurnal Material dan Energi Indonesia Departemen Fisika FMIPA Universitas Padjadjaran/2017	Vol.07/No.01/2017 http://jurnal.unpad.ac.id/jmei/article/view/12803/5819 http://jurnal.unpad.ac.id/jmei/article/view/12803/5819
	Analisis Mekanik Dan Difraksi Nano Komposit Termoplastik HDPE		Prosiding Seminar Nasional Fisika (EJurnal)	https://doi.org/10.21009/03.SNF2017.02.MPS.02
	Analisis Kekuatan Asphalt Concrete Wearing Cource (ACWC) dengan serbuk ban bekas sebagai Zat Aditif		Jurnal Ilmiah Fakultas Teknik Universitas Quality (Juitech)/Terakreditasi Sinta 6/2017	Vol.1/Issue 1/ 2017 http://www.portaluniversitasquality.ac.id:5388/ojssystem/index.php/JUITECH/article/view/6/26

Prosiding Seminar/Konferensi Internasional Terindeks

No.	Judul Artikel	Peran	Nama Prosiding, Tahun Terbit, Volume, Nomor, P-ISSN/E-ISSN	URL Artikel (jika ada)
	Banana peels activated carbon performance for the remediation of lead contaminated heavy metal water (Pb)	Penulis Kedua/ Penulis Koresponden	AIP Conference Proceedings, 2023 2480, 020004, 1551-7616/ 0094-243X	https://doi.org/10.1063/5.0107023
	Preparation and characterization of CTAB surfactant modified TiO2 nanoparticles as antibacterial fabric coating material	Penulis Kedua/ Penulis Koresponden	Journal of Physics: Conference Series, 2022, 2165, 012022, 1742-6596	https://iopscience.iop.org/article/10.1088/1742-6596/2165/1/012022
	Preparation and characterization of	Penulis Pertama/	Journal of Physics: Conference Series,	https://iopscience.iop.org/article/10.1088/1742-6596/2165/1/012023

	Bentonite-OPBA nanocomposite as filler	Penulis Koresponden	2022, 2165, 012023, 1742-6596	
	Mechanical Properties and Morphology Natural Rubber Blend with Bentonite and Carbon Black	Penulis Pertama/ Penulis Koresponden	IOP Conf.Series : Materials Science and Engineering /2017, 223, 1757-899X	http://iopscience.iop.org/article/10.1088/1757-899X/223/1/012003/meta

Buku

No.	Judul Buku	Tahun Penerbitan	ISBN	Penerbit	URL (jika ada)
1	Karakteristik Nano Komposit Termoplastik HDPE	2017	978-602-50622-7-8	Unimed Press	
2	Mekanika Fluida	2017	978-602-61175-1-9	Universitas Quality Press	
3	Pengolahan Pasir Besi Menjadi Nano Partikel Fe3O4 Sebagai Bahan Pengisi Nano Komposit Termoplastik HDPE	2016	978-602-431-007-3	Unimed Press	
4	Modul Praktikum Fisika Dasar 1	2020	9786239119621	Physical Society of Indonesia SUMUT	
5	Modul Praktikum Fisika Dasar 2	2020	9786239119645	Physical Society of Indonesia SUMUT	
6	Modul Praktikum Gelombang	2020	9786239119638	Physical Society of Indonesia SUMUT	
7	Termoplastik elastomer dengan bahan pengisi nano partikel abu tandan kosong kelapa sawit	2020	9786239494803	PD Aneka Industri dan Jasa Provsu	

Perolehan Kekayaan Intelektual (KI)

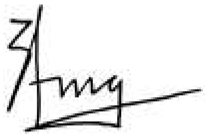
No.	Judul KI	Tahun Perolehan	Jenis KI	Nomor	Status KI	URL (jika ada)
1	Proses dan Formula Partikel	2017	Paten	P00201709358	Granted	

	Termoplastik High Density Poliethylene (HDPE) dengan Filler Nano Fe3O4					
2	Pengolahan Pasir Besi menjadi Nano Partikel Fe3O4 sebagai Bahan Pengisi Nano Komposit Termoplastik HDPE	2019	Hak Cipta	000139489	Granted	
3	Karakteristik Nano Komposit Termoplastik HDPE	2019	Hak Cipta	000139848	Granted	
4	Proses Pembuatan Material Nano Komposit Termoplastik High Density Polyethylene (HDPE) dengan Bahan Pengisi Abu Sekam Padi Berukuran Nano	2021	Paten Sederhana	IDS000004391	Granted	
5	Proses Pembuatan Isolator Listrik Berbasis Polimer Berbahan Resin Epoksi, Karet Silikon, dan Abu Serat Kelapa	2021	Paten Sederhana	IDS000004478	Granted	

Semua data yang saya isikan dan tercantum dalam biodata ini adalah benar dan dapat dipertanggungjawabkan secara hukum. Apabila di kemudian hari ternyata dijumpai ketidak-sesuaian dengan kenyataan, saya sanggup menirima sanksi.

Demikian biodata ini saya buat dengan sebenarnya untuk memenuhi salah satu persyaratan pengusulan proposal Talenta skema Penelitian Kerjasama Pemerintah.

Medan, 31 Juli 2023dir



Prof. Dr. Dra Erna Frida M.Si

3. Anggota

Nama	Dr. Andriayani S.Pd., M.Si.
NIDN//NIP	0005036903/ 196903051999032001
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Alamat e-mail	andriayani@gmail.com
ID Sinta	6040385
SISTER	ada (sudah diperbaharui)
H index Scopus	6

Publikasi di Jurnal Internasional Terindeks

No.	Judul Artikel	Peran	Nama Jurnal, Tahun Terbit, Volume, Nomor, P-ISSN/E-ISSN	URL Artikel (jika ada)
	Stability of mesoporous silica using ricinoleic methyl ester as a template with the addition of HCl and application of Cd2+ adsorption optimized by Box-Behnken design	Penulis Pertama/ Penulis Korespon den	RSC advances Volume 13, No 11, Maret 2023, Pages : 7329–7338 ISSN : 2046-2069	https://doi.org/10.1039/D2RA06973C
1	The Stabilization of Liquid Smoke through Hydrodeoxygenation Over Nickel Catalyst Loaded on Sarulla Natural Zeolite	Penulis Ketiga	Applied Sciences (Switzerland) – MDPI Appl. Sci. 2020, 10(12), 4126; https://doi.org/10.3390/app10124126	https://www.mdpi.com/2076-3417/10/12/4126
2	Synthesis of Mesoporous Silica from Tetraethylorthosilicate by Using sodium Ricinoleic Acid as a Template and 3-Aminopropyltrimethoxysilane as Co-Structure Directing Agent with Volume Variation of Hydrochloric acid 0.1N	Penulis utama	Advanced Material Research, Trans Tech Publication Ltd, Switzerland 789/2013; hal:124-131	https://www.scitepress.org/Papers/2018/100884/pdf/index.html
3	Optimization of Silicone Extraction from Tanjung Tioram Asahan Natural Sand through Magnesiothermic Reduction	Penulis utama	International Journal of Technology (IJTEC) Volume 6, Issue 7 (SE) Desember 2015	https://ijtech.eng.ui.ac.id/old/index.php/journal/article/view/1493

4	Magnesium Impregnated Silica Mesoporous Prepared using Ester Ricinoleic as Template for the Esterification	Penulis utama	In Proceedings of the 1st International Chemical Science and Technology Innovation (ICOCSTI 2019), SCITEPRESS – Science and Technology Publications, Lda.	https://www.scitepress.org/Papers/2019/89217/89217.pdf
5	Extraction Silica From Rice Husk With NaOH Leaching Agent With Temperature Variation Burning Rice Husk	Corresponding author	Vol. 14 | No. 3 |2125-2128| July - September | 2021 ISSN: 0974-1496 | e-ISSN: 0976-0083 | CODEN: RJCABP	http://rasayanjournal.co.in/admin/php/upload/3308_pdf.pdf
6.	Methanol Mass Variation of Mesoporous Silica Synthesis Using Ricinoleic Methyl Ester as A Template	Penulis utama	Volume 57/edisi 1/2022; hal: 617-624 DOI : 10.35741/issn.0258-2724.57.1.55	https://jsju.org/index.php/journal/article/view/1205
7.	Facile Method to Synthesize of N-Graphene Nano Sheets	Penulis Ketiga	Oriental Journal of chemistry Vol. 34, No. 4 ISSN : 0970 - 020X, ONLINE ISSN : 2231-5039	http://www.orientjchem.org/vol34no4/facile-method-to-synthesize-of-n-graphene-nano-sheets/
8.	GC-MS Analysis of Chemical Contents and Physical Properties of Essential Oil of Eucalyptus grandis from PT. Toba Pulp Lestari	Penulis Kelima	Asian Journal of Chemistry Vol. 31 No. 10 (2019): Vol 31 Issue 10	https://asianpubs.org/index.php/ajchem/article/view/459

Publikasi di Jurnal Nasional Terakreditasi

No.	Judul Artikel	Peran	Nama Jurnal, Tahun Terbit, Volume, Nomor, P-ISSN/E-ISSN	URL Artikel (jika ada)
1.	Pengaruh Temperatur Pentanuran pada Proses Isolasi Silikon (Si) secara Magnesiotermal dari Pasir Alam	Penulis utama	Proseding Seminar Nasional Pendidikan Sains (SNPS) No. ISSN: 2357-7022, hal: 418-425/ 2013	https://eprints.uai.ac.id/1504/1/ILS0116-20_Halaman-Awal.pdf

2.	Teacher Upgrading Skill in Preparing Materials and Examination Based on Images in Sibolga City	Penulis utama	ABDIMAS TALENTA ABDIMAS TALENTA 5 (2) 2020: 677-683	https://talenta.usu.ac.id/abdimas/article/view/5495

Prosiding Seminar/Konferensi Internasional Terindeks

No.	Judul Artikel	Peran	Nama Prosiding, Tahun Terbit, Volume, Nomor, P-ISSN/E-ISSN	URL Artikel (jika ada)
1	The effect concentration of tetraethylorthosilicate and variation HCl 0.1M for synthesis mesoporous silica using oleic acid as template and 3-aminopropyltrimethoxy silane as co-structure directing Agent	Penulis pertama	IOP Science Journal of Physics: Conference Series 1116 042006	https://iopscience.iop.org/article/10.1088/1742-6596/1116/4/042006
2	Increased of Purity Silicon from Natural Sand with variation of Heating Time through Magnesiothermal	Penulis utama	Proceedings The 2nd International Conference on Natural and Environmental Sciences (ICONES 2014), No. ISSN: 2407-2389 hal: 149-154/2014	http://jurnal.unsyiah.ac.id/ICONES/article/view/7042
3	Synthesis of Carbon Nanodots from Cellulose Nanocrystals Oil Palm Empty Fruit by Pyrolysis Method	Penulis keempat	IOP Science Journal of Physics: Conference Series 1120 012071	https://iopscience.iop.org/article/10.1088/1742-6596/1120/1/012071
4	The Isolation of Nanofiber Cellulose from Oil Palm Empty Fruit Bunch Via Steam Explosion and Hydrolisis with HCl 10%	Penulis keempat	IOP Conf. Series: Journal of Physics: Conf. Series **979**(2018) 012063 Doi:10.1088/1742-6596/979/012063	https://iopscience.iop.org/article/10.1088/1742-6596/979/1/012063
5.	Effect Of Variation Temperature At	Penulis kedua	AIP Conference Proceedings	https://aip.scitation.org/doi/abs/10.1063/5.0046151

	Burning Rice Husk To Obtain Silica		Conference Proceedings **2342**, 040001 (2021);	
6.	Chemical Reduction Of Silica Into Silicon From Extracted Quartz Sand Using Sodium Hydroxide And Hydrochloric Acid Solutions	Penulis utama	AIP Conference Proceedings Conference Proceedings **2342**, 040002 (2021);	https://aip.scitation.org/doi/abs/10.1063/5.0046150
7.	The effects of mass variation potassium chloride (KCl) on characteristics of nanosilicone from natural sand through the magnesiothermic method	Penulis Kedua	IOP Science Journal of Physics: Conference Series 1485 012051	https://iopscience.iop.org/article/10.1088/1742-6596/1485/1/012051
	Breeding season of Cormorant (Phalacrocorax sulcirostris) at Tanjung Rejo, Sumatera Utara	Penulis kedua	IOP Science Journal of Physics: Conference Series 305 012086	https://iopscience.iop.org/article/10.1088/1755-1315/305/1/012086

Buku

No.	Judul Buku	Tahun Penerbitan	ISBN	Penerbit	URL (jika ada)
-	-	-	-	-	-

Perolehan Kekayaan Intelektual (KI)

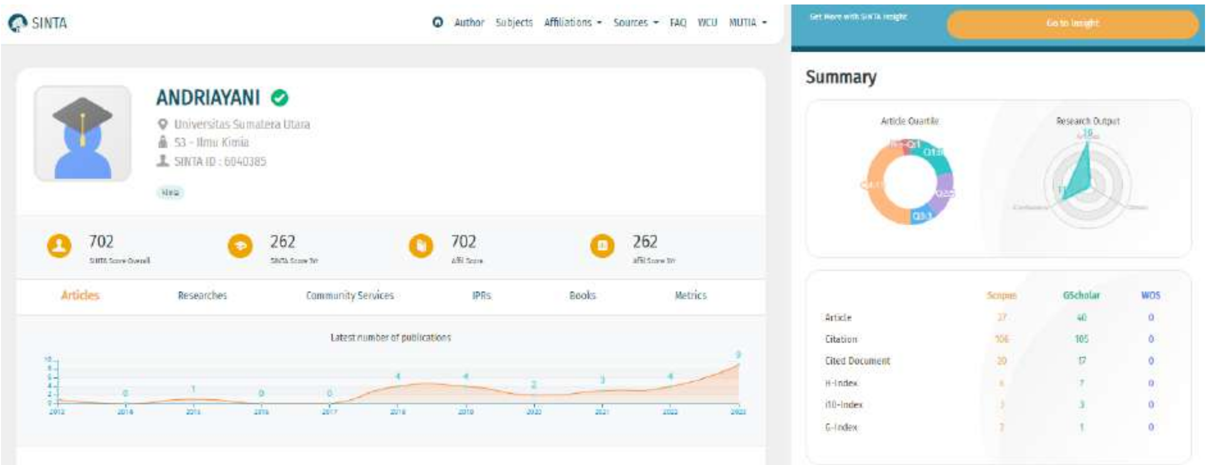
No.	Judul KI	Tahun Perolehan	Jenis KI	Nomor	Status KI	URL (jika ada)
1	Proses Ektraksi Pasir Alam Untuk Mendapatkan Silikon Secara Magnesiotermal	11 Desember 2020	Paten Sederhana	IDS000003429	Granted	

Semua data yang saya isikan dan tercantum dalam biodata ini adalah benar dan dapat dipertanggungjawabkan secara hukum. Apabila di kemudian hari ternyata dijumpai ketidak-sesuaian dengan kenyataan, saya sanggup menirima sanksi.

Demikian biodata ini saya buat dengan sebenarnya untuk memenuhi salah satu persyaratan pengusulan proposal Talenta skema Penelitian Kerjasama Pemerintah.

Medan, 31 Juli 2023

Dr. Andriayani, M.Si



4. Anggota

Nama	Prof. Dr. Perdinan Sinuhaji, MS.
NIDN//NIP	0010035905/ 195903101987031002
Pangkat/Jabatan	Guru Besar
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ID Sinta	6032392
SISTER	ada (sudah diperbaharui)
H index Scopus	5

Publikasi di Jurnal Internasional Terindeks

No.	Judul Artikel	Peran	Nama Jurnal, Tahun Terbit, Volume, Nomor, P-ISSN/E-ISSN	URL Artikel (jika ada)
1.	Characterization of Volcanic Ash of Mount Sinabung Erupting On 29th June 2014 Using XRD, SEM and AAS	First Author	IJSR. Issue 12. Vol. 3. ISSN (Online): 2319-7064	http://repository.usu.ac.id/bitstream/handle/123456789/70931/Fulltext.pdf?sequence=1&isAllowed=y
2.	Using Alumina and Volkanic Ash in Producing Catalytic Converter Ceramics	First Author	IJAER. 2017. Vol.12, Number 3. ISSN 0973-4562	http://repository.usu.ac.id/bitstream/handle/123456789/70935/Fulltext.pdf?sequence=1&isAllowed=y
3.	Obtaining tin (II) oxide by a chemical method	First Author	Functional Materials. 2021. 28. No.3. ISSN 1027-5495	http://functmaterials.org.ua/
4.	The utilization of carbonized coffee in purifying zinc dross waste by pyrometallurgy method	First Author	Elsevier: Case Studies in Thermal Engineering. 2020. 17. 100576	https://www.journals.elsevier.com/case-studies-in-thermal-engineering
5.	Using Alumina and Volcanic Ash in Producing Catalytic Converter Ceramics	First Author	IJAER. 2017. Vol. 12. No. 3. ISSN 0973-4562	http://www.ripublication.com/ijaer.htm
6.	The development of a novel FM nanoadsorbent for heavy metal remediation in polluted water	Fourth Author	South African Journal of Chemical Engineering. 2022. 39	https://www.journals.elsevier.com/south-african-journal-of-chemical-engineering
7.	Data on characterization, model, and adsorption rate of banana peel activated carbon (*Musa Acuminata*) for adsorbents of various	Fourth Author	Data in Brief. 2021. 39. 107611	https://www.journals.elsevier.com/data-in-brief

	heavy metals (Mn, Pb, Zn, Fe)			
8.	Fabrication and Characterization of the Sugar Palm Tree (Arenga pinnata) Fiber Composite Reinforced by Polyester Resin	Fifth Author	Fungtional Materials. 2019. 26. No. 1. ISSN 1027-5495	http://repository.usu.ac.id/handle/123456789/70944
9.	Effect of Sulfur Doped Nanotitania for Degradation of Remazol Yellow and Phenol	Third Author	Asian Journal of Chemistry. 2020. Vol.32. No. 12. ISSN 3019-3023	http://repository.usu.ac.id/handle/123456789/2591
10.	Study of Hydrothermal Synthesis of $NiFe_2O_4$ on Morphology, Crystallinity, Chemical and Magnetic Properties	First Author	Fungtional Materials. 2021. 28, No.2. ISSN 1027-5495	http://repository.usu.ac.id/handle/123456789/2592
11.	Microstructures, Magnetic and Electrical Properties of BaFe12O19/ZnO Composite Material	First Author	Int. J. Electrochem. Sci. 2021. 16	http://repository.usu.ac.id/handle/123456789/2593
12.	Investigation on Hydrothermal Synthesis of Spinel Ferrite CuFe2O4 on Morphology, Crystallinity, Chemical and Magnetic Properties	First Author	Functional Materials. 2021. 28. No. 1. ISSN 10275495	http://repository.usu.ac.id/handle/123456789/2596
13.	Influences of Co compositions in CoFe2O4 on Microstructures, Thermal, and Magnetic Properties	Fisrt Author	Elsevier: Case Studies in Thermal Engineering. 2021. 26. 101040	: http://repository.usu.ac.id/handle/123456789/2598
14.	Enhanced Calcination Temperatures of Zn0.6Ni0.2Cu0.2Fe2O	Third Author	Elsevier: Case Studies in Thermal Engineering. 2021. 25. 100892	http://repository.usu.ac.id/handle/123456789/2599

	4 on Thermal, Microstructures and Magnetic Properties using Co-precipitation Method			
15.	Optimization of Palm Oil Boiler Ash Biomass Waste as a Source of Silica with Various Preparation Methods	Fourth Author	Journal of Ecological Engineering 2022, 23(8), 193–199. ISSN 2299–8993, License CC-BY 4.0	http://www.jeeng.net/pdf-150694-76632?filename=Optimization%20of%20Palm%20Oil.pdf
16.	Properties of low-cost MgB 2 superconducting wires fabricated by high reduction cold rolling	Fourth Author	Elsevier: South African Journal of Chemical Engineering 41 (2022) 105–110	https://www.sciencedirect.com/science/article/abs/pii/S2214785323003401?via%3Dihub

Publikasi di Jurnal Nasional Terakreditasi

No.	Judul Artikel	Peran	Nama Jurnal, Tahun Terbit, Volume, Nomor, P-ISSN/E-ISSN	URL Artikel (jika ada)
-	-	-	-	-

Proseding Seminar/Konferensi Internasional Terindeks

No.	Judul Artikel	Peran	Nama Jurnal, Tahun Terbit, Volume, Nomor, P-ISSN/E-ISSN	URL Artikel (jika ada)
1	Manufacturing process and characterization of traditional ceramics using kaolin, quartz, feldspar, and clay raw materials	Penulis Pertama/ Penulis Koresponden	AIP Conference Proceedings, 2020, 2221, 1, 0094-243X/ 1551-7616	https://pubs.aip.org/aip/acp/article/2221/1/110020/687655/Manufacturing-process-and-characterization-of
2	Manufacturing process and characterization of porous ceramics with AAS, XRD and SEM-EDX	Penulis Pertama/ Penulis Koresponden	AIP Conference Proceedings, 2020, 2221, 1, 0094-243X/ 1551-7616	https://pubs.aip.org/aip/acp/article/2221/1/110012/687634/Manufacturing-process-and-characterization-of

3	Particle size influence of raw material grains on the characteristics of traditional ceramics	Penulis Pertama/ Penulis Koresponden	AIP Conference Proceedings, 2020, 2221, 1, 0094-243X/ 1551-7616	https://pubs.aip.org/aip/acp/article/2221/1/110017/687673/Particle-size-influence-of-raw-material-grains-on
4	Study of physical and magnetic properties of barium hexaferrite substituted by Nd2O3	Penulis Ketiga	AIP Conference Proceedings, 2020, 2221, 1, 0094-243X/ 1551-7616	https://pubs.aip.org/aip/acp/article/2221/1/110025/687679/Study-of-physical-and-magnetic-properties-of
5	Manufacturing and characterization of high water absorbtion paving block by utilizing waste of coffee skin and pumice with polyurethane resin	Penulis Kedua	AIP Conference Proceedings, 2020, 2221, 1, 0094-243X/ 1551-7616	https://pubs.aip.org/aip/acp/article/2221/1/110016/687675/Manufacturing-and-characterization-of-high-water
6	The Effect of Composite Bonded Magnet NdFeB/$BaFe_{12}O_{19}$ Composition with an addition of Bakelite to Physical and Magnetic Properties	Penulis Pertama/ Penulis Koresponden	IOP Conference Series: Journal of Physics, 2018, 1120, 012026, 17426588	https://iopscience.iop.org/article/10.1088/1742-6596/1120/1/012026
7	The Effect of Sintering Time on Superkonductor Wire Bi-Pb-Sr-Ca-Cu-O with Dopant Te Sheeted Ag Using Powder In-Tube Method	Penulis Pertama/ Penulis Koresponden	IOP Conference Series: Journal of Physics, 2018, 1120, 012027, 17426588	https://iopscience.iop.org/article/10.1088/1742-6596/1120/1/012027/meta
8	Analysis of Composition; Topography of Volcanic Materials Erupted from Mount Sinabung, Karo Regency, Indonesia	Penulis Pertama/ Penulis Koresponden	IOP Conference Series: Journal of Physics, 2018, 1116, 032035, 17426588	https://iopscience.iop.org/article/10.1088/1742-6596/1116/3/032035
9	Preparation and Characterization Of CTAB Surfactant Modified TiO2 Nanoparticles As Antibacterial Fabric Coating Material	Penulis Keempat	IOP Conference Series: Journal of Physics, 2022, 2165, 012022, 17426588	https://iopscience.iop.org/article/10.1088/1742-6596/2165/1/012022
10	Degradation Studies of MASbCl3 with variety of DMF and DMSO Solvents: A Lead-free Perovskite	Penulis Kedua/ Penulis Koresponden	AIP Conference Proceedings, 2021, 2368, 1, 0094-243X/ 1551-7616	https://pubs.aip.org/aip/acp/article-abstract/2368/1/020009/597394/Degradation-studies-of-MASbCl3-with-a-variety-of?redirectedFrom=fulltext

Penerbitan Buku

No.	Judul Buku	Tahun Penerbitan	ISBN	Penerbit	URL (jika ada)
1	Thin Film Teknologi	2012	9794585815	USU Press.	

Perolehan Kekayaan Intelektual (KI)

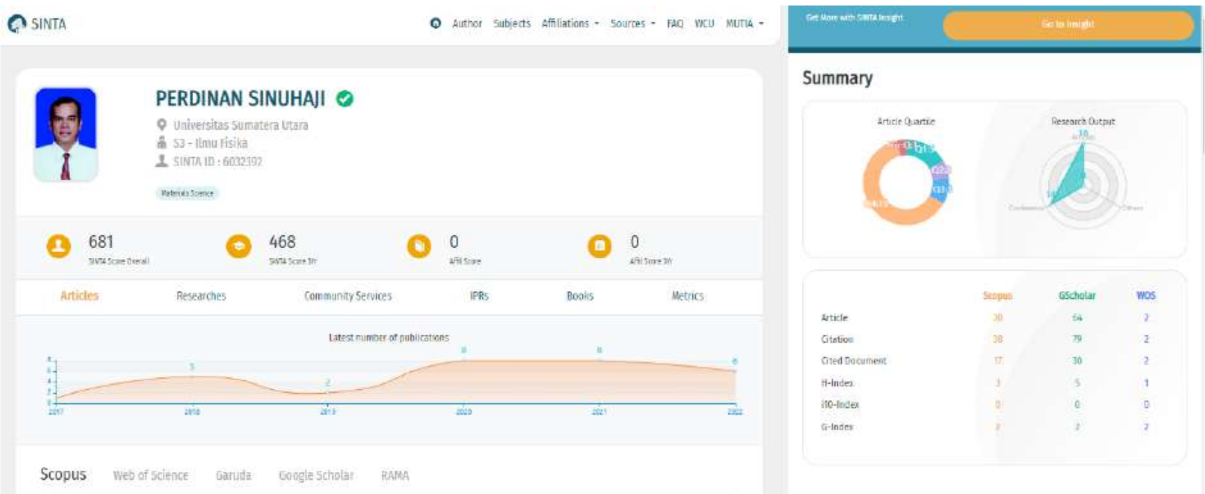
No.	Judul KI	Tahun Perolehan	Jenis KI	Nomor	Status KI	URL (jika ada)
-	-	-	-	-	-	-

Semua data yang saya isikan dan tercantum dalam biodata ini adalah benar dan dapat dipertanggungjawabkan secara hukum. Apabila di kemudian hari ternyata dijumpai ketidak-sesuaian dengan kenyataan, saya sanggup menerima sanksi.

Demikian biodata ini saya buat dengan sebenarnya untuk memenuhi salah satu persyaratan dalam pengajuan proposal Penelitian Dasar.

Medan, 31-07-2023
Anggota,

(Prof. Dr. Perdinan Sinuhaji, MS)



Lampiran 3. Surat Pernyataan Ketua Peneliti

KEMENTERIAN PENDIDIKAN, KEBUDAYAAN, RISET, DAN TEKNOLOGI
UNIVERSITAS SUMATERA UTARA
FAKULTAS MATEMATIKA DAN ILMU PENGETAHUAN ALAM
PROGRAM STUDI SARJANA FISIKA
Jalan Bioteknologi No . 1 Kampus USU Padang Bulan, Medan -20154

SURAT PERNYATAAN
KETUA PENGUSUL

Yang bertanda tangan di bawah ini:

Nama	: Dr.Susilawati, S.Si, M.Si
NIP	: 197412072000122001
Pangkat/Golongan	: Pembina/IVa
Jabatan Fungsional	: Lektor Kepala

Dengan ini menyatakan bahwa proposal saya dengan judul:
Filter Air Gambut Berbasis Zeolit Alam Pahae dan Karbon Aktif Cangkang Kemiri untuk Pengolahan Air Gambut Menjadi Air Bersih yang diusulkan dalam skema penelitian Kolaborasi Pemerintah untuk tahun anggaran 2023 **bersifat original dan belum dilakukan dan belum dibiayai oleh lembaga/sumber dana lain**.

Bilamana dikemudian hari ditemukan ketidaksesuaian dengan pernyataan ini, maka saya bersedia dituntut dan diproses sesuai dengan ketentuan yang berlaku dan mengembalikan seluruh biaya penugasan yang sudah diterima ke Kas Negara.

Demikian pernyataan ini dibuat dengan sesungguhnya dan dengan sebenar- benarnya.

Medan, 31 Juli 2023
Yang menyatakan,

METERAI TEMPEL 10000 610A8AKX451766811

Dr. Susilawati, S.Si, M.Si
NIP. 197412072000122001

Mengetahui,
Ketua Program Studi Sarjana Fisika

Dr. Tulus Ikhsan Nasution, M.Sc
NIP. 197407162008121002

Lampiran 4. Surat Pernyataan Rekognisi 20 SKS Mata Kuliah

KEMENTERIAN PENDIDIKAN, KEBUDAYAAN,
RISET, DAN TEKNOLOGI
UNIVERSITAS SUMATERA UTARA
FAKULTAS MATEMATIKA DAN ILMU PENGETAHUAN ALAM
Jalan Bioteknologi No.1 Kampus USU Padang Bulan, Medan – 20155
Telepon: (061) 8211050, 8214290 Fax: (061) 8214290
Laman: www.fmipa.usu.ac.id

SURAT PERNYATAAN KETUA PROGRAM STUDI
No. .085./UN5.2.1.8/KRK/2023

Yang bertanda tangan di bawah ini:

Nama : Dr. Tulus Ikhsan Nasution, S.Si., M.Sc.
NIDN/NIDK/NIP : 197407162008121002
Pangkat / Golongan : IIIc
Jabatan Fungsional : Lektor

Dengan ini menyatakan bahwa proposal saya dengan judul: “Filter Air Gambut Berbasis Zeolit Alam dan Karbon Aktif Cangkang Kemiri untuk Pengolahan Air Gambut Menjadi”, yang diusulkan dalam skema Penelitian Kolaborasi Pemerintah untuk tahun anggaran 2023 bersifat BISA MEREKOGNISI 4 SKS (Skripsi), Fakultas Matematika dan Ilmu Pengetahuan Alam, Universitas Sumatera Utara, Medan.

Demikian pernyataan ini dibuat dengan sesungguhnya dan dengan sebenar-benarnya.

Medan, 31 Juli 2023
Yang menyatakan,

Dr. Susilawati, S.Si., M.Si.
NIP. 197412072000122001

Mengetahui,
Ketua Prodi S1 Fisika

Dr. Tulus Ikhsan Nasution, S.Si., M.Sc.
NIP. 197407162008121002

KEMENTERIAN PENDIDIKAN, KEBUDAYAAN,
RISET, DAN TEKNOLOGI
UNIVERSITAS SUMATERA UTARA
FAKULTAS MATEMATIKA DAN ILMU PENGETAHUAN ALAM
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Telepon: (061) 8211050, 8214290 Fax: (061) 8214290
Laman: www.fmipa.usu.ac.id

Lampiran surat Nomor : 085 /UN5.2.1.8/KRK/2023

Rekognisi Mata Kuliah :

1. FIS 4201 : Tugas Akhir (4 sks)

Lampiran 5. Luaran penelitian Penelitian Talenta 2018 dan 2021

No	Tahun	Skema Penelitian	Judul Penelitian	Luaran*		
				Judul Luaran	Jurnal/ prosiding /buku dll	Link/ bukti lainnya bila belum terbit
1	2018	Penelitian Dasar	Peningkatan Kekerasan Filter Hidrogen Berbasis Zeolit Alam Pahae dengan Penambahan Clay	The Improvement of Mechanical Properties of Hydrogen Filter Based on Natural Zeolite from Pahae and Clay Addition		http://www.rasayanjournal.co.in/admin/php/upload/1315_pdf.pdf
2	2019	Penelitian Dasar	Pembuatan Nanozeolite dari Zeolit Alam Pahae Menggunakan High Energy Milling untuk Pemurnian Bioetanol	Preparation of pahae natural zeolite Nanoparticles using high energy milling and its Potential for bioethanol purification		http://rasayanjournal.co.in/admin/php/upload/3195_pdf.pdf
3	2020	-	-	-	-	-
4	2021	Penelitian Dasar	Nanofilter Zeolit-Arang Aktif Kulit Kakao Sebagai Adsorber Air Pada Pemurnian Bioethanol	The Effectiveness of Pahae Natural Zeolite−Cocoa Shell Activated Charcoal Nanofilter as a Water Adsorber in Bioethanol Purification		https://pubs.acs.org/doi/10.1021/acsomega.2c03614

* sertakan hardcopy artikel luaran dan bukti diterima bila belum terbit

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Vol. 13 | No. 3 |1785-1791| July - September | 2020
ISSN: 0974-1496 | e-ISSN: 0976-0083 | CODEN: RJCABP
http://www.rasayanjournal.com
http://www.rasayanjournal.co.in

THE IMPROVEMENT OF MECHANICAL PROPERTIES OF HYDROGEN FILTER BASED ON NATURAL ZEOLITE FROM PAHAE AND CLAY ADDITION

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ABSTRACT

The application of natural zeolite as a filtration material has resulted in the reduction of mechanical properties. Thus, in improving the mechanical characteristics, it requires an alternative material such as clay. This research aims to investigate the use of clay in improving the hardness property of the composite zeolite-clay. Physical and chemical treatments were performed to activate both zeolite clay which involved temperature at 150°C and acid condition respectively. The mixture of zeolite and clay was performed via mechanical mixing, while the composite was fabricated by using a mold-compressing technique, which was followed by sintering in various temperatures. The results showed that an increase in porosity values and Si/Al ratio was obtained from 3.53 to 3.82, so a medium level of the adsorbent level was achieved. The XRD analysis confirmed that filler clay increased the crystallinity characteristic which improved mechanical properties.

Keywords: Zeolite Pahae, Zeolite Clay, Adsorbent Materials, Hydrogen Based Filter, Mechanical Properties

INTRODUCTION

The implementation of zeolite as filtering material has been extensively used particularly as water vapor adsorbent [1,2]. Different types of zeolite have varied characteristics, such as natural zeolite from Pahae, North Sumatera, and it has been reported to have absorption level around 48.05% and 68.05% for 60 mesh and 200 mesh respectively, and the other zeolite from Cikalong has been recorded to have 42.60% and 51.60% for 60 mesh and 200 mesh respectively. Thus, the zeolite from Pahae can be utilized as an alternative material for filtering as it has better water adsorption than that from Cikalong. However, this zeolite has a drawback in the insufficient mechanical feature when it was fabricated in the form of powder.[1] To overcome this issue, a composite filter has been designed in form of solid by adding cacao skins as a filler, however, the hardness level is still low (35 N/m^2) even though it has adsorption level for 53.82%.[2] Therefore, a new composite filter made of new materials consists of improved mechanical and adsorption properties[2], and zeolite can be utilized as ethanol purification with distilled adsorption.[3]

One of the materials that can be used to enhance the mechanical (hardness) property is clay.[4] This material is also an affordable material which has varied characteristics, and it has been widely applied for several purification processes in bleaching vegetable oil, medications, catalyst, textiles, petroleum treatments as well as water filtration.[5] Meanwhile, clay also is composed of calcium[6], and it has the ability in enhancing hardness features when it is mixed by other materials such as zeolite. Nevertheless, the clay reinforcement is not only able to improve the mechanical property, but also it can act as fillers to cover the zeolite pores.[7] In this study, clay usage as fillers to fill the porous structures is proposed. The mixing process that is carried out is investigated to determine the mechanical and adsorption properties. Respectively, the characterizations are conducted by performing the X-Ray Diffraction (XRD), while the morphological characteristics are investigated throughout Scanning Electron Microscope Energy Dispersive (SEM-EDX).

EXPERIMENTAL

This study utilized two materials in fabricating the composite filter, and they were natural zeolite as matrixes collected from Pahae, North Sumatera, and clay as a filler. The amount of zeolite was supplied

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http://dx.doi.org/10.31788/ RJC.2020.1335678

from Pahae, Tarutung, Tapanuli Utara without initial treatments. The chemical reagents were supplied by Mallinckrodt Lab Guard, with analytical grade.

Zeolite and Clay Activation

The zeolite and clay powder were activated by performing chemical treatments by using sulphuric acid (H_2SO_4). First, the amounts of zeolite powder were added by 6% of H_2SO_4 at 70°C for 4 hours within constant stirring. Afterward, some distilled water was added into the mixture to reach pH 7, and then it was heated inside the oven at 105°C for 3 hours. Finally, the dried powder of chemical-activated zeolite was obtained. The same procedure was applied to clay to activate it.

Fabrication of Composite Zeolite-Clay

Activated zeolite and clay was fabricated by performing mixing and sintering process. These two materials were mixed and this mixture was placed inside a shaker Yami 550 cc YM1832. This mixture was then shaken for 10 minutes with varied compositions, and they were 100%: 0%; 95%:5%; 90%:10%; 85%:15%; and 75%: 25% (%w). Then, these mixture samples were added by several drops of distilled water and they were stirred several times. Next, the sample was placed into the moulding of Hydraulic Press Ytd27-200t with 5 tonnes of pressure for 10 minutes, and the same pressing treatments were done for the other compositions. Afterward, the samples were allowed to stand for 1 week in the open air to ensure their dryness which would be ready to be sintering. Finally, the dried samples were placed into a furnace for sintering treatments with 700°, 800°C, and 900°C within 4 hours of holding time. The sintering process was conducted repeatedly for other compositions of samples.

Characterizations

Measurement of Porosity

The investigation of porosity was performed to determine the amounts of sample pores due to their influence in adsorption property. These amounts have a value that is proportional to the characteristics of adsorption which can be considered as a ratio between the amount of pore volume of space and the amount of volume of a solid. The ratio can be determined in the form of percentage as the following equation:

$$\%\text{ of Porosity} = \left(\frac{m_b - m_k}{\rho_{air} - V_t}\right) \times 100\% \quad (1)$$

Adsorption Characteristic

The ability of zeolite in absorbing water produced by the electrolysis process can be determined through adsorption level tests on the hydrogen filter. Samples were immersed in water for 24 hours, and then they were allowed to stand in the open air for 24 hours. Next, the samples were placed into a water-hydrogen converter instrument equipped with a hydrogen sensor as it is described from the previous study[1].

RESULTS AND DISCUSSION

Porosity Measurements

The measurement of porosity in this study aims to investigate the effects of the diameter sizes of pores on the surface filter based on the different temperatures of sintering. The porosity of the filter was determined by performing weigh measure for both wet mass and dried mass of filter. The following Fig.-1 displays the porosity levels of samples for all varied temperatures of sintering and compositions.

According to Fig.-1 below, the highest percentage of porosity is displayed in a sample with 95%:5% of compositions at 900°C which contributed to 66.23%, while a sample which had only 100% of zeolite contributed a smaller percentage of porosity at the same temperature for 23.10%. In Fig.-1, it also can be seen that at the sintering process of 900°C, three compositions had the highest percentage of porosity among the compositions. However, the smallest percent weight of zeolite contributed to the highest percentage, which implied to the oxygen presence. This also implies the interaction of Silicon and oxygen which produces small hollow spaces in the same sizes or smaller sizes than the structures.[8] Meanwhile, clay is a soil material that has microscopic and sub-microscopic scales, which let clay to fill zeolite hollow spaces.[8] However, the use of clay as additive material must concern the composition, and based on the data obtained, the composition with the highest proportion of porosity level was that in the composition of 95%:5%.[8]

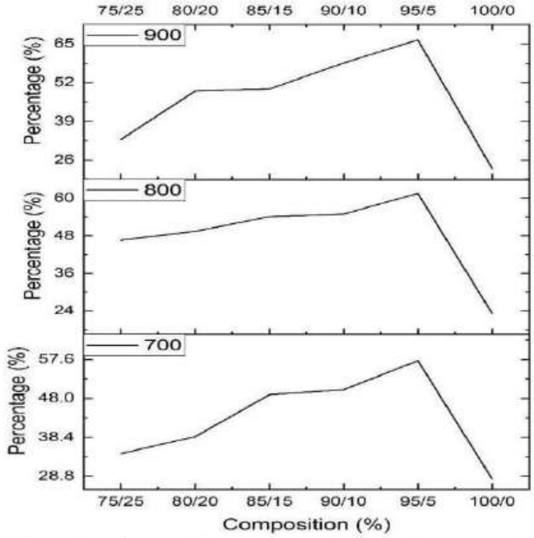

Fig.-1: Comparison of Porosity Percentage for Different Temperature of Sintering

Hardness Test

The investigation of the mechanical property was in the hardness feature. In this study, Hardness Vickers Tokyo instrumentation was performed to measure the hardness characteristic of samples. The clay as a filter is aimed to improve the hardness property which implies to use it in a longer time. As the best temperature of sintering occurred at 900°C, we measured the hardness property only for this temperature. The following Fig.-2 below and Table-1 highlight the hardness value of samples based on the compositions.

Table-1. Hardness Test Results Based on Varied Compositions

No.	Temperature	Composition (Z+C) (%)	Hardness (N/m^2)
1.	900°C	75 Z + 25 C	224.36
2.		80 Z + 20 C	205.88
3.		85 Z + 15 C	187.19
4.		90 Z + 10 C	143.09
5.		95 Z + 5 C	136.61
6.		100 Z + 0 C	136.46

Figure-2 illustrates an increasing trend based on clay composition in every sample to the hardness property of samples. Based on the line graph, the highest hardness value occurred in the composition of 75%:25% which accounted for 224.36 N/m^2, and the lowest hardness value was in the sample with no clay within the composition for 136.41 N/m^2. This was caused by the rising bulk of clay which affects the sizes of pores diameters of composites to be denser.[9] On the other hand, both clay and zeolite have almost similar chemical compositions, in which clay is composed by $Al_2Si_2O_5(OH)$ with tetrahedral structure[10], and it has been reported to contain mostly of silicon dioxide with percentage up to 50%, followed by aluminum oxide for over 30%, and water.[11]

Zeolite also has a tetrahedral structure which is mainly composed of AlO_2, $AlSi_2$, and H_2O, and it contains another metal oxide including SiO_2, Al_2O_3, Fe_2O_3, MgO, Na_2O, and K_2O [6]. However, clay has more stabilized chemical and mechanical properties which are better to be used as filler in forming physical and chemical interaction among elements within zeolite.[12,13] In this study, the usage of clay as reinforcement into zeolite increased the density, the physical interaction and chemical bonds, and hardness property, so in the land, it enhances the hardness property of soil to be optimum.[14]

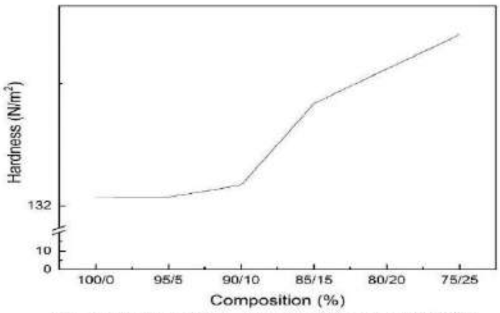

Fig.-2: Hardness Measurements of Samples at 900°C

SEM-EDX Characterisations

SEM results confirmed that at 900°C, both zeolite and clay were distributed evenly. Based on the photographic image of SEM, the diameter of the pores observed on the surface of the samples had different sizes of pores. The diameters of samples in five variations were 4.764 µm for 75%:25%, 4.764 µm for 80%:20%, 3.667 µm for 85%:15%, 3.464 µm for 90:10, 2.805 µm for 95%:5%, and 1.822 µm for 100%:0% in average. Samples added by filler increased the diameter of the pores compared to those without clay as a filler.

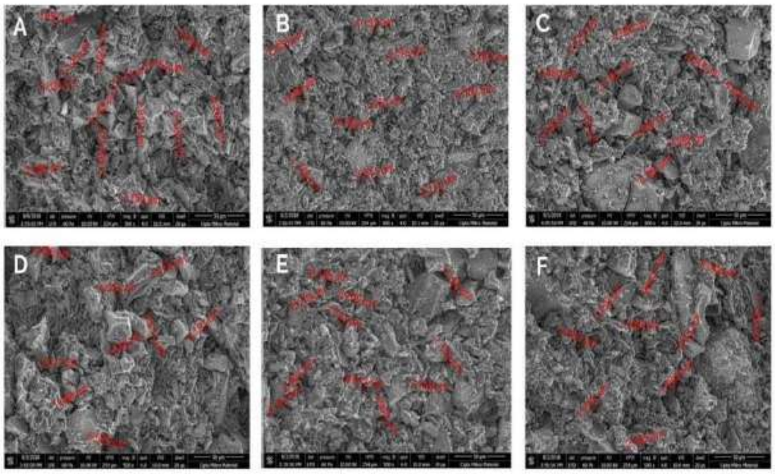

Fig.-3: SEM Microstructure Analysis of Samples; (A) 75/25; (B) 80/20; (C) 85/15; (D) 90/10; (E) 95/5; (F) 100/0

Figure-4 shows the elemental composition of all samples, and mostly they were contained by oxygen, silica, aluminium, iron, potassium, calcium, carbon, sodium and magnesium. The SEM-EDX also confirmed that oxygen was the highest element in all samples, and this suggested the presence of metal oxides which indicated the characteristics of zeolite. Such as silicon oxide (SiO_2) affected the pores into a smaller size which were distributed evenly on the surface as it is indicated by Fig.-4E. This results also implied to the ability of oxygen in generating uniformed small holes so that they could provide adsorption ability to the samples.

Based on the element composition, it can also be determined the ratio of Si/Al as it is influenced by the adsorption level of samples.[5] The EDX results for all five samples, the ratio of Si/Al were accounted for

3.55 (75%:25%), 3.75 (80%:20%), 3.82 (85%:15%), 3.82 (90%:10%), 3.53 (95%:5%). These ratios ranged from 2-5, which is classified to be intermediate adsorbent with modernite types of zeolite.[5]

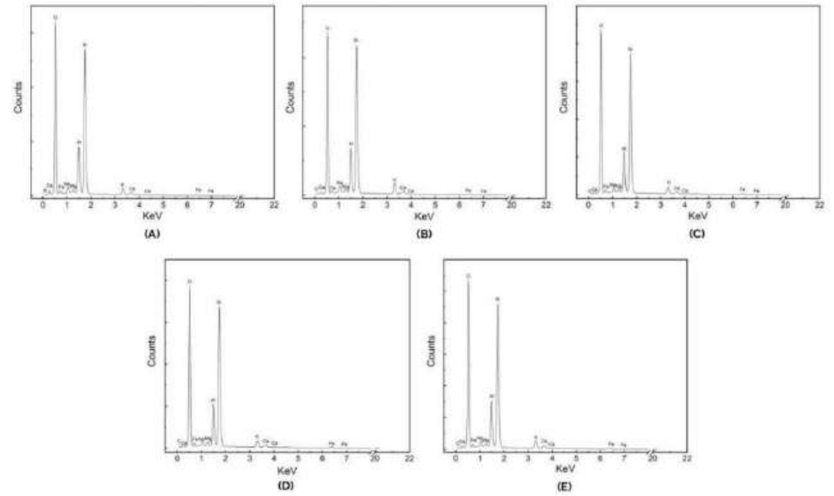

Fig.-4: SEM-EDX Elemental Analysis of Samples (A) 75/25%; (B) 80/20%; (C) 85/15%; (D) 90/10%; (E) 95/5%

XRD Analysis

Figure-5 displays the XRD results of samples. In zeolite, no peak intensity was occurred implying to the amorphous phase. The diffraction spectrum of natural zeolite has been reported to be primarily dominated by amorphous phase.[15] The previous study also has suggested that natural zeolite from Lampung has been reported still to be dominated by amorphous phase.[16]

Based on Fig.-5 too, the presence of peak intensity occurred in 30°-40° which indicated an amount of crystallinity within the spectrum of clay. When the samples were mixed, the peaks shifted, and the peak intensities were reduced. The samples with composition of 75%:25% had peak around 26.5699° (d = 3.35213 Å) with wavelength 1.53996Å, while the 95%:5% of composition contributed for wavelength 1.54054Å with peak around 20.8148° (d = 4.26413Å). The other compositions which are 80%:20%, 85%:15%, and 90%:10% contributed for peaks respectively 26.6033°, 26.4562°, and 22.1395°. The clay reinforcement implies the increase of crystallinity as clay has a higher crystallinity phase compared to those in the zeolite, which also improved the mechanical properties.

The XRD and SEM-EDX results also confirmed that the highest compositions of elements are Al, Ca, Na, O, and Si, formed into andesine, quartz, quartz low. As the increase of clay affected the crystallinity of the samples, it can be determined that the samples of 75%:25% had andesine, quartz and quartz low for 60%, 27.1%, and 12.9% respectively. The results for samples 95%:5% showed 93.9% of anorthoclase with forming elements such as Al, Si, Na, K, O, and Quartz (6.1%) and SiO_2.

Adsorption Test

In this study, the improvement made by clay as a reinforcer is determined to investigate its ability as an adsorbent. Thus, adsorption ability was performed to measure which samples with the high mechanical property have the ability in adsorbing water vapor. The following Figure 6 below illustrate the adsorption characteristic of samples.

Based on Fig.-6, the most optimal samples that were able in adsorbing was that in a composition of 95%:5%. In this composition, clay contributed to the lowest amount, suggesting that the decrease of adsorption ability occurred due to the increase of clay amount. However, this also implied the smallest value of hardness due to the low intensity of peak based on the XRD analysis. Regarding the control sample which was zeolite, the adsorption level of the composition 95%:5% was higher than it, suggesting that the porosity proportion contributed an important role as it was higher in this composition too. The zeolite-based filter was able to absorb 822 ppm, while in the zeolite filter with clay filler, the absorption value was 1095.15 ppm. The optimal composition as a filler was obtained at a composition of 95%:5% wt. at 900°C of sintering temperature.

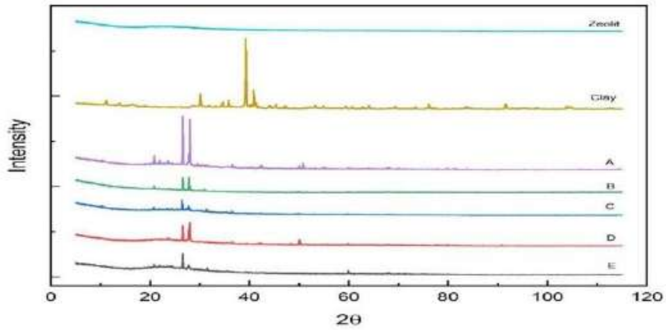

Fig.-5: XRD Analysis of Samples Zeolite, Clay, (A) 75/25%, (B) 80/20%, (C) 85/15%, (D) 90/10%, (E) 95/5%

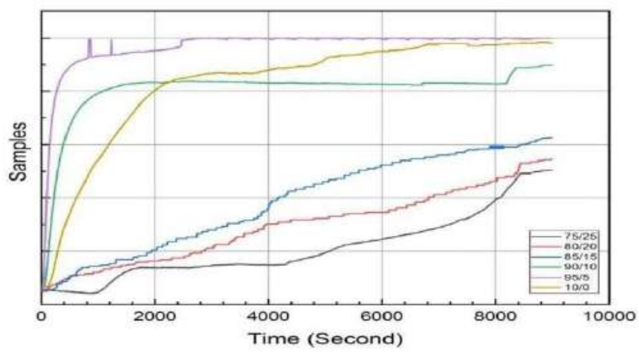

Fig.-6: Adsorption Tests for Samples

CONCLUSION

The use of clay as a filler was able to improve the mechanical property of the composite. From the porosity values from each sample, and the morphological characterizations confirmed the even distribution between zeolite and clay which can increase the diameter of the pores. The SEM-EDX analysis also showed that ratio Si/Al increased which classifies the composite into intermediate adsorbent, and the crystallinity values of samples reinforced by clay improved the hardness characteristics from the XRD analysis. Moreover, the best composition for adsorbing criteria was a sample with the lowest amount of clay, and there was a significant difference.

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REFERENCES

1. T.I. Nasution, Susilawati, F. Zebua, H. Nainggolan and I. Nainggolan, *Applied Mechanics and Material,*(2015), **DOI:**10.4028/www.scientific.net/amm.754-755.789
2. Susilawati, T.I. Nasution, F. Zebua and H. Nainggolan, *International Journal of Applied Engineering*

Research, **12**, 13(2017).
3. Susilawati, N. M. Noor, C. Kurniawan, I. Nainggolan and Y.A. Sihombing, *Journal of Physics: Conference Series,* **1116**, 13(2018), **DOI:**10.1088/1742-6596/1116/3/032037
4. Bussmann. Drying of Food and Food Ingredients with Zeolite. *TNO Environmental Energy Process Innovation,* (2000).
5. M.W. Ackley, S.U. Rege and H. Saxena, *Microporous and Mesoporous Materials,* **61,** 1(2003), **DOI:**10.1016/S1387-1811(03)00353-6
6. P. Sazama, Z. Sobalik, J. Dedecek, I. Jakubec, V. Parvulescu, Z. Bastl, J. Rathousky, H. Jirglova, *Angewwandte Chemie - International Edition,* **52**, 7(2013), **DOI:**10.1002/anie.201206557
7. J.R. Couper, D.W. Hertz and L.F. Smith. *Perry's Chemical Engineer 8th Edition. Perry's Chemical Engineers' Handbook* (2008), **DOI:**10.1036/0071511318
8. P.C. Van Geem, K.F.M.G.J. Scholle, G.P.M. Van Der Velden and W.S. Veeman, *The Journal of Physical Chemistry,* **92**, 6(1988), **DOI:**10.1021/j100317a042
9. R.G. Harris, J.D. Wells and B.B. Johnson, *Colloids Surfaces A: Physicochemical and Engineering Aspects,* **180**, 1(2001), **DOI:**10.1016/S0927-7757(00)00747-0
10. A. Sari and O. Ipýldak, *Bulletin of the Chemical Society of Ethiopia,* **20**, 2(2006), **DOI:**10.4314/bcse.v20i2.61410
11. S. Wang, Z. Nan, Y. Li and Z. Zhao, *Desalination,* **249**, 3(2009), **DOI:**10.1016/j.desal.2009.09.017
12. N. Owabor, C., M. Ono, U. & Isuekevbo, A, *Advances in Chemical Engineering and Science,* **2**, 3(2012), **DOI:**10.4236/aces.2012.23038
13. A. Nezamzadeh-Ejhieh and G Raja, *Journal of Chemistry,* **13**, (2013), **DOI:**10.1155/2013/685290
14. J. Ikhsan, B.B. Johnson, J.D. Wells and M.J. Angove, *Journal of Colloid and Interface Science,* **273**, 1(2004), **DOI:**10.1016/j.jcis.2004.01.061
15. T.E. Suharto, I. Gustian and T. Sundaryono, *Journal Gradien* **3**, 2(2007).
16. S.B. Ginting, D.S. Syukur and Y. Yulia, *Journal of Rekayasa Proses* **11**, 1(2017).

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PREPARATION OF PAHAE NATURAL ZEOLITE NANOPARTICLES USING HIGH ENERGY MILLING AND ITS POTENTIAL FOR BIOETHANOL PURIFICATION

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ABSTRACT

The utilization of natural zeolite as an adsorbent has taken much attention, especially on its ability for bioethanol purification. However, the purification of bioethanol using micro-size zeolite-based adsorbent only resulted in an insignificant increase in bioethanol concentration. Finding a new technique that can improve bioethanol concentration is quite needed. A necessary correlation between surface area and diameter size of the particle could be an excellent way to resolve this issue. The objective of this study was to prepare natural zeolite nanoparticles obtained from Pahae District using a technique so-called high energy milling (HEM) and to investigate its effectiveness for improving the concentration of bioethanol. In this study, unmilled zeolite of 44 microns size (325 mesh), was used as a comparison. The result of PSA and BET confirmed the advancement of HEM technique for obtaining nano-zeolite, which improved the surface area of the particle, but on the other hand, reduced the pore volume and diameter. The comparison material showed that it has a greater porosity than the prepared nano-zeolite. Gas chromatography analysis showed that nano-zeolite was able to be used to improve the concentration of bioethanol. This study concluded that zeolite-based adsorbent, which has nanosized, gave a more reliable result than the micro-size due to the enhancement of the surface area of the particle.

Keywords: Nanoparticle, Pahae Natural Zeolite, High Energy Milling, Adsorbent, Bioethanol Purification.

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INTRODUCTION

Zeolite has known as a porous material, it has several practical applications, e.g., as a filter or water vapor adsorbent, polymer electrolyte membranes, and the size of zeolite plays an essential role in the water vapor absorption rate[1-4]. In the previous study, Pahae natural zeolite, which has 200 mesh had higher water vapor adsorption capacity than Cikalong natural zeolite. With the high adsorption capacity of Pahae natural zeolite, this porous material can be a promising material as adsorbent[1]. A filter-based composite prepared from Pahae natural zeolite and cocoa shells showed an improvement in the adsorption capability from 25 to 53.82%[2]. Another study using Pahae natural zeolite was focused on bioethanol purification using distillation and adsorption techniques[3]. The activated Pahae natural zeolite was able to adsorb water up to 53.82%. It was able to improve the bioethanol concentration up to 93.28% with a contact time of 60 min[3].

The particle size of zeolite influences its adsorption capability, the smaller the zeolite particle size, the greater the surface area available for the adsorption, and this will affect the adsorption rate of material[5]. The activation process also plays an essential role in the effectiveness of zeolite capability. The effectiveness of zeolite's adsorption depends on the number and size of the opened pore that available on the surface of zeolite[6]. In Indonesia, as an abundant mineral, zeolite is constructed by anionic aluminosilicate as the primary building unit.

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This study aimed to prepare Pahae natural zeolite nanoparticles and to characterize their effectiveness for purifying bioethanol. Several characterizations were already performed for determining the characteristic of the obtained Pahae natural zeolite nanoparticle, i.e., water absorption, SEM, TEM, EDX, XRD, BET, PSA, and GC.

EXPERIMENTAL

Material

Pahae natural zeolite was obtained from Pahae District, Tapanuli Utara, Sumatera Utara, Indonesia, Sulphuric acid 96% was purchased from Mallinckrodt Lab Guard. Bioethanol which has 40% of concentration was provided by CV. Rudang Jaya. Ethanol of 96% was purchased from CV. Ampapaga.

Pahae Natural Zeolite Nanoparticle Preparation

Pahae natural zeolite nanoparticle was prepared using High Energy Milling (HEM E3D). Every 4.84 g of Pahae natural zeolite that was placed in the jar of HEM E3D was treated with 11 milling ball which weights 3.52 g of each ball[7]. Pahae natural zeolite that was not passed into the milling process was used as a comparison material which has 325 mesh of size. Both types of Pahae natural zeolite were chemically activated using sulfuric acid of 6% and the suspension was stirred at 70°C. After 4 h, Pahae natural zeolite was washed until the pH was neutralized and was dried in the oven at 100°C for one hour. The activated Pahae natural zeolite was then furnaced at 700, 800, and 900°C for 4 h[3].

Characterization

Water sorption of the material was evaluated using ASTM C20-00, and it can be calculated by weighing the mass of material before and after soaking in water (Eq.-1).

$$\%\text{Water Adsorption Capacity} = \left(\frac{\text{Final Mass} - \text{Initial Mass}}{\text{Initial Mass}}\right) \times 100\% \quad (1)$$

Bioethanol purification was performed using two different sizes of Pahae natural zeolite, i.e. 325 mesh and nanosize zeolite. About 50 g of Pahae natural zeolite was placed in beaker glass, and about 100 mL of bioethanol 40% was poured into beaker glass. While being stirred at 7 rpm under different contact times, i.e., 30, 45, 60, 75, and 90 min, the bioethanol was then evaporated using Rotary Evaporator with the rotation speed of 110-120 rpm at 78°C. The evaporated bioethanol was then analyzed using gas chromatography. The obtained concentration was then compared with ethanol 96%[3].

RESULTS AND DISCUSSION

Water Adsorption Capacity

The water adsorption capacity of Pahae natural zeolite was performed by following ASTM C20-00 and the result was shown in Fig.-1.

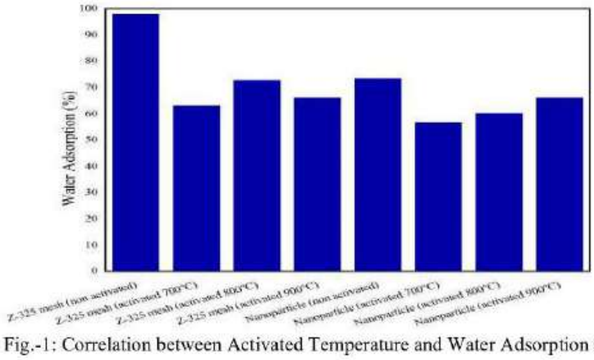

Fig.-1: Correlation between Activated Temperature and Water Adsorption Capacity

Figure-1 shows that non-activated Pahae natural zeolite which had 325 mesh of size had the highest water adsorption capacity, and the lowest one was shown by activated Pahae natural zeolite nanoparticle at 700°C, with the value of 98.29% and 57.02%, respectively. These results concluded that non-activated Pahae natural zeolite had the highest water adsorption capacity than others prepared zeolite nanoparticles. The zeolite particle size influences the selectivity of zeolite, which molecules are allowed or disallowed to fill the zeolite pores. The smaller the zeolite particle, the more selective the adsorption on the surface of zeolite.[8]

Morphological Analysis

The morphological of activated and non-activated zeolite which had 325 mesh of size that captured using a *scanning electron microscope* (SEM) can be seen in Fig.-2.

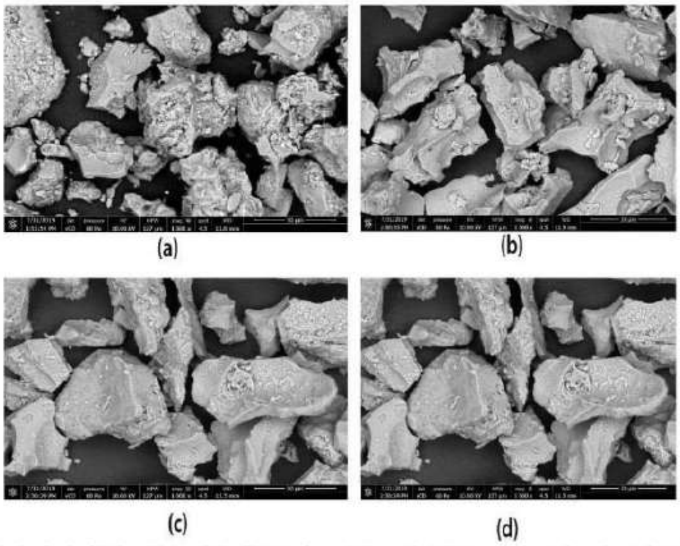

Fig.-2: Morphological of Pahae Natural Zeolite Surface -325 mesh: (a) Non-activated, activated at (b) 700°C, (c) 800°C, and (d) 900°C

Based on the SEM images (Fig.-2a), the contaminant can still be found at non-activated Pahae natural zeolite. The cleanest morphological surface was obtained after being activated at 700-900°C (Fig.-2b to d). A similar result was also found in the previous study, the cleanest surface was obtained after activating process.[9] The non-activated zeolite had crumbly and amorphous characteristics. A different result was obtained after the zeolite was activated, impregnated, and calcinated; lamellar pores structured was obtained.[10] This showed that the porous particle had a higher surface area and more potential as an adsorbent[11]. There is a strong correlation between the surface area of the adsorbent and the adsorption efficiency.[12]

The morphological structure of Pahae natural zeolite nanoparticle was captured using Transmission Electron Microscopy (TEM). Figure-3 shows the morphological of activated and non-activated zeolite nanoparticles. The non-activated zeolite nanoparticle image had dark color in several parts indicating the presence of contaminants, while the activated zeolite at 700-900°C has less contaminant that concluded from the less presence of dark color.[9] The activating process is an important process that influences the adsorbent properties.[13] The dark color can also be caused by the agglomerate formation due to the hydrophilic properties of zeolite[14]. Zeolite which has a smaller particle size will have a higher surface area and has high potential as an adsorbent, because the surface area of adsorbent plays an important role, especially on the adsorption efficiency.[12]

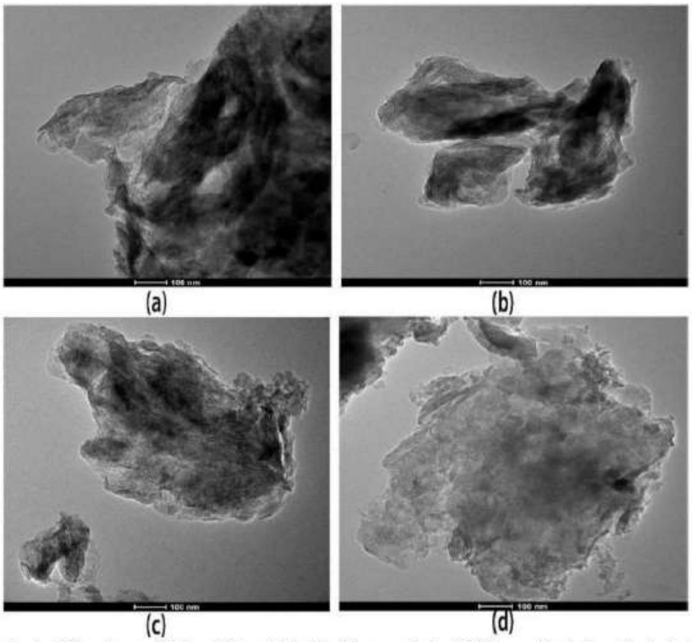

Fig.-3: Morphological Structure of Pahae Natural Zeolite Nanoparticle: (a) Non-activated; activated at (b) 700°C, (c) 800°C, and (d) 900°C

EDX Analysis

Zeolite is constructed by several elements, i.e., silicon, aluminum, oxygen, etc and binded several water molecules in its pores. Other elements that could be found in the zeolite structure are alkaline and alkaline earth metal groups. The non-activated Pahae natural zeolite which had 325 mesh of size was dominated by the presence of oxygen (51.3%), silica (22.1%), carbon (13.2%), and aluminum (6.8%) with the Si/Al ratio was about 3.25. Meanwhile, the Si/Al ratio of activated Pahae natural zeolite 325 mesh at 700, 800, and 900°C were about 3.25, 2.64, and 3.57, respectively. The atomic composition of each activated zeolite 325 mesh can be found in Table-1.

Table-1: Elemental Composition of Activated Pahae Natural Zeolite-325 Mesh

Atom	700°C (wt.%)	800°C (wt.%)	900°C (wt.%)
O	45.2	47.6	46.5
Si	26.0	27.2	26.8
C	11.7	6.0	10.3
Al	8.0	10.3	7.5

The Si/Al ratio of non-activated zeolite nanoparticles was about 3.86 with the atomic composition: oxygen (45.85%), silica (25.47%), carbon (15.88%), aluminum (6.59%). Meanwhile, the Si/Al ratio of activated Pahae natural zeolite nanoparticles at 700, 800, and 900°C were about 5.41, 6.22, and 3.70, respectively. The atomic composition of each activated zeolite nanoparticle can be found in Table-2.
The decrease of Al content in the zeolite was affected by the dealumination of zeolite[15] and it improved the hydrophilic properties of zeolite.[16,17] The lower the Al content in zeolite, the more enhance the Si/Al ratio. This phenomenon can be caused by the addition of sulfuric acid during the preparation.[9,18] Zeolite with high Si content will have hydrophobic properties and a high affinity to the hydrocarbon.[19] The

presence of carbon atom in zeolite is predicted can adsorb gas, i.e., water vapor. Based on the Si/Al ratio of Pahae natural zeolite, Pahae natural zeolite can be categorized as modernite type which has the intermediate capability to adsorb water. This result was supported by the previous studies that mentioned modernite type of zeolite can have a wide range of Si/Al ratio, i.e., 4.4-5.5[20] and 6.6-10.5.[17] Another study confirmed that zeolite with the small Si/Al ratio showed a strong affinity to water and ethanol molecules proven by the better result of water adsorption study than using zeolite which has high Si/Al ratio.[21]

Table-2: Elemental Composition of Activated Pahae Natural Zeolite Nanoparticle

Atom	700°C (wt.%)	800°C (wt.%)	900°C (wt.%)
O	48.73	46.88	50.04
Si	29.75	29.45	32.27
C	9.81	13.03	8.98
Al	5.49	4.73	8.71

X-Ray Diffraction (XRD) Analysis

X-Ray Diffraction (XRD) analysis of zeolite can be used to determine the presence of crystalline and amorphous regions on its structure. Figure-4 shows the diffractogram of activated and non-activated Pahae natural zeolite 325 mesh and nanoparticle.

Rietveld analysis on the diffractogram of Pahae natural zeolite (Fig.-4) confirmed that non-activated and activated Pahae natural zeolite nanoparticle at 700°C was consisted of two types of zeolite, i.e., modernite and keatite, while the other activated Pahae natural zeolite nanoparticle was only consisted by modernite type. The lattice crystal information of modernite and keatite type zeolite can be seen in Table-3.

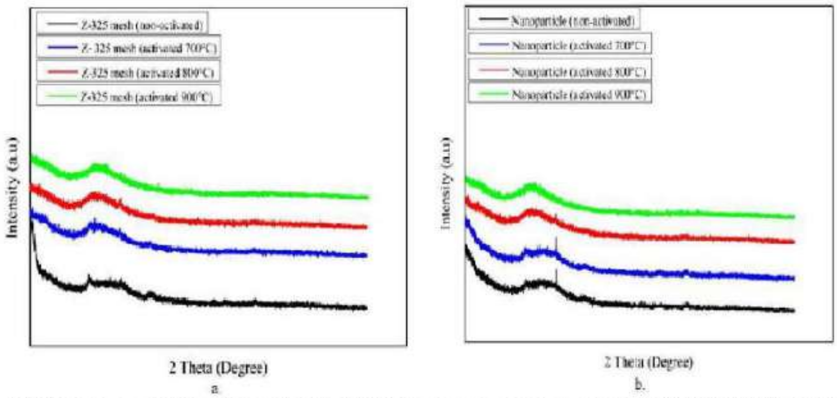

Fig.-4: Diffractogram of Pahae Natural Zeolite (a) 325 mesh: non-activated, activated at 700°C, 800°C, and 900°C, (b) Nanoparticle: non-activated, activated at 700°C, 800°C, and 900°C.

Table-3: Lattice Crystal of Pahae Natural Zeolite

Mineral Name:	Mordenite
Chemical Formula:	$Al_{1.956}Ca_{0.466}H_{34}K_{0.24}Na_{0.69}O_{31.18}Si_{10.044}$
Crystal System:	Orthorhombic
Space Group:	C m c 2_1
Mineral Name:	Keatite
Chemical Formula:	SiO_2
Crystal System:	Tetragonal
Space Group:	P 4_1 2_1 2

The previous study showed that zeolite can be constructed by several types of mineral, i.e., mordenite with $2\theta = 25.6405°$ and $2\theta = 27.7193°$, clinoptilolite with $2\theta = 22.2211°$, quart was also found in the zeolite with 2θ = 26.2564° and montmorillonite with 2θ = 21.8120°.[22] The obtained diffractogram of zeolite in this study showed the presence of amorphous structure[23] due to HEM treatment that was used in this study transformed the zeolite granules into fine powder. This process caused the decrease of zeolite crystallinity or the level of the order became smaller and there were more diffraction collisions due to the diffractogram become thickened.[19] This result was supported by a study stating that the fresh zeolite (without activation treatment) showed a high crystallinity property than the activated zeolite.[24]

Brunauer Emmett Teller (BET) Analysis

The BET analysis on activated and non-activated Pahae natural zeolite was performed to determine the surface area, pore radius, and pore volume that present in the treated zeolite. The BET result can be seen in Table-4.

Table-4: BET Result of Pahae Natural Zeolite 325 mesh and Nanoparticle

No.	Treatments	Surface Area (m^2/g)	Pore Volume (cc/g)	Pore Radius (Å)
1.	325 mesh (non-activated)	14.479	0.031	16.366
2.	325 mesh (activated 700°C)	9.955	0.020	16.289
3.	325 mesh (activated 800°C)	10.570	0.026	18.165
4.	325 mesh (activated 900°C)	2.298	0.010	64.206
5.	Nanoparticle (non-activated)	17.687	0.035	16.321
6.	Nanoparticle (activated 700°C)	20.721	0.041	16.283
7.	Nanoparticle (activated 800°C)	17.474	0.039	16.281
8.	Nanoparticle (activated 900°C)	3.969	0.010	16.369

Table-4 shows non-activated Pahae natural zeolite 325 mesh had higher surface area and pore volume than the activated Pahae natural zeolite of 325 mesh. On the other hand, the activated Pahae natural zeolite at 700°C showed a higher surface area and pore volume than the other treated Pahae natural zeolite nanoparticle. The agglomeration that might occur during the physical activation can be the main reason for this phenomenon. The previous study showed a similar phenomenon where the higher surface area was found at the zeolite which had a particle size of 38 μm (400 mesh) than zeolite that had a particle size of 75 μm (200 mesh).[16] Agglomeration is a unification of small particles to create bigger particles through physical interaction. Agglomeration also caused data misinterpretation, i.e., specific surface area, due to the gas adsorption during the BET analysis occurred in the agglomerate particle, not in the single-particle of zeolite.[7]

Particle Size Analyzer (PSA) Analysis

Table-5 shows the average diameter of all treated Pahae natural zeolite that was determined using PSA. Non-activated Pahae natural zeolite nanoparticles had the smallest diameter which about 118 nm. However, a different result was obtained on the Pahae natural zeolite of 325 mesh, the activated zeolite at 800°C has the smallest diameter, which about 251.9 nm. The HEM treatment plays an important role during the physical treatment, especially 10 h of the milling contact time can improve the effectiveness of particle collisions for obtaining particle with nanosize.[25] The top-down method using HEM can cause agglomeration if the process is done excessively.

Tabel-5: The Average Diameter of all treated Pahae Natural Zeolite

No.	Treatments	Average Diameter (nm)
1.	325 mesh (non-activated)	274.6
2.	325 mesh (activated 700°C)	814.1
3.	325 mesh (activated 800°C)	251.9
4.	325 mesh (activated 900°C)	1499.0
5.	Nanoparticle (non-activated)	118.4
6.	Nanoparticle (activated 700°C)	306.8
7.	Nanoparticle (activated 800°C)	1074.7
8.	Nanoparticle (activated 900°C)	637.4

The increase of activation temperature can induce the increase in diameter of zeolite particles due to the solidification of the sintering effect. The desorption of Si and Al atom has an important contribution to enhancing the porosity of zeolite, but due to the sintering effect, the result of this desorption effect cannot be seen. As the result, the higher diameter of zeolite particle was obtained at higher activation temperature.[26,27]

Bioethanol Purification

Gas chromatography analysis was performed to determine the purity level of bioethanol after treated with Pahae natural zeolite of 325 mesh and nanoparticle, and evaporating process. Table-6 shows the concentration of bioethanol after treatments.

Table-6: Bioethanol Concentration after treating with Pahae Natural Zeolite 325 mesh and Nanoparticle

No.	Zeolite	Contact Time	Initial Bioethanol Concentration (%)	Final Bioethanol Concentration (%)	The increase of Bioethanol Concentration (%)
1.	325 mesh	30 min	40	54.751	36.877
2.		45 min	40	52.626	31.565
3.		60 min	40	52.518	31.295
4.		75 min	40	46.503	16.257
5.		90 min	40	43.293	8.232
6.	nanoparticle	30 min	40	48.490	21.225
7.		45 min	40	75.591	88.977
8.		60 min	40	50.427	26.067
9.		75 min	40	49.052	22.630
10.		90 min	40	47.975	19.937

The optimum result of bioethanol concentration was found at the 45 min of contact time using Pahae natural zeolite nanoparticle, with the increase in bioethanol concentration was about 88.97 %. This result was supported with the PSA and BET result, where this treated zeolite has a smaller particle size than Pahae natural zeolite 325 mesh, i.e., 118.4 nm, and the higher surface area, i.e., 17.687 m^2/g. The contact time of zeolite with bioethanol influences the final concentration of bioethanol. The longer the contact time the more water and bioethanol that will be adsorbed on the zeolite surface, this caused a decrease in the increase of bioethanol concentration.

CONCLUSION

Pahae natural zeolite nanoparticles can improve the water adsorption capacity during bioethanol purification. This can be seen in the PSA analysis, the treated zeolite has 118.4 nm of particle size and 17.687 m^2/g of the surface area using BET. The ratio of Si/Al from EDX analysis confirms the presence of modernite in the Pahae natural zeolite, and this is supported by XRD analysis that confirms the presence of modernite and keatite. The treated Pahae natural zeolite nanoparticle has the potential to adsorb water vapor in bioethanol products. There is a significant result during the water vapor adsorption, the nanoparticle zeolite can increase the concentration of bioethanol up to 88.977 %, while the zeolite 325 mesh is only 36.877 %.

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REFERENCES

1. T.I. Nasution, Susilawati, F. Zebua, H. Nainggolan, and I. Nainggolan, *Applied Mechanics and Materials*, **754-755**, 789(2015), **DOI:**10.4028/www.scientific.net/AMM.754-755.789
2. Susilawati, T.I. Nasution, F. Zebua, and H. Nainggolan, *International Journal of Applied Engineering Research*, **12(13)**, 3914(2017)
3. Susilawati, M.N. Nasruddin, C. Kurniawan, I. Nainggolan, and Y.A. Sihombing, *Journal of Physics: Conference Series*, **1116(3)**, 032037(2018), **DOI:**10.1088/1742-6596/1116/3/032037
4. Y.A. Sihombing, Susilawati, S.U. Rahayu, and A. Siahaan, *Rasayan Journal of Chemistry*, **13(4)**, 2181(2020), **DOI:**10.31788/RJC.2020.1345906

5. A. Yamliha, B.D. Argo, and W.A. Nugroho, *Jurnal Bioproses Komoditas Tropis*, **1(2)**, 67(2013)
6. E. Heraldy, H.S.W, and Sulistiyono, *Indonesian Journal of Chemistry*, **3(2)**, 91(2003)
7. M. Muhriz, A. Subagio, and Pardoyo, *Jurnal Sains dan Matematika*, **19(1)**, 11(2011)
8. R. Wulandari, and C. Priyono, *Indonesian Journal on Medical Science*, **1(2)**, 60(2014)
9. T. Las, F. Firdiyono, and A. Hendrawan, *Valensi*, **2(2)**, 368(2011)
10. T. E. Suharto, I. Gustian, and A. Sundaryono, *Jurnal Gradien*, **3(2)**, 267(2007)
11. B. Hastuti, S. Hadi, and W. Purwendah, *International Journal on Advanced Science Engineering Information Technology*, **10(1)**, 351(2020), **DOI:**10.18517/ijaseit.10.1.10655
12. H. Javadian, F. Ghorbani, H.-a. Tayebi, and S.M.H. Asl, *Arabian Journal of Chemistry*, **8(6)**, 837(2015), **DOI:**10.1016/j.arabjc.2013.02.018
13. F. Azima, N. Nazir, and N.P. Sari, Internati*onal Journal on Advanced Science Engineering Information Technology*, **7(3)**, 916(2017), **DOI:**10.18517/ijaseit.7.3.1084
14. F. Gultom, B. Wirjosentono, Thamrin, H. Nainggolan, and Eddiyanto, *Procedia Chemistry*, **19**, 1007(2016), **DOI:**10.1016/j.proche.2016.03.150
15. A. Ates, *Journal of Colloid and Interface Science*, **523(1)**, 266(2018), **DOI:**10.1016/j.jcis.2018.03.115
16. L. Sentosa, B.S. Subagio, H. Rahman, and R.A. Yamin, *Jurnal Teknik Sipil*, **25(3)**, (2018), **DOI:**10.5614/jts.2018.25.3.5
17. C.D. Smedt, F. Ferrer, K. Leus, and P. Spanoghe, Adsorption Science & Technology, **33(5)**, 457(2015), **DOI:**10.1260/0263-6174.33.5.457
18. S.K. Wahono, J. Stalin, J. Addai-Mensah, W. Skinner, A. Vinu, and K. Vasilev, *Microporous and Mesoporous Materials*, **294**, 109871(2020), **DOI:**10.1016/j.micromeso.2019.109871
19. M. Sirait, N. Bukit, and U. Simarmata, *Jurnal Sains Materi Indonesia*, **16(1)**, 7(2014)
20. M.W. Ackley, S.U. Rege, and H. Saxena, *Microporous and Mesoporous Materials*, **61(1-3)**, 25(2003), **DOI:**10.1016/S1387-1811(03)00353-6
21. T. Yamamoto, Y.H. Kim, B.C. Kim, A. Endo, N. Thongprachan, and T. Ohmori, *Chemical Engineering Journal*, **181-182**, 443(2012), **DOI:**10.1016/j.cej.2011.11.110
22. A.W. Ningsih, E.M. Tamboesai, and A. Muchtar, *Jurnal Photon*, **6(1)**, 97(2015)
23. Susilawati, T.I. Nasution, and S. Khanifah, *Rasayan Journal of Chemistry*,**13(3)**, 1785(2020), **DOI:**10.31788/ RJC.2020.1335678
24. D.J.C. Yates, *Canadian Journal of Chemistry*, **46(10)**, 1695(1968), **DOI:**10.1139/v68-282
25. S. Mustafa, S.B. Widjanarko, *Jurnal Pangan dan Agroindustri* **3(2)**, 560(2015)
26. E. Wibowo, M. Rokhmat, S. Sutisna, K. Khairurrijal, and M. Abdullah, *Jurnal Matematika dan Sains*, **22(1)**, 37(2017), **DOI:**10.5614/jms.2017.22.1.10
27. I. Gustian, Ghufira, and D. Oktiarni, *Rasayan Journal of Chemistry*, **10(3)**, 689(2017), **DOI:**10.7324/RJC.2017.1031716

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Article

The Effectiveness of Pahae Natural Zeolite–Cocoa Shell Activated Charcoal Nanofilter as a Water Adsorber in Bioethanol Purification

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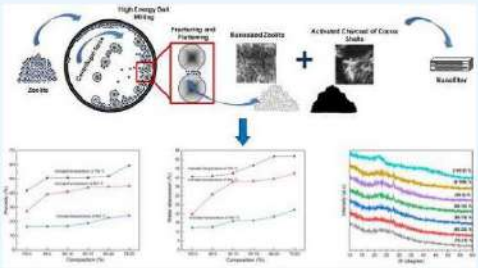

ABSTRACT: Pahae natural zeolite potentially can be used as a filtration material because of its high adsorption capacity. However, it is known that other supportive materials such as activated charcoal are needed to optimize the utilization of natural zeolite as an adsorber. This study aims to investigate the potential use of activated charcoal which was synthesized from cocoa shells waste and natural zeolite in nanosize as the adsorber in order to increase the concentration of bioethanol. The mixing process of nanozeolite and activated charcoal of cocoa shells was carried out through mechanical mixing, while the nanofilter was made using a press-printing technique followed by sintering at several temperature variations. The results showed that the activated zeolite produced in this study has a particle size of 118.4 nm with water absorption capacity of 52.08%. In line with that, the bioethanol concentration was increased up to 78.92% during the adsorption with a 45 min contact time with water vapor. Thus, based on the results, it can be concluded that nanosized zeolite-based adsorbents and activated charcoal produced from cocoa shells can be utilized as adsorbers to significantly increase the concentration of bioethanol generated.

1. INTRODUCTION

The lower fossil energy deposits become the basis for the development of research to find other energy sources in the form of renewable energy that is environmentally friendly and sustainable.[1] With current usage patterns, it is estimated that the remaining fossil energy will be depleted within the next 40–50 years.[2]

Biofuel is one of the renewable energy sources with abundant natural material sources. Bioethanol is a type of biofuel that is currently being researched. Bioethanol can be produced from natural carbohydrates such as sugar cane, potatoes, cassava, and corn.[3] Bioethanol production is expected to rise as a result of its utility as a gasoline additive. It is well-known that adding bioethanol to gasoline raises the octane number of the gasoline. It is difficult to manufacture bioethanol with high purity. Meanwhile, ethanol with a purity level of >99.5% is required for use as a fuel, and it must be completely dry and anhydrous to be noncorrosive.[4] Distillation and adsorption are two techniques that can be used to increase the purity of bioethanol. The distillation process is known for producing high-purity ethanol in a relatively short time, but it requires a large amount of raw material because reagents and catalysts must be continuously flowed during the process.[5,6] Meanwhile, other technologies, such as adsorption, are being promoted in the ethanol purification process because it requires little energy while producing a high level of productivity and purity. Adsorption is a purification technique that separates materials from an unwanted gas or liquid mixture.[7,8] The material to be separated is attracted by the solid adsorbent surface and bound by the surface forces. As a result, the type of adsorbent chosen has a significant impact on the success of this process. Adsorbents of high quality usually have a large adsorption surface area. Zeolite is one of the adsorbents that is commonly used to separate ethanol–water mixtures.[9,10]

Zeolite is an inorganic mineral rock that is widely used in Indonesia. Zeolite is a porous material with excellent physicochemical properties such as high cation exchange capacity, cation selectivity, and large pore volume.[11] Zeolite is used as an adsorber because of its regular amorphous structure with interconnected cavities in all directions, the ability to absorb small molecules, and a very large surface area.[12,13] Moreover, the ability of zeolites to exchange catalysts via cation adsorption is what makes them beneficial to be used as adsorber materials.[14,15] In addition, zeolite is also known as a porous material and has several practical uses, such as filters

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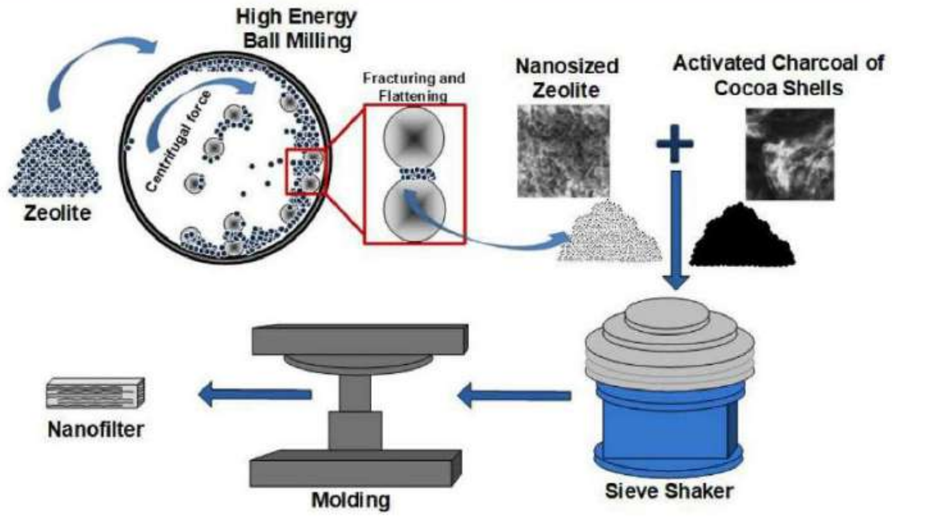

Figure 1. Illustration of nanofilter fabrication (Microsoft Visio 2007 was used by the author to create the illustration).

and absorbents of moisture.[16−18] The effect of zeolite adsorption is affected by the number and size of open pores on the zeolite surface.[19] As a result, the activation process has a significant impact in determining the effectiveness of the zeolite capacity.[20,21]

Pahae-activated natural zeolite can absorb up to 53.82% of its weight in water. A previous study found that Pahae natural zeolite with a mesh size of 200 had a higher water vapor adsorption capacity than Cikalong natural zeolite. Due to the high adsorption capacity of Pahae natural zeolite, this porous material has the potential to be used as an adsorbent.[16] Furthermore, another study reported the use of nanosized Pahae natural zeolite, which is known to be able to adsorb water up to 73.81%, in bioethanol purification via distillation and adsorption techniques and succeeded in increasing the concentration of bioethanol to 88.97% with a contact time of 45 min.[22,23] In addition, the size of the zeolite plays an important role in the rate of water vapor absorption:[16−18] the smaller the particle size of the zeolite the greater the surface area available for adsorption, and this affects the rate of adsorption of the material.[24,25] While activated carbon is used in this study because it is the most commonly used adsorber and has been successfully used in industrial wastewater and gas treatment for environmental protection and material recovery objectives, particularly in the purification of biofuel,[26] these qualities are due to its inherent characteristics, which include a large surface area, a microporous structure, a high porosity, and a high adsorption capacity.[27,28]

Nanofilters are solid-structured materials with repeated dimensions in the nanometer range, consisting of a combination of two or more inorganic/organic molecules containing at least one molecule of nanoscale size consisting of several materials that can share the role of a matrix or filler.[29,30] The nanofilter in this study was made of zeolite material, which serves as a matrix, and activated charcoal from cocoa rind, which serves as a filler. Cocoa shells were chosen because they are hydrophobic and have a high charcoal content, so they has the potential to be used as a source of activated charcoal.[31] In addition, this research is useful to increase the value of cocoa shell waste with low and economical processing costs. Furthermore, the basis of this research is supported by previous reports of the potential utilization of activated charcoal from cocoa shells combined with clay as an adsorber.[32,33] In line with that, other studies have also reported the potential use of a mixture of zeolite with cocoa rind as a filler.[17] The aim of this research is to create a zeolite−activated charcoal nanofilter from cocoa shells and test its efficacy for bioethanol purification. To investigate the characteristics of the zeolite-activated charcoal nanofilter obtained from cocoa shells, several characterizations were performed, including porosity, water absorption, hardness, SEM, EDX, XRD, PSA, FT-IR, gas chromatography, and XRF.

2. MATERIALS AND METHODS

2.1. Materials. Pahae natural zeolite was obtained from Pahae District (North Sumatra, Indonesia). Cocoa peel was obtained from Gunung Village, Tiga Binanga District (North Sumatra, Indonesia). 96% sulfuric acid was purchased from Mallinckrodt Baker, (Paris, KY). Bioethanol with a concentration of 96% was purchased from Merck (Darmstadt, Germany).

2.2. Pahae Natural Zeolite Nanoparticles Activation and Preparation. Pahae natural zeolite powder that passed a 74 m (200 mesh) filter was chemically activated with 6% sulfuric acid and agitated for 4 h at 70 °C at 550 rpm. After 4 h, Pahae natural zeolite was cleaned with distilled water until the pH was neutral and then dried in a 100 °C oven for 1 h. The high energy milling (HEM E3D) process was then used to create Pahae natural zeolite nanoparticles. Into the HEM E3D jar, 11 ball milling with a weight of 3.52 g per ball was used to process every 4.84 g of Pahae natural zeolite.[22,31]

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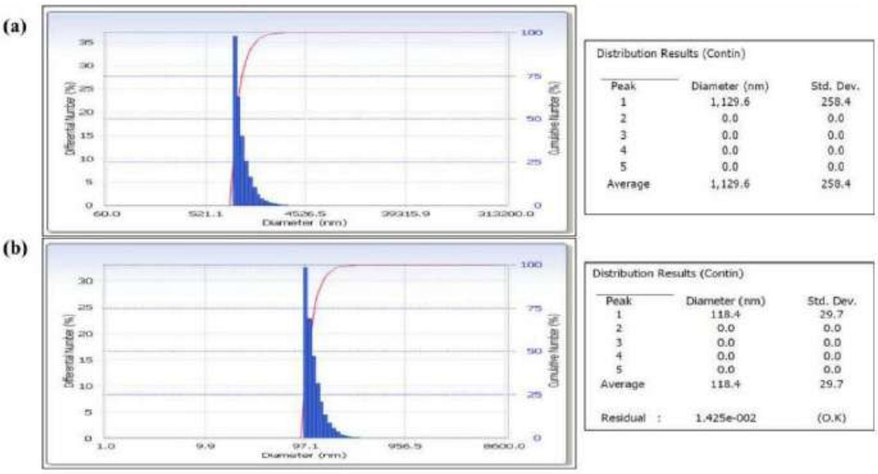

Figure 2. PSA results of activated zeolite (a) before and (b) after the ball-milling process.

2.3. Cocoa Shells Charcoal Process. The cocoa skin that was used had a yellow color. Then the cocoa skin was cleaned from any attached impurities, such as seeds and fruit flesh. After that, the cocoa shells were cut into small pieces and then dried under sunlight until dry (moisture content <8%). Then charcoal was made by carbonization using an MEMMERT UN55 oven (Germany) at 1500 °C for 1 h. After becoming charcoal, the cocoa shells were crushed using a mortar. The crushed cocoa shells were then sieved using a 74 m (200 mesh) sieve.

2.4. Zeolite-Activated Charcoal Nanofilter Cocoa Shells Production. Mixing and sintering processes were used in this study to create zeolite nanofilters and cocoa shell activated charcoal. These two ingredients were combined and placed in a 550 cc YM1832 Yami shaker. This mixture was then stirred for 5 min with variations in composition, namely (100:0)%, (95:5)%, (90:10)%, (85:15)%, (80:20)%, and (75:25)% wt. A few drops of aquadest were added to the mixture, which was then stirred several times. The sample was then placed for 10 min in a hydraulic press Ytd27-200t with a mass of 5 tons. For the other mixing compositions, the same molding procedure was used. After that, the sample was left out in the open for a week to avoid cracking during the heating process. After a week, the samples were physically activated for 4 h at temperatures of 700, 800, and 900 °C. All of the steps involved in making the nanofilter are illustrated in Figure 1.

2.5. Characterizations. The particle size distribution of the samples was determined using a Malvern Mastersizer 2000 laser light-scattering particle size analyzer, and the base of the spherical equivalent diameter of 300 individual particles of each sample was estimated. The water absorption capacity of the material is evaluated according to ASTM C20-00[34] and can be calculated according to eq 1. The porosity of the material was evaluated by referring to ASTM C642-06[35] and calculated using eq 2. The hardness test was conducted using a Matsuzawa Seiki Hardness Tester (Japan) with a load mass of 1 kg and a holding period of 30 s. The hardness value is then calculated using eq 3.

$$\%\text{water absorption} = \left(\frac{\text{final mass} - \text{initial mass}}{\text{initial mass}}\right) \times 100 \quad (2)$$

$$\%\text{porosity} = \left(\frac{\text{final mass} - \text{initial mass}}{\text{density of water} \times \text{water volume}}\right) \times 100 \quad (1)$$

$$H_v = 1,8544\frac{F}{d^2} \quad (3)$$

A scanning electron microscope (SEM) model JEOL JSM6390, in conjunction with an energy-dispersive X-ray (EDX) analyzer from Oxford Instruments, was used to examine the morphology and elemental composition of initial materials, intermediates, and end products. The crystallinity phase of the obtained sample was investigated using a Philips PW 1050 X-ray diffractometer. 2θ of the samples was scanned from 7 to 70°. The FTIR spectra of the samples were analyzed using the PerkinElmer System IR 2000 spectrometer at a wavenumber of 1400–400 cm^{-1}, with 100 scans using KBr pellets technic. Using an XGT-5200 XRF spectrometer, the chemical composition of the sample was determined. The ratio $[SiO_2]/[Al_2O_3]$ was calculated using this information.

2.6. Gas Chromatography Test for Bioethanol Purification. 100 mL of 40% bioethanol was poured into a glass beaker which already contained 50 g of nanofilter while stirring at 550 rpm with various contact times of 30, 45, 60, 75, and 90 min. The bioethanol was then evaporated using a rotary evaporator with a rotating speed of 110–120 rpm at a temperature of 78 °C. Evaporated bioethanol was then analyzed using gas chromatography. The concentration obtained was then compared with 96% ethanol.[36,37]

3. RESULTS AND DISCUSSION

3.1. Particle Size Analyzer (PSA) Test. The PSA analysis was conducted to determine the sample pore diameter of 74 m (200 mesh) zeolite particles before and after ball milling with HEM. The results of the analysis are shown in Figure 7.

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The average diameter of the activated Pahae natural zeolite was determined using PSA in Figure 2a,b. The PSA test findings in Figure 2a demonstrate that the activated zeolite measuring 74 m (200 mesh) before being processed with ball milling has a diameter distribution of about 1129.6 nm, while the PSA test findings in Figure 2b demonstrate that the activated zeolite measuring 74 m (200 mesh) after being processed with ball milling has a sample diameter distribution of roughly 118.4 nm. This demonstrates that decreasing the size of the zeolite using ball milling equipment combined with HEM treatment is successful. During physical treatment, HEM treatment is vital, and 10 h of milling contact time can increase the efficacy of particle collisions, resulting in nanosized particles.[38] The top-down method using HEM can cause agglomeration if the process is carried out excessively.[39]

3.2. Water Absorption Test. The water absorption test of the nanofilters was carried out by referring to ASTM C20-00, and the results are shown in Figure 3. According to the test results, the sample with a nanofilter composition of (75:25)% which is activated at 700 °C has the highest water absorption value with a value of 52.08%. Meanwhile, the lowest water absorption value is shown in the (100:0)% composition at 900 °C, which is only able to absorb water by 12.24%. Based on the tests carried out, it was analyzed that the addition of activated charcoal filler of cocoa shell on the nanofilter was able to increase the value of water absorption. Activated charcoal has a large surface area of up to 1500 m^2/g and an abundance of functional groups on its surface. As a result, it has been extensively employed for gas separation, solvent recovery, wastewater treatment, and as an effective catalyst in the process of biodiesel production.[40] From the results, it can also be analyzed that the water absorption value produced is directly proportional to the porosity value, where the larger the pores or cavities of a zeolite the higher the water absorption value. This is also in line with the results of the porosity test where in the water absorption test it was found that an increase in temperature in the activation process resulted in a decrease in water absorption in the nanofilter, where the higher the temperature, the smaller the water absorption value. This can occur because the surface of the nanofilter is closed; as a result, the distribution of pores is getting smaller and thus inhibits the water absorption process.

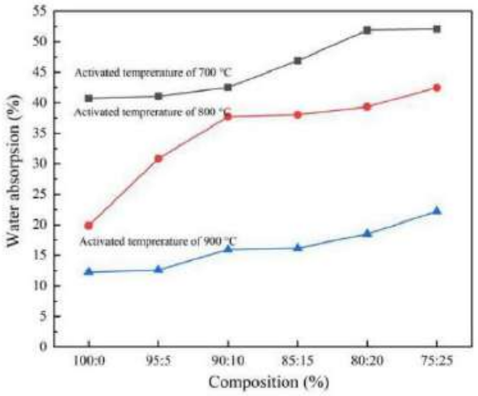

Figure 3. Correlation graph of composition againts water absorbsion.

3.3. Porosity Test. Porosity testing aims to determine the effect of different combustion temperatures on the size of the pore diameter on the surface of the nanofilter. Calculation of nanofilter porosity is determined by subtracting the dry mass of the wet mass of the nanofilter compared to the density and volume of water. The results obtained are shown in Figure 4.

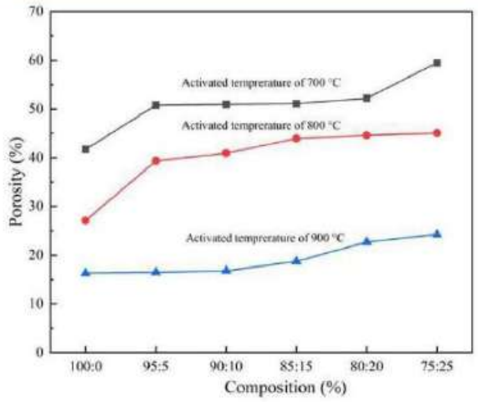

Figure 4. Correlation graph of composition against porosity.

According to the results shown in Figure 4, the sample with a nanofilter composition of (75:25) % that was activated at 700 °C had the highest porosity value of 59.52% when compared to the other samples. The physicochemical features of these materials may be preserved by exposing them to a temperature of 700 °C, producing porous structures, and increasing the reactivity of this material, resulting in zeolite-Activated carbon with great thermal stability.[41−43] Physical activation mainly refers to dry oxidation, which involves the reaction of the samples with gaseous (CO_2 and air), steam, or a combination of gaseous and steam at a temperature of 700 °C when the carbon dioxide was chosen during activation.[44,45] Meanwhile, samples with a (100:0) % nanofilter composition that were activated at 900 °C had the lowest porosity value of 16.34%. This suggests that adding cocoa shell activated charcoal filler to the nanofilter can increase the porosity value of the produced nanofilter. However, too high a temperature during the activation process is known to cause a decrease in the porosity of the sample. This could be experienced by the samples due to high-temperature activation, which causes a decrease in the distribution of pores on the adsorber as well as pore closure, which reduces pore diameter.

3.4. Hardness Test. The Hardness Vickers Tokyo tool was used to conduct a hardness test on a zeolite-activated charcoal nanofilter of cocoa shells. The results are shown in Figure 5. The depicted data were obtained from tests on several samples of nanofilters with varying compositions of zeolite and activated charcoal of cocoa shells. In the figure, it can be seen that the highest hardness value was observed in the sample with a (100:0)% nanofilter composition which was activated at a temperature of 900 °C with a hardness value of 601.970 MPa. Meanwhile, the lowest hardness value of

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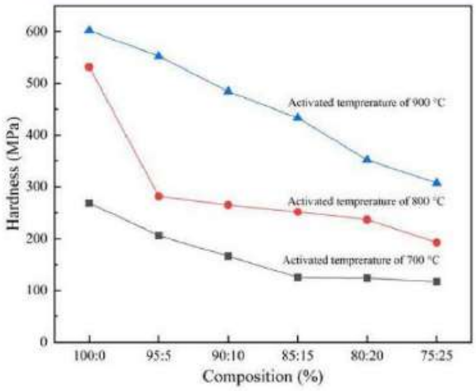

Figure 5. Correlation graph of composition againts hardness.

117.410 MPa was obtained in a sample with a composition of (75:25)% that was activated at a temperature of 700 °C. According to the results, the increase in activation temperature is correlated to the increase in sample hardness. This can be attributed to the high temperature used in the activation process, which reduces and tightens the pore diameter of the nanofilter, thereby increasing its hardness.

The hardness test results indicate that the hardness test is inversely proportional to the physical properties test. The addition of cocoa shell activated charcoal filler to the nanofilter is known to be unable to increase the hardness value. The hardness values of the activated samples at temperatures of 700, 800, and 900 °C continued to decrease when the mass of activated charcoal powder from cocoa shells continued to increase. This is due to the fact that the process of making samples using traditional printing and pressing techniques results in uneven distribution of zeolite and activated charcoal from cocoa shells. Furthermore, indications of the presence of vacancies between particles, which cause trapped oxygen in the sample during the compaction process, as well as the presence of impurities which prevent good intersurface bonding between nanofilter constituents, are thought to be factors that can reduce the hardness of the nanofilter.

3.5. Morphological Analysis. A scanning electron microscope (SEM) was used to analyze the surface morphology of the sample and determine the size of the pore diameter.

The results of morphological evaluations on all variations of the composition of the nanofilter activated at 700 °C are shown in Figure 6. The sample in this variation was chosen for SEM testing because it exhibited the optimum porosity and water absorption value compared to samples on others activation temperatures. The morphological test results on the five composition variations, which were activated at a temperature of 700 °C, revealed that the material composition

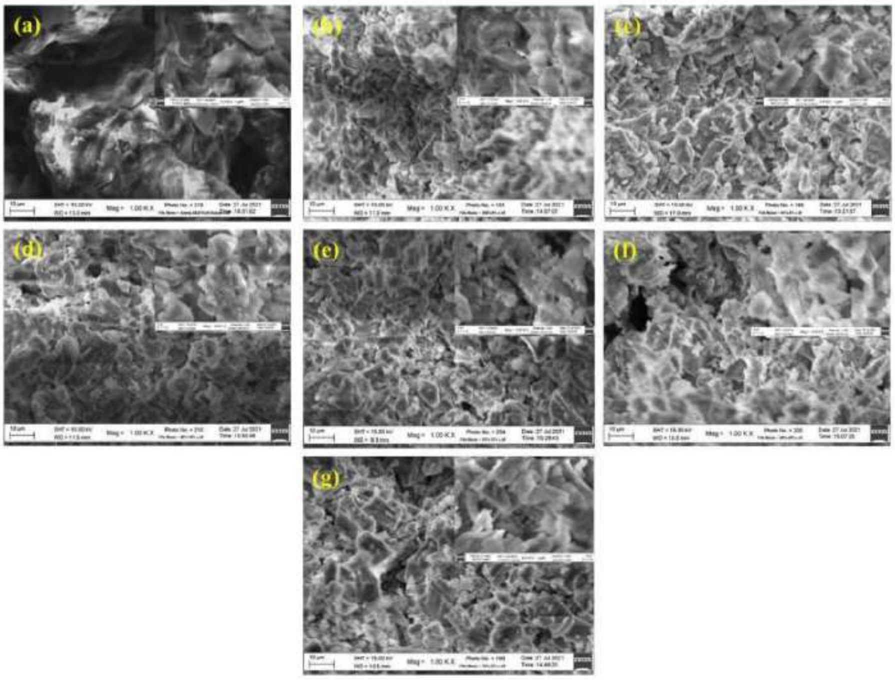

Figure 6. Surface morphology of the sample: (a) (0:100)%; (b) (100:0)%; (c) (95:5)%; (d) (90:10)%; (e) (85:15)%; (f) (80:20)%; and (g) (75:25)%.

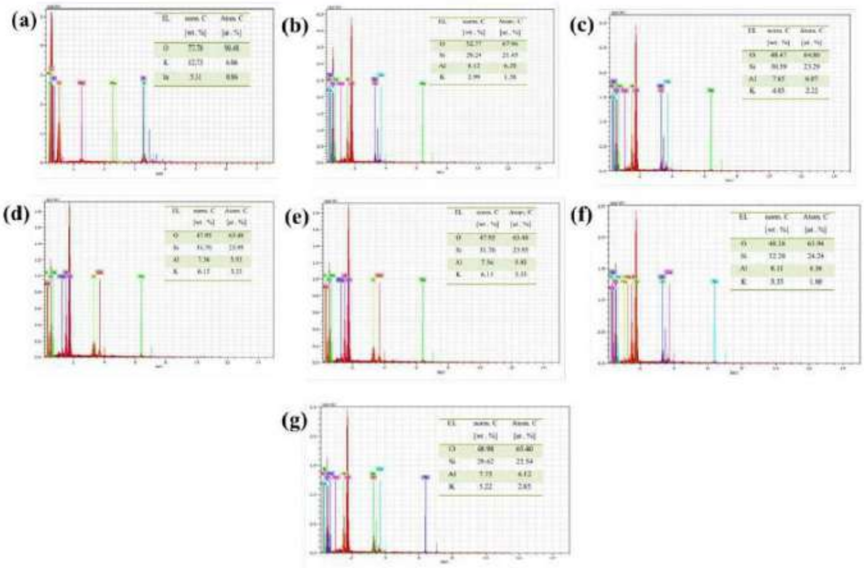

Figure 7. EDX elemental analysis of the sample: (a) (0:100)%; (b) (100:0)%; (c) 95:5)%; (d) (90:10)%; (e) (85:15)%; (f) (80:20)%; and (g) (75:25)%.

of the five samples had not been mixed evenly. This can be seen from the pore diameters on the surface of the tested nanofilters. The results of the pore diameters for all composition variations are as follows: (0:100)% (pure activated charcoal) with average d = 1.676 μm, (100:0)% (pure zeolite) average d = 1.070 μm (95:5)% average d = 2,547 μm, (90:10)% average d = 1.483 μm, (85:15)% average d = 1.548 μm, (80:20)% average d = 2.107 μm, and (75:25)% average d = 1.430 μm. Based on the scanning of the five nanofilters composition variations, it can be seen that the addition of cocoa shell activated charcoal filler in zeolite was able to increase the pore diameter compared to pure zeolite composition, which only had an average value of d = 1.070 μm.

3.6. EDX Analysis. Tests with EDX were carried out to determine the elemental content in the nanofilter that affects the adsorption power of the nanofilter, which can be seen in Figure 7.

Figure 7 shows the elemental content of all sample variations which were activated at 700 °C. The results of the analysis showed that most of the samples contained oxygen, silica, aluminum, ferron, potassium, calcium, charcoal, sodium, indium, and magnesium. The EDX analysis also confirmed that the presence of oxygen elements came from oxygen bound in SiO_2 compounds and free oxygen which was trapped in the nanofilter pores. The presence of oxygen is known to affect the formation of pores on the surface of the nanofilter considering the ability of oxygen to produce uniform small holes which in the end also determines the adsorption ability of the nanofilter. Based on the elemental content, the Si/Al ratio can be calculated, which will also affect the adsorption rate of the sample. The results of the Si/Al ratio of the six samples, (0:100)%, (100:0)%, (95:5)%, (90:10)%, (85:15)%, and (80:20)% were 3.60, 3.99, 4.20, 3.93, 3.97, and 3.83, respectively. From the results obtained, the ratio of the six samples is in the range of 2−5. Thus, all samples are classified as intermediate adsorbers with the type of modernite zeolite.

3.7. X-ray Diffraction (XRD) Analysis. The nanofilters was exposed to an X-ray Diffraction (XRD) analysis to determine the presence of crystalline and amorphous regions in its structure. Figure 8 depicts the nanofilters diffractogram of all composition variations at 700 °C activation temperature.

In samples with a composition of (100:0)%, which can be referred to as pure zeolite matrix, the resulting diffraction

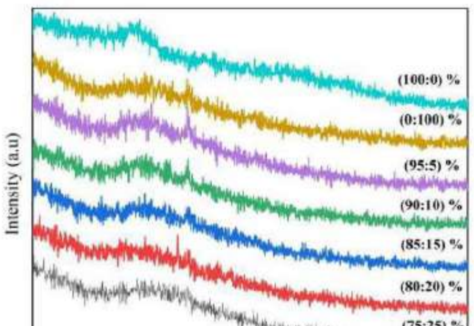

Figure 8. Diffractograms of the nanofilters with an activated temperature of 700 °C.

pattern is amorphous. Furthermore, with the presence of cocoa shell activated charcoal filler, it is expected that there will be an increase in the crystalline intensity of the nanofilter. However, the ensuing diffraction pattern in Figure 8 does not demonstrate a significant difference. All samples had an amorphous shape with nonsharp peaks. This demonstrates that adding cocoa shell activated charcoal to the nanofilter does not increase the crystalline intensity. The degree of crystallinity in the (95:5)% composition nanofilter is 8.41%, with the crystal area fraction of 635.75 and the amorphous area fraction of 7554.67. As a result, the nanofilter with a (95:5)% composition can be mentioned as an amorphous rather than a crystalline compound.

3.8. Fourier Transform Infrared Spectroscopy (FTIR) Analysis. FTIR analysis is intended to determine the functional groups and wave numbers based on the resulting absorption peaks. Figure 9 shows the results of the FTIR nanofilter test for all composition variations which were activated at a temperature of 700 °C.

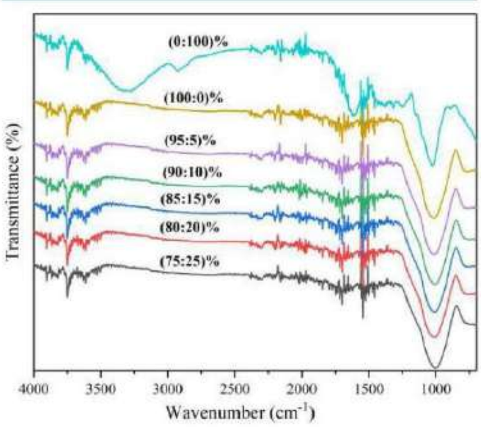

Figure 9. FTIR results of all samples with an activation temperature of 700 °C.

In Figure 9, it can be seen that all observed nanofilter samples showed OH bond peaks for the samples (0:100)%, (100:0)%, (95:5)%, (90:10)%, (85:15)%, (80:20)%, and (75:25)% at wavelengths 3287.36, 3742.43, 3742.79, 3742.35, 3742.53, 3742.57, and 3742.43 cm^{-1} respectively. Furthermore, it was discovered from the graph that all of the samples have the TO_4 [SiO_4] bond peak, which is at 1000–1100 cm^{-1}, as shown in Table 1.

3.9. XRF Analysis. XRF analysis is intended to determine the composition of the elemental compounds contained in the zeolite material used, as shown in Table 2.

The presence of elements in the form of oxides, namely alumina (Al_2O_3) and silica (SiO_2), which are the main components of the framework of natural zeolite and are equal to 10.84% (wt) for alumina and 66.733% (wt) for silica, can be proven based on the XRF test results on the zeolite sample as shown above. As a result, this natural zeolite has a Si/Al ratio of 6.15, indicating that the density of Al atoms in the zeolite crystal framework structure is quite high. This

Table 1. FTIR Test Results for the TO_4 [SiO_4] Wavelength Bond

No.	Treatment Variations	TO_4 [SiO_4] (cm^{-1})
1	Nanofilter with a (0:100)% composition	1028.95
2	Nanofilter with a (100:0)% composition, activated at temperature of 700 °C	1017.34
3	Nanofilter with a (95:5)% composition, activated at temperature of 700 °C	1013.93
4	Nanofilter with a (90:10) % composition, activated at temperature of 700 °C	1003.27
5	Nanofilter with a (85:15)% composition, activated at temperature of 700 °C	1010.44
6	Nanofilter with a (80:20)% composition, activated at temperature of 700 °C	1012.65
7	Nanofilter with a (75:25)% composition, activated at temperature of 700 °C	1003.09

natural zeolite has an alumina (Al_2O_3) purity of 10.882% (wt) and a silica (SiO_2) purity of 67.061% (wt).

2.10. Gas Chromatography Analysis on Bioethanol purification. Gas chromatography analysis was carried out to determine the level of purity of bioethanol after being treated with a nanofilter (with a composition of (75:25)% activated at 700 °C), as well as the evaporation process. Table 3 shows the concentration of bioethanol after treatment. Only nanofilters with a composition of (75:25)% with an activation temperature of 700 °C were used in this bioethanol purification test because the samples with this variation had the highest porosity value and the highest water absorption value in the porosity and water adsorption test, respectively.

The optimum concentration of bioethanol was obtained at a contact time of 45 min using a nanofilter ((75:25)% composition which was activated at 700 °C), with the result that the bioethanol concentration increased by about 78.92%. These results support the results of the PSA test and water absorption where the zeolite that has been activated and treated with HEM has a smaller particle size of 118.4 nm and a higher water absorption capacity of 52.08%; thus, it is able to absorb water optimally. This is due to the large number of pores on the surface of the nanofilter. In addition, the contact time of the nanofilter with bioethanol also needs to be considered because it affects the final concentration of bioethanol. The longer the contact time, the more water and bioethanol will be adsorbed on the surface of the nanofilter; this can cause a decrease in the concentration of bioethanol.

CONCLUSION

The activated zeolite produced in this study has a particle size of 118.4 nm and a higher water absorption capacity of 52.08%, which indicates the ability of the zeolite to absorb water. The presence of modernite in the Pahae natural zeolite was validated by the Si/Al ratio from the EDX study, and the amorphous nature of the diffraction pattern nanofilter sample was confirmed by the XRD analysis. The hardness values of the activated samples show that the sample which was activated at temperatures of 700 °C was the sample that has the optimum hardness value. During bioethanol purification, a cocoa shell activated charcoal–zeolite nanofilter was able to absorb water in bioethanol products. The zeolite-activated charcoal nanofilters containing cocoa shells were able to increase the concentration of bioethanol up to 78.92% during the adsorption with a 45 min contact time for water vapor.

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Table 2. XRF Test Results Data for Zeolite Samples

Element			Geology			Oxide		
Compd	Conc	Unit	Compd	Conc	Unit	Compd	Conc	Unit
Na	0	%	Na_2O	0	%	Na_2O	0	%
Mg	0.24	%	MgO	0.284	%	MgO	0.283	%
Al	8.742	%	Al_2O_3	10.882	%	Al_2O_3	10.84	%
Si	54.337	%	SiO_2	67.061	%	SiO_2	66.733	%
P	2.961	%	P_2O_5	3.302	%	P_2O_5	3.281	%
Cl	0.024	%	Cl	0.011	%	K_2O	7.908	%
K	14.446	%	K_2O	7.963	%	CaO	5.231	%
Ca	8.969	%	CaO	5.271	%	TiO_2	1.082	%
Ti	1.634	%	Ti	0.654	%	V_2O_5	0.023	%
V	0.034	%	V	0.013	%	Cr_2O_3	0.003	%
Cr	0.006	%	Cr	0.002	%	MnO	0.046	%
Mn	0.093	%	Mn	0.036	%	Fe_2O_3	3.951	%
Fe	7.208	%	Fe_2O_3	3.983	%	ZnO	0.011	%
Zn	0.025	%	Zn	0.009	%	Ga_2O_3	0.005	%

Table 3. Bioethanol Concentration after Treatment with a Nanofilter with a Composition of (75:25)% and Activated at 700 °C

No.	Composition	Contact Time (min)	Initial Bioethanol Concentration (%)	Final Bioethanol Concentration (%)	Increase of Bioethanol Concentration (%)
1	(75:25)%	30	40	47.21	18.02
2		45	40	71.57	78.92
3		60	40	57.62	44.05
4		75	40	51.63	29.07
5		90	40	49.21	23.02

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Notes

The authors declare no competing financial interest.

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REFERENCES

(1) Owusu, P. A.; Asumadu-Sarkodie, S. A review of renewable energy sources, sustainability issues and climate change mitigation. *Cogent Eng.* **2016**, *3* (1), 1167990.

(2) Zou, C.; Zhao, Q.; Zhang, G.; Xiong, B. Energy revolution: From a fossil energy era to a new energy era. *Nat. Gas Ind. B* **2016**, *3*, 1–11.

(3) Koçar, G.; Civaş, N. An overview of biofuels from energy crops: Current status and future prospects. *Renew Sustain Energy Rev.* **2013**, *28*, 900–916.

(4) Rosales-Calderon, O.; Arantes, V. A Review on Commercial-Scale High-Value Products That Can Be Produced alongside Cellulosic Ethanol. *BioMed. Central.* **2019**, *12*, 240.

(5) Tse, T. J.; Wiens, D. J.; Reaney, M. J. T. Production of bioethanol—a review of factors affecting ethanol yield. *Fermentation.* **2021**, *7*, 268.

(6) Mohd Azhar, S. H.; Abdulla, R.; Jambo, S. A.; Marbawi, H.; Gansaua, J. A.; Faik, A.A. M.; Rodrigues, K. F. Yeasts in sustainable bioethanol production: A review. *Biochem Biophys Reports* **2017**, *10*, 52–61.

(7) Karimi, S.; Yaraki, M. T.; Karri, R. R. A comprehensive review of the adsorption mechanisms and factors influencing the adsorption process from the perspective of bioethanol dehydration. *Renew Sustain Energy Rev.* **2019**, *107*, 535–553.

(8) Al-Asheh, S.; Banat, F.; Al-Lagtah, N. Separation of ethanol–water mixtures using molecular sieves and biobased adsorbents. *Chem. Eng. Res. Des.* **2004**, *82*, 855–864.

(9) Wang, S.; Peng, Y. Natural zeolites as effective adsorbents in water and wastewater treatment. *Chem. Eng. J.* **2010**, *156*, 11–24.

(10) Sudibandriyo, M.; Putri, F. A. The Effect of Various Zeolites as an Adsorbent for Bioethanol Purification using a Fixed Bed Adsorption Column. *Int. J. Technol.* **2020**, *11*, 1300–1308.

(11) Khaleque, A.; Alam, M. M.; Hoque, M.; Mondal, S.; Haider, J. B.; Xu, B.; Johir, M. A. H.; Karmakar, A. K.; Zhou, J. L.; Ahmed, M. B.; Moni, M. A. Zeolite synthesis from low-cost materials and environmental applications: A review. *Environ. Adv.* **2020**, *2*, 100019.

https://doi.org/10.1021/acsomega.2c03614
ACS Omega 2022, 7, 38417–38425

(12) Calabrese, L. Anticorrosion behavior of zeolite coatings obtained by in situ crystallization: A critical review. *Materials (Basel)* **2019**, *12* (1), 12010059.
(13) Zarrintaj, P.; Mahmodi, G.; Manouchehri, S. Zeolite in tissue engineering: Opportunities and challenges. *MedComm.* **2020**, *1*, 5−34.
(14) Kusumaningtyas, M. P.; Regina, G. L. D.; Ade, L. N. F.; Haiyina, H. A.; Nura, H. H.; Darminto, D. Synthesis of zeolites from Lombok pumice as silica source for ion exchanger. *1st Int. Basic Sci. Conf Towar Ext use basic Sci. enhancing Heal Environ. energy Biotechnol* **2017**, 244−247.
(15) Li, Y.; Li, L.; Yu, J. Applications of Zeolites in Sustainable Chemistry. *Chem.* **2017**, *3*, 928−949.
(16) Nasution, T. I.; Susilawati; Zebua, F.; Nainggolan, H.; Nainggolan, I. Manufacture of Water Vapour Filter Based on Natural Pahae Zeolite Used for Hydrogen Fueled Motor Cycle. *Appl. Mech Mater.* **2015**, *754*−*755*, 789−793.
(17) Susilawati; Nasution, T. I.; Zebua, F.; Nainggolan, H. Hydrogen purification using natural pahae zeolit and cocoa rind based filter. *Int. J. Appl. Eng. Res.* **2017**, *12*, 3914−3918.
(18) Susilawati; Nasruddin, M. N.; Kurniawan, C.; Nainggolan, I.; Sihombing, Y. A. Ethanol Purification Using Active Natural Pahae Zeolite by Adsorption Distillation Method. *J. Phys. Conf Ser.* **2018**, *1116*, 032037.
(19) Heraldy, E.; SW, H.; Sulistiyono, S. Characterization and Activation of Natural Zeolit From Ponorogo. *Indones J. Chem.* **2003**, *3*, 91−97.
(20) Sulistyowati, N.; Sriyanti, S.; Darmawan, A. Effect of Acid on Natural Zeolite Dealumination on Indigo Carmine Adsorption Capability. *J. Kim Sains dan Apl.* **2018**, *21*, 102−106.
(21) Fuss, V. L. B.; Bruj, G.; Dordai, L.; Roman, M.; Cadar, O.; Becze, A. Evaluation of the impact of different natural zeolite treatments on the capacity of eliminating/reducing odors and toxic compounds. *Materials (Basel).* **2021**, *14*. No. .3724
(22) Susilawati; Nasruddin, M. N.; Sihombing, Y. A.; Pakpahan, S. N. Y.; Ferdiansyah, B. Preparation of pahae natural zeolite nanoparticles using high energy milling and its potential for bioethanol purification. *Rasayan J. Chem.* **2021**, *14*, 1265−1272.
(23) Ackley, M. W.; Rege, S. U.; Saxena, H. Application of natural zeolites in the purification and separation of gases. *Microporous Mesoporous Mater.* **2003**, *61*, 25−42.
(24) Tsai, W. T.; Lai, C. W.; Hsien, K. J. Effect of particle size of activated clay on the adsorption of paraquat from aqueous solution. *J. Colloid Interface Sci.* **2003**, *263*, 29−34.
(25) Adam, M. R.; Othman, M. H. D.; Kadir, S. H. S. A. Influence of the natural zeolite particle size toward the ammonia adsorption activity in ceramic hollow fiber membrane. *Membranes (Basel)* **2020**, *10*, 1−18.
(26) Naji, S. Z.; Tye, C. T. A review of the synthesis of activated carbon for biodiesel production: Precursor, preparation, and modification. *Energy Convers Manag X.* **2022**, *13*, 100152.
(27) Olchowski, R.; Zieba, E.; Giannakoudakis, D. A.; Anastopoulos, I.; Dobrowolski, R.; Barczak, M. Tailoring surface chemistry of sugar-derived ordered mesoporous carbons towards efficient removal of diclofenac from aquatic environments. *Materials (Basel)* **2020**, *13*, 1−17.
(28) Şahin, Ö.; Saka, C. Preparation and characterization of activated carbon from acorn shell by physical activation with H2O-CO2 in two-step pretreatment. *Bioresour. Technol.* **2013**, *136*, 163−168.
(29) Goh, P. S.; Wong, K. C.; Ismail, A. F. Nanocomposite membranes for liquid and gas separations from the perspective of nanostructure dimensions. *Membranes (Basel)* **2020**, *10*, 1−29.
(30) Le, N. L.; Nunes, S. P. Materials and membrane technologies for water and energy sustainability. *Sustain Mater. Technol.* **2016**, *7*, 1−28.
(31) Ouattara, L. Y.; Kouassi, E. K. A.; Soro, D. Cocoa Pod Husks as Potential Sources of Renewable High-Value-Added Products: A Review of Current Valorizations and Future Prospects. *Bioresources* **2021**, 1988−2020.
(32) Susilawati; Sani, A.; Sihombing, Y. A.; Pakpahan, S. N. Y.; Ferdiansyah, B. The utilization of cocoa rind waste and clay as filter materials in purifying well water. *AIP Conf Proc.* **2020**, *2221*, 0−9.
(33) Susilawati; Siburian, J.; Sihombing, Y. A.; Ferdiansyah, B.; Pakpahan, S. N. Y. Fabrication and characterization of physical and mechanical properties based on clay and cacao rind porous ceramics. *AIP Conf Proc.* **2020**, *2221*, 0−9.
(34) ASTM C20-00. Standard Test Methods for Apparent Porosity, Water Absorption, Apparent Specific Gravity, and Bulk Density of Burned Refractory Brick and Shapes by Boiling Water. *Am. Soc. Test Mater.* **2015**, *00*, 1−3.
(35) ASTMC642-06. Standar Test Method Density, Absorption, Voids Hardened Concr. *Am. Soc. Test Mater.* **2008**, 11−13.
(36) Masturi, M.; Cristina, A.; Istiana, N.; Sunarno, S.; Dwijananti, P. Ethanol Production from Fermentation of Arum Manis Mango Seeds (*Mangifera indica* L.) using *Saccharomyces Crevisiaea*. *J. Bahan Alam Terbarukan* **2017**, *6*, 56−60.
(37) Bušić, A.; Mardetko, N.; Kundas, S. Bioethanol production from renewable raw materials and its separation and purification: A review. *Food Technol. Biotechnol* **2018**, *56*, 289−311.
(38) Siswanto, Y. A.; Hariyanto, M. Synthesis of Zinc Oxide (ZnO) Nanoparticle By Mechano-Chemical Method. *Proceeding The 1st IBSC: Towards The Extended Use Of Basic Science For Enhancing Health, Environment, Energy And Biotechnology* **2017**, *1*, 174−176.
(39) Naghdi, M.; Taheran, M.; Brar, S. K. A green method for production of nanobiochar by ball milling- optimization and characterization. *J. Clean Prod.* **2017**, *164*, 1394−1405.
(40) Tadda, M.; Ahsan, A.; Shitu, A. A Review on Activated Carbon from Biowaste: Process, Application and Prospects. *J. Adv. Civ. Eng. Pract. Res.* **2018**, *5*, 82−83.
(41) Burris, L. E.; Juenger, M. C. G. Effect of calcination on the reactivity of natural clinoptilolite zeolites used as supplementary cementitious materials. *Constr Build Mater.* **2020**, *258*, 119988.
(42) Pallarés, J.; González-Cencerrado, A.; Arauzo, I. Production and characterization of activated carbon from barley straw by physical activation with carbon dioxide and steam. *Biomass and Bioenergy.* **2018**, *115*, 64−73.
(43) Byamba-Ochir, N.; Shim, W. G.; Balathanigaimani, M. S.; Moon, H. Highly porous activated carbons prepared from carbon rich Mongolian anthracite by direct NaOH activation. *Appl. Surf. Sci.* **2016**, *379*, 331−337.
(44) Yahya, M. A.; Al-Qodah, Z.; Ngah, C. W. Z. Agricultural bio-waste materials as potential sustainable precursors used for activated carbon production: A review. *Renew Sustain Energy Rev.* **2015**, *46*, 218−235.
(45) Bouchelta, C.; Medjram, M. S.; Bertrand, O.; Bellat, J. P. Preparation and characterization of activated carbon from date stones by physical activation with steam. *J. Anal Appl. Pyrolysis.* **2008**, *82* (1), 70−77.

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Dalam pelaksana kegiatan penelitian skema Penelitian Kolaborasi Pemerintah Tahun 2023 di Universitas Sumatera Utara dengan judul Penelitian: Filter Air Gambut Berbasis Zeolit Alam Pahae dan Karbon Aktif Cangkang Kemiri untuk Pengolahan Air Gambut Menjadi Air Bersih.

Demikian surat pernyataan ini kami buat untuk dapat dipergunakan sebagaimana mestinya.

Tangerang Selatan, 31 Juli 2023
Kepala Pusat Riset Material Maju

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