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Research Paper

Selectivity Adsorption of Anionic Dyes by Macroalgae *E. cottonii*

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Abstract
The selectivity analysis of anionic dye adsorption by *E. cottonii* macroalgae has been successfully conducted in this study. Selectivity analysis encompassed congo red, direct yellow, methyl orange, and direct green dyes with measurements taken at 0, 2, 4, 6, 8, and 10-minute intervals. The dye concentration was standardized at 50 g/mL, and 20 mL of each dye solution was utilized. Variations in absorbance were assessed using a UV-Vis Spectrophotometer, revealing that *E. cottonii* exhibited the highest selectivity for methyl orange. Characterization through FT-IR indicated the presence of O−H, C−H aliphatic, C=N, C=C, C−O, and N−H bonds in the dried *E. cottonii* macroalgae material. These results affirm the superior selectivity of *E. cottonii* in adsorbing methyl orange, as demonstrated by the selectivity test.

Keywords
E. cottonii, Macroalgae, Selectivity, Anionic Dyes

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1. INTRODUCTION

There are roughly 30,000 species of green algae around the world (Santos et al., 2015), and their shapes change broadly. According to the color of the thallus, they can be classified into *Phaeophyceae* (brown), *Rhodophyceae* (red), and *Chlorophyceae* (green) algae (Zheng et al., 2020). Algae are commonly utilized for the extraction of hydrocolloids such as agar, carrageenan, and alginate (Charoensiddhi et al., 2020). One of the foremost well-known fish assets in Indonesia is algae, and in reality, algae cultivation has been well-created in later a long time. Algae or macroalgae are one of the foremost inexhaustible organic resources in Indonesia, accounting for roughly 8.6% of the full marine biota. Indonesia's algae territory is 1.2 million hectares and is considered the biggest algae territory in the world (Prakoso et al., 2018). Unfortunately, despite having well-processed items with tall included esteem, as it were 20-23% of algae cultivating in Indonesia produces crude materials. Among the algae species are Euchema cotonnii and Gracilaria, with an evaluated surrender proportion of 70:30. Indonesia sent out 80% of his *E. cottonii* items, whereas 80% of Gracilaria items were devoured locally (Puspawati et al., 2015). Extensive populations of *Eucheuma cottonii* also referred to as *Kappaphycus alvarezii*, are found on the inner surfaces of coral reefs in the Philippines, Indonesia, and East African island regions (Chan et al., 2013). Buton in southeast Sulawesi is one of the makers of *E. cottonii* algae, and its generation produced 70,313 tons (Puspawati et al., 2015).

The inexhaustible accessibility of algae in Indonesia ought to be optimized by changing these assets into other high-value items. Items obtained from algae incorporate biomaterials and biofuels. Macroalgae as a biomaterial moreover has a few employments, such as pharmaceutical (Shobier et al., 2020), polymer fabricating (Kammler et al., 2024), and adsorbent for the remediation of different contaminants in wastewater (Mittal et al., 2022; Soliman et al., 2019; Shobier et al., 2020; Lee et al., 2022; Park et al., 2016).

Dye effluent contained in wastewater can have a terrible effect on the environment (Palapa et al., 2019a). Undoubtedly the nearness of these substances within the oceanic environment reduces the oxygen and irritates the organic cycle of sea-going biota (Palapa et al., 2019b). Most colors are not instantly biodegradable and are noxious to sea-going life, indeed in small sums (Wijaya and Yuliasari, 2023). There are a few methods for the remediation of colors from wastewater. Different physical or chemical strategies have preferences and impediments. Illustrations of chemical strategies such as photocatalysis (Wijaya and Yuliasari, 2023) and physicochemical strategies such as particle trade, coagulation, adsorption, and film filtration (Ahmad et al., 2023; Raval et al., 2017; Hamad and Idrus, 2022). Numerous of them are costly, troublesome to utilize, and have constrained color division effectiveness. In any case, adsorption methods also have other preferences: they are more valuable, cheaper, less demanding to utilize and don't contain destructive substances (Palapa et al., 2019a).

In this research, macroalgae *E. cottonii* will be applied to adsorb the anionic dye pollutants. Selectivity testing will be carried out to see the best adsorption ability of macroalgae on

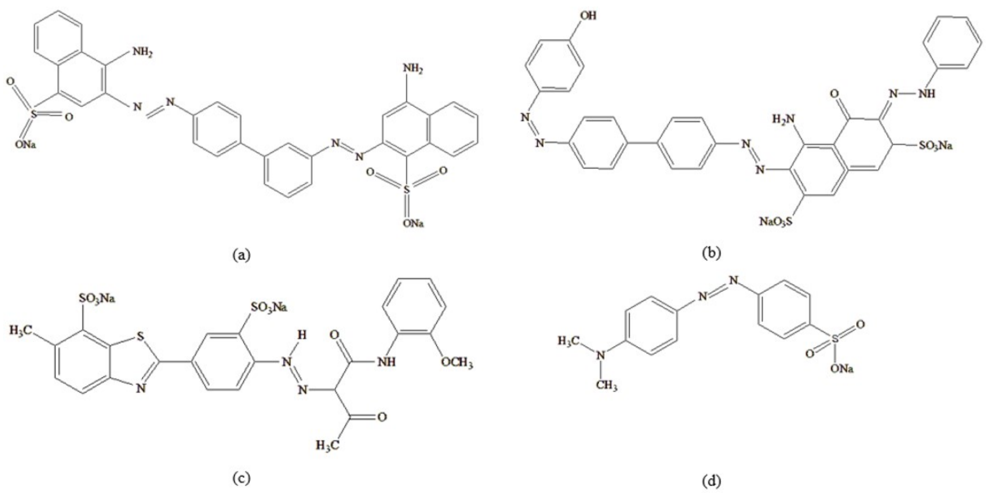

Figure 1. Chemical Structure of (a) CR ; (b) DG ; (c) DY and (d) MO Dyes

anionic dyes. Anionic dyes that will be used in this study are congo red (CR), direct green (DG), direct yellow (DY), and methyl orange (MO). Figure 1 shows the chemical structure of each dye. The pre-treated macroalgae will be characterized using FT-IR to ensure that the macroalgae used is *E. cottonii*.

2. EXPERIMENTAL SECTION

2.1 Materials and Characterizations

The macroalgae *E. cottonii* was collected from the marine waters of Maluku, Indonesia. Distilled water (H_2O), congo red (CR), direct yellow (DY), methyl orange (MO), and direct green (DG). Macroalgae were characterized using a Shimadzu Prestige-21 FTIR spectrophotometer, and the absorbance measurements of the dye's solution were conducted using a UV-visible Biobase spectrophotometer UV BK-1800PC.

2.2 Preparation of Macroalgae *E. cottonii*

E. cottonii is washed thoroughly to remove dirt and salt that is still attached. The wash is carried out repeatedly. Macroalgae was rinsed with distilled water and oven-dried for 5 hours at 80°C to remove the water content (Farobie et al., 2022). Dried macroalgae were then mashed and sifted using a 200 mesh and characterized using FT-IR.

2.3 Selectivity to Anionic Dyes

Selectivity tests were conducted by combining all anionic dyes in a solution of 20 ml, each dye having a concentration of 50 mg/L. Subsequently, 0.02 g of each adsorbent was introduced into the dye mixture, and the wavelength was measured within the range of 400–700 nm at intervals of 0, 2, 4, 6, 8, and 10 minutes (Wibiyan et al., 2023).

3. RESULTS AND DISCUSSION

3.1 Characterization of Macroalgae *E. cottonii*

The research conducted by Kim et al. (2010) and further discussed by Puspawati et al. (2015) unveiled that *E. cottonii* comprises approximately 7.11% cellulose. Additionally, Prakoso et al. (2018) performed an ultimate analysis on *E. cottonii*, revealing its composition: 21.11% Carbon, 4.26% Hydrogen, 0.35% Nitrogen, 57.73% Oxygen, and 2.97% Sulfur. Figure 2 illustrates the FTIR spectrum of the macroalgae *E. cottonii*. The vibrational peak at 3425.58 cm^{-1} is attributed to the -OH group, while the spectra at 2924.09 cm^{-1} and 2854.65 cm^{-1} are associated with C-H aliphatic bonding. The peak at 1636.64 cm^{-1} indicates the vibration of the C=N bond. The peaks at 1520 cm^{-1} correspond to the stretching of the aromatic groups present in lignin (Jumaidin et al., 2017). Additionally, the spectrum at 1373.32 cm^{-1} corresponds to the C=C bond in aromatic compounds, while the peak at 1000-1200 cm^{-1} is linked to the bonding of C-O in ethers and alcohols. The spectrum at 848.64 cm^{-1} corresponds to the C-H bonds in aromatic compounds, and peaks around 700 cm^{-1} indicate the bond vibration of N-H (amino group) (Jalilian et al., 2024; Lu et al., 2018).

According to Prakoso et al. (2018), the intensity of the O−H bond peak around 3500 cm^{-1} will decrease if a hydrothermal process is carried out on the macroalgae due to the dehydration of the macroalgae. The peak around 2900 cm^{-1} attributed to C−H aliphatic will also decrease, indicating the breakdown of some aliphatic long chains. Furthermore, the peaks around 1600 cm^{-1} and 1000 cm^{-1} will also decrease due to the removal of inorganic carbonate from raw materials and the breaking of C−O linkages during the hydrothermal process.

3.2 Adsorption Selectivity of Anionic Dyes

In this study, the selective adsorption of four anionic dyes - congo red (CR), methyl orange (MO), direct yellow (DY), and direct green (DG) - was examined at identical concentrations. Each dye had a distinct wavelength, with congo red at 495 nm, methyl orange at 464 nm, direct yellow at 412 nm, and direct green at 623 nm. The macroalgae *E. cottonii* was utilized as the adsorbent material. The adsorption process involved mixing each dye with 0.02 g of the adsorbent and shaking the mixture

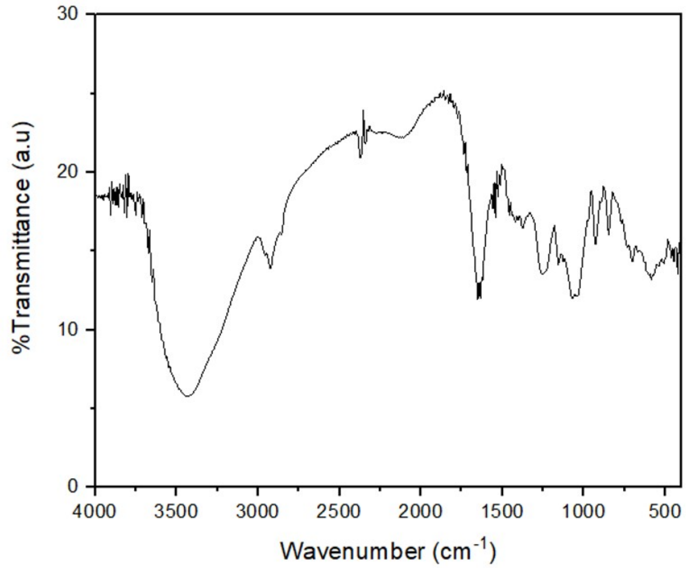

Figure 2. FTIR Spectrum of *E. cottonii*

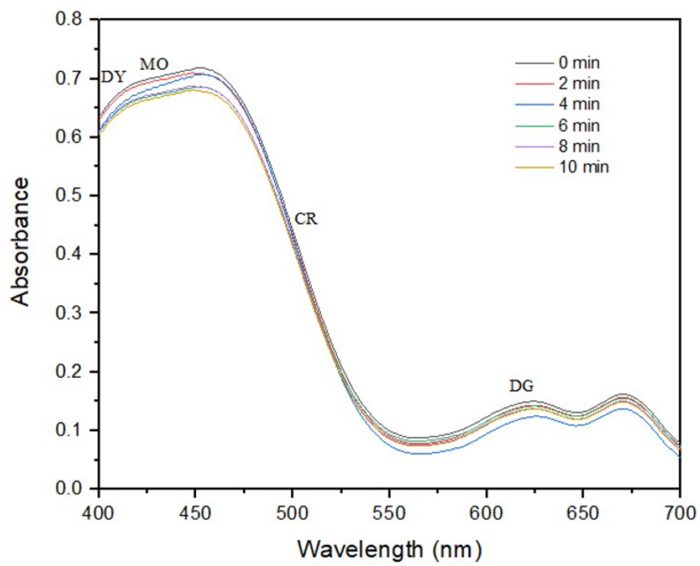

Figure 3. Selectivity of Anionic Dyes by *E. cottonii*

for intervals of 0, 2, 4, 6, 8, and 10 minutes. The wavelength was measured at each interval to determine which dye exhibited the highest selectivity for absorption into the macroalgae. The results revealed that among the four anionic dyes tested, methyl orange displayed the greatest selectivity. Figure 3 illustrates that methyl orange, the most selectively adsorbed dye, experienced the highest level of absorption on each adsorbent at a wavelength of 412 nm. Understanding the selectivity of dye adsorption is crucial as it provides insights into the adsorbent's capability to absorb specific dyes, which can have implications for wastewater treatment and environmental remediation processes.

4. CONCLUSIONS

In this study, the characterization of macroalgae *E. cottonii* shows that in the dried *E. cottonii* material, there are C−O, O−H, N−H, C−C, and C=N bonds derived from organic compounds in *E. cottonii* content. The study's results show that macroalgae *E. cottonii* is selective to adsorb anionic dyes. Specifically among the congo red, direct green, direct yellow, and methyl orange, *E. cottonii* most selectively adsorbs methyl orange, indicating that *E. cottonii* has potential as a good anionic dye adsorbent.

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REFERENCES

Ahmad, N., N. R. Palapa, and T. Taher (2023). Rice Husks as Green Adsorbents for Removal of Anionic Dyes: Kinetic, Isotherm and Thermodynamic Adsorption Studies. *Indonesian Journal of Material Research*, **1**(1); 23–28

Chan, S. W., H. Mirhosseini, F. S. Taip, T. C. Ling, and C. P. Tan (2013). Comparative Study on the Physicochemical Properties of κ-Carrageenan Extracted from *Kappaphycus alvarezii* (Doty) Doty ex Silva in Tawau, Sabah, Malaysia and Commercial κ-Carrageenans. *Food Hydrocolloids*, **30**(2); 581–588

Charoensiddhi, S., R. E. Abraham, P. Su, and W. Zhang (2020). Seaweed and Seaweed-Derived Metabolites as Prebiotics. In *Advances in Food and Nutrition Research*, volume 91. Elsevier Inc., 1st edition

Farobie, O., N. Syaftika, I. Masfuri, T. P. Rini, D. P. A. Lanank Es, A. Bayu, A. Amrullah, E. Hartulistiyoso, N. R. Moheimani, S. Karnjanakom, and Y. Matsumura (2022). Green Algae to Green Fuels: Syngas and Hydrochar Production from *Ulva lactuca* via Sub-critical Water Gasification. *Algal Research*, **67**(1); 102834

Hamad, H. N. and S. Idrus (2022). Recent Developments in the Application of Bio-Waste-Derived Adsorbents for the Removal of Methylene Blue from Wastewater: A Review. *Polymers*, **14**(4)

Jalilian, M., R. Bissessur, M. Ahmed, A. Hsiao, Q. S. He, and Y. Hu (2024). A Review: Hydrochar as Potential Adsorbents for Wastewater Treatment and CO_2 Adsorption. *Science of the Total Environment*, **914**(January); 169823

Jumaidin, R., S. M. Sapuan, M. Jawaid, M. R. Ishak, and J. Sahari (2017). Characteristics of *Eucheuma cottonii* Waste from East Malaysia: Physical, Thermal and Chemical Composition. *European Journal of Phycology*, **52**(2); 200–207

Kammler, S., A. Malvis Romero, C. Burkhardt, L. Baruth, G. Antranikian, A. Liese, and M. Kaltschmitt (2024). Macroalgae Valorization for the Production of Polymers, Chemicals, and Energy. *Biomass and Bioenergy*, **183**(November 2023); 107105

Lee, X. J., H. C. Ong, J. Ooi, K. L. Yu, T. C. Tham, W. H. Chen, and Y. S. Ok (2022). Engineered Macroalgal and Microalgal Adsorbents: Synthesis Routes and Adsorptive Performance on Hazardous Water Contaminants. *Journal of Hazardous Materials*, **423**(PA); 126921

Lu, Y., D. He, H. Lei, J. Hu, H. Huang, and H. Ren (2018). Adsorption of Cu (II) and Ni (II) from Aqueous Solutions by Taro Stalks Chemically Modified with Diethylenetriamine. *Environmental Science and Pollution Research*, **25**(18); 17425–17433

Mittal, R., R. Sharma, and K. S. M. S. Raghavarao (2022). Novel Adsorption Approach for the Enrichment of R-Phycoerythrin from Marine Macroalga *Gelidium pusillum*. *Algal Research*, **62**(November 2021); 102605

Palapa, N. R., B. R. Rahayu, T. Taher, R. Mohadi, and A. Lesbani (2019a). Kinetic Adsorption of Direct Yellow onto Zn/Al and Zn/Fe Layered Double Hydroxides. *Science and Technology Indonesia*, **4**(4); 101–104

Palapa, N. R., T. Taher, R. Mohadi, and A. Lesbani (2019b). Removal of Anionic Direct Dye Using Zn/Al, Zn/Fe and Zn/Cr Layered Double. *Science and Technology Indonesia*, **4**(3); 70–76

Park, S. H., H. J. Cho, C. Ryu, and Y. K. Park (2016). Removal of Copper(II) in Aqueous Solution Using Pyrolytic Biochars Derived from Red Macroalga *Porphyra tenera*. *Journal of Industrial and Engineering Chemistry*, **36**; 314–319

Prakoso, T., R. Nurastuti, R. Hendriansyah, J. Rizkiana, G. Suantika, and G. Guan (2018). Hydrothermal Carbonization of Seaweed for Advanced Biochar Production. *MATEC Web of Conferences*, **156**; 1–5

Puspawati, S., Wagiman, M. Ainuri, D. A. Nugraha, and Haslianti (2015). The Production of Bioethanol Fermentation Substrate from *Eucheuma cottonii* Seaweed through Hydrolysis by Cellulose Enzyme. *Agriculture and Agricultural Science Procedia*, **3**; 200–205

Raval, N. P., P. U. Shah, and N. K. Shah (2017). Malachite Green "A Cationic Dye" and Its Removal from Aqueous Solution by Adsorption. *Applied Water Science*, **7**(7); 3407–3445

Santos, S. A. O., C. Vilela, C. S. R. Freire, M. H. Abreu, S. M. Rocha, and A. J. D. Silvestre (2015). Chlorophyta and Rhodophyta Macroalgae: A Source of Health Promoting Phytochemicals. *Food Chemistry*, **183**; 122–128

Shobier, A. H., M. M. El-Sadaawy, and G. F. El-Said (2020). Removal of Hexavalent Chromium by Ecofriendly Raw Marine Green Alga *Ulva fasciata*: Kinetic, Thermodynamic and Isotherm Studies. *Egyptian Journal of Aquatic Research*, **46**(4); 325–331

Soliman, N. K., H. S. Mohamed, S. A. Ahmed, F. H. Sayed, A. H. Elghandour, and S. A. Ahmed (2019). Cd^{2+} and Cu^{2+} Removal by the Waste of the Marine Brown Macroalga *Hydroclathrus clathratus*. *Environmental Technology and Innovation*, **15**; 100365

Wibiyan, S., A. Wijaya, and P. M. S. B. N. Siregar (2023). Adsorption of Phenol Using Cellulose and Hydrochar: Kinetic, Isotherm, and Regeneration Studies. *Indonesian Journal of Material Research*, **1**(2); 61–67

Wijaya, A. and N. Yuliasari (2023). Biochar Derived from Rice Husk as Effective Adsorbent for the Removal Congo Red and Procion Red MX-5B Dyes. *Indonesian Journal of Material Research*, **1**(1); 1–7

Zheng, L. X., X. Q. Chen, and K. L. Cheong (2020). Current Trends in Marine Algae Polysaccharides: The Digestive Tract, Microbial Catabolism, and Prebiotic Potential. *International Journal of Biological Macromolecules*, **151**; 344–354

