

BAB V

KESIMPULAN DAN SARAN

5.1 Kesimpulan

Berdasarkan percobaan yang telah dilakukan, dapat disimpulkan bahwa:

1. Seiring dengan meningkatnya konsentrasi awal zat warna, profil *%removal* zat warna *Congo* merah mengalami penurunan dari 43,25% ke 30,34% (30°C); 56,74% ke 33,67% (40°C); dan 88,77% ke 41,04% (50°C). Hal ini dipengaruhi oleh menurunnya kemampuan muatan positif protein untuk menetralkan muatan negatif *Congo* merah yang mengalami kenaikan dalam larutan.
2. Pada konsentrasi yang sama, *%removal* zat warna *Congo* merah mengalami peningkatan dari 43,25% ke 88,77% seiring dengan naiknya temperatur koagulasi. Hal ini disebabkan oleh semakin tingginya kontak antara partikel dalam larutan pada temperatur yang lebih tinggi, sehingga flok yang terbentuk menjadi lebih banyak dan meningkatkan *%removal*.
3. Model kinetika *pseudo-second order* merupakan model yang paling cocok untuk menggambarkan proses koagulasi zat warna *Congo* merah dengan ekstrak biji petai cina, dengan nilai konstanta laju (k_2) berada pada rentang 2,1317 – 3,1997 g/mg.min (30°C); 1,3347 – 3,5101 g/mg.min (40°C) dan 1,1421 – 3,7192 g/mg.min (50°C). Model ini menunjukkan bahwa mekanisme adsorpsi-netralisasi muatannya merupakan *chemisorption* yang terjadi karena adanya interaksi antara gugus protein dan *Congo* merah.
4. Model isoterm Langmuir merupakan model yang paling cocok untuk menggambarkan proses koagulasi zat warna *Congo* merah dengan ekstrak biji petai cina, dengan nilai konstanta (K_L) berada pada rentang 0,0491 – 1,6650 L/mg. Model ini menunjukkan bahwa mekanisme adsorpsi-netralisasi terjadi pada permukaan yang homogen dan bersifat monolayer.
5. Hasil termodinamika menunjukkan proses adsorpsi zat warna *Congo* merah pada ekstrak biji petai cina berlangsung secara spontan yang ditunjukkan dengan energi bebas Gibbs bernilai negatif, endotermis yang ditunjukkan dengan entalpi bernilai positif (142,96 kJ/mol), serta adanya peningkatan ketidakteraturan interaksi pada permukaan koagulan yang ditunjukkan dengan entropi bernilai positif (0,45 kJ/mol.K).

5.2 Saran

Beberapa saran yang dapat diberikan untuk penelitian lebih lanjut adalah:

1. Perlu dilakukan pengecekan secara berkala pada pH larutan *Congo* merah agar tetap berada di bawah titik isoelektriknya sebelum dilakukan koagulasi

DAFTAR PUSTAKA

- Arakawa, T., and S. N. Timasheff. 1991. "The Interactions of Proteins with Salts, Amino Acids, and Sugars at High Concentration." 9:226–45.
- Ayawei, Nimibofa, Augustus Newton Ebelegi, and Donbebe Wankasi. 2017. "Modelling and Interpretation of Adsorption Isotherms." *Journal of Chemistry* 2017(September).
- Adeleke, O. Abdulrahman, Ab Aziz Abdul Latiff, Mohammed Radin Saphira, Zawawi Daud, Norli Ismail, Amimul Ahsan, N. Adila Ab Aziz, Adel Al-Gheethi, Vicky Kumar, Ayeronfe Fadilat, and Najeeya Apanidi. 2018. *1 -Principles and Mechanism of Adsorption for the Effective Treatment of Palm Oil Mill Effluent for Water Reuse*. Elsevier Inc.
- Antov, Mirjana G., Marina B. Šćiban, and Nada J. Petrović. 2010. "Proteins from Common Bean (*Phaseolus Vulgaris*) Seed as a Natural Coagulant for Potential Application in Water Turbidity Removal." *Bioresource Technology* 101(7):2167–72.
- Beltrán-Heredia, J., J. Sánchez-Martín, and A. Delgado-Regalado. 2009. "Removal of Carmine Indigo Dye with *Moringa Oleifera* Seed Extract." *Industrial and Engineering Chemistry Research* 48(14):6512–20.
- Binnie, Chris, and Martin Kimber. 2013. *Basic Water Treatment Fifth Edition*. London: ICE Publishing.
- Bratby, J. 2016. *Coagulation and Flocculation in Water and Wastewater Treatment - Second Edition*. London: IWA Publishing.
- Camp, Thomas R., Darrell A. Root, and B. V. Bhoota. 1940. "Effects of Temperature on Rate of Floc Formation." *Journal - American Water Works Association* 32(11):1913–27.
- Chethana, M., Laxmi Gayatri Sorokhaibam, Vinay M. Bhandari, S. Raja, and Vivek V. Ranade. 2016. "Green Approach to Dye Wastewater Treatment Using Biocoagulants." *ACS Sustainable Chemistry and Engineering* 4(5):2495–2507.
- Collins, Kim D. 2004. "Ions from the Hofmeister Series and Osmolytes : E V Ects on Proteins in Solution and in the Crystallization Process." 34:300–311.
- Curtis, R. A., and L. Lue. 2006. "A Molecular Approach to Bioseparations: Protein-Protein and Protein-Salt Interactions." *Chemical Engineering Science* 61(3):907–23.
- Da, A. 2001. "Adsorption from Theory to Practice." *Advances in Colloid and Interface Science*.
- Debnath, Sushanta, and Uday Chand Ghosh. 2008. "Kinetics, Isotherm and Thermodynamics for Cr(III) and Cr(VI) Adsorption from Aqueous Solutions by Crystalline Hydrous Titanium Oxide." *Journal of Chemical Thermodynamics* 40(1):67–77.
- Drengson, Alan R. 1984. "T H E Sacred and T H E Limits of T H E." *Office* 19(3):259–75.
- Ekpenyong, T. E. 1986. "Nutrient and Amino Acid Composition of *Leucaena Leucocephala* (Lam.) de Wit." *Animal Feed Science and Technology* 15(3):183–87.
- Ernest, Ezeh, Okeke Onyeka, Nwosu David, and Okeakpu Blessing. 2017. "Effects of PH, Dosage, Temperature and Mixing Speed on The Efficiency of Water Melon Seed in Removing the Turbidity and Colour of Atabong River, Awka-Ibom State, Nigeria." *International Journal of Advanced Engineering, Management and Science* 3(5):427–34.
- Foo, K. Y., and B. H. Hameed. 2010. "Insights into the Modeling of Adsorption Isotherm Systems." *Chemical Engineering Journal* 156(1):2–10.
- Freitas, Thabata Karoliny Formicoli Souza, Cibele Andrade Almeida Almeida, Daniele Domingos Manholer, Henrique Cesar Lopes Geraldino, Maisa Tatiane Ferreira de Souza, and Juliana Carla Garcia. 2018. *Review of Utilization Plant-Based Coagulants as*

- Alternatives to Textile Wastewater Treatment*. Vol. 10. Singapore: Springer Nature Singapore.
- Ghafari, Shahin, Hamidi Abdul Aziz, Mohamed Hasnain Isa, and Ali Akbar Zinatizadeh. 2009. "Application of Response Surface Methodology (RSM) to Optimize Coagulation-Flocculation Treatment of Leachate Using Poly-Aluminum Chloride (PAC) and Alum." *Journal of Hazardous Materials* 163(2-3):650-56.
- Gitleman, Lisa. 2014. "濟無No Title No Title No Title." *Paper Knowledge . Toward a Media History of Documents*.
- Herawati, Astrid, Riistika Asti, Bambang Ismuyanto, and A. S. Dwi Saptati N. Hidayati. 2017. "PENGARUH PH DAN DOSIS KOAGULAN EKSTRAK BIJI KELOR DALAM KOAGULASI TERHADAP PENGURANGAN KEKERUHAN LIMBAH CAIR." 1(1):28-31.
- Herman, Eliot M., and Brian A. Larkins. 1999. "Protein Storage Bodies and Vacuoles." *Plant Cell* 11(4):601-13.
- Ho, Y. S., and G. McKay. 1999. "Pseudo-Second Order Model for Sorption Processes." *Process Biochemistry*.
- Hong, Song, Cheng Wen, Jing He, Fuxing Gan, and Yuh Shan Ho. 2009. "Adsorption Thermodynamics of Methylene Blue onto Bentonite." *Journal of Hazardous Materials* 167(1-3):630-33.
- Hossain, Md Sohrab, Fatehah Omar, Ahmad Jaril Asis, Robert Thomas Bachmann, Md Zaidul Islam Sarker, and Mohd Omar Ab Kadir. 2019. "Effective Treatment of Palm Oil Mill Effluent Using FeSO₄ · 7H₂O Waste from Titanium Oxide Industry: Coagulation Adsorption Isotherm and Kinetics Studies." *Journal of Cleaner Production* 219:86-98.
- Howe, Edmund S. 1965. "Uncertainty and Other Associative Correlates of Ogood's D4." *Journal of Verbal Learning and Verbal Behavior* 4(6):498-509.
- Jadhav, Madhukar V., and Yogesh S. Mahajan. 2014. "Assessment of Feasibility of Natural Coagulants in Turbidity Removal and Modeling of Coagulation Process." *Desalination and Water Treatment* 52(31-33):5812-21.
- John, Crittenden C., R. Rhodes Trussel, David W. Hand, Kerry J. Howe, and George Tchobanoglus. 2012. *MHW's Water Treatment*. New Jersey: John Wiley & Sons, Inc.
- Katayon, S., Megat Johari, and L. A. Abdul Ghani. 2006. "Preservation of Coagulation Efficiency of Moringa Oleifera, a Natural Coagulant."
- Kristanda, Jovan, Kenneth Sandrosa Sintiago, Hans Kristianto, Susiana Prasetyo, and Asaf K. Sugih. 2020. "Optimization Study of Leucaena Leucocephala Seed Extract as Natural Coagulant on Decolorization of Aqueous Congo Red Solutions." *Arabian Journal for Science and Engineering*.
- Kristianto, Hans, Novitri Daulay, and Arenst Andreas Arie. 2019. "Adsorption of Ni(II) Ion onto Calcined Eggshells: A Study of Equilibrium Adsorption Isotherm." *Indonesian Journal of Chemistry* 19(1):143-50.
- Kristianto, Hans, Henni Rahman, Susiana Prasetyo, and Asaf K. Sugih. 2019. "Removal of Congo Red Aqueous Solution Using Leucaena Leucocephala Seed's Extract as Natural Coagulant." *Applied Water Science* 9(4):1-7.
- Kristianto, Hans, Edwin Reynaldi, Susiana Prasetyo, and Asaf K. Sugih. 2020. "Adsorbed Leucaena Protein on Citrate Modified Fe₃O₄ Nanoparticles: Synthesis, Characterization, and Its Application as Magnetic Coagulant." *Sustainable Environment Research* 30(1).

- Kumar, Arun. 2011. "Coagulation and Flocculation."
- Kumar, K. Vasanth, and S. Sivanesan. 2006. "Pseudo Second Order Kinetics and Pseudo Isotherms for Malachite Green onto Activated Carbon: Comparison of Linear and Non-Linear Regression Methods." *Journal of Hazardous Materials* 136(3):721–26.
- Largitte, L., and R. Pasquier. 2016. "A Review of the Kinetics Adsorption Models and Their Application to the Adsorption of Lead by an Activated Carbon." *Chemical Engineering Research and Design*.
- Lyubchik, Svetlana, Andrey Lyubchik, Olena Lygina, Sergiy Lyubchik, and Isabel Fonseca. 2011. "Comparison of the Thermodynamic Parameters Estimation for the Adsorption Process of the Metals from Liquid Phase on Activated Carbons." *Thermodynamics - Interaction Studies - Solids, Liquids and Gases* (February 2015).
- Mahmoodi, Niyaz Mohammad, Bagher Hayati, Mokhtar Arami, and Firoozmehr Mazaheri. 2010. "Single and Binary System Dye Removal from Colored Textile Wastewater by a Dendrimer as a Polymeric Nanoarchitecture: Equilibrium and Kinetics." *Journal of Chemical and Engineering Data* 55(11):4660–68.
- Mainieri, Davide, Francesca Morandini, Marie Maîtrejean, Andrea Saccani, Emanuela Pedrazzini, and Alessandro Vitale. 2014. "Protein Body Formation in the Endoplasmic Reticulum as an Evolution of Storage Protein Sorting to Vacuoles: Insights from Maize γ -Zein." *Frontiers in Plant Science* 5(JUL):0–11.
- Mane, Venkat S., Indra Deo Mall, and Vimal Chandra Srivastava. 2007. "Kinetic and Equilibrium Isotherm Studies for the Adsorptive Removal of Brilliant Green Dye from Aqueous Solution by Rice Husk Ash." *Journal of Environmental Management* 84(4):390–400.
- Mateus, Gustavo Affonso Pisano, Tássia Rhuna Tonial dos Santos, Isabela Sperandino Sanches, Marcela Fernandes Silva, Murilo Barbosa de Andrade, Michele Putti Paludo, Raquel Guttierrez Gomes, and Rosângela Bergamasco. 2020. "Evaluation of a Magnetic Coagulant Based on Fe₃O₄ Nanoparticles and Moringa Oleifera Extract on Tartrazine Removal: Coagulation-Adsorption and Kinetics Studies." *Environmental Technology (United Kingdom)* 41(13):1648–63.
- Mathuram, M., R. Meera, and G. Vijayaraghavan. 2018. "Application of Locally Sourced Plants as Natural Coagulants For Dye Removal from Wastewater : A Review." *Journal of Materials and Environmental Sciences* 2508(7):2058–70.
- Menkiti, M C, A. O. Okoani, and M. I. Ejimofor. 2018. "Adsorptive Study of Coagulation Treatment of Paint Wastewater Using Novel Brachystegia Eurycoma Extract." *Applied Water Science* 8(6):1–15.
- Menkiti, M. C., A. O. Okoani, and M. I. Ejimofor. 2018. "Adsorptive Study of Coagulation Treatment of Paint Wastewater Using Novel Brachystegia Eurycoma Extract." *Applied Water Science* 8(6).
- Moghaddam, Saeed Zajforoushan, and Esben Thormann. 2019. "The Hofmeister Series: Specific Ion Effects in Aqueous Polymer Solutions." *Journal of Colloid and Interface Science* 555:615–35.
- Nandiyanto, Asep Bayu Dani, Gabriela Chelvina Santiuly Girsang, Rina Maryanti, Risti Ragadhita, Sri Anggraeni, Fajar Miraz Fauzi, Putri Sakinah, Asita Puji Astuti, Dian Usdiyana, Meli Fiandini, Mauseni Wantika Dewi, and Abdulkareem Sh Mahdi Al-Obaidi. 2020. "Isotherm Adsorption Characteristics of Carbon Microparticles Prepared

- from Pineapple Peel Waste.” *Communications in Science and Technology* 5(1):31–39.
- Ndabigengesere, Anselme, K. Subba Narasiah, and Brian G. Talbot. 1995. “Active Agents and Mechanism of Coagulation of Turbid Waters Using Moringa Oleifera.” *Water Research* 29(2):703–10.
- Ngteni, Rahmat, Md Sohrab Hossain, Mohd Omar Ab Kadir, Ahmad Jaril Asis, and Zulhafiz Tajudin. 2020. “Kinetics and Isotherm Modeling for the Treatment of Rubber Processing Euent Using Iron (II) Sulphate Waste as a Coagulant.” *Water (Switzerland)* 12(6).
- Novák, P., and V. Havlíček. 2016. “Protein Extraction and Precipitation.” *Proteomic Profiling and Analytical Chemistry: The Crossroads: Second Edition* 52–62.
- Obiora-Okafo, I. A., O. D. Onukwuli, and C. N. Ezugwu. 2019. “Application of Kinetics and Mathematical Modelling for the Study of Colour Removal from Aqueous Solution Using Natural Organic Polymer.” *Desalination and Water Treatment* 165(October):362–73.
- Ohale, Paschal Enyinnaya, Chijioke Elijah Onu, Nonye Jennifer Ohale, and Stephen Nnanyereugo Oba. 2020. “Adsorptive Kinetics, Isotherm and Thermodynamic Analysis of Fishpond Effluent Coagulation Using Chitin Derived Coagulant from Waste Brachyura Shell.” *Chemical Engineering Journal Advances* 4(October):100036.
- Pacesa, Martin. 2017. “ADENOVIRAL HEXON PROTEINS FOR GENERATION OF VIRUS - SPECIFIC ANTIBODIES Martin Pa Česa Thesis Supervisor :” (March).
- Paşka, O., R. Ianoş, C. Păcurariu, and A. Brădeanu. 2014. “Magnetic Nanopowder as Effective Adsorbent for the Removal of Congo Red from Aqueous Solution.” *Water Science and Technology* 69(6):1234–40.
- Patel, Himanshu, and R. T. Vashi. 2012. “Removal of Congo Red Dye from Its Aqueous Solution Using Natural Coagulants.” *Journal of Saudi Chemical Society* 16(2):131–36.
- Pigorsch, E., A. Elhaddaoui, and S. Turrell. 1994. “Spectroscopic Study of PH and Solvent Effects on the Structure of Congo Red and Its Binding Mechanism to Amyloid-like Proteins.” *Spectrochimica Acta Part A: Molecular Spectroscopy* 50(12):2145–52.
- Pomeranz, Y. 1983. “Seed Proteins.” *Trends in Biochemical Sciences* 8(9):345.
- Purkait, M. K., A. Maiti, S. DasGupta, and S. De. 2007. “Removal of Congo Red Using Activated Carbon and Its Regeneration.” *Journal of Hazardous Materials* 145(1–2):287–95.
- Qiu, Hui, Lu Lv, Bing Cai Pan, Qing Jian Zhang, Wei Ming Zhang, and Quan Xing Zhang. 2009. “Critical Review in Adsorption Kinetic Models.” *Journal of Zhejiang University: Science A*.
- Ravina, Louis. 1993. “Everything You Want to Know about Coagulation & Flocculation”
- Robati, Dariush. 2013. “Pseudo-Second-Order Kinetic Equations for Modeling Adsorption Systems for Removal of Lead Ions Using Multi-Walled Carbon Nanotube.” *Journal of Nanostructure in Chemistry* 3(1):3–8.
- Saha, P. and Chowdhury, S. 2011. ‘Insight Into Adsorption Thermodynamics’, *Thermodynamics*. doi: 10.5772/13474.
- Sethi, Poonam, and Pushpa R. Kulkarni. 1993. “Fractionation of Leucaena Seed-Kernel Proteins Based on Their Solubility Characteristics.” 48:173–77.
- Shelton, H. M., and J. L. Brewbaker. 1990. “Leucaena Leucocephala - the Most Widely Used Forage Tree Legume.”
- Shewry, Peter R., Johnathan A. Napier, and Arthur S. Tatham. 1995. “Seed Storage Proteins : Structures ’ and Biosynthesis.” 7(July):945–56.
- da Silva, Larissa F., Andreia D. Barbosa, Heber M. de Paula, Lincoln L. Romualdo, and

- Leonardo S. Andrade. 2016. "Treatment of Paint Manufacturing Wastewater by Coagulation/Electrochemical Methods: Proposals for Disposal and/or Reuse of Treated Water." *Water Research*.
- Steensma, D. P. 2001. "'Congo' Red: Out of Africa?" *Archives of Pathology & Laboratory Medicine* 125(2):250–52.
- Tan, I. A. W., A. L. Ahmad, and B. H. Hameed. 2008. "Adsorption of Basic Dye on High-Surface-Area Activated Carbon Prepared from Coconut Husk: Equilibrium, Kinetic and Thermodynamic Studies." *Journal of Hazardous Materials*.
- Verma, Akshaya Kumar, Rajesh Roshan Dash, and Puspendu Bhunia. 2012. "A Review on Chemical Coagulation/Flocculation Technologies for Removal of Colour from Textile Wastewaters." *Journal of Environmental Management* 93(1):154–68.
- Vimonses, Vipasiri, Shaomin Lei, Bo Jin, Chris W. K. Chow, and Chris Saint. 2009. "Kinetic Study and Equilibrium Isotherm Analysis of Congo Red Adsorption by Clay Materials." *Chemical Engineering Journal*.
- Vishali, S., and R. Karthikeyan. 2018. "Application of Green Coagulants on Paint Industry Effluent – a Coagulation/flocculation Kinetic Study." *Desalination and Water Treatment* 122(January 2018):112–23.
- VN, Meena Devi, Ariharan VN, and Nagendra Prasad. 2013. "Nutritive Value and Potential Uses of *Leucaena Leucocephala* as Biofuel – A Mini Review." *Research Journal of Pharmaceutical, Biological and Chemical Sciences* 4(1):515–21.
- Wakefield. 2015. "Understanding Separation Essentials For Wastewater Treatment."
- Wang, Jianlong, and Xuan Guo. 2020. "Adsorption Kinetic Models: Physical Meanings, Applications, and Solving Methods." *Journal of Hazardous Materials* 390(January):122156.
- Wang, Lawrence K., Yung-Tse Hung, and Nazih K. Shamma. 2005. *Physicochemical Treatment Processes*. Totowa, New Jersey: Humana Press Inc.
- Xiao, Feng, Ju Chang Howard Huang, Bao jie Zhang, and Chong wei Cui. 2009. "Effects of Low Temperature on Coagulation Kinetics and Floc Surface Morphology Using Alum." *Desalination* 237(1–3):201–13.
- Zhang, Yanjie, and Paul S. Cremer. 2006. "Interactions between Macromolecules and Ions: The Hofmeister Series." *Current Opinion in Chemical Biology* 10(6):658–63.