Uluslararası İleri Doğa Bilimleri ve Mühendislik Araştırmaları Dergisi
Sayı 8, S. 201-206, 6, 2024

Araştırma Makalesi

International Journal of Advanced Natural Sciences and Engineering Researches
Volume 8, pp. 201-206, 6, 2024

Research Article

IJANSER

https://as-proceeding.com/index.php/ijanser
ISSN: 2980-0811

Comparative Analysis of Banana and Cempedak Peel Extracts as Natural coagulants at Different pH Levels in Wastewater Treatment

Nur Atikah Mat Ali[1], Suzylawati Ismail [1,*]

[1] *School of Chemical Engineering, Engineering Campus, Universiti Sains Malaysia, 14300, Nibong Tebal, Penang, Malaysia.*

Email of the corresponding author : (chsuzy@usm.my)

(Received: 23 July 2024, Accepted: 24 July 2024)

(4th International Conference on Scientific and Academic Research ICSAR 2024, July 19 - 20, 2024)

ATIF/REFERENCE: Ali, N. A. M. & Ismail, S. (2024). Comparative Analysis of Banana and Cempedak Peel Extracts as Natural coagulants at Different pH Levels in Wastewater Treatment. *International Journal of Advanced Natural Sciences and Engineering Researches*, 8(6), 201-206.

***Abstract* –** The increasing demand for sustainable water treatment has opened the potential of converting chemical-based coagulants to natural resources coagulants. Natural resources such as fruit peel, beans, and seeds offer eco-friendly alternatives compared to chemical coagulants. Other than that, plant-based coagulants reduce the production of harmful sludge and promote sustainable resources because of its availability on the market worldwide. This study investigates the effectiveness of Musa sp. (banana) peel and Artocarpus integer (cempedak) peel extract as natural coagulants for water treatment with different pH levels. Through controlled experiments, the performance measures based on their ability to reduce turbidity reduction. The banana-peel and cempedak-peel dried at temperatures 30℃ and 40℃ respectively. Then dried peels are ground and stored in an airtight container before extraction. Banana-peel and cempedak-peel were extracted separately using calcium chloride ($CaCl_2$) and used in the jar test experiment to reduce turbidity reduction at different pH values. The synthetic wastewater pH varied using 0.5M NaOH and 0.5M HCl. Each extract shows different results, whereas for banana-peel extract the turbidity reduction is higher at pH 9 but for cempedak-peel, the turbidity reduction will be higher at pH 5. The findings could encourage the use of natural resources coagulants in diverse wastewater treatment scenarios, reducing dependence on chemical-based coagulant treatment.

Keywords – Natural Coagulant, Banana Peel, Cempedak Peel, Extract Coagulant, Wastewater Treatment

I. INTRODUCTION

Contamination of water resources have increased the opportunity in water treatment agenda. The needs of clean and safe water become a major concern because the usage of water increased as the population growth. Several technologies have been implemented in water treatment procedure such as membrane separation [1]-[3], flocculation [4]-[5], solvent extraction [6]-[8], oxidation and reduction [9]-[13], ions exchange [14], electrolysis [15]-[17] and coagulation [18]-[20]. Among all, coagulation process in the low cost, simple and effective method for water treatment that have be applied [21]. At the early stage the usage of chemical coagulant has been implement to reduce the turbidity reduction in water treatment procedure. But the usage of chemical coagulant become a major issue as it promotes several problems such as chemical sludge [22], health issues [23] and higher cost [24]. To overcome the drawbacks, natural resources coagulant has been applied. Natural resources such as beans, seed and peel are most commonly used [25].

These resources were chosen because of their availability and effectiveness in reducing turbidity for the water treatment process.

All natural resources contain several polymers such as carbohydrates, polysaccharide and pectin. The efficiency of every natural coagulant depends on the contain and the procedure in processing the coagulant. Other than that, pH of the wastewater also is one of the main factors that decide whether the natural resources can work at its maximum capabilities or not. pH level may affect the solubility of coagulant and the particle charge of natural organic matter (NOM). In coagulation process, this is important to ensure the fine particle bind together and remove impurities. Different type of natural coagulant may respond differently to changes in pH of the wastewater and have their own optimal range of pH. The optimal pH value is importance to be studied in order to find the natural coagulant effective condition. By finding this may help in contribute to identify which natural coagulant suitable to be applied in specific industry. In this work, two different peel which is banana and cempedak will be used in order to study their optimal pH value as natural coagulant.

II. MATERIALS AND METHOD

A. *Preparation of synthetic water*

The synthetic turbid water was prepared using 10 g of kaolin powder added to 1 L of distilled water. Then the solution was stirred for 1 hour and allowed to settle for 24 hours at room temperature. For experimental purposes, the stock solution of synthetic water will be diluted to the desired turbidity using distilled water.

.

B. *Preparation of banana and cempedak peel extract*

Peels were collected and washed thoroughly with water to remove any surface impurities, and then cut into small pieces. The peels were then dried in a Venticell laboratory oven with temperature of 33℃ (72 hour) for Banana peel and 40℃ (120 hour) for Cempedak peel. After that, dried peels were ground and sieved to the particle size of 2mm for banana peel and 1mm for Cempedak peel. The dried peel powder was stored in an airtight container. For the extraction process, the desired amount of peel powder will be stirred in $CaCl_2$for about 15 minutes at 2500 rpm at room temperature. The peel extract solution will then be centrifuged for 10 minutes at 4400 rpm before used as coagulant. Fig. 1 provides an overview of the preparation of banana and cempedak peel extract and jar test experiment conducted in the experiment.

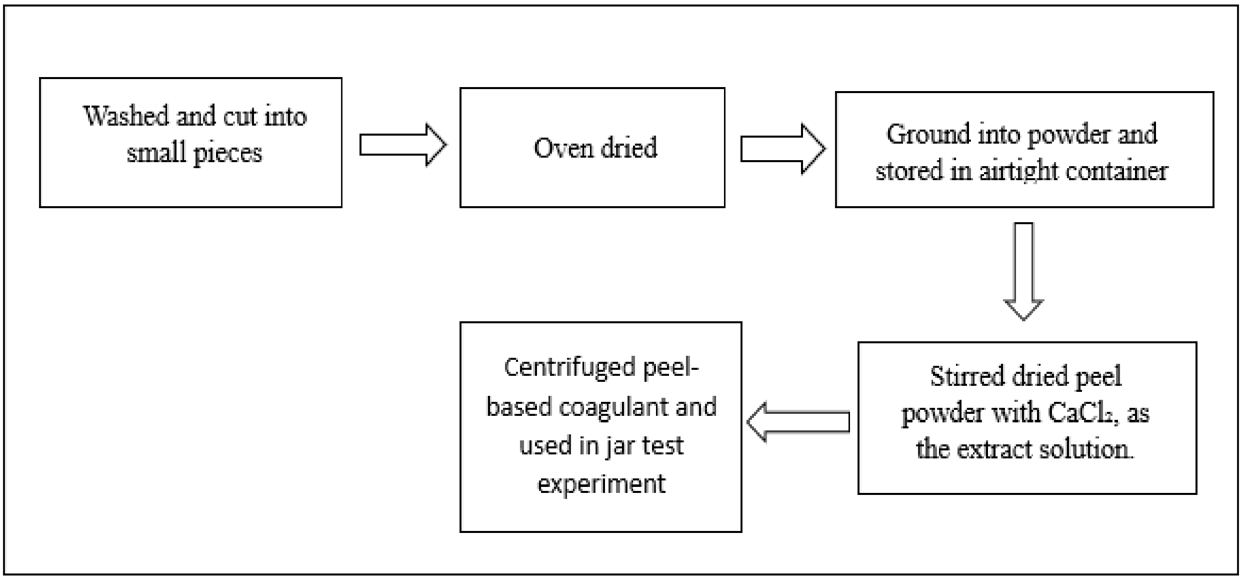

Fig. 1 Preparation of banana peel extract for Jar test study

C. *The jar test procedure*

A 500 ml beaker filled with synthetic wastewater was used in the jar test experiment. The desired amount of banana peel-based coagulant was added to each beaker containing synthetic turbid water with different pH values (3,5,7,9 and 11) for the jar test experiment. The pH of wastewater controlled by adding 0.5M HCl and 0.5M NaOH. Jar test was carried out using JLT 6 Velp Scientifica, which involved the step of rapid mixing at 100 rpm for 4 minutes, slow mixing at 40 rpm for 25 minutes and sedimentation for 1 hour. After the sedimentation process, the final turbidity reading will be taken and the steps repeated for cempedak peel-based coagulant. The percentage of turbidity removal calculated as:

$$\frac{initial\ turbidity - final\ turbidity}{initial\ turbidity} \times 100\% \quad \text{.........Equation 1}$$

III. RESULTS

A. *Performance evaluation of peel-based coagulant.*

The study will examine the ability of the both cempedak and banana peel-based coagulant to remove turbidity in the jar test experiment. The performance of the peel will be evaluated based on their efficiency in removing turbidity for different pH level of synthetic wastewater.

B. *Performance evaluation of peel-based coagulant on different pH wastewater.*

For the experiment, the pH of wastewater was altered to the required pH value before the jar test experiment procedure. The result for turbidity reduction using banana peel extract and cempedak peel extract illustrated in Fig 2.

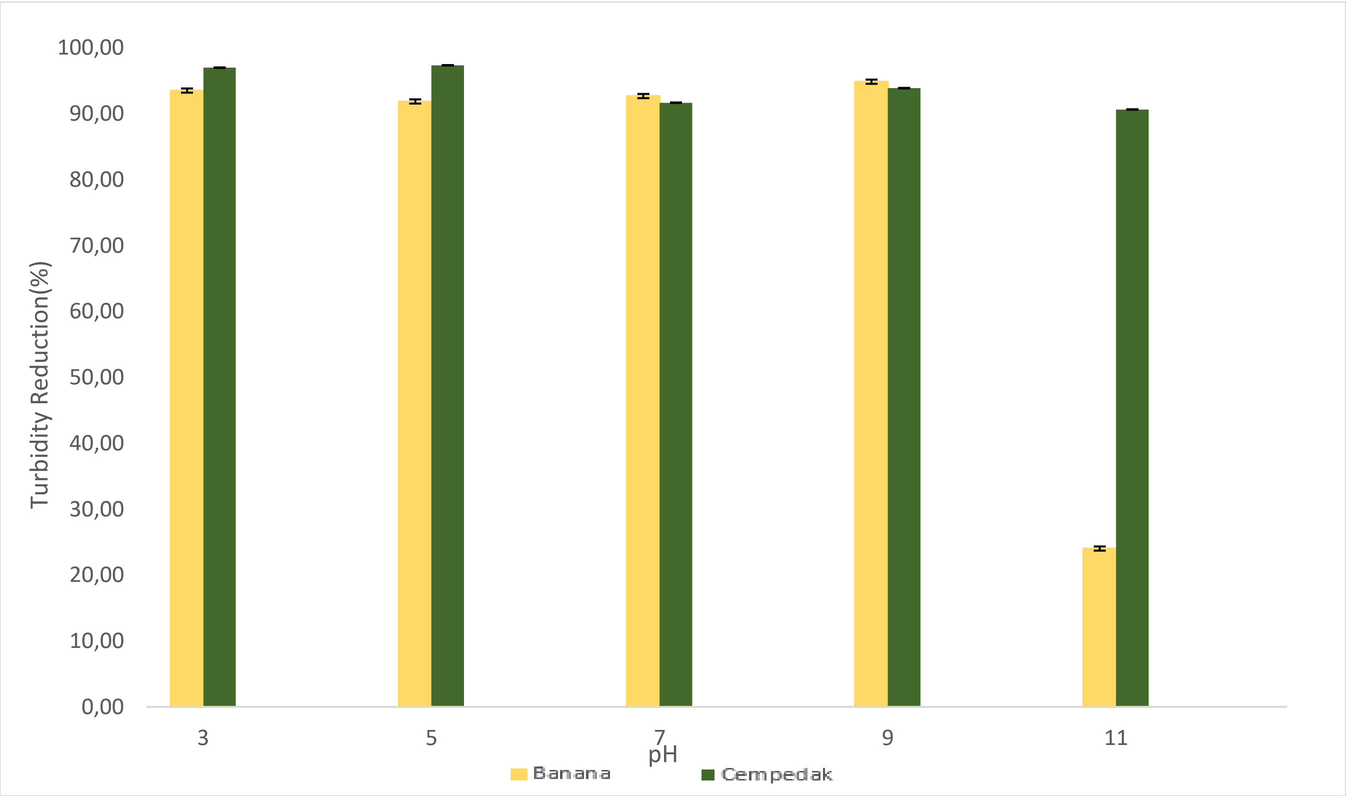

Fig. 2 Percentage of turbidity reduction at different pH level for banana-peel and cempedak-peel based coagulant

For cempedak-peel extract, its shows that the coagulation performance works the best at acidic solution. Cempedak peel-based coagulant work efficiently at pH 5 with turbidity reduction of 97.33%. But the turbidity reduction also will be slightly decreased at pH 3. The lowest turbidity reduction recorded is at pH 11 with 90.63%. On the other hand, banana-peel extract shows that the coagulant works effectively at pH 9 with turbidity 94.84%. At pH lower than that the turbidity reduction will be decrease, with a slight increase at pH 3 with 93.50% turbidity reduction. But for banana-peel extract at pH 11 the turbidity reduction will be much lower. From the experiment, at pH 11 both extracts will change the synthetic wastewater cloudier as soon as the extract is added to the jar test procedure. This indicates that at higher pH coagulation behavior for both extracts will be decreased.

IV. DISCUSSION

The effectiveness peel extract at lower pH levels can be attributed to the enhance solubility and availability of active compounds such as phenolics, flavonoids, and tannins. These compounds can interact with suspended particles in wastewater, leading to their aggregation and subsequent removal [26]-[27].

At higher pH level, such as observed in pH 11, the increased cloudiness can be due to several factors such as hydrolysis of active compounds or change in solubility. The coagulant properties of banana peel extract might diminish due to the hydrolysis of active compounds at higher pH, leading to less effective coagulation and increase dispersion of particles. in addition to that, the solubility of certain compounds in the extract may changes at higher pH, leading to the formation of colloidal suspensions that increase turbidity. The finding aligns with other researchers who have studied jackfruit peel as their extract coagulant which shows that at higher pH the turbidity reduction will be lower with less formation of flocs [28].

V. CONCLUSION

The result from the experiment shows that cempedak peel-based and banana peel-extract coagulant work efficiently at pH of 5 and 9, respectively. The differences shows that each fruit peels have their own optimal pH values. This study is important in order to find their specific areas for water treatment industries. Actual experiment should be made for further studies to specified the procedure and suitable application of the fruit peel extract based on industrial needs.

ACKNOWLEDGMENT

The authors would like to acknowledge the Long-Term Research Grant Scheme (LRGS/1/2018/USM/01/1/1) (LRGS/2018/USM-UKM/EWS/01) granted by the Ministry of Higher Education Malaysia for funding this research project.

REFERENCES

[1]. Wu, Q., & Chen, Q. (2020). Application of membrane separation technology in water treatment process. IOP Conference Series: Earth and Environmental Science, 508, 012048. https://doi.org/10.1088/1755-1315/508/1/012048.

[2]. Ramón López-Roldán, Rubalcaba, A., Jordi Martín-Alonso, González, S. L., V. Martí, & Cortina, J. (2016). Assessment of the water chemical quality improvement based on human health risk indexes: Application to a drinking water treatment plant incorporating membrane technologies. Science of the Total Environment, 540, 334–343.https://doi.org/10.1016/j.scitotenv.2015.04.045.

[3]. Asif, M. B., & Zhang, Z. (2021). Ceramic membrane technology for water and wastewater treatment: A critical review of performance, full-scale applications, membrane fouling and prospects. Chemical Engineering Journal, 418, 129481. https://doi.org/10.1016/j.cej.2021.129481

[4]. Muruganandam, L., Saravana Kumar, M. P., Jena, A., Gulla, S., & Godhwani, B. (2017). Treatment of waste water by coagulation and flocculation using biomaterials. IOP Conference Series: Materials Science and Engineering, 263, 032006. https://doi.org/10.1088/1757-899x/263/3/032006

[5]. Shestopalov, O., Briankin, O., Rykusova, N., & Hetta, O. (2019). Optimization of the flocculation process of industrial waste water treatment. ScienceRise, 1(12), 55–59. https://doi.org/10.15587/2313-8416.2019.189708

[6]. Kiezyk, P. R., & Mackay, D. (1971). Waste water treatment by solvent extraction. The Canadian Journal of Chemical Engineering, 49(6), 747–752. https://doi.org/10.1002/cjce.5450490607

[7]. Rajan, A., Sanju Sreedharan, & Babu. (2016). Solvent Extraction and Adsorption Technique for the Treatment of Pesticide Effluent. 3(2), 155–165. https://doi.org/10.5121/civej.2016.3214

[8]. Hu, G., Li, J., & Hou, H. (2015). A combination of solvent extraction and freeze thaw for oil recovery from petroleum refinery wastewater treatment pond sludge. Journal of Hazardous Materials, 283, 832–840. https://doi.org/10.1016/j.jhazmat.2014.10.028

[9]. Zhang, H., Sun, W., Zhang, J., & Ma, J. (2024). Vacuum-ultraviolet based advanced oxidation and reduction processes for water treatment. Journal of Hazardous Materials, 134432–134432. https://doi.org/10.1016/j.jhazmat.2024.134432

[10]. Ge, Y., Liu, J., Jiang, T., Hao, Y., Shen, X., Gong, Z., Qi, Z., & Yao, J. (2022). Self-disinfecting carbon filter: In situ spontaneous generation of reactive oxidative species via oxygen reduction reaction for efficient water treatment. Colloids and Surfaces A: Physicochemical and Engineering Aspects, 648, 129266. https://doi.org/10.1016/j.colsurfa.2022.129266

[11]. Wu, S., Shen, L., Lin, Y., Yin, K., & Yang, C. (2021). Sulfite-based advanced oxidation and reduction processes for water treatment. Chemical Engineering Journal, 414, 128872. https://doi.org/10.1016/j.cej.2021.128872

[12]. Li, M., Wen, Q., Chen, Z., Tang, Y., & Yang, B. (2020). Comparison of ozonation and UV based oxidation as pre-treatment process for ultrafiltration in wastewater reuse: Simultaneous water risks reduction and membrane fouling mitigation. Chemosphere, 244, 125449–125449. https://doi.org/10.1016/j.chemosphere.2019.125449

[13]. Simultaneous oxidation and reduction treatments of polluted water by a bio-electro reactor. (1996). Water Science and Technology, 34(9). https://doi.org/10.1016/s0273-1223(96)00792-5

[14]. Beita-Sandí, W., & Karanfil, T. (2017). Removal of both N-nitrosodimethylamine and trihalomethanes precursors in a single treatment using ion exchange resins. Water Research, 124, 20–28. https://doi.org/10.1016/j.watres.2017.07.028

[15]. Wei, J., & Wu, X. (2024). The potential of coupled water electrolysis with electrochemical wastewater treatments. International Journal of Hydrogen Energy, 68, 745–754. https://doi.org/10.1016/j.ijhydene.2024.04.308

[16]. Duan, D., Xu, F., Wang, T., Guo, Y., & Fu, H. (2023). The effect of filtration and electrolysis on ballast water treatment. Ocean Engineering, 268, 113301. https://doi.org/10.1016/j.oceaneng.2022.113301

[17]. Hu, Z., Yao, H., Deng, S., Zhang, C., Peng, S., Zhang, Z., & Li, D. (2023). Iron [Fe(0)]-carbon micro-electrolysis enhances simultaneous nitrogen and phosphorus removal in vertical flow constructed wetlands for advanced treatment of reclaimed water. Journal of Environmental Management, 335, 117528–117528. https://doi.org/10.1016/j.jenvman.2023.117528

[18]. Wang, L., Naif Abdullah Al-Dhabi, Huang, X., Luan, Z., Tang, W., Xu, Z., & Xu, W. (2024). Suitability of inorganic coagulants for algae-laden water treatment: trade-off between algae removal and cell viability, aggregate properties and coagulant residue. Journal of Hazardous Materials, 471, 134314–134314. https://doi.org/10.1016/j.jhazmat.2024.134314

[19]. Zaki, N., Nouhaila Hadoudi, Oumaima Fraiha, Nihade Bensitel, Asmae Charki, Hossain El Ouarghi, Amin Salhi, Amhamdi, H., & M'hamed Ahari. (2024). Analysis of the effectiveness of combining inorganic coagulants with chitosan and bentonite in the treatment of raw water. Sustainable Chemistry for the Environment, 100109–100109. https://doi.org/10.1016/j.scenv.2024.100109

[20]. Iwuozor, K. O., Adewale George Adeniyi, Ebuka Chizitere Emenike, Toluwalase Ojeyemi, Egbemhenghe, A. U., Okorie, C. J., Bridget Dunoi Ayoku, & Saliu, O. D. (2023). Prospects and challenges of utilizing sugarcane bagasse as a bio-coagulant precursor for water treatment. 39, e00805–e00805. https://doi.org/10.1016/j.btre.2023.e00805

[21]. Ibrahim, A., Yaser, A. Z., & Lamaming, J. (2021). Synthesising tannin-based coagulants for water and wastewater application: A review. Journal of Environmental Chemical Engineering, 9(1), 105007. https://doi.org/10.1016/j.jece.2020.105007

[22]. Tan, J., Huang, Y., Chi, B., Xiong, Z., Zhou, W., Yang, Z., Zhou, K., Ruan, X., Duan, X., Wang, M., & Zhang, J. (2024). Comparative study of iron and aluminium coagulants in conditioning sludge: sludge dewatering performance,

physicochemical properties, and risk of heavy metal migration. Journal of Environmental Chemical Engineering, 113168–113168. https://doi.org/10.1016/j.jece.2024.113168

[23]. Abdi Kemal Husen, Firomsa Bidira, Wendesen MekoninDesta, & Perumal Asaithambi. (2024). COD, Color, and Turbidity Reduction From Surface Water Using Natural Coagulants: Investigation and Optimization. Deleted Journal, 100007–100007. https://doi.org/10.1016/j.pes.2024.100007

[24]. Bernard, Prakash, O., Juneja, C., Panchal, D., Sylvere, N. K., & Pal, S. (2024). Development and techno-economic analysis of Grewia biopolymer-based dual coagulant system for wastewater treatment at pilot scale. Bioresource Technology, 397, 130514–130514. https://doi.org/10.1016/j.biortech.2024.130514

[25]. Saqib, S., Amna Muneer, Munir, R., Sayed, M., Muhammad Waqas, Tayyiba Aliyam, Younas, F., Mohammad Abul Farah, Mohamed Farouk Elsadek, & Noreen, S. (2024). Green Hybrid Coagulants for Water Treatment: An Innovative Approach Using Alum and Bentonite Clay Combined with Eco-friendly Plant Materials for Batch and Column Adsorption. Environmental Research, 119569–119569. https://doi.org/10.1016/j.envres.2024.119569

[26]. Mendez-Cantillo, N. N., Rodriguez-Diaz, Y. J., & Rodriguez-Jimenez, D. M. (2022). Analysis of Banana (Musa paradisiaca L.) as a Coagulant for Wastewater Treatment. Ingeniare: Revista Chilena de Ingeniería, 33(6), 125 - 135.

[27]. Mokhtar, N. M., Priyatharishini, M., & Kristanti, R. A. (2019). Study on the Effectiveness of Banana Peel Coagulant in Turbidity Reduction of Synthetic Wastewater. International Journal of Engineering and Technology, 6(1). https://doi.ord/10.15282/ijets.v6i1.2019

[28]. Priyatharishini, M., & Mokhtar, N. M. (2020). Performance of jackfruit (Artocarpus heterophyllus) peel coagulant in turbidity reduction under different pH of wastewater. Materials Today: Proceedings. https://doi.org/10.1016/j.matpr.2020.10.248