
Utilization Of Kepok Banana Peel (*Musa Paradisiaca*) As An Adsorbent To Reduce Levels Of Plus Metal In Paint And Body Repair Industrial Waste

Jesica Amelia Kischa Parante¹⁾, Sinardi²⁾

^{1,2)} Chemical Engineering Study Program, Faculty of Engineering Universitas Fajar Makassar Harapan Bangsa University

*Corresponding Author

Email : Jesicaparante23@gmail.com

Abstract

The increasing activity of paint and body repair workshops has contributed to the increasing volume of liquid waste containing heavy metals, especially lead (Pb), which is toxic and has the potential to pollute aquatic environments. Long-term exposure to Pb can have negative impacts on human health and ecosystem balance, so that effective, economical, and environmentally friendly waste treatment efforts are needed. One alternative that can be applied is the use of natural materials as adsorbents, such as kepok banana peels (*Musa paradisiaca*), which contain cellulose, hemicellulose, and lignin with active functional groups that have the potential to bind heavy metal ions. This study aims to determine the effect of variations in contact time on the adsorption efficiency of Pb metal and evaluate the ability of kepok banana peels as a natural adsorbent in reducing Pb levels in paint and body repair workshop wastewater. The research method used is an adsorption process with contact time variations of 0, 30, 60, 90, 120, and 150 minutes. The parameters observed include the initial concentration of Pb (C_0), the final concentration of Pb (C_t), the amount of Pb absorbed, and the removal efficiency. The results showed that increasing the contact time significantly affected the effectiveness of the adsorption process. The Pb removal efficiency increased gradually from 0.00% at 0 minutes to 47.69% at 90 minutes of contact time, which is the optimum condition for adsorption. At that time, the Pb concentration decreased from 0.65 mg/L to 0.34 mg/L, with the amount of Pb adsorbed reaching 0.31 mg/L. However, after passing the optimum contact time, the adsorption efficiency decreased at 120 and 150 minutes, which was thought to be caused by adsorbent saturation and the possibility of a desorption process. Based on the results obtained, it can be concluded that kepok banana peel has quite good potential as a natural adsorbent in reducing Pb metal levels from paint and body repair workshop industrial waste. The utilization of this organic waste is not only effective in the waste treatment process, but also supports the concept of sustainable environmental management through the application of simple, inexpensive, and environmentally friendly technology.

Keywords: Adsorption, Kepok Banana Peel, Heavy Metal Pb, Contact Time, Paint and Body Repair Workshop Waste.

INTRODUCTION

The growth of the automotive industry in Indonesia, particularly paint and body repair workshops, contributes significantly to the economic sector. However, these activities also create environmental problems in the form of liquid waste containing heavy metals, one of which is lead (Pb). Lead is widely used in vehicle paint materials and as a byproduct of body repair processes, making it likely to accumulate in the environment. High Pb content in waste is very dangerous because it is toxic, difficult to degrade, and can contaminate groundwater and harm human health, such as causing damage to the nervous system, kidney disorders, and reduced cognitive function (Yulia dan Putra, 2024).

Quantitatively, the chemical composition of vehicle paint shows that inorganic pigments make up about 20–30% of the total formulation, with heavy metals present within them. Lead compounds (Pb), such as lead chromate ($PbCrO_4$) and lead carbonate ($PbCO_3$), generally occur in the range of 0.5–5% of the pigment fraction or about 0.1–1.5% of the total paint weight, depending on the type and color of the paint. In addition to Pb, chromium (Cr) is present at around 0.2–2% as chromates or oxides, zinc (Zn) at about 1–3% in the form of zinc oxide (ZnO), and iron (Fe) at around 2–6% as iron oxide (Fe_2O_3). Resin or binder constitutes about 30–50% of the paint formulation and is dominated by organic polymer compounds, while solvents range from 15–30% and consist of aromatic and ketone compounds. Additives account for only about 1–5%, but they may contain metals such as cobalt (Co)

and manganese (Mn), each at approximately 0.01–0.1% as driers. These heavy metal contents significantly contribute to the high concentrations of Pb and other metals in liquid waste from paint and body repair workshops (Yulia dan Putra, 2024).

Various methods have been developed to reduce Pb levels in industrial wastewater, such as chemical precipitation, membrane filtration, and electrocoagulation. However, these methods often require high costs, hazardous chemicals, and generate new residues that are difficult to manage. Therefore, alternative technologies that are more economical, environmentally friendly, and easy to apply are needed. One widely studied method is adsorption using natural materials (Deswita et al., 2023).

Kepok banana peel (*Musa paradisiaca*) is an abundant organic waste in Indonesia, especially as a byproduct of consumption and banana-processing industries. Banana peel contains lignocellulose, cellulose, hemicellulose, as well as hydroxyl and carboxyl functional groups that can bind heavy metal ions through ion exchange mechanisms and electrostatic interactions. The use of kepok banana peel as an adsorbent not only helps reduce Pb levels in paint and body repair workshop waste but also adds value to organic waste that was previously unused (Ali et al., 2020).

Thus, research on the utilization of kepok banana peel as an adsorbent to reduce Pb levels in industrial waste from paint and body repair workshops is important to conduct. In addition to supporting efforts to control environmental pollution, this study also contributes to the application of the waste-to-product concept and the sustainable use of local resources.

RESEARCH METHODS

Research Location and Time

This research was conducted for approximately three months, from October to December 2025, in the Chemical Engineering Laboratory of ATIM.

Materials and Equipment

Materials

The materials used in this study were kepok banana peels, liquid waste from paint and body repair workshops, and 1 M HCl.

Equipment

The equipment used in this study included an oven, blender/grinder, sieve, pH meter, orbital shaker/agitator, centrifuge (optional), pipette, burette, 100 mL reaction flask (Erlenmeyer flask), AAS/ICP-OES spectrophotometer for Pb measurement, desiccator, analytical balance.

Research Variables

Fixed Variables

The fixed variables in this study were the sample surface area (250 μm) and the sample mass, which was 1 gram (Ali et al., 2020).

Independent Variable

The independent variable in this study was contact time (30, 60, 90, 120, 150 minutes).

Research Process

1. Adsorbent Preparation

- a. Wash the kepok banana peel thoroughly with running water, then with distilled water.
- b. Dry it in an oven at 60–80°C until dry.
- c. Grind it and sieve it to a powder size of 250 μm .
- d. Activate it with hydrochloric acid (HCl).
- e. Store it in a closed container until used.

2. Adsorption Process

- a. Prepare five Erlenmeyer flasks, each containing 10 mL of paint and body repair workshop wastewater solution.

- b. Add the same dose of kepok banana peel adsorbent (1 g) to each solution.
- c. Adjust the pH of the solution to the optimum value (pH 5).
- d. Stir using a shaker with varying contact times: 30, 60, 90, 120, and 150 minutes.
- e. After the contact time is reached, the solution is filtered to separate the adsorbent.
- f. Measure the residual Pb concentration in the filtrate using AAS/ICP-OES.

Data Analysis

Calculate the Pb reduction efficiency:

$$\% \text{Removal} = \frac{C_0 - C_t}{C_0} \times 100$$

with:

C_0 = initial concentration (mg/L)

C_t = concentration at time t (mg/L).

Flow diagram

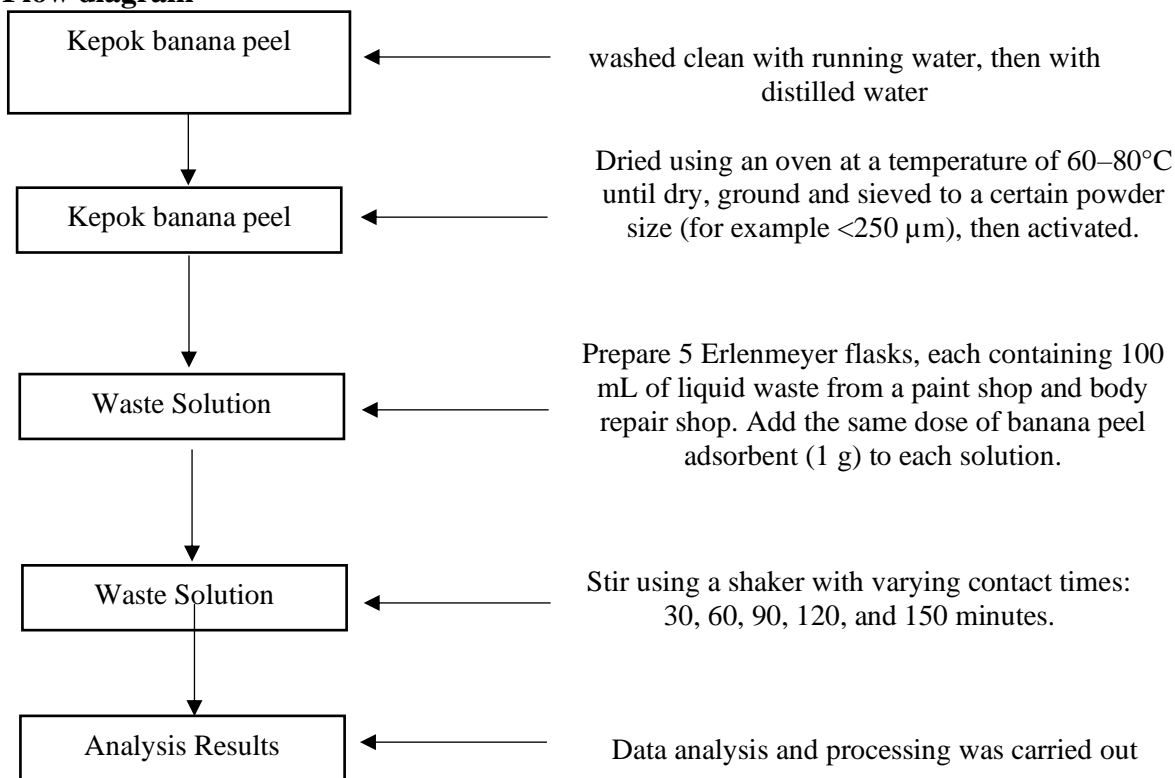


Figure 1. Research Flowchart

RESULTS AND DISCUSSION

In an effort to reduce environmental pollution caused by paint and body repair workshop waste, an effective, economical, and environmentally friendly processing method is needed. One alternative that can be utilized is the use of natural adsorbents, such as kepok banana peel (*Musa paradisiaca*), which has the potential to absorb heavy metals. This study aims to assess the ability of kepok banana peel as an adsorbent in reducing Pb metal levels, by examining the effect of contact time on changes in Pb concentration in solution. The results of observations include the initial concentration (C_0), final concentration (C_t), the amount of Pb absorbed, and removal efficiency, which are then presented in the following table as a basis for discussing the performance of the adsorption process.

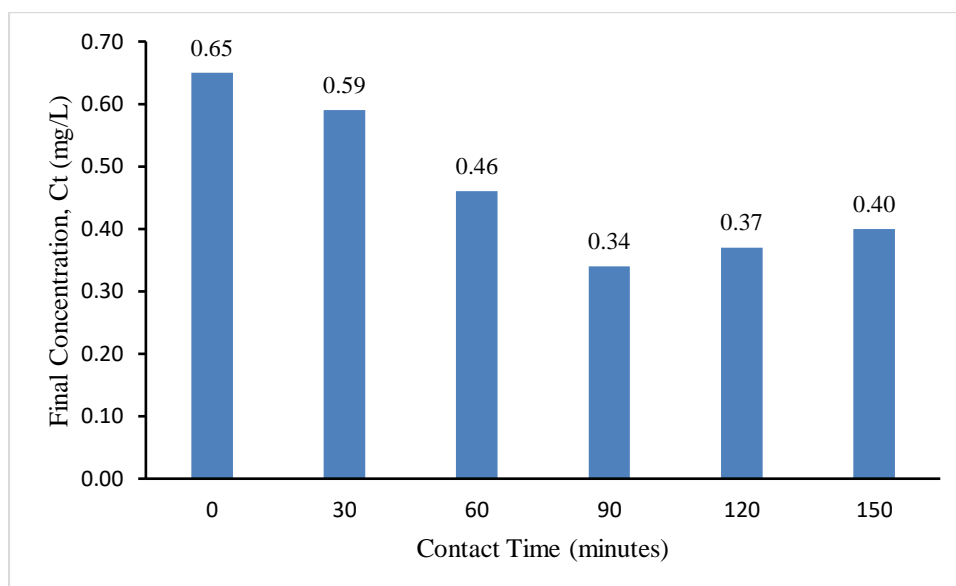


Figure 2. Pb Metal Reduction Analysis Results

The graph shows that the final Pb concentration (Ct) decreased with increasing contact time between the waste solution and the kepok banana peel adsorbent. At 0 minutes of contact time, the Pb concentration remained at its initial value of 0.65 mg/L because no adsorption had yet occurred. After 30 minutes, the Pb concentration decreased to 0.59 mg/L, indicating that the adsorption process had begun, although still limited.

A more significant decrease occurred at 60 minutes of contact time, when the Pb concentration decreased to 0.46 mg/L. This indicates that the longer the contact time, the more Pb ions interact with the adsorbent surface. The peak concentration decrease occurred at 90 minutes of contact time, with a Ct value of 0.34 mg/L. Under these conditions, the adsorption process was most effective because most of the active sites on the kepok banana peel surface were still available to bind Pb ions.

However, after the optimum contact times, at 120 and 150 minutes, the Pb concentration actually increased slightly to 0.37 mg/L and 0.40 mg/L, respectively. This phenomenon may be caused by adsorbent saturation, where most of the pores and active groups in the kepok banana peel are filled with Pb ions, resulting in decreased adsorption capacity. Furthermore, the possibility of desorption or re-release of Pb ions into the solution may also contribute to this increase in concentration (Kardiman et al., 2019).

Overall, these results indicate that kepok banana peel (*Musa paradisiaca*) has good potential as a natural adsorbent for reducing Pb levels in paint and body repair industry wastewater. The optimum contact time in this study was 90 minutes, which resulted in the greatest reduction in Pb concentration. These findings reinforce the point that utilizing organic waste as an adsorbent is not only technically effective but also supports efforts towards more environmentally friendly and sustainable waste management.

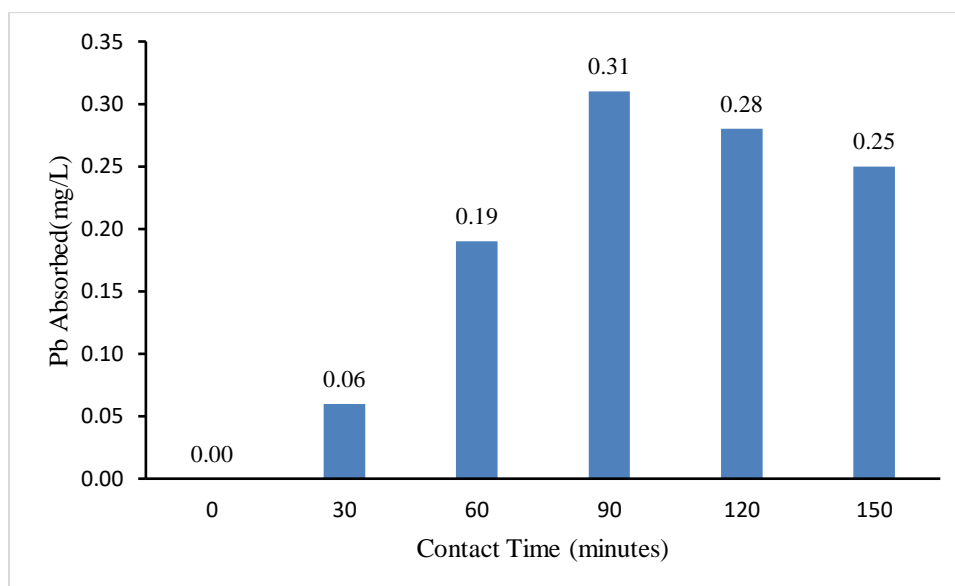


Figure 3. Analysis Results of Adsorbed Pb Amount

The graph shows that the amount of Pb adsorbed by the kepok banana peel adsorbent increased with increasing contact time. At a contact time of 0 minutes, no Pb adsorption occurred (0.00 mg/L) because no interaction between the adsorbent and the solution had yet occurred. After 30 minutes, the amount of Pb adsorbed increased to 0.06 mg/L, indicating that the adsorption process had begun, although it remained relatively low because Pb ion diffusion to the adsorbent surface was not optimal.

The increase in Pb adsorption became more significant at a contact time of 60 minutes, with a value of 0.19 mg/L. This indicates that the longer the contact time, the greater the opportunity for Pb ions to diffuse and bind to active sites on the adsorbent surface. This process is influenced by the presence of functional groups such as hydroxyl ($-OH$), carboxyl ($-COOH$), and amine ($-NH_2$) in the kepok banana peel, which play a crucial role in the adsorption mechanism through electrostatic interactions, ion exchange, and complex bond formation with Pb^{2+} ions.

Peak Pb adsorption occurred at a contact time of 90 minutes, with a value of 0.31 mg/L. Under these conditions, most of the adsorbent's active sites were still available and functioning optimally to bind Pb ions. This indicates that the adsorption process had reached a near-equilibrium state, where the adsorbent's Pb ion absorption rate was at its maximum.

However, after the optimum contact time, at 120 and 150 minutes, the amount of Pb adsorbed decreased to 0.28 mg/L and 0.25 mg/L, respectively. This decrease indicates that the adsorbent was beginning to experience saturation of active sites, resulting in a decline in its Pb ion binding capacity. Furthermore, desorption, the release of some of the Pb ions bound to the adsorbent surface back into the solution, can also occur due to weak bonds at some active sites or changes in the system's equilibrium (Rosema et al., 2021).

Related to wastewater Pb quality standards, based on Regulation of the Minister of Environment of the Republic of Indonesia Number 5 of 2014, the maximum Pb content limit in industrial wastewater is 0.1 mg/L. The results showed that the lowest final Pb concentration was obtained at 90 minutes of contact time, at 0.34 mg/L, which is still above the established quality standard. This condition indicates that although kepok banana peels have quite good adsorption capacity, the single adsorption process under these operating conditions does not fully meet the quality standard. Therefore, further optimization is needed, such as increasing the adsorbent dosage, modifying the adsorbent, or using a multistep adsorption process (Rosema et al., 2021).

Overall, the results of this study indicate that kepok banana peel (*Musa paradisiaca*) has the potential as a natural adsorbent in absorbing heavy metal Pb through the interaction mechanism of $-OH$, $-COOH$, and $-NH_2$ groups with Pb^{2+} ions. The optimum contact time for adsorption is at 90

minutes, before the saturation of active sites and the possibility of desorption, thus providing a strong scientific basis for further development in the treatment of liquid waste containing heavy metals.

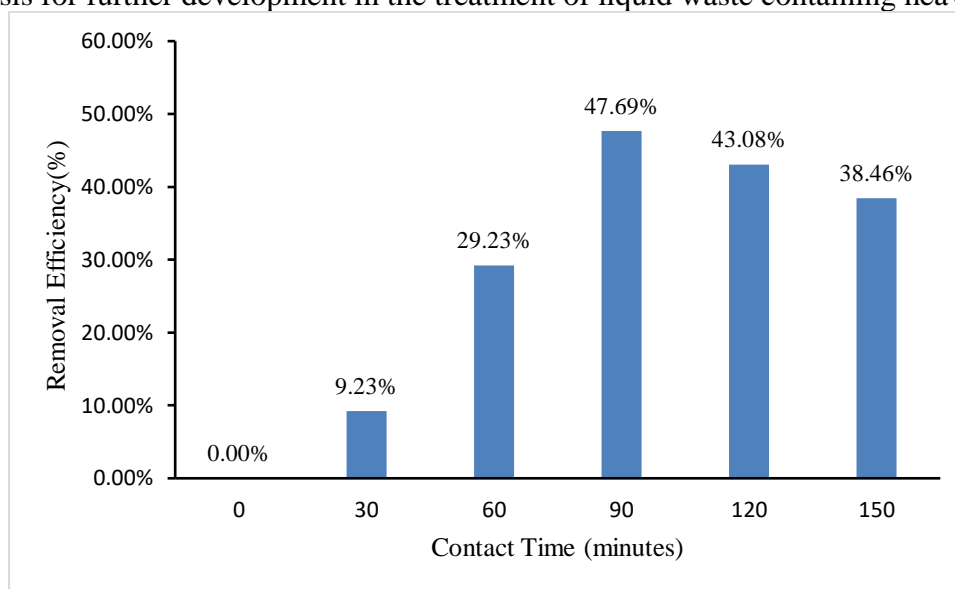


Figure 4. Removal Efficiency Analysis Results

The graph shows that the removal efficiency of Pb metal by the kepok banana peel adsorbent increased with increasing contact time until it reached optimum conditions. At a contact time of 0 minutes, the removal efficiency was still 0.00% because no adsorption process had occurred between the waste solution and the adsorbent. After 30 minutes, the removal efficiency increased to 9.23%, indicating that the Pb adsorption process had begun, although it remained relatively low.

A more significant increase in removal efficiency occurred at a contact time of 60 minutes, reaching 29.23%. This indicates that the longer the contact time, the greater the opportunity for Pb ions to interact with the adsorbent surface and bind to available active sites. The highest removal efficiency was achieved at a contact time of 90 minutes, at 47.69%. This indicates that the kepok banana peel adsorbent is most effective in reducing Pb levels in paint and body repair industry waste.

However, after the optimum contact time, removal efficiency decreased at 120 and 150 minutes, to 43.08% and 38.46%, respectively.

This decrease indicates that the adsorbent's capacity begins to diminish due to saturation of active sites, preventing all Pb ions from binding optimally. Furthermore, the possibility of desorption, the release of adsorbed Pb ions back into the solution, can also contribute to the decrease in removal efficiency at longer contact times (F. Sari et al., 2022).

Overall, these results indicate that the use of kepok banana (*Musa paradisiaca*) peels as a natural adsorbent has considerable potential for reducing Pb levels from paint and body repair industry wastewater. The optimum contact time obtained in this study was 90 minutes, with a removal efficiency of nearly 50%. These findings confirm that appropriate contact time regulation plays a crucial role in improving adsorption process performance and the effectiveness of wastewater treatment.

CONCLUSION

Based on the analysis results, it can be concluded that:

Variations in contact time have been shown to affect the adsorption efficiency of Pb metal. Removal efficiency increased with increasing contact time and reached an optimum value at 90 minutes with an efficiency of 47.69%. After this time, efficiency tended to decrease due to adsorbent saturation and possible desorption, indicating that contact time is a critical factor in determining the success of the adsorption process.

Kepok banana peel (*Musa paradisiaca*) has been shown to have quite good ability to reduce Pb levels in paint and body repair workshop wastewater. This is demonstrated by the decrease in Pb concentration from 0.65 mg/L to 0.34 mg/L under optimum conditions, with the amount of Pb adsorbed reaching 0.31 mg/L. Thus, Kepok banana peel has the potential to be used as an effective, economical, and environmentally friendly natural adsorbent in the treatment of waste containing heavy metals.

REFERENCES

- Ali, R. M., Hendrawati, T. Y., Ismiyati, I., & Fithriyah, N. H. (2020). Pengaruh Jenis Adsorben Terhadap Efektifitas Penurunan Kadar Timbal Limbah Cair Recycle Aki Bekas. *Jurnal Teknologi Universitas Muhammadiyah Jakarta*, 12(1), 87–92. <https://doi.org/10.24853/jurtek.12.1.87-92>
- Deswita, D., Muthia, R., & Hidayat, M. K. (2023). Pemanfaatan Musa Paradisiaca (Pisang Kepok) untuk Penurunan Frekuensi Buang Air Besar dalam Asuhan Keperawatan pada Anak Diare. In I. Wafiqah (Ed.), *Eureka Media Aksara*. Eureka Media Aksara.
- fadhilah, N. Fitri, Wibowo, E. B. T., Astuti, D. H., & Billah, M. (2021). Pemanfaatan Eceng Gondok sebagai Adsorben dengan Perlakuan Awal untuk Menurunkan Kadar Logam Berat Cu. *Chempro*, 2(01), 7–12. <https://doi.org/10.33005/chempro.v2i01.68>
- Fadlilah, I., Triwuri, N. A., & Pramita, A. (2022). Perbandingan Karbon Aktif-Tempurung Nipah dan Karbon Aktif-Kulit Pisang Kepok Teraktivasi Kalium Hidroksida. *Chemical Engineering Research Articles*, 5(1), 20–27. <https://doi.org/10.25273/cheesa.v5i1.10992.20-27>
- Holifah, H., Ambari, Y., Ningsih, A. W., Sinaga, B., & Nurrosyidah, I. H. (2020). Efektifitas Antiseptik Gel Hand Sanitizer Ekstrak Etanol Pelepah Pisang Kepok (*Musa Paradisiaca* L.) terhadap Bakteri *Staphylococcus Aureus* dan *Escherihia Coli*. *Jurnal Ilmiah Medicamento*, 6(2), 123–132. <https://doi.org/10.36733/medicamento.v6i2.1107>
- Kardiman, K., La Ifa, L. I., & Rasyid, R. (2019). Pembuatan Adsorben dari Sabut Kelapa sebagai Penyerap Logam Berat Pb(ii). *ILTEK*, 14(2), 2083–2087. <https://doi.org/10.47398/iltek.v14i2.421>
- Lestari, I. T., Yativa, R. P., & Dewi, Y. R. (2021). Formulasi Gel Kombinasi Ekstrak Etanol Kulit Pisang Ambon (*Musa Paradisiaca* Var. *Sapientum*) dan Madu Trigona dengan Basis Na-cmc. *Pharmasipha*, 5(2), 32–40. <https://doi.org/10.21111/pharmasipha.v5i2.6521>
- Maitimu, M., Wakano, D., & Sahertian, D. (2020). Nilai Gizi Kulit Buah Pisang Ambon Lumut (*Musa Acuminata* Colla) pada Beberapa Tingkat Kematangan Buah. *Rumphius Pattimura Biological Journal*, 2(1), 24–29.
- Masriatini, R. (2017). Pembuatan Karbon Aktif dari Kulit Pisang. *Jurnal Redoks*, 2(1), 53–57. <https://doi.org/10.31851/redoks.v2i1.2038>
- Murti, R. S., Kasmudjiastuti, E., Priatni, A., Rohaeti, E., & Masiswo, M. (2021a). Aplikasi Nanopartikel Perak dengan Bioreduktor Daun Sambiloto (*Andrographis Peniculata*) dan Kulit Pisang Kepok (*Musa Paradisiaca* L) sebagai Antibakteri pada Kulit. *Jurnal Riset Teknologi Industri*, 318–326. <https://doi.org/10.26578/jrti.v15i2.7246>

- Murti, R. S., Kasmudjiastuti, E., Priatni, A., Rohaeti, E., & Masiswo, M. (2021b). Aplikasi Nanopartikel Perak dengan Bioreduktor Daun Sambiloto (*Andrographis Peniculata*) dan Kulit Pisang Kepok (*Musa Paradisiaca L*) sebagai Antibakteri pada Kulit. *Indonesian Journal of Industrial Research*, 318–326. <https://doi.org/10.26578/jrti.v15i2.7246>
- Nurlaeli, P. D., Rifo Oktaviandra, R. R., & Billah, M. (2020). Pemanfaatan Tempurung Kluwak sebagai Adsorben dalam Menurunkan Kadar Logam Berat Tembaga. *Chempro*, 1(01), 41–45. <https://doi.org/10.33005/chempro.v1i01.40>
- Ramadanti, A. A., Wijayanti, K., & Isnawati, M. (2024). Ekstrak Kapsul Kulit Pisang Ambon (*Musa Acuminata Colla*) Sebagai Pendamping Terapi Tekanan Darah pada Wanita Usia Subur (WUS) Hipertensi. In *Eureka Media Aksara*. Eureka Media Aksara.
- Rosema, R., Supriyantini, E., & Sedjati, S. (2021). Pemanfaatan Kitosan untuk Menurunkan Kadar Logam Pb dalam Perairan yang Tercemar Minyak Bumi. *Buletin Oseanografi Marina*, 10(1), 61–66. <https://doi.org/10.14710/buloma.v10i1.31051>
- Sa'diyah, K., Suharti, P. H., Hendrawati, N., Pratamasari, F. A., & Rahayu, O. M. (2021). Pemanfaatan Serbuk Gergaji Kayu sebagai Karbon Aktif melalui Proses Pirolisis dan Aktivasi Kimia. *Chemical Engineering Research Articles*, 4(2), 91–99. <https://doi.org/10.25273/cheesa.v4i2.8589.91-99>
- Safitri, E., Amelia, D. S., Anggraini, E., Hanjarvelianti, S., & Selviana, S. (2021). Pkm Pendampingan Pembuatan Filtrasi Air dari Limbah Kulit Pisang Kepok dan Penerapan Phbs di Pondok Pesantren Hidayatul Muhsinin. *Abditani*, 4(1), 12–17. <https://doi.org/10.31970/abditani.v4i1.91>
- Sari, F., Fitriyano, G., Syamsudin, Redjeki, A. S., & Hadikusuma, H. (2022). Pengaruh pH dan Waktu Terhadap Adsorpsi Logam Timbal (Pb) dengan Arang Aktif dari Gambas (*Luffa acutangula*) atau Oyong Kering. *Jurnal Konversi*, 11(1), 31–38.
- Sari, L. P., Siregar, D. A., Syafitri, S., Yunita, Y., & Harahap, L. (2022). Pengolahan Limbah Kulit Pisang Menjadi Bahan Dasar Shampo di Desa Huta Raja. *Jurnal Adam*, 1(2), 120–124. <https://doi.org/10.37081/adam.v1i2.1113>
- Siregar, M. Z., & Syarif, A. A. (2020). Variasi Waktu Kontak Maksimum Adsorben Terhadap Logam Hg. *Jurnal Vorteks*, 1(1), 39–43.
- Susilawati, N., & Andryanie, F. (2019). Pengaruh Waktu Kontak dan Aktivasi Ampas Tebu terhadap Kapasitas Adsorpsi Logam Cr dan Mn. *Indonesian Journal of Industrial Research*, 2(2), 277–284.
- Wahyusi, K. N., Nikmah, S., & Anggraini, G. R. (2021). Sintesis Membran Kitosan untuk Pemisahan Ion Pb dalam Limbah Cair. *Jurnal Teknik Kimia UPN Veteran Jatim*, 16(1). https://doi.org/10.33005/jurnal_tekkim.v16i1.2841
- Yulia, I., & Putra, A. (2024). Potensi limbah organik: sumber dan aktifitasnya sebagai antifungi (*Candida albican*). In W. E. Fitri (Ed.), *Media SciTech*. Media SciTech.
- Yustinah, Y., Hudzaifah, H., Aprilia, M., & Ab, S. (2020). Kesenjangan Adsorpsi Logam Berat (Pb) dengan Adsorben Tanah Diatomit secara Batch. *Jurnal Konversi Universitas Muhammadiyah Jakarta*, 9(1). <https://doi.org/10.24853/konversi.9.1.12>
- Zuchrillah, D. R., Pudjiastuti, L., Puspita, N. F., Hamzah, A., Karisma, A. D., Surono, A., Altway, S., Ardiani, L., Rohmah, N. A., & Ningrum, E. O. (2020). Karakteristik Biokomposit Edible Film dari Campuran Kitosan dan Pektin Limbah Kulit Pisang Kepok (*Musa Acuminata*). *Chemical Engineering Research Articles*, 3(1), 33–41. <https://doi.org/10.25273/cheesa.v3i1.6659>