

Synthesis, Characterization, and Application of Biosorbent (*Ananas comosus* Morris) Leaves in Reducing the Physical Parameters of Peat Water

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Abstract **Background of the research:** Pineapple leaves are treated as waste after harvesting processes. The abundance of pineapple leaf wastes must improve its value as a biosorbent in reducing the parameters of peat water. The study aimed to characterize and utilize pineapple leaf wastes to purify peat water. The pineapple leaf waste was turned into a biosorbent and activated by adding 9% NaOH. Changes in the characteristics of the active biosorbent were analyzed based on Indonesian Standard (SNI) No. 0.06-3730-1995 in terms of the water content, ash content, Iodine adsorption capacity, and methylene blue adsorption capacity. FTIR was used for determining functional groups. Scanning Electron Microscope-Energy Dispersive X-ray Spectrophotometer (SEM-EDS) was used to determine the morphology and composition of the biosorbent. The results showed that the pineapple leaf biosorbent had a water content value of 0.53%, 7.11% ash content, 23.4778mg/g methylene blue adsorption capacity, and 197.3463mg/g iodine adsorption capacity. Functional groups of pineapple leaf biosorbent before and after activation were O-H stretching, C-H aromatic, C-H aliphatic, C=O carbonyl, C=C aromatic, and C-O. The elements contained in the pineapple leaf biosorbent before activation were C, O, N, Mg, Cl, K, Fe, and Ca. Otherwise, after activation Mg and Cl elements disappeared. Conclusions: The results showed that pineapple leaf biosorbent was quite good in improving the quality of peat water. Physical parameters include odor,

color, and total suspended solids, but pH value slightly increased. However, pineapple leaf biosorbent has not been able to reduce total dissolved solids.

Keywords Biosorbent, Pineapple Leaves, FTIR, SEM-EDS

1. Background

Human activities can harm the environment. These impacts can damage the ecosystem of living beings that depend on water utilization. One of the points in the Sustainable Development Goals (SDGs) in the environmental sector is to ensure that people achieve universal access to clean water and sanitation [1]. Numerous contaminants contribute to water pollution such as heavy metals, dyes, pesticides, fertilizers, and pharmaceuticals [2] [3] [4] [5] [6]. Agricultural wastes with high molecular weight components like cellulose, hemicelluloses, and lignin might provide a significant amount of biosorbent. Biosorbent materials derived from biomass or agricultural residues have attracted great attention because they can be produced from low-cost, highly abundant biomass or wastes, for example, pineapple leaves.

Previous research has proven the ability of pineapple

leaf biosorbents to adsorb the Ni, Zn, and Cu [7], Rose Bengal [8], and pesticides [9]. The adsorbent from pineapple leaves has many pores that come from the carbon in the composition of pineapple leaves so that it can absorb adsorbates such as heavy metals and dyes. The availability of chemical compounds such as high levels of cellulose in pineapple leaves can be used as a precursor for making activated carbon. Activated carbon from pineapple leaves can be used as a biosorbent because it has the characteristics of a large surface area and the results of the physisorption adsorption process tend to be directly proportional to the surface area of the biosorbent [10]. The larger the surface area, the more particles will experience adsorption. Activated carbon with a large surface area can be produced through physical and chemical activation processes.

Pineapple leaves contain 74.5-87.2% cellulose, 12.3-20.4% hemicellulose, 3.46-8.7% lignin, and other components [11]. These levels vary in function of the type of pineapple and the location of their harvesting. High levels of coloured substances and organic matter can cause health problems through the consumption of peat water without processing, including loss of teeth because the water is acidic [12]. Peat is one of the most widely used biomass fuels for energy [13]. Peat water treatment has also been carried out using ceramic membrane composite nanofiltration technology which can reduce Total Suspended Solids by 91.89% and Biological Oxygen Demand by 91.99% [14].

Peat water also contains organic or inorganic substances that can interfere with the body's metabolism [15]. Peat water is a red-brown natural color, organic-rich compounds, and positively charged colloidal particles in the presence of humic and fulvic acids [16]. These acids are heterogeneous in molecular weight, and humic acid is soluble in alkali but insoluble in acid, otherwise fulvic acid is soluble both in acids and alkali [17]. This study aims to determine the characteristics and ability of pineapple leaf biosorbent to adsorb and purify peat groundwater in Rimbo Panjang Village, Kampar Regency. Pineapple leaf waste also comes from the same place and was synthesized and characterized using Fourier Transform Infrared (FTIR), Scanning Electron Microscope (SEM), and Energy Dispersive X-ray Spectrophotometer (EDS).

2. Research Methods

The materials used in this study include pineapple leaves, peat water taken from Rimbo Panjang County, Kampar Regency Indonesia, aquadest, aqua DM, 9% of sodium hydroxide, methylene blue and iodine, 0.1N sodium thiosulphate anhydrate, 0.1N potassium iodate, 10% potassium iodide, 1% amylum, 0.1N iodine, 10% sulphuric acid, and *Whatman* No. 42.

Instruments used were centrifuge, Spectrophotometer Ultraviolet-Visible (UV-VIS) (Thermo Scientific Genesys

20), Oven (Mamert), Scanning Electron Microscopy (SEM) (Hitachi Flexsem 1000)-Energy Dispersive X-Ray (EDX) (Ametax Edax), Spektrofotometer (FTIR) (Pristige Spectrophotometer Shimadzu), Furnace, 100 and 200mesh Sieves, and glassware.

Pineapple leaves were washed using tap water and cut into small pieces, then dried by the sun and finally put in a furnace at 350 °C until charcoal. This obtained biosorbent was then mashed to a size of 100 - 200 mesh and activated by using 9% of NaOH. The water content (Indonesian National Standard 06-3730-1995), ashes content (06-3730-1995), Iodine adsorption capacity (06-3730-1995), and methylene blue adsorption capacity (SNI 06-3730-1995) of the pineapple leaf charcoal were determined.

Water content derived from pineapple leaf biosorbent was prepared in about 0.1 g and placed into an evaporator cup whose constant weight had been calculated. The sample was then dried in an oven at a temperature of 100 ± 5 °C for 30 minutes, cooled in a desiccator for 15 minutes, and then weighed. This treatment was carried out repeatedly until a constant weight was obtained.

The ash content was measured after heating the samples in crucibles at a temperature of 100 ± 5 °C and cooling to constant weight in a desiccator for 15 minutes. Then, 0.1 g of sample was put in crucibles, furnace at a temperature of 800 °C for 2 hours, cooled in a desiccator, and then weighed.

A sample of 0,5g of biosorbent was treated with 50 mL of 0.1N iodine solution, and centrifuged for 15 minutes at a speed of 2000 rpm. Five milliliters of supernatant were titrated with 0.1 Na₂S₂O₃ until the solution turned light yellow. Next, 2 drops of 1% starch solution were added and titrated again until the blue color disappeared. The absorption capacity of active carbon against iodine was calculated in Equation 1 (mg/g).

$$\text{Iodine adsorption (mg/g)} = \left[\frac{(V_1 \times N_1 - V_2 \times N_2) \times 126,91 \times fp}{w_a} \right] \quad (1)$$

Note:

V₁ = volume of titrations for blank

V₂ = volume of titrations for sample

N = Normality of Na₂SO₃ solution

fp = dilution factor

A sample of 0.25 g of leaf biosorbent was treated with 25.0 mL of 250 mg/L methylene blue solution and stirred in a magnetic stirrer for 15 minutes at 80 rpm for 1 hour. After that it was left to decant for an hour and then centrifugation process for 15 minutes at 2000 rpm. The upper supernatant absorbance was measured at 664nm using a UV-Vis Spectrophotometer. The absorption capacity of pineapple leaf biosorbent against methylene blue was determined using Equation 2.

$$\text{Methylene blue adsorption (mg/g)} = \frac{x_0 - x_1}{w} \times V \quad (2)$$

- X_0 : Initial concentration (mg/L)
 X : Final concentration (mg/L)
 V : Volume (L)
 W : sample weight (g)

The differences in the adsorption capacity of pineapple leaves before and after the activation were analyzed by FTIR and morphology by using SEM-EDX.

Determination of the Optimum Contact Time and Dosage of Biosorbent to Reduce Contamination Index of Peat Water

The optimum time of treatment was determined by treating 50,0mL of peat water with 0.10g of activated pineapple biosorbent for 10, 15, 30, and 60 minutes. The

mixture was stirred at 150 rpm using a magnetic stirrer [18]. The optimum dosage was determined by adding 50,0mL of peat water 0.05, 0.10, 0.15, and 0.20g of biosorbent, stirred at 150 rpm, and then filtered using Whatman No. 42 and analyzed.

3. Results

The biosorbent of pineapple leaves was characterized based on the Indonesian National Standard (SNI) No. 06-3730-1995 which includes water content, ash content, adsorption capacity to iodine, adsorption capacity to methylene blue, and area of activated carbon surfaces with characterization results presented in Table 1. The sampling location of pineapple leaf waste and peat water is showed in Figure 1.

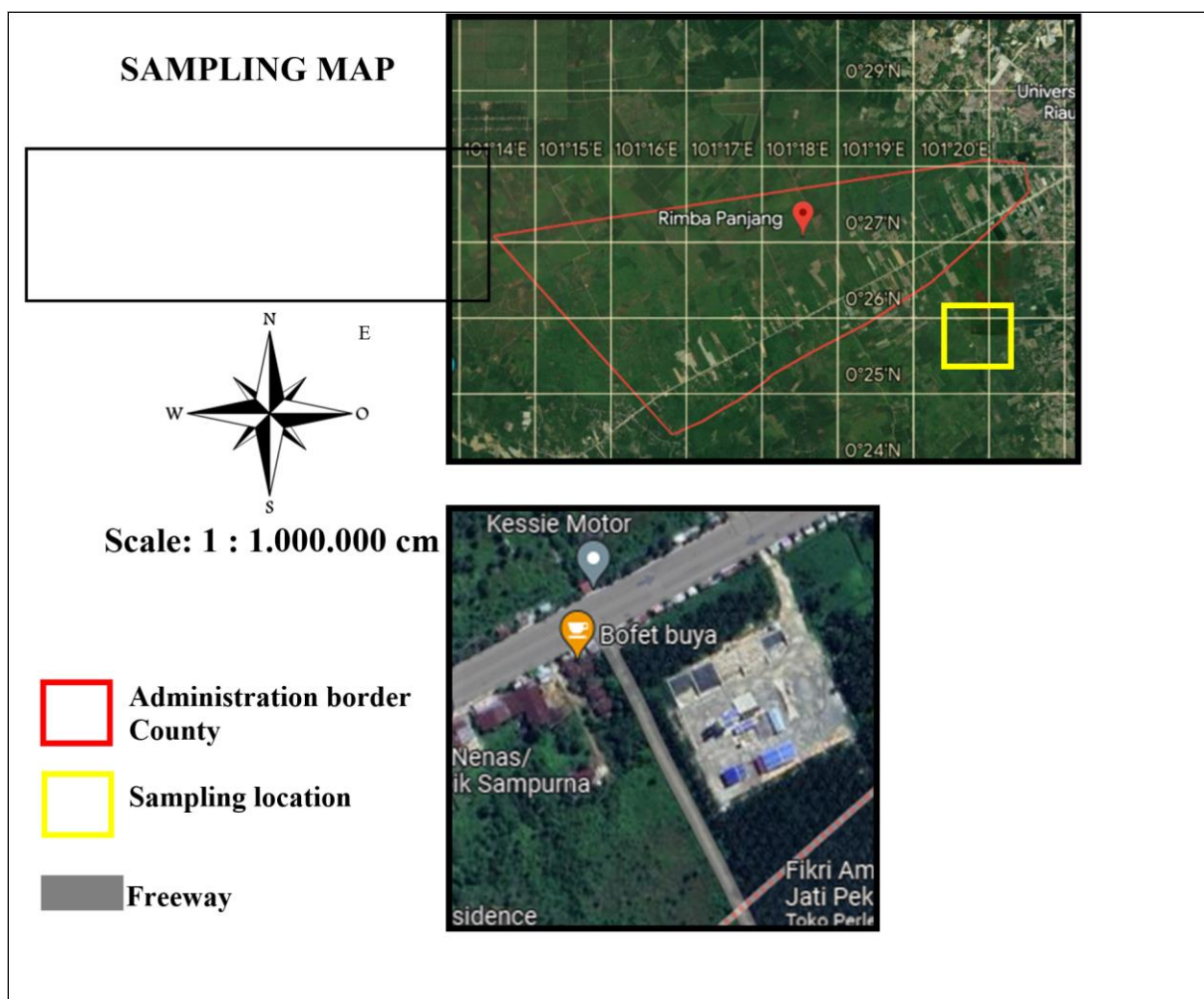


Figure 1. Sampling location of pineapple leaves and peat water

Table 1. Characterization results of before and activated pineapple leaf biosorbent

Before	Water content (%)	Ash content (%)	Iodine absorption (mg/g)	MB adsorption (mg/g)	Surface Area (mg/g)
S1	1.80	10.63	436.4750	21.6194	79.3105
S2	1.60	10.60	420.7927	21.3330	78.0446
S3	1.70	10.50	428.5887	21.2507	77.7436
After					
S1	0.40	6.30	230.7408	23.1796	85.1256
S2	0.70	7.16	163.9099	23.2685	84.0898
S3	0.50	7.87	197.3879	23.9854	79.3105
SNI	≤ 15	≤ 10	≥ 750	≥ 120	-

Morphological analysis of pineapple leaves biosorbents before and after being activated by 9% of NaOH using a Scanning Electron Microscope (SEM) instrument is in Figure 2. The results of the surface morphology analysis presented in Figure 2, showed differences in the surface of the pineapple leaf biosorbent pores before and after activation with 9% of NaOH.

The pores before activation (Figure 2a) were still closed by organic compounds and air, while Figure 2b after activation shows opened pores able to adsorb chemical compounds.

The elements contained in pineapple leaf biosorbent were determined using Energy Dispersive with 9% NaOH (5-minute activation temperature) as presented in Figure 2. The pineapple leaves showed a rough and irregular surface caused by activation resulting in a large number of pores with irregular surfaces spread throughout active carbon.

The activation process caused the release of many metallic impurities that led to the occurrence of more pores. The reduction of hydrocarbon compounds produces a carbon surface that looks increasingly clear. The activation process aims to enlarge the pores by breaking the hydrocarbon bonds or oxidizing the surface molecules. The surface area increases and affects the adsorption power. The activation process can cause the release of hydrocarbons, tar, and organic compounds attached to the biosorbent. The open pores amount increases at the biosorbent surface, and consequently the adsorption capacity of the biosorbent becomes high [19].

The water content produced is entirely by the minimum standard, namely <15%. The various NaOH concentrations, reaction times, and temperatures used as an activator act as a dehydrating agent because it has hygroscopic properties, and binds water molecules in the coconut coir with 1.50 M

NaOH can remove 69.82% of lignin from the cellulose structure [20].

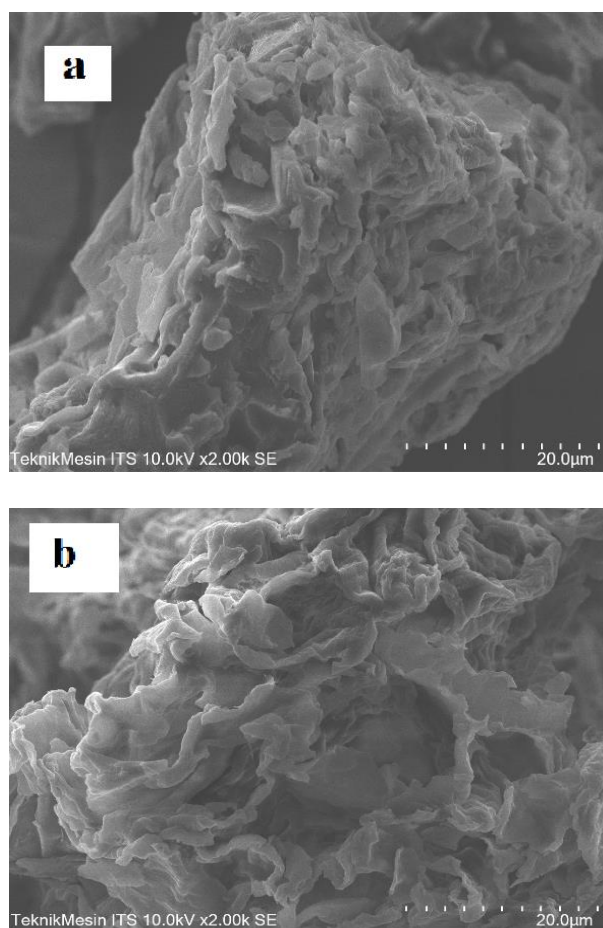


Figure 2. Surface morphology before (a) and activated the pineapple leaf's biosorbent (b).

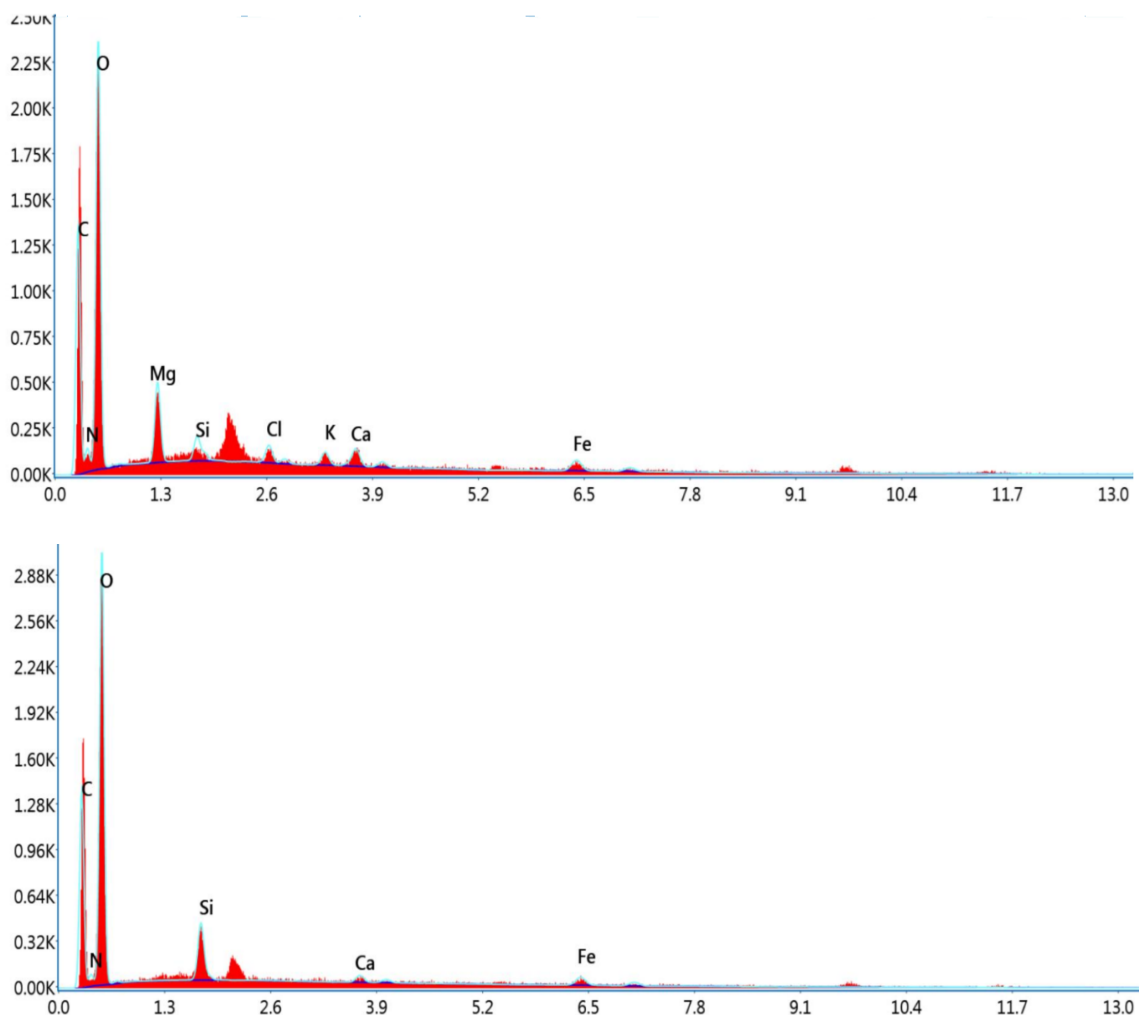


Figure 3. Elemental analysis of pineapple leaf biosorbent before (a) and after (b) activation

The elements contained in the pineapple leaf biosorbent before activation were C, O, N, Mg, Cl, K, Fe, and Ca. Otherwise, after activation Mg and Cl compounds disappeared (Figure 3). Mg and Cl might be diluted as complex compounds. A comparison of the elemental composition of the pineapple leaf biosorbent before and after activation with NaOH was presented in Table 2.

Table 2. Biosorbent element content of pineapple leaves before and after activation

Spl	Elemental Analysis (wt.%)							
	C	O	N	Fe	Si	Ca	Mg	Cl
Bef.	29.61	54.64	5.77	4.34	0.94	0.87	4.34	29.61
Aft.	29.08	62.39	3.42	-	2.79	-	-	29.08

Determination of the Functional Groups of Pineapple Leaf Biosorbent

The functional groups contained in the pineapple leaf biosorbent were analyzed using FTIR. The spectrum of the pineapple leaf biosorbent before and after NaOH activation is presented in Figure 4. The functional groups in pineapple leaves were O-H, C-H, C=O, C=C, and C-O.

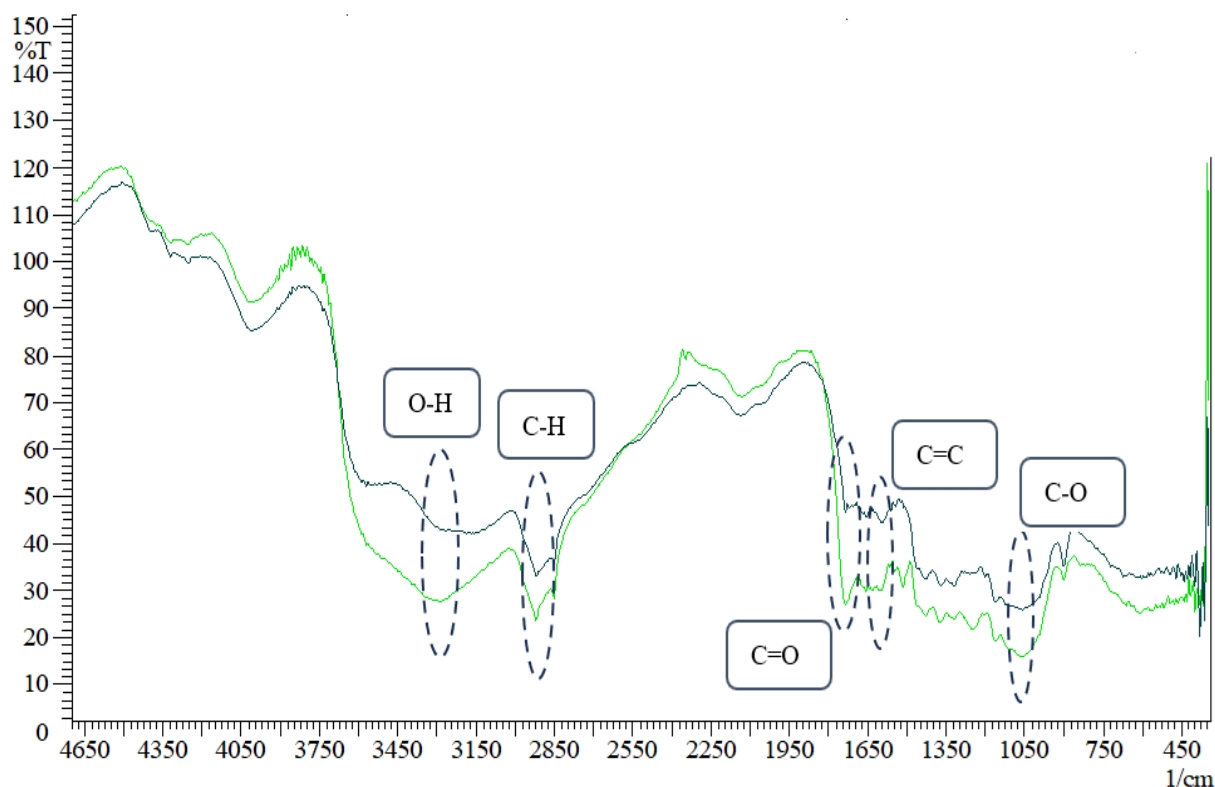


Figure 4. The spectrum of the pineapple leaf biosorbent before (green line) and after (black line) activation by NaOH.

Humic acid is a final product of microbial metabolism. The main functional groups found in humic acid are the -COOH, -OH, and quinone groups [21].

Application of Pineapple Leaf Biosorbent to Peat Water

Peat water is organic-rich surface water that contains a hydrophobic high molecular weight of natural organic matter in the form of humic and fulvic acids. In Table 3, it can be seen that the optimum contact time of the adsorbent was 15 minutes with an adsorbent of about 92.5%. The pH slightly changes. It is close to exceeding the safety limit for environmental waste this can be improved by increasing the adsorbent power and favoring the ability to lower the pH. Total Suspended Solid (TSS) decreased sharply, which means that the biosorbent was able to reduce it. On the other hand, Total Dissolved Solid (TDS) was unchanged. There are two physical water quality parameters that impair the quality of water resources: Total dissolved solids (TDS) and total suspended solids (TSS). Increased concentrations of TDS and TSS in water bodies limit them from serving their purpose of drinking due to the potential effects of anthropogenic and natural factors. Meanwhile, untreated peat water is unsafe to drink and can cause health issues [22]. Furthermore, peat water contains halogen ions and pathogenic bacteria, particularly in estuaries [23].

Table 4 showed that the 0.1g pineapple leaf biosorbent dosage was the optimum concentration to obtain an efficiency of 92.5% in 15 minutes of contact time. It was found that pH and TDS were unchanged and TSS slightly

decreased. The pH value should be between 6 and 8.5 to be safe. The presence of dissolved acids and carbon dioxide acidifies the water. In addition, some minerals can be found in an excessive amount of water that is acidic to meet the Energy Dispersive X-Ray (EDS) found.

Table 3. The effect of contact time pineapple leaf biosorbent and peat water

Contact time (min)	pH	TDS (mg)	TSS (mg/L)	Efficiency (%)
Untreated Peat water	5.62	531	132	-
10	5.29	524	42	47.5
15	6.29	521	6	92.5
30	5.94	509	12	85
60	5.78	530	46	42.5
90	5.70	531	70	12.5

Table 4. Effect of pineapple leaf biosorbent dosage in the studied parameters of peat water

Biosorbent (g)	pH	TDS (mg/L)	TSS (mg/L)	Efficiency (%)
Optimum contact time	6.29	521	6	92.5
0.05	5.69	519	45	43.75
0.1	6.29	502	6	92.5
0.2	5.60	524	54	32.5
0.2	5.60	524	54	32.5

4. Conclusions

This research can conclude that pineapple leaves can be used as a biosorbent to reduce the physical parameters of peat water. The characteristics of the pineapple leaf biosorbent were a water content value of 0.53%, 7.11% ash content, 23.4778mg/g methylene blue adsorption capacity, and 197.3463mg/g iodine adsorption capacity. The elements contained in the pineapple leaf biosorbent before activation were C, O, N, Mg, Cl, K, Fe, and Ca. On the other hand, after activation Mg and Cl elements disappeared from the treated peat water. Magnesium is present in peat water due to the source of pineapple agricultural land.

REFERENCES

- [1] Susanti, R., Rifardi, R and Kadarisman, Y., Peran Masyarakat dalam Pencapaian Target Sustainable Development Goals Desa Layak Air Bersih dan Sanitasi, *Journal of Education, Humaniora and Social Science* No. 3, Vol. 3, 2021. Mahesa Research Center. doi.org/10.34007/jehss.v3i3.535.
- [2] Azis, K. H. H., Mustafa, F. S., Omer, K. M., Hama, S., Hamarawf R. F., and Rahman, K.O., Heavy metal pollution in the aquatic environment: efficient and low-cost removal approaches to eliminate their toxicity: a review, *RSC Adv.* Vol. 13, No. 26, pp.17595–17610, 2023. doi: 10.1039/d3ra00723e.
- [3] Liu, Q., Pollution and Treatment of Dye Waste-Water, *IOP Conf. Ser.: Earth Environ. Sci.* Vol 514 052001, pp. 1-7, 2020. doi: 10.1088/1755-1315/514/5/052001.
- [4] Rad, S. M., Ray, A. K., and Barghi, S., Water Pollution and Agriculture Pesticide, *Clean Technol.* Vol. 4, No. 4, pp. 1088-1102, 2022. doi.org/10.3390/cleantechnol4040066.
- [5] Chai, Y., Pannel, D. J., and Pardey, P. G., Nudging farmers to reduce water pollution from nitrogen fertilizer, *Food Policy*, Vol. 120, No. 102525, 2023. doi.org/10.1016/j.foodpol.2023.102525.
- [6] Gurgendzde, D., and Romanovski, V., The Pharmaceutical Pollution of Water Resources Using the Example of the Kura River (Tbilisi, Georgia), *Water*, Vol. 15, No.14, pp. 2574, 2023. doi.org/10.3390/w15142574.
- [7] Iamsaard, K., Weng C-H., Yen, L-T., Jing-Hua Tzeng, J-H., Poonpakdee, C., Lin, Y-T., Adsorption of metal on pineapple leaf biochar: Key affecting factors, mechanism identification, and regeneration evaluation, *Bioresource Technology*. Vol. 344, Part A, 2022, 126131. doi.org/10.1016/j.biortech.2021.126131.
- [8] Hassan, S.S., El-Shafie, A.S., Zaher, N., and El-Azazy, M., Application of Pineapple Leaves as Adsorbents for Removal of Rose Bengal from Wastewater: Process Optimization Operating Face-Centered Central Composite Design (FCCCD), Vol. 25, No. 16, p. 3752, 2020. doi: 10.3390/molecules25163752.
- [9] Srikaow, A., Win, E.E., Amornsakchai, T., Kiatsiriroat, T., Kajitvichyanukul, P., and Smith, S.M., Biochar Derived from Pineapple Leaf Non-Fibrous Materials and Its Adsorption Capability for Pesticides, *National Library of Medicine, ACS Omega*, Vol. 8, No. 49, pp. 26147–26157, 2023. doi: 10.1021/acsomega.3c02328.
- [10] Fouda-Mbanga, B. G., & Tywabi-Ngeva, Z. 2022. Application of pineapple waste to the removal of toxic contaminants: A review. *Toxics*. Vol. 10 No.1), p.561, 2022. doi.org/10.3390/toxics10100561.
- [11] Daochalermwong, A., Chanka, N., Songsrirote, K., Dittanet, P., Niamnuy, C. & Seubsai, A., Removal of Heavy Metal Ions Using Modified Celluloses Prepared from Pineapple Leaf Fiber. *American Chemical Society Omega*. Vol. 5, No. 10, pp. 5285–5296, 2020. doi.org/10.1021/acsomega.9b04326.
- [12] Kritzberg, E.S., Hasselquist, E.M., Škerlep, M., Löffgren, S., Olsson, O., Stadmark, J., Valinia, S., Hansson L-A., Laudon, H., Browning of freshwaters: Consequences to ecosystem services, underlying drivers, and potential mitigation measures, *Review*, Vol. 49, pp. 375-390, 2020. doi.org/10.1007/s13280-019-01227-5.
- [13] Guillán, R.A., Lizama-Bahena, C., Trevino-Quintanilla, L.G., Barragan-Trinidad, M., Bustos, V., and Moeller-Chavez, G., Peat as a Potential Biomass to Remove Azo Dyes in Packed Biofilters, *Peer Review Chapter: 2022*, doi: 10.5772/intechopen.102691.
- [14] Sisnayanti, S., Komala, R., Yusya, MK., Aprianti, T., and Faizal, M., Peat Water Treatment Into Clean Water Using Composite Ceramic Membrane Nanofiltration Technology. *Jurnal Dinamika Penelitian Industri*. Vol. 33, No. 1, pp. 90-101, 2022. ISSN: 2477-4456. http://ejournal.kemenperi.go.id/dpi/article/view/7678/pdf_131.
- [15] Kane, E., Veverica, T., Malak, M.T., Chimner, R.A., Reduction-Oxidation Potential and Dissolved Organic Matter Composition in Northern Peat Soil: Interactive Controls of Water Table Position and Plant Functional Groups, *Journal of Geophysical Research: Biogeosciences*, Vol. 124, No. 11, pp. 3600-3617, 2019. doi: 10.1029/JG005339.
- [16] Qadafi, M., Wulan, D. R., Notodarmojo, S., and Zevi, Y., Characteristics and treatment methods for peat water as clean water sources: A mini review, *Water Cycle*, Vol. 4, pp 60-69, 2023. doi.org/10.1016/j.watcyc.2023.02.005.
- [17] Hou, D., He, J., Lu, C., Wang, W., and Zhang, F., Spatial Distribution of Humic Substances and Evaluation of Sediment, Organic Index on Lake Dalinouer, China, *Journal of Geochemistry*, Vol. 2014, Article ID 502597, pp. 1-13. doi.org/10.1155/2014/502597
- [18] Neupane, S., Ramesh, S.T., Gandhimati, R., Nidheesh, P.V., Pineapple leaf (*Ananas comosus*) powder as a biosorbent for the removal of crystal violet from aqueous solution, *Desalination and Water Treatment*, Vol. 54, No. 7, pp. 2041-2054. 2015. doi.org/10.1080/19443994.2014.903867.
- [19] Lano, A.L., Ledo, M. E. S, and Nitsae, M. Activated Charcoal from Siwalan Shell (*Borassus flabellifer* L.) with Potassium Hydroxide. *Biota: Jurnal Ilmu-Ilmu Hayati*. Vol. 5, No.1, p.8. 2020. doi:10.24002/biota.v5i1.2948.
- [20] Rahayu, A., Hanum, F.F., Amrillah, N. A.Z., Lee Wah Lim, L. W., and Salamah, S. Cellulose Extraction From Coconut

- Coir With Alkaline Delignification Process. *Journal of Fibers and Polymer Composites*, Vol. 1, pp. No.2, pp. 106-116, 2022.
- [21] Wang, R. W., Li, D., Zheng, G., Cao, Z., Deng, F., Nutrient recovery from biogas slurry via hydrothermal carbonization with different agricultural and forestry residue, *Chemical Engineering Journal*. Volume 455, Part 2, 140916. 2023. doi.org/10.1016/j.cej.2022.140916
- [22] Qadafi, M., Wulan, R., Notodarmojo, S and Zevi Y., Characteristics and treatment methods for peat water as clean water sources: A mini-review. *Water Cycle*, Vol. 4, pp. 60-69, 2023. doi.org/10.1016/j.watcyc.2023.02.005.
- [23] Chan, C., K. Norsuhaida, K., R. Mohamed, R., Using a peat media for laundry greywater filtration: geochemical and water quality check, *Middle-East, J. Sci. Res.*, Vo. 21, No. 8, pp. 1365-1370, 2014. doi: 10.5829/idosi.mejsr.2014.21.08.14522.