

# Innovative Water Purification Using Pineapple By-Product and Rice Husk: A Portable Filtration Approach

Nurfatin Nadiha Azizul<sup>1</sup>, Maizatul Sofea Mohd Mahat<sup>1</sup>, Siti Noraiza Ab Razak<sup>1,2\*</sup>, Nurul Nadia Adnan<sup>3</sup>

<sup>1</sup> Department of Science and Mathematics, Centre for Diploma Studies, Universiti Tun Hussein Onn Malaysia, Pagoh Higher Education Hub, 86000 Pagoh, Johor, MALAYSIA

<sup>2</sup> Mathematics and Application (MAP), Centre for Diploma Studies, Universiti Tun Hussein Onn Malaysia, Pagoh Higher Education Hub, 86000 Pagoh, Johor, MALAYSIA

<sup>3</sup> Department of Physics and Chemistry, Faculty of Applied Science and Technology, Universiti Tun Hussein Onn Malaysia, 84600, Pagoh, Johor, MALAYSIA

\*Corresponding Author: [noraiza@uthm.edu.my](mailto:noraiza@uthm.edu.my)

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## Abstract

The goal of this study is to address the dual challenges of providing clean water and reducing environmental waste by creating a filtration system that is easy to make, affordable and suitable for areas with limited access to clean water. Four types of activated carbon (AC) were prepared using heating method with different combinations of rice husk (RH) and pineapple waste (PW) (Sample A - 100% RH; Sample B - 100% PW; Sample C - 3:7 RH to PW; Sample D - 3:7 PW to RH). These AC were then employed into a portable water filter, separately to purify the river water. The water quality was analyzed based on its Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), ammoniacal nitrogen, Total Suspended Solids (TSS), Total Dissolved Solids (TDS), turbidity, Dissolved Oxygen (DO) and pH level. Sample C shows the best performance among other type of AC where the BOD is 67.76% , COD is 68%, ammoniacal nitrogen is 70.49%, TSS is 67.91%, DO is 54.84%, TDS is 58.19%, and turbidity is 71.03% compared with the real standard.

## 1. Introduction

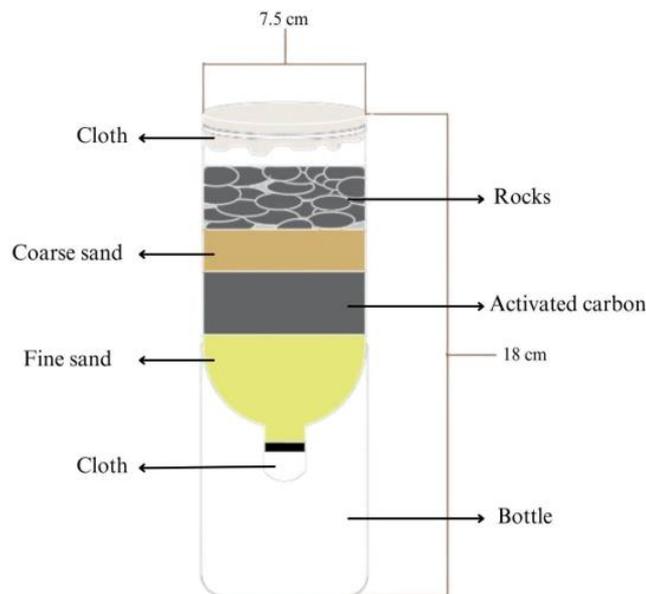
The conventional water filtration systems can be expensive, huge, or reliant on complex technologies, making them inaccessible to many communities. Some of the systems employ UV filtration to eliminate harmful effects from microorganisms in water [1]. This feature will indirectly increase the cost. Meanwhile, food waste, particularly from fruits like pineapples, is growing environmental concern, with significant amounts of by-products like peels and cores often discarded despite their potential value. Pineapple waste (PW) is reported to be rich in fiber and bioactive compounds. It also has demonstrated promising properties for water filtration, such as adsorbing contaminants and filtering out impurities. However, there has been limited exploration of their use in a portable, low-cost water filtration system that is easy to deploy in resource-scarce settings. This project proposed the dual challenge of water purification and food waste management by developing an innovative portable filtration system that utilizes pineapple peels and rice husk as natural filtering materials. Besides, this by-product is easier to be collected in almost every state in Malaysia. The project aims to provide an affordable, sustainable, and accessible method for producing safe water for daily, while reducing agricultural waste. This project is considered sustainable and environmentally friendly due to natural by-product resources used and bottle recycling as a portable container.

The advantage of these materials is not just in their chemical properties but also in their availability in agricultural economies. Pineapple, as one of the most grown tropical fruits, generates millions of tons of by-products every year globally [2]. Without proper waste management, these by-products can lead to environmental problems. Turning them into materials for water purification can help solve both waste management issues and the need for clean water. Portable filtration systems are becoming increasingly popular as they provide quick access to safe for domestic use, especially in remote areas refugee camps, or disaster-stricken regions. By using PW and rice husk (RH) in a water purification system this study aims to create a solution that is efficient, portable and environmentally friendly [3]. The use of agricultural waste for water purification represents an innovative and environmentally friendly approach that aligns with global sustainability goals. PW is reportedly rich in fibrous and adsorptive qualities, and RH, known for their high silica content, demonstrates significant potential in removing impurities from contaminated water [4]. By integrating these materials into a portable filtration system, this study aims to offer a practical solution for communities with limited access to clean water. Such innovations not only improve public health outcomes but also promote environmental conservation by repurposing agricultural waste that would otherwise be discarded.

The main objective of this study is to determine which type or composition of activated carbon (AC) most effectively improves the chemical properties of contaminated river water. Besides, the chemical properties of purified water in terms of pH level, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), ammoniacal nitrogen, Total suspended solid (TSS), dissolved oxygen (DO), Total dissolved solid (TDS) and turbidity.

## 2. Material and Method

The raw material used in this project are PW and RH. In addition, fine sand, coarse sand and rocks were used as a layer in the water filter system. A piece of cloth was used to seal the bottom part of water filter container. A 1.5 L drinking plastic bottle was used as the container. Height for drinking plastic bottle is 18 cm and width is 7.5 cm [5]. There four types of AC were employed into the water filter system, that are 100% of RH (Sample A), 100% of PW (Sample B), 3:7 ratio of RH to PW (Sample C), and 3:7 ratio of PW to RH. The total weight of each AC used in the water filter system is 100 g. All materials were layered inside a container as shown in Fig. 1. Meanwhile, Fig. 2 shows the process flow of this study [6].



**Fig. 1** The schematic diagram of the water filter system

The portable water purification system utilizing pineapple by-products and RH model were designed and assembled as a compact filtration unit. Initially, the pineapple waste was cleaned using distilled water before being cut and was sieved to desired mesh size of 1-2 mm. Then, it dried under sunlight at standard atmospheric pressure for a week until the sample became hardened so that it was crushed easily. The dried and hardened sample were crushed into fine material using Grinding and Sieving Crusher (GSC) to achieve a consistent texture as GAC.

The samples were heated using muffle furnace at 400°C for three hours to produce activated carbon. The same steps were repeated for rice husk but with a desired mesh size of 1-3 mm and heated at 300°C for three hours to produce activated carbon as well. The project flowchart is illustrated in Fig. 3.2.

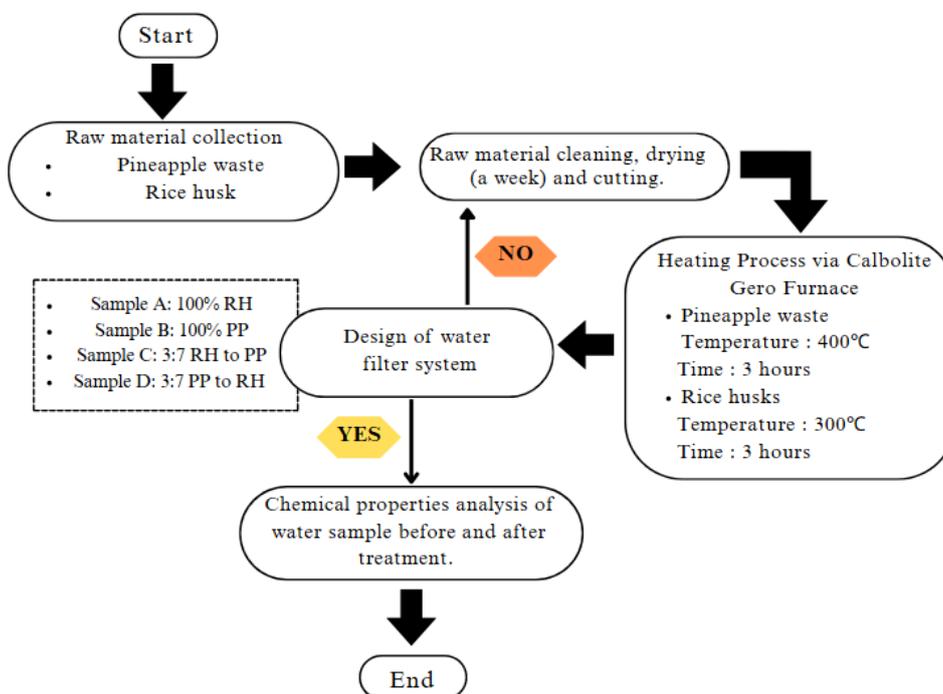


Fig. 2 Flowchart of the project starting from sample preparation to chemical properties analysis of purified water

### 3. Results and Discussion

This section presents and discusses the results of the analyses of Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), ammoniacal nitrogen, Total Suspended Solids (TSS), Total Dissolved Solids (TDS), turbidity, Dissolved Oxygen (DO) and pH level of water samples.

Table 1 Result chemical properties before and after treatment

Parameter	Before Treatment		After Treatment		
	Water Sample	Sample A	Sample B	Sample C	Sample D
BOD (mg/L)	15.2	5.8	6.4	4.9	5.2
COD (mg/L)	40.0	14.5	16.3	12.8	13.5
Ammoniacal Nitrogen (mg/L)	6.1	2.2	2.6	1.8	1.9
TSS (mg/L)	88.5	32.0	36.5	28.4	29.1
TDS (mg/L)	190.4	88.1	92.5	79.6	82.3
DO (mg/L)	2.8	5.6	5.1	6.2	6.0
Turbidity (NTU)	64.2	22.4	24.7	18.6	19.5

Table 1 shows the chemical properties before and after treatment of the water sample collected from Sungai Panchor, Muar. Each property will be discussed further in the following sub-topics that be compared with Environmental Quality Act 1974 and National Water Quality Standards for Malaysia [7][8].

### 3.1 BOD and DO Analysis

BOD and DO are closely related but it inversely proportional indicators of water quality. For example, when the value of BOD is high, DO value will be decreased and if BOD value is low, value of DO will increase. BOD value should be below 50 mg/L and DO range must be above 5 to 7 mg/L to show that the water is safe for daily use refer to Environmental Quality Act 1974 which is Standard B and National Water Quality Standards for Malaysia. Based on Table 1, the value of BOD and DO of water sample before the treatment process are 15.2 mg/L and 2.8 mg/L, respectively. After being treated, all samples showed positive effects for both parameters. but the most effective AC is Sample C. The BOD decreased from 15.2 mg/L to 4.9 mg/L while the DO value increased from 2.8 mg/L to 6.2 mg/L. For Sample A, Sample B and Sample D AC, the BOD decreased to 5.8 mg/L, 6.4 mg/L and 5.2 mg/L while DO value increased to 5.6 mg/L, 5.1 mg/L and 6.0 mg/L. This improvement happened due to large surface area of AC and micropores that trap dissolved organic compounds such as algae, microorganisms or oil in the water sample. By removing these compounds, bacteria need less oxygen to break them down. Hence, more oxygen remains dissolved and leads to an increase in DO and decrease in BOD.

### 3.2 COD Analysis

The change in COD value shows in Table 1 and all samples passed the standard of National Water Quality Standards for Malaysia by refer Class IIA, which is less than 25 mg/L. This shows that the AC effectively removed organic pollutants by trapping many types of organic compounds in water. As a result, less oxygen is needed to treat the water, which leads to a lower COD value. COD is important when measure the quality of water because it can measure how much oxygen is needed to break down organic matter in water through chemical reactions and high COD value means the water is polluted. The COD before the treatment is 40 mg/L. When the water sample being treated with Sample A and Sample B AC, the COD decreases to 14.5 mg/L and 16.3 mg/L, respectively. Besides, the COD value also shows a significant decreases when the water sample was treated with Sample C and Sample D, where the reading drop from 40 mg/L to 12.8 mg/L and 13.5 mg/L, respectively.

### 3.3 Ammoniacal Nitrogen Analysis

The untreated water sample had the highest ammoniacal nitrogen level at 6.1 mg/L, which is too high for domestic use. The standard ammoniacal nitrogen level for safe use is reported to be at <20 mg/L [7]. After the treatment, Sample C showed the lowest value at 1.8 mg/L, followed closely by Sample D at 1.9 mg/L. Sample A and Sample B showed slightly higher values at 2.2 mg/L and 2.6 mg/L. This means that Sample C is the most effective at reducing ammonia nitrogen. Lower ammonia nitrogen is good because it indicates cleaner water and is safer for domestic use, as high levels can be harmful to health and the environment. Reducing ammoniacal nitrogen is important because it helps prevent problems like unpleasant odors. It also helps protect the environment, especially aquatic life because high ammonia levels can reduce oxygen in water and affect fish and other organisms. Having lower ammoniacal nitrogen after treatment is a sign that the water is better and safer to use.

### 3.4 TSS and TDS Analysis

TSS refers to the solid particles that are suspended in water, like dirt, sand, or organic matter, while TDS refers to the number of dissolved substances such as minerals, salts and metals that are present in the water. The untreated water sample had the highest TSS value at 88.5 mg/L and the highest TDS value at 190.4 mg/L. This shows that the water sample was highly polluted. After treatment, all four samples showed a clear reduction in both TSS and TDS values. For TSS, Sample C recorded the lowest value at 28.4 mg/L, followed by Sample D 29.1 mg/L, Sample A 32 mg/L and Sample B 36.5 mg/L. That means the Sample C was the most effective in removing suspended particles that followed the Environmental Quality Act 1974. For TDS, Sample C also showed the lowest reading at 79.6 mg/L, followed Sample A 88.1 mg/L, Sample C 92.5 mg/L and Sample D 82.3 mg/, which means Sample C was also the most effective in reducing dissolved solids that followed National Water Quality Standards for Malaysia. Lower levels of TSS and TDS are important because it indicates that the water is cleaner, and safer for daily use. High TSS can make water look dirty and clog filters, while high TDS can affect the taste and safety of the water.

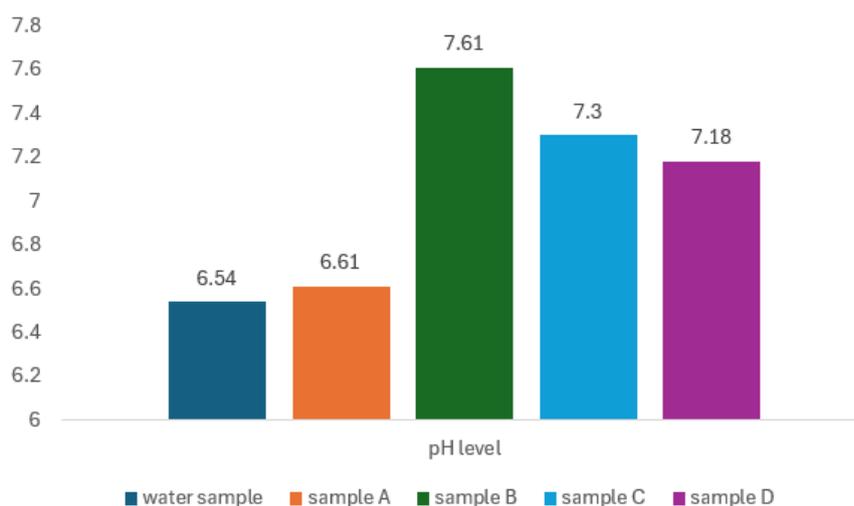
### 3.5 Turbidity Analysis

Turbidity is the measure of how clear or cloudy the water is, and it is caused by suspended particles such as dirt, microorganism, and other impurities. Its measured in NTU (Nephelometric Turbidity Units). The untreated water sample had the highest turbidity level at 64.2 NTU, which indicates that the water was very cloudy. After treatment, all four samples showed a significant reduction in turbidity. Sample C has the lowest turbidity at 18.6 NTU that good value followed National Water Quality Standards for Malaysia than others which is Sample D 19.5 NTU, Sample A 22.4 NTU and Sample B NTU. This means that Sample C is the most effective in reducing turbidity

and making the water clearer. Lower turbidity is important because its not only improves the appearance of the water but also reduces the risk of harmful microorganism hiding in the particles.

### 3.6 pH Level

Fig. 3 shows the results of the pH meter test. Water samples such as raw river water often contain organic acids from pollutants and contaminants, which causes pH to lower. To increase pH value, activated carbon absorbs these acids to reduce the number of contaminants and then it will raise the pH closer to the neutral range. The surface of activated carbon also has functional groups that can neutralize acids and help to maintain pH level. During the activation process, basic minerals such as potassium, carbon and magnesium are released into the water to balance the acidity by acting as weak bases. After treatment, there is a change in the pH value, which is increasing from slightly acidic to the neutral range. From the result, the pH level of the water sample after being treated by all AC samples shows a standard pH value as recognized by the Environmental Quality Act 1974 which is in the range between 5.5 to 9.0 for daily use. For example, pH levels for Sample A, Sample C and Sample D are 6.61 mg/L, 7.3 mg/L and 7.18 mg/L. However, Sample B AC is the best compared to others which is 7.61 mg/L because the pH value is more stable and better for skin because it is neutral to slightly alkaline.



**Fig. 3** The pH level of the water sample before and after treatment

## 4. Conclusion

This study successfully developed a low-cost, eco-friendly portable water filtration system using PW and RH as activated carbon. All types of AC (Sample A to Sample D) are significantly improved water quality by reducing BOD, COD, ammoniacal nitrogen, TSS, TDS, and turbidity, while increasing the DO levels. All parameters used are in accordance with the standards set by Environmental Quality Act 1974 which is Standard B and National Water Quality Standards for Malaysia. The 3:7 ratio of RH to PW mixture performed best across most parameters, especially in reducing organic pollutants and solids. AC derives from a combination of 30% RH, and 70% PW is the most effective formulation for purifying river water. For future studies, it is suggested that the portable water filtration system be tested using different types of water source, such as greywater or rainwater. This is to see if the filtration system is still effective when used on water with different levels and types of contamination. Another suggestion is to experiment with other agricultural waste materials like banana peel or sugarcane to compare their effectiveness as activated carbon. This can help to create a more flexible and low-cost solution for clean water, especially in rural areas.

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## Conflict of Interest

Authors declare that there is no conflict of interest regarding the publication of the paper.

## Author Contribution

The authors confirm contribution to the paper as follows: **study conception and design:** Nurfatim Nadiha Azizul, Maizatul Sofea Mohd Mahat, Siti Noraiza Ab Razak; **data collection:** Nurfatim Nadiha Azizul, Maizatul Sofea Mohd Mahat; **analysis and interpretation of results:** Nurfatim Nadiha Azizul, Maizatul Sofea Mohd Mahat; **draft manuscript preparation:** Nurfatim Nadiha Azizul, Maizatul Sofea Mohd Mahat; Siti Noraiza Ab Razak; All authors reviewed the results and approved the final version of the manuscript.

## References

- [1] H. Nikkhah, D. Ipekçi, W. Xiang, Z. Stoll, P. Xu, B. Li, et al., "Challenges and opportunities of recovering lithium from seawater, produced water, geothermal brines, and salt lakes using conventional and emerging technologies," *Chemical Engineering Journal*, vol. 498, no. 155349, April 2024.
- [2] N. Asadullah, K. Ngwangam, P. Rachtanapun, G. Kasi, J. Han, and W. Tongdeesoontorn, "Utilization of macadamia nutshell-derived activated carbon for enhanced congo red adsorption," *Bioresource Technology Reports*, vol. 27, no. 101955, Sep 2024.
- [3] M. N. Nasehir Khan, M. R. R. Mohd Arif Zainol, M. F. Mohamad Yusop, and M. A. Ahmad, "Turning waste into wonder: Arsenic removal using rice husk based activated carbon," *Journal of Engineering Research (Kuwait)*, vol. 13, no. 3, pp. 2503-2516, Sep 2025.
- [4] Y. M. Peralta, R. Molina, and S. Moreno, "Rice husk silica: A review from conventional uses to new catalysts for advanced oxidation processes," *Journal of Environmental Management*, vol. 370, no. 122735, Oct 2024.
- [5] A. R. Jacob, A. Azmi, and M. K. A. Amat Mustajab, "Physical and chemical activation effect on activated carbon prepared from local pineapple waste," *Applied Mechanics and Materials*, vol. 699, pp. 87-92, 2014.
- [6] Y. K. Siong, J. Idris, and M. Atabaki, "Performance of activated carbon in water filters," *Water Resources*, vol. 32, no. 3, pp. 1-19, 2013.
- [7] Department of Environmental Malaysia, *Environmental Quality Industrial Effluent Regulations 2009 - P.U.A 434-2009*, Percetakan Nasional Malaysia Berhad, 2009.
- [8] M. S. Ummah, "National water quality standard for Malaysia," *Sustainability (Switzerland)*, vol. 11, no. 1, pp. 1-14, 2019.