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# Innovative Solutions for Melaka's River Water Treatment

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**ABSTRACT**

Melaka's rivers, essential for agriculture, drinking water, and transportation, face growing pollution challenges due to urbanization and industry, threatening their ecological balance. This study delved into the assessment of river water quality in Melaka and the design of a practical water treatment device tailored for river water purification. Extensive testing, involving Total Dissolved Solids (TDS) and pH analysis, shed light on the existing poor state of the Melaka River water. The devised water treatment device, encompassing diverse filter materials and a submersible pump, yielded noteworthy outcomes. Notably, experiment 4, employing activated carbon and cotton wool for both inlet and outlet, demonstrated the highest efficacy, reducing TDS levels by a remarkable 44.21%, surpassing other trials. The employed materials exhibited the potential to neutralize pH levels and clarify river water, with cotton wool effectively trapping residues and impurities.

## 1. Introduction

Water, vital for life and found abundantly on Earth, is a clear, odorless liquid. Its unique properties impact climate, sustain ecosystems, and support biological processes. Seawater, covering 70% of the planet, is mostly pure water with some salt and trace elements. Marine life is diverse, including plankton, plants, invertebrates, fish, and mammals. Rivers are flowing bodies of water, crucial for ecosystems and often stretching thousands of miles. Water's pH varies due to factors like carbon dioxide dissolution and natural processes, usually ranging from slightly acidic to slightly alkaline. Innovative sewage treatment tanks enhance cleaning efficiency and allow circular treatment for sewage through activated carbon and biological packing layers. Countries worldwide face challenges in meeting the increasing demand for water supply due to rapid urbanization and population growth, impacting the health and well-being of their citizens [1].

Surface water encompasses flowing or standing water found on the Earth's surface, including streams, rivers, and reservoirs [2]. Rivers, often situated in densely populated and industrialized regions, provide crucial resources for human consumption, agriculture, and industry [3,4]. However,

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the water quality of rivers is frequently compromised by a wide range of natural and human-induced pollutants entering the river, leading to its degradation [5]. Pollution sources may include various human activities such as sewage discharges, agricultural runoff, industrial waste disposal, human waste, and natural processes [4]. In recent times, water pollution has become a pressing issue in Malaysia. The rivers in Malaysia have traditionally been extensively utilized for domestic purposes, agriculture, drinking, cooking, washing, and everyday requirements [6].

Rivers are vital to Malaysian society and the environment. They support cities, but water quality issues are a concern. "Water quality" refers to water's ability to sustain various uses [7]. 98% of water is from rivers, with 70% used in agriculture, impacting people's lives through transportation, recreation, electricity, irrigation, and drinking water. Urbanization and modernization contribute to river water pollution in Malaysia [8]. According to the 2020 Department of the Environment data, there were 579 rivers in 2008, and currently, 672 rivers are monitored as shown in Figure 1 [9]. In the Malaysian Environmental Quality Report 2020, out of these 672 rivers, 443 (66%) had satisfactory water quality, 195 (29%) were significantly polluted, and 34 (5%) were severely polluted. Factors contributing to this pollution include high levels of biochemical oxygen demand (BOD), ammoniacal Nitrogen (AN), and suspended solids (SS) [9]. Excessive BOD is often due to untreated sewage and industrial/agricultural waste, while ineffective land removal and excavation techniques are major causes of SS [9]. Animal agriculture and domestic waste may be the primary sources of AN pollution [9]. The upstream areas of Skudai River and its tributaries had superior water quality compared to downstream sections [10]. There was a notable rise in key water quality parameters (BOD, NH3-N, etc.) downstream, suggesting local pollutants might be gradually impacting the river's water quality [10].


**Fig. 1.** Water quality trend of river in Malaysia 2008-2020 [9]

Waste from agriculture, industrial sewage, and human activities is affecting the boundary between clean water and wastewater, reducing the fresh water supply [11]. Water ecosystems provide essential services like food production, habitat creation, and flood control, but contamination can lead to diseases like hepatitis and pneumonia. Non-biological impurities such as silica, sodium, and heavy metals like cadmium and lead are also present. Pathogenic microorganisms like Salmonella, Poliovirus, and Giardia can be found in river water, emphasizing the need for early detection to prevent infections. Common contaminants in river water include E. coli, Giardia, Cryptosporidium, Legionella, and Pseudomonas [12]. Microalgal cultivation in photobioreactors offers an effective solution for wastewater treatment [13].

Effluents from the textile industry containing elevated levels of heavy metals are a significant source of water pollution. Employing activated carbon derived from agricultural waste like banana peels through adsorption presents an economical and environmentally friendly method for treating textile wastewater [14]. The research also highlighted the benefits of silica content present in agricultural waste. It serves not only as an affordable raw material but also as a problem-solving component that improves the removal of heavy metals in textile wastewater [15]. In another study, activated carbon sourced from coconut shells proved to be a successful method for eliminating Rhodamine-B from wastewater [16]. Zeolite demonstrates effectiveness in eliminating heavy metals from textile wastewater, exhibiting a removal rate exceeding 50% for lead (Pb), chromium (Cr), cadmium (Cd), and copper (Cu). The introduction of alum into zeolite significantly amplifies heavy metal removal, achieving removal rates of up to 80% for Cd and Cu [17].

Melaka River is situated in the historic city of Melaka, Malaysia. It flows through the central part of the city, serving as a vital watercourse with a length of approximately 10 kilometers. The width of the Melaka River can vary along its course, encompassing narrower sections in some areas and wider expanses in others. The river plays a crucial role in the cultural and economic life of Melaka, historically serving as a trade route. Today, Melaka River has become a popular tourist attraction, with activities such as river cruises allowing visitors to explore its scenic surroundings and historical landmarks. The riverbanks are adorned with vibrant murals and provide a picturesque backdrop for the city's cultural heritage.

The water quality in the Melaka River has been on the decline due to a rise in sources of pollution. Incidents of environmental pollution, such as a fish kill episode, have been reported in the Melaka River [18]. This event saw a significant number of wildlife and freshwater fish found floating and deceased in the river due to a decrease in dissolved oxygen concentration [19]. Local guides and fishermen reported similar incidents occurring multiple times in previous years [20]. Melaka River frequently experienced foul smells due to gas emissions during hot weather, adversely affecting the local populace [21]. This observation was supported by Rosli *et al.,* [19], which categorized the downstream section of Melaka River as highly polluted due to its dark brown appearance and noxious odor. This deterioration was likely due to the area's high population density and rapid urban development. In a recent development, hotspot analysis was conducted in the Melaka River basin utilizing GIS-based pattern recognition techniques [22]. This analysis aimed to pinpoint pollutant sources and underscored the crucial need to grasp the interconnection between land usage and water quality at a catchment scale, allowing for effective measures to counter ongoing deterioration and combat severe pollution.

The quality of river water is a critical concern for both environmental preservation and public health. Rivers play a fundamental role in supporting ecosystems, serving as sources of drinking water, and contributing to various economic activities. In the Malaysian state of Melaka, the health of its rivers is of paramount importance, given their significance to the region's vitality. However, issues related to water quality have raised substantial challenges. Ensuring that river water is safe for consumption and suitable for its various applications necessitates innovative solutions. This study delves into the evaluation of Melaka's river water status and the development of an efficient water treatment device tailored to address these challenges. Through rigorous testing and experimentation, this research aims to not only diagnose the state of Melaka's rivers but also to propose practical strategies for enhancing river water quality and sustainability.

## 2. Experimental Setup

### *2.1 Design of Water Treatment Device*

Autodesk Inventor Professional 2023 was used to design the water treatment device. The concept involves employing a rectangular box as the primary container for the water treatment process. This container will feature two strategically positioned holes at opposite ends, serving as the water inlet and outlet. Figure 2 illustrates the design of the water treatment device.

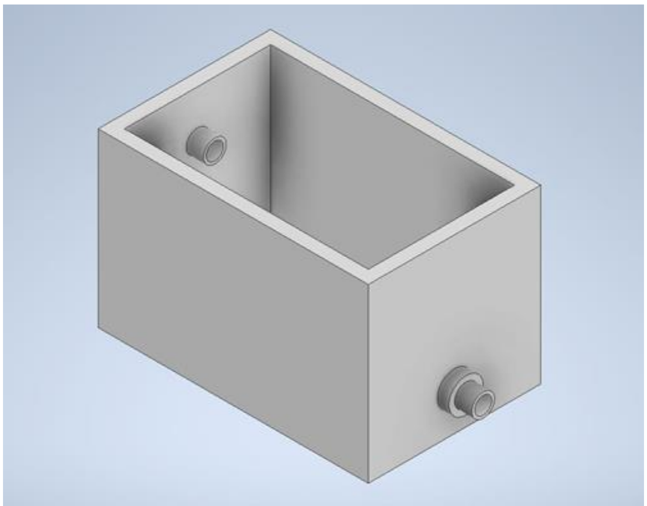


**Fig. 2.** Design of water treatment device

### *2.2 Materials*

In this experiment, we will employ three materials: sand, activated carbon, and zeolite. Sand is chosen for its ease of use, cost-effectiveness, and efficiency in removing floating particles. Despite its relatively short lifespan, activated carbon is selected for its proficiency in eliminating bad tastes and odors, affordability, and low maintenance requirements. Zeolite, known for its ability to absorb oil and heavy metals, is included due to its long lifespan, cost-effectiveness, and easy maintenance.

### *2.3 Methodology*

We modified a rectangular box by drilling two 15mm diameter holes on the left and right sides, inserting 15mm PVC tank connectors into these holes. The container is then layered with water treatment materials, washed and rinsed beforehand to remove residue. Starting from the bottom, we placed coarse silica sand (2mm-4mm), followed by medium fine silica sand (1mm-2.8mm), and finally fine silica sand (0.5mm-1.5mm). The setup is completed with zeolite and activated carbon.

To assess river water quality, we used a Total Dissolved Solids (TDS) meter, a water quality tester, before initiating the treatment experiment. A pH test follows the quality assessment. Afterward, the river water is transferred to a container. A submersible water pump in the container draws the water, connected to 16mm diameter, 3-meter long PVC hose. The hose links the pump outlet to the water treatment device water inlet, allowing the river water to be drawn into the treatment system. Figure 3 illustrates the experimental setup of the water treatment device.

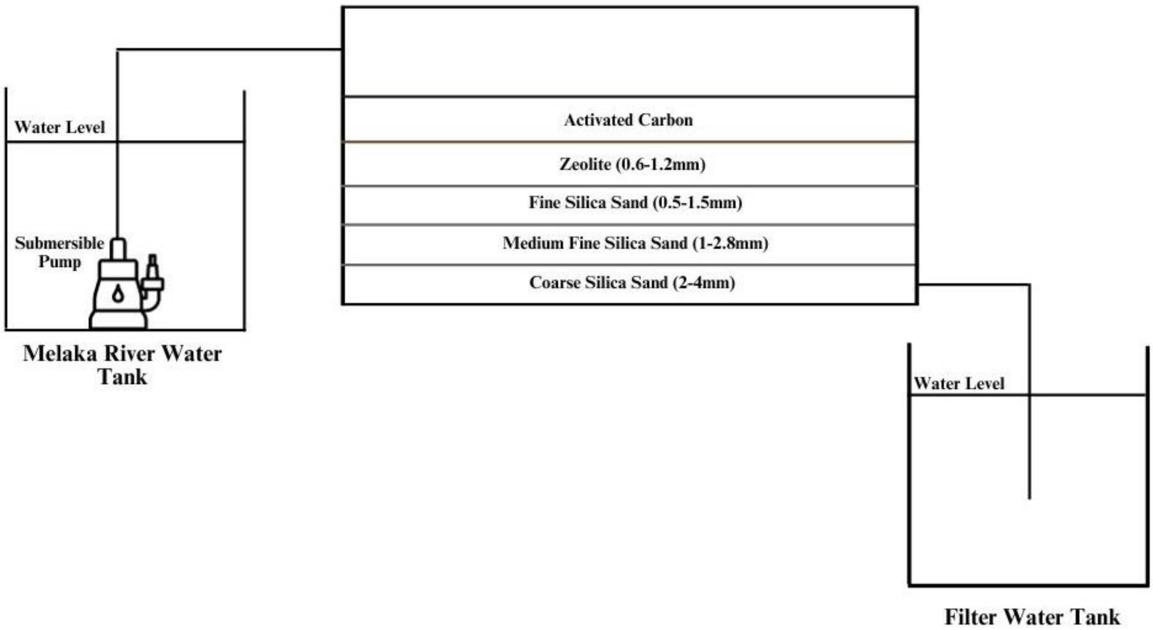



**Fig. 3.** Experimental setup of water treatment device

After completing the setup, the submersible water pump is activated to commence the experiment. Purified water is then collected at the outlet of the water treatment device, and the assessment of river water quality begins using the TDS meter and pH tester. Once data collection is finished, the filter media at both the water inlet and outlet will be replaced with cotton wool.

## 3. Results and Discussion

We conducted the experiment four times, altering the material configuration to assess the significance of the materials used in the water treatment device. In the first stage, we employed the water treatment device with sand and zeolite without activated carbon, using coffee filter paper. In the second stage, we replaced it with cotton wool. In the third and fourth stages, we introduced activated carbon along with coffee filter paper and cotton wool, respectively.

Table 1 to Table 4 present the results of the TDS and pH measurements for experiments 1, 2, 3 and 4, respectively. This experiment involves testing water quality before and after experiment. To ensure accuracy, the experiment is repeated three times to calculate an average value. The data in Table 1 to Table 4 show that the water treatment process effectively reduced TDS levels and slightly adjusted the pH of the water.

**Table 1**
Experiment 1 without Activated Carbon and Coffee Filter Paper

| | TDS, ppm | | pH | |
|---|---|---|---|---|
| | Before | After | Before | After |
| 1 | 745 | 617 | 10 | 8.5 |
| 2 | 750 | 608 | 9.6 | 8.0 |
| 3 | 742 | 612 | 10 | 8.0 |
| Average | 745.66 | 612.33 | 9.87 | 8.17 |

**Table 2**
Experiment 2 without Activated Carbon and Cotton Wool

| | TDS, ppm | | pH | |
|---|---|---|---|---|
| | Before | After | Before | After |
| 1 | 698 | 580 | 10 | 8.0 |
| 2 | 686 | 569 | 9.6 | 7.6 |
| 3 | 694 | 574 | 10 | 8.0 |
| Average | 692.67 | 574.33 | 9.87 | 7.87 |

**Table 3**
Experiment 3 with Activated Carbon and Coffee Filter Paper

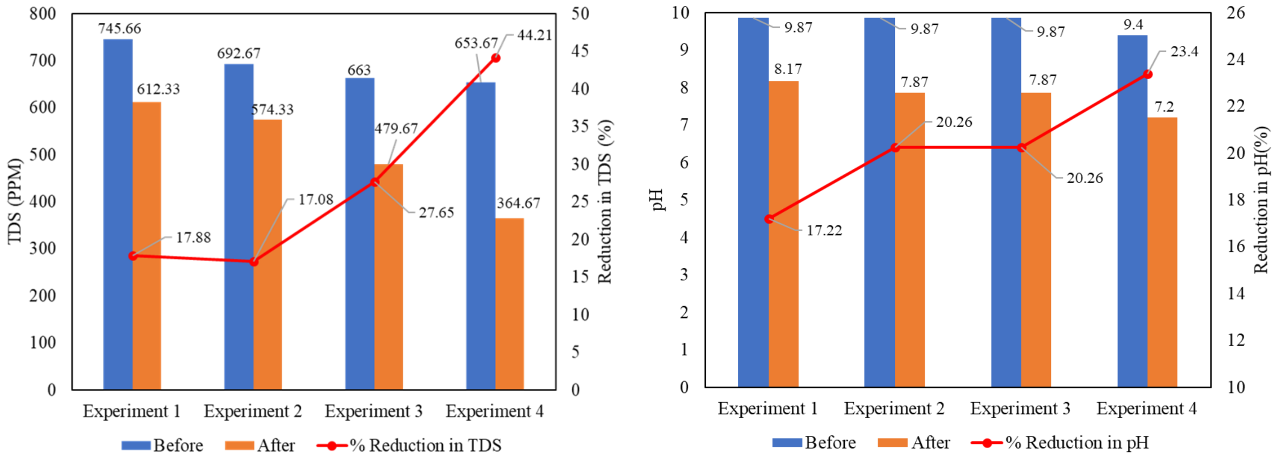
| | TDS, ppm | | pH | |
|---|---|---|---|---|
| | Before | After | Before | After |
| 1 | 662 | 484 | 10 | 8.0 |
| 2 | 668 | 475 | 10 | 7.6 |
| 3 | 659 | 480 | 9.6 | 8.0 |
| Average | 663 | 479.67 | 9.87 | 7.87 |

**Table 4**
Experiment 4 without Activated Carbon and Cotton Wool

| | TDS, ppm | | pH | |
|---|---|---|---|---|
| | Before | After | Before | After |
| 1 | 655 | 366 | 9.6 | 7.0 |
| 2 | 660 | 358 | 9.6 | 7.0 |
| 3 | 646 | 370 | 9.0 | 7.6 |
| Average | 653.67 | 364.67 | 9.4 | 7.2 |

Figure 4(a) and Figure 4(b) illustrate the experimental results for TDS and pH, respectively. In Figure 4(a), the experiments aimed at evaluating the effectiveness of a water treatment device in reducing TDS levels in river water, employing activated carbon and various filter materials. Initial TDS levels before treatment were 745.66 PPM, 692.67 PPM, 663 and 653.67 PPM for experiments 1, 2, 3 and 4, respectively. These values suggest that the water sources used in these experiments contained a high to moderate concentration of dissolved solids. After the water treatment process, the TDS levels decreased to 612.33 PPM, 574.33 PPM, 479.67 PPM and 364.67 for experiments 1, 2, 3, and 4, respectively. These lower values indicate that the treatment process effectively removed a significant portion of the dissolved solids from the water. The findings revealed that incorporating activated carbon significantly improved TDS reduction, with Experiment 3 (activated carbon with coffee filter paper) demonstrating a substantial reduction of 27.65%, and Experiment 4 (activated carbon with cotton wool) achieving the highest reduction at 44.21%. Remarkably, research conducted by Kamal *et al.,* [23] and Erabee and Ethaib [24], corroborate the significant role of activated carbon in TDS adsorption due to its large surface area. These results underscore the importance of activated carbon in enhancing water treatment efficacy. Additionally, the choice of filter material played a role, with coffee filter paper slightly outperforming cotton wool. These findings highlight the potential for optimizing the treatment process to further enhance water quality improvement, making this approach promising for practical applications and environmental preservation.

The experiments explored the water treatment device impact on pH levels in river water, varying the use of activated carbon and different filter materials as shown in Figure 4(b). The initial pH levels before treatment were 9.87, 9.87, 9.87 and 10.0 for experiments 1, 2, 3 and 4, respectively. These values indicate that the water sources were alkaline, as they are above the neutral pH of 7.0. Extremely high pH levels can be problematic for aquatic life. After the treatment process, the pH levels decreased to 8.17, 7.87, 7.87 and 8.0 for experiments 1, 2, 3 and 4, respectively. This reduction in pH suggests that the treatment process made the water slightly more acidic. The results consistently showed a decrease in pH levels after treatment in all experiments, indicating the device's effectiveness in reducing water alkalinity. The reduction percentages ranged from 17.22% to 23.4%, with Experiment 4 demonstrating the highest reduction. While activated carbon appeared to have a limited influence on pH reduction compared to its impact on TDS reduction, the findings underscore the potential for fine-tuning pH adjustments through the treatment process for specific water quality improvement goals. These results have environmental implications, highlighting the importance of monitoring and controlling pH levels within suitable ranges for different applications to ensure both water quality improvement and ecosystem preservation.




(a) (b)

**Fig. 4.** Experimental results before and after treatment (a) TDS (b) pH

## 4. Conclusions

The study conducted on the river water status in Melaka and the design of a water treatment device for river water has yielded significant insights. The results from TDS and pH testing have revealed the poor quality of the river water in Melaka. The designed water treatment device, incorporating filter materials and a submersible pump, has provided valuable data. Experiment 4, utilizing activated carbon and cotton wool for both inlet and outlet, delivered the most promising results, reducing the total dissolved solids (TDS) in river water from an initial average of 653.67 PPM to an average of 364.67 PPM, representing a remarkable 44.21% reduction—the highest among the experiments conducted. The materials used, including coarse sand, medium fine sand, fine sand, zeolite, and activated carbon, have demonstrated the potential to neutralize pH levels and clarify the river water. Cotton wool proved effective in trapping residues and impurities.

In terms of future improvements, there are several recommendations to enhance the water treatment device's performance. Firstly, increasing the device's size to accommodate more filter materials could lead to improved water quality outcomes. Additionally, the inclusion of ion-exchange resins may help remove specific ions and contaminants, enhancing the device's effectiveness. Consideration can also be given to incorporating a reverse osmosis membrane, although its high cost should be weighed against its potential benefits. Lastly, the introduction of ceramic filters, known for their ability to trap bacteria and sediment, could further enhance the water quality of the river. The choice of filter material should align with the specific impurities present in the water and the desired water quality goals, emphasizing the importance of tailored solutions for optimal results.

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