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PERFORMANCE OF CORN COB ACTIVATED CARBON AS FILTER MEDIA IN RAINWATER TREATMENT

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Abstract— This study investigates the utilisation of corn cob activated carbon filters in rainwater collection systems. A significant number of conventional water filters utilise non-recyclable materials, hence giving rise to environmental problems over their disposal. The research encompassed the development of a filter utilising corn cob as a natural waste material, the evaluation of water quality pre- and post-treatment, and the assessment of the filter's efficacy. The activated carbon layer varied among the three designs: Design 1 had no activated carbon, Design 2 had 10 g, and Design 3 had 50 g. The experiments conducted assessed multiple water quality indicators, such as turbidity, colour, pH, nitrate, total

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dissolved solids, coliform, and E. coli. The examination of the gathered data indicated that Design 3 is the most efficacious course of treatment. The study conclusively demonstrated the effectiveness of corn cob activated carbon filters in substantially enhancing the quality of rainwater.

I. Introduction

Rainwater harvesting systems have evolved as a realistic and sustainable way to minimise the negative impacts of water scarcity. These systems are designed to capture, transport, gather, and retain rainfall from rooftops for a range of uses, such as household, industrial, and replenishing groundwater [1]. Nevertheless, in order to safely use rainwater, particularly for non-potable uses, it is crucial to employ effective disinfection methods that fulfil rigorous quality standards [2].

An effective method for enhancing the quality of collected rainwater entails utilising activated carbon filters constructed from environmentally sustainable materials [3-5]. This filtration technology has the potential to decrease dependence on centralised systems and improve community resilience by offering an autonomous way to purify rainwater [6,7]. This study examines the utilisation of corn cob activated carbon filters for rainwater treatment, a technique specifically applicable to countries such as Malaysia, where water treatment facilities often cease operations, resulting in water scarcity.

II. Methodology

A. Rainwater

The rainwater harvesting sample was collected from the collection area at Block 1 Complex of Engineering, Universiti Teknologi MARA, Shah Alam. A rainwater sample of approximately 2000 ml was collected for the purpose of analysing and testing. The rainwater sample was collected from a single event of rainfall.

Water bottles were utilised for the purpose of containing water samples and were appropriately marked with labels indicating the specific date and time of collection. The sample was promptly transported to the laboratory within 24 hours. The rainwater samples were analysed to assess their physical, chemical, and bacterial characteristics using specific parameters.

B. Corn Cob Activated Carbon

The primary source of material to produce activated carbon in this study was corn cobs acquired from a local market in Shah Alam, Selangor. Originally, corn kernels were manually extracted from the cobs, thereafter, sliced into 5mm sections, and left to dry in the sun for a duration of two days in order to decrease the moisture content. The dried corn cob pieces were subjected to a pre-carbonization procedure at a temperature of 400°C for a duration of two hours in a muffle furnace. After undergoing pre-carbonization, the corn cobs were ground and sieved to obtain self-adhesive carbon particles with a grain size less than 600 mesh. Subsequently, chemical activation took place by thoroughly mixing the carbon grains with potassium hydroxide at a variable ratio of 1:2. Subsequently, the mixture was transported to a muffle furnace and subjected to a temperature of 900°C for a duration of one hour, so initiating the activation process of the carbon. Rinsing the activated carbon multiple times with distilled water eliminated contaminants, leading to a pH level of 9. Afterward, the activated carbon was subjected to a drying process at a temperature of 105°C for a duration of 24 hours to ensure thorough removal of moisture prior to its utilisation in the filtration procedure.

C. Filter Design

The filter system was designed in three distinct setups, each consisting of a cotton layer, a sand layer, an activated carbon layer, and a tiny rock layer. Two of the designs utilised activated carbon in different quantities: 0g, 10g, and 50g. The remaining layers were maintained at a fixed height of 3 cm apiece. The initial water quality measures, such as turbidity, colour, pH, nitrate, and total dissolved solids, were evaluated. Each filter design treated 500 cc of rainwater, and the treated samples were correctly labelled. In order to evaluate the efficiency of the filters, a sequence of physical, chemical, and bacterial examinations was performed on the rainwater that had been filtered. The data were examined to assess the effect of the filtering process on enhancing water quality.

The rainwater samples that had been filtered were tested for several tests in order to assess their quality after the filtration process. The tests comprised physical evaluations, including measurements of turbidity and colour, chemical analyses such as pH, nitrate concentrations, and total dissolved solids, as well as biological tests to identify coliforms and E. coli.

Figure 1: Corn Cob Activated Carbon Production

Figure 2: 3 Filter Designs

D. Data Collections

Multiple tests, including physical, chemical, and biological testing, were performed to assess the quality of the rainfall. The experiments were conducted to assess the effectiveness of the filter in enhancing water quality. The physical tests conducted included turbidity testing, colour testing, and pH measurement. The chemical tests conducted included the nitrate test and the measurement of total dissolved solids. Additionally, biological tests were performed to detect the presence of coliform bacteria and E. coli. The test results were compared to evaluate the influence of the filtering process on the rainwater quality.

III. Results and Discussion

A. Rainwater Characteristics

The early collected rainfall samples offer valuable insights into the initial characteristics of rainfall. The turbidity measurement of 6.51 NTU and colour value of 17.5 Pt/Co. The pH level of 7.75 indicates a slightly alkaline nature. The rainwater at the specific area where it precipitates has a low nitrate concentration of merely 0.28 mg/L. The TDS value of 9.75 mg/L signifies a little presence of dissolved minerals and salts, indicating the exceptional purity of the rainfall. However, the coliform bacteria count, recorded at 1011.2 MPN and the E. coli count is relatively low at 3 MPN.

Table 1: Untreated Rainwater Characteristics

Parameter	Data		
	RW1	RW2	Average
Turbidity	5.35	7.66	6.51
Colour	17	18	17.5
pH	7.95	7.55	7.75
Nitrate	0.25	0.31	0.28
Total dissolved solid	7.5	12	9.75
Coliform	1011.2	1011.2	1011.2
E. coli	3	3	3

B. Treated Rainwater

The study showed that using corn cob activated carbon helps make rainwater clearer and safer to drink. Turbidity, which is how cloudy the water is, started at 6.51 NTU in untreated rainwater. When no activated carbon was used (Design 1), turbidity dropped to 3.43 NTU, removing 47.31% of the cloudiness using only cotton and sand. Adding 10 grams of activated carbon (Design 2) reduced turbidity to 2.27 NTU, a 65.13% improvement. The best result came with 50 grams of activated carbon (Design 3), reducing turbidity to 1.58 NTU, a 75.73% reduction. This shows that more activated carbon leads to clearer water.

For color, untreated rainwater started with a color value of 17.5 Pt/Co. Design 1 reduced the color by 5.7%, while Design 2 removed 22.9%, and Design 3 achieved the best result with a 42.9% reduction. This proves that activated carbon plays an important role in removing color. However, other materials like coconut shell activated carbon are better, as they can remove up to 90% of the color.

The pH of rainwater was 7.75, slightly basic. Design 1 had a pH of 7.24, slightly acidic. With 10 grams of activated carbon in Design 2, the pH increased to 8.52, and with 50 grams in Design 3, it rose to 8.95, the most basic result. This shows that activated carbon raises the pH of filtered water.

For nitrate removal, Design 1 (no activated carbon) had very little effect. Adding 10 grams of activated carbon (Design 2) improved nitrate removal, and 50 grams (Design 3) removed the most nitrates. This shows that the tiny holes in activated carbon traps are more nitrates as the amount of carbon increases.

Activated carbon also helps remove dissolved solids and bacteria. Without it, Design 1 removed 30.77% of solids and 64.90% of coliform bacteria. Adding 10 grams of activated carbon in Design 2 raised solid removal to 76.92% and bacteria removal to 92.28%. With 50 grams in Design 3, solid removal reached 84.62%, and bacteria removal improved to 97.34%.

Table 2: Summary of Percentage Removal for Each Filter Design

Parameter	Percentage removal (%)		
	Design 1	Design 2	Design 3
Turbidity	47.31	65.13	75.73
Colour	5.7	22.9	42.9
pH	7.24	8.52	8.95
Nitrate	23.21	76.79	83.93
Total dissolved solid	30.77	76.92	84.62
Coliform	64.9	92.28	97.34
E. coli	83.33	100	100

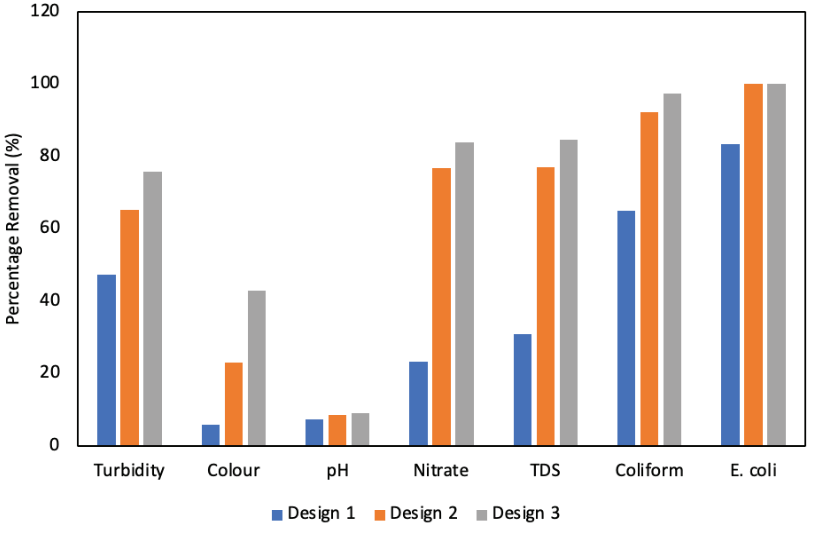

Figure 3: Percentage Removal of Each Filter Design

For E. coli, Designs 2 and 3 both removed 100%, showing that just 10 grams of activated carbon is enough for complete removal.

Overall, Design 3 was the best, removing the most turbidity (75.73%), color (42.9%), nitrates (83.93%), solids (84.62%), and coliform bacteria (97.34%). However, Design 2 also performed well and could be cheaper and easier to use. These results show that activated carbon is very effective for water filtration, making rainwater cleaner and safer. It is evident that activated corn cob is highly effective in enhancing water quality in both the Kubanni River and River Shika. It showed that activated corn cob outperforms charcoal and bone char in reducing contaminants from the water sources [4].

IV. Conclusion

The development of activated carbon filters using corn cobs resulted in three distinct designs, each effectively improving the quality of rainwater. The filters showed notable reductions in turbidity, color, nitrate, total dissolved solids, coliform, and E. coli levels, indicating enhanced water quality post-treatment. Furthermore, the assessment of filter effectiveness demonstrated that Design 3 was the most efficient, achieving significant removal percentages for various contaminants. Therefore, the study successfully met its objectives, showcasing the potential of corn cob activated carbon filters for rainwater treatment.

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