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Utilizing Activated Carbon for the Remediation of Textile Waste in River Water

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Abstract

Organic and chemical contamination of surface and groundwater resources in the Valapattanam River in Kannur district, coupled with dumping of waste and unscientific sewage disposal has raised concerns about the health hazards for people living in the river basin areas. The environmental monitoring programme on water quality conducted by the Kerala State Council for Science, Technology and Environment is an eye-opener to the water pollution in the river basin.

This study explores a sustainable solution remarkably for reducing river water contaminated by textile waste using activated carbon (AC) from various agricultural and food waste products, like sawdust, sugarcane bagasse, rice husk, garlic peel, pistachio shell and areca nut husk as adsorbents. The effectiveness of AC were measured through its physical properties such as moisture content, bulk density, iodine number and cation exchange capacity (CEC) along with its ability to improve water quality parameters like dissolved oxygen (DO) levels and total hardness of water. Analysis of dye adsorption using methylene blue and malachite green were also performed. The findings reveal that activated carbon, sourced from a variety of waste products, is a viable and environmentally friendly option for reducing water pollution and enhancing its quality.

Index Terms: Activated carbon, Saw dust, Sugarcane bagasse, Rice husk, Garlic peel, Pistachio shell, Areca nut husk, Moisture content, Bulk density, Cation exchange capacity (CEC), Dissolved oxygen (DO), Total hardness, Carbonisation, Methylene blue, Malachite green, Eco-friendly water treatment.

1. INTRODUCTION

Valapattanam River, also known for its mangrove forests and fishing harbour, is the major source of water in Kannur, a district in North Kerala which stretches a majestic 110 kilometres to the Arabian Sea. Its banks are a testament to India's rich heritage in wood-based industries, with the renowned Western India Plywood Limited standing as a giant in this sector. Settlements along its course, in their daily rhythms, inadvertently contribute to sewage and refuse, compromising the river's purity. Industries nestled in its lower reaches discharge between 50 to 200 kilolitres of waste per day. The heavy use of fertilizers and pesticides in these fields trickles into the river, further degrading its water quality. This narrative, painted by the Kerala State Pollution Control, is a call to action—a reminder of the delicate balance between industry and ecology, and the pressing need to adopt sustainable practices to preserve the health of the Valapattanam River for generations to come. [1].

The dyeing industry generates wastewater that is a significant environmental challenge. Synthetic dyes, popular for their longevity and colour options, are the primary culprit for the high concentration of used dyes in the wastewater. These dyes, being complex organic compounds, are stubborn pollutants that resist breakdown, leading to the deterioration of water quality and posing risks to aquatic life. They obstruct sunlight penetration, affecting photosynthesis, and are linked to serious health concerns like skin cancer and genetic mutations [2]. These pollutants increase the water's biological and chemical oxygen demand (BOD and COD), hinder plant growth, and can accumulate in the food chain, potentially causing toxicity, mutations, and cancer in higher organisms [3].

To combat this, traditional techniques like chemical oxidation and membrane separation are effective but have limitations, including chemical overuse and incomplete colour removal [4]. Adsorption stands out as a superior method due to its simplicity, efficiency, and eco-friendliness. Activated carbon, known for its expansive surface area and thermal stability, is particularly effective in adsorbing textile dyes, making it a preferred choice for water purification and does not require specialized equipment [2]. Effective measures must be adopted to protect and preserve aquatic life and water quality.

The successful application of our eco-friendly approach not only holds promise for restoring water quality but also for protecting aquatic ecosystems and public health. Ultimately, future studies on the same could pave the way for innovative solutions to environmental challenges like water pollution. Moreover, this study also encourages the recycling of waste materials into valuable resources, aligning with global efforts towards environmental conservation and sustainable industry practices.

2. REVIEW OF LITERATURE

Activated carbon, also known as activated charcoal, is a highly porous substance that excels at capturing primarily organic compounds from gases or liquids. Its widespread use as a purifier is due to its high carbon content, minimal ash presence, and diverse pore sizes, making it ideal for extracting natural organic substances, as well as unpleasant tastes and odours. The adsorption process involves the physical binding of molecules from gases or liquids to the vast surface area provided by activated carbon. Unlike graphite, activated carbon retains an irregular atomic structure even under heat, which contributes to its excellent filtration properties through abundant surface area and minuscule cavities. The porosity of activated carbon, which is integral to its adsorptive power, encompasses surface area, pore volume, and pore size distribution [5]. As noted in activated carbons are inherently porous and may contain mineral matter as ash up to 15%. The porosity originates from the carbonization process and is amplified during activation—a step that eliminates tar and other carbon-based substances from the gaps between primary crystallites. The source material and the specific activation method greatly influence the final pore structure and size distribution. The activation process involves a reaction with an activating agent, clearing away residual carbon and defining the quantity and dimensions of the pores in the final product. [6].

Sugarcane bagasse and sawdust are viable raw materials for activated carbon production due to their global abundance of 1.9 billion tonnes in all over the world making it the largest crop by production quantity and 130 lakh tonnes in India and roughly 224 tonnes of areca nut husk are produced every year in India. Other materials such as rice husk, garlic peel, pistachio shells, and areca nut husk also offer valuable adsorptive properties. These materials are abundant; sugarcane production reaches 1.9 billion tonnes globally, and India alone produces 130 lakh tonnes. Rice husk, a by-product of rice milling agro-based biomass industry, contains silica and has a microporous structure making it a good adsorbent. Garlic peel is not only cost-effective but also efficient in dye removal. Pistachio shells and areca nut husk, often considered waste, have significant cellulose content, making them suitable for adsorption after proper activation due to its good mechanical properties, non-toxic and easy disposability after use. These diverse materials present a sustainable approach to managing waste and treating water, turning what is often discarded into a resource for environmental purification.

3. MATERIALS AND METHODS

3.1 Collection of raw materials

Low-cost agricultural and wood wastes such as rice husk, sugarcane bagasse, pistachio shell, areca nut husk, garlic peel and sawdust were obtained from nearby markets and households because of their abundance in nature and cost-effectiveness.

3.2 Carbonisation of raw materials

After the collection of carbonaceous raw materials, they were dehydrated by heating at a temperature of 230°C for different time periods.

3.3 Activation of carbon by phosphoric acid

The dehydrated samples were chemically activated using phosphoric acid in a ratio of 1:1.

3.4 Characterization of activated carbon

Percentage Moisture Content

1gram of activated precursors were weighed, dried at 80℃ in an oven, and the weight was measured again until it stayed constant. This weight was then referred to as dry weight. The percentage moisture content was calculated using the formula:

% Moisture Content = Initial weight (wet weight) - Final weight (dry weight) /Initial weight x 100

Bulk Density

The mass of the activated carbon precursors were measured and recorded. A measured volume of water (100 mL) was placed within a graduated cylinder. Note the water volume in the cylinder. The volume of the sample is represented by this volume increase.

Bulk density can be calculated as:

Bulk density = Mass of the sample / Volume of the sample.

Iodine number

The milligram of iodine adsorbed by one gram of carbon is known as iodine number. The activated carbon surface area and micropore content can be roughly estimated using iodine number. Iodine number was calculated using the ASTM standard procedure. [7].

Iodine number was calculated using the formula:

Iodine number (mg/g) = (B-A) x CF

where, ‘B’ is the blank reading and ‘A’ is the titrant value

‘CF’ refers to the conversion factor.

CF = N x E x 10/ W x B (‘N’ is the normality of iodine, ‘E’ is the equivalent weight of iodine and ‘W’ denotes the weight of activated carbon used).

Cation exchange capacity

The cation exchange capacity of the activated carbon samples were measured using a modified version of Boehm’s approach. Activated carbon of various samples were weighed and put into a flask. 20 mL of 0.1M NaOH solution was added to it. The flasks were shaken for 24 hours to bring them to equilibrium. Following equilibration, phenolphthalein was used as an indicator in a titration with 0.1N HCl to determine the NaOH concentration. The titration process is continued until the pink colouration is gone[8].

CEC can be calculated using the formula:

CEC = (N_1-N_2) x V / m (where, N_1 and N_2 are the normalities of NaOH before and after equilibration, ‘V’ is the volume of NaOH taken in the flask and ‘m’ is the mass of activated carbon taken)

3.5 Analysis of water sample treated with activated carbon

Dissolved Oxygen

The level of dissolved oxygen in water is an indicator of the health of waterbodies with higher oxygen levels signifying a thriving ecosystem and lower pollution levels. Winkler’s method is utilized to determine the DO content of the water body.

Dissolved oxygen of the water sample can be calculated by the formula:

O_2mg/L = Titrant value x 0.25N x 8 x 1000 / Volume of the sample

Total Hardness

To estimate the hardness of water sample, take 100 mL of sample water in a flask and then add 2-3 mL of ammonia buffer. Add Eriochrome Black-T indicator to the solution, which turns it wine red. The solution is then titrated against EDTA until the wine-red colour changes into a blue colour sample. [9].

Total hardness can be calculated as:

Total Hardness as $CaCO_3$ (mg/L) = Titrant value x NCF x 1000 / Volume of the sample

Adsorption of Methylene blue and Malachite green from water using different activated carbons

Stock solution preparation

Methylene blue and malachite green were employed as adsorbates for the adsorption procedure. A stock solution containing 0.01 g of methylene blue and malachite green was made by dissolving the ingredients in 1000 mL of distilled water.

Activated carbon

Activated carbon of saw dust, sugarcane bagasse, pistachio shell, areca nut husk, rice husk and garlic peel were utilised in varied proportions for conducting adsorption of methylene blue and malachite green from water separately.

Adsorption

Five 250 mL volumetric flasks were used for this, and various weighted amounts of activated carbon- 0.2g, 0.4g, 0.6g, 0.8g, 1.0g, were introduced to each of these flasks. Once the activated carbon has been added, add the methylene blue and malachite green solution from the prepared stock until the 100 mL threshold is reached.

As the reaction developed, the absorbance of the solution was measured. It was observed that as time went on, the dye solution colour lightened and eventually turned colourless. A colorimeter was used to measure the OD measurements at intervals of one hour and then on alternate days.

Following the completion of the adsorption procedure, a bar graph was constructed to show the extent of adsorption caused by various concentrations of activated carbon sources.

4. RESULTS AND DISCUSSION

4.1. Percentage Moisture Content

Percentage moisture content of areca nut shell, garlic peel, saw dust, rice husk are 24.78% ,31.18 %,25.8 %,19.7 % respectively with all having a negative sign which indicates that it all lost moisture during drying. Sugarcane bagasse has a moisture content of 29.14% and pistachio shell moisture content of 18.9%. The ± 0 indicates minimal variation.

Among these materials, garlic peel exhibits the most significant moisture content at 31.18%, potentially due to its inherent organic properties. In contrast, pistachio shell records the least moisture content at 18.9%, indicating it is comparatively drier. Sawdust and rice husk present comparable moisture percentages, both evidencing moisture loss during the drying phase.

Table 1. Percentage Moisture content of various samples of activated carbon

S.No	Sample	Moisture Content (In Percentage %)
1.	Areca Nut Shell	24.776 -0.003
2.	Garlic Peel	31.184 -0.005
3.	Sugarcane Bagasse	29.139 + 0.004
4.	Saw Dust	25.867 - 0.046
5.	Pistachio Shell	18.9 ± 0
6.	Rice Husk	19.712 -0.001

*The values represents % moisture content assessed in triplicates

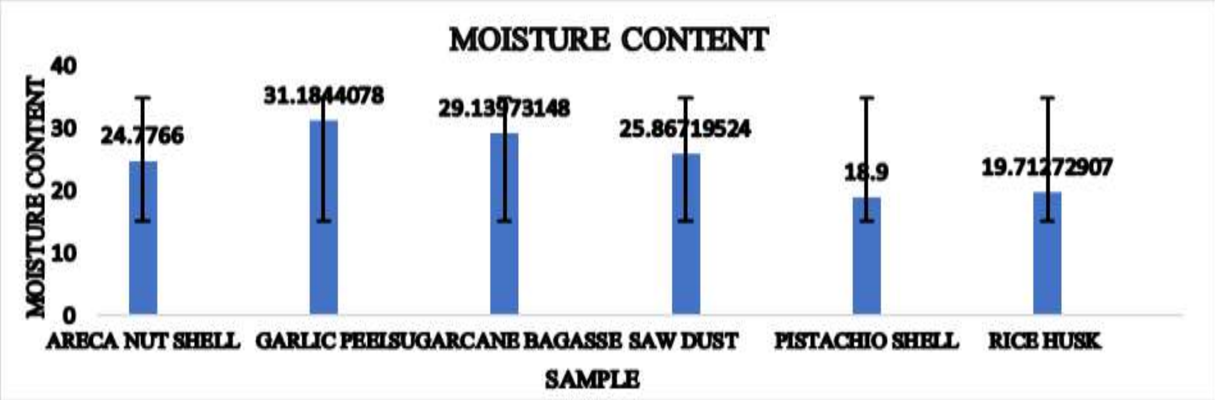

Figure 1. Percentage moisture content of various samples

4.2. Bulk Density

Rice husk and pistachio shell are lightweight with bulk densities of 0.5004 g/cm³ and 0.5012 g/cm³ respectively. Saw dust is slightly denser with a bulk density of 0.5093 g/cm³. Garlic peel has a higher bulk density of 1.0053 g/cm³ due to its denser nature. Sugarcane bagasse is lightweight with a bulk density of approximately 0.5015 g/cm³. Areca nut shell has the highest bulk density of approximately 1.0067 g/cm³, making it the densest material.

Table 2. Bulk Density of various samples of activated carbon

S.No.	Sample	Bulk Density (g/cm^3)*
1.	Rice Husk	0.500 ± 0.0003
2.	Pistachio Shell	0.501 ± 0.0008
3.	Saw Dust	0.509 ± 0.0004
4.	Garlic Peel	1.005 ± 0.0004
5.	Sugarcane Bagasse	0.501 ± 0.0005
6.	Areca Nut Shell	1.006 ± 0.004

*The values represent bulk density assessed in triplicates

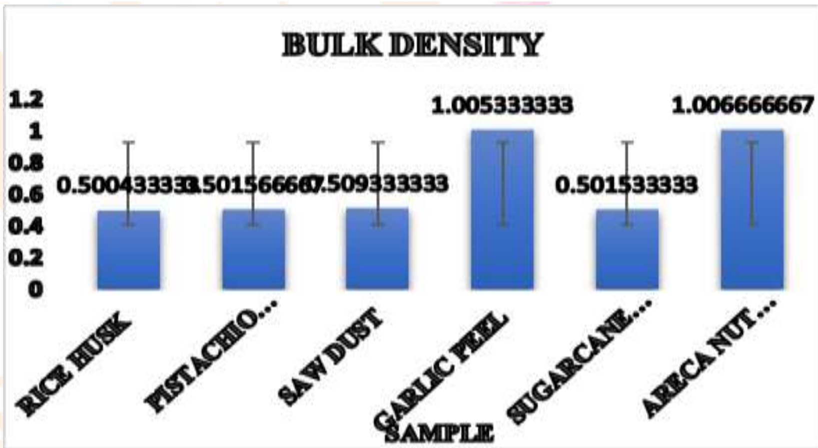

Figure 2. Bulk Density of various samples of activated carbon expressed in g/cm^3

4.3. Iodine Number

The iodine number of Saw Dust is approximately 355.32 mg/g, while Sugarcane Bagasse has the highest iodine number of all samples with approximately 1057.35 mg/g indicating the most unsaturation. Rice Husk has a lower iodine number of approximately 199.41 mg/g. Garlic Peel falls in between with an iodine number of approximately 246.34 mg/g. Pistachio Shell has a moderate unsaturation with an iodine number of approximately 201.88 mg/g. Areca nut shell has the second-highest iodine number, approximately 545.21 mg/g.

Figure 3 .

a)Sample before titration

b)Sample after titration

Table 3. Iodine number of various samples of activated carbon

S.No	Sample	Iodine Number (mg/g) *
1.	Saw Dust	355.32 ± 0.00
2.	Sugarcane Bagasse	1057.35 ± 0.20
3.	Rice Husk	199.406 ± 0.42
4.	Garlic Peel	246.34 ± 0.00
5.	Pistachio Shell	201.883 ± 0.11
6.	Arecanut Shell	545.21 ± 0.00

*The values represent iodine number assessed in triplicates

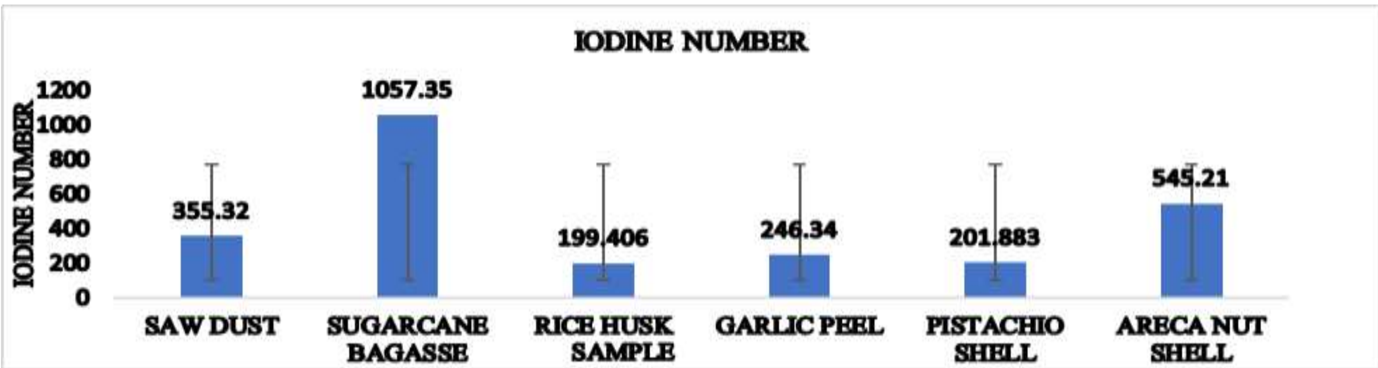

Figure 4. Iodine number of various samples of activated carbon expressed in forms of mg/g

4.4. Cation Exchange Capacity

The Cation Exchange Capacity (CEC) of different samples were measured. Saw dust has the highest CEC with 19.3 meq/g indicating its ability to retain cations, while sugarcane bagasse has a moderate CEC of 15.44 meq/g, similar to garlic peel. Areca nut shell has a slightly lower CEC of 13.9 meq/g. Rice husk and pistachio shell have similar CEC values at 18.24 and 17.8 meq/g, respectively. Overall, saw dust has the highest CEC among the samples.

Table 4. Cation Exchange Capacity of various samples of activated carbons.

S.No	Sample	Cation Exchange Capacity (meq /g) *
1.	Sugarcane Bagasse	15.44 ± 0.353
2.	Garlic Peel	14.7 ± 1.131
3.	Arecanut shell	13.9 ± 0.565
4.	Saw Dust	19.3 ± 0
5.	Rice Husk	18.24 ± 0.602
6.	Pisthachio Shell	17.8 ± 0.057

*The values represent CEC assessed in triplicates

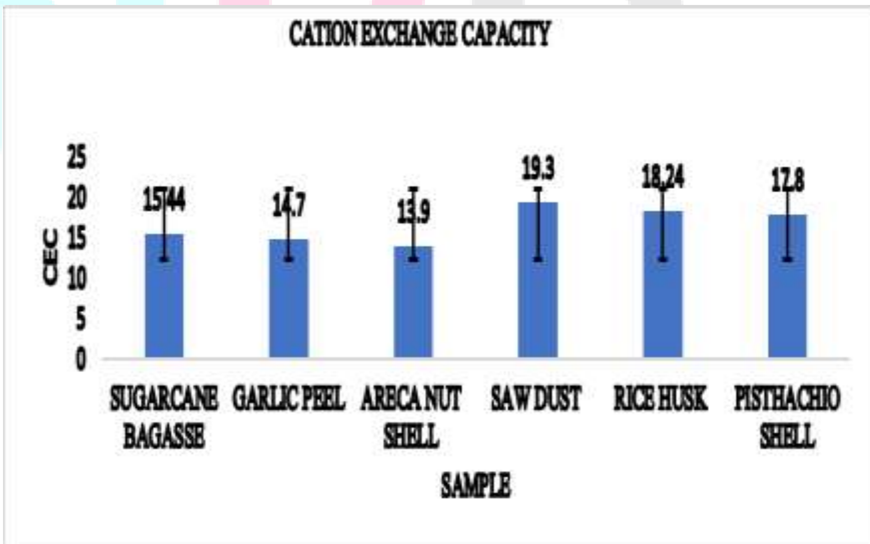

Figure 5. CEC of various samples of activated carbon expressed in forms of meq/g

4.5. ANALYSIS OF WATER SAMPLE TREATED WITH ACTIVATED CARBON

4.5.1. Dissolved Oxygen

The water samples treated with different carbonaceous sources were analysed for dissolved oxygen (DO) content. The results showed that the water sample had the highest DO content, which is expected for natural water. Samples treated with saw dust and rice husk had increased DO, while pistachio shell had the lowest DO content. Samples treated with garlic peel, sugarcane bagasse, and rice husk had similar DO levels. Samples treated with sugarcane bagasse and areca nut shell had maximum iodine values indicating their maximum pore size, but this led to a reduction in the amount of oxygen present in the water. The activated carbon may have retained the oxygen molecules within its porous structure, leading to a reduction in the amount of oxygen present in the water.

Table 5. Dissolved oxygen of various activated carbons.

S.No	Sample	Dissolved Oxygen (Mg/L) *
1.	Water Sample	52.56 ± 0.65
2.	Rice Husk	41.32 ± 0.05
3.	Pistachio Shell	24 ± 0.10
4.	Saw Dust	41.68± 0.11
5.	Garlic Peel	22.68 ± 0.11
6.	Sugarcane Bagasse	22.68± 0.05
7.	Areca Nut Shell	18.65 ± 0.05

*****The values represent DO assessed in triplicates.

Figure 6. DO Titration

FEPA Limits of Dissolved oxygen (mg/l): 5 – 20

Thus, in this case a sample treated with Arecanut shell was brought between the limits along with sugarcane bagasse and garlic peel nearing the same.

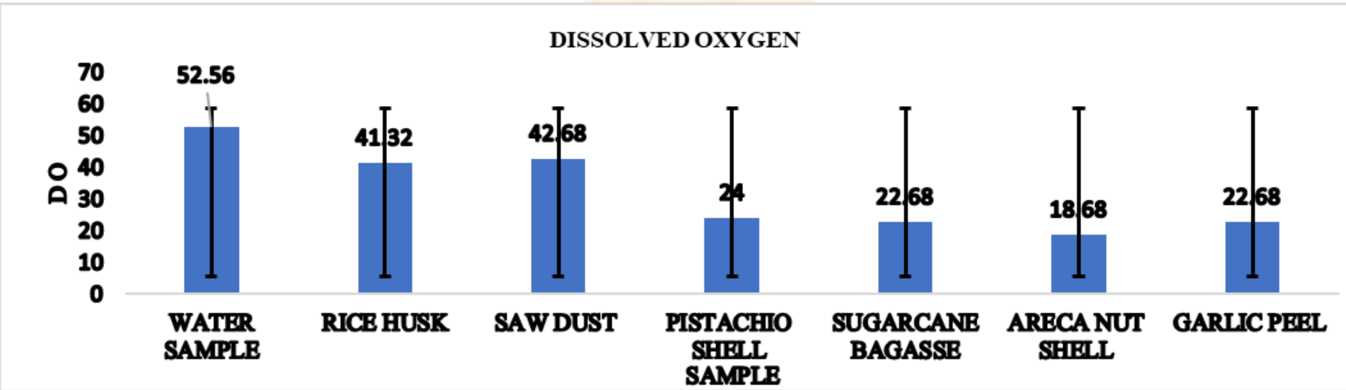

Figure 7. Dissolved oxygen of various samples of activated carbon expressed in forms of mg/ L.

4.5. 2. Total Hardness

Water samples treated with different natural substances were tested for their total hardness. The results showed that the pistachio shell treated water had moderate hardness at 101 mg/L, while the sugar cane bagasse treated water had a relatively low hardness of 74.5 mg/L. Sawdust treated water had the lowest hardness at 62.3 mg/L, followed by areca nut shell treated water at approximately 61 mg/L. Garlic peel treated water had higher hardness at approximately 81.67 mg/L, while rice husk treated water had moderate hardness at approximately 97.3 mg/L.

Table 6. Total hardness of various samples of activated carbon

S.No	Sample	Total Hardness $CaCO_3$ (Mg/L) *
1.	Water	118.67 ± 0.15
2.	Pistachio Shell	101 ± 0.14
3.	Sugarcane Bagasse	74.5 ± 0.07
4.	Saw Dust	62.3 ± 0.25
5.	Areca Nut Shell	61 ± 0.10
6.	Garlic Peel	81.67 ± 0.15
7.	Rice Husk	97.3 ± 0.11

*The values represent total hardness assessed in triplicates

Figure 8.Total Hardness

According to the WHO 2004 limits; 0-50: soft

50-100: moderately soft

100-105: slightly hard

Thus, in this study the water sample treated with 5 out of 6 samples of activated carbon reduced the hardness of water and brought down to the category of moderately soft as per the limits.

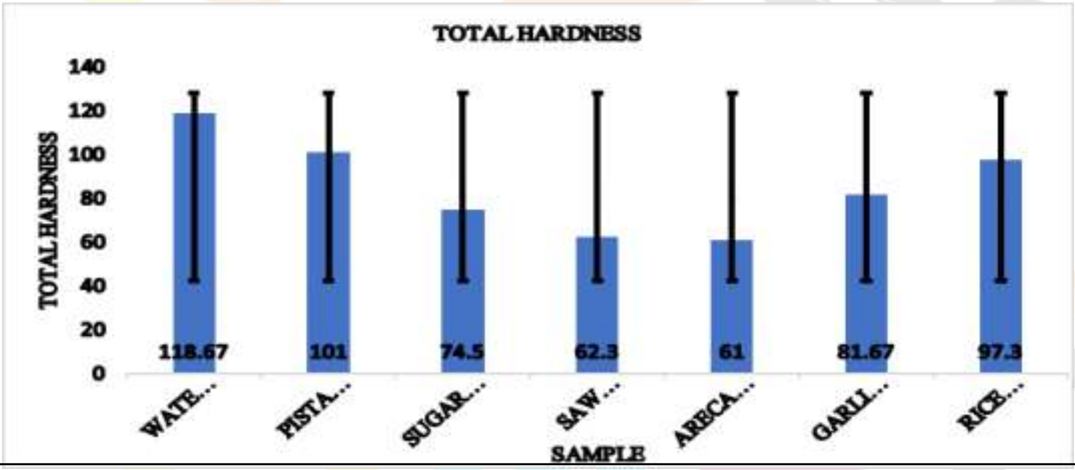

Figure 9. Total hardness as of CaCO3 of various samples of activated carbon expressed in forms of mg/L

4.5.3. ADSORPTION OF METHYLENE BLUE FROM WATER USING DIFFERENT ACTIVATED CARBONS

Comparing the absorbance for different activated carbon samples derived from various sources: sawdust, sugarcane bagasse, pistachio shell, areca nut shell, rice husk, and garlic peel and analysing the results showed that the absorbance values decrease over time with the lowest absorbance at 5 days (120 hours) Sugarcane bagasse shows the highest absorbance at 1 hour (0.44), indicating good adsorption capacity. Pistachio shell also performs well with an absorbance of 0.52 at 1 hour. Garlic peel has a consistent absorbance over time, suggesting stability. Sawdust, areca nut shell and rice husk exhibit lower absorbance values. Thus, we can interpret based on absorbance data that sugarcane bagasse and pistachio shell are the most promising activated carbon samples. Among these, sugarcane bagasse stands out for its consistent performance and high initial absorbance due to its combination of surface area, functional groups, and natural carbon content that makes it an excellent adsorbent.

Table 7. Adsorption of Methylene Blue dye using Saw Dust as activated carbon

Time	Wavelength	Absorbance Of Activated Carbon Of Saw Dust				
		0.2g	**0.4g**	**0.6g**	**0.8g**	**1.0g**
1hour	668 nm	0.48	0.39	0.38	0.34	0.33
2 hours		0.46	0.35	0.31	0.26	0.23
72 hours		0.29	0.06	0.05	0.04	0.03
120 hours		0.09	0.01	0.00	-0.01	-0.05

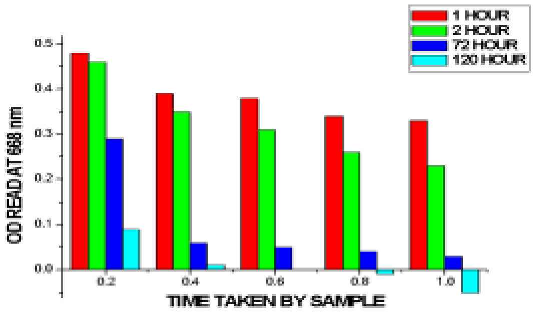

Figure 10.Adsorption of Methylene Blue dye using Saw Dust as activated carbon

Table 8. Adsorption of Methylene Blue dye using Sugarcane Bagasse as activated carbon

Time	Wavelength	Absorbance Of Activated Carbon Of Sugarcane Bagasse				
		0.2g	0.4g	0.6g	0.8g	1.0g
1 hour	668 nm	0.44	0.38	0.36	0.31	0.14
2 hours		0.40	0.35	0.33	0.23	0.07
72 hours		0.21	0.13	0.10	0.08	0.05
120 hours		0.06	0.05	0.03	0.02	-0.01

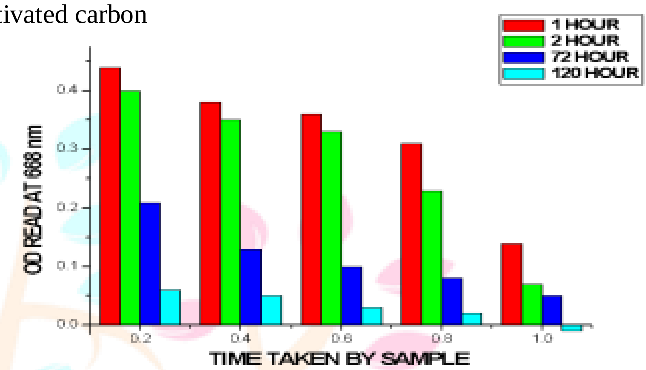

Figure 11.Adsorption of Methylene Blue dye using Sugarcane Bagasse as activated carbon

Table 9. Adsorption of Methylene Blue dye using Pistachio shell as activated carbon

Time	Wavelength	Absorbance Of Activated Carbon Of Pistachio Shell				
	668 nm	**0.2g**	**0.4g**	**0.6g**	**0.8g**	**1.0g**
1 hour		0.52	0.49	0.38	0.32	0.28
2 hours		0.46	0.40	0.25	0.18	0.15
72 hours		0.22	0.17	0.10	0.08	0.04
120 hours		0.12	0.09	0.03	0.01	-0.02

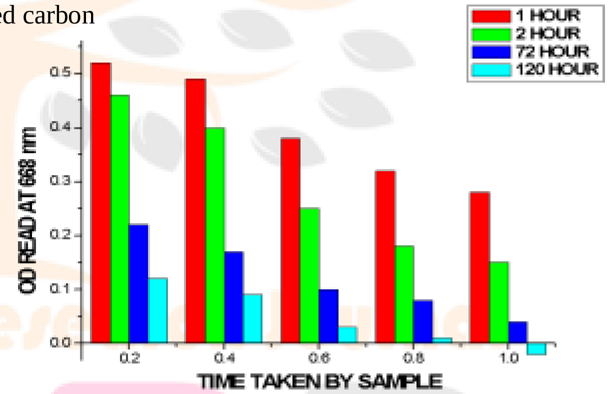

Figure 12.Adsorption of Methylene Blue dye using Pistachio shell as activated carbon

Table 10. Adsorption of Methylene Blue dye using Arecanut shell as activated carbon

Time	Wavelength	Absorbance Of Activated Carbon Of ArecaNut Shell				
		0.2g	**0.4g**	**0.6g**	**0.8g**	**1.0g**
1 hour	668 nm	0.44	0.38	0.29	0.28	0.26
2 hours		0.34	0.31	0.15	0.14	0.08
72 hours		0.22	0.18	0.07	0.06	0.04
120 hrs		0.03	0.02	0.00	-0.01	-0.02

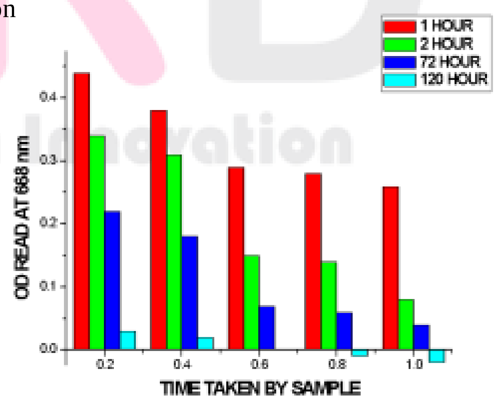

Figure 13. Adsorption of Methylene Blue dye using Arecanut shell as activated carbon

Table 11. Adsorption of Methylene Blue dye using Rice Husk as activated carbon

Time	Wavelength	Absorbance Of Activated Carbon Of Rice Husk				
		0.2g	**0.4g**	**0.6g**	**0.8g**	**1.0g**
1 hour	668 nm	0.34	0.30	0.26	0.24	0.20
2 hour		0.30	0.24	0.22	0.18	0.15
72 hours		0.21	0.18	0.15	0.12	0.09
120 hrs		0.05	0.03	0.01	0.01	-0.03

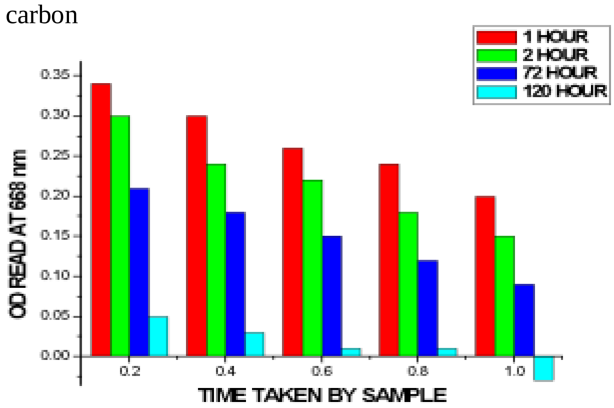

Figure 15.Adsorption of Methylene Blue dye using Rice Husk as activated carbon

Table 12. Adsorption of Methylene Blue dye using Garlic Peel as activated carbon

Time	Wavelength	Absorbance Of Activated Carbon Of Garlic Peel				
	668 nm	**0.2g**	**0.4g**	**0.6g**	**0.8g**	**1.0g**
1 hr		0.52	0.50	0.49	0.48	0.45
2 hrs		0.49	0.46	0.45	0.44	0.42
72 hrs		0.37	0.31	0.29	0.28	0.17
120 hrs		0.20	0.18	0.16	0.14	0.00
168 hrs		0.18	0.15	0.12	0.11	0.00

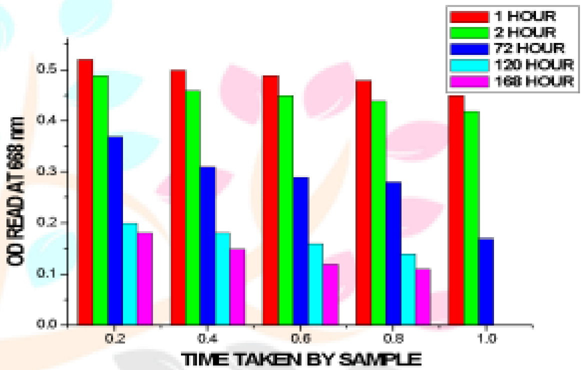

Figure 15.Adsorption of Methylene Blue dye using Garlic Peel as activated carbon

Figure 16.Adsorption of Methylene Blue dye using a sample of activated carbon – 1 st Day

Figure 17 .Adsorption of Methylene Blue dye using a sample of activated carbon - 5 th Day

4.5.4.ADSORPTION OF MALACHITE GREEN FROM WATER USING DIFFERENT ACTIVATED CARBONS

Comparing the absorbance for different activated carbon samples derived from various sources: sawdust, sugarcane bagasse, pistachio shell, areca nut shell, rice husk, and garlic peel and analysing the results showed that the absorbance values decrease over time with the lowest absorbance at 5 days (120 hour). All the samples show gradual decline in absorbance over time indicating dye adsorption. Among all the samples garlic peel shows the highest adsorption efficiency for malachite green dye. Factors like surface area, pore structure, and chemical composition.

Figure 18.Adsorption of Malachite green dye using a sample of activated carbon – 1 st Day

Figure 19.Adsorption of Malachite green dye using a sample of activated carbon - 5 th Day

Table 13. Adsorption of Malachite Green using Saw Dust as activated carbon

Time	Wavelength	Absorbance Of Activated Carbon Of Saw Dust				
		0.2g	0.4g	0.6g	0.8g	1.0g
1 hour	614 nm	0.43	0.33	0.27	0.20	0.09
2 hrs		0.42	0.31	0.23	0.14	0.08
72 hrs		0.33	0.22	0.14	0.10	0.06
120 hrs		0.26	0.10	0.03	0.01	0.00

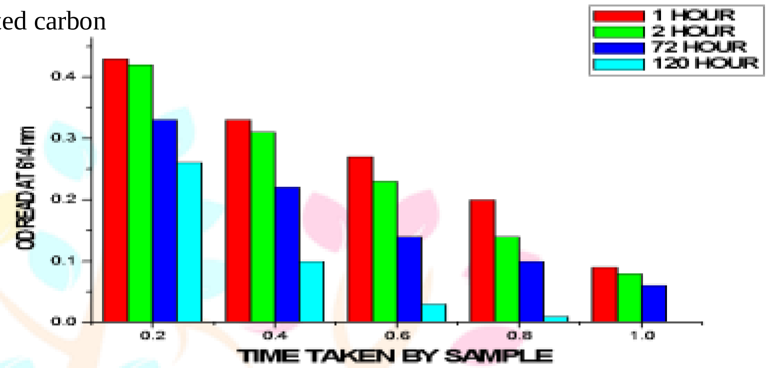

Figure 20.Adsorption of Malachite Green using Saw Dust as activated carbon

Table 14. Adsorption of Malachite Green using Sugarcane Bagasse as activated carbon

Time	Wavelength	Absorbance Of Activated Carbon Of Sugarcane Bagasse				
		0.2g	0.4g	0.6g	0.8g	1.0g
1 hour	614 nm	0.48	0.17	0.15	0.13	0.09
2 hrs		0.46	0.14	0.11	0.08	0.05
72 hrs		0.16	0.08	0.00	-0.01	-0.02

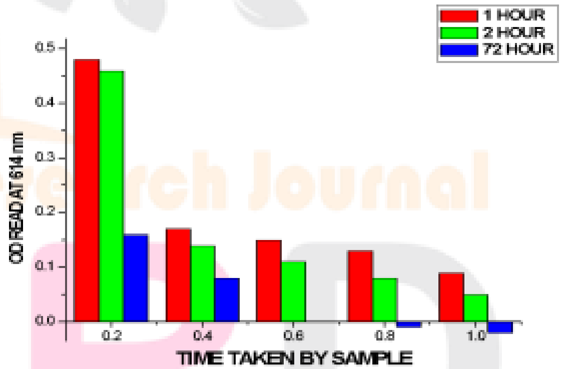

Figure 21. Adsorption of Malachite Green using Sugarcane Bagasse as activated carbon

Table 15. Adsorption of Malachite Green using Pistachio Shell as activated carbon

Time	Wavelength	Absorbance Of Activated Carbon Of Pistachio Shell				
	614 nm	0.2g	0.4g	0.6g	0.8g	1.0g
1 hour		0.55	0.42	0.28	0.27	0.24
2 hrs		0.48	0.36	0.24	0.20	0.07
72 hrs		0.21	0.07	0.06	0.03	0.01
120 hrs		0.11	0.05	0.04	0.01	-0.01

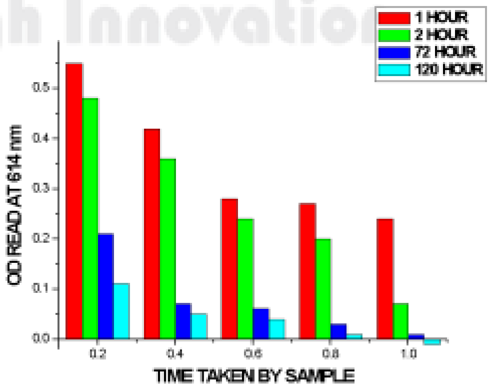

Figure 22.Adsorption of Malachite Green using Pistachio Shell as activated carbon

Table 16. Adsorption of Malachite Green using Areca nut shell as activated carbon

Time	**Wavelength**	**Absorbance Of Activated Carbon Of Areca Nut Shell**				
	614 nm	**0.2g**	**0.4g**	**0.6g**	**0.8g**	**1.0g**
1 hour		0.46	0.42	0.34	0.32	0.31
2 hrs		0.44	0.40	0.32	0.31	0.29
72 hrs		0.34	0.25	0.18	0.14	0.10
120 hrs		0.16	0.08	0.06	0.04	0.00

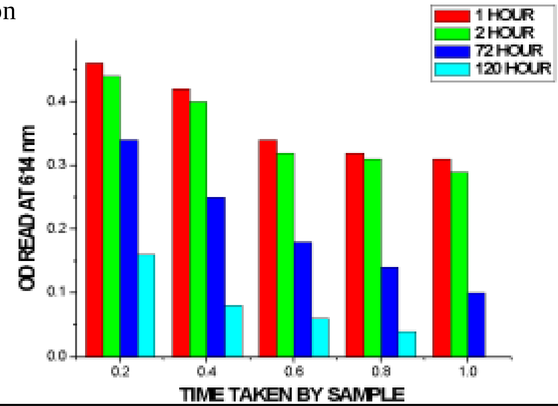

Figure 23**.** Adsorption of Malachite Green using Arecanut shell as activated carbon

Table 17. Adsorption of Malachite Green using Rice Husk as activated carbon

Time	**Wavelength**	**Absorbance Of Activated Carbon Of Rice Husk**				
	614 nm	**0.2g**	**0.4g**	**0.6g**	**0.8g**	**1.0g**
1 hour		0.33	0.29	0.25	0.23	0.22
2 hrs		0.26	0.22	0.20	0.18	0.14
72 hrs		0.10	0.07	0.06	0.05	0.02
120 hrs		0.03	0.02	0.01	0.00	-0.03

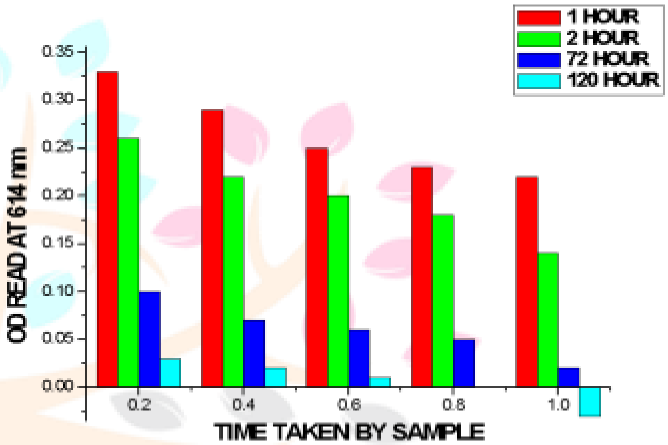

Figure 24**.**Adsorption of Malachite Green using Rice Husk as activated carbon

Table 18. Adsorption of Malachite Green using Garlic Peel as activated carbon

Time	**Wavelength**	**Absorbance Of Activated Carbon Of Garlic Peel**				
	614 nm	**0.2g**	**0.4g**	**0.6g**	**0.8g**	**1.0g**
1 hour		0.20	0.16	0.14	0.12	0.08
2 hrs		0.18	0.14	0.10	0.08	0.05
72 hrs		0.04	0.03	0.02	0.00	-0.02

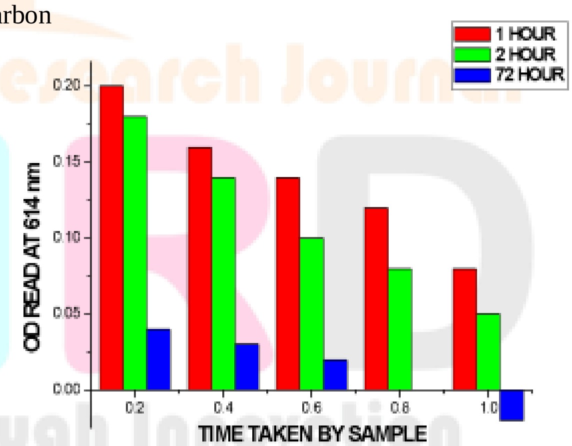

Figure 25**.**Adsorption of Malachite Green using Garlic Peel as activated carbon

5.CONCLUSION

The analysis of different samples reveals their physical and chemical properties. Garlic peel has the highest moisture content 31.18% and bulk density, likely due to its organic composition, whereas pistachio shell is the driest with only 18.9% moisture and lowest bulk density. The iodine number, which indicates unsaturation levels, is highest in sugarcane bagasse, suggesting it has the most unsaturated compounds, while rice husk is at the other end of the spectrum, while saw dust has the highest CEC implying a superior ability to hold onto cations. The study indicates that treating water with activated carbon samples normalized the dissolved oxygen (DO) levels to acceptable standards. The observed decrease in DO, when compared to the untreated water sample, is attributed to the capacity of activated carbon to absorb oxygen within its pores. This is further supported by the high iodine numbers in sugarcane bagasse and arecanut shell, which imply larger pore sizes. Consequently, the diminished DO in water processed with these materials suggests that the oxygen is likely being held in the pores of the activated carbon.

The analysis also demonstrates that the total hardness of the water, a measure of its overall hardness, was initially classified as slightly hard at 118.67 mg/L. However, after treatment with five of the six activated carbon samples, the water's hardness was reduced to a level that is considered moderately soft.

The study also compared the adsorption properties of different activated carbon samples for dye molecules. Among different activated carbon samples, sugarcane bagasse and pistachio shell showed high initial absorbance, indicating strong adsorption capabilities. Garlic peel maintained consistent absorbance, suggesting stability, while sawdust, areca nut shell, and rice husk had lower absorbance. Over time, all samples exhibited a decline in absorbance, pointing to dye adsorption. Garlic peel was particularly efficient in adsorbing malachite green dye due to its ample surface area and pore structure.

To sum up, sugarcane bagasse and pistachio shell are highlighted as the most effective activated carbon samples, with sugarcane bagasse excelling in adsorption capacity. This research offers significant insights into the adsorption qualities of various activated carbon samples, beneficial for environmental applications like wastewater treatment.

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