Study on Treatment of Polluted Water Using Activated Carbon Extracted from *Prosopis Juliflora*

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Prosopis juliflora, Activated Carbon, adsorption, carbonization

ABSTRACT

Rural water sources like wells, borewells, ponds, lakes, etc have characteristic taste and odour making it objectionable for domestic purposes. Activated carbon known for thousands of years is an effective way for purifying water. At present activated carbon is prepared on a large scale from coir pith which involves burning for carbonization and treating it with any acid for activation.

In India, Prosopis juliflora is a widely distributed weed. This plant has many ill effects such as excess depletion of ground water, non-nutritive feed for livestock, loss of grass cover, depletion of native plants, etc. It is largely used as a fire-wood and the utilized wood is either disposed off or used as manure to some extent

This project involves utilization of this burnt fire-wood from Prosopis juliflora to prepare activated carbon and using it to purify locally available water. The process of purification involves introducing activated carbon bed in a column comprising. The source water is feed into this column through which the flow is regulated for certain detention period. After adsorption of taste and odour from the water, the purified water can be collected from the bottom of the column. The efficiency this materials is analysed and the suitability of this project under rural level is determined.

The exhausted carbon which has toxic wastes in it is used as a partial replacement of sand in concrete and the corresponding strength of the concrete is learnt.

1. INTRODUCTION

The purpose of water purification is to remove unwanted materials present in water thereby making it suitable for domestic and drinking purpose. Water treatment now a day involves sedimentation, filtration, chlorination, etc which is being implemented successfully in many parts of India, but a major part of India still suffers with improper water supply or polluted water source. Hence it becomes necessary to find a cheap, easy, efficient and effective way of purifying water which can be implemented successfully in rural levels which lack pure water supply.

Burnt biological matter with high carbon content is used to extract activated carbon known for its purifying properties. In India, *Prosopis juliflora* is a weed, largely used as a fire-wood and the utilized wood is either disposed off or used as manure to some extent. Hence the burnt carbon can be utilized for purification of water at a cheaper cost without heavy operation. The purification process is simply an adsorption process and does not involve any chemical reactions. Wood or carbonaceous product on burning gets activated, the activation is simply the process of increasing the surface area of the carbon atom and inducing a positively charged atom. The charged atom owing to its increased surface area readily adsorbs negative ions, removing taste, odour and finally purifying the water for drinking and domestic purpose. Activated carbon production is done commercially using coir pith for powdered and coconut shells for granular AC. AC from a weed plant are an intelligent way of getting rid of the weed. Adding fuel to the selection, this weed is used as a fire wood thereby saving the effort of burning ie carbonizing the product. The adsorption phenomenon is a safe way of water purification where no chemical reaction takes places. Adsorption from AC is known for ages and many materials ranging from rice husk to waste tyre is used in AC production. Activating makes the carbon positively charged, making it capable of adsorbing all negatively charged ions. The negatively charged ions form a layer of negative charge capable of attracting positive ions and the process goes on till the attracting forces finally diminishes to a neutral charge. This project involves utilization of this burnt fire-wood from *Prosopis juliflora* to prepare activated carbon and using it to purify locally available water thereby comparing its suitability at rural areas rich with the studied raw material.

The project is to aggregate and establish a set of practical principles, guidelines, and procedures to utilize AC from *Prosopis Juliflora* for purification of water. The project primarily addresses theoretical and technical aspects of Activated Carbon extraction, usage and analyses of the AC efficiency using column study inorder to determine

effective depth and optimum time for a given water sample. The procedures are applicable to the analyse AC from uncontrolled burning of any source utilized at rural level namely agricultural wastes.

The Primary Objective is to extract activated carbon from *Prosopis juliflora* to purify polluted water of Trippur district, thereby studying its suitability for domestic purpose and to dispose the exhausted AC as partial replacement of sand in concrete. The *Secondary Objective is to* analyse the physical and chemical characteristics before and after treatement namely Colour and Odour, Ph, Turbidity, Total Suspended Solids, Total Dissolved Solids, COD, Total Hardness and finally to determine the suitability of the project at rural level.

2. STUDY AREA

The study area is located in the central part of Tamil Nadu (lat. 11°06'19"N; long. 77°30'14"E and lat.11°03'51"N; long. 77°47'52"E). Tirupur is a Textile city in the Indian state of Tamil Nadu, situated around 47 km from Coimbatore, is located on the banks of Noyyal River. Fondly called as the Dollar city, Tirupur is a textile hub and a vast generator of employment to over six lakh people has crossed the export value of Rs. 12000 crore till last year. Tirupur is the 'knitwear capital' of India. It has spurred up the textile industry in India for the past three decades. Its economic boom boosts the morale of Indian industrialists. It contributes to a huge amount of foreign exchange in India. Tirupur had suffered many environmental issues due to Textile Dyeing problems. In recent past, number of Dyeing and Bleaching units and few other Industrial and Common Effluent Treatment Plants were closed as they did not fulfill 'zero liquid discharge' condition for effluent treatment.

3. METHODS AND METHODOLOGY

3.1 DATA COLLECTION

The sample chosen for study is effluent outlet from a Textile Dyeing industry after Tertiary treatment. The treatment plant is located at Arulpuram, 7 km from river Noyyal. This Effluent treatment plant is a 'Zero Liquid Discharge' plant which collects the raw effluent from the Dyeing industry and recycles it back as input product in dyeing process.

3.2. METHODOLOGY

After the review of literature and problem identification in the area, the methodology was arrived, the branches of *Prosiopis juliflora* plant is cut, cleaned and allowed to remain under sun till it gets completely dried. Then the dried wood is taken and burnt in an uncontrolled manner similar to that of the burning activities followed in rural area. The burning is continued till the charcoal is obtained. Then, obtained charcoal is collected and crushed by mechanical means. The crushed powder is passed through the standard sieve of sizes varying from 4.75 mm to 75 µm. The powder that passed through 600 µm sieve is selected and rinsed thoroughly using distilled water and the dried product is the Activated Carbon (AC). The same is stored in an air tight container.

Figure 1 (a) Burning process of AC

Fig 1 Burning, Crushing, Sieving, Washing and Drying of AC

4. RESULTS AND DISCUSSION

4.1 COLUMN DESIGN PARAMETERS

Usually, depth of activated carbon beds is based on the concentration of the influent. In a laboratory the diameter of the columns can be scaled down to 30 mm. We have chosen a diameter of 30mm; and column height of 0.45m. The flow rate from the column is about 1.5ml/min. The column material is of glass so that it does not interfere with the water characters.

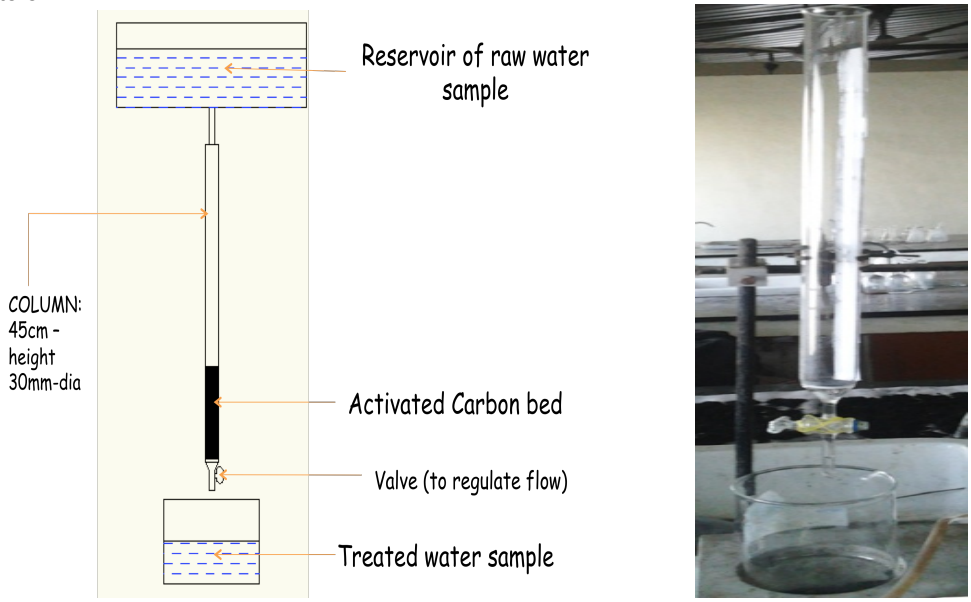

Fig 2 Column description

To determine the optimum depth for 250 ml water sample, bed depth ranging from 15cm to lower value is setup in the column at a flow rate of 1.5ml/min. The depth at which the extent of purification begins to change is the critical depth and the optimum depth for the given sample will be slightly higher than this depth.

4.2 INITIAL ANALYSIS OF OUTLET WATER

The initial concentration of the water sample is analysed to determine the extent of removal of impurities by AC. The physical and chemical parameters are tabulated against the permissible value to find the amount of pollutant present in the sample.

4.2.1 PHYSICAL CHARECTERISTICS

The physical characteristic of the water deals with visual, taste and odour of the water, namely colour, odour and turbidity.

Table 1 Physical characteristics of water before treatment

PARAMETERS	UNITS	PERMISSIBLE LIMITS	OUTLET FROM DYEING INDUSTRY
Colour	Cobalt scale	Less than 10	6
Odour	Threshold	1	2
Turbidity	NTU	5-10	55

Dissolved organic matter from decaying vegetables or some inorganic materials, such as coloured soils, etc., may impart colour to the water. For public water supplies, the colour number on cobalt scale should not exceed 20 and should preferably be less than 10. As the outlet is more than the permissible value, it requires treatement.

If large amount of suspended matter such as clay, silt or some other finely divided organic materials are present in water, it will appear to be muddy or turbid in appearance. The turbidity depends upon the fineness and concentration of particles present in water. Turbidimeter is used to measure turbidity. The permissible limit for turbidity ranges from 5 to 10 NTU. The turbidity value is more than the permissing

4.2.2 CHEMICAL CHARECTERISTICS

The chemical characteristic of the water deals with the presence of ions and other salts present in the water are shown in Table 2

Table 2 Chemical characteristics of water before treatment

PARAMETERS	UNITS	PERMISSIBLE LIMITS	OUTLET FROM DYEING INDUSTRY
pH	-	6.5-8.5	9
TSS	mg/l	500	1100
TDS	mg/l	500	7700
DO	mg/l	4-8	6.6
COD	mg/l	10	144
Total Hardness	mg/l	300 -600	160

The chemical characteristic of the water sample exceeds in all the above aspects hence treatment is essential, each parameters are directly or indirectly related to each other and hence the removal of one parameter will affect the other.

The pH value of water indicates the logarithm of reciprocal of hydrogen ion concentration present in water. It is thus an indicator of the acidity or the alkalinity of water. The total solids (suspended as well as dissolved solids) imparts turbudity to the water and forms visible flakes in water and makes the water undesirable for drinking. Hardness is the characteristic which prevents the formation of sufficient leather or foam, when such hard waters are mixed with soap. It is usually caused by the presence of Calcium and Magnesium salts present in water, which form scum by reaction with soap.

4.3 ANALYSIS USING AC FINER THAN 600µm

The column shown in fig.1 is setup and the AC prepared from the specimen plant is introduced into it. The removal of pollutant is studied by pouring water into the column. To determine the optimum depth for water of 250ml, bed depth ranging from 15cm to lower value is setup in the column at a flow rate of 1.5ml/min.

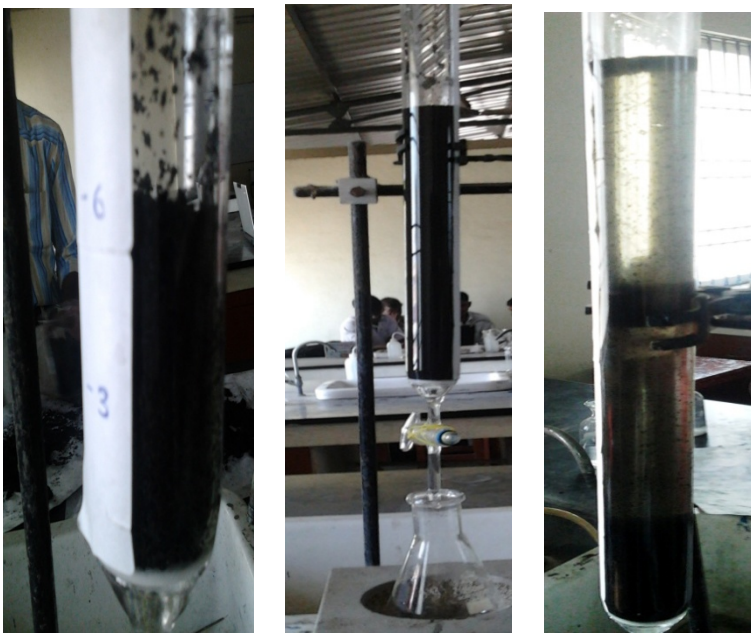

Fig 3 Introducing AC and water into the column

Table 3 Water parameters at different AC depth

PARAMETER	UNITS	DEPTH OF AC BED FOR 25ml WATER				
		15cm	12cm	9cm	6cm	3cm
Colour	Cobalt scale	0	0	0	1	6
Odour	Threshold	0	0	0	0	0
Ph	-	7.3	7.3	7.3	7.8	8.1
Turbidity	NTU	0	0	0	22	38
TSS	mg/l	5	5	5	15	34
TDS	mg/l	112	112	112	2027	3090
DO	mg/l	8.2	8.2	8.2	7.3	6.9
COD	mg/l	35	35	35	38	53
Total Hardness	mg/l	77	77	77	117	119

Fig 4 Untreated water, 3cm AC, 6cm AC, 9cm AC depth treated water.

For the given sample all the parameters were analysed at different depths and it was observed that the effect of removal started declining as the depth declined from 9cm hence the optimum depth should be below 9cm and above 6cm. For experimental work the optimum depth is worked as 9cm.To have a clear view of the effect of varying the depth, the percentage of removal is tabulated to find the optimum depth for the given water sample.

Table 4 Determination of Optimum depth of AC Bed

Parameter	**Depth of AC bed for 250ml water and percent removal**				
	15cm	**12cm**	**9cm**	**6cm**	**3cm**
	%	%	%	%	%
Turbidity	100	100	100	60	30.91
TSS	99.54	99.54	99.54	98.63	96.91
TDS	98.54	98.54	98.54	73.67	59.87
COD	69.29	69,29	69.29	66.66	53.51
TH	51.87	51.87	51.87	26.875	25.625

Fig 5 Variation of purification from untreated sample to completely treated water

The graphical representation of the above value is done below to show the variation of the readings obtained.

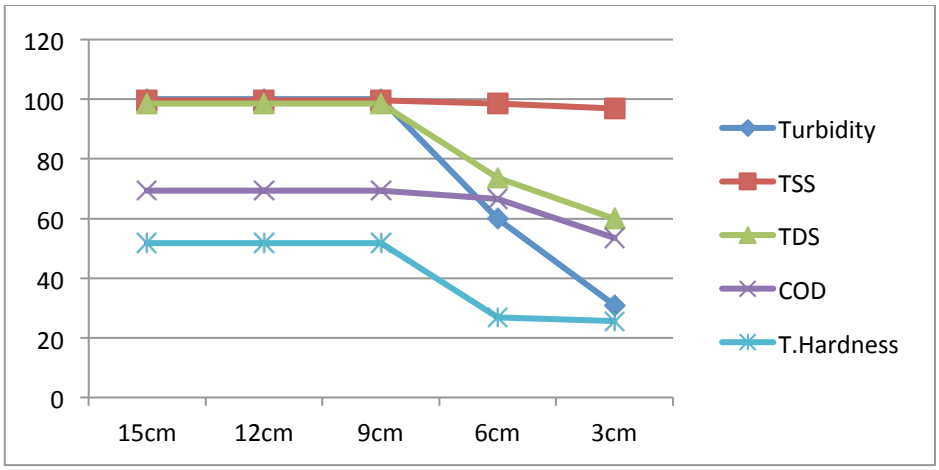

Fig 6 Graph showing the declination of efficiency of AC with reduction in AC depth

The tubidity and TDS reading showed the drastic changes when depth was reduced from 9cm to 6cm, while other readings showed considerable reduction in removing impurities. As purification was lower at 6cm, the optimum depth is taken as 9cm. This indicates the AC from this simple process is very effective in removing taste, odour and colour.

4.3.1 PHYSICAL CHARECTERISTICS AFTER TREATMENT

The physical characteristics after removal is studied to determine the effect of AC in removal of colour odour and other direct parameters and the results are tabulated

Table 5 Physical Characteristics of water after treatment

PARAMETERS	UNITS	LIMITS	OUTLET FROM DYEING INDUSTRY	TREATMENT USING AC (600µm)	PERCENT REMOVAL (%)
Colour	Cobalt scale	Less than 10	6	0	100
Odour	Threshold	1	2	0	100
Turbidity	NTU	5-10	55	0	100

The removal of colour was very effective as the sample water colour changed from crystal yellow to colourless.Odour removal was more effective reducing the threshold number from 1 to 0.Turbidity removal being 100% indicates that the removal of TDS and TSS being very effective.From the above results it is learnt that AC is very effective in removing and reducing the undesirable physical characteristics.

Treated water

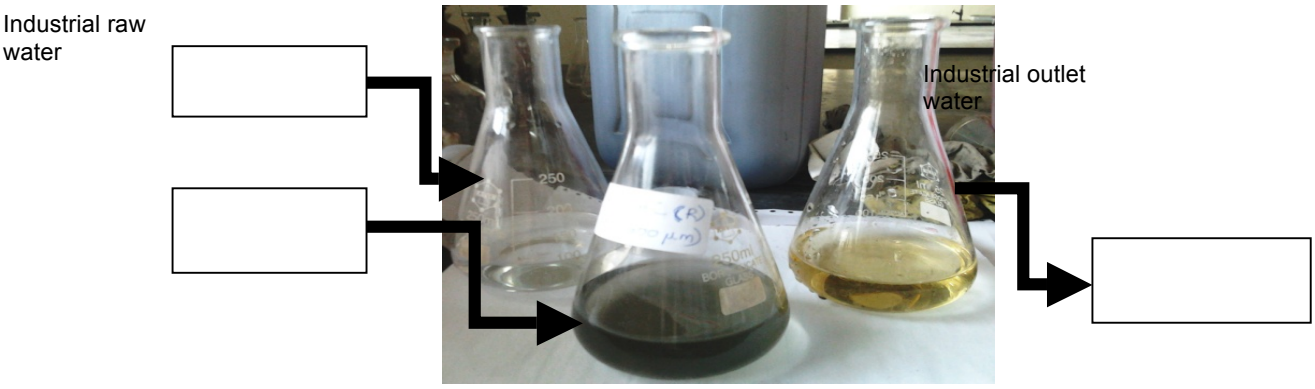

Fig 7 Treated water, raw industrial water and industrial outlet water (used or study)

4.3.2 CHEMICAL CHARECTERISTICS

Table 6 Chemical Characteristics of water after treatment

PARAMETERS	UNITS	LIMITS	OUTLET FROM DYEING INDUSTRY	TREATMENT USING AC (600µm)	PERCENT REMOVAL (%)
pH	-	6.5-8.5	9	7.3	-
TSS	mg/l	500	1100	5	99.54
TDS	mg/l	500	7700	112	98.54
DO	mg/l	4-8	6.6	8.2	-
COD	mg/l	10	144	35	69.29
Total Hardness	mg/l	300 -600	160	27	51.87

The pH of the sample was reduced from 9 to 7.3 bringing it to the permissible limit. The results showed appreciable decrease in the total suspended and dissolved solids, the TSS was reduced from 1100 to 5 and the TDS was reduced from 7700 to 112. The dissolved oxygen content increased from 6.6 to 8.2 which is not objectionable to that extent. The COD before treatment was 144mg/l which declined to 35mg/l. The Total .hardness as other parameters showed reduction from 160mg/l to 27mg/l. The efficiency of the material though not very attractive but is acceptable in terms of its availability and suitability.

4.4 PARTIAL REPLACEMENT OF SAND WITH AC IN CONCRETE

The exhausted AC is used as a partial replacement of sand in concrete, where 5%, 10% and 15% of the sand weight in M20 design mix of concrete is replaced with AC and the corresponding 3^{rd}, 7^{th} and 28^{th} day strength of the replaced concrete is determined as per IS456 code is determined.

Fig 8 Casting process of the replaced concrete

Fig 9 Compression test on the replaced concrete

The test results showed satisfactory strength of concrete with replacement of sand with AC.

5. CONCLUSION

This project provides an cost effective way of purifying water at household level. It provides an economic, easy and safe way of purifying water. Places inaccessible with treated pure water can be benefited from this project. The future recommendations are

I. Controlled burning of the sample and futher treatement in acid for improved activation can be done for comparative analysis.
II. Combination of AC from different sources can be analysed.
III.

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