Evaluation of Bio-Based Fibers for Treatment of Wastewater from Textile Industry

Chris Sheba M., Mohan Dhas S., Ashwin G.

Abstract*: *Reuse of treated textile wastewater can preserve the water bodies from pollution and reduces the demand for fresh water in industries. Providing treatment facility from all polluting sources is difficult and expensive. Hence there is a high demand for innovative technologies at lower cost which consumes low energy for wastewater treatment. Filtration process is done to separate the contaminant from the wastewater. An experimental study was carried out to upgrade the conventional treatment process by the introduction of bio-based filter media. The filtration tank was designed and packed with the natural fibers such as coconut fiber, sugarcane bagasse, and banana pith fiber separately in each trial. The treated sample was collected for every 3 hours for a period of 2 days. The removal efficiency of BOD, COD and Turbidity for each fiber was tested and compared to conclude the efficient natural fiber for the treatment process.

Index Terms*: *Banana pith fiber, Coconut fiber, Sugarcane bagasse fiber, Textile Wastewater

I. INTRODUCTION

Water is considered as the most important and priceless commodity on Earth as it is essential for every living being. The wastewater generated from the different steps in textile mills have high pH, temperature, color, alkalinity, detergent and oil content, suspended and dissolved solids, hazardous and non-degradable matter [1]. Untreated disposal of this wastewater poses serious environmental problem due to their color and high COD [2]. Conventional wastewater treatment has been employed for treating this wastewater. However, the disposal of the sludge generated is a humongous task and improper disposal causes contamination and spreading of environmental diseases [3, 4, 5]. However, textile wastewater is difficult to treat as they contain dyes which are recalcitrant organic molecules, stable to light and are resistant to aerobic digestion. Also, textile ranks first in usage of dyes and chemicals for textile production. [6] Conventional methods of treatment are inefficient in decolorization. Therefore, alternate and innovative methods of treatment are necessary.

A large amount of water is been used by the textile industry for the production process. To produce 1 kilogram of textile, about 200 liters of water is been consumed. [7] Textile dyeing industries in Tirupur and Karur of Tamil Nadu (India) usually discharge effluents ranging between 80 and 200 m^3/t of production [6]. The textile wastewater also have high BOD and COD indication its polluting nature [8].

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Filtration has been used to treat textile wastewater conventionally. Advancements such as Reverse Osmosis, Electrodialysis. Nanofiltration [9], Fluidized bed reactor [1], etc. has been investigated. Fibers has been used as filtration media. It should be noted that textile products contains fibers (Synthetic, Protein, and Cellulose fibers) as well [10]. The utilization of local-available bio-fibers resources as natural biofiber support media for the wastewater treatment is of an increasing interest for applications due to its low cost and low technology [11, 12]. The textile wastewater needs environmental friendly, effective treatment process. Nowadays biological wastewater treatment seems to be a most promising tool in treatment of wastewater which is having economic advantage, both in terms of capital investment and operating cost. [13] Plant fibres have characteristics of great interest in the area of polymeric composites; these include low density, low cost, biodegradability and little need for treatment equipment [14]. Kenaf, oil palm, jute, sisal, hemp, banana stem, pinapple leaf, flax and bagasse are some of the important natural fibers [15]. In this study, bio-based fibers such as Coconut Fiber, Banana Stem Fiber and Sugarcane Bagasse Fiber, was tested for its efficiency in removing BOD, COD and turbidity of textile wastewater.

II. MATERIALS AND METHODS

A. Sampling of Wastewater

Wastewater sample was collected from the common effluent treatment plant at Tirupur, Tamil Nadu. The wastewater is analyzed according to standard protocols, to determine the initial parameters such as pH, Total Solids (TS), Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Volatile solids (VS), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and chlorides.

B. Coconut Fiber

The coconut has natural fiber where it is thick, strong and has high abrasion resistance which is extracted from the outer shell of the coconut. The length of the coconut fiber varies from 6 – 8 inches and diameter varies from 0.10 – 1.50 mm. The density of coconut fiber is 1.40 g/cm^3. The coconut fiber was collected from the local vendor, cleaned and dried [16, 17, 18, 19].

C. Banana Stem Fiber

Banana plants not only produce delicious fruits it also provides natural fibers. The length of the fiber varies from 3 – 12.2 meters and of diameter varies from 0.08 - 0.25 mm. The density of banana fiber is 1,350 kg/m^3. The banana pith was procured from the local market. It was sliced

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and the layers separated. These layers were sundried for 2 weeks [20, 19].

D. Sugarcane Bagasse Fiber

Sugarcane bagasse fibres are produced after the extraction of juice form the sugarcane. The length sugarcane bagasse fibre varies from 0.80 – 2.80 mm and of diameter varies from 0.01 - 0.035 mm. Sugarcane was obtained from the market and pressed to excrete the juice. The bagasse was sundried for 2 weeks [21, 13, 12].

E. Experimental Setup

The filter tank was constructed with the dimension of 30x30x75cm (Fig. 1). At the height of 20cm from bottom, a support was made to place mesh mould which contains the above mentioned, densely packed fiber. Each fiber was packed at the density of 50Kg/m^3. A tap was fixed at the bottom of the tank to discharge the treated water. The treated water was continuously aerated by using aeration pump. The discharged water was collected in a container and was circulated back to the tank by using submersible pump (1/4 Hp). The wastewater was made to flow at a rate of 0.5L/min. This process was done continuously for 48hrs in separate batches using the fibers individually. The treated sample is taken for every 3hrs once and is tested.

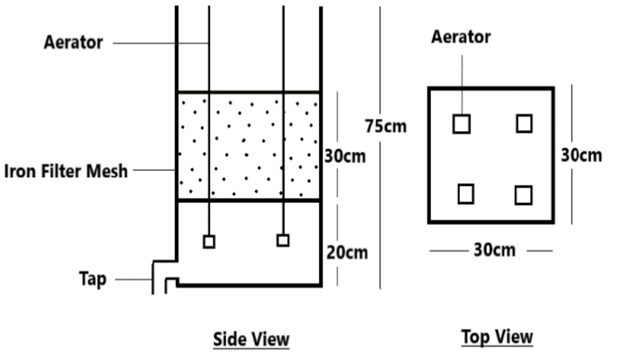

Fig. 1 Experimental Setup

III. RESULTS AND DISSCUSSION

A. Initial Characteristics of sampled Textile wastewater

The initial characteristics of the sampled wastewater are tabulated in Table 2. When compared to the Effluent standards set by CPCB of the Government of India (Table 1), the discharged wastewater was within the effluent standard limits.

B. Final Characteristics Of Tested Wastewater

(a) Coconut Fiber

The removal efficiency using Coconut fiber for every 3hrs was recorded and the BOD, COD and Turbidity were found. The Figures **Fig. 2**, **Fig. 3** and **Fig. 4** shows change trend of the wastewater's characteristics over the study period. From this experiment, the removal efficiency of BOD is 77%, COD is 29% and turbidity is 33% after 9 hrs. The maximum removal efficiency of BOD is 95%, COD is 62% and turbidity 39%.

(b) Sugarcane Bagasse Fiber

The removal efficiency using Sugarcane Bagasse fiber for every 3hrs was recorded and the BOD, COD and Turbidity were found. The Figures **Fig. 5**, Fig. **6** and **Fig. 7** shows change trend of the wastewater's characteristics over the study period. From this experiment, the removal efficiency of BOD is 18%. COD is 20% and turbidity is 19% after 9hrs. The maximum removal efficiency of BOD is 65%, COD is 45% and turbidity 28%.

(c) Banana Pith Fiber

The removal efficiency using Banana Pith fiber for every 3hrs was recorded and the BOD, COD and Turbidity were found. The Figures **Fig. 8**, **Fig. 9** and **Fig. 10** shows change trend of the wastewater's characteristics over the study period. From this experiment, the removal efficiency of BOD is 36%, COD is 12% and turbidity is 17% after 9hrs. The maximum removal efficiency of BOD is 65%, COD is 49% and turbidity 31%.

Table 1 Effluent Standards

PARAMETER	VALUE
pH	6.5 – 9
BOD	500 - 1010 (mg/L)
COD	1600 - 3200 (mg/L)
Total solids	4040 – 7500 (mg/L)
Dissolved solids	2900 - 3700 (mg/L)
Suspended solids	830 – 1580 (mg/L)
Volatile Solids	900 – 1670 (mg/L)
Chlorides	980 – 2185 (mg/L)
Turbidity	55 – 140 NTU

Table 2 Initial Characteristics

Parameters	Test Results
pH	8.68
Turbidity	61.8 NTU
BOD	573 mg/L
COD	2380 mg/L
Total Solids	0.05g/mL
Suspended Solids	0.015g/mL
Volatile Solids	0.015g/mL
Chlorides	378.46mg/L

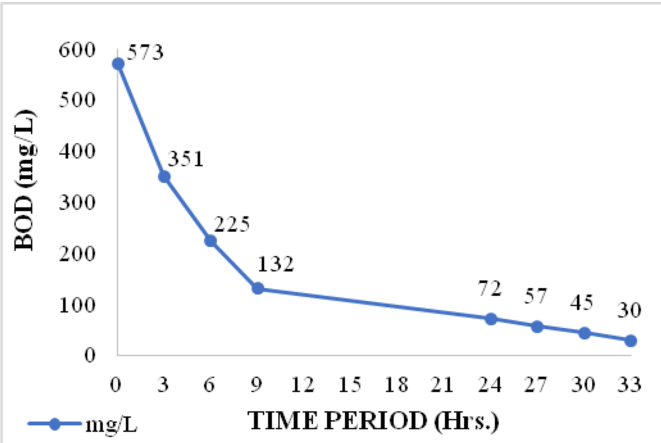

Fig. 2. BOD change using Coconut Fiber

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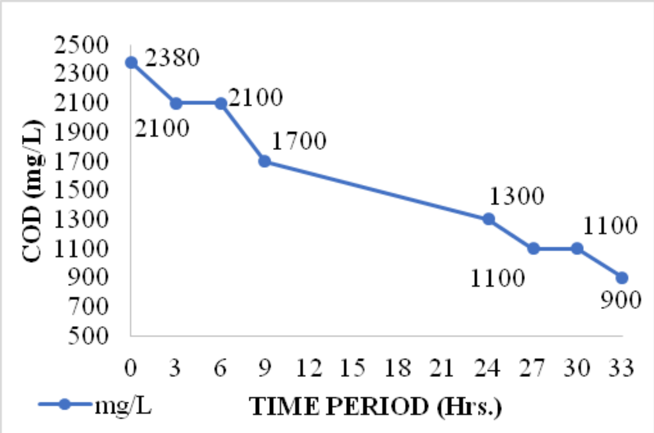

Fig. 3 COD Change using Coconut Fiber

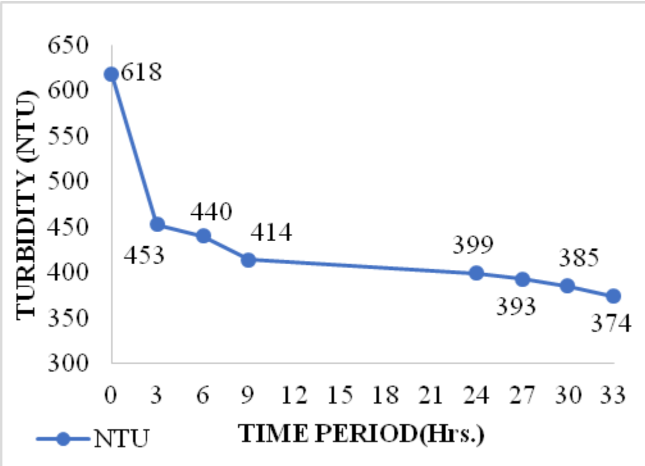

Fig. 4 Turbidity Change using Coconut Fiber

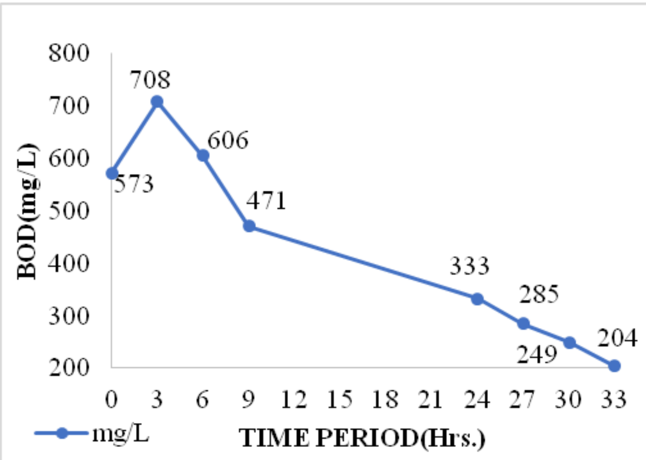

Fig. 5 BOD change using Sugarcane Bagasse Fiber

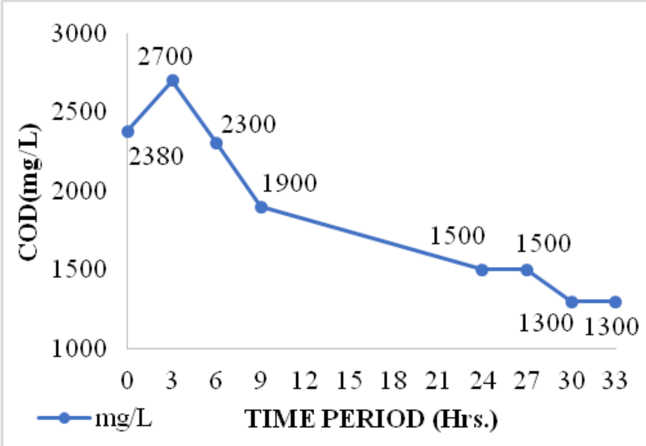

Fig. 6 COD change using Sugarcane Bagasse Fiber

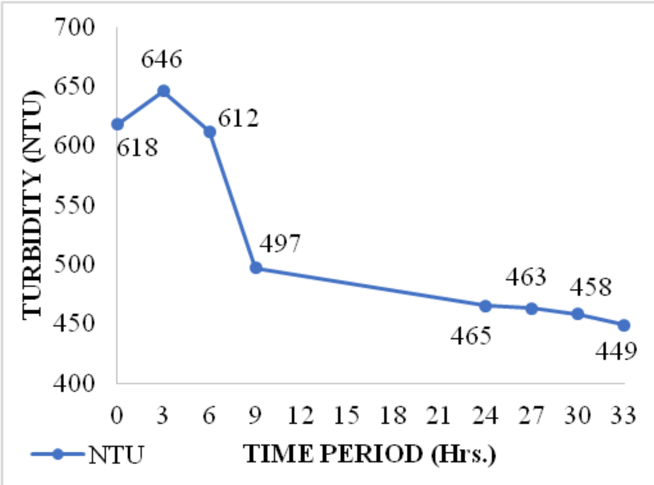

Fig. 7 Turbidity change using Sugarcane Bagasse Fiber

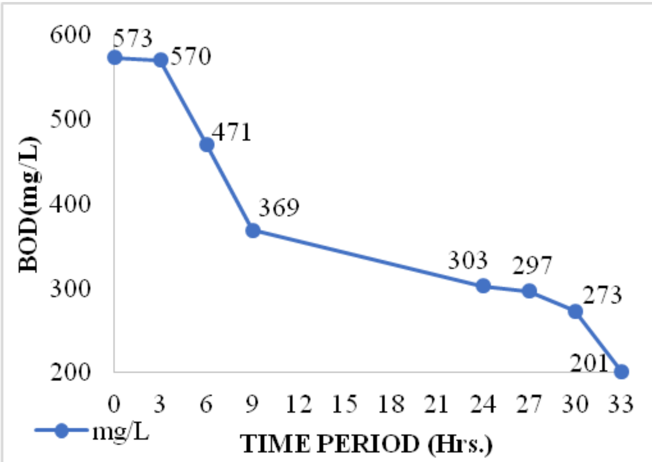

Fig. 8 BOD change using Banana Pith Fiber

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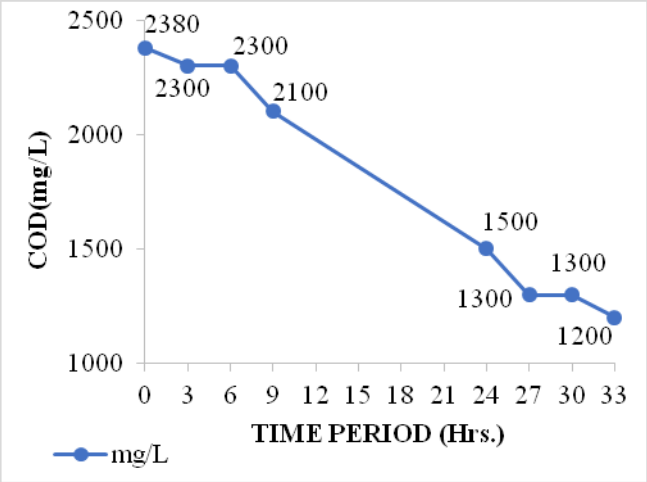

Fig. 9 COD change using Banana Pith Fiber

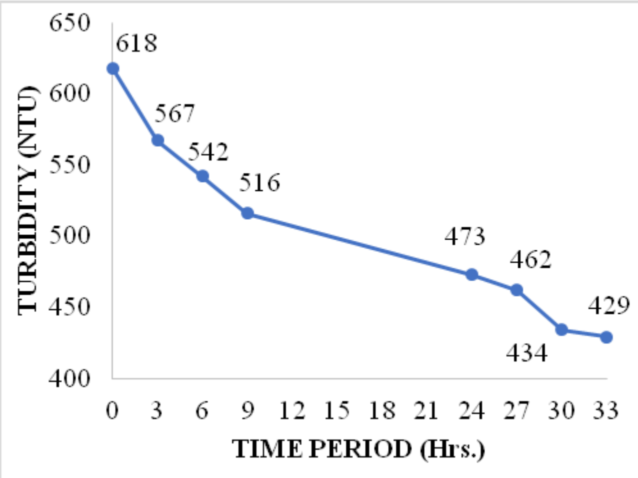

Fig. 10 Turbidity change using Banana Pith Fiber

IV. CONCLUSION

In this study, from the various experimental filter media, the Coconut fiber shows good result in removal of BOD, COD & turbidity than the Sugarcane bagasse fiber and Banana pith fiber. The Coconut fiber almost removes 95% of BOD which is present in the wastewater. Banana Pith fiber shows average removal efficiency when compared to the coconut fiber and sugarcane bagasse. After few hours of treatment process, the sugarcane fibers and banana pith fibers started to decompose and produce odor. The treatment process should be conducted at a minimum time of at least 9hrs up to maximum time of 2 days. This system will perform well for future needs and have less cost of production and maintenance. It provides an economically feasible and eco-friendly technology which is useful for improving the textile wastewater treatment. This project will help to understand a new approach of an eco-friendly low-cost filtration technique.

Bio-based fibers are naturally decomposed materials. These Bio-based fibers can be disposed easily by Landfill method directly if it is free from the chemicals that are discharged from the textile industry.

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Chris Sheba M. is an Environmental Engineering Specialist, working as Assistant Professor in the Civil Engineering Department of Sri Ramakrishna Institute of Technology, Coimbatore. She has done her undergraduate and postgraduate studies from top colleges in Tamil Nadu. She has a deep passion for conserving and preserving the environment around us. Expanding the students' mind towards conservation, researching for innovative techniques and improving methods for environmental waste treatment and management are her personal goals.

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