DECOLOURIZATION OF YAMUNA WATER USING PEANUT HULL IN PACKED BED REACTOR

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ABSTRACT

Water pollution is a global concern that has led to a scarcity of usable water and has caused monumental damage to the water ecosystems. Yamuna River is known to be one of the most polluted rivers in India owing to unrestricted direct discharge of sewage and effluent into it. The holy river Yamuna has become so polluted that water practically looks grey-black and has a repulsive stinking smell to it. The latest reports, the BOD level of Yamuna water reached 93 mg/L and the TDS level reached 1500 mg/L (highest in the stretch of Yamuna near Nizamuddin bridge). This needs to be remedied by introducing efficient and cost-effective strategies for the control of contaminants ideally at the point of generation or before discharge. Pollutants like heavy metals, pesticides, dyes, etc. make water toxic resulting in serious health effects on consumption. The present study was undertaken to study the efficiency of peanut hull for the removal of color from the water of the river Yamuna. Peanut hull is an abundantly available agro-waste material that can be obtained all over India and is harmless to the environment. The study was carried out in a packed bed reactor packed with peanut hull powder. Raw peanut hull demonstrated excellent color removal potential in the study. Then, raw peanut hull was chemically modified using 2% formaldehyde (HCHO) which stabilized the material and increased reusability and efficiency. The bioreactor was constructed and was packed evenly with a crushed peanut hull. Yamuna water was applied drop-wise and recycled through the reactor continuously for 10 hours. After about 5 cycles the approximately about 97% of color removal was obtained in the first run. The second stage was performed with chemically modified crushed peanut hull which further increases the efficiency and shows up to 100% removal of color from the Yamuna river. This technique can also be employed for the decolorization of wastewater effluent from paper industries, food industries, and textile industries. Moreover, in this way, the dual purpose of wastewater treatment, as well as sustainable use of solid waste, can be achieved.

Keywords: Contaminants, Decolourization, Packed Bed Reactor, Peanut Hull, Sustainability, Wastewater Treatment, Yamuna Water.

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INTRODUCTION

Water is the most precious resource in life. The rivers are an invaluable source of water, but drastic industrialization and urbanization have to lead to high water pollution^{1,2}. Yamuna river is known to be the most polluted river in the Delhi- NCR region of India owing to the discharge of effluents from numerous industries into it. Moreover, domestic activities bathing, cloth washing, cattle wadding and domestic sewage add to the pollution. Many effluents lead to eutrophication resulting in the growth of harmful microorganisms. These harmful microorganisms are responsible for significant health risks such as allergies, eye irritation, skin infections, effect digestive tract, mutagenic disease and cancer^{3,4}. This uncontrolled pollution restricts photosynthesis and affects the aquatic ecosystem also changes the natural color of Yamuna river water to dark grey black⁵. The central pollution board (CPCB), Central water commission (CWC), Delhi pollution control committee (DPCC), State pollution control board (SPCB) monitors 19 locations of Yamuna river continuously and it is reported that water of Yamuna is unfit for drinking purpose⁶. A stretch of Nizamuddin Bridge of Delhi found that BOD and COD levels approached 93 mg/l and 155mg/l respectively which are much higher than compared to permissible level⁷. The

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dissolved organic carbon (DOC) of Yamuna water ranges between 4.0-6.8mg/l, color unit 40-65 and chlorine removed color causing chemicals are up to 78%⁸.

Considering the nationwide scarcity of water particularly, Delhi-NCR urgent measures to clean the Yamuna are required. The methods presently being employed have not been much fruitful⁹. Moreover, many methods are too costly to be feasible. The use of agro-waste for water treatment is an attractive emerging area where two problems of solid waste management and wastewater treatment can be solved together. Treatment via agro-waste material of color causing compounds from the river has lots of benefits. It is a cost-effective process, doesn't produce any sludge, easy to implement and an eco-friendly process. By using agro-waste products sustainability of solid waste could be achieved. Several types of agro-waste materials such as Rice husk, Bagasse, Peat, Bamboo, Date pits, Palm tree waste, Coconut husk and Tea can be used to treat effluents that contain different dyes¹⁰. Agro waste materials adsorb and absorb several pollutants. Moreover, different types of enzymes present in waste material can result in the removal of coloring (Table-1). Treatment via agro-waste material of color causing compounds from the river has lots of benefits. It is a cost-effective process, doesn't produce any sludge, easy to implement and an eco-friendly process. By using agro-waste products sustainability of solid waste could be achieved.

Table-1: Different Agro-waste Reported For Efficient Removal of Dyes

Agro-waste (Adsorbent)	Dye Name	% Removal Range	References
Activated Rice Husk	Acid Yellow 36	45-80	11
Fly Ash	Methylene Blue	36-45	12
Modified Alumina	Crystal Violet	20-80	13
Kaolin	Crystal Violet	65-95	14
Pine Leaves	Methylene Blue	20-80	15
Tobacco Stem Ash	Methylene Blue	60-81	16

In the present study, peanut hulls were used to remove color causing compounds from the Yamuna river. Peanut hulls are easily available agro-waste. So, it is a cost-effective process. In a previous study, the Peanut hull has shown high efficiency to remove different dyes such as safranin-o, methylene blue, neutral red, brilliant cresyl blue¹⁷. Peanut hull has different structural components such as lignin (28.8%), cellulose (37%), carbohydrates (25%) and protein (8.2%) which may be responsible for absorption of coloring agents.

EXPERIMENTAL

Preparation of Biosorbent Sample

Peanut hull was collected from the local Faridabad market. Peanut hull waste (PHW) was rinsed with distilled water 2-3 times to remove dirt and impurities. Washed PHW was dried in hot air. PHW was chemically modified overnight with formaldehyde solution (2%v/v) to stabilize the adsorbent, washed to remove traces of formaldehyde and dried.

Construction and Packing of Packed Bed Bioreactor

The packed bed bioreactors used in the study was constructed using transparent plastic transparent pipe (30cm length, 2.54cm diameter). The reactor was packed with crushed PHW and sealed with gauze (Fig.-1) The volume packed bed volume was 152.0 ml and the mass of PHW powder used for packing the reactor was 30 g.

Water Sample

Yamuna water sample was collected from the Delhi stretch of the Nizamuddin bridge (Shastri park). The water sample was dark grey-black with a strong foul smell.

Determination of TSS

Measurement of settle-able solids in water was carried out using a standard filter paper method. Distilled water was passed through filter paper and subsequently, the filter was dried and weighed. Then on the same filter paper, the wastewater sample was filtered. The solids retained on the filter paper were weighed and TSS was calculated using the following Eq.-1.

$$TSS = \frac{(A-B) \times 1000}{\text{Vol of sample}} \quad (1)$$

Where, A is the weight of filter paper + dried residue, B is the weight of filter paper.

Determination of TDS

The TDS was determined by evaporating a known volume of sample in a china dish on a hot plate (Eq.-2):

$$TDS = \frac{(A-B) \times 1000}{\text{Vol of sample}} \quad (2)$$

Where, A is the weight of dried residue + china dish, B is the weight of china dish.

Fig.-1: Constructed Bioreactor filled with Crushed Peanut Hulls

Determination of Dissolved Oxygen (DO)

300ml of wastewater sample was taken in a BOD bottle. 2ml of 48% w/v Manganese sulphate was added to the water sample and mixed thoroughly by inverting the bottle. Subsequently, 2ml of alkali-iodide-azide (500g NaOH and 135g sodium iodide dissolved in 1L distilled water. 10 g sodium Azide dissolved in 40 ml distilled water with stirring. Both the solutions were mixed after cooling) solution was added to the water sample. The flocs formed were dissolved using 2ml of concentrated sulphuric acid. Exactly 200ml of the solution was poured into a new flask and titrated with 0.025 M sodium thiosulphate until the pale yellow color was obtained. Then the starch solution was added. This led to the formation of the blue color of the starch-iodide complex. The titration was continued until the solution decolorized completely. Dissolved oxygen was calculated using the following equation:

$$\frac{0.2 \times 1000 \times 0.025}{200} \quad (3)$$

RESULTS AND DISCUSSION

Comparison of water quality parameters of Yamuna water samples before and after treatment are given in Table-2.

Table-2: Yamuna Water Quality Parameters Before and After Treatment.

Parameters	Observations (Before Treatment)	Observations (After Treatment)
Colour	Black-grey	Colorless
Smell	Foul odor	No odor
pH	7.0	6.8
D.O	0.7mg/l	0.9mg/l
TSS	1000mg/l	220mg/l
TDS	4140mg/l	3450mg/l

The Colour of Yamuna River was black and grey because of organic waste, sewage, and dyes. The smell of the Yamuna river water was pungent due to excessive pollution. Dissolved oxygen was as low as 0.7mg/l. TSS and TDS levels were very high. After treatment, these parameters showed considerable improvement.

Cyclic Mode Operation of Packed Bed Reactor

100 ml of Yamuna water sample was cycled through the bioreactor for 5 hours at room temperature. The sample was taken every hour. These samples were centrifuged at 2000 RPM for 10 min to remove suspended particles. The optical density of the water sample was determined at 620nm. The % removal of color from Yamuna water was calculated by the following equation:

$$\% R = \frac{100 \times (C_o - C_e)}{C_o} \quad (4)$$

Where, R is the % removal of color compounds from the sample, C_o - initial absorbance, C_e - final absorbance.

The residence time of the 100 ml solution was 1 h. The adsorption of colored impurities in wastewater increases with time of contact reaching saturation by 5h. When adsorption was continued further, the peanut hull themselves release colored compounds leading to an increase in OD. Maximum removal of up to 97% was observed in 4 h of reactor operation (Fig.-2).

Fig.-2: Removal of Dye in Cyclic Mode

To stabilize the adsorbent, the peanut hull adsorbent was modified using formaldehyde (2%v/v) and used for water treatment. Color removal of Yamuna water through modified peanut hulls showed removal up to 100% removal in 6 cycles (Fig.-3).

Fig.-3: Decolourization using Modified Adsorbent.

Non-cyclic Mode

In the non-cyclic mode in 50 ml of Yamuna water was cycled through bioreactor having modified peanut hulls each hour. The total volume of treated water was 750ml. The process was continued for 15 h. The removal efficiency obtained was between 98 in the first 8 h however the efficiency of the reactor falls after the 9th hour. Thus it can be concluded that a modified peanut hull has the excellent capability for the treatment of wastewater (Fig.-4).

Fig.-4: Dye Decolorization in Non-cyclic Mode.

CONCLUSION

In this study, the main objective was to treat Yamuna water and improve the quality parameters. Especially, the objective was to remove coloring compounds present in the River water. Modified peanut hull showed excellent adsorbent properties for adsorption of impurities from water. The decolorization efficiency of 100% was obtained with a modified peanut hull as adsorbent. Moreover, in non-cyclic mode, the reactor 750 ml of water could be effectively treated in 15h of operation. Peanut hull thus have excellent properties to be used as an adsorbent for the treatment of River water leading to considerable improvement in quality parameters like color, odor, and dissolved oxygen. Thus, the present work makes a strong case for the effectiveness of peanut hull as bio-adsorbent for dye decolorization of wastewater.

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