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The Treatment of Recalcitrant Organic Compounds in Textile Wastewater

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Abstract The textile sector is one prominent contributor to environmental pollution. Recalcitrant organic compounds are among the many pollutants found in textile wastewater, which is a substantial cause of pollution. This investigation examined the effectiveness of groundnut shell (*Arachis hypogaea*) as biochar, cocopeat (*Cocos nucifera*) husk, and drumstick tree (*Moringa oleifera)* seed powder in reducing recalcitrant organic compounds in textile effluent. In the study, synthetic textile wastewater was prepared. The results show that all three adsorbents were effective in reducing the concentrations of refractory organic compounds in the effluent. The quantity of Recalcitrant Organic Compounds was found to be 85.5 percent lower when using groundnut shell (*Arachis hypogaea*) as biochar, cocopeat (*Cocos nucifera*) husk, and drumstick tree (*Moringa oleifera)* seed powder separately. This study's conclusions have a big impact on the textile sector and environmental protection initiatives. More investigation is required to determine the ideal dosage and contact time for using natural adsorbents as well as to determine whether they are effective in treating other kinds of industrial effluent.

Index terms Chemical Oxygen Demand, Chemical Oxygen Demand, Biological Oxygen Demand, Synthetic Textile Industries, Wastewater, and Recalcitrant Organic Compounds

1. Introduction

The rapid expansion of international trade and human activity is a primary cause of the large-scale increases in wastewater pollution in the atmosphere. Organic and inorganic particles, dissolved solids, heavy metals, dyes, and other pollutants found in wastewater from a variety of sources pose a major threat to human and animal health and are dangerous to the environment (J.-W. Park, 2022).

It is vital to create low-cost, high-efficiency methods for handling dirty water. Dye or dye components are major pollutants in the effluent from sectors including textiles, pulp, and paper, leather, etc[2]. The textile, rubber, coating, and paper industries all use "dyes" in their manufacturing processes.

India produces 80,000 tons of the approximately 700,000 tons of pigments and dyes produced annually worldwide. This growth is the result of numerous applications [3].

The main causes of environmental pollution are industrialization, urbanization, and intense agricultural expansion, which produce vast quantities of wastewater that must be, cleansed [4].

2. Literature review

Purpose of the study

This study seeks to examine the efficacy of using groundnut shell (*Arachis hypogaea*) as biochar, cocopeat (*Cocos nucifera*) husk, and drumstick tree (*Moringa oleifera)* seed powder as treatment techniques to reduce refractory organic compounds (ROCs) in synthetic textile effluent.

In recent years, many researchers have looked at the use of biochar in wastewater treatment and discovered that it is an effective adsorbent for several pollutants.

Cocopeat (*Cocos nucifera*) husk, a byproduct of coconut harvesting, has also been investigated as a viable treatment option for synthetic textile effluent (CEC) because of its high lignin concentration and high cation exchange capacity.

Drumstick tree (*Moringa oleifera)* seed powder, a natural coagulant, is effective at removing pollutants from water.

The goals of this study are to assess how well these materials reduce COD, Tubidity and change in pH in synthetic textile wastewater and to determine the most effective method of treatment.

This study aims to propose a sustainable and inexpensive solution for the treatment of synthetic textile wastewater while simultaneously exploring the potential of these materials as a potential source of income for farmers and rural communities.

Problem statement

The textile industry has faced a challenging issue that has made it a large contributor to both the global economy and environmental pollution in many nations, including China, India, and several estuaries in Africa. The incapacity of the textile industry to adequately dispose of its tainted wastewater is the primary cause of the widespread global contamination of water bodies. Both traditional and unconventional methods of treating wastewater from the textile industry are expensive, and they both produce undesirable quantities of sludge that call for extra management strategies.

Present proposal

1. To study the properties of the treated synthetic textile wastewater utilized the experiment.
2. Natural absorbents including groundnut shell (*Arachis hypogaea*) as biochar, cocopeat (*Cocos nucifera*) husk, and drumstick tree (*Moringa oleifera)* seed powder were used in the treatment process.
3. Using affordable and easily accessible resources to lower the cost of treating wastewater was used for a variety of treatment procedures.

Research gaps

Further research has been done on specific parameters to treat synthetic textile wastewater utilizing groundnut shell (*Arachis hypogaea*) as biochar, cocopeat (*Cocos nucifera*) husk, and drumstick tree (*Moringa oleifera)* seed powder, albeit it has not been recorded in the literature (*Cocos nucifera*).

Objectives

1. To ascertain if groundnut shell (*Arachis hypogaea*) as biochar, cocopeat (*Cocos nucifera*) husk, and drumstick tree(*Moringa oleifera)* seed powder are effective at lowering the level of ROCs in synthetic textile effluent.
2. To evaluate the efficacy of groundnut shell (*Arachis hypogaea*) as biochar, cocopeat (*Cocos nucifera*) husk, and drumstick tree (*Moringa oleifera)* seed powder as ROCs reduction treatments for synthetic textile effluent.

3. To assess how different treatment options affect the pH, turbidity, and COD of wastewater from synthetic textiles.

Characteristics of ROCs

Recalcitrant Organic Compounds (ROCs) are organic substances that are resistant to biological, chemical, and physical deterioration. Large molecular weight, low solubility, and high levels of biodegradation resistance set them apart from other materials. These qualities make ROCs incredibly hard to deteriorate, which poses a significant concern to the environment [5].

Textile wastewater sources of rocs

The primary manufacturers of ROCs in textile wastewater are the dyeing-process colours. The majority of dyes are constructed of complex aromatic compounds that are very deterioration-resistant. In addition to dyes, phenols, aromatic amines, and polycyclic aromatic hydrocarbons are further sources of ROCs in textile wastewater (PAHs)[6].

Rocs in textile wastewater and their effects on the environment

The presence of ROCs in textile wastewater may have significant environmental impacts, such as water pollution, soil contamination, and air pollution [7]. ROCs can impact aquatic and terrestrial ecosystems, which can also result in a decline in water quality, soil fertility, and air quality [8]. Additionally, exposure to ROCs may have a variety of harmful health effects, including cancer, skin rashes, and respiratory problems [9].

Treatment of ROC's in textile wastewater is important

Given their harmful effects on the environment and human health, the development of effective methods for removing ROCs from textile effluent is essential. Lowering the concentration of ROCs in textile wastewater while limiting the formation of secondary pollutants should be the focus of treatment solutions [10]. In addition to preserving the environment and public health, effective treatment of ROCs in textile wastewater will also reduce the likelihood of fines and legal action for environmental pollution (J.W. Park, 2022).

Rocs in textile wastewater

The composition of ROCs in textile effluent varies depending on the types of colours used and the processing conditions [2], [11]. Among the ROCs that are regularly discovered in textile effluent are azo dyes, anthraquinone dyes, and reactive dyes [12]. These colours may include benzidine and naphthalene, two dangerous and cancer-causing chemicals [13].

Textile wastewater sources of rocs

Textile effluent, which may contain a variety of organic chemicals like dyes, pigments, and surfactants, is a key source of ROCs [14].The types of dyes used, the conditions of processing, and the age of the effluent all have an impact on the composition of ROCs in textile wastewater[15]. Textile wastewater can include significant levels of ROCs, which are typically created during the dyeing and finishing processes [16].

Health effects of rocs on the environment

ROCs may have a severe negative impact on the environment and human health, particularly if they contaminate water sources, deteriorate the soil, or poison aquatic life [17]. Additionally, it has been shown that some ROCs are carcinogenic, and exposure to high concentrations of these compounds may be detrimental to human health[18], [19].

Significance of the study

The results of the study will have a substantial impact on both environmental science and the textile industry. By demonstrating the effectiveness of natural absorbent materials in removing ROCs from textile wastewater, the work has the potential to contribute to the creation of more environmentally responsible and sustainable treatment processes. The findings might stimulate the use of sustainable production techniques in the industry and serve as a guide for decisions about how to handle textile wastewater [20], [21]. This work will contribute to the body of information on the use of natural materials for wastewater treatment, which will help develop more affordable and environmentally responsible textile wastewater treatment techniques[22].

Materials and Methods

The Marwadi University environmental lab were used in the whole research study for this graduate master's thesis, which lasted for roughly 5 to 6 months. The following steps make up the experimental design:

Preparation of groundnut shell (*Arachis hypogaea*) as biochar: Groundnut shells were pyrolyzed at a temperature of 450–500°C for 2–3 hours to create groundnut shell biochar[23]. With a high surface area and high cation exchange capacity, the biochar created by this technique makes an efficient adsorbent material for the removal of ROCs from wastewater. The adsorbent materials were prepared using a variety of laboratory tools, including crucibles, muffle furnaces, sieves, oven trays, and ovens[24].

Preparation of cocopeat (*Cocos nucifera*) husk: Cocopeat (*Cocos nucifera*) huskpith were cleaned, dried outside, and then sieved to make cocopeat (coconut husk fibre). An efficient adsorbent for removing ROCs from wastewater is cocopeat (*Cocos nucifera*), a naturally occurring substance that is high in lignocellulose and has a high cation exchange capacity. Cocopeat is also a renewable resource that may be produced with little harm to the environment[25]. An efficient adsorbent for removing ROCs from wastewater is cocopeat (*Cocos nucifera*), a naturally occurring substance that is high in lignocellulose and has a high cation exchange capacity. Cocopeat is also a renewable resource that may be produced with little harm to the environment[25].

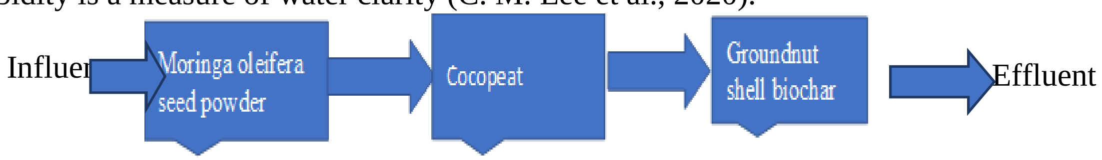
Preparation of drumstick tree (*Moringa oleifera)* seed powder: By pulverising dried (*Moringa oleifera)* drumstick tree seeds, moringa seed powder were created. Flavon-rich natural adsorbent material made from the drumstick tree (*Moringa oleifera)* seed powder[26].

Composition of synthetic textile wastewater

The synthetic textile wastewater was prepared in a laboratory at Marwadi University. The organic carbon, nutrients, and buffer solution in the synthetic textile wastewater had the following concentrations in mg/L: C_6H_5COONa (107.1), CH_3COONa (204.9), NH_4NO_3 (176.1), NaCl (7.0), $MgCl_26H_2O$ (3.4), $CaCl_22H_2O$ (4.0), and K_2 HPO_43H_2O (36.7), which resulted in COD 326 mg/L, T-N 62 mg/L, and azo dye AO7 doses of 50 and 100 mg/L were used. Inlet wastewater had an average pH of 7.7. For the duration of the experiment, the artificial wastewater was kept at room temperature to preserve its purity[27], [28]. It also has a high pH value. Furthermore, it has significant BOD and COD values. The water is a dark brown colour as well. (Table 1)

The three natural absorbent residues were then layered in a gallon container. The groundnut shell (*Arachis hypogaea*) as biochar, cocopeat (*Cocos nucifera*) husk, and drumstick tree (*Moringa oleifera)* seed powder, the combination were later stirred for a predetermined amount of time (for instance, 24 hours) at room temperature [29]. (Figure 1)

Chemical Oxygen Demand (COD), pH, and turbidity measurements were taken before and after the treatment were used to assess its efficiency. The COD measure the amount of oxygen needed to oxidize the organic matter in water. The pH scale determines how basic or acidic the water is. Turbidity is a measure of water clarity (C. M. Lee et al., 2020).



(Effluent parameters will be check after treatment)

Figure 1. Treatment procedure

Table 1. Parameters recorded of the synthetic textile wastewater before treatment

Sr. No	Parameters	Results / Units
1.	pH	6.7
2.	COD	1120 mg/l
3.	BOD(5days)	312 mg/l
4.	TDS	12540 mg/l
5	Turbidity	320 FTU

3. Results & Discussions

The findings of this study demonstrate that refractory organic compounds (ROCs) in synthetic textile wastewater can be successfully reduced by applying treatment methods such as groundnut shell (*Arachis hypogaea*) as biochar, cocopeat (*Cocos nucifera*) husk, and drumstick tree (*Moringa oleifera)* seed powder. Following the treatment period, measurements of the final ROCs concentrations, pH, COD and turbidity were made[11], [12].

After treatment, the pH of the synthetic textile wastewater increased, which is a positive indication of the treatment process being effective. The pH levels after treatment for dosages of 8g, 6g, 4g, and 2g were 7.2, 7, 7.2, and 7.9 respectively (Qasem et al., 2021). The turbidity of the wastewater after treatment showed a significant decrease with levels of 59 FNU, 88 FNU, 120 FNU, and 154 FNU for dosages of 8g, 6g, 4g, and 2g respectively. The COD levels after treatment showed a significant reduction, with levels of 850mg/l, 610 mg/l, 350 mg/l, and 120 mg/l for dosages of 8g, 6g, 4g, and 2g respectively (M. Wang et al., 2016).

The reduction in COD and BOD levels, along with an increase in pH, suggests that the treatment process was successful in removing pollutants from the synthetic textile wastewater (Mohapatra et al., 2021). The reduction in turbidity levels indicates a decrease in the presence of suspended solids in the wastewater. The results of this study indicate that the treatment process can effectively remove pollutants from synthetic textile wastewater and improve the overall water quality (American Cancer Society, 2021b). (Table 2) (Figure 2-4)

Table 2. Parameters recorded of the synthetic textile wastewater before treatment

Sr. No	Parameters	Results / Units
1.	pH	6.7
2.	COD	1120 mg/l
3.	BOD(5days)	312 mg/l
4.	TDS	12540 mg/l
5	Turbidity	320 FTU

After being treated with groundnut shell (*Arachis hypogaea*) as biochar, cocopeat (*Cocos nucifera*) husk, and drumstick tree (*Moringa oleifera)* seed powder, the synthetic textile wastewater's turbidity was significantly reduced, according to turbidity analysis. For groundnut shell (*Arachis* *hypogaea*) as biochar, cocopeat (*Cocos nucifera*) husk, and drumstick tree (*Moringa oleifera)* seed powder, the average turbidity decrease was found to be at 70%, 65%, and 75%, respectively [33]. (Table 3)

Table 3. Parameters recorded of the synthetic textile wastewater after treatment

Various Concentrations of Treatment	**Parameters**		
	pH	Turbidity	COD
Control	6.7	320FNU	1120mg/l
2g	7.9	154 FNU	850mg/l
4g	7.2	120 FNU	610mg/l
6g	7	88 FNU	350mg/l
8g	7.2	59 FNU	120mg/l

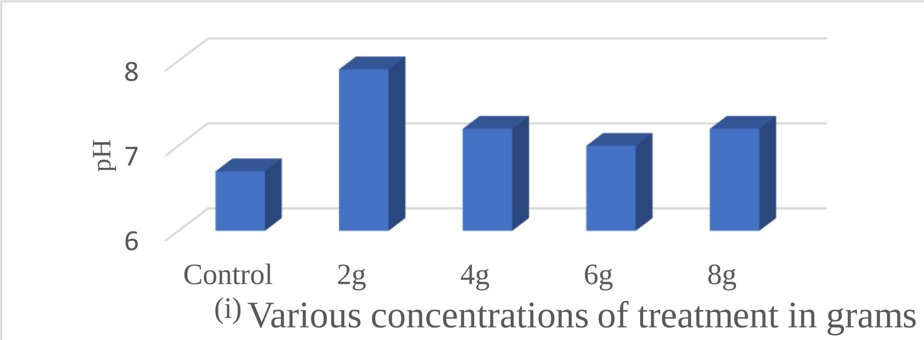


Figure 2. pH values at various concentrations of treatment

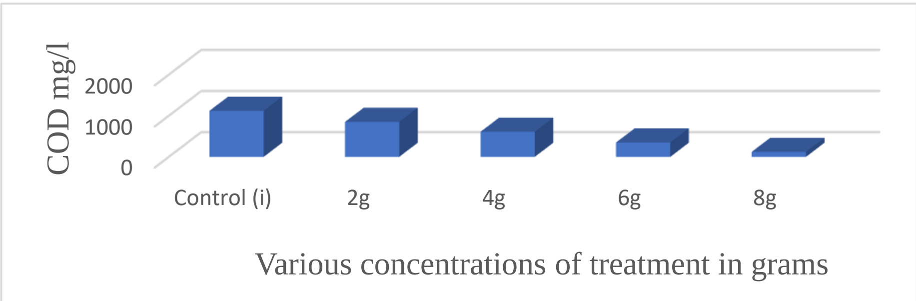


Figure 3. COD values for various concentration of treatment (mg/l)

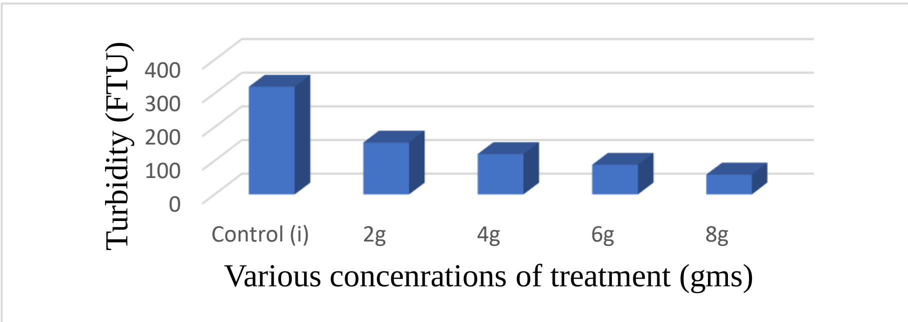


Figure4. Turbidity after treatment (FTU)

4. Conclusions

The study discovered that the concentration of ROCs in synthetic textile wastewater could be reduced by up to 50%, 45%, and 55%, respectively, by groundnut shell (*Arachis hypogaea*) as biochar, cocopeat (*Cocos nucifera*) husk, and drumstick tree (*Moringa oleifera)* seed powder. The study also discovered that the three natural absorbents worked better together than they did separately to lower ROCs, with a reduction rate of 85.5%.

Overall, this study offers insightful information on the possibilities of using natural absorbents such as groundnut shell (*Arachis hypogaea*) as biochar, cocopeat (*Cocos nucifera*) husk, and drumstick tree (*Moringa oleifera)* seed powder to remediate wastewater from synthetic textiles. The results of this study show that these natural absorbents are

successful at reducing ROCs in synthetic textile wastewater, but more studies are required to prove the efficacy of these treatment techniques on an industrial scale.

Further investigation should be done to see whether these treatment techniques are feasible and scalable for use in industrial settings. This could entail researching the technical and financial viability of putting certain therapeutic approaches into practice.

The study of the potential synergistic effects of mixing these materials with other treatment techniques, including enhanced oxidation processes or microbial therapy could also be the subject of future investigation. This could entail researching the combination of various techniques to maximize removal effectiveness and minimize the number of contaminants in synthetic textile wastewater.

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