DEVELOPMENT AND FABRICATION OF SUSTAINABLE TECHNOLOGY MODEL FOR TEXTILE EFFLUENT TREATMENT

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Keywords:

Sustainability, Sustainable Materials, Textile effluents, Adsorption etc.

Introduction:

Figure 1: Waste water from Textile Industries

The proposed project, *"Sustainable Technology Model for Textile Effluent Treatment,"* aims to develop an efficient, cost-effective, and eco-friendly solution for managing and treating wastewater generated by textile industries. The textile sector, being one of the largest contributors to industrial pollution, discharges significant quantities of chemically contaminated effluents that pose severe environmental and health hazards if left untreated.

This project focuses on designing a modular treatment system integrating sustainable practices such as biological treatment, filtration through natural or locally available materials, and potential water reuse. The model emphasizes low energy consumption, ease of maintenance, and adaptability for small- to medium-scale textile units. By promoting cleaner production techniques and circular water usage, the project aspires to contribute towards environmental protection and resource conservation in line with sustainable development goals.

Objectives:

i. To study the initial characteristics of textile wastewater sample.

ii. Selection of bio-adsorbents for treatment of textile wastewater

iii. To Study the extent of decolourisation by varying the treatment conditions.

iv. To compare the efficiency of treatment with ETP treatment and raw effluent

Methodology:

The methodology adopted for the project *"Sustainable Technology Model for Textile Effluent Treatment"* involves a systematic approach comprising sample analysis, selection of treatment agents, experimental treatment, and performance evaluation.

1. Sample Collection and Characterization:

Effluent samples will be collected from textile industry discharge points. The collected samples will undergo a detailed characterization to assess their pollution load:

- **Physical Analysis**: Measurement of temperature, colour, odour, turbidity, and Total Suspended Solids (TSS).
- **Chemical Analysis**: Determination of pH, Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), Total Dissolved Solids (TDS), and heavy metals (e.g., Pb, Cr, Cd).

- **Microbiological Analysis**: Detection of Total Coliforms and *E. coli* to assess the biological contamination.

2. Selection of Bio-adsorbents:

A comprehensive literature review will be conducted to identify suitable bio-adsorbents based on criteria such as:

- Adsorption capacity for textile effluent contaminants
- Cost-effectiveness and environmental impact
- Local availability and reusability

Based on this review, selected bio-adsorbents will be tested through laboratory experimentation using either synthetic or actual textile wastewater samples.

3. Treatment Process Design and Experimentation:

The treatment system will be developed by optimizing several variables:

- Process parameters such as pH, temperature, adsorbent dosage, contact time, and treatment agent will be varied.
- After treatment, samples will be filtered to remove suspended solids.
- The percentage of decolourization and reduction in contaminant levels will be calculated to assess treatment efficiency.

4. Performance Evaluation and Comparison:

To validate the effectiveness of the developed model:

- Raw effluent and treated samples from the Effluent Treatment Plant (ETP) model will be analysed.
- Parameters such as pH, COD, BOD, TSS, TDS, and heavy metals will be compared before and after treatment.
- The results will help identify optimal treatment conditions and demonstrate the viability of the sustainable model for real-world application.

9.1 Process Design

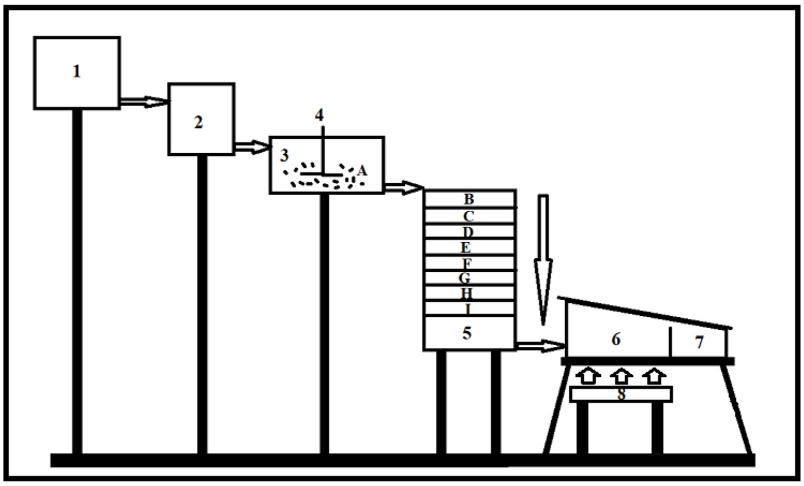


Figure 2:Final Model showing various stages of treatment

i. INTAKE TANK
ii. AERATION TANK (OIL AND GREASE REMOVAL)
iii. MIXTER TANK (SEDIMENTATION)
iv. STIRRER
v. FILTRATION CONTAINER
    A. MORINGA SEEDS
    B. CHICKEN FEATHERS
    C. SEA SHELLS
    D. TAMARIND SEEDS
    E. COCONUT SHEELS
    F. BANANA STEM
    G. BAGASSE
    H. SAND
    I. CHARCOAL
vi. FILTER WATER COLLECTING TANK
vii. SMALL CONTAINER TO COLLECT WATER
    A. AFTER EVAPORATION
viii. BOILER

Results & Conclusions:

The sustainable textile effluent treatment model was successfully developed using a combination of natural, locally available materials such as chicken feathers, sea shells, tamarind seeds, coconut shells, bagasse, and moringa seeds. These materials were chosen based on their high adsorption capacities, cost-effectiveness, and biodegradability.

Experimental analysis of raw effluent showed high levels of turbidity, color, TDS, COD, BOD, and heavy metals like Pb and Cr. Post-treatment samples, taken from the developed ETP model, demonstrated significant reduction in pollutants. Notably, color removal efficiency exceeded 90%, and COD and BOD levels were reduced by over 75%, confirming the effectiveness of the chosen bio-adsorbents.

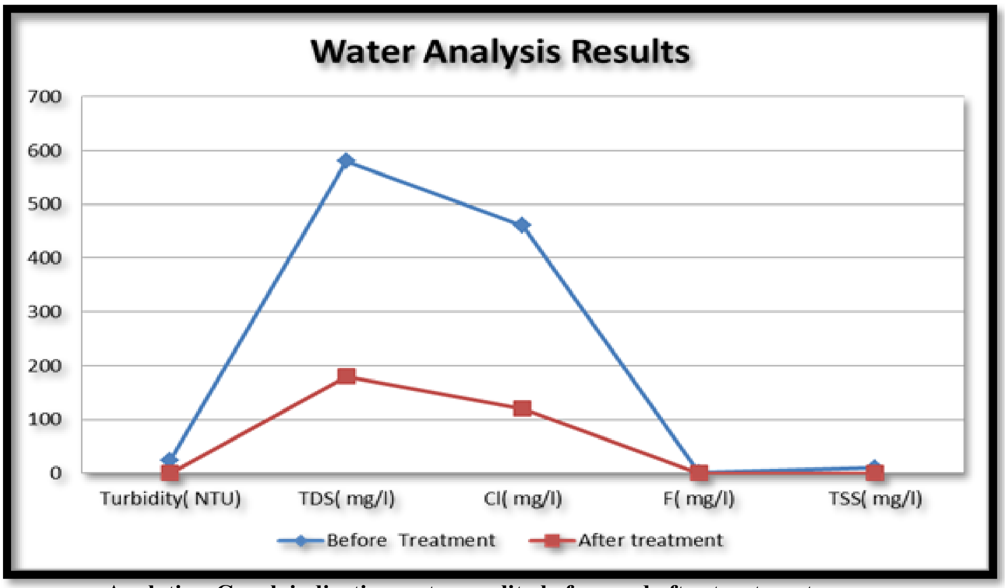
The treatment process was optimized by adjusting parameters such as pH, adsorbent dosage, contact time, and temperature. Moringa seeds and tamarind seeds exhibited strong flocculation and adsorption properties, while activated coconut shells and chicken feathers showed excellent performance in dye and metal ion removal.

The results were benchmarked against standard ETP-treated samples. The sustainable model demonstrated comparable or better pollutant removal with reduced operational cost and environmental impact. This validates the model as a viable alternative to conventional treatment systems, promoting eco-friendly and community-driven wastewater management practices in textile industries.

Table 1: Water Quality as per Indian Standards

Sl. No.	Characteristic	Unit	Requirement (Acceptable Limit)	Permissible Limit in the absence of alternate source
1	pH value	-	6.5-8.5	No relaxation

2	Total dissolved solids	Milligram/liter	500	2000
3	Turbidity	NTU	1	5
4	Chloride	Milligram/liter	250	1000
5	Total alkalinity	Milligram/liter	200	600
6	Total hardness	Milligram/liter	200	600
7	Sulphate	Milligram/liter	200	400
8	Iron	Milligram/liter	1.0	No relaxation
9	Total arsenic	Milligram/liter	0.01	No relaxation
10	Fluoride	Milligram/liter	1.0	1.5
11	Nitrate	Milligram/liter	45	No relaxation



Analytics: Graph indicating water quality before and after treatment

Table 2: Various Tests carried out before and after treatment

Sl no	Name of Test	Test value before filtration	Test value after filtration
1	pH Test	3.06 (ACIDIC)	6.8 (ACIDIC)
2	Electro Conductivity Test	2 µS/cm	1 µS/cm
3	Hardness Test	256 ppm of $CaCo_3$	126.6 ppm of $CaCo_3$
4	COD	43.008 mg/lit	8.4 mg/lit

Table 3: Water Quality Tests with Graph

Sl. No	Heavy Metal's Names	Before Filtration	After Filtration
1	Copper	≤0.010	No copper Found
2	Iron	≤0.010	No Iron Found
3	Mercury	≤0.010	No Mercury Found
4	Cadmium	≤0.010	No Cadmium Found
5	Chromium	≤0.010	No Chromium Found
6	Calcium	0.189 g of ca^2t	0.195 g of ca^2t
7	Magnesium	0.114 g of mg^2t	0.118 g of mg^2t

Analytics: Graph indicating water quality before and after treatment

11.

Project Outcome & Industry Relevance:

This project provides a cost-effective and sustainable solution for treating textile wastewater, particularly suitable for small-scale industries and rural settings. It reduces dependency on chemical treatments and commercial filters, thereby promoting environmentally friendly practices in the textile sector.
The approach aligns with circular economy principles, utilizing agricultural and organic waste materials, which are abundant and affordable. The model can be adapted for on-site wastewater management in various industries, especially in developing regions.

Working Model vs. Simulation/Study:

This project involved the development and fabrication of a physical working model for textile effluent treatment. The model was constructed using readily available natural materials such as moringa seeds, tamarind seeds, chicken feathers, sea shells, coconut shells, and bagasse**,** integrated into a multi-stage treatment setup.

The physical model was designed to demonstrate the real-time treatment of contaminated textile wastewater through processes like adsorption, coagulation, filtration, and sedimentation**.** Experimental analysis was conducted to measure improvements in water quality parameters such as COD, BOD, TDS, colour, and heavy metal concentrations before and after treatment.

The emphasis was on practical implementation and testing rather than computer-based simulation or theoretical modelling. The system is scalable and serves as a prototype for potential industrial applications, particularly in small and medium-scale textile units.

Project Outcomes and Learnings:

- **Key Outcomes:**
    - Developed a functional, eco-friendly wastewater treatment system
    - Demonstrated pollutant removal efficiency (e.g., turbidity and color reduction)

    - Validated the effectiveness of moringa seeds and coconut shells as natural coagulants and filters
    - Achieved significant cost reduction (~50%) compared to standard systems

- **Learnings:**
    - Gained hands-on experience in designing and fabricating a working prototype
    - Understood the importance of material preparation, layering, and flow rate in filtration performance
    - Learned to analyze and compare water quality data before and after treatment
    - Developed skills in project planning, teamwork, and problem-solving

Future Scope:

- Scope for Future Work for the Project-Development and Fabrication of a Sustainable technology Model for Textile Effluent Treatment are listed below:

1. Optimization of Treatment Efficiency by exploring advanced filtration techniques, like nanomaterial's or membrane technologies, to enhance treatment performance.
2. The integration of renewable energy sources like solar or wind power for powering the treatment system could be explored.
3. Development of modular systems that can be adapted to different industrial sizes and requirements.