

# Treatment of Textile Industrial Wastewater using Hydrophilized Polyamide Nanofiltration Membrane for Water Recovery and Reuse

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## Abstract

*The textile industry is very water intensive. Water is used for cleaning the raw material and for many flushing steps during the entire production process. During the process a large quantity of wastewater is produced which consists of dyes, heavy metals, pigments, and surfactants in high concentration levels all around the world. Dyes and other chemical laden wastewater released by textile industries is a major concern for the treatment which causes an important threat to serious environmental and public health problems before discharge. Membrane technology plays a key role in effective separation of textile industry wastewater (TIWW) in terms of “state of the art technologies”. Nanofiltration is one of the most effective separation processes for the removal of pollutants from TIWW. The present study mainly focused on the following issues such as characteristics of wastewater, minimization, treatment, recycle/reuse and final disposal of wastewater. The paper deals with the description of the treatment of TIWW using the Hydrophilized polyamide-based Nanofiltration membrane (HPA-100-NF). The experiments were conducted to a significant reduction in parameters such as COD, TDS, Turbidity, and color. From the results, the % of water recovery was found to be 70-80% successful. The complete removal of color and turbidity was observed which states the overall process was technically feasible and cost-effective and beneficial for the environment. The treated water can be reused for various purposes such as gardening, landscaping, groundwater recharge, irrigation, floor cleaning, and cooling towers in industries to protect the environment as well as save freshwater for the future generation.*

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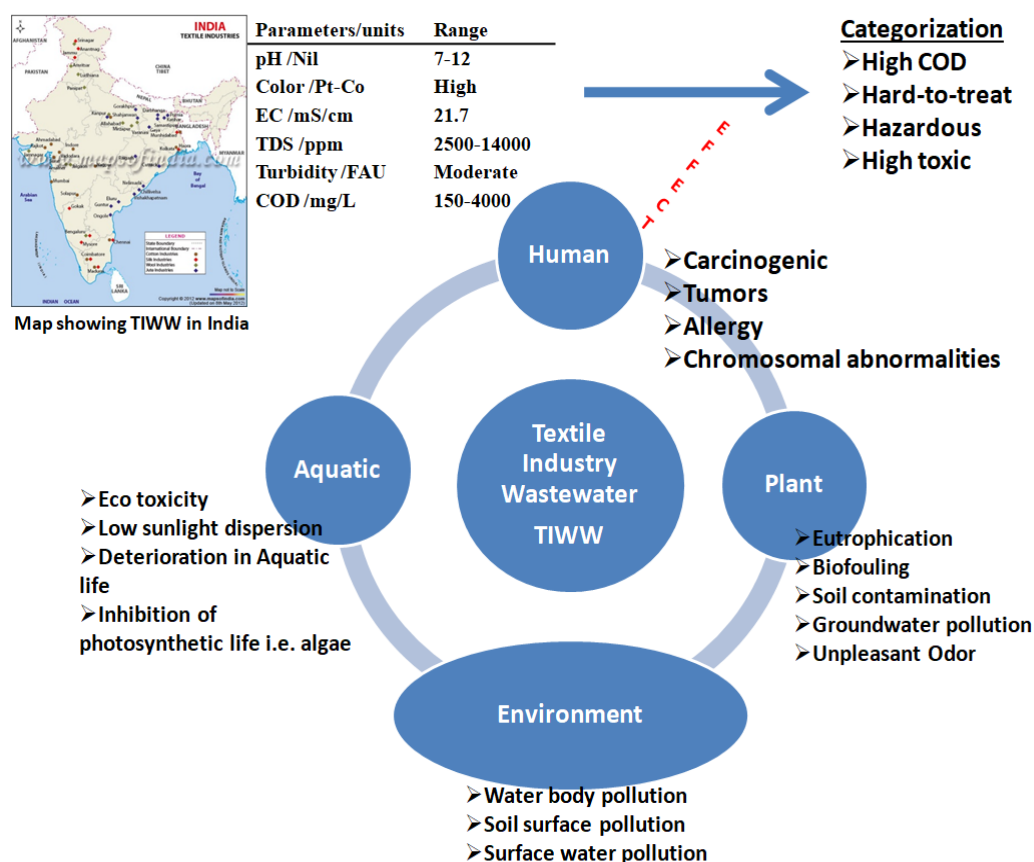
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**Keywords:** Textile industrial wastewater, Hydrophilized polyamide Nanofiltration membrane, Chemical oxygen demand, Color, Water reuse.

## INTRODUCTION

Textile industry is one of the largest garment manufacturing sectors for the production of various types of fibres using different machines, techniques and chemicals which are rich in complex dyes, solvents, whitening and antifoaming agents, and various additives [1, 2]. Figure 1 shows the textile factories use huge quantities of fresh water for the production of various varieties of garments and discharge large volumes of wastewater with high concentration of total dissolved solids (TDS), total suspended solids

(TSS) as organic and inorganic contaminants, chemical oxygen demand (COD), pH, electrical conductivity with rich in color contains mixture of complex dyes which causes harm to the environment as well as aquatic ecosystem [3, 4, 5]. The different types of dyes used in textile manufacturing industry includes acid, basic, disperse, direct, reactive, solvent, sulfur, natural, and azoic which are very toxic and hazardous to environmental pollution etc. Therefore, it is necessary to treat textile wastewater before discharging into the environment for the removal of complex dyes and other contaminants after attaining the permissible limits. Till to date, numerous methods have been developed to deal with wastewater from the textile industry, among that membrane technology is growing tremendously than conventional processes for producing good-quality reusable water for reuse in various applications in the same industry with safe and effective process [6, 7].



**Figure 1.** Effect of textile industry wastewater.

The aim of the paper study is to performance and evaluates the textile industrial wastewater using hydrophilized polyamide nanofiltration (HPA-NF) membrane as advanced treatment. This process shows significant reduction in color, turbidity, COD, TDS, and good water recovery was successfully achieved. The treated water can be used for various applications like gardening, floor cleaning, washing, toilet flushing, groundwater recharge, and other non-domestic applications to save fresh water for future generation as safe and clean environmentally sustainable process.

## EXPERIMENTAL METHODOLOGY

### Analysis of Collected Samples

Textile industrial wastewater (TIWW) was collected from the nearby textile industry for performing experimental trials and for water recovery and reuse. A large quantity of wastewater is being discharged directly to the outlets and causes harm to the environment that shows more impact

on aquatic, soil, groundwater, and human life. Some of the parameters exceeded the limit value of environmental standards. Insoluble matter was considered as total suspended solids (TSS), a high cloudy appearance leads to turbidity and due to the high concentration of dyes the water will be thick in color. Other parameters were also analyzed for pH, total dissolved solids (TDS), and chemical oxygen demand (COD) [8]. The typical composition of TIWW is presented in Table 1 and the analytical methods as follows.

**Table 1.** Analysis of textile industrial wastewater.

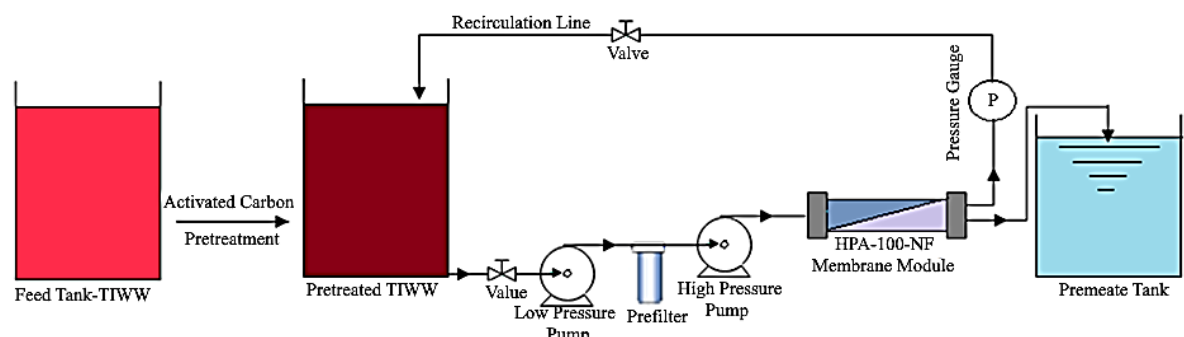
| Parameters | Units | Raw feed                             | Activated carbonfiltrate | Permeate |
|------------|-------|--------------------------------------|--------------------------|----------|
|            |       | Textile industrial wastewater (TIWW) |                          |          |
| pH         | Nil   | 12.65                                | 12.20                    | 12.10    |
| Color      | Pt-Co | High                                 | Moderate                 | Low      |
| EC         | mS/cm | 21.7                                 | 19.7                     | 5.0      |
| TDS        | ppm   | 14000                                | 12608                    | 3200     |
| Turbidity  | FAU   | Moderate                             | Low                      | Low      |
| COD        | mg/L  | 4000                                 | 2000                     | 150      |

### Analytical Methods

Analysis of the TIWW sample was carried out based on standard APHA methods. Physicochemical parameters like pH, TDS, turbidity, electrical conductivity (EC), COD, color and odor of the sample was analyzed during the experimental trials [9]. The pH was measured by a digital pH meter of Make: DCM-900, Electrical Conductivity (EC) was measured using a digital conductivity meter of Make: DPH-504, the unit was represented in mS/cm. TDS was determined by HM digital meter, units are presented in ppm. Turbidity was measured using colorimeter of Model DR/890, HACH Company, units are FAU. Color intensity was estimated using the colorimeter of Model DR/890, units are represented in Pt-Co. The COD was performed using a closed refluxing method with COD digester, from HACH Company, Bangalore, India [10, 11, 12, 13].

### Experimental Setup of Nanofiltration Membrane System

In the present study, the experiment was performed to treat TIWW using hydrophilized polyamide (HPA-100-NF) Nanofiltration membrane of pore size of 0.001  $\mu\text{m}$  as shown in Figure 2. The collected wastewater was first pre-treated with activated carbon to reduce the color content before feeding to the membrane process. The pre-treated sample was fed to the membrane module with the help of a booster pump as a pressure driving force. The operating pressure of 5  $\text{kg}/\text{cm}^2$  was applied on the membrane, can be recorded by fixing pressure gauge and control valve to obtain treated water as permeate. The treated water was collected in a separate tank for reuse in various applications.



**Figure 2.** Schematic process flow diagram of Nanofiltration membrane system.

### Cleaning of Membrane

The membrane cleaning was carried out to know the performance of the NF membrane. The membrane cleaning was done after each batch experiment by washing with acid, alkali and

demineralized water flushing. After completion of the experiment, the membrane can be cleaned with normal tap water and followed by chemical cleaning. The cleaning with chemical treatment using 1% aqueous citric acid for 15 min followed by water wash for 10 min. The membrane was further washed with a mixture of 1% NaOH, 0.5% EDTA and 0.2% of SLS for 15 min followed by a water wash for 10 min [14, 15]. To enhance the lifespan of the membrane, it can be stored in sodium metabisulphate (SMBS) for further experimental purposes.

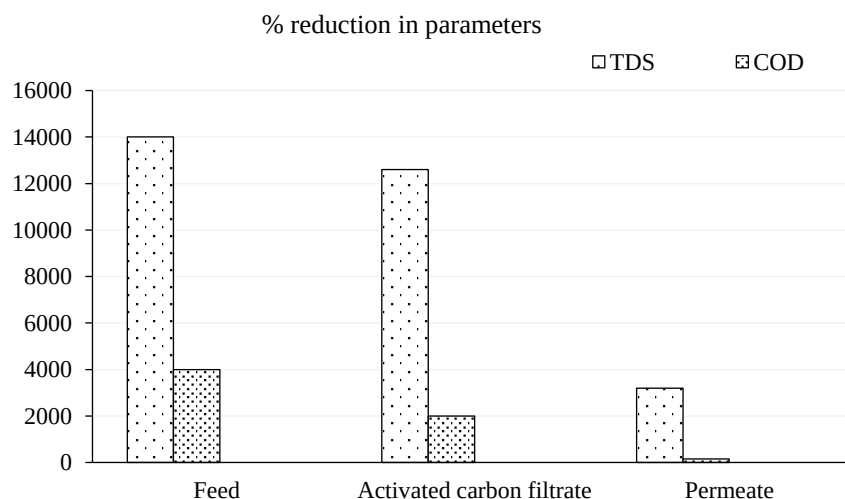
## RESULTS AND DISCUSSIONS

### Experimental Study Results

In this present study, the results obtained using hydrophilized polyamide (HPA-100-NF) Nanofiltration membrane shows a significant reduction in parameters of TIWW. The COD, TDS, Electrical conductivity, Color, and Turbidity of the influent was recorded as 4000 mg/L, 14000 ppm, 21.7 mS/cm, very high and moderate. The NF filtration showed drastic reduction in the permeate sample values recorded as 150 mg/L, 3200 ppm, 5.0 mS/cm, transparent in color and clear in turbidity which was provided in Table 2 and represented in Figure 3. Nanofiltration process is an advanced and novel technology for the effective removal of pollutants from textile industrial wastewater with satisfactory results. The effective removal of suspended particles and organic matter shows that the recovered water can be used in various applications. Further, pilot plant studies are under process for the treatment of textile industrial wastewater to produce good quality treated water for reuse.

**Table 2** Removal of impurities.

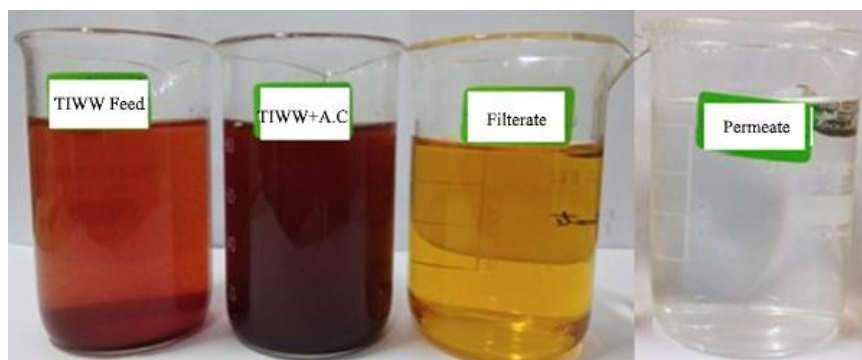
| % Removal of impurities |                                      |
|-------------------------|--------------------------------------|
| Parameters/Units        | Textile industrial wastewater (TIWW) |
| TDS (ppm)               | 77                                   |
| Color (Pt-Co)           | 100                                  |
| Turbidity (FAU)         | 100                                  |
| COD (mg/L)              | 96                                   |



**Figure 3.** Reduction in TDS and COD of wastewater during the experiment.

### Color Intensity

The photograph of the samples of feed and treated textile effluents before and after HPA nanofiltration membrane is shown in Figure 4. The color intensity of TIWW for raw feed sample is a dark brownish color with a high cloudy appearance. The color content of the treated sample after the membrane process is very effective and attractive in complete removal when compared to feed sample which was achieved to PCB standards as represented in units of Pt-Co [16, 17].



**Figure 4.** Color intensity before and after treatment process.

## CONCLUSIONS

The treatment of TIWW using the Hydrophilized polyamide-based Nanofiltration membrane (HPA-100-NF) process shows a significant reduction in parameters and more advantageous than existing processes which produce pure water in high levels can be reused for various primary step applications. In the present study up to 80%, water recovery was obtained, and reuse of quality water has become a reality and fall under the pollution control board (PCB) standards. The technology is considered to be more advanced with good water recovery, complete removal of color followed by significant reduction in other contaminants to reuse in various purposes which make the process effective and efficient by providing reusable water to the industry needs.

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