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Research paper



Study on Application of Membrane Technology in Treatment of Effluent from Dyeing Industries in Erode, TamilNadu

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Abstract

The textile dyeing industry is one of the hazardous polluting industries which uses water as the major source for their production and substantially the generation of wastewater leads to be a huge burden in treatment. The existing treatment methods adopted in most of the dyeing industries are said to be very old and its efficiency of removal is very less and at the same time it does not meet the standards for trade effluent discharge as prescribed by the regulatory boards. The study carried out on the application of Activated Carbon Filter (ACF) outlet in three stages of Reverse Osmosis results in reduction of 52% and the Total Dissolved Solids (TDS) is reduced to 226 ppm under the operation time of 10 hours. Significance reduction in pH, BOD, COD, TSS and Sulphates. The results say that the new technology of applying Nano-filtration and ultra-filtration will increase the efficiency of treatment. The effluent characteristics with the help this technology satisfy the standards.

Key words: *Reverse Osmosis, Wastewater Characteristics, Total Dissolved Solids*

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1. Introduction

The dyeing industry requires huge water consumption due to its varied complex parts of its manufacturing processes. A textile manufacturing industry utilizes many dyes, primary and secondary chemicals which renders the required quality in the cloth materials[1]. Enormous quantity of water are utilized by the textile processing units for the manufacturing process which results in the release of pollutants into the environment such as air, water and on land. The utilization of raw material and the addition of a variety of chemicals for obtaining the finished or required product pave way for the release or generation of harmful pollutants into the environment. Dyeing process effluents are known to posses high color, pH and COD content due to the usage of various chemicals. The textile wastewaters which possess high amounts of total dissolved solids interfere with the quality of groundwater making it unfit for public usage[2]. Consideration and appropriate treatment should be taken into account to ensure that the final discharge will not cause any harm to society and the environment. A variety of methods such as, chemical precipitation, adsorption, ion exchange process, electrocoagulation, membrane systems, and even biological treatments have been used for dye removal from industrial effluent [3-4]. The usage of membrane technology systems for the treatment of wastewater are on the high rise than the normally used systems because of its high efficiency, easy availability, low operation and maintenance costs. Another application of using membrane technology is that the treated wastewater can be recovered/ reused which can be re-supplied to the manufacturing process. Nanofiltration is a membrane technology whose treatment properties lie between reverse osmosis and ultrafiltration. Nanofiltration typically uses pressure as a driving force for separating the materials. Ultrafiltration also uses pressure for the removal of particles. The utilization of membrane technology for the treatment of dyeing industry wastewater will have a significant positive impact on the entire ecosystem[5-7].

TamilNadu has a huge quantity of dyeing units positioned especially at Erode and Tirupur districts. Erode district is divided into 7 taluks – Erode, Dharapuram, Sathyamangalam, Gobichettipalayam, Bhavani, Kangayam and Perundurai. The taluks are further sub-divided into 20 blocks, which are further classified into 549 villages. The district lies between the co-ordinates of 11.3410° N, 77.7172° E and has a total area of 5,722.64sq.kms. The total population according to 2011 census is 22, 59,608 persons. The total number of cotton and textile units available at Erode district is approximately 4,928. These include large, medium and small scale industries. The magnitude of wastewater generated per industry is approximately 30,000 litres/day[3].

2. Methods and Materials

Wastewater Treatment System

A typical wastewater treatment system consisting of mechanical (primary), biological (secondary) and advanced (tertiary) treatment units as shown in Figure 1.

Membrane Technologies:

Membrane technological treatment is required after the secondary treatment. It serves as a final stage in the treatment process[8,9]. The application of membrane technology serves as the final stage in the wastewater treatment process. The treatment of wastewater using membrane systems is costly and therefore proper decision

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should be adopted in selecting the appropriate membrane specifications to achieve the required outputs[10-12].

Three Stages of RO Unit:

The treated water from Activated Carbon Filter is pumped through RO plants which consist of three stages with recoveries of 70%, 50% and 50% respectively. The overall recovery from 3 stages will be collected in a permeate storage tank for reuse in the dyeing process. The three stage RO unit is represented in Figure 2.

- **RO FirstStage:**

The first stage has five numbers of brackish water elements housed in a single five element housing. The expected recovery in this stage is 70%. The reject from the stage is of 10,000 TDS. The advantages of using brackish water membrane in the first stage are the use of lesser energy for high recovery, the ability to handle. TDS drops due to feed dilutions reduced membrane fouling because of high trans-membrane flow rates. The reject from the brackish water stage is feed to second stage of filtration

- **RO SecondStage:**

The second stage has 3 numbers of seawater membrane housed in single three element housing. The expected recovery in this stage is 50%. The reject from this stage is of 20,000 ppm. The reject from this stage is sent to the third stage of filtration process.

- **RO ThirdStage:**

The third stage has 2 numbers of seawater membrane housed in single two element housings. The expected recovery in this stage is 50%. The reject from this stage is of 40,000 PPM. The reject from this stage is sent to solar evaporation pan for natural evaporation.
The final reject from the last stage is finally sent to the solar evaporation pan for natural evaporation. The dried salt from the solar pond will be collected in HDPE bags and stored inside a shed[13-18].

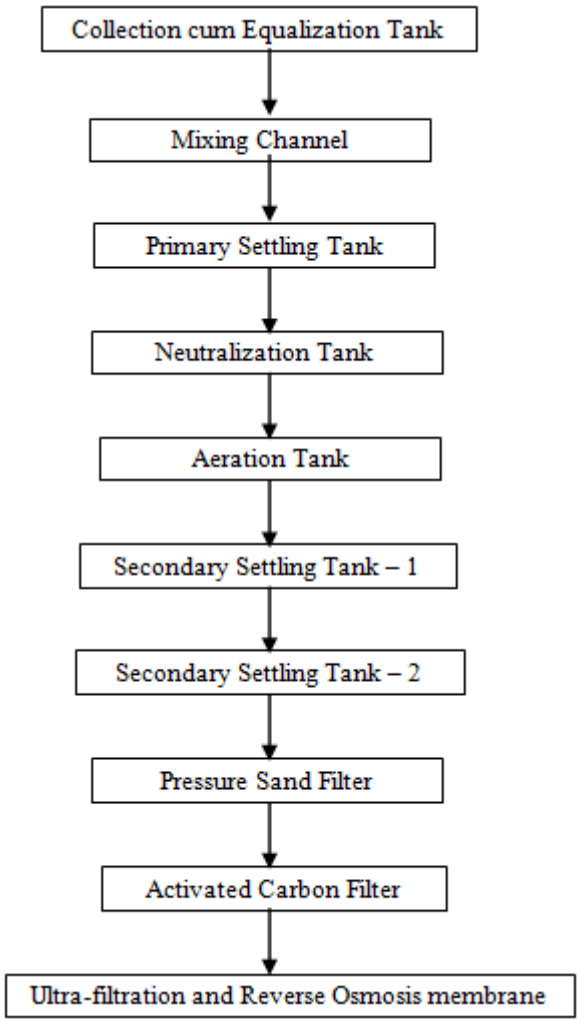

Fig. 1: Wastewater treatment system

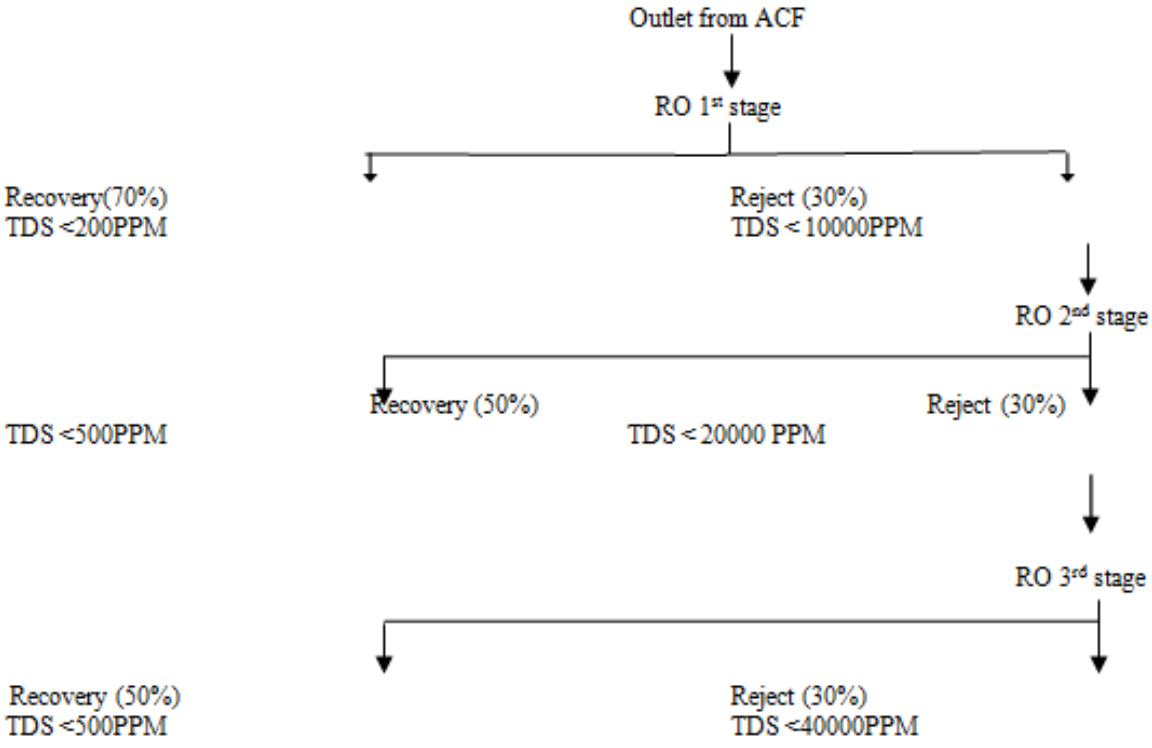

Fig. 2: Three stage RO unit

Nano-filtration process

Nanofiltration is a widely known technique which utilizes membrane systems for the treatment of different types of wastewater irrespective of its varied characteristics and properties. It has many commercial and operative advantages. Nanofiltration systems can be operated at low or minimum feed pressuresdueto its high specific flux rates[19]. When compared with Reverse Osmosis membrane systems, Nanofiltration mechanism posses lesser salt rejections which means it has lesser affinity towards the removal of salt compounds such as sodium and chloride. The membrane utilized in nanofiltration process has the capacity to reject particulates, colloidal particles in suspension, microbial contaminants etc., They can operate at high specific flux rates with minimum power consumption. Nanofiltration systems are very helpful in reuse/ recovery of wastewater which can be applied to communal, commercial as well as industrial applications[20]. The utilization of nanofiltration in Membrane Hybrid systems can make the last stage of Reverse Osmosis systems highly efficient in the recovery of wastewater[19-22]. The application of membrane technology for the treatment of dye industry wastewater is shown in Figure 3

Ultrafiltration Membrane

Ultrafiltration process utilizes pressure for separating the particles from the influent. The application of pressure inside the membrane helps in the separation of particulates. This system is applied for the removal of particulate and microbiological species[23]. These systems have lower process and staff requirements but needs time to time cleaning. Ultrafiltration membranes normally have a higher life time of four years than Reverse osmosis membranes. Various types or models of membranes are utilized in ultrafiltration systems such as plate and frame, spiral and wound, hollow-fibre and tubular layouts which are available commercially[23-25].

The membrane model, dimensions and specifications for use in the ultrafiltration system is given below:
Manufacturer: Koch Membrane systems
Model name: TARGA 10072-871-35-PMC
Membrane construction: Hollow fiber
Fiber Diameter: 0.035 inch (0.9mm)
Diameter: 10.75 inches (273 mm)
Length: 72 inches (1829 mm)
Membrane area: 80.9 m^2
Maximum pressure: 45 psi (3bar)
Temperature range: 0 – 40 C

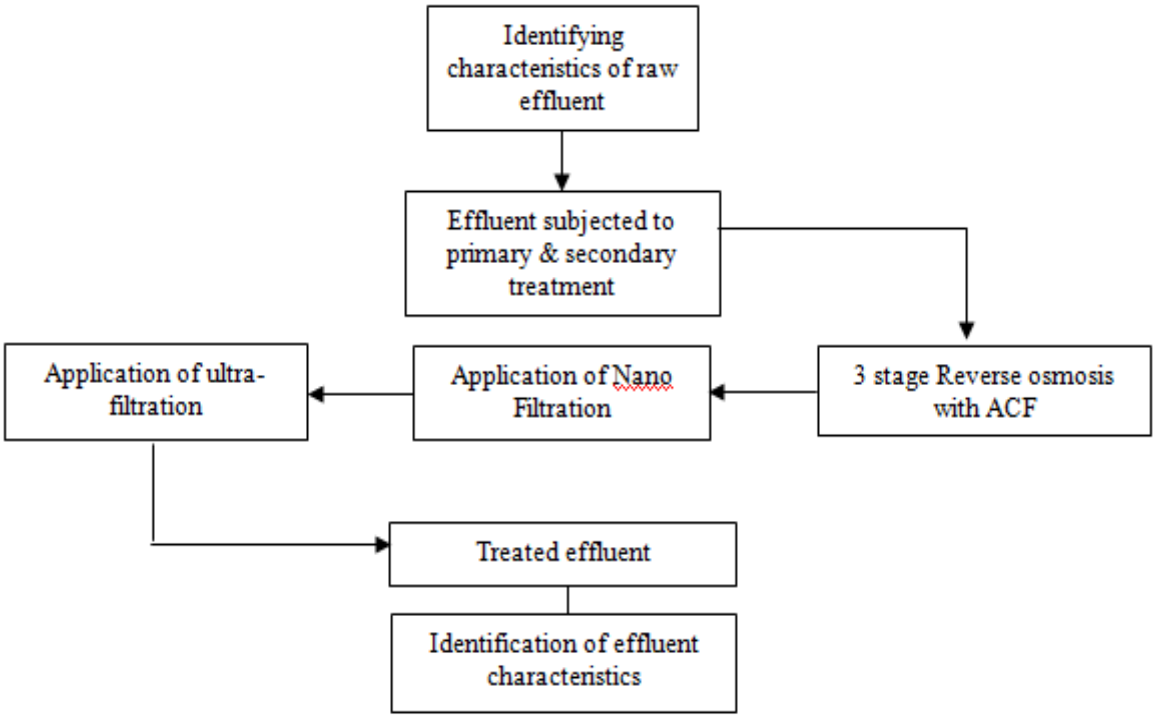

Fig. 3: Application of Membrane Technologies

3. Results and Discussion

The wastewater from the dyeing industry are analyzed to study the characteristics of the effluent generated from the industry. The characteristics of raw effluent are shown in Table 1.

Table 1: Physico-chemical properties of raw effluent

S.No	Parameters	Value	Unit
1	Color	Colored	---
2	pH	9-11	---
3	Total Dissolved Solids	2500	mg/L
4	Chemical Oxygen Demand	600	mg/L
5	Biochemical Oxygen Demand at 20° C	250	mg/L
6	Total Suspended Solids	500	mg/L
7	Total Hardness as $CaCO_3$	500	mg/L
8	Calcium	40	mg/L
9	Magnesium	30	mg/L
10	Chlorides as Cl	1000	mg/L

11	Sulphates as SO_4	400	mg/L
12	Total Alkalinity	400	mg/L
13	Total Iron as Fe	1	mg/L

The values of pH, Total Dissolved Solids and Chemical Oxygen Demand present in the raw untreated wastewater of the dyeing industry is above the desirable and permissible limits of trade effluent standards as prescribed by TNPCB. High amounts of TDS present in water will decrease the quality of water making it unsuitable for drinking and cooking purposes. Furthermore it will induce digestive problems in humans. Excessive COD concentration in water leading to death in aquatic life. Parameters such as BOD, TSS, Total Hardness, Calcium, Magnesium, Chlorides, Sulphates, Total alkalinity and Iron are satisfying the limits as prescribed by the regulations.

Table 2: Trade Effluent Discharge Standards

S.No.	Parameters	Desirable Limit	Permissible Limit
1	pH	6.5-8.5	No relaxation
2	Total Dissolved Solids (mg/L)	500	2000
3	Chemical Oxygen Demand (mg/L)	250	250
4	Biochemical Oxygen Demand (mg/L)	30	350
5	Total Suspended Solids (mg/L)	100	600
6	Total Hardness as $CaCO_3$ (mg/L)	300	600
7	Calcium (Ca) (mg/L)	75	200
8	Iron (Fe) (mg/L)	0.3	1.0
9	Magnesium (Mg) (mg/L)	30	100
10	Chloride (Cl) (mg/L)	250	1000
11	Sulphate (SO_4) (mg/L)	200	400
12	Total Alkalinity (mg/L)	200	600
13	Total Iron as Fe (mg/L)	0.3	1

Table 3: Treated wastewater properties

S.No	Parameter	Value
1	pH	5.75
2	Turbidity	Nil
3	Total Dissolved Solids	500 mg/L
4	Biochemical Oxygen Demand	Nil
5	Chemical Oxygen Demand	Nil
6	Total hardness	Nil
7	SDI	Nil

The trade effluent discharge standards for treated wastewater is shown in Table 2. The treated effluent using membrane technology is analyzed for the reduction in value and compared with the Drinking water specifications. The treated effluent characteristics is shown in Table 3. The treated effluent using membrane technology is analyzed for the reduction in values and compared with the Drinking water specifications. The treated effluent characteristics are shown in Table 3. The pH of the untreated raw effluent decreases from 9 to 5.75. Other parameters such as BOD, COD and total hardness has been reduced considerably by the application of Membrane technologies.

4. Conclusion

The treatment consists of three different types like primary, secondary and tertiary treatments. The primary treatment reduces the colour and removes the suspended particles in the wastewater. The secondary treatment consists of activated sludge process where the BOD, COD etc., arereduced. The final membrane treatment system is used to reduce the total dissolved solids and chemical oxygen demand present in the wastewater. The treatment plant adopted can purify the wastewater and can reuseit The usage of new technologies replacing the conventional ones will reduce the working cost and also ensure higher purity of water. The above treatment of the water makes it possible to safe guard the health of the people and aims towards ISO 14001 and Sustainable Development.

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