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Textile wastewater treatment using reverse osmosis and SDI

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ABSTRACT

Textile industry is the major source of water consumption and wastewater pollution. There are various treatment techniques to remove textile wastewater pollution. Textile wet processing unit involves a variety of chemicals comprising a various class of dyes along with huge amount of water resulting from wet processing operation. The conservations of chemical become a most important aspect for environment specially in consideration of the pollution phenomenon and increasing cost of chemicals in order to make the industry much more competitive in the globalize context. For that reason, liquid waste management and waste volume reduction by the product recovery are essential. In the case of India many wet processing industries and about 80% of these are woven fabric dyeing industries are needed to feed the fabric in the garments industries. For these reasons, effluent treatment planning is a burning question for a wet processing unit. In order to solve these problems as textile technologist we should define many corrective measures. This paper deals with the effluent standards and different wastages of woven fabric wet processing industries along with reverse osmosis treatment and SDI (Silt Density Index) explained in detail. It also deals with the various advantages, comparison of RO feed and permeates, RO feed and reject parameters of Silica, Sulphate, Free Chlorine, Chlorides, Silicate and S.D.Index. RO feed and permeate parameters Si reduced by – 95.46%, SO4 reduced by – 99.19%, Cl^- reduced by – 94.51%, SiO2 reduced by – 95.22% and SDI reduced by – 100.00%.

Introduction

Drewes (2003) study the Reverse osmosis (RO) membranes are widely used in drinking water, wastewater and industrial applications. The use of RO membranes in advanced wastewater reclamation using secondary treated wastewater effluent to produce water for indirect potable use has also increased over the past few years. However, a major impediment in the application of RO membrane technology for desalination and wastewater reclamation is membrane fouling. Barker (2000) investigate the advanced water reclamation, secondary effluent from wastewater treatment plants contains dissolved organic matter, commonly known as effluent organic matter. When the second wastewater effluent is introduced to the RO membrane processes as feed water, the presence of effluent organic matter contributes to organic fouling.

Amjad (1993) study the membrane – based separation processes like Ultrafiltration (UF) and Reverse Osmosis (RO) have been applied for treating a wide variety of industrial effluents.

Chain (1977) investigate the most of the effluents from different industrial source were used to be discharged directly in the soil or in ground water. But due to stringent environmental restrictions, Central Pollution Control Board (CPCB) has become vigilant and has imposed very stringent measures for recovering pure water from such industrial effluents. However, for the treatment of an effluent by conventional methods like aerobic and non-aerobic digestion, the ratio of biological oxygen demand (BOD) to COD should be >0.6.

Walter (2006) study the membrane processes, namely, reverse osmosis (RO), nanofiltration (NO), ultrafitration (UF) and microfiltration (MF) are continuing to get more and more attention world wide for their effectiveness in water treatment. RO got recognition as an alternative option among other conventional treatment processes in the early 1960s when it was successfully used for the first time in the desalination of seawater. As a result of continuous research and development in this field, a new generation of RO membranes which can operate under ultra-low pressure was developed in the beginning of 1995. This new generation of RO and NF were able to produce double the quantity of flux of the conventional RO and NF at low operating pressure without sacrificing the quality of the produced water by keeping the rejection of the organic and inorganic species at the same level.

Schwinge (2004) study the membranes are manufactured in different shapes and configurations, the most popular are spiral wound membrane (SWM), hollow fibre, tubular and frame and plate module with the target to reach an optimal performance for both operating conditions and configurating modules. Studying how different variables in the process change along the membrane play an important role in the optimization process and it was the issue for most of the researches both numerically and experimentally. Previous studies reported that across the longitudinal direction of the SWMs a fall in the permeate flow rate and a rise in the permeate and concentrate concentrations always took place.

Brian (1965) study the finite difference method was used by Brian to calculate the salt concentration polarization over the length of the membrane for the case of permeate surface. The results obtained were compared with a constant flux model across the membrane length.

Bhattacharyya (1990) investigate in used a finite element method to predict flux behaviour and concentration polarization

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throughout various configurations of RO membranes. The results obtained from this study were in total agreement with previous work regarding increase in concentration and decrease in permeate flux along the membrane length.

Fletcher (2004) In another numerical study, the effect of gravity on the permeation velocity and salt mass fraction through out the membrane were investigated. Their results showed that the effect of gravity cannot be overlooked along the channel with the adverse gravity conditions giving the highest salt concentrations and lowest flux at the membrane surface.

Drewes (2006) investigate the RO process is gaining wider use for contaminant removal in advanced water and wastewater treatment and desalination. Advancements in membrane developments result in the production of better and more economical membranes. These are yielding the desired result of being adopted as an efficient water treatment technology. However, membrane fouling is still a great hindrance for operation and cost efficiency. Fouling phenomena could severely limit membrane process efficiency as they lead to several deleterious effects including flux decline, possible permeate quality decrease and a gradual membrane degradation. An uneconomical increase in applied pressure and the need for frequent cleaning (shortening membrane life) or replacement become the necessary options if the rate of water production is to be maintained constant. The effect of fouling has been investigated extensively by numerous researchers.

Machenbach (1998) study the membrane process the increasing cost of water and its wasteful consumption have now induced a treatment process which is integrated in in-plant water circuits rather than as a subsequent treatment. From this standpoint, membrane filtration offers potential applications. Processes using membranes provide very interesting possibilities of separating hydrolyzed dyestuffs and dyeing auxiliaries, thus simultaneously reducing coloration and the BOD/COD of the wastewater.

Tinghui (1983) investigate the Reverse osmosis membranes have a retention rate of 90% or more for most types of ionic compounds and produce a high quality of permeate. Decoloration and the elimination of chemical auxiliaries in dye house wastewater can be carried out in a single step. Reverse osmosis permeates the removal of all mineral salts, hydrolyzed reactive dyes and chemical auxiliaries. The problem involved is that the higher the concentration of salts, the more important the osmotic pressure becomes and therefore the greater the energy required.

Erswell (1988) study the Nanofiltation membranes retain organic compounds of low molecular weight, divalent ions or large monovalent ions, such as hydrolyzed reactive dyes as well as dyeing auxiliaries. (Tang, 2002) investigate the effect of the concentration of dyes has been frequently reported in dye house effluents as well as the concentration of salt and the pressure. In most published studies concerning dye house effluents, the concentration of mineral salts does not exceed 20 g L^{-1} and the concentration of dyestuff 1.5 g L^{-1} . (Abari, 2002) study the effluents are reconstituted with generally only one dye and the volume studied is low. (Freger, 2000) study the treatment of wastewater after dyeing by nanofiltration thus represents one of the rate applications possible for the treatment of solutions with highly concentrated and complex solution.

Watters (1991) study the Ultrafiltration enables the elimination of macromolecules and particles but the elimination of polluting substances, such as color is never complete (between 31% and 76%). (Rott, 1999) study the even in the best of cases, the quality of the treated wastewater does not permit its reuse for feeding sensitive processes, such as the dyeing of textile. Ciardelli (2001) study Ultrafiltration can only be used as a pretreatment for reverse osmosis or in combination with a biological reactor. (Mignani, 1999)

Al-Malack, (1997) study the Microfiltration is suitable for treating dye baths containing pigment dyes as well as subsequent rinsing baths. Sadr Ghayeni (1998) investigate the auxiliaries remain in the retentant. Microfiltration can be used as a pretreatment for nanofiltration or reverse osmosis

Hitendra Bhuptawat (2007) investigates the water extract of Moringa. Oleifera seed was applied to a treatment sequence comprising coagulation-flocculation-sedimentation-sand filtration. Model waters (kaolinite suspensions) of turbidities 10, 100, 300 and 700 NTU were prepared. For the 10 NTU water, the optimum dose was only evident when sand filtration was incorporated into the treatment.

Zhi Lin Li, Wei Liu, Xin Fang. Chen (2010) study the feasibility of using laccase to treat oily wastewater was examined. When only laccase was added to the synthetic oily wastewater, the suitable technological conditions were laccase at 3 U/ml, pH at 6.0, a temperature of 30°C, and a reaction time of 6 h for the initial oil concentration of 120 mg/L. Under those conditions, the rate of oil removal was as high as 69%. The effects of Mg^{2+}, Mn^{2+}, Cu^{2+}, and Fe^{2+} ions in wastewater on the rate of oil removal using laccase were investigated. The results showed that $Cu^{2+}$and Fe^{2+} ions obviously inhibited the catalytic performance of laccase under the studied concentration. On the other hand, Mg^{2+} and Mn^{2+} ions only had slight effects on the rate of oil removal for the range of concentrations studied. A 95% oil removal rate could be obtained when actual wastewaters were treated using laccase with the additive chitosan under the suitable technological conditions.

Fons Moi. Pang, Sheau Ping. Teng, Tjoon Tow. Teng (2009) investigates the hydroxide precipitation and coagulation-flocculation methods were used to treat wastewater containing lead, zinc, copper, and iron. The concentrations of heavy metals in the synthetic wastewater range from 1 to 14 mg/L for lead, 5 to 90 mg/L for zinc, 3 to 90 mg/L for copper and 5 to 45 mg/L for iron. Individual Zn(II) and Cu(II) with concentrations below 90 mg/L and Fe(III) with concentrations below 45 mg/L were removed up to 99% by the precipitation method in the pH range of 8.7 to 9.6, 8.1 to 11.1, and 6.2 to 7.1, respectively.

Daniel Babineau, Dominique Chartray, Roland Leduc (2009) investigates the treatment of municipal wastewaters by physical-chemical methods normally requires the use of a metallic salt coagulant and a synthetic coagulant aid. Integrating the sustainable development concept in the treatment of waters favours the use of renewable resources such as natural biopolymers. In order to better understand the peculiarities of using a product of natural origin in municipal wastewater treatment, laboratory testing (jar tests) was achieved with chitosan as a coagulant aid, as well as full-scale testing in a medium size physical-chemical wastewater treatment plant. The full-scale test was performed in two parallel, identical systems treating the same wastewater under the same conditions. The one using a combination of alum with a synthetic polymer (AL/SP) was compared with the other which used alum and chitosan (AL/CH). Removals for COD, SS, and total phosphorus reached 87%, 95% and 93%, respectively, for the AL/CH combination. These results are similar to those obtained for COD and SS with the AL/SP combination. Some results show a coagulant dosage (alum) up to 24.8% lower with chitosan as the usual coagulant aid. For total phosphorus, however, the results show that removals.

Methodology

One of the leading woven fabric-dyeing units, SIPCOT, Perundurai, Erode, visited for manufacturing process and wastewater quantity were collected. Effluent samples collected from Reverse Osmosis feed, permeate and reject parameters. Following parameters were tested

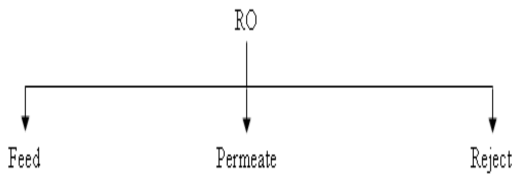
1. Silica
2. Sulphate
3. Free Chlorine
4. Chlorides
5. Silicate
6. S.D. Index

Then comparison between the results of RO feed and Permeate, RO feed and rejects parameters.

Results and Discussion

The present work focus on the process and treatment methodology adopted in woven fabric dyeing industry. Four numbers of soft flow reactor (batch process), two numbers of beam dyeing machine and three numbers of padding are used for dyeing.

Three stages of treatment water tested like, RO feed, RO Permeate and RO reject. Each stage tested in following parameters of Silica, Sulphate, Free Chlorine, Chlorides, Silicate and Silt Density Index (S.D. Index).



Reverse Osmosis (10 Lack liters capacity)

- Membrane: Polyamide
  Spiral wound
  5 Micron size
  Membrane diameter 8”
- Dosing:
  Dosing for pH correction - HCl
  Dosing for Dechlorination - Sodium Metta Bi Sulphite (SMBS)
  Dosing for Anti sclentent - Phospanic Acid Base
- RO – I; 1st stage feed: 6 Vessel & 4 Vessel (2nd stage feed)
  [6 X 6: 4 X 6]
  [6 Vessel X6 Membrane: 4 Vessel X 6 Membrane]
  (10 X 6 = 60 Membrane)
- RO – II; 1st stage 2 Vessel & 1 Vessel (2nd stage)
  [2 X 6: 1 X 6]
  [2 Vessel X6 Membrane: 1 Vessel X 6 Membrane]
  (3 X 6 = 18 Membrane)
  (Vessel length 6 meters, Sprial wound membrane 6 numbers, each membrane length1M)
- Flow Rate
  Feed water 50 m³/hour
  Permeate 45 m³/hour
  Reject to evaporator 5 m³/hour

Table 1, Reverse Osmosis feed parameters

Days	Si ppm	SO4 ppm	Free Cl2 ppm	Cl¯ ppm	SiO2 Ppm	SD Index
1.	5.47	284	Nil	1276	11.76	4.2
2.	5.31	253	Nil	1270	11.40	3.0
3.	5.75	242	Nil	1150	12.36	4.0
4.	5.90	236	Nil	1092	11.88	4.4
5.	4.90	222	Nil	1040	10.29	3.5
6.	5.5	272	Nil	1190	10.98	4.0
7.	6.17	266	Nil	1210	12.02	4.4
8.	5.22	240	Nil	1160	11.06	3.0
9.	5.30	234	Nil	1210	10.96	3.2
10.	5.42	246	Nil	1226	10.84	3.4

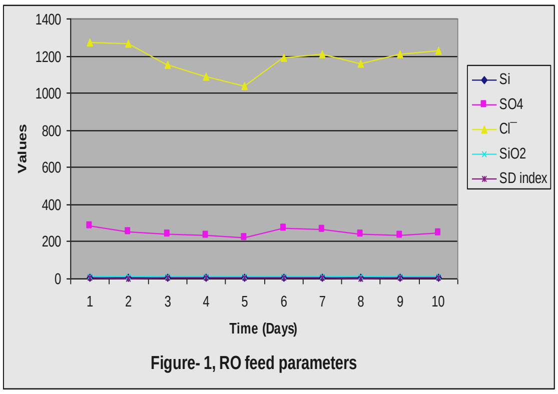


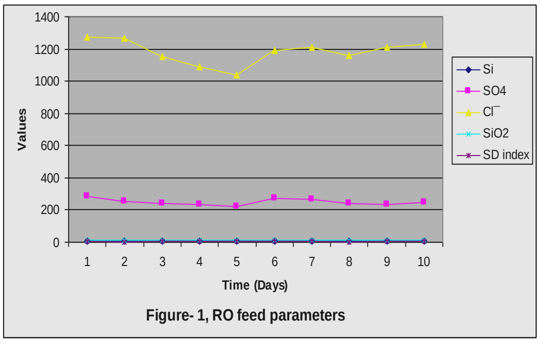
Figure- 1, RO feed parameters

Table 1 and figure 1, show the characteristics of RO feed parameters in the frequency of ten days.

Si maximum value of - 6.17 ppm,
SO4 maximum value of – 284 ppm,
Free Cl2 value is Nil,
Cl¯ maximum value of – 1276 ppm,
SiO2 maximum value of – 12.36 ppm and
SDI maximum value of – 4.4

Table 2, Reverse Osmosis permeate parameters

Days	Si ppm	SO4 ppm	Free Cl2 ppm	Cl¯ ppm	SiO2 ppm	SD Index
1.	0.34	4	Nil	74	0.72	Nil
2.	0.32	3	Nil	80	0.67	Nil
3.	0.36	2	Nil	82	0.75	Nil
4.	0.36	3	Nil	70	0.76	Nil
5.	0.32	2	Nil	85	0.67	Nil
6.	0.35	3	Nil	72	0.74	Nil
7.	0.36	4	Nil	76	0.76	Nil
8.	0.28	3	Nil	70	0.59	Nil
9.	0.29	3	Nil	74	0.61	Nil
10.	0.31	4	Nil	78	0.65	Nil



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4.	0.36	3	Nil	70	0.76	Nil
5.	0.32	2	Nil	85	0.67	Nil
6.	0.35	3	Nil	72	0.74	Nil
7.	0.36	4	Nil	76	0.76	Nil
8.	0.28	3	Nil	70	0.59	Nil
9.	0.29	3	Nil	74	0.61	Nil
10.	0.31	4	Nil	78	0.65	Nil

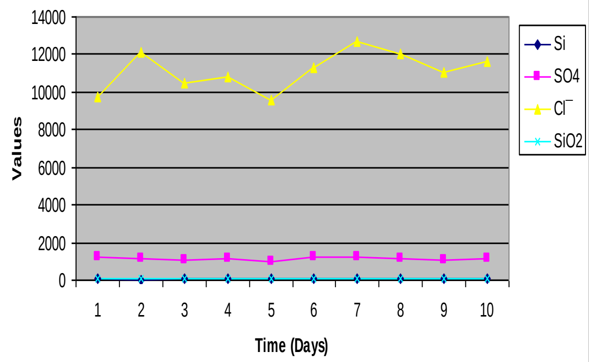

Figure- 3. RO reject parameters

Table – 3 and figure – 3, show that the RO reject parameters. The comparison between RO feed and reject parameters was given below.

Si reduced by – 88.08%
SO4 reduced by –76.72% %
Cl^- reduced by –89.94%%
SiO2 reduced by –88.86 %

Figure 4 Reverse Osmosis plant 10 Lack liters capacity

Figure 4,5,6 shows the RO 10 lack liters capacity, RO stage I, stage II and RO dosing tank. Figure 7 show the soft flow dyeing machine 1000 KLD capacity and Figure 8 show the Beam dyeing machine 500 KLD capacities.

Figure 5 Reverse Osmosis Plant Stage I and II

Figure 6 Reverse Osmosis dosing tanks

Figure 7 Soft flow dyeing machine

Figure 8 Beam dyeing machine

Silt Density Index (SDI)

SDI = $(1- t_1 / t_2)$ X 100 / T_{15}

Where,

t_1 = initial time taken (for 500 ml sample)
t_2 = final time taken (for 500 ml sample)
T_{15} = time duration 15 minutes

Example :

t1 = 44 sec (2 kg pressure)
t2 = 80 sec (2 kg pressure)
SDI = [1-(44/80)] X100/15
SDI = 3.0
Standard value of SDI < 5.
[SDI paper: cellulose nitrate
Paper dia = 47 mm
Pore size = 0.45 micronContent

- colloidal silica
- silt (fine particals)
- living(or) non living organism i.e, >0.45 micron]

Conclusion

- The recycling of treated wastewater and zero wastewater discharge concept are found technically feasible and economically viable in the textile dyeing industries located in the area of Erode.
- Reduction percentage between RO feed and permeate Si – 95.46%,

SO4 reduced by – 99.19%, Cl¯ reduced by – 94.51%,

SiO2 reduced by – 95.22% and SDI reduced by – 100.00%.

- The most attracting part of water recovered from these membranes is its extremely low hardness, which is always demanded in textile sector for an improved finish and better quality of dyeing.
- Reverse osmosis membrane technologies are of the most importance several advantages are given below:

o Separation does not require addition of chemicals as may be the case in the water clarification, by means of coagulation-flocculation process

o Decreased the production cost

o High permeability to water

o High efficiency of the membranes in selective mineral rejection

Nomenclature

Cl^- - Chlorides

Free Cl_2 – Free Chlorine

SO_4 – Sulphate

SO_3 – Sulphide

Si – Silica

ppm – Parts Per Million

RO – Reverse Osmosis

SiO2 – Silicate

SDI - Silt Density Index

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