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Study on Treatment and Re-use of Wash Water Effluent Form Textile Processing by Membrane Techniques

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Abstract

Textile processing units at Erode, Karur, Namakkal and Tirupur districts of Tamilnadu, India generates chemically toxic waste water there by polluting sub-soil and surface water of water bodies in particular River Cauvery. In Erode district, a model Common effluent treatment plant (CETP) was promoted by State Industrial Promotion Corporation of Tamilnadu Ltd, at Perundurai with 14 textile units as stake holders. Waste water from textile processing units contains a complex mixture of dyes, which are highly resistant to conventional treatment technology. As the characteristics of wash water effluent and dye bath effluent are variable, various physical, chemical and biological treatment methods are adopted for the treatment. Most of the perennial rivers in Tamilnadu have less surface flow water and dried during summer season. Due to this non-sustainability condition of water source of Cauvery River, all the processing industries are facing high production loss and necessitated treating and reusing the wash water effluent using a novel technology. In this study, Reverse Osmosis technique is adopted to treat the wash water effluent and reuse the membrane treated wash water for processing textile products there by aiming for zero discharge to protect green environment. Based on the experimental results an embedded system membrane method with biological treatment is best suited for effective recovery of permeate.

Keywords: Reverse Osmosis, Wash water effluent, Dye bath effluent, Zero discharge

1. Introduction

The Perundurai common effluent treatment plant company Ltd (PECTP) with 14 individual textile processing units as stake holders has setup two separate effluent management system - one to treat the wash water effluent and the other to treat dye bath effluent.

The individual units are allowed to discharge the wash water effluent with TDS less than2100 ppm (Kulkarni, V.G). The treated wash water effluent after conventional primary treatment through bar screening, equalization, flash mixing, clariflocculation, stabilization, sent for irrigating non-edible plantations in 70 acres. The characteristics of raw wash water effluent and treated wash water effluent is furnished below in table: 1

The stake holders of PETCP requires more than 3000m^3/day of water and SIPCOT is supplying the raw Cauvery river water at Rs 20/m^3 for industrial use. The surface flow in Cauvery River is dwindling day by day and completely dry sometimes. The uncertainty in availability of water shall have a direct impact in operation of processing units (Brady JA) and casts a shadow on the production in this textile cluster. The surveillance of dying units can be safe guarded only by making sustainable water source. Recycling of treated wash water by adopting reverse osmosis system for processing in inevitable factor for achieving industrial development (World Water Council (2008)) and zero discharge to avoid pollution of available sub-soil drinking water for future needs.

2. Treatability studies of Primary treated wash water effluent

The pretreatment of feed water to Reverse Osmosis (RO) is to optimize the performance and the life of membrane element. Pretreatment equipment is engineered to accomplish this task by meeting the following objectives

1) Insure the compatibility of the feed streams with RO Membrane
2) Reduce or eliminates the potential for scale formation on the membrane or in the element flow channels.
3) Reduce the RO cleaning frequency by reducing the fouling potential of the feed stream.

The primary wash water effluent of PCETP has to be pretreated for conditioning the feed water to RO system. The various physical, chemical and biological treatability studies are carried out.

2.1 Physiochemical Treatment:

Various Physio-chemical treatment methods have been employed in the pre-treatment to reduce BOD (Biological Oxygen Demand), COD (Chemical Oxygen Demand), TSS (Total Suspended Solids) and Color. The results of physical and chemical treatments are tabulated in table no: 3 (i).

2.2 Biological Treatment

Conventional biological treatment process can degrade the mixture of waste water from textile industry, if the BOD/COD ratio is > 0.3 (Anil Kumar 2005). As the primary treated wash water effluent satisfies the above conditions, it is subjected to aerobic bacteriological treatment. The activated sludge treatment method was employed in simulated system (***Dr. A. Mary Saral***). The efficiency of simulated bacteriological treatment is shown.

The characteristics of biologically treated wash water effluent are as tabulated in Table 3 (i).

From the results, it is noticed that, the highest efficiency of reduction is by membrane bio-reactor. Since the cost of this treatment is high, it is not preferred for practical applications. Organic scavenger appears to be the best suited method for common effluent treatment.

2.3 Reverse Osmosis System:

Introduction to Reverse Osmosis

Reverse Osmosis is a water purification technique that reduces the quantity of dissolved solids in solution or from wastewaters produced in many industrial applications. RO uses waterline pressure to push raw wastewater against a special semi permeable membrane. It is essentially a molecular squeezing process which causes H_2O molecules to separate from the contaminants. The separated water molecules then pass through inside the membrane. The contaminants are washed from the membrane and disposed off.

Osmosis

Osmosis is a natural process involving the fluid flow of across a semi-permeable membrane barrier. Consider a tank of pure water with a semi-permeable membrane dividing it into two sides. Pure water in contact with both sides of an ideal semi permeable membrane at equal pressure and temperature has no net flow across the membrane because the chemical potential is equal on both sides. lf a soluble salt is added on one side, the chemical potential of this salt solution is reduced. Osmotic flow from the pure water side across the membrane to the salt solution side will occur until the equilibrium of chemical potential is restored. In scientific terms, the two sides of the tank have a difference in their "Chemical potentials" and the solution equalize, by osmosis, its chemical potential throughout the system. Equilibrium occurs when the hydrostatic pressure differential resulting from the volume changes on both sides is equal to the osmotic pressure. The osmotic pressure is a solution property proportional to the salt concentration and independent of the membrane.

Reverse Osmosis

With the tank in Figure la, the water moves to the salty side of the membrane until equilibrium is achieved. Application of an external pressure to the salt solution side equal to the osmotic pressure will also cause equilibrium (Figure Ib).

Additional pressure will raise the chemical potential of the water in the salt solution and cause a solvent flow to the pure water side, because it now has a lower chemical potential. This phenomenon is called reverse osmosis.

The driving force of the reverse osmosis process is applied pressure. The amount of energy required for osmotic separation is directly related to the salinity of the solution. Thus, more energy is required to produce the same amount of water from solutions with higher concentrations of salt.

To avoid bio fouling, to have long life of membrane and to achieve higher efficiency, the values (specified in table 2) are suggested for feed water by membrane manufacturers.

As the characteristics of biologically treated wash water are on higher side to fit as feed water to RO system, additional pretreatments are essential. The biologically treated wash water effluent is treated through pressure sand filter and chemical dosing for pH adjustment. The characteristics of the effluent after treatment is as below

Since the COD and BOD values are slightly exceed the limitations, the effluent from sand filter is treated through ultra filtration. Now the treated effluent is having the characteristics suitable for feed water.

Spiral wound type construction membrane is used in the RO system. Permeate from UF is treated with spiral wound type membrane. The permeate from RO system will have the following characteristics

Effective recovery of permeate is about 90% and the reject is 10%. The characteristics of permeate is much better than the Cauvery river water characteristics.

3. Results and Discussions

Textile finishers use vast quantities of water, but the availability of Cauvery river water through out the year for the required quantity with permissible limit of characteristics for processing is un certain. So the processing units are supplied with raw water from nearby bore well source through tankers. It costs around Rs 40/m^3.

Due to varying characteristic of available Cauvery river water and bore well water, the quantity of chemical usage varies and quality of textile products are affected. Due to scarcity of river water source and uncertainty of water availability, the reuse of permeate water will result sustainability of quality water and avoid interruption in production.

3.1 Benefits

- recovery of quality water to be reused for processing
- Water for processing will be of same characteristics and automation of chemical dosing can be made to avoid spillage, excess dosing and to reduce man power (Kundzewicz, Zbigniew W. (2007)).
- Protection of sub-soil water in the near by area due to high TDS and chemically toxic effluent discharged for non-edible plantations,
- Saves chemicals in dying process due to better quality water for processing
- Better finishing of textile products due to the quality water.
- Satisfying the TNPCB norms.
- Improves the image of the factory among the buyers and there by increasing the orders.

Conclusion and perspectives

i) Preventing environmental pollution due to reduced discharge of industrial effluent at present and ap proaching for zero discharge

ii) Conservation of water resources in the nearby habitations.

iii) Improved quality of finished textile products.

iv) Saving the consumption of chemicals, thereby reducing the production costs and pollution in the environment.

As the RO system is a new technology in CETP, the performance of RO system has to be evaluated in detail over a period of time and the advantages and solutions to overcome the practical problems is to be studied.

Literature reveals that, in biological treatment, fungi reduce the BOD, COD content in the effluent efficiently than bacteria. The fungal treatment of effluent reduces the load in feed water and also increases the membrane performance and life.

The suspended solids in the wash water effluent vary from 200-600 mg/l. chemical dosing of 350 mg/l of $FeSO_4$ and 250 mg/l of lime to the effluent with average TSS level of 400 mg/l will generate about 1000 mg/l of dry solids and a total quantity of 2 tones /day. Over dosing of chemicals and using sulphate based chemicals produce excess sludge generation. At present, the dosage of chemicals is controlled manually, with respect to pH of effluent in flash mixture.

pH based dosage do not indicate the actual requirement of $FeSO_4$

Over dosing of $FeSO_4$ will result in reddish color of effluent and additional requirement of lime, causing wastage of chemical and increased cost of treatment.

Dosing $FeSO_4$, lime in flask mixture, results in wastage of chemicals as $FeSO_4$ will not have enough time for reaction.

Presence of calcium sulphate in the effluent due to the dosing of $FeSO_4$, is affecting the performance of RO system. Hence ferrous chloride may be used in the place of $FeSO_4$ to avoid calcium sulphate.

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Table 1. Characteristics of Wash Water Effluent

S.No	Parameter	Units	Analysis Value	
			Raw Wash Water Effluent	Treated Wash Water Effluent
1	pH	-	8.5	7.45
2	Suspended Solids	mg/l	820	85
3	TDS (inorganic)	mg/l	1665	1770
4	BOD	mg/l	320	140
5	COD	mg/l	700	415
6	Color	pt-co	1680	180
7	Silica	mg/l	22	18
8	Total Hardness	mg/l	177	171
9	Calcium Hardness	mg/l	115	95
10	Sulphates	mg/l	410	215

Table 2. Properties of wash water before and after treatment

S.No	Parameters.	Properties Required for treating in RO	Pre treated wash Water	RO Treated Wash Water	Biologically Treated Wash Water	R.O. Feed Water
1.	pH	6.5 - 7.5	7.5	6.5	7.6	6.3
2.	BOD_5	< 5 mg/l	9.0 mg/l	7.3 mg/l	8.2 mg/l	-
3.	COD	< 50 mg/l	80 mg/l	70 mg/l	80 mg/l	-
4.	Total Hardness	< 1000 mg/l	115 mg/l	100 mg/l	115mg/l	28 mg/l
5	TDS	< 2100 mg/l	1800 mg/l	200 mg/l	1700 mg/l	80mg/l

Table 3. Treatability studies of Primary treated wash water effluent

(i) Physio-chemical Method

S.No	Parameter	Value reported after 1° treatment for wash water	% reduction by the treatment using	
			Ozonation	Wet air oxidation
Dosage		-	3%ozone generator –contact time 0.5 – 2.5 m	100– 800 ppm
1.	BOD	140 mg/l	46-50	30-55
2.	COD	415 mg/l	50-55	35-60
3.	TSS	82 mg/l	-	33-42
4.	Color	180 Pt-Co	51-53	52-63

S.No	Parameter	% reduction by the treatment using			
		Activated Carbon Filters	Chemical Oxidation –hypo chloride	Wet Land Filtration	Chemical Oxidation - peroxide
Dosage		Granulated packed bed contact time 30 min to 4 hr	50-500 ppm	0.5 – 4.5 days retention time	5 vol soln dosage (15 – 220 mg/l)
5.	BOD	30-40	45-63	44-85	45-60
6.	COD	35-55	55 – 68	62-86	53-62
7.	TSS	-	-	73-76	-
8.	Color	45-60	55-60	61-82	45-62

S.No	Parameter	% reduction by the treatment using		
		Organic scavenger	Catalytic Oxidation	Fenton treatment
Dosage		Contact ime 10 mins	Hypo Dosage (50 – 200 mg/l), silver catalyst dosage (20 – 50 mg/l)	Peroxide Dosage (20 -250 mg/l), $FeSo_4$ (100 – 400 mg/l)
9.	BOD	83	50-67	45-60
10.	COD	80	60-78	44-52
11.	TSS	32	-	-
12.	Color	80	65-74	65-72

(ii) Biological Method

S.No	Parameter	Membrane bioreactor with 1 KD UF	Bio-sorption
	Dosage Tried		VSS Conc. 25 g/l – 68 g/l
1.	BOD	83-86	25-35
2.	COD	76	23-32
3.	TSS	100	55-65
4	Color	66	27-33

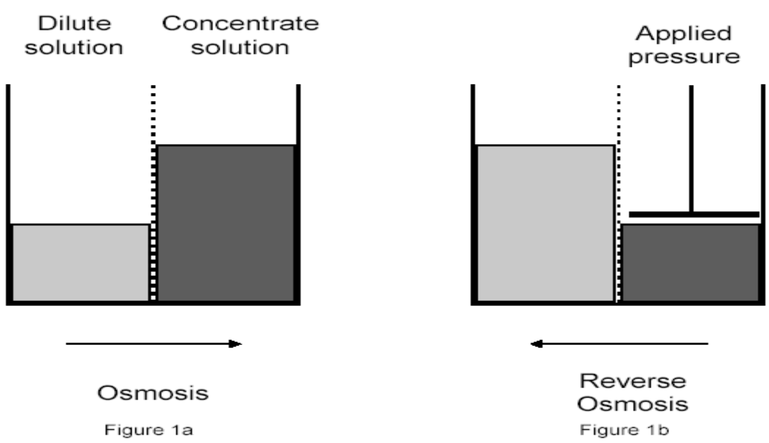

Figure 1. Reverse Osmosis

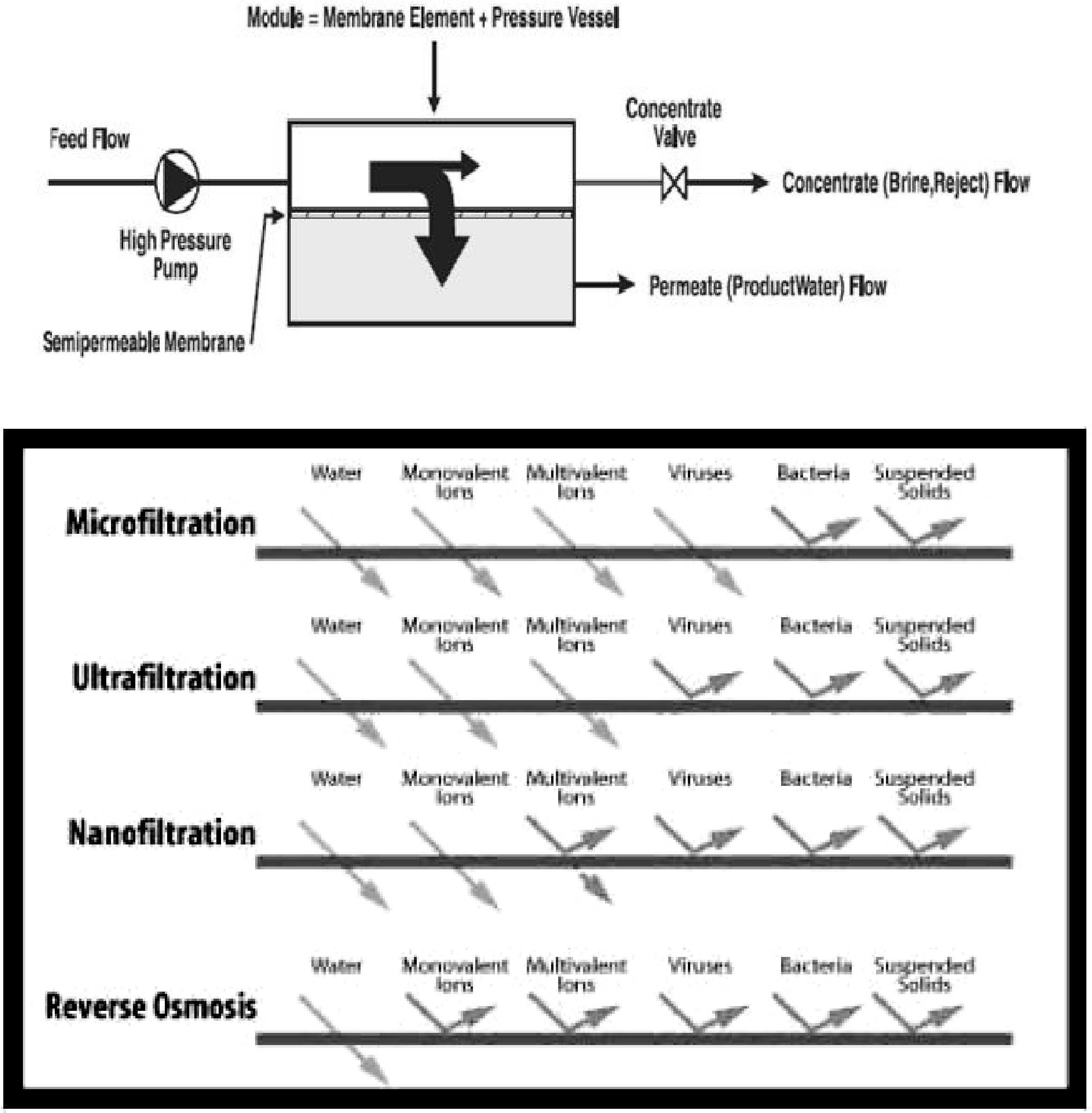

Figure 2. Flow Chart for Reverse Osmosis