ADVANCED TREATMENT OF TEXTILE YARN DYEING WASTE WATER TOWARDS REUSE USING REVERSE OSMOSIS MEMBRANE

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Abstract

The textile dye house industries used valuable dyes, which are clearly visible if discharged into public water ways. Thus, their disposal creator both an aesthetic and environmental waste water problem. In this paper study an treatment of textile yarn dyeing waste water using with Reverse Osmosis(RO), textile dyes recovers, water way pollution is avoided, waste water can be treated new techniques to produce freshwater quality for non-potable uses of reasonable work.

Two methods of treatment like, Dye bath waste water and Wash water. This process of yarn dyeing effluents which are collected separately and following treatment for maximum recycling of recovered waters. Wash water is treated using a sequence of physicochemical and biological unit process, the waste water passed into two stages of RO membrane system which the permeate is reused for processes. The rejects about 8 – 12% of the inlet volume is subject to RO for sent to evaporators. Dye bath water after treating, the permeate is used in process for dye bath preparation and reject of about 20 – 25% is sent to multi effect evaporator. The effects of repeated usage on the performance efficiency of the RO studies and the results should a decrease of pH, TSS, BOD, COD and Total Hardness when monitored over time.

Keywords: Recycling of waste water, textile effluent, pH, COD, BOD, Total hardness

I. INTRODUCTION

Waste water discharged from a textile wet processing plant contains various types of impurities depending on the type of raw materials, dyes, chemicals, auxiliaries and process used. Some of these impurities are considered toxic while some are not. The toxicity or harmfulness also depends on the amount present in a certain amount of processed or waste water. Different types of water application also require different level of acceptable toxicity. For example water is used for drinking purposes, irrigation in the fields, in various types of textiles, chemicals, food processing, and leather processing, pharmaceutical industries and also to maintain the aquatic life in the canals and rivers. In all these cases different level of purity in terms of toxicity and harmfulness are required. About 50% of the textile mills are using approximately 200 – 250 liters of water per kg of fabric produced while about 20% of the mills are using below 200 liters of water per kg of fabric depending on the process sequence and water utilization practices adopted in the mill. Water pollution by the textile mills in mainly attributable to various waste liquor coming out of the unit operations in wet processing such as desizing, scouring, bleaching, mercerizing, dyeing, printing and finishing.

Water is essential to all forms of life Erode and Tirupur in Tamilnadu are well known textile centers in India particularly for textile processing. The main water resources for these industries are Noyyal, Bhavani and Cauvery rivers. Most of the textile industries situated in these regions are small and medium, which are unorganized in nature in view of effluent treatment facilities. Most of the color effluents are discharged into the river particularly into river Noyyal, without any proper treatment. So it is necessary to find low cost and affordable treatment for the colors textile wastewater [1].

The reagents used in textile industry are very diverse in chemical composition. Over 7,00,000 tons of approximately 10,000 types of dyes and pigments are produced to be discharged as industrial effluent during the textile dyeing processes. Conventional biotreatment methods are not effective for the most of the synthetic dyestuffs due to the complex polyaromatic structure and recalcitrant nature of the dyes [2].

The textile dyeing industry is regarded as water intensive sector as it used water as the principal medium for applying dyes and chemicals and removing of impurities [3]. The main environmental concern is therefore about the amount of water discharged and the chemical, load it carries. To illustrate, for each ton of produced fabric 20 – 350m^3 of water are consumed, the rather wide range reflecting the variety of involved processes and process sequences [4]. In order to reduce environmental impact, discharge limits imposed on textile mills are becoming even more stringent. Stricter regulations are forcing plant managers to upgrade existing waste treatment systems or install new systems where none were needed in the part. Moreover, in future reuse of purified effluents will be of increasing relevance due to raising water prices as well as to preserve natural water resources. The textile processing industry is therefore a prime candidate for the development of advanced water treatment strategies [5]. The quality of textile wastewater depends very much on the employed coloring matters, dyestuffs and accompanying chemicals as well as the process itself. Depending on the season and the fashion, the compositions of textile wastewater were of the same process changes often. About 8000 different coloring matters and 6900 additives are known and lead to an organic as well as inorganic pollution of the wastewater [6].

Organic matter represents the main emission load for textile waste water suggesting treatment based on biological processes. However, the introduction of effective and sustainable water recycling techniques in this branch of production is often prevented by recalcitrant organic compounds and remaining colour. Because of poor biodegradability and sometimes even toxicity of the textile wastewater components, an advanced treatment technology is necessary. Especially if reuse of treated wastewater is the objective, extensive removal of organic contents as well as almost complete decolourization is required [5].

The textile industry uses valuable dyes, which are clearly visible if discharged into public water ways. Thus, these disposals create both an aesthetic and environmental wastewater problems. At the same time, the textile industry continually seeks to conserve water and would economically benefit from dye recovered and reused. Second, water way pollution is avoided, and third, reusable water is produced [7].

II. LITERATURE REVIEW

A. pH

pH is the negative log base of hydrogen ion concentration and is unit-less. The hydrogen-ion concentration is an important quality parameter. The concentration range for existence of most biological life is quite narrow and critical [8]. The hydrogen-ion concentration in water is closely connected with the extent to which water molecules dissociate [9]. The solubility of heavy metals is dependent on the pH, due to this a lot of process units are heavily dependent on pH such as chemical treatment.

B. Total Dissolved Solids

Total Dissolved Solids, TDS, describes the amount of dissolved compounds in the water and is similar to conductivity. Water is a good solvent and picks up impurities easily. Dissolved solids refer to any minerals, salts, metals, cations or anions, which are dissolved in water. TDS consists of inorganic salts (principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides and sulphates). It also consists of some small amounts of organic matter that are dissolved in water. TDS concentration is the sum of the cations (positively charged ion) and the anions (negatively charged ions) in the water. TDS tells the quantity of dissolved ions but not the nature of them [10]. TDS is an indicator to determine the general quality of the water. High TDS concentration is not a health hazard but more an aesthetic matter. However, if higher TDS is found it can indicate that some metal levels, such as lead or aluminum, are very high.

Chemical Oxygen Demand, COD, is the amount of oxygen needed to chemically oxidize the organics in the water. A strong oxidizing agent, commonly used is potassium dichromate, which is used to oxidize the organic matter instead of microorganisms used in BOD. COD measures the same thing as BOD, but has the advantage of only taking two hours to produce the result. The temperature needs to be elevated and some inorganic compounds will interface with the test, so these have to be removed before hand. The COD is in general higher than the BOD because more compounds can be chemically oxidized than biologically oxidized. Different types of water have different translations between BOD and COD.

C. Chemical Oxygen Demand

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D. Biological Oxygen Demand

Biological Oxygen Demand, BOD, measures the readily biodegradable organic carbon. There are a number of different tests developed to determine the organic content of wastewater. BOD measures the dissolved oxygen used by microorganisms when they are oxidizing organic matter. BOD_5 is the amount of dissolved oxygen used from the water sample by microorganisms as they break down the organic matter at 20°C, over a five days period. Clean waters have a BOD_5 value of less then 1 mg/l and wastewater has between 150-1000 mg/l [9]. BOD_5 is widely used around the world for measuring organic compounds in the wastewater but it has limitations. Firstly a high concentration of active bacteria is required. Secondly only the biodegradable organics are measured. Thirdly a particularly long period of time is necessary to obtain the results. Fourthly BOD does not have stoichiometric validity after the soluble organic present in the solution has been used.

E. Total Suspended Solids

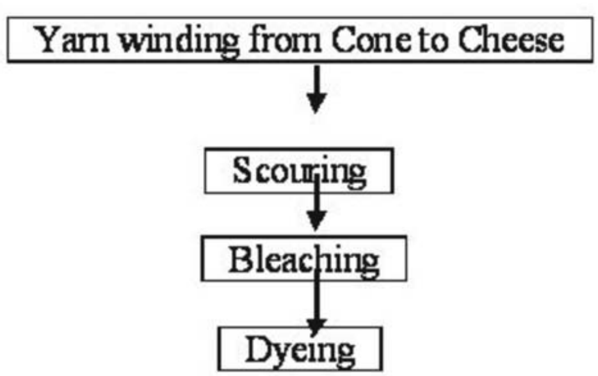
Total Suspended Solids, TSS, includes all particles in a known volume of liquid not passing through a filter of 1.2 micrometer pore size. TSS is measured in mg/l. The filter-solid fraction consists of colloidal and dissolved solids of particles of both inorganic, organic molecules and ions. The particles have a size of 10^{-3}-10^{-6} m [8]. TSS is commonly used to measure the amount of particles removed during the treatment process.

III. MATERIALS AND METHODS

A. Materials

The textile processing sector may be classified into four categories namely woven fabric dyeing, Knitted fabric dyeing, yarn dyeing and printing. The present work focus on the process and treatment methodology adopted in various sector listed above.

This paper one of the leading yarn dyeing unit, SIPCOT, Perundurai, Erode, visited and information on manufacturing process and waste water quantity were collected. Ten number of yarn dyeing machines are used for dyeing with different capacities. The process is described in Figure 3.0.



g.3. 0.Sequencepr ocessof yar ndy ei ng

The total quality of yarn processed in the unit is 3500 – 4000 kgs/day and the volume of effluent generated is of the order of 300 – 400 m³/day. Effluents are segregated into dye bath wastewater and wash water treatment is effected accordingly.

The effluent samples were collected during the yarn dyeing process and tested as per APHA, AWWA and WEF standards. For this purpose eleven locations have been identified which is as follows.

i) Wash water untreated effluent
ii) Dye bath plant feed parameters
iii) Wash water treated effluent (Biological – inlet Parameters)
iv) Biological treatment – secondary clarifier
v) Tertiary clarifier – DMF (Dual Media Filter) output
vi) Ultrafiltration feed parameters
vii) Ultrafiltration Permeate parameters
viii) Ultrafiltration reject parameters
ix) Feed parameters of Reverse Osmosis
x) Permeate parameters of Reverse Osmosis
xi) Reject parameters of Reverse Osmosis

B. Treatment Method

1, Sequence process for Wash water Plant (Pre treatment – I)

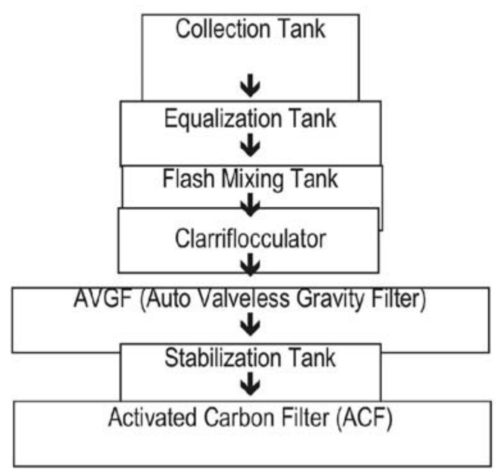


Fig. 3.1. Sequence process for Wash water Plant (Pre treatment – I)

2, Sequence process for Biological and Tertiary Treatment (Pre treatment II)

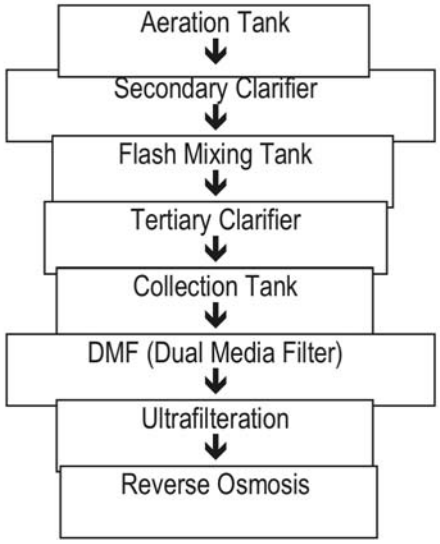
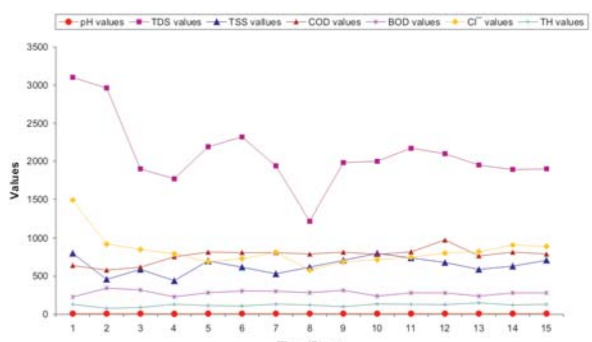


Fig. 3.2. Sequence process for Biological and Tertiary Treatment (Pre treatment II)

IV. RESULTS & DISCUSSION

Table .4.1 Wash water untreated effluent

Day	pH	TDS ppm	TSS ppm	COD ppm	BOD ppm	Cl^- ppm	Total Alkalinity ppm	Total Hardness ppm
1	7.86	3100	800	640	225	1493	1150	130
2	8.77	2960	460	580	345	922	1200	80
3	7.74	1900	590	620	320	851	1175	90
4	7.41	1770	440	756	230	795	1300	130
5	8.40	2190	700	816	285	690	1190	116
6	8.34	2320	620	808	305	730	1120	108
7	8.26	1940	530	810	301	815	1240	132
8	8.35	1220	620	792	284	580	1220	120
9	8.27	1980	710	816	315	690	1180	100
10	8.71	2000	800	784	240	716	1200	135
11	8.28	2170	740	818	280	750	1170	130
12	8.21	2100	680	976	280	802	1200	126
13	8.67	1950	590	768	240	820	1050	150
14	8.30	1890	630	815	280	910	1120	120
15	8.28	1900	710	790	282	890	1140	130



ig 4. 1 WashWater unteratedeffluent combinedvalues

] Table - 4.1 and Figure – 4.1, show that the characteristics of wash water untreated effluent in the frequency of fifteen days.

Table 4.2. Dye bath plant feed parameters

Day	pH	TDS ppm	TSS ppm
1	9.02	30570	6500
2	9.06	45700	10500
3	9.00	32200	8100
4	9.06	37200	8200
5	9.12	32300	9400
6	9.10	34600	8900
7	9.07	30200	8800
8	9.31	33400	7900
9	9.11	36900	8200
10	9.20	37400	8600
11	9.22	39300	8200
12	9.08	36600	9300
13	9.01	33600	8800
14	9.16	34800	9300
15	9.22	35100	9400

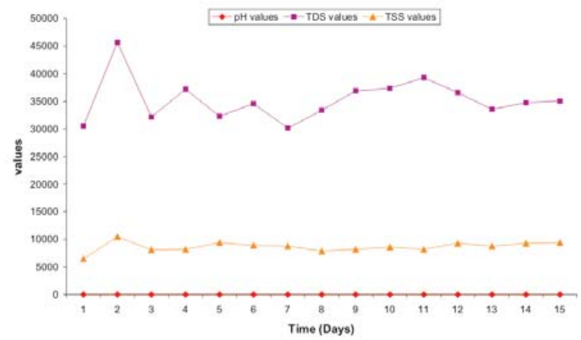
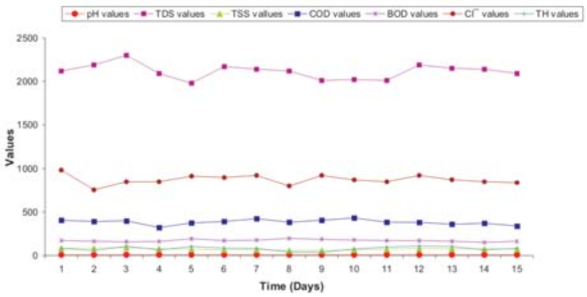


Fig. 4.2. Dye bath plant feed parameters comblned values

Table – 4.2 and Figure – 4.2, represent the characteristics of untreated dye bath plant feed parameters in the frequency of fifteen days.

Table .4.3 Wash water treated effluent (Biological inlet parameters)

Day	pH	TDS ppm	TSS ppm	COD ppm	BOD ppm	Cl^- ppm	Total Hard ness ppm	Turbidity NTU
1	8.1	2120	82	408	170	985	80	16.1
2	8.0	2190	86	392	162	756	58	10.4
3	8.0	2300	90	400	158	851	106	16.7
4	7.29	2090	78	320	160	850	65	14.9
5	7.91	1980	74	376	192	914	104	13.4
6	7.10	2170	64	392	172	900	86	15.4
7	6.90	2140	68	424	176	921	80	13.6
8	8.10	2120	56	384	198	800	40	14.0
9	7.94	2010	58	408	186	922	36	13.5
10	7.37	2020	64	432	180	870	75	9.8
11	7.21	2010	72	384	172	850	98	12.7
12	6.84	2190	80	380	170	922	110	10.4
13	7.02	2150	78	360	164	872	104	10.6
14	7.04	2140	74	370	150	851	66	13.0
15	7.09	2090	72	340	163	840	84	13.3



ig 4.3 Wash water treated effluent (Biological inlet parameters) combined values

Table - 4.3 and Figure - 4.3, show that the characteristics of wash water treated effluent (Biological inlet parameters). The following results show the comparison between untreated and treated of wash water effluents.

- pH reduced by 21.37%,
- TDS reduced by 36.13%,
- TSS reduced by 93.00%,
- COD reduced by 67.21%,
- BOD reduced by 56.52% and
- Total Hardness reduced by 76.00%.

Table 4.4. Biological treatments (Secondary clarifier)

Day	pH	TDS ppm	TSS ppm	COD ppm	BOD ppm	Cl^- ppm	Total Alkalinity ppm	Total Hardness ppm
1	7.20	2290	90	80	26	957	-	68
2	7.22	2240	110	64	22	856	-	74
3	7.33	2270	98	86	30	865	-	82
4	6.89	2280	88	58	26	964	-	62
5	7.39	2190	102	80	24	921	-	60
6	7.20	2120	69	88	32	808	-	80
7	7.21	2090	76	96	30	872	-	72
8	7.31	2120	80	88	18	957	-	76
9	7.37	2100	84	80	30	836	-	80
10	7.20	2000	92	64	28	840	-	58
11	7.24	2200	102	72	30	890	-	60
12	7.21	2090	104	64	32	866	-	52
13	7.17	2110	100	96	30	920	-	56
14	7.20	2020	98	84	28	906	-	59
15	7.16	2030	86	62	24	860	-	62

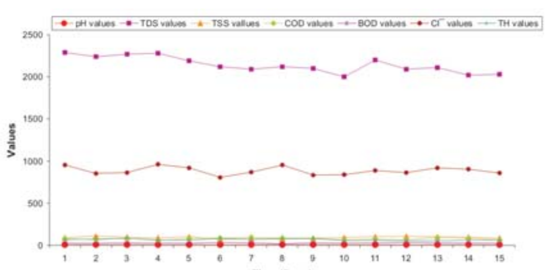


Fig. 4.4. Biological treatment (Secondary clarifier) combined values

Table – 4.4 and figure – 4.4, show that the characteristics of Biological treatment (secondary clarifier) parameters of pH, TSS, TDS, COD, BOD, Cl^- and Total Hardness.

Table 4.5. Tertiary clarifier DMF (Dual Media Filter) output

Day	pH	TDS ppm	TSS ppm	COD ppm	BOD ppm	Cl^- ppm	Total Hardness ppm	Total Alkalinity ppm	Turbidity NTU
1	6.77	2270	40	40	32	918	70	225	0.1
2	6.70	2240	20	40	28	836	86	170	0.1
3	6.41	2310	40	40	28	886	82	210	0.2
4	7.39	2210	40	42	26	936	85	220	0.1
5	7.21	2190	60	56	26	930	96	260	0.1
6	6.90	2150	40	64	28	971	72	262	0.1
7	7.27	2110	40	64	30	992	74	240	0.2
8	6.80	2120	40	56	28	837	76	200	0.1
9	7.26	2000	40	64	28	907	60	190	0.2
10	6.72	1950	40	64	22	850	44	140	0.2
11	7.10	2080	60	40	20	920	70	210	0.1
12	7.04	2210	42	24	32	880	56	150	0.4
13	6.78	2090	62	56	30	910	96	220	0.4
14	7.10	2120	42	60	28	840	80	190	0.3
15	7.12	2100	48	52	24	870	76	200	0.1

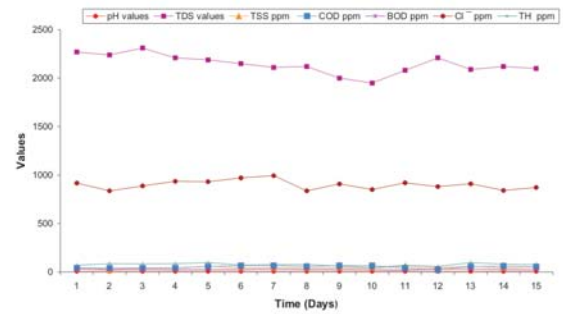


Fig. 4.5. Teritiary clarifier DMF (Dual Media Filter) output combined values

Table - 4.5 and figure – 4.5, show that the characteristics of Tertiary clarifier DMF (Dual Media Filter) out put parameters of pH, TDS, TSS, COD, BOD, Cl^-, Total Hardness, Total Alkalinity and Turbidity. Table – 4.6 Ultrafiltration feed parameters

Table 4.6. and figure – 4.6, show that the Ultrafiltration feed parameters.

Day	pH	TDS ppm	Cl^- ppm	Total Hardness ppm	Total Alkalinity ppm	Turbidity NTU	Free Cl_2 ppm
1	6.70	2270	1060	110	122	0.1	0.20
2	6.74	2160	1100	116	134	0.1	0.20
3	6.75	2290	1090	122	130	0.2	0.21
4	6.89	2280	1200	120	120	0.1	0.27
5	7.00	2170	1220	126	122	0.1	0.22
6	6.74	2190	1060	130	140	0.2	0.19
7	6.91	2180	1010	118	146	0.1	0.14
8	7.03	2160	1210	108	152	0.3	0.23
9	7.20	2130	1200	102	140	0.1	0.22
10	7.19	2000	1090	104	145	0.2	0.22
11	7.22	1990	1100	96	135	0.1	0.20
12	7.12	2250	1120	99	120	0.1	0.22
13	6.70	2340	1210	100	125	0.1	0.24
14	6.90	2120	1120	88	126	0.2	0.24
15	7.10	2100	1140	106	128	0.1	0.20

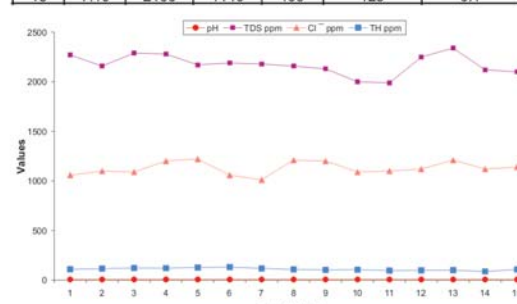


Fig. 4.6. Ultra Filtration feed parameters combined values

Table 4.7. Ultrafiltration permeate parameters

DAY	pH	TDS ppm	Cl^- ppm	Total Hardness ppm
1	7.15	2200	940	100
2	7.02	2110	1020	106
3	7.20	2240	1030	110
4	7.06	2250	1110	102
5	7.12	2160	1120	108
6	7.22	2170	1000	114
7	7.26	2100	960	110
8	7.10	2110	1130	98
9	7.22	2050	1110	92
10	7.24	2010	1010	98
11	7.20	2000	1030	90
12	7.18	2060	1060	92
13	7.10	2130	1130	94
14	7.22	2060	1050	98
15	7.21	2020	1030	94

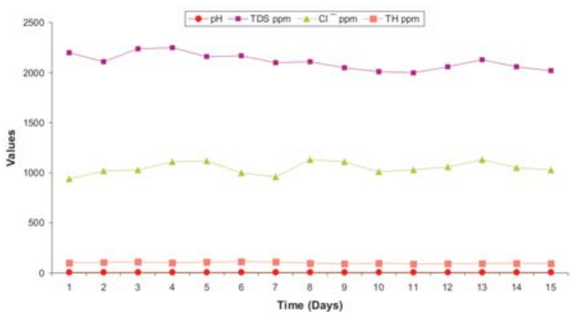


Fig. 4.7. Ultra filtration permeate parameters combined values

Table – 4.7 and figure – 4.7, show that the Ultrafiltration permeate parameters, which is the comparison between feed and permeate of parameters of ultrafiltration given below.

TDS reduced by - 14.53%

Cl^- reduced by - 22.31%.

Table .4.8 Ultra filtration reject parameters

DAY	pH	TDS ppm
1	7.50	2360
2	7.60	2290
3	7.65	2280
4	7.78	2270
5	7.48	2170
6	7.32	2180
7	7.10	2150
8	7.00	2130
9	7.16	2100
10	6.59	2010
11	7.21	2020
12	6.74	2270
13	6.64	2250
14	7.12	2120
15	6.80	2160

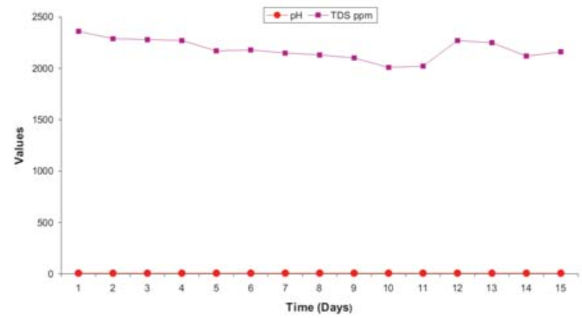


Fig. 4.8. Ultra filtration reject parameters comblined values

Table – 4.8 and figure – 4.8, show that the Ultrafiltration reject parameters, which is the comparison between feed and reject parameters of ultrafiltration percentage given below.

pH reduced by - 8.73%

TDS reduced by – 14.10%

Table 4.9. Reverse Osmosis feed parameters

Day	pH	TDS ppm	COD ppm	Cl^- ppm	Total Hardness ppm	Total Alkalinity ppm	SO_4 ppm	SO_3 ppm	Face Cl_2 ppm	Si ppm	Fe ppm
1	6.80	2360	40	1001	90	125	265	7.7	Nil	12.50	0.10
2	6.90	2270	32	929	90	125	264	9.2	Nil	10.17	0.09
3	7.20	2280	40	893	80	150	300	4.8	Nil	7.36	0.10
4	6.88	2220	34	993	100	140	280	6.2	Nil	8.16	0.11
5	6.72	2280	40	990	82	160	270	4.7	Nil	8.10	0.10
6	7.12	2180	64	921	86	150	272	5.2	Nil	9.40	0.10
7	7.23	2150	64	780	66	170	256	9.7	Nil	9.70	0.11
8	7.12	2160	60	907	81	160	262	5.7	Nil	9.20	0.12
9	7.07	2130	65	850	72	166	248	4.9	Nil	8.90	0.11
10	7.12	2190	40	920	101	150	260	3.2	Nil	8.30	0.09
11	7.21	1980	24	800	78	160	264	5.7	Nil	8.20	0.08
12	6.60	2160	26	879	68	110	270	2.2	Nil	8.60	0.10
13	6.90	2340	56	920	75	90	284	3.5	Nil	8.10	0.4
14	6.82	2190	58	910	84	110	270	5.6	Nil	8.20	0.10
15	6.78	2230	62	890	76	130	277	6.1	Nil	8.30	0.09

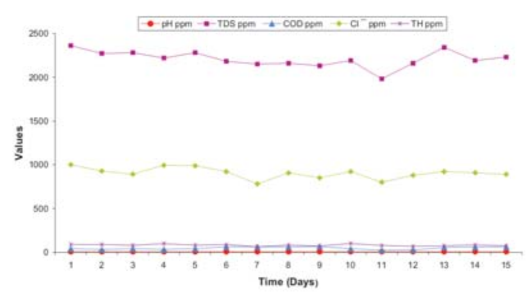


Fig. 4.9. Reverse osmosis feed parameters combined values

Table – 4.9 and figure – 4.9, show that the reverse osmosis feed parameters of pH, TDS, Cl^-, Total Hardness, Total Alkalinity, SO_4, SO_3, Si and Fe in the frequency of fifteen days.

Table 4.10. Reverse Osmosis Permeate parameters

DAY	pH	TDS ppm	Cl¯ ppm	Total Hardness ppm
1	6.02	106	64	5.0
2	6.37	72	45	1.5
3	6.0	91	56	3.0
4	6.42	119	62	4.0
5	6.40	100	62	6.0
6	6.24	102	54	3.0
7	6.62	91	60	6.0
8	6.82	118	62	5.5
9	6.27	110	63	3.0
10	6.65	81	58	5.5
11	6.35	117	59	4.0
12	6.30	99	60	4.5
13	5.98	108	52	8.4
14	6.22	102	60	4.9
15	6.41	98	54	5.6

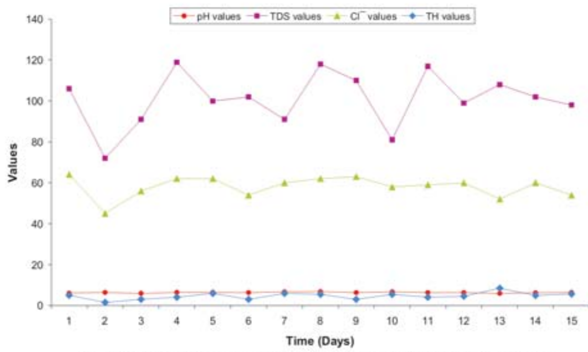


Fig. 4.10. Reverse osmosis permeate parameters combined values

Table 4.10 and figure 4.10, show that the reverse osmosis permeate parameters, form the results a comparison was made between reverse osmosis feed and permeate, the ratio can be given that,

pH reduced by – 17.29%,
TDS reduced by – 96.95%,
Cl¯ reduced by – 95.50% and
Total Hardness reduced by – 98.51%.

Table 4.11. Reverse Osmosis Reject parameters

DAY	pH	TDS ppm	Cl¯ ppm	Total Hardness ppm
1	7.05	21900	9310	628
2	7.25	21100	9740	730
3	7.22	20000	9220	692
4	7.26	20500	9010	850
5	7.28	17100	8690	810
6	7.18	21400	9006	920
7	7.46	21400	9020	910
8	7.56	20200	9870	865
9	7.47	19800	9220	920
10	7.46	20200	10200	840
11	7.38	20700	10620	692
12	7.25	20600	11010	746
13	7.34	21350	10940	802
14	7.52	20620	9440	820
15	7.43	21010	9010	932

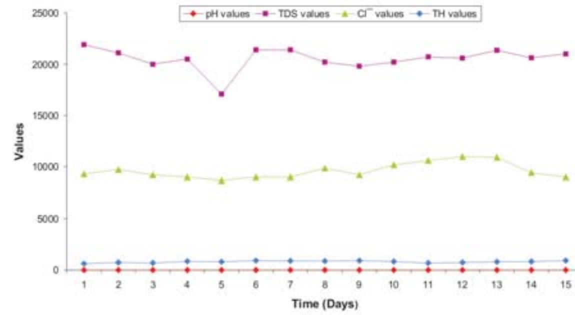


Fig. 4.11. Reverse osmosis reject parameters combined values

Table 4.11 and figure 4.11, show that the reverse osmosis reject parameters of pH, TDS, Cl¯ and Total Hardness. The comparison between reverse osmosis feed and reject was given below.

pH reduced by – 10.32%,

TDS reduced by – 90.62%,

Cl¯ reduced by – 92.92% and

Total Hardness reduced by 92.92%.

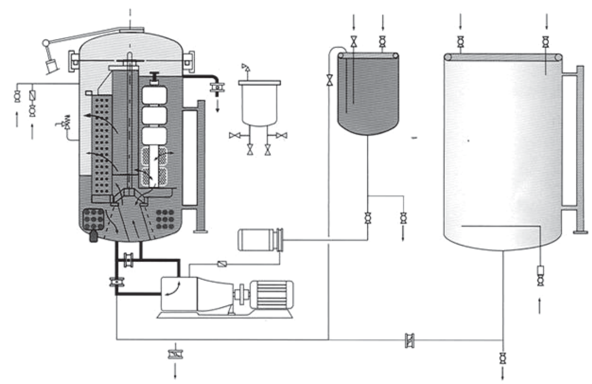


Fig. 4.12. Dye liquor flow through cheeses dyeing machine

V. CONCLUSIONS

From the study, the following conclusions can be derived:

- RO was successfully used for the treatment of yarn dyeing effluent.
- The textile plant effluent was treated by a biological treatment process.
- The recycling of treated waste water and zero waste water discharge concept are found technically flexible and economically visible in the textile dyeing industries. The average percent removals of BOD, COD, TDS and Chlorides in the advance treatment technology are in the range of 88 – 98%, 91-97% and 75- 97% respectively.

- Waste water can be treated new techniques to produce fresh water quality for non-portable uses at reasonable cost.
- Reverse osmosis permeate gives better results of TDS - 96%, Cl^{-} - 95% and Total Hardness – 99% reduced.
- These industries have a telling need for technologically feasible and economically justifiable means for
  - Product, process ad quality improvement
  - Sustainable technology for processing
  - Effluent utilization of process water
  - Clean and green technology aiming at zero discharge eventually.
- 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.
- 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:
  - Separation does not require addition of chemicals as may be the case in the water clarification, by means of coagulation- flocculation process
  - Decreased the production cost
  - High permeability to water
  - High efficiency of the membranes in selective mineral rejection
- RO removed:
  - Ionic
  - Non-ionic
  - Particulate (metals/ non living organisms)
  - Microbiological
  - Remove purified water from a feed stream [permeate 90 – 93%]

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NOMENCLATURE

pH – Percentage of hydrogen
PCETP – Perundurai Common Effluent Treatment Plant
AVGF – Automatic valve gravity filter
ACF – Automatic carbon filter
TDS – Total Dissolved Solids
TSS – Total Suspended solids
COD – Chemical Oxygen Demand
BOD – Biological Oxygen Demand
Ca (OH) – Lime
NaCl – Sodium Chloride
$FeSO_4$ – Iron sulphate
Cl^- - Chlorides
Cl_2 – Free Chlorine
TH – Total Hardness
SO_4 – Sulphate
SO_3 – Sulphide
Si – Silica
Fe – Iron
PPM – Parts Per Million
NTU – Nephelometric Turbidity Unit
PCB – Pollution Control Board
UF – Ultrafiltration
RO – Reverse Osmosis
DAP – Di-ammonium phosphate
TNPCB – Tamil Nadu Pollution Control Board
APHA – American Public Health Association
AWWA – American Water Work Association
WEF – Water Environment Federation

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