Cost- Benefit Analysis of Wastewater Recycling Plant for Textile Wet Processing

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Abstract

Water has been a cheaper commodity for a very long period and never accounted for in processing cost. Now it becomes scarce and a priced commodity and the costs for water and its treatment to make it suitable for processing have escalated to the newer heights necessitating its inclusion in production costs. Water conservation techniques must be instigated in the textile industries. The industries must take initiatives to implement water management practices. Also it is necessary to encourage industries for investment in various water recycling methods. Treated wastewater from city wastewater plant is disposed either on land or in river. This water causes various land pollution problems and water pollution. This treated waste water can be used in textile wet processing by retreating it. The treatment plant comprises water storage tank, Oil and gas removal trap, Slow sand filter, Granular Activated carbon unit (GAC), Chlorination unit, two stage ion exchange unit with strong acid cation exchange resin SAC) and strong base anion exchange resin (SBA). This paper focuses on cost benefit analysis of wastewater recycling plant for textile wet processing

Keywords: Wastewater recycling, textile wet processing, GAC technology, strong acid cation exchange resin, strong base anion exchange resin, cost benefit analysis

1. Introduction

Water usage in textile industry and importance of water recycling:

There are many sources of water, the most common being: Surface sources, such as rivers, Deep wells and shallow wells, Municipal or public water systems, Reclaimed waste streams. (Smith and Rucker, 1987) The textile industry in India has been pioneer industry. Indian textile industry is the 2nd largest in the world. Overall India is world's 8th largest economy and among the 10 industrialized countries (Patel, 2004). If global break up of fresh water is seen then from 100 % of freshwater, 20 % is being used by the industries which are responsible for large production of effluents (Himesh, 2001). The rapid growth in population and particularly in urbanization has resulted in sharp increase in generation of these two wastes. In India alone 19000 million liters of sewage is generated every day of which more than 25% is attributed to class I cities. Out of this quantity of sewage 13000 million liters per day (MLD) is collected out of which at the most half is treated to some extent. In terms of nutrients and water availability, economic value of this quantity of domestic sewage has been estimated as Rs. One crore per day. As regards industrial wastewater generation, the same is estimated 10000 MLD, 40% is from small scale industries (Patankar, 2006). Wastewater reclamation and reuse is one element of water resources development and management which provides an innovative and alternative option for agriculture, municipalities and industries (Al-Sulaimi and Asano, 2000). The availability of alternative water sources such as reclaimed municipal waste water or recycled process water can foster more efficient water use practices that translate in to significant cost savings in industries (Tchobanoglous, 1998).

2. Materials and Methods

Pilot treatment plant was prepared and treatment was given to treated municipal wastewater. Units in recycling plant comprises Municipal treated water storage tank, Oil & Grease removal unit, Slow Sand filter (SSF), Granular Activated Carbon filter (GAC), Chlorination unit Cationic Exchange Resin (SAC) and Anionic Exchange Resin (SBA).

Details of Pilot treatment plant:

1. Municipal treated water storage tank: To store the treated wastewater for further treatments. Also acts as a sedimentation tank.

2. Oil & Grease removal unit: Oil & Grease can be removed with this unit .

3. Slow Sand filter (SSF): Slow sand filter is provided with various layers of sand of different particle size.

4. Granular Activated Carbon filter (GAC): Through this the color and odor from the wastewater is removed.

5. Chlorination unit: This is carried out to disinfect the sewage. For this sodium hypochlorite solution (22 gpl) with various dosages was used.

6. Cationic Exchange Resin (SAC): Here cations like Na^{+} Mg^{++}, Ca^{++} etc was exchanged with H^{+} ions. The cationic exchange resin used was strong acid type. It is a premium quality strong acid cation exchange resin containing nuclear sulphonic acid groups having high exchange capacity, combined with excellent physical and chemical stability and operating characteristics. It is ideally suited for use in a wide range of pH and temperature conditions. It is supplied in hydrogen form for two stages and mixed bed demineralization and in sodium form for softening. It is also used for de-alkalization and chemical processing.

7. Anionic Exchange Resin (SBA): Here anions like $S04^{--}$, $CO3^{--}$, Cl^{-} etc was exchanged with OH^{-} ions. The anionic exchange rein used was strong base type. It is a strong base anion exchange resin based on polystyrene matrix, containing quaternary Ammonium group. It has excellent chemical and operating characteristics along with excellent physical properties due to its crack-free nature. It has a good operating capacity for weak acids like silicic and carbonic along with strong mineral acids, when used in water treatment along with strong acid cation exchange resin. It is ideally suited for use in a wide range of pH and temperatures. It is supplied as moist spherical bead in the chloride form with a particle size distribution to provide good kinetics and minimum pressure drop. Figure 2.1 shows Pilot treatment plant.

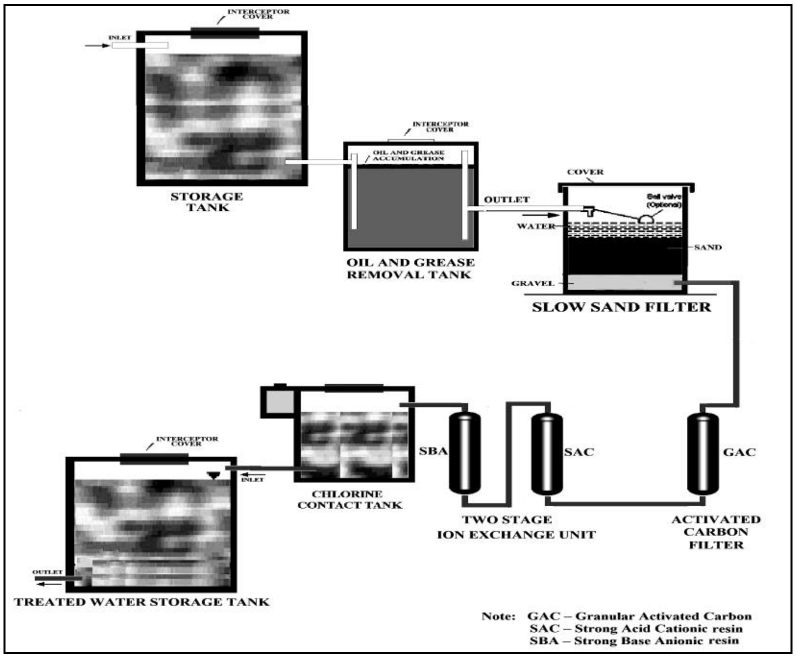

Figure 2.1 Pilot Treatment Plant

Figure 2.2 Photograph of Pilot Treatment Plant

3. Treatment Of Wastewater:

Wastewater was treated to fulfil the requirements of cotton textile wet processing. Following norms were target to treat the wastewater. Shown in table 3.1

Table 3.1 Targeted values of various parameters

Sr. No.	Parameter	Expected treatment quality
1	Total Dissolved Solids (TDS)	400 mg/l
2	Hardness	Less than 70 mg/l
3	Oil and Grease	Less than 1 mg/l
4	Most Probable Number (MPN)/100 ml	Nil
5	Colour	Nil
6	Odour	Nil

3.1 Testing and analysis of wastewater using pilot treatment plant:

Details of TDS, Hardness and oil and Grease inlet and outlet of plant are shown in table 3.2, 3.3 and 3.4

Table 3.2 Total Dissolved Solids (TDS)

Sr. No.	Day	Inlet (mg/l)	Outlet (mg/l)
1	1	930	412
2	2	911	421
3	3	845	423
4	4	865	457
5	5	765	402
6	6	865	438
7	7	852	423

Table 3.3 Hardness

Sr. No.	Day	Inlet (mg/l)	Outlet (mg/l)
1	1	427	31
2	2	413	31
3	3	392	24
4	4	342	24
5	5	368	15
6	6	425	22
7	7	433	18

Table 3.4 Oil and Grease

Sr. No.	Day	Inlet (mg/l)	Outlet (mg/l)
1	1	12	0
2	2	25	0
3	3	25	0
4	4	24	0
5	5	18	0
6	6	31	0
7	7	23	0

3.2 Chlorination:

Optimum chlorine dosage was found with various trials of NaOCl. Following table shows various dosages and corresponding Most probable number (MPN/100 ml). Chlorine contact time was kept 30 minutes. Residual chlorine was measured for every dosage found between 0.2 to 0.3 mg/l.

4. Cost-Benefit analysis of the plant:

Hardness of wastewater = 450 mg/l as $CaCo_3$

Calculation of major costs on maintenance of Cationic Exchange Resin (SAC), Anionic Exchange Resin (SBA) and Chlorination unit is carried out as under.

4.1 Cationic Exchange Resin (SAC):
Total treatment capacity of resin = 1.8 to1.2 meq/ml
Considering 60% operating capacity of resin,
Operating capacity of resin used = 1.08 meq/ml = 1080 meq/l
Hardness concentration of wastewater can worked out in meq/l by using formula weight of $CaCo_3$
1 ppm as $CaCo_3$ = 0.02 meq/l or
One equivalent of calcium carbonate = (40 + 12 +3*16) / 2 = 50 mg /eq = 50 mg/ meq
Hardness concentration in meq/l = 450/ 50 = 9 meq/l
Quantity of water treated by one liter resin = 1080/9 = 120 liters.
Regeneration with 60 gm HCL /liter of resin = 120 liters of water.
HCL / liter = 60/ 120 = 0.5 gm/liter
Commercial rate of HCL Rs. 5/- per kg
Cost per liter = 5/1000*0.5 = Rs. 0.0025 / liter of water

4.2 Strong base anion exchange resin (SBA):
Total treatment capacity of resin = 1.3 meq/ml
Considering 60% operating capacity of resin,
Operating capacity of resin used = 0.78 meq/ml = 780 meq/l
Quantity of water treated with one liter resin = 780/9 = 86.67 liter
Regenerating with NaOH and considering 30gms NaOH / liter
Quantity of NaOH/liter = 30/86.67 = 0.346 gm/liter
Commercial cost of NaOH = Rs. 40/- per kg.
Cost per liter = 40/1000*0.346 = Rs. 0.01384 /liter of water

4.3 Chlorine treatment:
Chlorination charges can be worked out as below,
Commercial cost of Chlorine = Rs. 10/- per kg = Rs. 10/1000 gms
Dosages of Chlorine = 1 ppm per liter of water
Cost of chlorination = 10/1000*0.0001 = Rs. 0.00001 / liter of water
Water to be treated 18 MLD = 18000 m^3/day = 900 m^3/hour
Plant working hours = 20 Hours/day

4.4 Electricity charges:
Gravity and continuous flow plant, Feed flow pump 150 HP, anion cation plant pumps (2 nos.) of 75 HP and considering other electricity charges of the plant = 50 HP
Total electricity consumption = 350 HP
Rs. 5/- Kwh * 0.746 Kwh/hp * 350 * 20 hrs/day = Rs . 26110 = 00
Amp. Drawn 0.75 %. Therefore Cost/day = Rs. 26110 * 0.75 = Rs. 19582.50
Cost per liter = Rs. 19582.50 / 18000000 = Rs. 0.001088/ liter of water

4.5 Maintenance charges of plant:
Maintenance charges for pumps in plant, blowers in degasifiers & other charges. Considering Rs. 500/day.
Cost per liter of water = Rs. 500 / 180000000 = Rs. 0.00002778/ liter of water

4.6 Depreciation costs:
Continuous Automation Control by Instrumentation, Regeneration - flow 0.5 Hrs/Hr each 2 sets of Anion + Cation beds. Sand + Carbon Filters of Capacity of 15 m^3 each, chlorinator- one, Oil-grease Removing Tanks- 2 Nos, Centrifugal Pumps -0=250, 125 liters/sec. Initial cost of plant can be estimated as Rs.40000000/-
Calculating depreciation Rs. 40000000/ (5*365) = Rs. 21917.80 /day
Depreciation cost /liter = Rs. 21917.80 /180000000= Rs. 0.001218/liter

4.7 Staff salaries:
Workers Rs. 150/ day, plant supervisor Rs.250/day, Manager = Rs. 350/ day
Total salary Rs. 1500/ day
Cost of salary worked out per liter of water = Rs. 1500/ 180000000 = Rs. 0.0000833 /liter

4.8 Miscellaneous charges:

Office stationary, testing, printing charges etc. considering Rs. 100/ day

Cost per liter = Rs. 100/ 180000000 = Rs. 0.0000055/liter of water

4.9 Cost-benefit considerations:

Total cost of water per liter can be worked out by addition of all above parameters,

Overall cost = Rs. 0.0025 + Rs. 0.01384 + Rs. 0.00001 + Rs. 0.001088 + Rs. 0.00002778 + Rs. 0.001218 + Rs. 0.0000833 + Rs. 0.0000055 = 0.01877258/liter of water

Overall cost = 18.77 per 1000 liter of water with TDS less than 400 mg/liter.

With profit overall sale cost of water = Rs. 20.00 per 1000 liter of water

This water cost can be reduced if we get income by selling Oil & Grease & Value added Products which are manufactured from drained TDS of recycling plant. At present Textile industry is purchasing water at Rs. 22 to 25 per 1000 liter of water with TDS more than 1200 mg/liter.

Profit per 1000 liter (1 m^3) = Rs.20.00 – Rs.18.77 = Rs. 1.23

Daily profit = 18000 m^3 * 1.23 = Rs. 22140/-

Annual profit = Rs. 22140 * 365 days = Rs. 80, 81,100/-

5. Conclusion:

Recycled wastewater is having many benefits. This benefit analysis can be carried out as economical benefits and societal benefits.

1. Quality of fabric will enhanced with recycled water .At present textile industries are purchasing water of TDS 900 to 1200 mg/l which leads fabric production with less quality.
2. Textile industry facing strong water crisis. These industries are purchasing water at higher cost. Such water recycling projects may give economical solution to the industries.
3. Disposing wastewater on land or any water body may cause harmful environmental effects. The treated wastewater which would have been wasted can be utilized with effective and economical technology.
4. Improvement in fabric rewashing system so that there is economy in water usage in textile industry.
5. There is dye saving in wet processing which is additional benefit to industry.
6. K/s values of dyed fabric found significantly improved.
7. Washing and rubbing fatness of fabric observed with both ISO-105 and AATCC methods are satisfactory.

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