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Reducing the total dissolved solids in textile effluent: An integrated approach

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Abstract
The present research investigated the reduction of total dissolved solids (TDS) of untreated textile effluent by means of integrated approach. Biological method of TDS reduction using native microorganism were not successful as they were not effective in TDS reduction. Chemical method of treating the waste water using alum produced more sludge and increased the TDS content of the effluent. The physical methods like membrane filters, micro filters, ultra filters, nano filters and reverse osmosis were successful in TDS reduction but fetch additional cost. Integrated approach of biological and physical methods would solve the TDS problem and lower the treatment cost.

Keywords: Total dissolved solids, textile effluent, approach

Introduction
Water pollution is a major threat across the world due to the release of toxic and hazardous substances into the water bodies. Anthropogenic influence of water resource is a global problem. The major pollutants such as dye and other contaminants from the textile industries are said to affect the aquatic life. The discharge of textile effluent into water bodies adversely affects water resources, soil fertility, aquatic organisms and ecosystem integrity. Textile industry wastewater carries the contaminants responsible for the continuous pollution of the environment. Textile wastewater contains substantial pollution loads in terms of total dissolved solids (TDS).
Textile industry, one of the major contributors of the economy of Coimbatore. Coimbatore is not only known for its textile business and gaining profits through their textile industries but also in giving knowledge to students through their research and academic institutes. The world is too busy developing; Coimbatore houses a lot of research-based ideas in connection with textiles. An environmental conflict in this region is due to the enormous growth of the textile industries and operation of bleaching and dyeing units in the past 50 years. The known history of textile industry and its pollution is Orathapalayam Dam, in 1995, four years after the completion of dam work, downstream farmers objected to the release of water, which had become highly contaminated from the dyeing and bleaching units. In 1997 the fisheries department closed its operations at the reservoir and the High Court ordered dam water not be released for irrigation (Jayakumar and Rajagopal, 2007) [3]. Now the Orathapalayam Dam has become a mere storage tank for industrial effluent, which could neither be discharged into the river, nor be stored due to percolation and contamination of groundwater aquifers. Industrial pollution in Tiruppur has significantly affected the Noyyal River, totally contaminated the Orathapalayam Dam, contaminated the Cauvery river, caused great economic loss for farmers and affected residents' health (Akilan, 2016) [1]. The High Court mandated polluting units connect to a common effluent treatment plant or install individual effluent treatment plants. More than 160 units were shut down, but observers say treated effluents do not meet standards prescribed by the Pollution Control Board, particularly regarding total dissolved solids and chlorides. According to state Pollution Control Board rules, 'red' and 'orange' category units (highest polluting industries, which include dyeing and bleaching) should be situated 1 km from a river/ stream or any other water source. In Tiruppur, as at 2007, about 239 units were located less than 300 m from the Noyyal River. About 83 per cent of the individual effluent treatment plants discharge their effluents directly or indirectly into the water bodies (Jayakumar and Rajagopal, 2007) [3]. This not only the case of Tiruppur, but also in many parts of the state having textile and dying unit.

The textile industry consumes huge quantities of water and produces large volume of wastewater from different dyeing and finishing processes. Waste water from printing and dyeing units is often rich in colour, containing residues to reactive dyes and chemical. It requires proper treatment before being released into the environment (Geetha and Jeganathan, 2006) [2]. The toxic effects of dyes and other organic contaminants from industrial sector on the general public are widely accepted. Increasing public concern about environmental issues had led to closure of several small scale industries in the past decade. The conventional treatment systems like physical, chemical treatment and physico - chemical treatment followed by biological treatment system are installed in majority of textile industries.

Biological method of Total Dissolved Solids reduction using native microorganism is not successful as they are not much effective in TDS reduction when the effluent contains high TDS. Chemical method of treating the waste water using alum produces more sludge and exhibits high TDS. So chemical method is also not suitable for TDS reduction. The Physical methods like Membrane filters, Micro filters, Ultra filters, Nano filters and Reverse Osmosis is successful in TDS reduction but these technologies needs attention in changing the filters then and there which may add additional cost in the treatment process. The Electrical Conductivity of bore well water was successfully reduced using neem bark powder, a physical approach (Prasanthrajan *et al.* 2018) [4]. So, integrated approach of biological (Reduction of organic load by maintaining high Mixed Liquid Suspended Solids in the biological treatment tank will improve the life of physical filters and Reverse Osmosis system) and physical (Micro filters, Ultra filters, Nano Filters and Reverse Osmosis) would solve the TDS problem and reduce the operating cost considerably. With this view, the present investigation was undertaken to reduce the TDS of textile effluent through integrated treatment process.

Methodology

Waste water samples (Raw effluent and treated effluent) were collected from Common Effluent Treatment Plant, Telugupalayam, Coimbatore and subjected to pH, EC and TDS analysis. In order to test the effectiveness of alum in TDS reduction and sludge formation, a known quantity of effluent (100 ml) was taken in 10 different glass beakers. The alum was added at different quantity (0.5 to 5.0 g) in all the beakers containing textile effluent and allowed to react for about one hour. After one hour the samples were subjected to TDS, EC analysis and quantified the sludge formation on dry weight basis. Similar experiment was conducted with reduced concentration of alum in another set of beakers (alum @ 0.1 to 1 g/100 ml) for comparison. The experiments were repeated thrice for comparison.

Since textile industry utilizes a huge amount of water and contains a considerable amount of total dissolved solids thereby rendering the water resistant to degradation, the need of the hour is to have selected and adapted microorganisms for reduction of TDS from textile wastewaters. So it is essential to isolate suitable bacterial colonies from textile effluent that are capable of reducing TDS. Serial dilution method were followed to isolate the bacterial colonies from the textile effluents. The isolated cultures were transferred to slant and from there they were transferred to a flask (250 ml) containing nutrient broth. The microorganisms were allowed to multiply for about a week. Five bacterial cultures were isolated and used individually and as a consortium TDS reduction. While preparing nutrient broth, textile effluent has been used as diluents water instead of deionized water.

Glucose	5 g
Peptone	5 g
Beef extract	3 g
NaCl	5 g
Textile effluent	1000 ml
pH	7.1

A laboratory column study was also conducted to test the efficiency of conventional adsorbents in reducing the TDS in textile effluent. A 6 cm vide mouth and 45 cm height glass column was filled with river sand, activated charcoal, glass wool in different layers. A known quantity of textile effluent (1000 ml) with TDS 8946 mg L^{-1} was passed through the packed column at the flow rate of 1.5 ml per minute. The effluents were collected at the bottom of the column through an attached close/open glass stopper. In an another study, raw effluent was passed through different filters like Micro filters, Ultra filters and Reverse Osmosis plant. Further it passed through the Nano filters to remove the salts from the R.O reject.

Results and Discussion

The raw effluent had high TDS content of 8500 to 11100 mg L^{-1}. The treated effluent too had comparatively high TDS (6900 mg L^{-1}) as the permissible limit of industrial effluent for safer disposal is 2100 mg L^{-1}. The raw effluent (pH 5.9) and CETP treated effluent (pH 6.2) were acidic in pH with the EC value of 16.9 and 10.7 dS m^{-1} respectively (Table 1).

Table 1: Characteristics of Raw and treated effluent collected from CETP, Telugupalayam, Coimbatore, Tamil Nadu

Water quality parameter	Raw effluent	CETP treated effluent
pH	5.9	6.2
EC (dS m^{-1})	16.7	10.7
TDS (mg L^{-1})	11100	6900

In the first set of experiment (0.5 to 5.0 g of alum / 100 ml of effluent) and second set 0.1 to 1.0 g of alum / 100 ml of effluent was added to know the effect of alum in TDS reduction and sludge production. Addition of alum increased the sludge production and TDS content of the effluent (Table 2 and Table 3). Form this study it is clearly understood that the concentration of alum is directly proportional to TDS, EC and quantity of sludge produced. Hence, alum is not suitable for the reduction of TDS in the effluent.

Table 2: Influence of alum on TDS, EC and sludge production

Quantity of alum added (g /100 ml of Effluent)	TDS (mg L^{-1})	EC (dS m^{-1})	Quantity of sludge produced (g per 100 ml)
0.5	11000	11.8	8.3
1.0	12500	12.0	10.2
1.5	13300	13.1	13.0
2.0	14200	13.9	13.8
2.5	14600	14.6	14.1
3.0	15300	17.8	14.9
3.5	16700	17.2	16.0
4.0	20160	19.0	19.2
4.5	24000	19.3	23.0
5.0	26600	19.6	25.0

Values are mean of three replications

Table 3: Influence of reduced quantity of alum on TDS, EC and sludge production

Quantity of alum added (g /100 ml of Effluent)	TDS (mg L^{-1})	EC (dS m^{-1})	Quantity of sludge produced (g per 100 ml)
0.1	9800	10.3	8.0
0.2	9950	10.5	8.0
0.3	10100	10.5	8.1
0.4	10400	10.9	8.1
0.5	11050	11.1	9.2
0.6	11100	11.3	10.3
0.7	11125	11.3	10.5
0.8	11200	11.4	10.9
0.9	12250	11.7	10.9
1.0	12300	11.9	11.0

Values are mean of three replications

The biological treatment methods are of utmost importance, as they work without adversely affecting the environment as in the case of physicochemical treatment processes, which are also an economic burden on the industry because of the expensive infrastructure and maintenance required for their implementation. Besides, the problem of accumulation of such components in some other form, at some other site is another crucial drawback which can be overcome by using biological treatment methods. The best possible approach towards solving the aforesaid problem, therefore, is to devise biological methods for the reduction of TDS levels. Five microbial cultures were isolated from the textile effluent and used for TDS reduction using textile effluent. The initial TDS content of textile effluent was 7250 mg L^{-1}. The TDS on 15th day was measured and it was found that the TDS reduction by the isolated microbial cultures was very low.

Table 4: TDS reduction using native microorganisms

Treatments	TDS (mg L^{-1})	
	Initial	15th day
T_1 - Bacterial Strain 1	7248	7100
T_2 - Bacterial Strain 2	7245	7158
T_3 - Bacterial Strain 3	7249	6820
T_4 - Bacterial Strain 4	7249	7126
T_5 - Bacterial Strain 5	7244	7010
T_6 - Bacterial Consortium	7245	6905

Values are mean of three replications

From the present study it was found that the isolated microorganisms are not capable of reducing the TDS to the expected level (<2100 mg L^{-1}). This might be due to the high load of TDS content in the effluent. When microorganisms used as consortium are also not able to reduce the TDS to the expected level.

Table 5: Microbial load before and after the incubation study

Treatments	Bacterial Population (x 10^5 CFU)	
	Initial	15th day
T_1 - Bacterial Strain 1	28	10
T_2 - Bacterial Strain 2	29	12
T_3 - Bacterial Strain 3	32	16
T_4 - Bacterial Strain 4	26	15
T_5 - Bacterial Strain 5	24	12
T_6 - Bacterial Consortium	29	18

Efficiency of conventional and physical treatment methods in reducing the TDS

In the column study, a known quantity of textile effluent (1000 ml) with TDS 8946 mg L^{-1} was passed through the packed column at the flow rate of 1.5 ml per minute. The effluents were collected at the bottom of the column through an attached close/open glass stopper. The treated effluent recorded TDS value of 7542 mg L^{-1}. The raw effluent containing 6700 mg L^{-1} of TDS was passed through different filters like Micro filters, Ultra filters and Reverse Osmosis plant. The TDS level of the effluent after it passed through the above said filters was 218 mg L^{-1}. The reduction of TDS is around 97 per cent. Further it passed through the Nano filters to remove the salts from the R.O reject which attained complete removal of TDS

Conclusion

Biological method of TDS reduction using native microorganism was not successful as they were not effective in TDS reduction. Chemical method of treating the waste water using alum produced more sludge and in turn increased the TDS. So, chemical method is also not suitable for TDS reduction. The Physical methods like membrane filters, micro filters, ultra filters, nano filters and reverse osmosis is successful in TDS reduction but it needs attention in changing the filters then and there. So, integrated approach of biological (Reduction of organic load by maintaining high Mixed Liquid Suspended Solids in the biological treatment tank will improve the life of physical filters and Reverse Osmosis system) and physical (micro filters, ultra filters, nano filters and reverse osmosis) would solve the TDS problem and reduce the operating cost considerably.

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