TOTAL DISSOLVED SOLIDS AND CHEMICAL OXYGEN DEMAND REDUCTION IN TEXTILE DYEING INDUSTRY EFFLUENT BY TREATING WITH DIFFERENT PENICILLIUM SPECIES

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ABSTRACT:-

Combating environmental pollution is a key challenge in the present scenario. In this context, the dye effluent of the Textile industries has been identified as one of the major pollutant of water ways. In Ethiopia, Adama is one of the major textiles sector contributing to a sizeable chunk to the economy of the country. The presence of total dissolved solids and chemical oxygen demand are the major factors for the pollution load in the dye effluent. Quite a large amount of research has gone into preventing pollution by reducing the total dissolved solids and chemical oxygen demand. The chemical and biological methods have been tried to reduce the pollution level of the dye effluents, the latter method using microbial organisms is attractive because of mild operating conditions and the economy of the process. With this view, experiments have been conducted to degrade the dye effluents using three penicillium species penicillium chrysogenum, penicillium expansum and penicillium funiculosum. The primary treated waste water TDS values are reduced to 2300 mg/lit from 6100 mg/lit which meets the pollution control standards. So it is strongly recommended that the primary treated effluent were degraded well by the penicillium species and can be reused in the textile industries.

Keywords: Textile dye effluent, Total dissolved solid, Chemical Oxygen Demand, Penicillium chrysogenum, Penicillium expansum, Penicillium funiculosum.

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INTRODUCTION:

The transformation of raw textile product like cotton to final usable form involves different stages; (1) Fiber production (2) Intermediate dry processes like spinning, weaving and knitting (3) Intermediate wet processes like slashing, desizing, kiering/scouring, bleaching, mercerizing and dyeing and (4) Finishing like printing, cutting, stitching, packing, etc. The intermediate wet processes may be carried out on yarn or fabric. Since the environmental issues of textile industry result from intermediate wet processing. Each step in the wet processing stages produced a quite large amount of effluent which contains more total dissolved solids.

In recent years many researches were undergoing to reduce the total dissolved solids in textile dye effluents. Katayon Sayed et al(2004), the treatment of textile waste water by advanced oxidation process was studied. The advanced oxidation process holds great promise to provide alternative for better treatment and the protection of environment.

The electrodialysis process with bipolar membranes for the treatment of textile waste water were investigated by Palanivel, K et al(2006), where the preliminary studies were conducted with sodium chloride solution in batch recirculation mode. This method reduces the total dissolved solids by considerable amount.

Dr.Kurian Joseph (2005) investigated a cleaner production approach for minimization of total dissolved solids in reactive dyeing effluent. About 900 small and medium scale units carry out such operations in Tiruppur, a small city in south India. The studies shows that a combination of low material to liquor ratio dyeing machines and low salt reactive dyes along with dye bath segregation would reduce the salt consumption and pollution load due to TDS by about 80%.

Marques et al (2009) reports on the viability of the electroflocculation process Chemical Oxygen Demand (COD), turbidity and colour removal from a raw effluent originated from a particular textile industry related to hemp manufacture. This result indicates that, under the studied operational conditions, electroflocculation of the effluents may constitute viable alternate for COD and colour removal.

Manickkam Sathiyamoorthy et al (2011) investigated the biological process for the reduction of total dissolved solids in textile dye effluent. The effluent from a textile industry was treated biologically by using four different micro-organisms namely, *Aspergillus manginii*,

penicillium chrysogenum, penicillium expansum and debaryomyces hemsenii var.h. The result shows that the TDS was reduced considerably by *penicillium expansum.*

Large amount of textile dye effluents are being produced each and every day in the dyeing industries. Around 3 lakhs liters are produced by a single dyeing unit. This water was not disposed properly which in turn affects the environment and leads to pollution. For treating the effluent, different methods were used. In this present work the effluent was treated by the three different micro-organisms namely *penicillium chrysogenum, penicillium expansum and penicillium funiculosum* to reduce the pH, TDS and COD.

S.No.	Activities	Water consumption		Effluent	
		Range	Average	Range	Average
1	Sizing / Slashing	50 - 820	435	50 - 820	435
2	Desizing	250 - 2100	1175	250 - 2100	1175
3	Kiering / Scouring	2000 - 4500	3250	2000 - 4500	3250
4	Bleaching	2400 - 4800	3600	2250 - 4600	3425
	a) Yarn (Hypochlorite)	2400 - 3200	2800	2250 - 3050	2650
	b) Yarn (Hydrogen peroxide)	2400 - 3200	2800	2250 - 3050	2650
	c) Cloth (Hypochlorite)	4000 - 4800	4400	3800 - 4600	4200
	d) Cloth (Hydrogen peroxide)	4000 - 4800	4400	3800 - 4600	4200
5	Mercerizing	1700 - 3200	2450	1700 - 3200	2450
6	Dyeing	3600 - 17600	10600	3500 - 17500	10500
	a) Yarn (light and medium shades)	3600 - 4800	4200	3500 - 4700	4100
	b) Yarn (dark shades)	4800 - 6400	5600	4700 - 6300	5500
	c) Yarn (very dark shade)	6600 - 8800	7700	6500 - 8700	7600
	d) Cloth (light and medium shades)	7800 - 9600	8700	7700 - 9500	8600
	e) Cloth (dark shades)	10400-12800	11600	10300-12700	11500
	f) Cloth (very dark shade)	14300-17600	15950	14200-17500	15850

Table 1: Approximate water consumption and effluent generation in different wet processing stages in textile industries. (lit/100kg)

Pollution load:

The total pollution load generated by textile processing units was estimated for the parameters like total dissolved solids (TDS), Chloride, Sulphate, Total suspended solids (TSS),

chemical oxygen demand (COD), Biological oxygen demand (BOD), and Oil & Grease. For load estimation, the quantity of effluent and its quality is considered.

Total Dissolved Solids (TDS):

TDS concentration in textile effluent is very high. Moreover the reduction of TDS is a major challenge in terms of treatment. The chlorides and sulphates are the major contributors to the elevated TDS.

The various characteristics and standards to be followed have been tabulated here under.

S.No.	Parameters	Pollution control standards	Bleaching		Dyeing		Bleaching + Dyeing	
			Untreated	Treated	Untreated	Treated	Untreated	Treated
1	pH	5 – 9	7.8	8.1	8.6	8.2	7.78	8.1
2	TDS	2500	7845	6870	8209	7319	4243	4876
3	TSS	120	280	175	380	153	158	89
4	COD	275	356	328	340	319	286	276
5	BOD	50	58	37	135	28	41	21

Table 2: Effluent treatment characteristics for a textile industry in Adama.
(other than pH, all values are in mg/litre)

MATERIALS AND METHODS:

Micro-organisms:

The micro-organisms *Penicillium Chrysogenum*, *Penicillium expansum and Penicillium funiculosum* used in the present study were obtained from the Microbial Type Culture Collection & Gene Bank (M.T.C.C), Chandigarh, India, based on their salt tolerance since the inorganic compound constitutes the major contamination in the raw effluent and the primary treated effluent in the form of total dissolved solid. The specifications and the growth medium for the above microbial cultures are listed as below.

***Penicillium Chrysogenum* (M.T.C.C.2818)**

Growth condition: Aerobic, Temperature: 30^0C, Incubation Period: 7 days, Subculture: 30 days, Special features: Production of penicillin & cheese, Growth Medium: CYA.

Composition of CYA: Czapek concentrate: 10 ml, K_2HPO_4: 1 g, Yeast extract: 5 g, Sucrose: 30 g, Agar: 15 g, Distilled water: 1 lit.

Czapek concentrate: $NaNO_3$: 30 g, KCl: 5 g, $MgSO_4.7H_2O$: 5 g, $FeSO_4.7H_2O$: 0.1 g, Distilled water: 100 ml.

***Penicillium expansum* (M.T.C.C.1348)**

Growth condition: Aerobic, Temperature: 25^0C, Incubation Period: 5 days, Subculture: 30 days, Growth Medium: CYA.

***Penicillium funiculosum* (M.T.C.C.3372)**

Growth condition: Aerobic, Temperature: 27^0C, Incubation Period: 5 days, Subculture: 30 days, Growth Medium: CYA.

Sample effluent collection:

The raw textile dye effluent was obtained from a Textile Factory in Adama. The samples were collected from two points in the same unit, sample 1 from the collection tank at a depth of 10 feet and sample 2 was from the secondary collection tank after waste water was primarily treated. The raw effluent is referred as **effluent 1** whereas the primary treated water as **effluent 2**.

Determination of physio-chemical parameters:

The collected effluent was analyzed for its physio-chemical parameters. The pH was measured using pH meter. The effluent samples were passed through a filter, evaporated and then dried. The TDS was found to be comprised of colloidal and dissolved solids. Colloids were typically in the size range from 0.001 to 1 micrometer. A known volume of the sample was refluxed with a known excess of standard $K_2Cr_2O_7$ (Potassium dichromate) and dil.H_2SO_4

(Sulphuric acid) in the presence of a little Ag_2SO_4 (Silver sulphate) catalyst for 1.5 hours. The unreacted $K_2Cr_2O_7$ was then titrated against standard Mohr's salt solution (ammonium iron sulfate, is a double salt of iron sulfate and ammonium sulfate, with the formula $[NH_4]_2[Fe][SO_4]_2 \cdot 6H_2O$). The oxygen equivalent of $K_2Cr_2O_7$ consumed was taken as a measure of the COD. The results have been tabulated as follows:

Samples	pH	TDS (mg/litre)	COD (mg/litre)
Effluent 1	10.6	9600	650
Effluent 2	10.2	6500	450

Table 3: Initial characteristics of the effluents

Degradation experimental procedure:

The cleaned flasks were used for the preparation of the nutrient agar medium. The compositions of the growth medium are added to the flask. Three separate flasks with growth medium are prepared. After adding the required compositions, the flask is plugged with non adsorbent cotton and covered with aluminum foil paper. Then these flasks were autoclaved at 122^0C. The growth medium is transferred to the needed level in the test tubes. For each medium, three test tubes are prepared for the subculture. Allow 10 to 15 mins for the agar to solidification and then inoculated the strains of the cultures in their respective medium. The mouth of the test tube is plugged with cotton and incubated in the incubators to the specified temperature and period of the cultures.

Parallely, the medium is transferred to Petri plates in a similar way as in test tubes and the culture strains are inoculated. In this way, the culture strains can be purified and effective mycelium of the strain can be obtained. Due to the multiplication of the cells by utilizing the growth medium, the culture attains a good, steady and effective growth. These can be highly utilized in the biological process of water treatment. When the subculture time is over, the

cultures attain a sufficient state to undergo the biological degradation process of the two effluents.

Nutrient broth medium i.e. the nutrient medium used earlier is prepared without agar for each culture and autoclaved in a flask. The subcultures are inoculated in the respective broth medium. These broth cultures are then incubated in a shaker incubator at 120 rpm and corresponding temperature of the cultures. Exactly after 48 hours the incubation for the broth medium is stopped in order to treat the effluents.

100 ml of both raw effluent and primary treated effluents are taken separately in five 250 ml flasks and one 1000 ml flasks for each species respectively. Since the treatment is carried out for 5 days, individual flask for each day is considered for each species. Also a reference flask with more volume is done to find out the variation in the results between them. 5% of the broth culture is added to the above flasks containing effluents in the laminar flow chamber. The flasks are moved to the shakers at 120 rpm and room temperature for the treatment process. The agitation is given to benefit the contact between the organisms and contaminates of the effluent. More over the room temperature provides a better support for the treatment and will be easier to predict the degradation.

One flask from each culture and 100 ml from the reference flask of each culture were withdrawn from the shaker after 24 hours of treatment to test the degradation of the effluent. The parameters such as pH, TDS and COD and are tested during this period. Similarly for every 24 hours, the above said process is carried out.

RESULTS AND DISCUSSION:

The textile dye effluents were taken from the dyeing industry in Adama in two different forms and the biological treatment was conducted. The three different biological cultures have been used for the degradation experiment of the effluent in the form of broth. Different trials were conducted for the degradation experiment. Since the dyeing industries consider the parameters such as pH, TDS and COD as the major factors for the pollution load, experimental attention has been focused towards them.

The results obtained from the experiments using two effluents were shown in the following tables (TDS and COD values are in mg/litre) for the three micro-organisms.

Samples	Parameter	Day 1	Day 2	Day 3	Day 4	Day 5
Effluent 1	pH	8.56	8.35	7.81	7.59	7.28
	TDS	8500	7600	7100	6800	6200
	COD	620	580	560	530	460
Effluent 2	pH	8.34	7.61	7.48	7.20	7.05
	TDS	5800	5200	4800	4500	4200
	COD	430	390	370	360	340

Table 4: *Penicillium Chrysogenum*

Samples	Parameter	Day 1	Day 2	Day 3	Day 4	Day 5
Effluent 1	pH	8.37	8.24	7.65	7.22	7.04
	TDS	8300	7300	6500	5400	5200
	COD	610	560	540	520	490
Effluent 2	pH	8.29	7.56	7.28	7.10	7.02
	TDS	6100	5100	4500	3400	2300
	COD	410	380	340	310	270

Table 5: *Penicillium Expansum*

Samples	Parameter	Day 1	Day 2	Day 3	Day 4	Day 5
Effluent 1	pH	8.48	8.39	7.83	7.69	7.12
	TDS	8800	7500	7200	6600	6400
	COD	630	590	570	490	470
Effluent 2	pH	8.42	7.81	7.68	7.32	7.25
	TDS	5900	5400	5100	4800	4500
	COD	440	410	390	360	350

Table 6: *Penicillium funiculosum*

The activities of different microorganisms for the two effluents were graphically represented in the following figures:

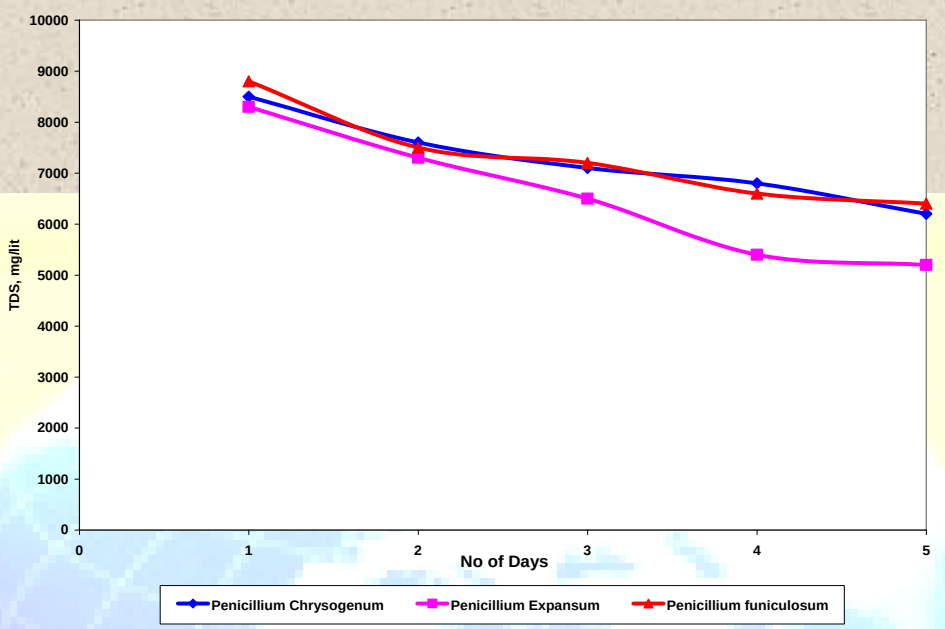

Figure 1: Effluent 1 – TDS

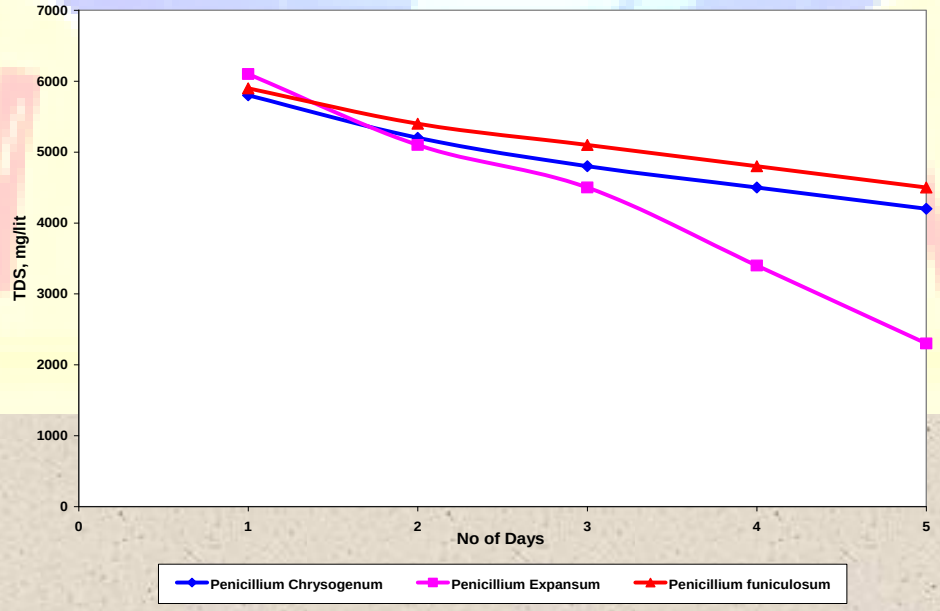

Figure 2: Effluent 2 – TDS

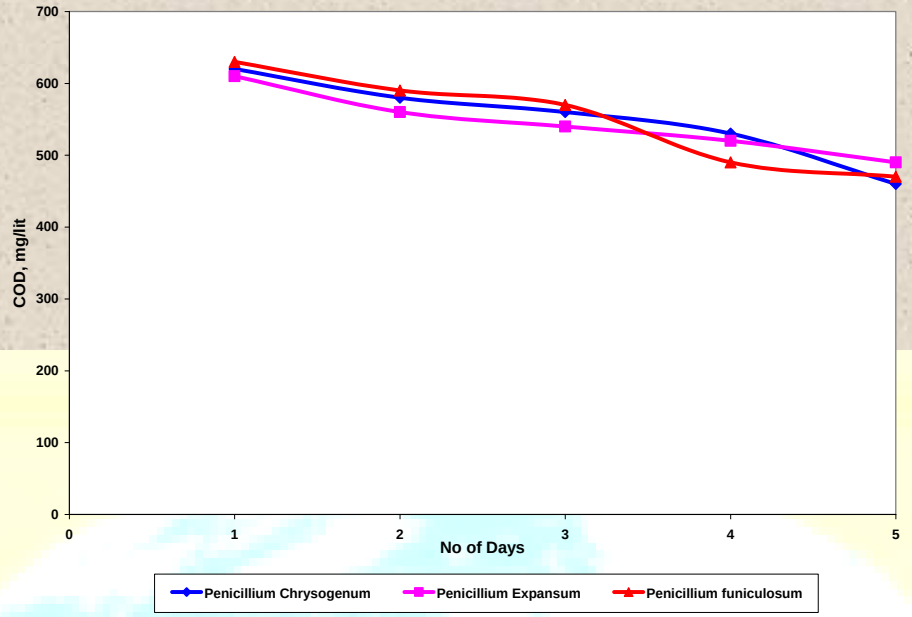

Figure 3: Effluent 1 – COD

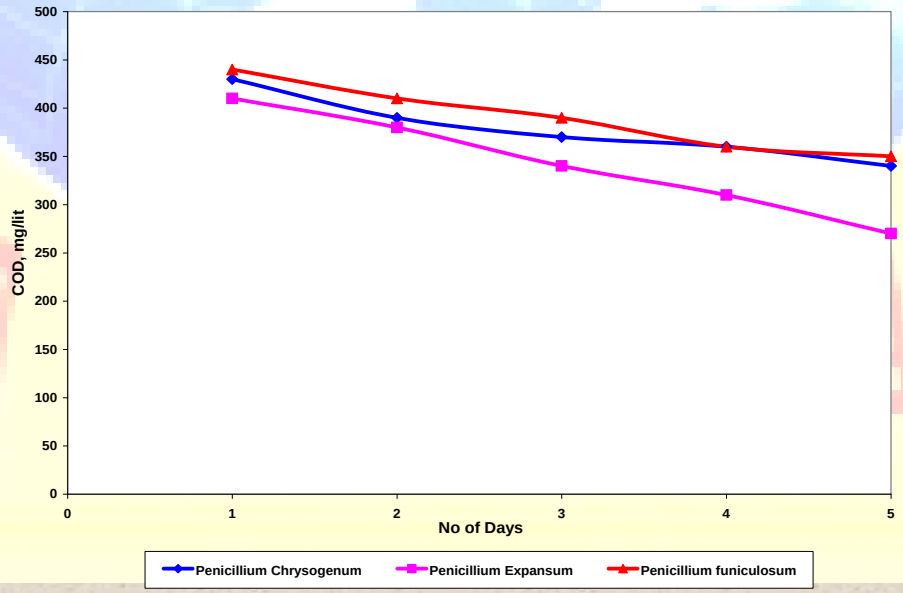

Figure 4: Effluent 2 – COD

CONCLUSION:

The textile dye effluents contain higher values of TDS, pH and COD. This will adversely affect the soil fertility as well as the environment. Biological method of effluent treatment was employed as it is a promising and economically viable technology in treating textile dye effluents. It provides a better elimination of long term liability risks. Many literatures suggest that the biological method is acting efficient in the reduction of TDS. The biological treatment of dye effluent using the different micro-organisms was studied. Among them the *penicillium species* were well suited for the TDS reduction in the textile dye effluent. Since the dye effluent is industrial waste water and a combination of several dyes and chemicals, single dye structure has not been focused. In order to attain better results and the future treatment process for the industries, effluent from collection tank has been recommended. From the experiments and analysis, it is suggested that the effluent 2 can be well degraded by the *Penicillium species* and reused in the textile industries.

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