Available online at http://www.ijims.com
ISSN - (Print): 2519 – 7908 ; ISSN - (Electronic): 2348 – 0343
IF:4.335; Index Copernicus (IC) Value: 60.59; Peer-reviewed Journal

Physico-Chemical Characterization Of Textile Effluent From A Dyeing Industry In Tiruppur Of Tamil Nadu

Leena, R. [1]* and Selvaraj, D. [2]

1.Assistant Professor of Zoology, Deptt. of Zoology and Research Centre, Scott Christian College (Autonomous), Nagercoil

2 Associate Professor of Zoology, Deptt. of Zoology and Research Centre, Scott Christian College (Autonomous), Nagercoil

Corresponding author: Leena, R.

Abstract

The physico-chemical parameters of various textile industrial effluents vary depending on the type of dyes and processing chemicals used. The major pollution indicating parameters like TS, TDS, TSS, DO, COD, BOD, pH, alkalinity, chlorides, sulphates and heavy metals were analyzed. The estimated parameters were compared with the stipulated standard values put forth by WHO, BIS and TNPCB. The effluent was highly turbid with high values for TDS, TSS, alkalinity, chlorides, sulphates and iron. The study also showed elevated levels of some heavy metals. Physico- chemical analysis indicate that the effluent samples have higher values for most of the parameters and exceed the permissible limits. Based on the estimated characteristics, it is revealed that the effluent is not suitable for direct discharge into water stream and need a suitable technology for the treatment before discharge.

Key words: Textile industry, effluent, physico-chemical parameters, water quality, water pollution, textile dyes.

Introduction

Textile industries have been placed in the category of most polluting industries by the Ministry of Environment and Forests, Government of India. Textile industries are one of the largest water users and polluters resulting in high wastewater generation[1]. Considering the volume and composition of effluent, the textile wastewater is rated as the most polluting among all wastewaters in the industrial sectors[2]. The diversity in composition of chemical reagents used in textile industries contributes much to water pollution. Textile effluents are among the most difficult to treat wastewaters due to their considerable amount of toxic substances[3].

Important pollutants in textile effluents are recalcitrant organics, colourants, toxicants and inhibitory compounds, surfactants, chlorinated compounds, salts, high temperature (more than 40°C) and high pH due to the large amount of alkali present in it. In general, textile industry wastewaters are coloured, highly alkaline and high in biochemical oxygen demand (BOD), suspended solids and temperature[4]. The wastewater volume and composition varies from mill to mill and typically contain byproducts, residual dyes and auxiliary chemicals.

The textile dye effluents discharged into water bodies reduce water transparency and thus reduce the dissolved oxygen concentration affecting aerobic organisms[5]. Three main kinds of ecological risks associated with this pollutant are loss of productivity in soil and water ecosystem, pollution of groundwater due to metal leaching and the accumulation of pollutants in the food chain affects aquatic and terrestrial vegetation as well as animals including humans. Consequently, textile wastewaters can lead to an alteration in the equilibrium of the aquatic ecosystems.

Colour in the effluent is one of the most important indicators of water pollution and the discharge of highly coloured effluents are aesthetically displeasing and may lead to reduced light penetration[6]. This significantly affects the photosynthetic activity of aquatic plants in the affected water medium. The high concentration of nitrogen in the textile industrial effluents can cause eutrophication in the closed water bodies.

Apart from the most toxic heavy metals like Chromium (Cr) chemical impurities of the dye house effluents mostly comprise of the following dissolved substances such as inorganic salt cations like Fe, Zn, Cu, Ca and Na; anions like SO_4^{2-}, NO_3^-, PO_4^{2-} and parameters such as DO, TSS and TDS (APHA, 1995). Dyes contribute to overall toxicity at all processing stages leading to high level of BOD, salinity, colour, surfactants, fibers, heavy metals and turbidity[7]. Characterization of textile wastewater is very important to develop strategies for water treatment and reuse.

An attempt has been undertaken for complete characterization of physico- chemical parameters of the wastewater collected from a textile Industry in Tiruppur of Tamil Nadu.

Materials And Methods

Sampling And Analysis Of Effluent

Sampling: Tiruppur, the leading cotton knitwear industrial cluster in Tamil Nadu, South India (lat. 11° 6' O" N, Long. 77° 21' O" E) was chosen for the collection of effluent sample. The textile effluent was collected from the discharge tank of a textile mill. Spot and grab method of sampling was followed.

pH and temperature were determined at the sampling site itself. The pH was determined using pH meter (Elico digital pH meter, model L1120) and temperature was recorded using a laboratory thermometer. The effluent sample was transported to the laboratory and refrigerated until further analysis in accordance with the standard methods.[8,9,10]

Analysis of the effluent

Physical parameters

The sample was analyzed for 7 physical parameters. Sample colour was tested by U- 3010 spectrophotometer (Hitachi, Japan). Electrical conductivity was determined by conductivity meter (Jeneway EC meter, model 4070). Turbidity was estimated using a nephelometer. Density was measured using a vibrating flow densimeter. Total solids (TS), Total dissolved solids (TDS) and Total suspended solids (TSS) were estimated by evaporation method.

Chemical parameters

Chemical oxygen demand (COD) was determined by the dichromate digestion method[11]. BOD was estimated by fixed control dilution method. Acidity, total alkalinity, bicarbonate alkalinity and carbonate alkalinity were estimated by titration methods. Magnesium was estimated as the difference between total hardness and calcium as $CaCo_3$. The modified Winkler's method[12] was followed to estimate the Dissolved Oxygen content in the water sample. The automated phenate method was employed for the estimation of ammoniacal nitrogen[13]. Total Nitrogen content was determined by per sulfate/ UV digestion method. The amount of chloride ions in the water sample was determined following Mohr's method[14]. The concentration of sulphate, sulphide, sulphite, phenol, phosphate and surfactants in the sample were measured spectrophotometrically. Sodium (as Na) content in the effluent was determined by flame emission photometry at 589 nm. Potassium (as K) was determined using a standard type of flame photometer at a wavelength of 766.5 nm. Boron (as B) in the effluent sample was estimated by Carmine method[15].

Heavy metals

Colorimetric method was followed for the estimation of Fe^{2+}, Fe^{3+} and Mn concentration. Mercury (Mg^{2+}) in the effluent sample was estimated by flameless atomic absorption method. Lead and Cadmium contents were estimated by spectrophotometric method. Atomic Absorption Spectrophotometer (AAS) was used to find out the concentration of zinc and nickel in the effluent water sample. Copper concentration was estimated spectrophotometrically.

Results

Of the physical parameters tested, the pH of the effluent was slightly alkaline (9.5) and the temperature was 39° C. The colour of the effluent was glistening yellow with a pungent odour. It was slightly dense (0.998 g/cc) with turbidity value of 6 NTU. Total Dissolved Solids (TDS) value was 6764 mg/l which was far above the permissible limits for discharge of trade effluents into inland surface waters. Total Suspended Solids (TSS) was also very high (216 mg/l) against the permissible limit of 100 mg/l as fixed by the Tamil Nadu Pollution Control Board (Table 1.1).

Among the chemical parameters studied, the total alkalinity was high (1300 mg/l). Bicarbonate and Carbonate alkalinity also recorded high as 940 mg/l and 360 mg/l respectively. The Dissolved Oxygen (DO) content was very low (1.05 mg/l). The Chemical Oxygen Demand (COD) was recorded as 321 mg/l which was higher than 250 mg/l as tolerance limit fixed by TN PCB. The Biological Oxygen Demand (BOD) was also higher (46 mg/l) against the TN PCB discharge limit of 30 mg/l. Content of oil, grease and petroleum ether extractable matters were very high (43 mg/l) as compared to the discharge limit of 10 mg/l fixed by TN PCB (Table 1.2).

The chloride content was 3040 mg/l and exceeded the limits set by TN PCB (1000 mg/l), Bureau of Indian Standards (250 mg/l) and World Health Organization (250 mg/l). The sulphate content was 360 mg/l which fell within the limits fixed by TN PCB (1000 mg/l) and WHO (400 mg/l) but exceeded the limit of BIS (200 mg/l). Manganese content was recorded as 60 mg/l which exceeded the limit of BIS (30 mg/l). Fluoride content was 1.1 mg/l which was within the limits of TN PCB and WHO but exceeded the permissible values of BIS. Sodium content (1999 mg/l) was much higher than the discharge limit fixed by WHO (400 mg/l) (Table 1.3).

Heavy metal analysis of the effluent showed the presence of 10 metals of which the total chromium (2.24 mg/l) and cadmium content (2.2 mg/l) exceeded the discharge limits of TN PCB (2 mg/l for Cr and Cd), BIS (0.01 mg/l for Cd) and WHO (0.01 mg/l for Cd). The level of copper was 1.27 mg/l which was within the discharge values (3mg/l) set by TN PCB but exceeded the values of WHO (1mg/l) and BIS (1.5 mg/l). Zinc content was 1.7 mg/l which was well within the limits of BIS and WHO (5 mg/l) but exceeded the values of TN PCB (1.7 mg/l) (Table 1.4).

Discussion

The estimated physico-chemical characteristics of the effluent water sample were compared with the standard permissible limits for the safe discharge of trade effluents into natural water bodies. During collection, temperature of the effluent sample was 39° C which was much higher than the normal discharge values. Discharge of these effluents in the water bodies cause direct loss to aquatic ecosystem. These effluents can result in a wide variety of changes in aquatic plant communities, including changes in species composition, standing crop, net production[16, 17] and a loss of floral and faunal diversity[18].

Elevated temperature typically decreases the level of dissolved oxygen of water. This can harm fishes, amphibians and other aquatic organisms. Many aquatic species fail to reproduce at elevated temperatures. Primary producers are affected by warm waters because this can increase plant growth rates, resulting in a shorter life span and species over population. This can lead to algal bloom which again reduces oxygen levels in the water. Temperature changes of even one or two degree Celsius can cause significant changes in metabolism of the aquatic animals. The colour of the effluent sample also was found unacceptable to be discharged into the natural water body. The effluents collected were highly coloured and odorous. This agreed with the previous findings regarding textile effluents[19] wherein the effluents from textile industries studied were highly coloured and had a foul smell. The effluent was shining yellow in colour and this may possibly due to the colour of dye Golden yellow used in the textile dyeing. Moreover, discharge of coloured effluents into water bodies may reduce the penetration of sunlight leading to a decrease in photosynthetic rate.

pH of the effluent sample studied was 9.5 which was slightly above the permissible range. Increased pH in the effluent samples was due to the excessive use of carbonate, bicarbonate, hydrogen peroxide and sodium hydroxide during the bleaching process. The addition of excess lime (Calcium oxide) during the initial (preliminary) treatment process was also responsible for the high pH value[20]. Elevated values of pH (ranging from 7.85-12.85) and EC values (36.3, 21.4 and 95.5 ds/m respectively for 3 samples) were reported[21]. These elevated values of pH and EC were likely due to the excessive chemicals used in the process of bleaching and sizing where sodium chloride and sodium hydroxide were used in large amounts.

Similar higher values of pH values were obtained in related studies [22, 23] (ranging from 5.8 – 10.5) in their respective studies on characterization of textile wastewater. pH affects most chemical and biological processes in water and it is one of the most important environmental factors limiting the distribution of species in aquatic habitats. The optimum pH for most aquatic organisms falls between 6.5 to 8. Fluctuating pH or sustained pH outside this range reduces biological diversity in aquatic ecosystem because it causes physiological stress to many species and can result in decreased reproduction, decreased growth, disease or death. Even small changes in pH can shift community composition in streams because pH alters the chemical state of many pollutants like copper and ammonia changing their solubility, transport or bioavailability. This can increase exposure of the toxic metals and nutrients to aquatic plants and animals. Extreme pH values are also known to inhibit conventional biological wastewater treatment processes.

The colloidal and suspended impurities in the effluent cause turbidity in the receiving streams. Higher value of turbidity showed that the content of colloidal matter in the wastewater was high and by implication, the wastewater contained high concentration of solids. The solids present, besides affecting the growth of plants directly also affect the soil structure permeability as well as aeration indirectly affecting the growth of fauna. This reduces light penetration and ultimately decreases the rate of photosynthesis[24]. The results from the present study indicated the mean values of physical parameters namely turbidity (6 NTU), total solids (6980 mg/l) and total suspended solids (216 mg/l) were significantly higher than the standard permissible limits for discharge of textile effluents.

In a related work, there were reports of higher TSS value (55-2500 mg/l) for raw textile wastewater22. Higher values for TDS (1800-4400 mg/l) and TSS (150-1100 mg/l) for actual textile effluents were reported23. In another similar work, TS (1528.5 mg/l) and TDS (450 mg/l) values which were within FEPA standard for effluent discharge to surface waters in Nigeria were reported25.But the value of 1078.5 mg/l for suspended solid was higher than 30 mg/l of FEPA standard. Higher values for total solids (6.5g/kg), settleable solids (3.15 g/kg) and the volatile solids (4.15 g/kg) were reported[26]. In a similar study, very high values for TS (9200 mg/l), TDS (2800 mg/l) and TSS (6200 mg/l) were reported[27]. Electrical conductivity of the effluent sample was much higher (11.31 mS/cm) than in previous reports[28] in which values ranging from 1.1 to 3.4 mS/cm were recorded.

BOD (46 mg/l) and COD (321 mg/l) of the effluent tested were much higher than the standard permissible limits. The high values of BOD and COD showed that the effluent is highly oxygen demanding waste that caused the depletion of Dissolved oxygen (DO) which is the fundamental requirement for aquatic life. Moreover, the higher value of COD indicated the pollution potential of the textile effluents. The dissolved oxygen content of 1.05 mg/l was relatively low. A healthy body of water should have a DO of atleast 5.2 mg/l[29]. In a similar study[23], very high values for BOD (145 – 236 mg/l) and COD (370 – 665 mg/l) were recorded for textile wastewater. If effluent with high levels of ammoniacal nitrogen is discharged untreated to the environment, depletion of receiving water body resources may set in as the ammonia is oxidized to nitrate by some group of bacteria. This can then promote plant and algal growth leading to eutrophication of the water body.

Of the other chemical parameters tested bicarbonate alkalinity (940 mg/l) as well as carbonate alkalinity (360 mg/l) was found to be higher than the normal limits. Oil and grease as well as other petroleum ether extractable matters were also higher (43 mg/l) than the permissible limit of 10 mg/l. Another major problem in the textile industry is associated with the use of surfactants, emulsifiers and dispersants. Surfactants are widely used in the industry to improve the solubility/ dispensability of the chemicals in water. The present study revealed the presence of surfactants in detectable limits.

The organic content in the effluent sample was found to be very high. Although nutrients/ minerals are essential for primary production, high concentrations can trigger an eutrophication process in the receiving water streams. The dissolved minerals may increase salinity of the water and thus may render it unfit for irrigation and consumption. Impurities such as sulphites and nitrates can cause depletion of dissolved oxygen content of water. Of the mineral contents of the effluent, the values of sulphate, calcium, magnesium, sodium and fluoride (360 mg/l, 120 mg/l, 60 mg/l, 1999 mg/l and 1.1 mg/l respectively) contents were appreciably higher than the prescribed discharge limits. The levels of Ca and Mg cations in the effluent which combine and lead to the total hardness of water were also found to be very high. The sulphate ion (SO_4^{2-}) content was found to be within the permissible limits but the Chloride (Cl^-) content was found to be remarkably higher which was an index of surface pollution level. The high sodium (salt) concentration in ground water leads to the formation of saline soil and is a serious hazard to agriculture. The phenolic content was found to be 1.8 mg/l which was higher than the permissible limit as set by TNPCB (1 mg/l). The value was higher than the other two standards of BIS (0.001 mg/l) and WHO (0.002 mg/l) and is considered to be toxic if not treated. In textile industry operations, phosphates are used in buffers as builders for scouring, water conditioners and surfactants as flame retarders. In the present study also, the phosphate levels were higher than the prescribed safety limits.Composition of heavy metals was also higher when compared to the standard values with 1.1004 mg/l for iron, 2.2 mg/l for cadmium, 0.7 mg/l for arsenic and 0.2 mg/l for lead. Chromium content of effluent (2.24 mg/l) was found to be higher than the 2 mg/l as prescribed by the TNPCB. Copper content (1.27 mg/l) of the effluent was higher than the standards prescribed by WHO (1 mg/l). Metals found in a textile mill's effluent come from many sources. Metals are used as oxidizing agents, copper after treatment for direct dyes, organometallic finishes and as essential ingredients in several dyes. Metals in textile wastewaters can also inhibit biological treatment.

Mercury content was found to be high in the studied effluent with a value of 0.9 mg/l. Water contaminated with metallic effluents can cause severe health problems. Lead for instance can interfere with enzyme activities and functions of red blood cells. It can affect nerves and brain functioning even at low concentrations[30]. Mercury, cadmium and chromium can bio accumulate and through food chain reach toxic levels in man[31].

Zinc content was found to be high (1.7 mg/l) in the effluent which was higher than the safety limit set by TN PCB. Nickel content (1.4 mg/l) was within the prescribed discharge limit. Heavy metal toxicity can result in damaged or reduced mental and central nervous function, low energy levels and damage to blood cells , lungs , kidneys, liver and other vital organs. Long term exposure may result in slowly progressing physical, muscular and neurological degenerative processes that mimic Alzheimer's disease, Parkinson's disease, Muscular dystrophy and multiple sclerosis. Allergies are also common and repeated long – term contact with some metals or their compounds are carcinogenic and highly toxic.

Results of the heavy metal analysis in the present study showed considerably higher values for Cr, Zn, Ni, Cd, Cu, Mn and Pb. The results agreed with several of the previous findings[32,33] who recorded similar higher values for heavy metals.

Conclusion

Water drained out from textile processing units must have low TDS, total hardness, BOD, COD and heavy metals according to standards fixed by TNPCB, BIS and WHO. However, the values of most of the parameters studied exceeds the permissible limit and indicate the need for further proper treatment. With the installation of CETP (Common Effluent Treatment Plant) for detoxification of textile effluents, the hazardous impact of these effluents on the environment could be reduced.

References

1. Ghoreishi, S.M. and Haghihi, R. Chemical catalytic reaction and biological oxidation for treatment of non-biodegradable textile effluent. Chemical Engineering and Technology Journal, 2003, 95:163- 169.

2. Awomeso, J.A., Taiwo, A.M., Gbadebo, A.M. And Adenowo, J.A. Studies on the pollution of water body by textile industry effluents in Logos, Nigeria. J. Appl. Sci. Environ. Sanit. Sby., 2010, 5: 353-359.

3. Hai, F.I.,Yamamoto, K.and Fukushi, K. Hybrid treatment system for the dye waste water. Crit. Rev. Env. Sci.Tech., 2007, 37: 315- 377.

4. Mohan, N., Balasubramaniun, N. and Basha, A.C. Electrochemical oxidation of textile waste water and its reuse. J. Hazard. Mater., 2007, B 147: 644-651.

5. Vijayaragavan, K. and Yun, Y.S. Bacterial bio sorbents and biosorption. Biotechnol. Adv., 2008, 26: 266- 291.

6. Khehra, M.S., Saini, H.S., Sharma, D.K., Chadha, B.S. and Chimni, S.S. Biodegradation of azo dye C.I Acid red 88 by an anoxic-anaerobic sequential bioreactor. Dyes and Pigments, 2006, 70: 1-7.

7. Wynne, G., Maharaj, D, and Buckley, C. Cleaner production in the textile industry- lessons from the Danish experience, School of Chemical Engineering, University of Natal, Durban, South Africa, 2001, pp:33.

8. Greenberg, A.E., Clasceri, A.E.and Eaton, A.D. Standard methods for the examination of water and waste water,18th edition. American Public Health Association, Washington,DC. 1992, pp:212.

9. Rump, H.H and Krish,H. Laboratory manual for the examination of water and waste water and soil. 2nd Edition, VCH publishers, New York, 1992, pp:321.

10. APHA, Standard methods for the examination of water and waste water. 20th Edition, American Public Health Association, Washington D.C., New York, U.S.A., 1998.

11. Jirka, A.M. and Carter, M.J. Micro semi-automated analysis of surface and waste water for chemical oxygen demand. Analytical chemistry, 1975, 47 (8): 1397- 1402.

12. Winkler, L.S. The determination of dissolved oxygen. Ber. Dtsch. Chem. Ges., 1888, 21: 2843-2855.

13. Thayer, G.W. Comparison of two storage methods for the analysis of nitrogen and phosphorous fractions in estuarine water. Chesapeake Sci., 1970, 11: 55.

14. Doughty, H.W. Mohrs method for the determination of silver and halogens in other than natural solutions. J.Am.Chem.Soc., 1924, 46 (12): 2707- 2709.

15. Hatcher, J.T. and Wilcox, L.V. Colorimetric determination of Boron using Carmine. Anal.Chem., 1950, 22 (4): 567- 569.

16. Grace, J.B. and Tilly, L.J. Distribution of abundance of submerged macrophytes, including Myriophyllum spicatum.L. (Angiospermae) in a reactor cooling reactor cooling reservoir. Archive. F. Hydrobiologic., 1976, 77:475-487.

17. Haag, R.W. and Gorham, P.R. Effects of thermal effluent on standing crop and net production of Elodia Canadensis and other submerged macrophytes in Lake Wabamun, Alberta. The Journal of Applied Ecology, 1977, 14: 835- 851.

18. Brown, J.P. Reduction of polymeric azo and nitric dyes by intestinal bacteria. Applied and Environmental Microbiology, 1971, 41: 1283-1286.

19. Faryal, R and Hameed, A. Isolation and Characterization of various fungal strains from textile effluent for their use in bioremediation. Pak.J.Bot.,2005, 37 (4): 1003- 1008.

20. Basker, R., Begun, K.M.M.S. and Sundaram, S. Characterization and reuse of textile effluent treatment plant waste sludge in clay bricks. Journal of the University of chemical technology and Metallurgy, 2006, 41 (4): 473- 478.

21. Abd, El-Rahim, W.M. and Moawad, H. Testing all performance of small scale bioremediation unit designed for bio removal /enzymatic biodegradation of azo dye residues. New York science journal, 2010, 3 (3):77-92.

22. Idris, A., Hashim, R., Rahman, R.A., Ahmad, W.A., Ibrahim, Z, Razak, P.R.A., Zin, H.M. and Baker, I. Application of bioremediation process for textile waste water treatment using pilot plant. International Journal of Engineering and Technology, 2007, 4 (2): 228- 234.

23. Aslam, M.M., Baig, M.A., Hassan, I., Qazi, I.A., Malik, M. and Saeed, H. Textile waste water characterization and reduction of its COD and BOD by oxidation. Electronic Journal of Environmental, Agricultural and Food Chemistry, 2004, 3(6):804- 811.

24. Sofianosheen, S., Haqnawaz, C. and Khalil-Ur-Rehman, F. Physico-chemical characterization of effluents of local textile Industries of Faisalabad, Pakistan. Pakistan Int. J. Agri. Biol., 2000, 2 (3):232-233.

26. Asia, I. O. and Akporhonor, E.E. Characterization and physico chemical treatment of waste water from rubber processing factory. International Journal of physical science, 2007, 2(3): 061- 071.

27. Manikandan, B., Ramamurthi, V., Karthikeyan, R. and Sundararaman, T.R. Bioleaching of textile dye effluent using mixed culture through an immobilized packed bed bio reactor (IPBBR). Modern Applied Science, 2009, 3 (5):131- 135.

28. Bes-Pia, A., Mendoza-Roca, J.A., Alcania-Miranda, M.I., Iborra-Clar, A .and Iborra-Clar, M.I. Reuse of waste water of the textile industry after its treatement with a combination of physico-chemical treatment and membrane technologies.Desalination, 2002, 149:169-174.

29. Adermoroti, C. M. A. Standard methods for water and effluent analysis. 1st edition, Foludex Press Ltd. Ibadan, Nigeria, 1996, pp:38-84.

30. Ezeronye, O.V. and Ubalua, A.O. Studies on the effect of abattoir and industrial effluents on the heavy metals and microbial quality of Aba river. Afr. J. Biotechnol., 2005, 4 (3): 266- 272.

31. Howells, G. Acid rain and rain waters. Ellis Horwood series in Environmental Science Ellis Horwood Ltd, New York, 1990, pp:134-136.

32. Srivastava, S. and Thakur, I.S. Evaluation of biosorption potency of Acinetobacter sp. for removal of hexavalent Chromium from tannery effluent. Iran. J. Environ. Heal. Sci. Eng., 2008, 5 (3):195- 200.

33. Das, D and Mishra, S. Simultaneous reduction of phenol and chromium from textile industry effluent using mixed culture of microorganisms. Journal of Environmental Research and Development, 2012, 7 (2A): 946- 957.

Table 1.1. Physical parameters of the untreated textile effluent and their permissible limits

S.No.	Parameters	Unit	Effluent water sample	*Permissible Limits		
				a TN PCB	b BIS	c WHO
1	**p H**	-	9.5	NM	NM	NM
2	**Temperature**	°C	39	NM	NM	NM
3	**Colour**	Hazen	356	NM	5 (Pt-Co scale)	15 (Pt-Co scale)
4	**Turbidity**	NTU	6	NM	5	5
5	**Density**	g/cc	0.998	NM	NM	NM
6	**Electrical Conductivity**	mS/cm	11.31	NM	NM	NM
7	**Total Solids (TS)**	mg/l	6980	NM	NM	NM
8	**Total Dissolved Solids (TDS)**	mg/l	6764	2100	500	1000
9	**Total Suspended Solids (TSS)**	mg/l	216	100	NM	NM

***Permissible limits for discharge of trade effluents into inland surface waters as fixed by**

a) Pollution Control Board of Tamil Nadu [TN PCB]

b) Bureau of Indian Standards [BIS]

c) World Health Organization [WHO]; NM- Not Mentioned

Table 1.2. Chemical parameters of the untreated textile effluent and their permissible limits

S.No.	Parameters	Unit	Effluent water sample	*Permissible Limits		
				a TN PCB	b BIS	c WHO
1	**Total Hardness as $CaCO_3$**	mg/l	180	NM	300	500
2	**Total Alkalinity as $CaCO_3$**	mg/l	1300	NM	NM	NM
3	**Bicarbonate Alkalinity as $CaCO_3$**	mg/l	940	NM	NM	NM
4	**Carbonate Alkalinity as $CaCO_3$**	mg/l	360	NM	NM	NM
5	**Inorganic Acidity**	mg/l	A	NM	NM	NM
6	**Dissolved Oxygen (DO) as O_2**	mg/l	1.05	NM	NM	NM
7	**Chemical Oxygen Demand (COD)**	mg/l	321	250	NM	NM
8	**Biochemical Oxygen Demand (BOD)**	mg/l	46	30	NM	NM
9	**Ammoniacal Nitrogen as N**	mg/l	31.45	50	NM	NM
10	**Total Nitrogen as N**	mg/l	8.85	100	NM	NM
11	**Oil and grease, petroleum ether extractable matters**	mg/l	43	10	NM	NM
12	**Surfactants**	-	P	NM	NM	NM

Table 1.3. Mineral content of untreated textile effluent and their permissible limits

S.No.	Parameters	Unit	Effluent water sample	*Permissible Limits		
				a TN PCB	b BIS	c WHO
1	**Chlorides as Cl^-**	mg/l	3040	1000	250	250
2	**Sulphates as SO_4^-**	mg/l	360	1000	200	400
3	**Calcium as $CACO_3$**	mg/l	120	NM	75	NM
4	**Magnesium as Mg**	mg/l	60	NM	30	NM
5	**Fluoride as F^-**	mg/l	1.1	2	1	1.5
6	**Sulphide as S_2^-**	mg/l	2.7	2	NM	NM
7	**Sulphite as SO_3^{2-}**	mg/l	1.4	NM	NM	NM
8	**Phenols as C_6H_5OH**	mg/l	1.8	1	0.001	0.002
9	**Nitrate as NO^{3-}**	mg/l	48.7	NM	45	45
10	**Phosphate as PO_4^{3-}**	mg/l	8	5	NM	NM
11	**Sodium as Na**	mg/l	1999	NM	NM	200
12	**Potassium as K**	mg/l	77	NM	NM	NM
13	**Boron as B**	mg/l	2.0	2	NM	NM

Table 1.4. Heavy metal content of the untreated textile effluent and their permissible limits

S.No.	Parameters	Unit	Effluent water sample	*Permissible Limits		
				a TN PCB	b BIS	c WHO
1	**Iron as Fe**	mg/l	1.1004	NM	1	0.3
2	**Manganese as Mn**	mg/l	0.15	NM	0.3	0.1
3	**Total Chromium as Cr**	mg/l	2.24	2	NM	NM
4	**Mercury as Hg**	mg/l	0.9	0.01	0.001	0.001
5	**Cadmium as Cd**	mg/l	2.2	2	0.01	0.01
6	**Arsenic as As**	mg/l	0.7	0.2	0.05	0.05
7	**Lead as Pb**	mg/l	0.2	0.1	0.01	0.05
8	**Zinc as Zn**	mg/l	1.7	1	5	5
9	**Copper as Cu**	mg/l	1.27	3	1.5	1
10	**Nickel as Ni**	mg/l	1.4	3	NM	NM