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Study on Physico-Chemical Parameters of Water from Different Dyeing Units Effluents in Ludhiana City, India

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ABSTRACT: The present study was undertaken on the physico-chemical parameters of water from different dyeing units in Ludhiana city, India. Standard procedures were adopted to calculate the physical and chemical properties in water samples. Wastewater was analyzed for various water qualities like pH, TDS, Alkalinity, Hardness, COD, etc. The results from the analysis of dyeing wastewater show that most of the parameters were higher than the MPL (Maximum Permissible Limit) and that may cause changes in the water chemistry as well. Hence the flow of this dyeing wastewater into the river causes the serious pollution problems. A perspective of environmental pollution associated with various dyeing units and its remedies are described.

Keywords: Physico-chemical parameters; Small dyeing units; effluents and impacts.

INTRODUCTION: Dyes are complex aromatic molecular structures which are intended to be stable and consequently are difficult to degrade. At present, there are more than 100,000 dyes available commercially (of which azo dyes, represent about 70% on weight basis), and over 1 million tons dyes are produced per year, of which 50% are textile dyes.[1] In India alone, dyestuff industry produces around 60,000 metric tons of dyes, which is approximately 6.6% of total colorants used worldwide.[2] The largest consumer of the dyes is the textile industry accounting for two third of the total production of dyes.[3]

Textile industry consumes a large volume of water and chemicals during wet processing stages and delivers considerable quantities of colorants along with other chemicals. Dyes being tinctorially stronger are visible in water at concentrations as low as 1 ppm. One of the major factors responsible for release of water-insoluble as well as water-soluble dyes in the wastewaters is the improper dye uptake as well as the degree of fixation on the substrate which is governed by several factors such as depth of the shade, application method, material to liquor ratio and pH etc. For almost all dye-fibre combinations, exhaustion and degree of fixation of dye decreases with increasing depth of the shade. Due to high composition variability and high colour intensity, wastewater from textile dyeing facilities is difficult to treat satisfactorily. It is estimated that approximately 2% of the dyes produced are discharged directly in aqueous effluent, and 10% is subsequently lost during the coloration process. It is reasonable to assume that approximately 20% of the colorants enter the environment through effluents from the wastewater treatment plants. The presence of such compounds in the industrial wastewaters may create serious environmental problems due to toxicity to aquatic life and mutagenicity to humans. In spite of resistance to biodegradation under aerobic conditions, dyes (in particular azo dyes) undergo reductive splitting of the azo bond relatively easily under anaerobic conditions releasing corresponding aromatic amines. Anaerobic decolorization is considered to be microbiologically a nonspecific process.

The textile dyeing and finishing industry has created a huge pollution problem as it is one of the most chemically intensive industries on earth, and the No. 1 polluter of clean water (after agriculture). More than 3600 individual textile dyes are being manufactured by the Industry today. The industry is using more than 8000 chemicals in various processes of textile manufacture including dyeing and printing. Many of these chemicals are poisonous and damaging to human health directly or indirectly. Large quantities of water are required for textile processing, dyeing and printing. The daily water consumption of an average sized textile mill having a production of about 8000 kg of fabric per day is about 1.6 million liters. 16% of this is consumed in dyeing and 8% in printing. Specific water consumption for dyeing varies from 30 - 50 litres per kg of cloth depending on the type of dye used. The overall water consumption of yarn dyeing is about 60 litres per kg of yarn. Dyeing section contributes to 15% - 20% of the total waste water flow. Water is also required for washing the dyed and printed fabric and yarn to achieve washing fastness and bright backgrounds. Washing agents like caustic soda based soaps; enzymes etc. are used for the purpose. This removes the surplus colour and paste from the substrate. Water is also needed for cleaning the printing machines to remove loose colour paste from printing blankets, printing screens and dyeing vessels.[4 & 5] It takes about 500 gallons of water to produce enough fabric to cover one sofa. The World Bank estimates that 17 to 20 percent of industrial water pollution comes from textile dyeing and finishing treatment given to fabric. Some 72 toxic chemicals have been identified in water solely from textile dyeing, 30 of which cannot be removed5. This represents an appalling environmental problem for the clothing and textile manufacturers.

Mills discharge millions of gallons of this effluent as hazardous toxic waste, full of colour and organic chemicals from dyeing and finishing salts. Presence of sulphur, naphthol, vat dyes, nitrates, acetic acid, soaps, chromium compounds and heavy metals like copper, arsenic, lead, cadmium, mercury, nickel, and cobalt and certain auxiliary chemicals all collectively make the effluent highly toxic. Other harmful chemicals present in the water may be formaldehyde based dye fixing agents, hydrocarbon based softeners and non bio degradable dyeing chemicals. The mill effluent is also often of a high temperature and pH, both of which are extremely damaging. The colloidal matter present along with colours and oily scum increases the turbidity and gives the water a bad appearance and foul smell. It prevents the penetration of sunlight necessary for the process of photosynthesis.[6] This interferes with the Oxygen transfer mechanism at air water interface. Depletion of dissolved Oxygen in water is the most serious effect of textile waste as dissolved oxygen is very essential for marine life. This also hinders with self purification process of water. In addition when this effluent is allowed to flow in the fields it clogs the pores of the soil resulting in loss of soil productivity. The texture of soil gets hardened and penetration of roots is prevented.

The waste water that flows in the drains corrodes and incrustates the sewerage pipes. If allowed to flow in drains and rivers it effects the quality of drinking water in hand pumps making it unfit for human consumption. It also leads to leakage in drains increasing their maintenance cost. Such polluted water can be a breeding ground for bacteria and viruses. Impurities in water affect the textile processing in many ways. In scouring and bleaching they impart a yellow tinge to white fabric.

In dyeing stage metallic ions present in water sometimes combine with the dyes causing dullness in shades. Textile effluent is a cause of significant amount of environmental degradation and human illnesses. About 40 percent of globally used colorants contain organically bound chlorine a known carcinogen. All the organic materials present in the wastewater from a textile industry are of great concern in water treatment because they react with many disinfectants especially chlorine. Chemicals evaporate into the air we breathe or are absorbed through our skin and show up as allergic reactions and may cause harm to children even before birth

MATERIALS AND METHODS:

Study area: There are 268 dyeing industries in Ludhiana (Punjab), of which 10 industries are in large scale and 258 are in medium and small scale sector. Out of 258 medium and small scale dyeing industries, 200 dyeing units are located in 5 clusters namely Tajpur Road (73 industries, discharge-40 MLD), Industrial Area-A (37 industries, discharge-20 MLD), Focal Point (53 industries, discharge-40 MLD), Rahon Road (19 industries, discharge-15 MLD) and Bahadurke Road (18 industries, discharge-15 MLD). The remaining 58 small and medium dyeing industries are scattered in various parts of the Ludhiana city. The textile dyeing industries are generating 150 MLD of wastewater from their process which is having organic as well as chemical pollutants. The level of BOD concentration varies in the range of 500-700 mg/l. All the 268 dyeing units have installed effluent treatment plant to treat their wastewater, out of which 36 no. of units are required to carry out major upgradation of their existing effluent treatment plants so as to achieve the standards laid down by the Board and the remaining 10 units are required only minor upgradation in their existing treatment facilities. For the present investigation, following four observation sites (Site I, Site II, Site III and Site IV) have been selected (Table 1).

Experimental: All the chemicals used in the study were of analytical grade and procured from Hi Media and Merck. Grab effluent samples from sites were collected in triplicates in pre cleaned plastic cans from four selected sites during 2015 and were transported and stored at 4°C in accordance with standard procedures (APHA, 1998). pH, temperature and DO were recorded at the site. Other parameters BOD, COD, hardness, chloride, alkalinity, nitrate, phosphate, TS, TDS were analyzed according to their minimum retention time. The bottles were washed with dilute acid, doubled distilled water and rinsed with effluent prior to sampling. Different cloth dyeing industries were selected for the present study based on random sampling technique and in each unit two sampling sites were studied.

Sampling Sites

Sampling Sites	Activity	Characteristics	Distance from the Budha Nallah	Other influences
Site I	Maximum Activity Area	About 60 Small scale units and 5 medium scale industries that are involved in cloth dyeing. Most of the time dyes are being manufacture at the processing unit by medium size industries	Within 3 km^2	Sewage from households/ industries/ agriculture land
Site II	Moderate Activity Area	About 35 Small scale units and 1 medium scale industries that are involved in cloth dyeing.	Within 10 km^2	Sewage from households/agriculture area
Site III	Minimum Activity Area	10 scattered small dye units who are also involved with other professions	Within 15 km^2	Sewage from agriculture land
Site IV	No activity Area	No cloth dyeing units were seen in this sampling station	Within 20 km^2	Sewage from agriculture, domestic

RESULTS AND DISCUSSION: The physical and chemical properties of Ludhiana city were examined in this study and the impact caused by dyes on the properties of water. Results obtained have shown that samples collected from different areas exhibited relatively similar characteristics in terms of their physical and chemical quality. The results have revealed a general decline in the water quality of the most of the parameters investigated, due to the dyes present in it.

The **pH** values of the samples of water was 6.00±1.55, 6.47±0.42, 6.43±0.53 and 6.46±0.16 at sampling Site I, II, III & IV, respectively during summer (Table 2), However, it was 5.25±0.37, 5.89±0.43, 6.28±0.37 and 6.46±0.41 at sampling Site I, II, III & IV, respectively during monsoon (Table 3). All the samples in the present investigation showed higher values than the BIS and that of control. According to the Safe Drinking Water Committee (2005), high and low pH levels are objectionable because of the corrosive effect on the metallic water receptacles due to low pH. Low pH could result in the metallic taste frequently associated with some packaged water. High pH levels are undesirable since they may impart a bitter taste to the water (Safe Drinking Water Committee, 2005). pH above 11 cause skin, eye and mucous membrane damages to the consumers.

The **electrical conductivity** (µs/cm) of all the samples was high (1.64±0.57, 1.38±0.42, 1.28±0.20 and 1.03±0.16 during summer) due to the presence of different ions of dyes that are being added to water by dying industry. The electrical conductivity of water measures the capacity of water to conduct electrical current and it is directly related to the concentration of salts dissolved in water.

The **total alkalinity** (mg/l) values of the samples of water was 86.25±48.80, 152.00±25.12, 176.25±54.85 & 119.25±61.02 at sampling Site I, II, III & IV, respectively during winter (Table 1). However it was reported as 156.50±10.60, 127.50±23.33, 195.00±39.59 & 215.00±26.87 at sampling Site I, II, III & IV, respectively during post monsoon (Table 4). The determination of alkalinity provides an idea of the nature of salts present in it. If the alkalinity is equal to hardness, then only calcium and magnesium salts are present. If alkalinity is greater than hardness it indicates the presence of basic salts via cu^{2+} and mg^{2+}. When alkalinity is less than hardness, natural salts of calcium and magnesium present that are not carbonates, but sulphates.[9] In this study the alkalinity is due to presence of sulphates. The reason for the alkaline range may be due to mixing up of the alkaline chemicals, soaps and detergents as well.

Total dissolved solids (mg/l) ranged between 1367.90±397.62 to 1580.35±966.49 during winter, 1849.40±589.88 to 2524.56±678.36 during summer, 1615.90±600.67 to 2454.23±1512.82 during monsoon and 2047.90±1421.28 to 3152.95±1329.71 during post monsoon at different sampling sites. (Table 1, 2, 3 and 4). The concentration of total dissolved solids (TDS) indicated that all the samples of water contained varied concentrations of dissolved mineral elements for the mineral nutrition of consumers. The source of TDS in water is attributed to natural sources, domestic wastewaters, municipal runoffs and industrial wastewaters. However, apart from that different dyes add the burdens of TDS in the water samples. Water containing TDS concentration below 1000 mg/l is usually acceptable to consumers, although acceptability may vary according to circumstances.[10] However, the presence of high levels of TDS in water may be objectionable to consumers owing to the resulting taste and to excessive scaling in water pipes, heaters, boilers and household appliances. Water with extremely low concentrations of TDS may also be unacceptable to consumers because of its flat, insipid taste.

Dissolved oxygen (mg/l) was reported only at site IV during all the seasons. (The World Health Organization (2007) and BIS have not set any permissible limit for dissolved oxygen concentration in drinking water. The oxidation of constituent minerals in water could also have taste and odour problems as well as decreased disinfection efficiency are to be anticipated if the water contains more than 0.2 mg/l of ammonia contributed to low concentration of dissolved oxygen. The low DO reduces water clarity and affects the pH of water body. The dye industry increases the turbidity of water that in turn reduces oxygen of water as it blows the penetration of sunlight.

The **COD** (mg/l) values of the samples of water was 0.03±0.02, 0.26±0.23, 0.20±0.27 & 0.01±0.01 at sampling Site I, II, III & IV, respectively during winter (Table 1) and The COD (mg/l) values of the samples of water was 0.02±0.01, 0.28±0.22, 0.03±0.01 & 0.01±0.01 at sampling Site I, II, III & IV, respectively during Summer (Table 2). The COD (mg/l) values of the samples of water was 0.08±0.06, 0.06±0.04, 0.03±0.01 & 0.02±0.01 at sampling Site I, II, III & IV, respectively during monsoon (Table 3) and The COD (mg/l) values of the samples of water was 0.04±0.002, 0.04±0.003, 0.03±0.01 & 0.02±0.01 at sampling Site I, II, III & IV, respectively during post monsoon (Table 4). Chemical oxygen demand is a common used parameter for the characterization of organic matter present in textile wastewaters; it depends on the dyes used in the production process. The textile industry consumes large quantities of water and produces large volumes of wastewater from different steps in the dyeing and finishing processes. Wastewater from printing and dyeing units is often rich in colour, containing residues of reactive dyes and chemicals, such as complex components, many aerosols, high COD and BOD concentration as well as much more hard-to-degrade materials.

Table 1: Physico-chemical properties of dye effluent during winter.

Sites	pH	Colour	Turbidity	Conductivity	TDS	TSS	DO	TH	TA	BOD	COD
Site I	5.42± 0.49	644.75± 45.77	111.50± 11.70	1.56± 0.32	1477.77± 638.98	46.90± 3.59	0±0	306.75± 124.33	86.25± 48.80	66.75± 9.67	0.03± 0.02
Site II	6.25± 0.26	551.5± 166.63	117.50± 39.13	1.41± 0.32	1367.90± 397.62	46.80± 16.69	0±0	334.25± 20.98	152.00± 25.12	54.00± 6.16	0.26± 0.23
Site III	6.54± 0.54	564.75± 84.36	95.57± 21.56	1.16± 0.21	1580.35± 966.49	34.60± 11.68	0±0	331.00± 17.92	176.25± 54.85	51.00± 6.87	0.20± 0.27
Site IV	6.51±. 0.18	398.00± 188.47	28.25± 20.48	0.83± 0.25	1540.92± 1022.98	11.27± 8.76	1.05± 0.68	215.25± 16.52	119.25± 61.02	29.00± 7.07	0.01± 0.01

Table 2: Physico-chemical properties of dye effluent during summer.

Sites	pH	Colour	Turbidity	Conductivity	TDS	TSS	DO	TH	TA	BOD	COD
Site I	6.00± 1.55	673.33± 17.92	89.00± 43.86	1.64± 0.57	2524.56± 678.36	45.73± 2.23	0±0	380.00± 17.08	81.00± 17.05	64.00± 5.29	0.02± 0.01
Site II	6.47± 0.42	664.33± 17.38	108.66± 16.56	1.38± 0.42	1849.40± 589.88	33.76± 6.97	0±0	362.00± 15.09	121.66± 76.51	59.66± 7.57	0.28± 0.22
Site III	6.43± 0.53	528.00± 16.00	103.66± 17.00	1.28± 0.20	2519.70± 600.90	40.70± 26.95	0±0	342.66± 22.03	128.66± 44.79	57.33± 8.32	0.03± 0.01
Site IV	6.46± 0.16	296.00± 11.13	31.00± 24.97	1.03± 0.16	2109.93± 932.51	6.96± 2.93	1.20± 0.69	225.33± 15.14	175.00± 27.62	28.66± 12.22	0.01± 0.01

Table 3: Physico-chemical properties of dye effluent during Monsoon.

Sites	pH	Colour	Turbidity	Conductivity	TDS	TSS	DO	TH	TA	BOD	COD
Site I	5.25± 0.37	601.00± 147.72	197.00± 128.37	1.10± 0.61	2350.30± 304.46	59.36± 8.24	0±0	396.33± 40.42	160.33± 14.74	65.66± 5.68	0.08± 0.06
Site II	5.89± 0.43	565± 100.50	122.00± 6.24	1.58± 0.71	2391.56± 610.97	44.46± 16.09	0±0	265.66± 132.59	217.00± 91.42	59.00± 6.24	0.06± 0.04
Site III	6.28± 0.37	503.00± 152.05	108.00± 19.07	1.09± 0.09	2454.23± 1512.82	42.23± 24.50	0±0	306.00± 75.43	302.00± 45.82	58.33± 6.65	0.03± 0.01
Site IV	6.46± 0.41	317.66± 24.82	84.66± 51.50	1.72± 1.01	1615.90± 600.67	24.80± 18.24	0.93± 0.11	258.33± 63.79	298.00± 137.39	28.33± 3.21	0.02± 0.01

Table 4: Physico-chemical properties of dye effluent during Post Monsoon.

Sites	pH	Colour	Turbidity	Conductivity	TDS	TSS	DO	TH	TA	BOD	COD
Site I	5.96± 0.82	598.00± 93.33	183± 48.08	1.54± 0.31	2632.10± 528.77	38.30± 12.86	0±0	394.50± 79.90	156.50± 10.60	109.50± 62.93	0.04± 0.002
Site II	5.31± 2.02	717.00± 83.43	114.50± 16.26	1.14± 0.11	3152.95± 1329.71	32.75± 5.58	0±0	305.00± 9.89	127.50± 23.33	115.00± 75.53	0.04± 0.003
Site III	5.99± 0.92	601.00± 103.23	105.00± 8.48	1.14± 0.22	3063.70± 7.21	29.95± 0.21	0±0	339.00± 55.15	195.00± 39.59	103.50± 36.06	0.03± 0.01
Site IV	5.55± 1.49	478.00± 260.21	455± 23.33	1.22± 0.11	2047.90± 1421.28	17.75± 14.07	3.5± 3.53	217.00± 7.07	215.00± 26.87	16.50± 2.12	0.02± 0.01

The textile dye industry is considered to be one of the fast growing industries and has a share in GDP of the country. However, this industry produces tones of effluents concentrated with dyes and there are only few industries in our country that are treating dye effluent before discharging the same in aquatic environment. Although it is recommended that waste water from dye industries should be recycled due high level of contamination in dyeing and finishing process. The dyes are undesirable to the environment due to the presence of toxic and carcinogenic substance like benzedrine, naphthalene and other aromatic compounds.[7] Most of the dyes are azo dyes that are very highly toxic, carcinogenic and explosive due to the presence of anililine. The azo dyes are considered to be deadly poisons. Sometimes due to the presence of copper and zinc these dyes turn out to be carcinogenic in nature and with formaldehyde they become carcinogenic in nature. The dyes whose structure containing free aromatic amine groups become highly toxic on reduction and cleavage due to the presence of bacterial degradation. These strongly coloured azo compounds are frequently used as dyes known as azo dyes. The one made from phenylamine (aniline) is known as "aniline yellow" may change the properties of water due to following reactions.

CONCLUSION: The physico-chemical parameters of water samples from different sites observed that some parameters are within the tolerance limit while few were very higher than their MPL, that may have serious environmental and health impact. The discharge of these untreated effluents from dyeing units directly into the river can highly raise the pollution level of me water body. This water cannot be used for drinking purpose and unfit even for domestic irrigation. To protect water ecosystems from further degradation, government should pass legislation for strict compliance of the dyeing units and industries to treat their effluents /recycle at their own cost.

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