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ANALYSIS OF PHYSICOCHEMICAL PROPERTIES OF THE EFFLUENT SAMPLE IN AHMEDABAD, GUJARAT

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ABSTRACT

Depending on the dyes and processing chemicals used, different textile industrial effluents have different physicochemical parameters. Sample of textile industrial effluent was collected from Ahmedabad, Gujarat. The major pollution indicating physicochemical parameters like Temperature, pH, turbidity, color, odour, EC, Chloride, Fluoride, Phosphate, Hardness, COD, BOD, TDS AND TSS were determined using standard procedures. The results of the physicochemical analysis show that most of the parameters in the effluent samples are higher than the allowed limits. The BIS (Bureau of Indian Standard) water quality standards were compared to the findings of this analysis. According to the study, several rural communities that primarily rely on the receiving water bodies as their source of domestic water face a health risk as a result of direct discharge of untreated textile effluents. The effluent cannot be discharged directly into a water stream on the basis of the estimated characteristics and must be treated using a suitable technology before it can be discharged.

Keywords: Physical and Chemical Parameters, Effluent, Textile Industry, BIS, Water Pollution

1. INTRODUCTION

Due to the overexploitation of natural water resources, the quick pace of industrialization, and the improper treatment of industrial effluents, which has led to severe water pollution, the availability of fresh water has become a huge concern for the entire world. The textile industry is one such sector that has a particularly high impact on water contamination. The considerable water used to colour and wash textiles is ultimately discharged into aquatic bodies. As a result, textile effluents spread into water bodies, deteriorating biodiversity and posing a significant threat to plants, animals, and human health. Textile effluents contain toxic metals, high TDS, and a lot of color, which makes it harder for pollutants in wastewater to break down on their own **[1]**.

The Ministry of Environment and Forests, Government of India, has classified the textile industry as one of the most polluting industries **[2][3]**. Recalcitrant organics, colourants, toxicants, and inhibitory chemicals, surfactants, chlorinated compounds, salts, high temperature (greater than 40°C), and high pH due to the significant amount of alkali present are important pollutants in textile effluents. Aerobic organisms are negatively impacted by the textile dye effluents put into water bodies because they make the water less transparent and hence have less dissolved oxygen **[4]**. There are three broad categories that make up the textile industry. These include synthetic fiber (polyster, nylon, spandex, acrylic, and polypropylene), cellulose fiber (cotton, rayon, linen, ramie, hemp, and lyocell), and protein fiber (wool, angora, mohair, cashmere, and silk). Chemicals and dyes used in the textile industry vary for each fiber, primarily based on the type of fabric being produced. Synthetic fibers are now used in more than 80% of the textile industry **[5]**. The loss of productivity in soil and water ecosystems, metal leaching-related groundwater pollution, and the build-up of contaminants in the food chain damage both aquatic and terrestrial vegetation as well as animals, including humans. As a result, wastewater from the textile industry may change the aquatic ecosystems' balance.

Typically, dyes are categorized according to their chemical structure and application. The structure of dyes, which are made up of a large number of atoms, is extremely intricate. Auxochromes are the atoms that give or intensify the color of the dyes, whereas chromophores are the atoms that are responsible for the dye's color. azo (–N=N–), carbonyl (–C=O), methine (–CH=), nitro (–NO2), and quinoid groups are the important chromophores. Amine (–NH3), carboxyl (–COOH), sulfonate (–SO3H), and hydroxyl (–OH) are the most significant auxochromes **[5]**. There are more than 1,00,000 dyes that can be purchased on the market, and it is estimated that more than 7 x10^5 tons of dye are produced annually **[6]**.

Dyes can be classified in a number of ways, e.g. by source (natural and synthetic dyes), type of chromophore group (azo dyes, nitro and nitroso dyes, indigo dyes, etc.), core structure (cationic and anionic dyes) and industrial classification [7].

One of the most important indicators of water pollution is the color of the effluent. The discharge of effluents with a lot of color is unappealing to the eye and may prevent light from getting through. In the affected water medium, this has a significant impact on the photosynthetic activity of aquatic plants. Eutrophication in closed water bodies can be caused by the high nitrogen concentration in textile industrial effluents **[8]**. Particularly, dye-containing effluent discharge into the water environment is undesirable due to their color, release directly, and breakdown products that are toxic, carcinogenic, or mutagenic to life forms, particularly carcinogenic compounds like benzidine and naphthalene **[9] [10]**. Due to the high levels of contamination in dyeing and finishing processes, it has been suggested that treated wastewater be recycled (i.e. dyes and their breakdown products, pigments, dye, intermediate, auxiliary chemicals and heavy metals **[11] [12][13][14]**.

The purpose of this research is to determine the physicochemical impact that the effluent from textile mills has on the wastewater stream by collecting and analyzing samples of irrigated or contaminated textile mill effluent.

2. MATERIALS AND METHODS

2.1 Collection of Sample (Sampling):

The samples of untreated effluent were collected from Textile and dye industrial area located around GIDC, Ahmedabad. Effluent sample was collected from Common Effluent Treatment Plant (CETP). The effluent sample was collected in plastic/glass containers, which are previously cleaned and sterilized as per standard methods.

pH and temperature were recorded during sample collection. A pH meter was used to determine the pH (Digital pH meter) and A laboratory thermometer was used to measure the temperature. The effluent sample was transported to the laboratory and refrigerated until further analysis.

2.2 Physicochemical analysis of effluent sample:

Physico-chemical characterization of effluent samples was carried out by standard methods prescribed by APHA (1995). Physico-chemical parameters such as temperature, color, pH, electrical conductivity (EC), chloride, hardness, chemical oxygen demand (COD), biological oxygen demand (BOD), total dissolved solids (TDS) and total suspended solids (TSS) were studied.

2.2.1 Determination of the sample temperature:

Procedure: 50 ml of the effluent sample is mixed well and is poured into 100 ml of Erlenmeyer flask. After this a standardized thermometer is immersed into it for 2 minutes. Then after 2 minutes, the temperature of the effluent sample was recorded. Temperature of the sample was taken at the time of sample collection.

2.2.2 Determination of pH:

Procedure: The electrode of the pH meter is rinsed through distilled water before use. After this the pH electrode is dipped into standard pH solutions i.e, pH-4 and pH-7 and therefore the standardization or calibration of the pH meter is done. Following this 50 ml of the effluent sample was taken in a beaker and its pH was measured.

2.2.3 Determination of turbidity:

Procedure: 10 ml of sample was placed in the test tubes and measured the turbidity at different ranges and values were recorded as "NTU" (Nephelometric Turbidity Unit). The ranges present in the turbidity meter are:

0 - 1 range - 0.05 NTU

1 - 10 range - 0.1 NTU

10 - 40 range - 1.0 NTU

40 – 100 range – 5.0 NTU

100 - 400 range - 10.0 NTU

2.2.4 Determination of color:

Procedure: The sample color is observed by filling a matched nessler tube to the 50 ml mark with sample and comparing it with standards. Look vertically downward through tubes toward a white or spectral surface placed at such an angle that the light is reflected upward through the columns of liquid. If turbidity is present and has not been removed report as "Apparent Color". If the color value exceeds 70 units, then the sample is diluted with distilled water in known proportion.

Calculation: Color unit pt. Co. Scale = Reading x Dilution

2.2.5 Determination of Electrical Conductivity:

Procedure: For analysis of conductivity of effluent sample, standardization of meter has been carried out through standard KCl (0.01 M) solution at 25°C. After standardization of the conductivity meter, electrode is dipped into beaker containing 50 ml of the effluent sample.

Calculation: $$\frac{\text{Specific conductance of N / 100KCl solution in µmhos/cm}}{\text{Measured conductance of N / 100KCl solution in µmhos/cm}}$$

2.2.6 Determination of chloride:

Procedure: 50 ml of the effluent sample was taken into 100ml Erlenmeyer conical flask. 1 ml of 5% K_2CrO_4 was added into it. This solution was titrated against $AgNO_3$ until color changes from yellow to brick red indicating saturation of chloride ions. Burette reading was recorded to calculate chloride ions concentration.

Calculation: Blank sample (distilled water) was also run to estimate chloride. For calculating chloride content below formula was used.

$$\text{Chloride (mg/L)} = \frac{V_a - V_b \times \text{Normality} \times 35.45 \times 1000}{\text{Volume of Sample taken}}$$

Here,

V_a= volume of $AgNO_3$ consumed for effluent sample

V_b = volume of $AgNO_3$ consumed for blank sample

Normality = normality of $AgNO_3$

35.45= molecular weight of Chloride

Volume of sample taken = 50 ml

2.2.7 Determination of Fluoride:

Procedure: Took 20 ml of the sample in a beaker to which 2 ml of TISAB reagent is added. Then dip the fluoride electrode in the sample and waited until a constant reading appears. The instrument directly gives the reading.

2.2.8 Determination of Phosphate:

Procedure: 50 ml of effluent sample was taken in a conical flask and to it 2 ml of ammonium molybdate was added along with was added a few drops of stannous chloride reagent. The solution will turn blue color from colorless. Then the blue color solution was analyzed with a spectrophotometer at optical density 690 nm. Concentration of phosphate was calculated with the help of standard curve.

Calculation:

$$\text{Phosphate, } PO_4^{3-} \text{ (mg/L)} = \frac{\text{OD} \times \text{Factor}}{\text{Sample taken (ml)}}$$

2.2.9 Determination of Hardness:

Procedure: For estimation of hardness in effluent sample 50 ml of sample was taken into 100 ml of Erlenmeyer flask. Ammonium buffer solution was added into it to set the pH around 10. Around 2-3 drops of Erichrome Black T indicator were further added into flask which turns the color of solution to wine red. Then sample was titrated against the 0.01M EDTA solution till the color changes to blue. The burette reading was recorded for calculation.

Calculation:

$$\text{Hardness } (CaCO_3 \text{ mg/L}) = \frac{V(EDTA) \times \text{Normality of EDTA} \times 50 \times 1000}{\text{Volume of Sample taken}}$$

Here,

V (EDTA) = volume of EDTA consumed for effluent sample

Normality of EDTA = 0.01M

50= Equivalent weight of $CaCO_3$

Volume of sample taken = 50 ml

2.2.10 Determination of Chemical Oxygen method:

Procedure: 20 ml of the effluent sample was taken in a COD tube, to which was added a pinch of $HgSO_4$. After this was added 5 ml of Sulphuric acid. Then with the help of a pipette was added 10 ml of $K_2Cr_2O_7$ solution. After this was added 25 ml of Sulphuric acid again. The tubes were then placed in a COD digester for 2 hours at 150°C. Following the digestion the tubes were placed in a water bath until cool down. Then ferroin indicator was added to all the tubes, followed by titration against FAS. The burette reading was recorded.

Calculation:

$$\text{Normality of FAS} = \frac{\text{N of } K_2Cr_2O_7 \times \text{Vol of } K_2Cr_2O_7}{\text{N of } K_2Cr_2O_7 \times \text{Vol of } K_2Cr_2O_7}$$

$$\text{Factor} = \text{Normality of FAS} \times 8000$$

$$\text{COD (mg/L)} = \frac{\text{Burette reading} \times \text{Factor}}{\text{Volume of Sample taken}}$$

2.2.11 Determination of Biological Oxygen Demand (BOD)

Procedure: Dilution Water was prepared by adding 1 ml /L of each reagent 1,2,3,4 in air saturated distilled water. Requisite quantity of sample was taken in a volumetric flask and was diluted upto the mark by siphoning with dilution water and mixed well. The bottles are closed with a stopper after removal of air bubble. Then three BOD bottles were rinsed with the diluted sample first and then filled with the sample. With the help of a DO meter, initial DO for one bottle was determined and the other two bottles were kept in an incubator at 27°C for 3 days. Then after three days of incubation, the final DO is determined.

Calculation:

When sample is undiluted

BOD (mg/L) = DO before incubation – DO after incubation

- When sample is diluted,

$$BOD\ (mg/L) = DO_1 - DO_3 \times 1000$$

Where,

DO1 = Initial DO

DO3 = DO after 3 days of incubation

P = % dilution of sample

- When sample is seeded,

$$BOD\ (mg/L) = \frac{DO1 - DO3 - (B1 - B3)\ F \times 1000}{P}$$

Where,

B1 = DO of seed control before incubation

B2 = DO of seed control after three days of incubation

F = % seed in diluted sample

2.2.12 Determination of Total Dissolved Solids (TDS)

Procedure: Clean and dry beaker was weighed and noted at W1. Then 50 ml of filtered effluent sample was poured into the beaker and the beaker was kept on steam bath for evaporation of water content at 80°C. After evaporation of water content the beaker was transferred into an oven for approximately 1 hour at 180°C. After 1 hour, the beaker was removed from oven and placed inside desiccators until it cools down. Then after cooling down, the beaker was weighed again and denoted as W2.

Calculation:

$$TDS\ (mg/L) = \frac{W2 - W1 \quad X\ 100}{\text{Volume of Sample taken}}$$

Here,

W2 = weight of the beaker after evaporation of sample

W1= weight of the beaker before loading of sample

Volume of sample taken = 50 m

2.2.13 Determination of Total Suspended Solids (TSS)

Procedure: Filter paper was weighed and denoted as W1. 50 ml of effluent sample was filtered through pre weighed filter paper. The filter paper was then carefully removed from filtration apparatus and transferred to a petri dish. Then the filter paper is dried for at at least 1 hour in an oven at 103°C to

105°C and later placed inside a desiccator for cool down. After cooling filter paper was weighed again and the weight was denoted as W2.

Calculation:

$$\text{TSS (mg/L)} = \frac{W2 - W1 \quad X\ 100}{\text{Volume of Sample taken}}$$

Here,

W2 = weight of filter paper after evaporation of sample

W1= weight of filter paper before loading of sample

Volume of sample taken = 50 ml

RESULTS:

Of the physical parameters examined, the various industrial processes are typically what determine the colour of the effluent sample. The measurement and removal of colour are crucial steps because without proper processing, some effluents have varied colours that may be caused by the presence of dissolved salts. In present investigation, the effluent was a bright yellow colour and smelled strongly. The pH of the effluent was slightly alkaline (7.47) and temperature was 38ºC. It was slightly dense with turbidity value of 10 NTU. Total Dissolved Solids (TDS) value was 1908 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 (327 mg/l). That is higher than permissible limit of BIS and WHO. It is shown in **Table 1**.

Among the chemical parameter tested, carbonate alkalinity recorded high 350mg/l. The chemical oxygen demand (COD) was recorded as 464mg/l which was higher than 250 mg/l as tolerance limit fixed by pollution control boards (PCB, Environmental Standards). The biological oxygen demand (BOD) was also higher (231 mg/l) against the CPCB discharge limit of 30mg/l.

The chloride content was 489 mg/l and exceeded the limits set by Bureau of Indian Standards (250 mg/l) and World Health Organization (250 mg/l). Fluoride content was 0.636 mg/l which was within the limits of PCB and WHO. Phosphate content was 1.8 mg/l which was within the limits of CPCB and WHO. It is shown in **Table 2**.

Discussion:

The standard permissible limits for the safe discharge of trade effluents into natural water bodies were compared to the estimated physicochemical characteristics of the effluent water sample. The temperature of the effluent sample during collection was 38° C, which was significantly higher than the normal discharge values. These effluents directly harm the aquatic ecosystem when discharged into water bodies. A wide range of changes in aquatic plant communities can be caused by these effluents, including changes in species composition, standing crop, net production, and a decrease in floral and faunal diversity **[15][16][17]**. The amount of dissolved oxygen in water typically decreases when the temperature is raised. Amphibians, fish, and other aquatic creatures may suffer as a result. At higher temperatures, many aquatic species are unable to reproduce. Warm waters have an effect on primary producers because they can speed up plant growth, which can result in shorter life spans and species overpopulation. The aquatic animals' metabolisms can change significantly even if the temperature changes by just one or two degrees Celsius. The color of the sample of the effluent was also deemed unacceptable for release into the natural water body. The collected effluents had a strong color and smell. This was in line with previous research on textile effluents, which found that the effluents from the studied textile industries were highly colored and had an unpleasant odor **[18]**. The bright yellow color of the effluent may have been caused by the dye Golden yellow that was used to dye textiles.

The studied effluent sample had a pH of 7.47, which was slightly higher than the acceptable range. During the bleaching process, the excessive use of carbonate, bicarbonate, hydrogen peroxide, and sodium hydroxide led to an increase in pH in the effluent samples. The addition of excess lime (Calcium oxide) during the initial (preliminary) treatment process was also responsible for the high pH value **[19]**. 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 **[20]**. The excessive use of sodium hydroxide and sodium chloride in large quantities during the bleaching and sizing processes likely contributed to the elevated pH and EC values. Similar higher pH values (ranging from 5.8 to 10.5) were found in related studies **[21][22]**, regarding the characterization of textile wastewater.

Turbidity in the receiving streams is caused by the effluent's suspended and colloidal impurities. A higher value of turbidity indicated that the wastewater contained a high concentration of solids and had a high content of colloidal matter. In addition to directly affecting plant growth, the present solids also have an effect on the permeability of the soil structure and indirectly affect the growth of fauna through aeration. Because of this, less light can enter the plant, which ultimately slows down photosynthesis **[23]**. The results from the present study indicated the mean values of physical parameters namely turbidity 9 NTU) and total suspended solids (327 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 wastewater **[24]**. Higher values for TDS (1800-4400 mg/l) and TSS (150-1100 mg/l) for actual textile effluents were reported (Manikandan et al., 2009). In another similar work, TDS (450 mg/l) values which were within FEPA standard for effluent discharge to surface waters in Nigeria were reported (Asia et al., 2007). But the value of 327 mg/l for suspended solid was higher than 30 mg/l of FEPA standard. In a similar study, very high values for TDS (2800 mg/l) and TSS (6200 mg/l) were reported **[25]**. Electrical conductivity of the effluent sample was much higher (11.31 mS/cm) than in previous reports in which values ranging from 1.1 to 3.4 mS/cm were recorded.

BOD (231 mg/l) and COD (764 mg/l) of the effluent tested were much higher than the standard permissible limits. The high levels of BOD and COD indicated that the effluent is a waste that requires a lot of oxygen, which led to the depletion of dissolved oxygen (DO), which is essential for aquatic life.

Additionally, the textile effluents' potential for pollution was indicated by their higher COD values. It had a relatively low dissolved oxygen concentration of 1.05 mg/l. A DO of at least 5.2 mg/l should be present in a healthy body of water **[26]**. Textile wastewater exhibited extremely high levels of BOD (145–236 mg/l) and COD (370–665 mg/l) in a comparable study **[22]**. Of the other chemical parameters tested carbonate alkalinity (350 mg/l) was found to be higher than the normal limits. Phosphates are utilized in buffers as builders for scouring, water conditioners as flame retardants, and surfactants as flame retardants in textile industry operations. In the present study also, the phosphate levels were higher than the prescribed safety limits. but the Chloride (Cl-) content was found to be remarkably higher which was an index of surface pollution level.

Table 1: Physical parameters of the untreated textile effluent and their permissible limits

S.No.	Parameters	Unit	Effluent water sample
1.	Temperature	°C	38
2	pH	-	7.47
3	Turbidity	NTU	95
4	Color	Hazen	360
5	EC	µS/cm	3624
6	TDS	mg/l	1908
7	TSS	mg/l	327

Table 2: Chemical parameters of the untreated textile effluent and their permissible limits

S.No.	Parameters	Unit	Effluent water sample
1.	Chloride	mg/l	38
2	Fluoride	mg/l	7.47
3	Phosphate	mg/l	95
4	Hardness	mg/l	360
5	COD	mg/l	3624
6	BOD	mg/l	231

CONCLUSION:

According to standards established by PCB, BIS, and WHO, water drained from textile processing units must have low TDS, total hardness, BOD, COD, and minerals. However, the majority of the studied parameters have values that are above the allowed range, indicating that proper treatment is required. The hazardous effects of textile effluents on the environment could be reduced with the installation of a CETP (Common Effluent Treatment Plant) for detoxification.

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