Investigation of the physical and chemical characteristics of effluents collected from the textile region of Bagru, Jaipur (Rajasthan, India)

Abstract

All over the world, one of the largest water polluters is the textile industry. The coloured and bad odour effluent discharged from such industries pollutes not only the water bodies but also affects groundwater quality and adversely impacts aquatic and soil ecosystems. In the present study, 35 water samples were collected from different dyeing units of the Bagru textile area (Rajasthan, India) which is famous for using natural dyes for textile processing. The physico-chemical analysis of these water samples shows that all parameters exceeded the permitted range recommended by the Central Pollution Control Board (CPCB) and World Health Organization (WHO). The results of this analysis indicate the use of synthetic dyes for dyeing and printing in Bagru textile industries. Based on the estimated characteristics, these textile effluents need to be properly treated before releasing into the environment to prevent the contamination of soil suitable for cultivation purposes and groundwater used for drinking.

Keywords: Textile industry, water polluter, contamination, physico-chemical analysis, groundwater quality, ecosystem

- ## Introduction

The environmental pollution caused by the discharge of poorly treated effluents from textile industry has gained increased attention from last few decades. The textile industry is one of the largest generators of contaminated liquid effluents, because of the use of high quantity of water in the dyeing and finishing process. It is evaluated that every year worldwide, 280,000 tons of textile dyes are discharged in industrial effluents (Jin *et al.*, 2007). Most of textile dyestuffs (more than 3000 different varieties) are produced by using synthetic dyes because in comparison to natural dyes, they are stable, and cost effective to synthesize and they are available in variety of colours (Chang *et al.*, 2004). In paper, textile, food, cosmetics, leather and pharmaceutical industries, these dyes are used to a great extent (Telke *et al*., 2008)

Most of the textile dyes are carcinogenic, which when accumulated in body, leads to alteration in several physiological and biological functions (Rawat *et al.*, 2016). Furthermore, the types of synthetic dyes used in the processing stages of dyeing decide the dissolved oxygen, pH value, organic and inorganic content of wastewater (Banat *et al*., 1996)

The textile industrial waste disposal into open landfill area or nearby water bodies is the major reason behind the pollutant accumulation along with reduced solar energy entry within the water bodies, reduced organic deposition and dissolved oxygen concentration, accumulation of toxic pollutants leading to the destruction of both biotic and abiotic community drastically (Vandevivere *et al*., 1998; Stolz, 2001)

Due to the steady rise in population and urbanization, wastewater discharge into the environment has dramatically increased in many developing nations, including India (Pirsaheb *et al*., 2014; Preisner, 2020). The Indian Textile industry is one of the largest in the world and Rajasthan, one of the states of India, has a longstanding legacy in the textile industries. The capital of the Rajasthan state, Jaipur, has a distinct niche in the corporate and tourism worlds for the resources and business markets. Jaipur is primarily recognized globally as the "Pink City" due to its rich heritage in traditional art and craft, handicrafts, history, and historical themes. The study area of this investigation is Bagru, which is the well-known global hub for block printing, indigo dyeing, and natural dyeing. In terms of resources for the textile industry, Bagru is noteworthy. Bagru is located 30 kilometres away from Jaipur on National Highway No. 8 (the Delhi-Jaipur-Mumbai GVK Expressway), in a geographic location of 26° 49' 0 North, 75° 33' 0 East of Jaipur (Pink City). Bagru printing has an approximately 450-year history. Raiger and Chippa communities make up the majority of Bagru's population. These people moved to Bagru from Jaipur because the Sanjaria River provided water and chikkni mitti, which is needed for the dyeing process. Despite the river drying up 20 years ago, many printing families still live in the region. Dabu printing is the town's most famous export. Due to their dual toxicity, Bagru's coloured effluents from several cluster units (printing and dyeing) have received a lot of attention. Additionally, the effluent from these units and companies was dumped into open spaces and agricultural land, negatively impacting the native plants and animals as well as the general health of the communities and their surrounding people (Sharma *et al.*, 2014). This study's foundation is the investigation of the physico-chemical characteristics of the water in the Bagru textile region, which may assist in determining the detrimental effects of the disposal of textile waste water on ground water quality as well as on the environment and subsequent use of this waste water for irrigation purposes.

- **Materials and methods**
- **Collection of water samples-**

The 35 waste water samples were collected from different textile and printing units of the Bagru region in sterilized polyethylene bottles and were labelled as textile unit effluent (BTEF1 to BTEF35). The temperature and pH were noted while collecting the samples. The pH was measured with a digital pH meter and the temperature was measured using a laboratory thermometer. After being transferred to the lab, the effluent samples were kept in the refrigerator for additional examination.

- **Physico-chemical analysis of collected textile effluent sample-**

The standard procedures were followed in the physico-chemical evaluation of effluent samples (American Public Health Association, 1998). In this study, physico-chemical parameters including total dissolved solids (TDS), temperature, pH, electrical conductivity (EC), chloride, chemical oxygen demand (COD) and biological oxygen demand (BOD) were examined.

- **Determination of the temperature of collected water samples-**

  The temperature was recorded when the samples were being collected. 25 ml effluent sample was taken in the Erlenmeyer flask and thoroughly mixed. Following this, a standardized thermometer was submerged in it and allowed enough time for the temperature to stabilize. After the temperature was noted down, the thermometer was removed from the flask, wiped it to clean and then recapped it for further use.

- **Determination of the pH of collected effluent samples-**

The pH was also measured while collecting the wastewater samples. Before use, the electrode of the pH meter (Konvio Neer Digital pH Meter) was rinsed with distilled water. Subsequently, the pH electrode was immersed in standard pH solutions, specifically pH 4 and pH 7, for the calibration of the pH meter. After that, 25 ml of the effluent sample was taken in the beaker to determine its pH.

- **Determination of the electrical conductivity (EC) of collected water samples-**

  Standard KCl (0.01 M) solution was used to standardize the conductivity meter (Labsphere Laboratory LS601 Conductivity Meter) in order to analyse the conductivity of the effluent sample at 25°C. Following the conductivity meter's standardization, the electrode is immersed into a beaker containing 25 ml of the wastewater sample.

  EC (mS/cm) = 0.001

- **Determination of the chloride content in collected water samples-**

  In a 100 ml Erlenmeyer conical flask, 25 ml effluent sample was taken and 1 ml of 5% K_2CrO_4 was added to it. Then this solution was titrated against $AgNO_3$ until the yellow colour changed to brick red, signifying that the chloride ions were saturated. To determine the concentration of chloride ions, the burette reading was noted. Distilled water was used as a blank to estimate chloride.

  The following formula was used to calculate chloride ions concentration.

Chloride (mg/L) =

Here,

Va= volume of $AgNO_3$ used

for effluent sample

Vb = volume of $AgNO_3$ used

for blank sample

Normality = normality of AgNO3 (0.0141N)

- **Determination of the chemical oxygen demand (COD) of collected water samples-** 10 ml of water sample was taken into a round bottom reflex flask and diluted it up to 50 ml using distilled water. 1 ml of Mercuric sulfate ($HgSO_4$) solution was then added to the flask and mixed thoroughly. After that 5 ml of Potassium dichromate ($K_2Cr_2O_7$) solution was added, followed by 15 ml Silver sulfate - Sulfuric acid solution that was added slowly and carefully. Then the reflex condenser was connected and the content was digested at 150□ for 2 hours. After digestion, the flask was cooled down in water bath. 2-4 drops of ferroin indicator were then added to the flask and then titrate against 0.025 M Ferrous ammonium sulfate (FAS) solution. The blank was also prepared in the same way using distilled water.

The chemical oxygen demand (COD) was determined by using the following formula.

COD (mg/L) =

Here,

DF – Dilution Factor

M – Molarity of standardized Ferrous Ammonium Sulfate (FAS) solution

VB – Volume of titrant used in titration with blank preparation

VS – Volume of titrant used in titration with sample preparation

- **Determination of the biological oxygen demand (BOD) of collected water samples-** First the dilution water was prepared by adding 5 ml each of 27.5% w/v solution of Calcium carbonate, 22.5% of w/v solution of Magnesium sulfate, 0.15% w/v solution of Ferric chloride and Phosphate buffer solution in 5 litres of double distilled water. After that four 300 ml BOD bottles were taken and then the required quantity of sample was added to two of them and was diluted up to the mark with diluted water. The remaining two BOD bottles were also filled with dilution water and used as blank. All four bottles were closed immediately to avoid any air bubbles. One sample and one blank were incubated at 27□ for three days. The remaining sample and blank were analysed immediately to determine dissolved oxygen (DO). The final DO was determined after incubation of three days to calculate BOD.

The biological oxygen demand (BOD) was determined by using the following formula.

BOD mg/l = (B.R. for sample at D_0 –D_3) dilution factor

Dilution factor =

Here,

B.R. = Burette reading of titrant

D_0 = Initial dissolved oxygen of the sample (mg/l)

D_3 = Dissolved oxygen of the sample after 3 days incubation (mg/l)

- **Determination of the total dissolved solids (TDS) of collected water samples-**

The weight of clean and dry beakers was taken and noted as initial weight W1. Then the 100 ml water sample was filtered through the Whatman filter paper and filtrate was collected into that beaker. After that, the beaker was kept in the oven at 103 for 24 hours to dry the water filtrate. After drying, the beaker was allowed to cool down and then weighed again, recorded as W2.

The total dissolved solids (TDS) were determined using the following formula.

TDS (mg/L) = 1000

Here,

W2 = Final Weight of the beaker after evaporation of the sample

W1= Initial weight of the beaker

V = Volume of sample taken

- **Result and Discussion**

The current investigation aimed to study the physico-chemical characteristics of textile wastewater. This study may help to identify the negative impacts of disposing of textile wastewater on the soil environment, groundwater quality and the use of this wastewater for irrigation purposes. In this study, it was found that before releasing textile effluents into the sewage, appropriate treatment techniques are needed because all the physico-chemical parameters were found to be on the higher side in terms of pollution levels.

- **Colour and Odour:** In this investigation, the colour of the collected textile wastewater samples was recorded from grey to black depending on the type of dye used. The odour was strong and unpleasant which may be due to volatile compounds. The colour of the effluent is one of the most significant markers of water contamination. The release of highly coloured effluents is visually unpleasant and could make it difficult for light to get through. This significantly affects the metabolic processes of aquatic vegetation in the impacted water bodies (Khehra *et al.*, 2006).

- **Temperature (□):** Chemical and biological interactions in water are impacted by temperature. The Figure 1 shows temperature variations of different effluents collected from textile industries and dyeing units. The standard temperature of dischargeable effluent is 30□. The temperature of collected samples was found in the range of 26.5□ to 37□. The temperature of effluent samples which was noted as 37° C, was considerably higher than the typical discharge values. When these effluents are dumped into water bodies, they cause direct harm to the aquatic environment. These effluents have the potential to alter aquatic plant communities in a variety of ways such as changes in species composition, growing crops, and a decline in diversity of flora and fauna (Grace and Tilly, 1976).

- **pH:** The Figure 2 shows the pH variations of collected water samples. When it comes to effluent discharge into water bodies, the Central Pollution Control Board (CPCB) advises keeping the pH level between 6 and 9. In this study, The pH of the collected wastewater sample was found in the range of 5.49 to 11.71. If the pH is too high or too low, it can harm aquatic life and humans and disrupt their biological processes. The pH of effluent samples increases as a result of the overuse of carbonate, bicarbonate, hydrogen peroxide, and sodium hydroxide during the bleaching process. The effluent's high pH is also a sign of overuse of dyes. Although the pH of wastewater has little effect on health, it does affect several chemical reactions. pH typically limits biological activity and several chemical treatment procedures (Verma and Dalela, 1975).

Figure 2: pH analysis of collected water samples

- **Electrical conductivity (mS/cm):** The potential of a solution to conduct a flow of electric current is measured by its electric conductivity (EC), which is dependent on the temperature, presence and total concentration of ions in the water as well as their mobility. It is a useful indicator of the overall salt content of wastewater. One of the key factors used to assess whether water is suitable for irrigation is its conductivity (Sultana *et al*., 2009). The standard range of EC for textile effluents is 2-3 mS/cm. The Figure 3 shows the variable range of EC for investigated textile effluents which was found between 0.872 mS/cm to 6.34 mS/cm. The samples which showed the exceeded values of EC are not suitable for irrigation and need further treatment.

Figure 3: Electrical conductivity (mS/cm) of collected water samples

- **Chloride (mg/L):** According to WHO, the standard value of Chloride content for textile wastewater is 250 mg/L. The Figure 4 shows that the chloride content of collected water samples was found in the range of 225 mg/L to 667 mg/L which is much higher than the permissible value. The chloride content of some water samples (BTEF2, BTEF3, BTEF5, BTEF7, BTEF12, BTEF16, BTEF18, BTEF24, BTEF26, BTEF27, BTEF32, BTEF34 and BTEF35) could not be calculated due to their strong colours. Wastewater containing chloride could be the result of the water softening process or from recharging softeners such as sodium chloride. The majority of the chloride found in wastewater is derived from raw water used in dyeing processes. Some dyes need additional chlorine added as a fixing agent. The high chloride content of wastewater released into the environment causes scorching of the leaf margins, tiny and thicker leaves, and can decrease plant growth overall (Palani *et al*., 2015).

Figure 4: Chloride (mg/L) content of water sample

- **Chemical oxygen demand (mg/L):** A high COD signifies the presence of organic materials in wastewater that are resistant to biological processes and potentially harmful. It analyses the concentration of chemically oxidizing materials in water as well as the amount of oxygen needed for the chemical oxidation of organic matter (Sawyer and McCarty, 1978). The Figure 5 shows that the COD value of investigated water samples was found between 1147 mg/L to 2347 mg/L in the current study which is higher side than the standard value of COD which is 250 mg/L according to CPCB.

Figure 5: Chemical oxygen demand (mg/L) analysis of collected water samples

- **Biological oxygen demand (mg/L):** All aquatic life, including the microorganisms that carry out the purification processes of water bodies, depends on dissolved oxygen.

Fish and other aquatic organisms require oxygen to survive, just like land animals do. An oxygen-rich water sources are considered healthy, whereas oxygen-depleted water bodies indicate severe pollution. Biological oxygen demand (BOD) measures how much oxygen is needed by aquatic organisms to break down the biodegradable organic matter present in water into simpler compounds (Sultana *et al*., 2009). The standard value of BOD for textile effluent is 30 mg/L. The BOD of analysed water samples was found in the range of 278 mg/L to 1034 mg/L as shown in Figure 6. The higher the value of BOD, the higher the presence of pollutants in water bodies is indicated. A high BOD suggests that the waste water may not have enough oxygen for living organisms to survive which would result in the eradication of aquatic life.

Figure 6: Biological oxygen demand (mg/L) analysis of collected water samples

- **Total dissolved solids (mg/L):** All the inorganic salts and other materials dissolved in water are measured as total dissolved solids (TDS). If wastewater with a high TDS value is used as irrigation water, it could result in salinity issues. According to CPCB, the standard value of TDS is 2000 mg/L. The Figure 7 shows that the TDS of investigated samples were found in the range of 286 mg/L to 8416 mg/L which were far above the permissible value.

Figure 7: Total dissolved solids (mg/L) of collected water samples

- **Conclusion**

Bagru textile area is known for using natural dyes but the results from physico-chemical analysis of water samples collected from various dyeing units present a completely different picture. Wastewater discharged from textile processing facilities must have minimal total dissolved solids, biological oxygen demand, chemical oxygen demand, and pH, per CPCB and WHO requirements. Nonetheless, the temperature, EC, TDS, BOD, COD, pH, and chloride content showed a high discrepancy from the recommended standard values in the present investigation. As almost all of the parameters under investigation exhibit levels exceeding the permitted range, it signifies the necessity for appropriate intervention. So the treatment of effluents discharged from the Bagru textile industries is crucial for the environment as well as for human health. Installing a CETP (Common Effluent Treatment Plant) along with bacteria-mediated bioremediation for detoxification could lessen the harmful impacts of textile effluents on the environment.

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