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Analysis of Water Quality after Holi festival using Physico-chemical parameters

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Abstract

Holi is one of the most celebrated festivals in India and is traditionally associated with the use of natural colours obtained from flowers, herbs, and plant materials. In recent years, synthetic industrial dyes containing hazardous chemicals and heavy metals have largely replaced natural colours during Holi celebrations. These synthetic colours are non-biodegradable and may adversely affect environmental and human health after being discharged into water bodies. The present study was conducted to evaluate the impact of Holi colours on water quality through analysis of selected physico-chemical parameters of wastewater collected after Holi celebrations. The wastewater sample was analysed for pH, total dissolved solids (TDS), total hardness, turbidity, colour, and chromium concentration using standard analytical methods. Instruments such as digital pH meter, nephelometer, colorimeter, and Atomic Absorption Spectrophotometer (AAS) were used for analysis. The obtained results revealed significant deterioration in water quality. Elevated levels of turbidity, hardness, dissolved solids, and chromium concentration were observed when compared with permissible limits recommended by the World Health Organization (WHO). The findings indicate that synthetic Holi colours contribute considerably to water pollution and may create ecological and health-related hazards. The study emphasizes the importance of promoting eco-friendly natural colours and water conservation practices for sustainable Holi celebrations.

Keywords: Holi festival, synthetic dyes, wastewater analysis, water pollution, turbidity, total dissolved solids, chromium contamination, environmental impact.

Introduction

India is known for its rich cultural heritage and colourful festivals. Holi, popularly known as the "Festival of Colours," is celebrated throughout the country with great enthusiasm. Traditionally, Holi colours were prepared from natural sources such as turmeric, sandalwood, flowers, leaves, and herbal extracts. These natural colours were biodegradable and environmentally safe.

However, modern Holi celebrations increasingly involve the use of synthetic chemical colours due to their low cost, easy availability, and bright appearance. Most commercially available colours contain harmful chemicals and heavy metals such as chromium, lead, copper, and mercury. These substances may cause skin allergies, respiratory problems, eye irritation, and various toxic effects.

During Holi celebrations, coloured water enters drainage systems and eventually contaminates rivers, lakes, ponds, and groundwater resources. Synthetic dyes are highly stable compounds and are resistant to biological degradation. Their presence in water bodies reduces light penetration, decreases dissolved oxygen concentration, and affects photosynthetic activity of aquatic plants.

Heavy metals present in these colours are particularly dangerous because of their toxic and bioaccumulative nature. Continuous contamination of water resources may adversely affect aquatic organisms as well as human health.

The present study was therefore undertaken to evaluate the effect of synthetic Holi colours on selected physico-chemical parameters of wastewater and to create awareness regarding environmentally safe Holi celebrations.

Materials and Methods

The present study was conducted in Virar (West), Palghar District, Maharashtra, India, immediately after the Holi festival. Virar is a rapidly developing suburban region with dense residential colonies, educational institutions, and commercial establishments. During Holi celebrations, large quantities of coloured water containing synthetic dyes, pigments, and other additives are discharged into roadside drains and storm water channels. These coloured effluents may contain heavy metals, suspended solids, and dissolved salts, leading to temporary deterioration of water quality.

Wastewater samples were collected from five representative locations covering educational and residential areas to evaluate the impact of Holi celebrations on physicochemical characteristics of wastewater[1].

Sample Collection: Wastewater generated immediately after Holi celebrations was collected from drainage channels receiving coloured wastewater from different sampling areas of Virar (West), Maharashtra. Samples were collected on the same day as the festival in pre-cleaned high-density polyethylene (HDPE) containers of 2 L capacity following the **WHO (2022)** guidelines[5] and APHA Standard Methods (23rd Edition) for wastewater sampling.

Approximately 2 L of wastewater was collected from each sampling location. Samples were transported to the Chemistry Laboratory of VIVA College, Virar (West) in an insulated ice box and analysed within 24 hours.

Table-1: Sample Collection Points.

Sample Code	Collection Point	Location
S1	VIVA College Campus	Virar (W), Maharashtra
S2	Rajguru chs.	Virar (W), Maharashtra
S3	Sandeep Garden chs.	Virar (W), Maharashtra
S4	Virar Garden chs.	Virar (W), Maharashtra
S5	Yashwant Nagar	Virar (W), Maharashtra

Physico-Chemical Analysis: The collected wastewater sample was analysed for various physico-chemical parameters including pH, total dissolved solids (TDS), total hardness, turbidity, colour, and chromium concentration using standard analytical procedures.

Table-2: The instruments and methods employed are listed below:

Parameter	Method/Instrument	Instrument
pH	Electrometric Method	Digital pH Meter
Total Hardness	EDTA Titration Method	Glassware
Total Dissolved Solids	Filtration and Gravimetric Evaporation	Hot Air Oven
Turbidity	Nephelometric Method	Nephelometer
Colour	Spectrophotometric Method	Colorimeter
Chromium (Cr)	Atomic Absorption Spectrophotometry	AAS

All instruments were calibrated prior to analysis, and analytical reagent grade chemicals were used throughout the experiment.

Atomic Absorption Spectrophotometer (AAS): Chromium concentration was determined using an Atomic Absorption Spectrophotometer (AAS, Shimadzu AA-7000) installed in the Soil and Water Testing Laboratory, VIVA Centre for Advanced Research & Development, Virar (W), Maharashtra, India.

Instrumental conditions: i. Wavelength: 357.9 nm, ii. Flame: Air–Acetylene, iii. Calibration: Five standard chromium solutions, iv. Detection Limit: 0.01 mg/L.

Calibration was carried out using certified chromium standard solutions before sample analysis.

Determination of pH: The pH of the wastewater sample was determined using a calibrated digital pH meter. pH indicates the acidic or alkaline nature of water and plays an important role in aquatic chemical reactions.

Determination of Total Dissolved Solids (TDS): The wastewater sample was filtered through Whatman No. 42 filter paper. A measured volume of filtrate was evaporated to dryness in a pre-weighed dish at 180°C until constant weight was achieved. The increase in weight represented the total dissolved solids.

Determination of Total Hardness: Total hardness was estimated using EDTA complexometric titration with the Eriochrome Black-T indicator. Hardness mainly arises due to calcium and magnesium ions present in water.

Determination of Turbidity: Turbidity was measured using a nephelometer and expressed in Nephelometric Turbidity Units (NTU).

Determination of Colour: The colour intensity of the wastewater sample was determined using a colorimeter within the visible wavelength range of 400–700 nm.

Determination of Chromium Concentration: Chromium concentration was estimated using Atomic Absorption Spectrophotometry (AAS) using standard chromium solutions for calibration.

Results and Discussion

Table-3: Physico-Chemical Characteristics of Holi Wastewater.

Parameter	Observed Value	WHO Permissible Limit
pH	6.36	6.5 – 8.5
Total Hardness	720 ppm	15 – 375 ppm
Total Dissolved Solids	2400 mg/L	500 – 1000 mg/L
Turbidity	11.7 NTU	≤ 5 NTU
Colour	Violet	Colourless
Chromium (Cr)	0.200 mg/L	≤ 0.05 mg/L

Table-4: pH of Wastewater Samples.

Sample	pH
S1	7.28
S2	7.59
S3	8.20
S4	8.05
S5	7.80
Mean	7.78

Table-5: Total Hardness.

Sample	Hardness (mg/L)
S1	322
S2	342
S3	359
S4	337
S5	315
Mean	335

Table-6: Total Dissolved Solids (TDS).

Sample	TDS (mg/L)
S1	728
S2	719
S3	800
S4	850
S5	780
Mean	775.4

Table-7: Turbidity.

Sample	Turbidity (NTU)
S1	27
S2	33
S3	37
S4	32
S5	31
Mean	32

Table-8: Colour.

Sample	Colour (Pt-Co)
S1	123
S2	154
S3	150
S4	142
S5	137
Mean	141.2

Table-9: Chromium Concentration.

Sample	Chromium (mg/L)
S1	0.080
S2	0.091
S3	0.100
S4	0.085
S5	0.089
Mean	0.089

The physicochemical characteristics of wastewater collected after Holi celebrations indicated significant deterioration in water quality.

Results and Discussion

The analysis of wastewater collected after Holi celebrations clearly indicated significant deterioration in water quality due to synthetic colours and associated contaminants.

The mean pH (7.78) remained within the WHO permissible range (6.5–8.5), indicating slightly alkaline conditions and was below the WHO recommended range for drinking water. Variations in pH may influence biological and chemical processes occurring in aquatic systems.

The total hardness of the wastewater sample The mean total hardness (335 mg/L) was recorded as 720 ppm, which was considerably higher than permissible limits. High hardness affects water suitability for domestic and industrial applications was above the desirable limit of 200mg/L but below the maximum acceptable value of 500mg/L, reflecting elevated calcium and magnesium salts.

The mean TDS (775.4mg/L) exceeded the desirable WHO guideline[5] value of 500 mg/L, indicating increased dissolved

salts from synthetic colours and festival-related contaminants. Elevated TDS levels reduce water quality, affect taste, and decrease oxygen solubility.

The mean turbidity (32 NTU) was considerably higher than the WHO recommended limit of 5 NTU, suggesting a high concentration of suspended coloured particles. High turbidity reduces light penetration into water bodies and adversely affects photosynthetic activity and aquatic organisms.

The violet colour observed in the wastewater sample confirmed contamination due to synthetic dyes. Such coloured pollutants interfere with natural aquatic processes and contribute to environmental degradation.

The mean chromium concentration (0.089 mg/L) exceeded the WHO guideline[5] value of 0.05 mg/L, indicating contamination by chromium-containing pigments commonly used in synthetic Holi colours. Elevated chromium levels are of environmental concern because prolonged exposure may pose toxic effects on aquatic organisms and human health.

Overall, the results demonstrate that wastewater generated after Holi celebrations contains elevated levels of suspended solids, dissolved salts, hardness, and chromium compared with WHO guideline[5] values, highlighting the need for appropriate treatment before discharge into natural water bodies. Overall, the findings demonstrate that synthetic Holi colours contribute substantially to water pollution and environmental hazards.

Conclusion

The present investigation clearly demonstrated that wastewater generated after Holi celebrations undergoes significant deterioration in physico-chemical quality due to the presence of synthetic colours and associated contaminants. The analysed parameters such as turbidity, total dissolved solids (TDS), total hardness, and chromium concentration were found to exceed the permissible limits recommended by the World Health Organization (WHO)[5], indicating serious contamination of water resources.

The elevated TDS and hardness values indicate increased ionic and dissolved pollutant load in water, while high turbidity reduces light penetration and adversely affects photosynthetic activity and dissolved oxygen availability in aquatic ecosystems. The presence of synthetic dyes in wastewater also interferes with natural biological processes and may inhibit microbial activity essential for ecological balance.

Particularly alarming was the concentration of chromium detected in the sample water, which exceeded the permissible limit and suggests contamination from heavy metal-based pigments used in synthetic Holi colours. Continuous discharge of such contaminated wastewater into natural water bodies may lead to bioaccumulation and biomagnification of toxic metals in aquatic organisms, ultimately posing risks to human health through the food chain.

The findings of this study confirm that indiscriminate use of chemically synthesized Holi colours contributes substantially to environmental pollution and degradation of water quality. Therefore, strict regulations should be implemented regarding the manufacture, composition, and sale of synthetic colours containing toxic substances and heavy metals[2-5].

The study strongly recommends the promotion of eco-friendly herbal colours prepared from natural sources such as flowers, turmeric, leaves, sandalwood, and plant extracts. In addition, public awareness programmes and environmental education campaigns should be conducted to encourage sustainable celebration practices, including the adoption of dry Holi to minimize water wastage.

Further studies involving seasonal monitoring, biological oxygen demand (BOD), chemical oxygen demand (COD), microbial analysis, and assessment of additional heavy metals are recommended for comprehensive evaluation of the environmental impact of festival-related wastewater pollution. Many previous studies have already shown that low-cost charcoal prepared from agricultural waste can effectively remove Chromium from water. Therefore, in this study we will prepare a low-cost adsorbent from Chikoo (*Manilkara zapota*) peel and seeds and use it to remove Chromium. This method will not only help in cleaning water but will also promote the utilization of waste.

Thus, environmentally responsible celebration of festivals is essential for conservation of water resources, protection of aquatic ecosystems, and achievement of sustainable environmental management.

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