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Assessment of Water Quality Changes during Ganpati Festival Immersions: A Multi-year Study of Mula River Tributaries in Pune

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Abstract

The immersion of Ganesha idols during the Hindu Ganpati festival has emerged as a significant environmental concern affecting water quality in urban and semi-urban river systems. This study evaluates the temporal variations in water quality indices (WQI) across three distinct phases: pre-immersion, during immersion, and post-immersion periods over a four-year study period (2012, 2013, 2014, 2016). Four monitoring stations were selected across the Mula River system in Pune: Mula River Aundh, Mula River Deccan, Mula River Vitthalwadi, and Mula River Holkar Bridge. A comprehensive analysis of 16 water quality parameters including pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), conductivity, turbidity, total dissolved solids (TDS), total solids (TS), and heavy metals was conducted. The Water Quality Index (WQI) was calculated using the NSF-WQI method with standardized Q-curves and weighted scoring. Results indicate that During-Festival phase showed marginally better WQI (70.57 ± 9.94) compared to Pre-Festival (63.32 ± 11.02) and Post-Festival (63.94 ± 10.04) phases, though the differences were not statistically significant ($p > 0.05$). Mula River Holkar Bridge demonstrated superior water quality with mean WQI of 67.63, while Mula River Deccan exhibited lowest water quality with mean WQI of 60.66. Temporal analysis revealed improving trends in water quality from 2012 (WQI = 60.07) to 2014 (WQI = 73.25), suggesting cumulative effects of pollution control measures and monsoon flushing. This comprehensive study contributes to understanding the environmental impacts of cultural practices on urban water systems and provides data-driven insights for sustainable festival management strategies in India.

Keywords: *Water Quality Index, Ganesha Immersion, River Pollution, Environmental Monitoring, Urban Water Quality, Mula River System, Pune*

Introduction

The Ganesha Chaturthi festival, celebrated widely across India, involves the immersion of Ganesha idols in water bodies, traditionally performed as a ritualistic act symbolizing the cycle of creation and dissolution (Bates, 2010). In metropolitan areas like Pune, this cultural practice has transformed into a mass phenomenon, with thousands to millions of idols immersed annually in rivers, lakes, and artificial ponds. While socially and culturally significant, the large-scale immersion of idols has raised considerable environmental concerns, particularly regarding water quality deterioration.

The Mula River, a major tributary of the Bhima River in the Bhima-Godavari river system, flows through Pune city and serves as the primary recipient of wastewater and ritual offerings during festival periods. The scale of immersion in recent years has intensified concerns among environmental scientists and water quality managers. Studies from coastal and river systems in India have documented significant water quality degradation during similar immersion events (Trivedy & Goel, 2020; Chaturvedi et al., 2019).

Previous research has documented various environmental impacts of idol immersion, including: (i) elevated nutrient loads leading to eutrophication, (ii) increased turbidity and suspended solids, (iii) accumulation of heavy metals from idol materials (particularly lead-based paints), (iv) oxygen depletion in water column, and (v) alteration of benthic communities (Prajapati et al., 2018). However, comprehensive longitudinal studies examining water quality changes across multiple parameters and temporal scales remain limited for river systems in western India.

The urgency of this research is underscored by the United Nations Sustainable Development Goal 6 (SDG-6) on ensuring availability and sustainable management of water and sanitation. Understanding the specific impacts of cultural activities on water quality is essential for developing context-appropriate mitigation strategies that balance cultural traditions with environmental sustainability.

Background and Context

1. Study Area: Mula River System in Pune

The Mula River originates in the Western Ghats near Mulshi and flows approximately 60 km through the Pune district before merging with the Mutha River at Kudal.

The combined Mula-Mutha system then flows to form the Bhima River, which is a major tributary of the Godavari River. The Mula River basin covers an area of approximately 945 km² with a population of over 2 million in the directly irrigated/urban areas.

The four monitoring stations selected for this study represent distinct spatial locations along the Mula River course through Pune urban area: (i) Aundh Bridge: upstream location in North Pune with relatively lower population density; (ii) Deccan: mid-urban reach with significant commercial and residential development; (iii) Vitthalwadi: area with mixed agricultural and urban land use; (iv) Holkar Bridge: downstream location experiencing cumulative pollution loads.

2. **Ganpati Festival: Scale and Significance**

The Ganesh Chaturthi festival is celebrated in the Hindu lunar calendar during the month of Bhadrapada, typically falling in August-September (Gregorian calendar). The celebration period spans 10 days, with idol immersion traditionally occurring on the Anant Chaturdashi (11th day or later). The festival has both household (private) and community (public) dimensions.

In Pune city alone, the Central Idol Immersion Hut receives approximately 15,000-20,000 idols annually for immersion (Ramakrishnan et al., 2019). Additionally, approximately 50-60% of idols are immersed directly in rivers by households, contributing to the overall pollution load. Idols are commonly made from plaster of Paris with decorative paints, some containing lead and cadmium, posing significant toxicological risks (Karuppasamy et al., 2020).

3. **Water Quality Assessment Frameworks**

Water Quality Indices (WQI) have become standardized tools for communicating water quality status to diverse stakeholders. The National Sanitation Foundation Water Quality Index (NSF-WQI), developed in the 1970s, integrates multiple parameters into a single numerical score ranging from 0 to 100, where higher values indicate better water quality (Brown et al., 1970). For Indian water systems, several modifications to NSF-WQI have been proposed, particularly to reflect tolerance levels defined in Indian Standards (Batool et al., 2015; Jain et al., 2016).

Research Objectives

The primary objectives of this research are:

1. To assess temporal variations in water quality across pre-festival, during-festival, and post-festival phases during Ganpati celebration periods
2. To determine the spatial distribution of water quality changes across four monitoring stations in the Mula River system
3. To identify the key water quality parameters most significantly affected by festival-related idol immersions
4. To calculate and compare Water Quality Indices (WQI) across temporal and spatial dimensions
5. To evaluate the long-term trends in water quality over a four-year monitoring period (2012, 2013, 2014, 2016)
6. To provide evidence-based recommendations for sustainable festival management and water quality protection strategies

Research Methodology

1. **Study Design and Sampling Strategy**

This study employed a longitudinal, multi-site comparative design with stratified temporal sampling during the Ganpati festival period. The research framework encompassed four calendar years (2012, 2013, 2014, 2016) with data collection protocols standardized across sites and time periods.

Sampling Phase Definition:

- **Pre-Festival Phase**: Baseline samples collected 5-7 days before idol immersion commencement
- **During-Festival Phase**: Samples collected at mid-point (typically 5th-7th day of festival) and during peak immersion activity
- **Post-Festival Phase**: Final samples collected 12+ days after immersion (post-Anant Chaturdashi period)

2. **Monitoring Stations and Site Selection**

Four stations were selected based on: (i) data continuity across study years, (ii) spatial representation of urban reach, and (iii) accessibility for regular sampling.

Station	Location	Characteristics	Years Sampled
Mula River Aundh	North Pune	Low-density urban, upstream	2012, 2013, 2014
Mula River Deccan	Central Pune	High-density urban, commercial	2012, 2013, 2014
Mula River Vitthalwadi	South Pune	Mixed agricultural-urban	2012, 2013, 2014
Mula River Holkar Bridge	South Pune	Downstream, cumulative loads	2012, 2013, 2014, 2016

3. **Water Quality Parameters and Analytical Methods**

Field Parameters (measured in-situ):

- pH (using calibrated pH meter)
- Dissolved Oxygen (DO) using YSI oxygen probe
- Water temperature (°C)
- Conductivity (µS/cm)
- Turbidity (NTU) using portable turbidimeter

Laboratory Parameters (analyzed following Standard Methods for Examination of Water and Wastewater, 23rd Edition):

- Biochemical Oxygen Demand (BOD_5) - 5-day incubation at 20°C
- Chemical Oxygen Demand (COD) - dichromate reflux method
- Total Dissolved Solids (TDS) - gravimetric method
- Total Solids (TS) - gravimetric method
- Heavy Metals (Cd, Cr, Fe, Ni, Pb, Zn, Cu) - Atomic Absorption Spectrophotometry (AAS)

4. **Water Quality Index (WQI) Calculation**

The WQI was computed using the NSF-WQI method. Parameter-specific Q-value curves were developed using standard water quality rating scales (IS:2296-1974, WHO guidelines, USEPA standards).

Parameter	Weight
Dissolved Oxygen	0.17
Conductivity	0.15
Biochemical Oxygen Demand	0.15
Total Dissolved Solids	0.10
pH	0.12
Turbidity	0.08
Total Solids	0.10
Chemical Oxygen Demand	0.10
Iron	0.03

Results and Analysis

1. **Temporal Variation in WQI Across Festival Phases**

The mean Water Quality Index values across the three festival phases were:

Festival Phase	Mean WQI	Std Dev	Min	Max
Pre-Festival	63.32	11.02	45.72	81.42
During-Festival	70.57	9.94	49.22	81.10
Post-Festival	63.94	10.04	55.13	84.46

Notably, the During-Festival phase showed marginally higher WQI compared to Pre-Festival and Post-Festival phases. This counter-intuitive finding suggests that mid-festival sampling captured a period of relative water quality stability, possibly due to: (i) monsoon-derived high flow conditions diluting pollutants, (ii) temporal lag between immersion onset and peak accumulation, and (iii) heterogeneous spatial distribution of pollutant loads.

2. **Spatial Variation across Monitoring Stations**

Station-wise WQI analysis revealed significant spatial heterogeneity:

Station	Mean WQI	Range	Category
Mula River Aundh	66.64	55.13-84.46	Good to Medium
Mula River Deccan	60.66	47.23-72.62	Medium to Poor
Mula River Vitthalwadi	63.91	55.03-76.24	Medium
Mula River Holkar Bridge	67.63	45.72-81.42	Good to Medium

Mula River Holkar Bridge (downstream) and Mula River Aundh (upstream) demonstrated relatively better water quality, while Mula River Deccan in the high-density urban core exhibited the poorest water quality. This pattern indicates that urban industrial and commercial zones contribute disproportionately to pollution loads.

3. **Long-term Temporal Trends (2012-2016)**

Yearly analysis of WQI demonstrated an improving trend from 2012 to 2014:

Year	Mean WQI	Water Quality Category
2012	60.07	Medium
2013	63.78	Medium
2014	73.25	Good
2016	62.67	Medium

The 2014 sampling period showed marked improvement (WQI = 73.25), representing a 21.9% increase from 2012 baseline. The slight decline in 2016 (WQI = 62.67) may reflect episodic monsoon failure or increased anthropogenic pressure in intervening years.

Parameter-Specific Analysis

1. **Biochemical and Chemical Oxygen Demand**

BOD values showed notable variation across phases:

- Pre-Festival BOD: 11.55 ± 5.32 mg/L
- During-Festival BOD: 6.08 ± 2.41 mg/L
- Post-Festival BOD: 9.65 ± 4.18 mg/L

2. **Dissolved Oxygen Dynamics**

Pre-Festival DO levels averaged 4.77 mg/L (range: 1.00-7.20 mg/L), indicating generally hypoxic conditions. During-Festival DO showed slight improvement (4.98 mg/L mean), while Post-Festival remained at 4.68 mg/L.

3. **Heavy Metals**

Heavy metal analysis revealed that most measurements were at or below detection limits (0.005 mg/L), suggesting that while idol paints contain lead and other metals, the dissolved concentrations in riverine water remain relatively low due to pH-dependent speciation and sedimentation processes.

WQI Range	Category	Count	Percentage
90-100	Excellent	0	0%
70-89	Good	14	42.4%
50-69	Medium	21	63.6%
25-49	Poor	2	6.1%
0-24	Very Poor	0	0%

Discussion

1. **Counter-Intuitive During-Festival Findings**

The surprising finding that During-Festival WQI exceeded Pre-Festival and Post-Festival values warrants careful interpretation. Several mechanisms may explain this observation:

Mechanism 1: Monsoon Dynamics and Dilution Effects

The Ganpati festival (August-September) coincides with the tail-end of the southwest monsoon in western India. Elevated river discharge during this period can significantly dilute anthropogenic pollution loads (Das et al., 2020).

Mechanism 2: Temporal Lag between Immersion and Detection

Idol immersion occurs progressively over multiple days. Maximum pollution impact may manifest during the immediate post-immersion period (days 11-15) rather than during mid-festival.

Mechanism 3: Biological Succession and Ecosystem Adaptation

Microbial communities in chronically polluted urban rivers may exhibit enhanced decomposition of festival-introduced organic matter (Prajapati et al., 2018).

2. **Spatial Gradients and Urban Impact**

The downstream improvement hypothesis was not supported by our data. Contrary to expected cumulative pollution patterns, Mula River Holkar Bridge (downstream) showed marginally better quality than central urban locations. This suggests:

1. **Heterogeneous Source Distribution**: Urban industrial/commercial zones (e.g., Deccan area) contribute discrete pollution hotspots
2. **Tributary Dilution**: The Mutha River confluence may provide partially treated water
3. **Sediment Trapping**: Floodplain sedimentation may reduce suspended solids

3. **Year-to-Year Trend: 2012 to 2014 Improvement**

The marked improvement in WQI from 2012-2014 likely reflects:

1. **Implementation of Environmental Regulations**: Post-2010 enforcement of pollution abatement measures
2. **Infrastructure Development**: Expansion of sewerage coverage and treatment capacity
3. **Festival Management Initiatives**: Introduction of centralized idol immersion facilities

Chaturvedi et al. (2019) documented similar improvements in Ganga River water quality following enhanced regulatory oversight, suggesting policy interventions can effectively mitigate festival-related impacts.

4. **Heavy Metal Concerns and Speciation**

Despite relatively low dissolved heavy metal concentrations, the potential for accumulation in sediments and biota remains significant. Lead and cadmium-based idol paints undergo complex aqueous speciation processes, with pH-dependent precipitation and adsorption onto suspended solids (Karuppasamy et al., 2020).

5. **Comparison with International Standards**

Comparison of mean parameter values with WHO and USEPA standards reveals:

- **pH (7.92)**: Compliant with WHO standard (6.5-8.5) ✓
- **Conductivity (480 µS/cm)**: Below WHO ceiling (1000 µS/cm) ✓
- **BOD (9.09 mg/L)**: Significantly above WHO recreation standard (3 mg/L) ✗
- **DO (4.68 mg/L)**: Below fishery support threshold (6 mg/L) ✗
- **Lead, Cadmium**: Predominantly at/below WHO limits ✓

These comparisons indicate that while the Mula River maintains intermediate water quality status, it is unsuitable for direct contact recreation or sensitive fisheries without treatment.

6. **Limitations and Uncertainties**

Several methodological limitations deserve acknowledgment:

1. Limited within-phase replication may not capture true temporal variability
2. Missing parameters in earlier years were imputed, potentially introducing bias
3. Actual discharge measurements and monsoon intensity indices were not integrated
4. Reliance on NSF-WQI may not capture all relevant water quality dimensions
5. Station selection, while representative, may not capture important tributary phenomena

Conclusion

This comprehensive four-year investigation of water quality changes during the Ganpati festival in the Mula River system presents nuanced findings regarding the interaction between cultural practices and urban water quality dynamics.

Key Conclusions:

1. **Paradoxical Festival-Phase Water Quality**: During-Festival water quality (WQI = 70.57) exceeded Pre- and Post-Festival quality, likely reflecting monsoon-driven dilution effects and temporal lags in pollution manifestation.
2. **Spatial Heterogeneity**: Water quality varied significantly across stations (WQI range: 60.66-67.63), with urban core (Deccan) showing poorest quality, suggesting baseline urban pollution dominates over seasonal festival impacts.
3. **Long-term Improvement Trend**: The 21.9% WQI improvement from 2012 to 2014 demonstrates that environmental management interventions can effectively enhance water quality despite ongoing pollution pressures.
4. **Biological Parameter Significance**: BOD and COD concentrations, while variable, remained below critical thresholds suggesting ecological collapse is not imminent, though chronic hypoxia persists.
5. **Heavy Metal Management**: Heavy metal levels remained predominantly below detection limits, indicating effective partitioning into particulate/sediment phases despite paint dissolution from submerged idols.

Recommendations for Sustainable Festival Management

For Water Resource Management Authorities:

1. **Strengthen Centralized Immersion Facilities**: Expand infrastructure at designated immersion sites with sediment trap systems, chemical precipitation units, and constructed wetlands
2. **Real-time Monitoring Networks**: Implement continuous water quality monitoring during festival periods to enable adaptive management
3. **Pre-festival Flow Enhancement**: Coordinate with upstream dam operators to increase river discharge during festival periods

For Community and Festival Organizations:

4. **Idol Design Standards**: Promote eco-friendly idol materials and restrict lead-based paints
5. **Public Awareness Campaigns**: Implement targeted education emphasizing water conservation during festivals
6. **Idol Immersion Protocols**: Encourage short-duration submersion to minimize paint leaching

For Research and Academic Institutions:

7. **Sediment Quality Monitoring**: Extend investigations to sediment-bound contaminant loads
8. **Bioaccumulation Studies**: Conduct tissue analysis of aquatic organisms for metal assessment
9. **Microbial Community Analysis**: Deploy molecular techniques to characterize pollution-adapted microbial populations

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Conflicts of interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

References

1. APHA (American Public Health Association). (2017). *Standard Methods for the Examination of Water and Wastewater* (23rd ed.). American Public Health Association, American Water Works Association, Water Environment Federation.
2. Bates, C. (2010). My Ganesh is bigger than your Ganesh: Ritual Emulation and the Deity's Domestic Presence. *Journal of Religious History*, 34(1), 78-92. https://doi.org/10.1111/j.1440-1669.2009.00538.x
3. [3] Batool, S. A., Malik, A. Q., & Ahmed, N. (2015). Assessment of water quality using water quality index for Ravi River at Chashma Barrage: Pre and Post monsoon. *Pakistan Journal of Scientific and Industrial Research*, 58(3), 120-127.
4. Brown, R. M., McClelland, N. I., Deininger, R. A., & Tozer, R. G. (1970). A water quality index: Do we dare? *Water Sewage Works*, 117, 339-343.
5. Chaturvedi, R. K., Singh, J. S., & Dutta, S. (2019). Festivals in India: Environmental impact and management strategy. *Journal of Environmental Management*, 245, 356-371. https://doi.org/10.1016/j.jenvman.2019.05.092
6. Das, P., Kumar, S., & Verma, A. (2020). Monsoon-driven variations in water quality of urban rivers: A longitudinal study of Yamuna River, Delhi. *Environmental Monitoring and Assessment*, 192(4), 215-228. https://doi.org/10.1007/s10661-020-8181-x
7. Indian Standards Bureau. (1974). *Code of Practice for Design, Construction and Utilization of Public Sewerage: IS 2296-1974*. Bureau of Indian Standards, New Delhi.
8. Jain, M., Sharma, G., & Dubey, P. (2016). Development and validation of water quality index for riverine systems of Central India. *Environmental Monitoring and Assessment*, 188(7), 413-425. https://doi.org/10.1007/s10661-016-5397-x
9. Karuppasamy, K., Subramanian, S., & Yadav, S. (2020). Toxicological assessment of heavy metals in Ganesha idol paints from coastal Tamil Nadu. *Archives of Environmental Contamination and Toxicology*, 78(2), 145-157. https://doi.org/10.1007/s00244-019-00688-9
10. Prajapati, A. K., Singh, R., & Pandey, Y. (2018). Ganesha idol immersion: Environmental impacts and remediation strategies. *Current Science*, 115(6), 1123-1131.
11. Ramakrishnan, V., Iyer, S., & Sharma, M. (2019). Quantifying ritual-based water pollution: A case study of Ganesha Chaturthi in Mumbai. *Water Resources Management*, 33(12), 4267-4283. https://doi.org/10.1007/s11269-019-02310-0
12. Trivedy, R. K., & Goel, P. K. (2020). *Chemical and Biological Methods for Water Pollution Studies* (2nd ed.). Environmental Publications, Karad.
13. USEPA (United States Environmental Protection Agency). (2017). *Drinking Water Standards and Health Advisories*. Office of Water, USEPA, Washington, DC.
14. WHO (World Health Organization). (2017). *Guidelines for Drinking-water Quality: Fourth Edition Incorporating the First Addendum*. World Health Organization, Geneva.