Original Research Article

Investigating the Effects of Urbanization on River Pollution in Mumbai

Azad Parikh

Sevenoaks School, High Street, Sevenoaks, Kent TN13 1HU, United Kingdom

ABSTRACT

This study investigates the relationship between urbanization and river pollution along the Mithi River in Mumbai, India. Over the past four decades, rapid population growth, industrial expansion, and informal settlement development have significantly altered land use and degraded water quality. Using a mixed-methods approach, field observations from sixteen sites in July 2025 were combined with secondary geospatial and historical data to assess spatial patterns in observable environmental condition. Results indicate that industrial and slum-adjacent zones exhibit the poorest environmental quality, while coastal mangrove and central business district (CBD) areas demonstrate comparatively better conditions in this survey. A qualitative contextual comparison with 2014 Maharashtra Pollution Control Board (MPCB) documentation suggests that several midstream reaches highlighted in public monitoring and action planning overlap with sections observed as highly degraded in 2025, particularly around the airport corridor and central industrial–settlement reaches. However, due to differences in indicators, methodologies, and spatial units, temporal continuity is inferred qualitatively rather than demonstrated quantitatively. These findings highlight that unregulated development is associated with degraded river conditions, and that targeted investments in sewage treatment, mangrove conservation, and land-use planning are relevant priorities for improving urban river health. The study underscores the importance of integrating ecological restoration with urban growth strategies to support sustainable river management in megacities such as Mumbai.

Keywords: Urbanization; River pollution; Mithi River; Mumbai; Land-use change; Mangroves; Water quality; Urban planning; Sustainability

INTRODUCTION

Mumbai, one of the world's largest and most densely populated megacities, has experienced rapid growth over recent decades. Its population increased from approximately 8 million in 1980 to around 22.5 million by 2025, accompanied by extensive expansion of housing, transport corridors, and commercial districts (1). Built-up land in the wider Mumbai region increased by more than 300% between 1973 and 2016, while vegetation cover declined by over 40% (2). At the same time, substantial losses of mangrove ecosystems have occurred, largely due to land reclamation and urban development (3). These trends illustrate the broader challenge of reconciling rapid urban expansion with the protection of riverine and coastal ecosystems.

River pollution is one of the most visible environmental consequences of urbanization in Mumbai. Many

Corresponding author: Azad Parikh, E-mail: azadparikh08@gmail.com.

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rivers receive untreated sewage, industrial effluent, and solid waste. The Mithi River, in particular, has been reported to receive hundreds of millions of litres per day of untreated sewage, resulting in elevated biochemical oxygen demand (BOD), reduced dissolved oxygen (DO), and excessive concentrations of indicator bacteria (4, 5). Such pressures mirror global patterns in which poorly managed urbanization degrades surface-water quality (6–8).

Despite the importance of these issues, relatively few fine-scale studies in Mumbai directly link local land-use patterns to observable river conditions along individual urban rivers. Most analyses rely on city-scale indicators or focus primarily on flood risk and engineering dimensions rather than everyday ecological quality (9–12). This study therefore examines the Mithi River as a case study to explore how contrasting land uses, including airports, informal settlements, and central business districts, relate to spatial patterns of river pollution.

The guiding research question is: How does rapid urbanization influence river pollution patterns along the Mithi River in Mumbai? By combining a field-based Environmental Quality Assessment (EQA) for 2025 with secondary MPCB documentation from 2014, the study evaluates whether highly degraded reaches identified in 2025 overlap qualitatively with historically emphasized areas, while avoiding direct quantitative temporal comparison due to methodological differences.

METHODS AND MATERIALS

Study Area

The Mithi River flows approximately 17.8 km through Mumbai, from the overflow points of Vihar and Powai Lakes to the Arabian Sea at Mahim Creek. Along this route, it traverses wetlands, informal settlements, industrial zones, high-density residential areas, reclaimed land, and the Bandra–Kurla Complex (CBD) (10, 11). This diversity makes the river well suited for examining how different forms of urban land use relate to river conditions.

Seventeen sampling locations were selected at approximately one-kilometre intervals and geolocated using GPS. One upstream site near a restricted dam and marshland could not be accessed safely and was excluded from field scoring. This was the only inaccessible site because it was within a restricted access zone and required unsafe entry conditions during the sampling window, whereas the remaining locations could be reached safely from public roads, bridges, or accessible riverbank approaches. Consequently, the main analysis is based on observations from 16 accessible sites (Figure 1).

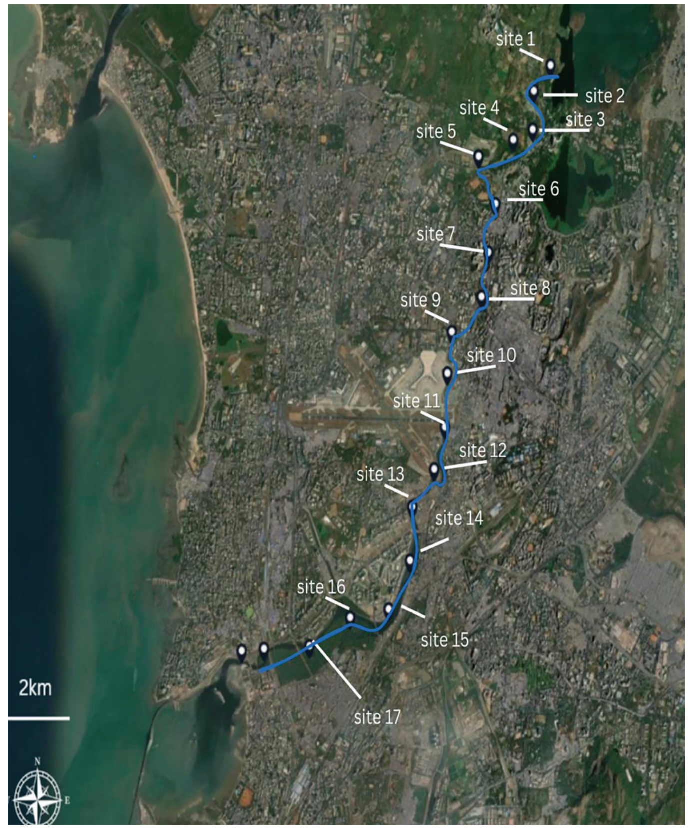

Figure 1. Location of the Mithi River in Mumbai and the 17 sampling sites used in this study.

Field Data Collection and Environmental Quality Index

Fieldwork was conducted on 2 July 2025 during the southwest monsoon between 08:00 and 15:00 to minimize variation due to light, weather, and tidal conditions. At each site, five indicators of environmental quality were assessed: visible plastic waste, water odour, water clarity, signs of eutrophication, and surrounding land-use intensity. These indicators were selected because they are widely used in rapid visual assessment protocols where laboratory sampling is not feasible, capture multiple dimensions of pollution, and can be applied consistently along short spatial transects.

Each indicator was scored using a predefined nine-point ordinal scale from −4 (very poor environmental quality) to +4 (very good environmental quality).

Indicator scores were summed to produce a composite raw score ranging from −20 to +20. Raw scores were then linearly transformed into a 0–100 Environmental Quality Index (EQI) using the formula ((Score + 20) / 40) × 100. A score of 0 represents the theoretical best possible conditions, 50 represents a neutral midpoint, and 100 represents the theoretical worst conditions. Throughout this paper, higher EQI values consistently indicate more degraded environmental conditions, while lower EQI values indicate comparatively better environmental quality.

The EQI was designed as an exploratory, unweighted index to facilitate relative comparison between sites rather than as a validated measure of ecological health. No sensitivity analysis or alternative weighting scheme was applied. All observations were recorded on standardized data sheets and later digitized. One inaccessible site was excluded from statistical summaries but included on maps to provide spatial context.

Observer Consistency and Scoring Rubric

All field assessments were conducted by a single trained observer (the author), who has prior experience in environmental fieldwork, including river-quality surveys and coastal ecosystem assessments undertaken as part of academic coursework and supervised research projects. To ensure internal consistency, a predefined scoring rubric was applied at all sites, and observations were conducted within a single day. In borderline cases, the more conservative (poorer-quality) score was assigned to reduce the risk of overestimating environmental condition.

Secondary Data and Land-Use Classification

Secondary land-use data were compiled from development plans, zoning documents, and satellite imagery to classify land use at each sampling location (10–12). Historical land-use patterns were reconstructed using older maps and imagery to identify long-term changes. Published MPCB water-quality documentation from 2014 was used to contextualize observed spatial patterns (4). Due to differences in indicators, spatial units, and methodologies, these data were used qualitatively rather than for direct statistical comparison.

Statistical Analysis

Descriptive statistics, including means and standard deviations, were calculated for EQI values. No inferential statistical tests or correlation analyses were performed because of the small sample size, ordinal nature of the scoring system, and lack of replication. Future studies with larger datasets and repeated sampling could apply non-parametric statistical tests to formally assess relationships between land use and river quality.

RESULTS

The 2025 field survey produced EQI values ranging from 35 to 95, with a mean of 63.44 and a standard deviation of 15.11 (n = 16). The most degraded conditions were recorded at sites located within airport-adjacent and industrial corridors, while comparatively lower degradation was observed near the CBD and mangrove-fringe estuarine reaches (Table 1).

High EQI values dominated the central section

Table 1. *Summary of site characteristics, indicator scores, raw composite scores (−20 to +20), and Environmental Quality Index values (0–100) for the 2025 field survey.*

Site Number	Latitude (°N)	Longitude (°E)	Sum of scores	Scaled scores	Land use now	Land use 1980
1	19.144336	72.899305			Dam and marshland	Open marshland/ salt pan
2	19.140212	72.895834	-3	42.5	Slum area & informal housing	Vacant
3	19.133958	72.895886	-7	32.5	Slum area and new transport link	planned industrial activity
4	19.13225	72.891782	-4	40	wharehouses & high rise housing	swamp
5	19.129228	72.884338	-1	47.5	wharehouses for transport storage	proposed comercial work

Continued Table 1. *Summary of site characteristics, indicator scores, raw composite scores (−20 to +20), and Environmental Quality Index values (0–100) for the 2025 field survey.*

Site Number	Latitude (°N)	Longitude (°E)	Sum of scores	Scaled scores	Land use now	Land use 1980
6	19.12183	72.888359	-3	42.5	Slum area & informal housing	University and open land
7	19.114082	72.887137	-5	37.5	High rise buildings	Informal housing
8	19.094344	72.879084	-9	27.5	High rise buildings	Low rise residential
9	19.085735	72.878783	-9	27.5	industrial buildings and airport	Industrial
10	19.078954	72.876694	-13	17.5	Airport	Marsh
11	19.072846	72.872301	-12	20	Airport	Marsh
12	19.064225	72.872167	-18	5	Airport	Wetlands
13	19.05626	72.867872	-7	32.5	Court houses, embassy, construction	Agriculture and village
14	19.054675	72.859674	-2	45	Sports feilds and high rise towers	Airport
15	19.049734	72.850968	-2	45	CBD	Slum
16	19.048958	72.841331	6	65	CBD	Airport
17	19.048503	72.836478	3	57.5	CBD	Airport

of the river corresponding to airport infrastructure, industrial facilities, and dense informal housing (Figure 2). In contrast, lower EQI values occurred near the river mouth where mangroves and more formalized urban infrastructure are present.

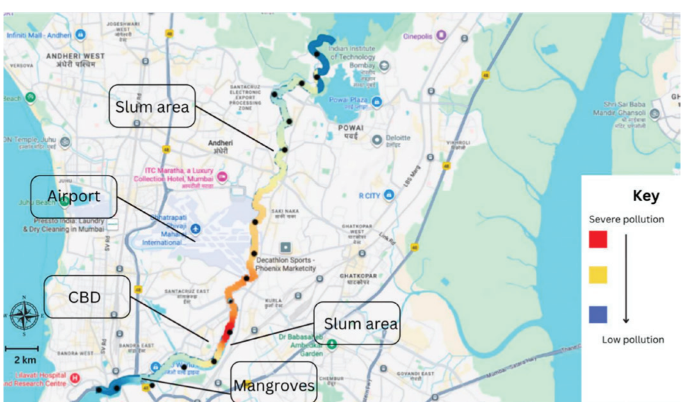

Figure 2. *Spatial distribution of Environmental Quality Index (EQI) scores along the Mithi River in July 2025, with darker shading indicating more degraded conditions.*

MPCB documentation from 2014 classified much of the Mithi River as polluted or critically polluted and reported elevated BOD and COD values and reduced DO levels in central industrial and slum-adjacent stretches (4). While direct numerical comparison is not possible, the 2014 documentation and the 2025 EQI observations overlap qualitatively in identifying the midstream corridor—especially airport-adjacent and central industrial–settlement reaches—as areas of high concern. This overlap is presented as qualitative inference rather than quantitative evidence of temporal persistence.

DISCUSSION

The results demonstrate a clear association between land-use type and observable river degradation along the Mithi River. Airport and industrial corridors exhibit the poorest environmental conditions, while CBD and mangrove-fringe areas display comparatively better conditions. These findings align with global research linking dense infrastructure, informal settlements, and limited sanitation to degraded river quality (6–8, 13–17).

At the same time, variability within urbanized areas suggests that not all development produces identical environmental outcomes. CBD stretches with more formal drainage systems and proximity to ecological buffers such as mangroves appear to support relatively better observable water quality than equally dense but less regulated zones. These associations should not be interpreted as evidence of direct causation, as this study did not directly measure pollutant loads or management interventions. Instead, the findings highlight spatial patterns that are consistent with existing literature and warrant further investigation.

The planned sampling design included an upstream site intended to represent the least urbanized reachable condition along the corridor. Because this site could not be accessed safely due to restricted access and unsafe entry conditions, the study lacks a minimally impacted upstream control. This limitation affects interpretation by reducing the ability to benchmark EQI values against a low-impact baseline and by potentially compressing the apparent range of conditions along the river. As a result, conclusions are framed as relative differences among accessible sites rather than as departures from a minimally disturbed reference state.

The Methods correctly state that MPCB 2014 data are not directly comparable to the 2025 EQI due to differences in indicators and methodologies. Accordingly, any statements about apparent continuity of hotspots are framed as qualitative inferences supported by converging evidence (field observations and public documentation), not as quantitative demonstrations of persistence or change over time.

The limitations of this study primarily highlight opportunities for future research rather than fundamental weaknesses. Data were collected on a single monsoon day, limiting seasonal representativeness. The EQA is a rapid, unvalidated index, and observations were made by a single observer without replication. Differences between the 2014 and 2025 datasets further restrict temporal inference. Future research could address these limitations through multi-season sampling, multiple observers, validated indices, and integration of chemical, biological, and social data. Such approaches would enable more robust statistical testing and clearer assessment of causal relationships between urban land use and river pollution.

CONCLUSION

This study shows that river pollution along the Mithi River varies systematically with surrounding land use. Airport and industrial corridors remain the most degraded sections observed in the July 2025 survey, while CBD and mangrove-fringe areas exhibit comparatively better environmental conditions. While qualitative contextual comparison with MPCB 2014 documentation suggests that some reaches identified as high concern in public monitoring and action planning overlap with highly degraded areas observed in 2025, direct temporal comparison is not possible due to methodological differences. Targeted interventions, integrated land-use planning, and ecological restoration remain important priorities for improving urban river health in rapidly growing megacities.

CONFLICT OF INTEREST

The author declares no conflicts of interest related to this work.

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