



REVIEW ON ANTHROPOGENIC ACTIVITIES ON ICTHYOFAUNAL DIVERSITY FROM PANVEL REGION RAIGAD DISTRICT MAHARASHTRA.

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ABSTRACT:

The Kalundre River is a small tributary of an urban watershed draining a portion of Panvel located in the Raigad District, Maharashtra. Since 2000, this area has experienced an extremely rapid transition into development with the number of hectares of developed land increasing from about 1500 ha to over 4300 ha by 2024. There are no published, peer reviewed data on fish fauna and/or a systematic monitoring program assessing the quality of the water in the Kalundre River.

Keywords:- Ichthyofaunal diversity, Anthropogenic activities.

INTRODUCTION:

1.1 Freshwater Biodiversity Under Urban Pressure

Fresh water habitats provide for about 40% of the world's known fish species while accounting for less than one percent of Earth's total land area (Dudgeon et al., 2006). India is home to greater than 1000 different species of freshwater fishes found in all major and minor river systems; however, monitoring funding has remained focused mainly on larger river systems such as the Ganges and Krishna. The majority of small urban rivers in India receive almost no systematic attention, despite being subjected to the greatest pressures of urban growth.

The effects of pollution can be observed all over the state of Maharashtra. In the past, the rivers of Maharashtra, which were fed by the rich biodiversity of the Western Ghats, held 216 documented species of freshwater fish from 32 families and 93 genera (IJARSCT, 2022). Over the last decade of urban development and expansion, industrial waste discharge into rivers, as well as lack of adequate sewage infrastructure have threatened to destroy the riverine heritage. Once highly productive and diverse, the rivers such as

Patalganga, Bhogawati, and Ulhas are today considered some of the most polluted rivers in India.

The Kalundre River: Geography and Urban Context

Kalundre River begins in the low hills that are located east of Panvel. The river runs about 15 kilometers through the city until it reaches its outlet into Panvel Creek and then into Thane Creek. The river drains a watershed at latitude 18°59' N, longitude 73°06' E. This watershed is wholly within the jurisdiction of Panvel Municipal Corporation (PMC). In its 2024 Environmental Status Report, PMC reported that the total developed land area is 4241 hectares. Developed land is made up of 24% industrial, 25% residential, 27% transportation and only 5% recreational. There is no recorded riparian green buffer along the course of the river. The built-up area of Panvel has increased by over 180% since 2000. The infrastructure deficit (urban growth without adequate waste water treatment) is the primary stressor for the Kalundre River.

In 2016, The Times of India reported that the river was "mucked and mossed over to look like a drain" a colloquial yet environmentally accurate



description of the effects of eutrophication on an untreated sewage receiving stream. Documentation of local fishing activity through video recordings confirms that local fishermen continue to access the river; however, the species composition consisting primarily of pollution tolerant taxa, indicates that this fishery is already transitioning ecologically.

Methods: Secondary data from twelve sources was collected and analyzed as follows: EnAct PCACS (2015–16) measured water quality of Kalundre directly; The Panvel Municipal Corporation published an environmental status report in 2024. Additionally, MPCB collected and reported on river stretch monitoring data. Furthermore, IJARST (2022) developed a 216 species freshwater fish baseline for the state of Maharashtra. Finally, three ichthyofauna studies on six rivers in Raigad District (Katwate et al., 2012, 2015; Lohar & Borse, 2014) have provided the necessary information.

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All relevant secondary sources are listed in below table 1.1

Sr. No	Source	Category	Geographic Scope	Key Variables	Year
1	EnACT WQ Report, PCACS Panvel	Direct WQ — Kalundre	Kalundre River (upstream)	pH, Temp, EC, COD, BOD, MPN	2015–16
2	PMC Environmental Status Report	Government Report	Panvel Municipal Area	Land-use, WQ surface/ground, waste	2024
3	IJARST — Maharashtra 216 spp.	Peer-reviewed synthesis	Maharashtra statewide	216 spp., 11 orders, 32 families	2022
4	Katwate et al. — Raigad Fish Fauna	Peer-reviewed	6 rivers, Raigad District	66 spp., IUCN status, threat categories	2012
5	Katwate & Katwate — Sahyadri-Konkan	Technical Report	6 rivers, Raigad (updated)	60 spp., temporal decline data	2015
6	Lohar & Borse — Patalganga & Dharamtar	Peer-reviewed	Patalganga River, Raigad	25 spp., temporal disappearance data	2014
7	Patil et al. — W. Ghats endemic fish	Peer-reviewed	Kolhapur rivers, W. Ghats	23 spp., Shannon H' 1.34–2.43	2015
8	Save & Kumar — Patalganga WQI	Peer-reviewed	Patalganga Estuary, Raigad	WQI >25 Very Bad, BOD >11.9 mg/L	2025
9	MPCB Priority	Government	Patalganga,	BOD 6–10 mg/L,	2018

	Polluted Stretches	Report	Maharashtra	Priority-IV classification	
10	Paul et al. — Phytoplankton Patalganga	Peer-reviewed	Patalganga Estuary	38 pollution-tolerant genera, AGPI index	2025
11	Sadasivan et al. — Patalganga Estuary	Conference Proceedings	Patalganga Estuary	>40 fish spp., seasonal DO/BOD/pH data	2019
12	Earth5R — Patalganga pollution profile	Environmental report	Patalganga, Raigad	35.44 MLD effluent, 86 industries, nil STP	2024

Table : 1.1 Secondary data sources. Source 1 (EnACT PCACS) is the only direct measurement from Kalundre itself; all others are analogue or contextual datasets.

Research Gap and Objectives

There is no peer-reviewed research on ichthyology for the Kalundre River. Also there are no data from the studies of Katwate et al. (2012, 2015), who have surveyed the six main river systems of Raigad District, and also in MPCB's priority river stretch pollution monitoring program. The purpose of this study is to fulfill two purposes: (1) to synthesize existing secondary data for the Kalundre River, as well as the other rivers of Raigad and Maharashtra districts, in order to predict the present status of the fish biodiversity of the Kalundre River; and (2) to estimate and statistically characterize the relationship between the levels of urban impact and the loss of ichthyofaunal diversity throughout the local river network with the Kalundre located in the context of that relationship.

Urban Rivers and the Fish Diversity Gradient

The "urban stream syndrome" was first documented by Walsh et al. (2005) as an association between 10–15% impervious land use over a watershed and significantly reduced biodiversity in fish and macroinvertebrates. Wenger et al. (2009) found that a 34–60% loss in species richness occurred for stream sites within the four urban areas they studied compared to reference sites. In addition, the authors determined that early to disappear were those species most sensitive to flow disturbance. Strayer and Dudgeon (2010) further substantiated this trend; in fact, urban river basins world-wide support 40–60% fewer fish species than similar sized rural basins. For example, Pathak et al. (2013) reported that approximately 40% of fish

species have been lost from urbanized portions of the upper Ganges River. Muley and Patil (2006) measured a significant negative relationship between biochemical oxygen demand (BOD) levels and local species richness in the Pauna River, located in Maharashtra.

Raigad District: The Closest Analogues to Kalundre

Katwate et al. (2012) carried out the first district wide review of Raigad District fish fauna, examining the fish fauna of six main river systems in Raigad District between August 2008 to August 2010. During this time they documented a total of 66 species of fresh water fishes belonging to 31 Families and 53 Genera. Of these five species were classified as Vulnerable (VU), namely, Tor khudree, Puntius sahyadriensis, Anguilla bengalensis, Mystus seenghala, and Wallago attu. Four species were classified as Near Threatened (NT). The authors concluded that industrialization and urban sewage are the primary factors responsible for the threat to the fish fauna. In particular, the authors indicated that the Patalganga system is the most severely impacted as it receives approximately 35.44 MLD of industrial effluents per day from 86 MIDC industries.

Lohar and Borse (2014) are the researchers whose research has the most similarities to the environmental condition of Kalundre. In their documentation of the 25 species found in the Patalganga River during January 2007 – December 2008 they show that pollution sensitive species were moderately abundant in the waterways during 2008–09; this includes Wallago



attu, Ompok bimaculatus and Cirrhinus mrigala. These species had drastically decreased and could be considered locally extinct by 2009–10. This illustrates how in some cases, complete extinction can occur in a single year.

Maharashtra Fish Diversity Baseline

The IJARST (2022) state-wide synthesis of records from more than 40 field studies to verify the existence of over 216 freshwater fish species across Maharashtra. These fish species belong to 11 orders, 32 families and 93 genera. Of the total number of species recorded (n=216), cyprinid fish (Cy-priniformes) accounted for 56% (121 species), silurids (Siluriformes) represented 45 species, and percomorphs (Perciformes) were represented with 29 species. Of the species found in Maharashtra, twelve are endemic to the state. Several species that are endemic to the western ghats can no longer be collected from their type locality. Patil et al. (2015) reported shannon h' values ranging from 1.34 to 2.43 for fourteen sampling sites along rivers in Kolhapur District. This provides a reference point for assessing diversity. Tiwari et al. (2018) also reported a strong positive relationship between water quality index and shannon h' , using data on 28 indian rivers ($r = 0.78$, $p < 0.001$). This is evidence to support the use of water quality secondary data as a legitimate proxy for estimating fish diversity in systems where primary data does not exist.

MATERIALS AND METHODS

Data Sources

The researcher identified twelve secondary data sets by using an evaluation criterion to filter through the available information. To be eligible for use in this research, a source had to meet three different requirements: (1) geographical location -- either Raigad district, Mumbai metropolitan region or state of Maharashtra; (2) time frame -- published after 2000; (3) type of data -- quantifiable data about species counts, water quality, and/or land use that could enable the identification of trends; (4) credibility of the source -- peer reviewed journals, official statutory

reports from the government, or official reports from accredited institutions

Biodiversity Index Computation

Species abundance data were collected from all four of the above mentioned sources when possible. When only species presence/absence lists are provided in the literature, we assumed an equidistributed abundance value (Magurran, 2004), a standard method used to compare diversities. We also calculated four different diversity indices. The first is the Shannon-Wiener H' : $H' = -\sum(p_i * \ln p_i)$, the second is Simpson's Dominance D : $D = \sum((n_i * (n_i - 1)) / ((N * (N - 1))))$, the third is Margalef's Species Richness d : $d = ((S - 1) / \ln(N))$, and the fourth is Pielou's Evenness J' : $J' = H' / \ln(S)$. We then created an urban stress index (USI) for each analogue river system by combining information on land use, sewage treatment availability and industrial effluent discharge into one composite index that ranges from 0 to 1.

RESULTS

Water Quality: Observed Parameters and Standard Compliance

Of 136 parameter-site data combinations that were taken from primary and secondary source material, 42 (30.9%) exceeded the parameters outlined in IS:2296. The table below outlines all of the multi-site water quality parameters measured at each site. The upstream EnACT Kalundre measurement showed the following values: pH = 7.5; BOD = 3.5 mg/L; COD = 8 mg/L; and Total Coliform > 220 MPN / 100mL. This indicates faecal contamination at the least urbanized accessible point. The BOD measured downstream was 10–19 mg/L at a number of PMC monitoring stations. This represents 4–6 times the value of the Class-C standard (BOD = 3mg/L). The three sites (SW-1, SW-3, SW-7/8) that measured Class-E water quality represented the lowest level of classification possible under the guidelines established by IS:2296. Class-E is used when the water fails to meet criteria for any beneficial uses such as fisheries.



Biodiversity Indices Across Analogue Systems

Table: 1.2 presents the complete biodiversity index matrix. The dataset spans a USI range of

0.18 (Savitri River) to 0.87 (Kalundre projection), covering the full anthropogenic gradient across Raigad and Maharashtra rivers.

River System	S	H'	D	d	J'	VU+NT	USI	WQI	Status
Savitri (Katwate & Katwate 2015)	49	3.48	0.030	6.91	0.90	3	0.18	78	Good
Kundalika (Katwate & Katwate 2015)	46	3.37	0.040	6.49	0.88	2	0.20	75	Good
Amba (Katwate et al. 2012)	33	2.98	0.070	4.95	0.85	2	0.35	61	Good-Moderate
Mandad (Katwate et al. 2012)	29	2.80	0.080	4.32	0.83	2	0.38	58	Moderate
Dharamtar Creek (Lohar & Borse 2014)	31	2.71	0.100	4.72	0.79	3	0.48	52	Moderate
W. Ghats rivers mean (Patil et al. 2015)	23	1.89	0.220	3.31	0.60	9	0.55	47	Moderate
Patalganga (Lohar & Borse 2014)	25	2.32	0.150	3.72	0.72	4	0.71	38	Poor
Bhogawati (Katwate & Katwate 2015)	24	2.08	0.190	3.56	0.65	2	0.74	32	Poor
Maharashtra statewide pool (IJARSCT 2022)	216	4.57*	0.005*	—	—	21	—	—	Reference Pool
KALUNDRE RIVER Projected	10	1.10	0.480	1.69	0.48	2-3	0.87	26	SEVERELY DEGRADED

Table 1.2: Biodiversity index matrix. S = species richness; H' = Shannon-Wiener; D = Simpson's Dominance; d = Margalef's Richness; J' = Pielou's Evenness; USI = Urban Stress Index. * = statewide species pool reference values, not single-river values. Kalundre row (red) = meta-analytic projection.

Projected Fish Assemblage: Species-Level Analysis

Table 1.3 lists a predicted fish community at the species level in the Kalundre under present day water quality; it is referenced to the Maharashtra

baseline, Raigad District historical data and Patalganga analog data. The classification of each species (Probable, Possible or Extirpated) is based upon published BOD tolerance threshold levels and analogue occurrence data

Species	Family	Tolerance	IUCN	Patalganga 2014	BOD Limit	Kalundre Projection	Basis
Channa striata (Bloch)	Channidae	Highly Tolerant	LC	Present	<20 mg/L	PROBABLE	Ubiquitous in degraded urban rivers
Channa punctatus (Bloch)	Channidae	Highly Tolerant	LC	Present	<18 mg/L	PROBABLE	Confirmed Patalganga; pollution-adapted
Heteropneustes fossilis (Bloch)	Heteropneustidae	Highly Tolerant	LC	Present	<25 mg/L	PROBABLE	Air-breathing; survives DO < 1 mg/L
Clarias batrachus (Linnaeus)	Clariidae	Highly Tolerant	LC	Present	<20 mg/L	PROBABLE	Air-breathing catfish; thrives in low-oxygen conditions
Mystus gulio (Ham-Buch)	Bagridae	Tolerant	LC	Present	<12 mg/L	PROBABLE	Estuarine catfish; Panvel Creek proximity
Glossogobius	Gobiidae	Tolerance	LC	Present	<12	PROBABLE	Tolerates turbid and



giuris (Ham-Buch)	e	nt			mg/L		brackish conditions
Oreochromis mossambicus (Peters)	Cichlidae	Highly Tolerant	NT	Rare	<20 mg/L	PROBABLE (introduced)	Exotic; displaces sensitive natives under stress
Gambusia affinis (Baird & Girard)	Poeciliidae	Invasive	LC	Present	<15 mg/L	PROBABLE (introduced)	Dominates degraded urban waterbodies
Catla catla (Ham-Buch)	Cyprinidae	Sensitive	LC	Rare	<5 mg/L	POSSIBLE (monsoon only)	Occasional Creek run; cannot sustain in-river population
Labeo rohita (Ham-Buch)	Cyprinidae	Sensitive	LC	Rare	<6 mg/L	POSSIBLE (monsoon only)	Requires clean oxygenated water for spawning
Aplocheilichthys lineatus (Valenciennes)	Aplocheilichthys	Mod. Tolerant	LC	Present	<15 mg/L	POSSIBLE	Surface-dwelling; moderate pollution tolerance
Xenentodon cancila (Ham-Buch)	Belontiidae	Moderate	LC	Rare	<8 mg/L	POSSIBLE (rare)	Occasional in cleaner monsoon flows
Tor khudree (Sykes)	Cyprinidae	Sensitive	VU	Absent	<3 mg/L	EXTIRPATED	BOD exceedances eliminate this species; IUCN Vulnerable
Puntius sahyadriensis Silas	Cyprinidae	Sensitive	VU	Absent	<3 mg/L	EXTIRPATED	W. Ghats endemic; pristine habitat essential; VU
Anguilla bengalensis (Gray)	Anguillidae	Moderate	VU	Absent	<6 mg/L	EXTIRPATED	Migratory corridor disrupted by weirs and pollution; VU
Wallago attu (Schneider)	Siluridae	Sensitive	VU	Absent	<5 mg/L	EXTIRPATED	Apex predator; requires structurally complex clean habitat; VU
Ompok bimaculatus (Bloch)	Siluridae	Sensitive	LC	Absent	<5 mg/L	EXTIRPATED	Disappeared Patalganga within one year of BOD rise
Mystus seenghala (Sykes)	Bagridae	Moderate	VU	Absent	<8 mg/L	EXTIRPATED	Large catfish requiring clean benthos; VU
Nemacheilus anguilla Annandale	Balitoridae	Highly Sensitive	LC	Absent	<3 mg/L	EXTIRPATED	Loach; requires well-oxygenated gravelly substrate
Neolissocheilus hexagonolepis (McClelland)	Cyprinidae	Highly Sensitive	NT	Absent	<2 mg/L	EXTIRPATED	Mahseer relative; requires pristine fast-flowing water; NT

Table 1.3: Projected Kalundre fish assemblage. PROBABLE (8 species, green) = likely present year-round; POSSIBLE (4 species, amber) = seasonal occurrence; EXTIRPATED (8 species, red) = eliminated by documented BOD/DO conditions. Four IUCN Vulnerable taxa are among the extirpated group.

Biodiversity Collapse: Mechanisms and Evidence

Kalundre falls into the "severely degraded" category with an estimated Shannon H' of 1.10 -- below values obtained on the worst impacted rivers in Raigad (Bhogawati H' = 2.08 and Patalganga H' = 2.32). This gap between 2.08 and 1.10 represents the structural impoverishment versus the functional collapse of a community. A

functioning community has all of its members present (apex predators, benthic processors, mid-water planktivores, ecosystem engineers), while a community approaching functional collapse has lost all of these except the survivors (air breathing specialists and exotic introductions that now have no competition). It is the loss of four IUCN vulnerable species (Tor khudree, Puntius sahyadriensis, Wallago attu and Anguilla



bengalensis) that links this study to a broader conservation urgency.

high-stress end of this empirically-based relationship is therefore entirely logical.

Significance and Limitations

By its very nature, this study is a secondary data analysis; thus, the predictions it provides are based upon inference from analog systems rather than actual observation. The EnACT 2015–16 data represents a single sampling event (a "snapshot") at a single upstream point of entry. Thus, no information can be obtained regarding longitudinal water quality gradients or possible micro-habitats that could isolate sensitive populations. It is essential to state these limitations. The main value of this analysis is to document the available baseline evidence necessary to justify a properly funded field study. A 12-month ichthyological survey conducted along five longitudinal transects and involving three seasonal sampling events will convert the predictions provided herein into empirical results. Through use of a Pearson $r = -0.912$ correlation coefficient, across eight independent river systems, the secondary data approach has demonstrated convincingly the magnitude and consistency of the urban stress profile. In light of the documentation of water quality, land-use, and absence of sewage treatment, the Kalundre's position at the extreme high-stress end of this empirically-based relationship is therefore entirely logical.

CONCLUSIONS

This study presents the first quantified biodiversity assessment of the Kalundre River, Panvel, derived from a structured meta-analysis of 12 secondary data sources. Four conclusions emerge from the evidence.

Four principal conclusions of the study.

The Kalundre is not a river that has been destroyed. Rather, it is a river that is in the course of destruction. The process of this destruction is presently un-monitored, un-documented, and un-addressed by the regulatory

infrastructure designed to stop such occurrences. The 216 freshwater fish species identified across Maharashtra; and the nine threatened taxa confirmed from Raigad District alone, do not exist simply as abstracts within databases. These represent the living capital of an aquatic ecosystem that originally flowed undisturbed from the forested Western Ghats to the mangrove covered creek of Panvel. The Kalundre represents what happens in the void created between these two systems when the water flowing through it can no longer support the biological life it was intended to carry.

Severe loss of diversity predicted. Kalundre can be expected to have only 8 – 12 species (Shannon $H' \approx 1.10$) in the future; an estimated decrease of 67 – 75 percent from the expected number of 35 species for a similar size watershed. This prediction was made using data from a strong Pearson correlation ($r = -0.912$, $p = 0.0018$) developed across eight other Raigad and Maharashtra Rivers that are analogues of the Kalundre River. The results were further supported by a WQI-based regression analysis ($r = 0.913$, $p = 0.0017$).

IUCN vulnerable species forecast to be extinct by the year 2050 and which have been reported in Raigad District — *tor khudree*, *puntius sahyadriensis*, *wallago attu*, and *anguilla bengalensis* — cannot survive under water quality conditions documented in Kalundre. All of these species are over their published survival limits for the BOD exceedances of 4-6 times the standard for class-c (is:2296) at downstream sites. Water quality crisis: Of 136 different combinations for the site parameters, 42 (30.9%) had parameter values that are in excess of those contained in the British Standard Code of Practice for Water Quality for Agricultural Use (IS:2296). Additionally, three of the sites exhibited class E (very poor) water quality. The site, SW-3, recorded an electrical conductivity value of 2,720 micro-Siemens per centimeter ($\mu\text{S}/\text{cm}$) which is approximately 1.2 times the British Standard for



Electrical Conductivity; the Chemical Oxygen Demand (COD) was recorded to be as high as 74 milligrams per liter (mg/L) at some of the surface water sampling locations and ranged from 27 to 74 mg/L at all surface water sampling locations; and dissolved oxygen (DO) levels were near the minimum survival limit of 4.0 milligrams per liter (mg/L) for aquatic life. secondary data) of the status of fish diversity for the river and is the first to place Kalundre's current condition as part of documented decline of urban rivers in Raigad district. The study will provide the specific locations, time frames and parameters that a follow-up field study would need to investigate and locate Kalundre in relation to Maharashtra's obligation under the Biological Diversity Act and its registration requirements in People's Biodiversity Registers.

Conflict of Interest: The authors declare no conflict of interest.

Data Availability: All secondary data sources are publicly available and fully cited.

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