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Thermal Stress and Aquatic Degradation: Assessing the Impact of Extreme Summer Temperatures on Macroinvertebrate and Fish Biodiversity from Waghadi River in Ghatanji, Dist. Yavatmal.

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Abstract: *Seasonal temperature spikes present a severe threat to lotic ecosystems in semi-arid regions of Maharashtra. This study investigates the impact of extreme hot summer temperatures on the abundance and biodiversity of aquatic fauna in the Waghadi River, located in Ghatanji, District Yavatmal. The Study carried out in 2026 Pre-summer months (Feb) and Peak- summer months (April, May). Water quality parameters and biological indicators (zooplankton, macroinvertebrates, and fish species) were monitored across pre-summer (February) and peak-summer (May) periods. The results indicate that elevated summer temperatures often exceeding 40C ambient and 34C water temperature induce severe thermal stress, drastic reduction in dissolved oxygen (DO), and high evaporation rates, leading to habitat fragmentation. A significant decline in species richness and a shift toward pollution-tolerant taxa were observed during peak summer. This study underscores the urgent need for local riparian management and conservation strategies to mitigate climate-induced thermal degradation in local river systems.*

Keywords: Aquatic Ecosystem, Diversity, Physiochemical parameter, Thermal stress

I. INTRODUCTION

Water is probably the only natural resource to touch all aspects of human civilization from agricultural and industrial development and having the cultural and religious values. Water is a necessity for all living beings, without it; there would be no life. Degradation in ecology is correlated to depletion in the basic natural resources in quality as well as in quantity. Freshwater, a basic life supporting system is one of the main natural resources is on decline. In the recent years this situation is aggravated by the impacts of climate change as a result of global warming. Depletion and degradation in the natural and manmade water resources directly influences life in mosaic of ecosystems and habitats, natural cycles and ultimately the biodiversity, including man.

Aquatic ecosystems in tropical and semi-arid regions are highly vulnerable to seasonal climate fluctuations. Temperature is a primary abiotic driver that governs the metabolic rates, physiological processes, and life cycles of aquatic organisms. The Waghadi River, flowing through the Ghatanji taluka of Yavatmal district, Maharashtra, serves as a vital lifeline for local agriculture, domestic use, and regional biodiversity. However, Yavatmal regularly experiences extreme summer heatwaves, with ambient temperatures frequently soaring between 42C and 47C. During these peak summer months, the Waghadi River experiences: Severe water volume reduction and pool fragmentation. Accelerated eutrophication and concentrated anthropogenic pollutants. Critical thermal stress on endemic aquatic biota.This research aims to evaluate how these extreme summer temperatures affect the overall abundance, distribution, and biodiversity of the river's aquatic ecosystem.

II. MATERIALS AND METHODS

2.1 Study Area

The study will focus on the Waghadi River, which is one of the most significant tributaries of the Painganga River. It streaches approximately 80 km and originates from various cities in the Yavatmal District, including Ghatanji, Kalamb, Pandharkawada, and Yavatmal. The Waghadi River passes through several villages that are close to these cities The study was conducted along a stretch of the Waghadi River in Ghatanji, Yavatmal. Three distinct sampling stations (S1: Upstream, S2: Midstream near urban runoff, S3: Downstream) were selected based on varying levels of human intervention and water depth.

Station 1 **Station 2**

Station 3

2.2 Physico-Chemical Analysis

To understand the seasonal variations in water quality, parameters were assessed bi-weekly from February (Pre-summer) through April-May (Peak-summer). This timeframe was selected to capture the transition from moderate climatic conditions to the intense heat and evaporation characteristic of the peak-summer months.

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Water samples were collected at consistent intervals to ensure statistical representation across the study period. All collection procedures adhered to standard protocols to minimize contamination and ensure sample integrity from the point of collection to the point of analysis. Collection done bi-weekly between February (Pre-summer) and April-May (Peak-summer). Surface water temperature, pH, and Dissolved Oxygen (DO) were measured on-site using digital probes and standard Winkler's titration methods.

2.3 Biological Sampling

Biological sampling was conducted concurrently with physico-chemical analysis to evaluate the community structure and ecological health of the study site across the pre-summer to peak-summer gradient. Diverse collection techniques were employed to target specific trophic levels and taxonomic groups.

Zooplankton & Phytoplankton: Collected using standard plankton nets (mesh size 50mm) and preserved in 4% formalin. Macroinvertebrates: Gathered using kick-nets and manual sorting from under rocks. Ichthyofauna (Fish): Sampled with the help of local fishermen using cast nets. Fish species were identified on-site using standard taxonomic keys. Morphometric measurements (total length and weight) were recorded, and after documentation, the majority of specimens were released back into the water to minimize ecological impact.

III. RESULTS AND DISCUSSION

3.1 Physico-Chemical Shifts:

As ambient temperatures climbed, water quality deteriorated significantly. The inverse relationship between water temperature and dissolved oxygen was starkly evident.

Parameters	Pre-Summer (Jan-Feb) Average	Peak- Summer (March-April-May)	Impact Assessment
Ambient Temperature (°C)	31.5	44.2	Drastic atmospheric heating
Water Temperature(°C)	24.8	33.5	Approaching critical thermal limits
Dissolved Oxygen (mg/L)	7.4	3.8	Hypoxic conditions dangerous for fish
pH Level	7.6	8.4	Increased alkalinity due to concentration
Total Dissolved Solids (mg/L)	280	590	Severe evaporation concentrates ions

Table 1: overall Analysis of Physiochemical parameter

3.2 Impact on Aquatic Biodiversity

Biodiversity Collapse Note: Extreme heat creates "ecological bottlenecks." Species unable to tolerate high temperatures or low DO either perish or migrate to deeper, shaded pools, resulting in a localized collapse of biodiversity.

Plankton Abundance: Pre-summer collections showed a healthy balance of diatoms and green algae. In contrast, peak-summer samples were dominated by cyanobacteria (blue-green algae), which thrive in warmer, nutrient-rich waters, forming toxic algal blooms.

Macroinvertebrates: Sensitive taxa like Ephemeroptera (mayflies) and Trichoptera (caddisflies) vanished almost entirely by May. They were replaced by highly resilient, pollution-tolerant species like Chironomidae larvae (bloodworms) and Physae (snails).

Fish Diversity: Major carps (Labeo rohita, Catla catla) showed signs of severe respiratory stress and localized mortality in shallow pools. Hardy air-breathing species like Channa marulius (Snakehead) and Clarias batrachus (Magur) managed to persist, skewing the overall biodiversity index.

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Aquatic Species Group/ Taxa	Pre-Summer (February-2026)	Peak-Summer (April-May-2026)	Ecological Context & Key Drivers
Phytoplankton: Green Algae & Diatoms	+ +	_	Die off due to water temperatures exceeding 33°C.
Phytoplankton: Cyanobacteria (Blue-Green)	+	+ +	Thrives in warm, nutrient-rich water to form toxic blooms.
Zooplankton (*Daphnia*, *Cyclops*)	+ +	_	Suffers massive starvation due to the green algae crash.
Macroinvertebrates: Sensitive Taxa *(Mayflies/Caddisflies)*	+ +	_	Vanish almost entirely due to low DO and high thermal stress.
Macroinvertebrates: Tolerant Taxa *(Bloodworms/Snails)*	+	+ +	Highly resilient; replaces sensitive species in polluted zones.
Fish: Native Major Carps *(Rohu, Catla)*	+ +	_	Experience severe respiratory stress and localized mortality in pools.
Fish: Air-Breathing Species *(Snakehead, Magur)*	+	++	Persist and dominate the shrinking, hypoxic pool traps.

Table 2: Abundancy pattern of Aquatic Species

3.3 Disruption of Trophic Interdependencies and Food Web Collapse

In a balanced lotic ecosystem like the Waghadi River, aquatic species do not exist in isolation; they are bound by intricate trophic links (predator-prey relationships) and symbiotic dependencies. High summer temperatures act as a systemic shockwave, triggering cascading failures across these ecological networks.

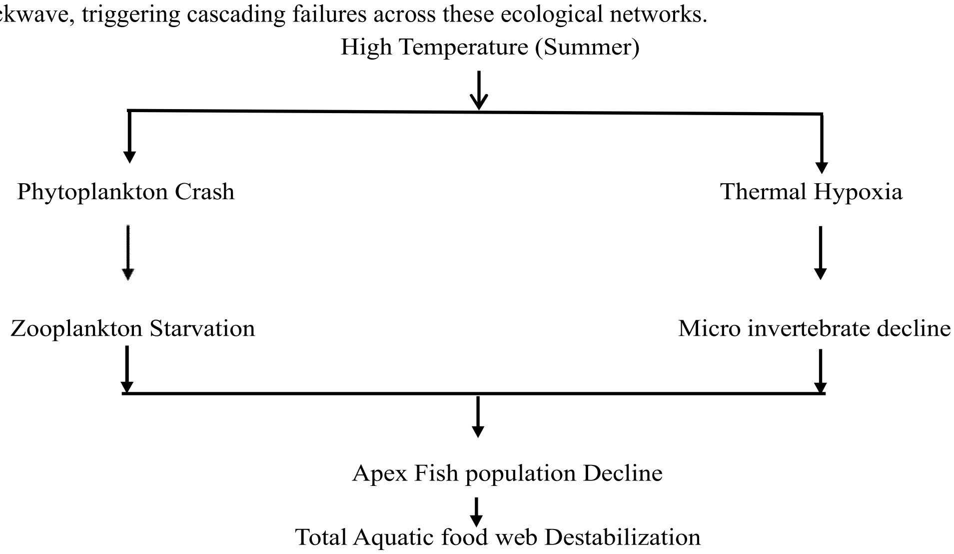

Fig.1: Impact of Heat stress

1. Bottom-Up Trophic Cascades (Plankton to Micro-consumers) Phytoplankton form the primary trophic base of the Waghadi River. When water temperatures exceed 33°c, sensitive green algae die off, replaced by unpalatable, toxin-producing cyanobacteria (blue-green algae). The Interdependency: Primary consumers like zooplankton (Daphnia, Cyclops) rely heavily on green algae for food. Temperature Impact: Because zooplankton cannot digest cyanobacteria,

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they suffer massive starvation and reproductive failure. This sudden collapse of the zooplankton population starves the small juvenile fish that depend entirely on them for protein.

2.Loss of Key Macroinvertebrate Foraging Links Benthic macroinvertebrates serve as the vital energetic bridge between decaying organic matter and higher vertebrates (fishes and amphibians). The Interdependency: Predatory macroinvertebrates control pest populations (like mosquito larvae), while scraper and shredder insects keep algal growth checked and clean the riverbed.
Temperature Impact: Under thermal stress and low dissolved oxygen, sensitive shredders like mayfly and caddisfly nymphs disappear. Without these shredders, organic leaf litter rots at an accelerated, unconsumed rate, fueling further bacterial growth and oxygen depletion. Consequently, insectivorous fish lose their primary summer food source, forcing them into starvation.

3.Habitat Co-dependence and the Pool Trap:
As the Waghadi River dries and breaks into isolated pools during May, various species are forced into high-density, confined micro-habitats. The Interdependency: Larger predatory fish rely on the presence of structural shelter (submerged weeds, roots) and a steady supply of smaller prey fish to survive the dry season.
Temperature Impact: Elevated temperatures accelerate the decay of aquatic vegetation, destroying hiding spots. In these shrinking, unshaded pools, prey and predators are packed tightly together. Initially, this leads to over-predation (predators rapidly exhausting their food supply). Once the smaller prey species are eradicated, the apex predators (Channa, Clarias) face starvation, compounding the stress of the already hypoxic, overheated water.

4. Breakdown of Host-Parasite and Symbiotic Cycles
Certain species rely on others to complete their life cycles. For instance, freshwater mussels (Unionidae) produce larvae (glochidia) that must temporarily attach to the gills of specific host fish to develop.
The Interdependency: Mussel populations depend strictly on the presence and migration of native fish.
Temperature Impact: If the host fish species migrate away to escape hot zones, or die from thermal shock, the reproductive cycle of the freshwater mussel is completely severed. The long-term loss of these filter-feeding mussels severely damages water filtration capacity, leading to permanently cloudier, more polluted river water.

IV. CONCLUSION AND RECOMMENDATIONS

The study conducted during the 2026 summer months along the Waghadi River provides definitive evidence that extreme seasonal temperature spikes driven by regional climate change and anthropogenic pressures pose a critical threat to semi-arid lotic ecosystems. The research successfully demonstrates a direct link between severe physical degradation and a localized collapse of biological diversity.
The Waghadi River ecosystem is under immense ecological strain due to elevated summer temperatures, a situation further exacerbated by regional climate change and water abstraction. The dangerous drop in Dissolved Oxygen combined with concentrated thermal stress significantly reduces species richness, shifting the ecosystem from a diverse lotic community to a simplified, highly stressed habitat dominated by pollution-tolerant species.

Physico-Chemical Degradation
As ambient summer temperatures soared between 42°C and 47°C, the river's water temperature climbed to an average of 33.5°C, approaching critical thermal limits for aquatic life. This extreme heat triggered heavy evaporation, leading to severe habitat fragmentation and water volume reduction that broke the river into isolated "pool traps". Concurrently, water quality deteriorated sharply: Total Dissolved Solids (TDS) doubled to 590 mg/L, alkalinity increased (pH 8.4), and Dissolved Oxygen (DO) plunged to a hypoxic and dangerous 3.8 mg/L.

Biodiversity Collapse & Community Shifts

The combined forces of thermal stress and hypoxia created severe ecological bottlenecks, resulting in a dramatic loss of species richness and a heavily skewed biodiversity index: Planktons**:** Highly nutritious diatoms and green algae vanished, replaced by unpalatable, toxin-producing cyanobacteria (blue-green algae) blooms. Macroinvertebrates**:** Clean-water indicators like mayflies (*Ephemeroptera*) and caddisflies (*Trichoptera*) completely disappeared, leaving the benthic community dominated by resilient, pollution-tolerant taxa like bloodworms (*Chironomidae*) and snails (*Physae*). Fish**:** Sensitive native major carps (*Labeo rohita*, *Catla catla*) suffered severe respiratory stress and localized mortality, shifting the community dominance entirely to ultra-hardy, air-breathing species like Snakehead (*Channa marulius*) and Magur (*Clarias batrachus*).

Cascading Trophic Failure

The degradation was not isolated to individual species but caused a systemic breakdown of the entire aquatic food web. The inability of zooplankton to digest blue-green algae triggered a bottom-up starvation cascade that decimated primary consumers and juvenile fish. Furthermore, forced crowding in shrinking pools led to temporary over-predation, which quickly gave way to apex predator starvation. Long-term symbiotic cycles were also severed, as the loss of host fish halted the reproduction of filter-feeding freshwater mussels, permanently damaging the river's natural filtration capacity.

Proposed Mitigation Strategies:

Riparian Reforestation: Planting native trees along the banks of the Waghadi River to create canopy cover, effectively shading the water and reducing summer surface water temperatures by 2°C to 4°C.

Desilting and Pool Creation: Strategic desilting of the riverbed to maintain deeper pools that provide thermal refugia for fish during dry spells.

Strict Effluent Regulation: Restricting domestic and agricultural runoff into the river during summer to prevent catastrophic eutrophication and oxygen depletion.

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