Impact of River Water Pollution on Growth Performance and Condition Factor of (Channa punctatus) in District Shahjahanpur, Uttar Pradesh, India

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Abstract: *The present study investigates the physicochemical parameters of river water and their impact on the growth performance of Channa punctatus in District Shahjahanpur, Uttar Pradesh. Water quality analysis revealed elevated temperature (40.4°C air, 31.5°C water), high turbidity (27.60 NTU), alkaline pH (8.62), and organic pollution indicators including low dissolved oxygen (5.14 mg/l), elevated biological oxygen demand (6.84 mg/l), and chemical oxygen demand (43.60 mg/l). Comparative assessment of fish populations between clear water (Group A) and polluted water (Group B) sites demonstrated significant reductions in growth parameters: average length decreased by 2.79%, average weight reduced by 32.12%, and condition factor (K) declined by 25.85% in polluted habitats. Size-class analysis revealed that smaller individuals (6-9 cm) showed greater pollution sensitivity with 30.60% weight reduction compared to 32.89% in larger individuals (11-16 cm). The condition factor declined from 1.47±0.17 in clear water to 1.09±0.22 in polluted water, indicating poor health status in contaminated environments. These findings establish clear linkages between water quality degradation and impaired fish growth, highlighting the need for urgent conservation measures in Shahjahanpur's riverine ecosystems.*

Keywords: *Channa punctatus, water pollution, condition factor, length-weight relationship, river health, Shahjahanpur*

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Introduction

Freshwater ecosystems everywhere are under serious threat, and it's pretty much because of us—industrial waste, runoff from farms, and untreated sewage all end up in rivers and lakes, ruining water quality and wiping out aquatic life (Islam, M.M., et al. 2025). Rivers that wind through cities and industrial zones get hit the hardest. They collect a mess of pollutants— heavy metals, chemicals, all sorts of organic junk—that make it tough, sometimes impossible, for fish and other creatures to survive (Jargal, N., et al. 2024). In India, rapid industrial growth and booming cities have only made things worse. Many rivers now carry untreated or barely treated wastewater, decimating fish populations and hurting the people who rely on fishing to make a living.

Channa punctatus (Bloch, 1793), a hardy, air-breathing freshwater fish, is found all across the Indian subcontinent and plays a big role in local fisheries. Because it's tough, can handle low oxygen, and sits high up the food chain, it's often used to monitor water pollution. As a predator that eats smaller fish, crustaceans, and insects, C. punctatus tends to pick up pollutants through its food. This means pollution hits it especially hard, building up over time (Jhan, N. & Chandra, R. 2010). Studies already show that when this fish accumulates too much heavy metal, its growth and ability to reproduce take a hit—which could spell trouble for the whole fishery in the long run.

One way to check a fish's health is by looking at its condition factor (K), which comes from comparing its length and weight. If the value drops below 1.0, it's a red flag—poor nutrition, stress, or a bad environment are likely to blame (ICSF, 2021). The length-weight relationship also tells us how a fish grows: the exponent 'b' shows if it's growing evenly (b=3) or not, and pollution can mess with this balance. In Uttar Pradesh's Shahjahanpur district, several rivers flow—including the Garra, which joins the Ganga. Fish kills have happened here before, mostly because factories along the river dump toxic waste straight into the water (APHA, 2017). Pesticide plants and other industries have been caught releasing untreated, poisonous effluents, leading to mass die-offs

and long-term ecological damage. Even with all this, there hasn't been much research on how pollution affects fish health in this area, especially when the damage isn't immediately obvious.

This study set out to do three things: first, to measure key water quality parameters at different sites in Shahjahanpur; second, to compare how C. punctatus populations are doing—looking at their length, weight, and condition factor—in clean versus polluted water; and third, to figure out exactly how much pollution is changing their growth. The results give us a starting point for monitoring the health of these rivers and can help guide future conservation efforts.

Materials and Methods

Study Area

This study took place in the river systems around Shahjahanpur District, Uttar Pradesh, India (about 27°88'N, 79°91'E). We picked two different types of sites for comparison: clear water areas (Group A) with little human activity, and polluted sites (Group B) where factories and homes dump their wastewater. For the polluted sites, we focused on spots near known industrial discharge points, especially around pesticide factories—places that have already been linked to fish kills in the past (APHA, 2017).

Water Quality Analysis

We collected water samples from both types of sites throughout the study. We checked a range of physicochemical features: color (by eye), smell, air and water temperature, turbidity, pH, dissolved oxygen (DO), biological oxygen demand (BOD), and chemical oxygen demand (COD). We used a mercury thermometer for temperature, measured turbidity with the nephelometric method (NTU), checked pH with a digital meter, measured DO using Winkler's titration, BOD after 5 days at 20°C, and COD by the dichromate reflux method, following standard procedures (Jhan, N. & Chandra, R. 2010). For accuracy, we ran each test three times and reported averages with standard error where it made sense.

Fish Collection and Biometry

We caught 120 Channa punctatus from both site types, using cast and gill nets with help from local fishermen. Fish were sorted into two size groups by total length: small (6–9 cm) and medium (11–16 cm). For the clear water sites, these groups were labeled A-I and A-II; for the polluted sites, B-I and B-II. Dividing them up this way helped us see how pollution affects different life stages.We measured total length from snout to tail tip on a board accurate to 0.1 cm, and weighed each fish on an electronic scale (0.01 g precision) after gently blotting off extra water. All measurements came from fresh fish, right after catching, to avoid any drying

that might throw off the numbers.2.4 Condition Factor Calculation

The condition factor (K) was calculated using Fulton's condition factor formula:

$$K = (W / L^3) \times 100$$

where W = body weight in grams, L = total length in centimeters, and the factor 100 is used to bring the value close to unity . This index assumes isometric growth and provides a measure of fish plumpness and general well-being. Values of K around 1.0 indicate good condition, while values substantially below 1.0 suggest poor nutritional status or environmental stress.

Results

Water Quality Parameters

Physicochemical analysis of water from the study sites revealed marked differences in quality parameters, with polluted sites showing signs of organic enrichment and reduced oxygen status (Table 1). Water colour at polluted sites was described as brownish with foul odour, indicating organic pollution and possible industrial contamination.

Table 1: Physicochemical Parameters of River Water at Study Sites in District Shahjahanpur

Parameter	Value
Colour	Brownish
Odour	Foul smell
Air Temperature (°C)	40.4
Water Temperature (°C)	31.5 ± 0.173
Turbidity (NTU)	27.60 ± 0.017

pH	8.62 ± 0.017
Dissolved Oxygen (mg/l)	5.14 ± 0.033
BOD (mg/l)	6.84 ± 0.136
COD (mg/l)	43.60 ± 0.569

The water was pretty warm at 31.5°C—warm enough to speed up how fast things live and grow, but it also means there's less oxygen dissolved in the water. Turbidity was high (27.60 NTU), so there's a lot of stuff floating around—maybe from factories or just organic gunk. The pH was 8.62, which is on the alkaline side, hinting at possible contamination from some kind of industrial waste. Dissolved oxygen came in at 5.14 mg/l, which is lower than what tropical freshwater fish really need (they do best with 6-8 mg/l), so you can bet the fish and other creatures are feeling the strain. The BOD was 6.84 mg/l and COD shot up to 43.60 mg/l. Those numbers tell you there's a lot of organic pollution, and with COD so much higher than BOD, it points to chemical pollutants in the mix—probably from industrial sources.

Length-Weight Relationships and Condition Factor

Comparative analysis of Channa punctatus populations between clear water (Group A) and polluted water (Group B) sites revealed consistent reductions in growth parameters across both size classes (Table 2).

Table 2: Length, Weight and Condition Factor of Channa punctatus in Clear Water and Polluted Water Habitats

Group	Size Class	Length (cm)	Weight (g)	K factor (%)
Group A (Clear water)				
	A-I (6-9 cm)	8.12 ± 0.88	10.13 ± 0.02	1.89 ± 0.03
	A-II (11-16 cm)	12.67 ± 0.05	21.38 ± 0.08	1.05 ± 0.13
	Average	**10.39 ± 0.442**	**15.75 ± 0.05**	**1.47 ± 0.17**
Group B (Polluted water)				
	B-I (6-9 cm)	7.88 ± 0.07	7.03 ± 0.07	1.43 ± 0.06
	B-II (11-16 cm)	12.32 ± 0.05	14.35 ± 0.02	0.76 ± 0.19
	Average	**10.10 ± 0.06**	**10.69 ± 0.04**	**1.09 ± 0.22**
Percentage Change		**2.79%**	**32.12%**	**25.85%**

In clear water, the smaller fish (A-I: 6-9 cm) averaged around 8.1 cm in length and weighed just over 10 grams. Their condition factor reached 1.89, indicating they were in excellent condition. The medium-sized group (A-II: 11-

16 cm) grew as expected, reaching about 12.7 cm and 21.4 grams, with a condition factor of 1.05. That's still considered healthy, since anything above 1.0 means they're doing well. However, things were different in polluted water. The small fish there (B-I) didn't grow as much. They were slightly shorter (7.88 cm, a decrease of almost 3%) and much lighter (only 7 grams, about 30% less than those in clean water). Their condition factor dropped to 1.43, not as good—a decrease of about 24%. The medium-sized fish (B-II) fared even worse. Their length dropped a bit to 12.3 cm (almost 3% less), but their weight fell sharply to just 14.4 grams—a reduction of nearly 33%. Most concerning, their condition factor sank to 0.76. That's below 1.0, which signals significant stress and poor health.

Overall Population Effects

When considering both size groups together, fish from the clear water (Group A) had an average length of 10.39 cm, an average weight of 15.75 grams, and a condition factor of 1.47. In contrast, fish from polluted water (Group B) showed a slight decrease in average length to 10.10 cm, but their average weight dropped much more, down to 10.69 grams. Their condition factor also decreased to 1.09. This means that, compared to fish in clear water, those living in polluted environments were almost 3% shorter, about a third lighter, and their condition factor was roughly 26% lower

(see Figure 1). The main point isn't just that they are a bit smaller—the much greater loss in weight compared to length suggests that pollution seriously affects their energy stores and general health. These fish become thinner and less robust, with reduced energy reserves in their bodies.

Size-class analysis revealed differential sensitivity to pollution stress. Small individuals (6-9 cm) in polluted water showed 30.60% weight reduction compared to clear water counterparts of the same size class. Medium-sized individuals (11-16 cm) showed slightly greater weight reduction (32.89%), suggesting that larger fish, with their longer exposure history and higher trophic position, may accumulate greater pollutant burdens.

The condition factor decline was more pronounced in medium-sized fish (27.62% reduction from 1.05 to 0.76) compared to small fish (24.34% reduction from 1.89 to 1.43). This differential response likely reflects both cumulative exposure effects and the higher metabolic demands of larger individuals, making them more susceptible to pollution-induced stress.

Discussion

The findings from this study clearly show that Shahjahanpur's rivers are facing significant organic and chemical pollution. The numbers speak for themselves—BOD is at 6.84 mg/l and COD reaches 43.60 mg/l. These values are well

above safe levels for fish (ideally, BOD shouldn't exceed 3 mg/l if you want healthy fish populations). The COD to BOD ratio is about 6.4 to 1, indicating there's more than just typical organic pollution at play. This suggests the presence of industrial chemicals, maybe even some harmful xenobiotics. Dissolved oxygen measures 5.14 mg/l. While that's above the bare minimum that fish need to survive (generally around 4 mg/l), it's still not enough for them to thrive, grow, or reproduce normally. Channa punctatus, a species that can breathe air thanks to specialized organs, manages to cope with these harsh conditions better than species that rely only on water-breathing. That probably explains why they're still found in these rivers even when other, more sensitive fish have vanished. Still, they aren't completely safe—lower condition factors show that being able to breathe air doesn't fully protect them from the effects of pollution.

The pH level is another concern. It's at 8.62, higher than the usual freshwater range of 6.5 to 8.0. This is likely due to factories releasing alkaline waste into the river. Higher pH makes ammonia more toxic, further stressing aquatic life. Turbidity is also high at 27.60 NTU. This reduces light penetration, which hampers photosynthesis, and makes it harder for sight-hunting fish to find food. Overall, these water quality problems are similar to what's seen in polluted rivers worldwide. Industrial and

municipal waste combine to create a complex mix of stressors that severely affect fish communities. The high temperatures don't help either—31.5°C in the water and 40.4°C in the air. While some of this is likely seasonal, it could also point to factories discharging hot water, making matters worse. Warmer water holds less oxygen, so fish have an even harder time surviving.

Pollution Impacts on Fish Growth

C. punctatus from polluted environments lost an average of 32.12% of their body weight—a significant drop that seriously impacts their growth and, frankly, spells trouble for fishery yields. This matches earlier research showing that heavy metal contamination in Bangladesh's rivers reduces both growth and reproductive health in C. punctata. Fish from these polluted waters just don't do well; they show poor results on wellness indices and their growth rates actually decline.

The causes behind this aren't straightforward. Pollution puts the fish under stress, forcing their bodies to work harder to detoxify—boosting antioxidant enzymes, increasing metallothionein production, and repairing cellular damage (Hore, M., et al. 2025). All this extra effort burns up energy that would normally go into growth. Plus, pollution can lower their appetite or interfere with digestion, so even when the fish eat, they don't absorb as much nutrition. There's also real internal

damage—liver, kidney, gills—that disrupts vital functions required for growth.

It's notable that weight drops much more than length (32.12% compared to 2.79%). This suggests pollution mainly depletes tissue and energy reserves, rather than affecting bone growth. The condition factor backs this up: fish from polluted habitats have K values 25.85% lower than those from clean environments. For mid-sized fish, the condition factor falls to 0.76—below 1.0—which is concerning. When this value drops under one, it usually signals poor nutrition, not enough energy reserves, and a higher risk of disease and stress.

The differential response between size classes provides insights into pollution exposure dynamics. Smaller fish (6-9 cm) in polluted water, while showing substantial weight reduction (30.60%), maintained condition factor above 1.0 (1.43). This may reflect shorter exposure duration, lower trophic position with reduced bioaccumulation, or ontogenetic differences in pollutant handling capacity. Medium-sized fish (11-16 cm), with longer environmental exposure and higher trophic feeding habits, accumulate greater pollutant burdens and show more severe condition decline (K=0.76). This pattern aligns with bioaccumulation dynamics documented for Channa punctatus in contaminated environments. As a predatory species feeding on smaller fish and invertebrates, C. punctatus occupies a higher trophic position and accumulates pollutants through dietary transfer in addition to branchial uptake. Studies in Bangladesh detected significant concentrations of cadmium, chromium, mercury, and lead in C. punctata muscle tissues from polluted rivers, with corresponding impairments in growth and reproductive parameters. The size-dependent accumulation pattern means that larger, older individuals in contaminated sites carry higher pollutant loads and show more pronounced physiological effects.

The findings of this study must be interpreted within the regional context of industrial pollution in Shahjahanpur district. Previous investigations have documented fish mortality events in the Ganga River system attributed to toxic effluents from industrial units in Shahjahanpur. Pesticide manufacturing units operating along riverbanks have been implicated in discharging untreated effluents containing toxic substances that poison river water, causing downstream fish kills extending into Kannauj and Unnao districts. The Garra River, originating from Shahjahanpur and merging with the Ganga, has been specifically identified as a conduit for industrial pollutants. The water quality parameters recorded in this study—particularly elevated COD and reduced DO—are consistent with inputs from industrial sources. Pesticide manufacturing effluents typically contain complex organic compounds,

solvents, and heavy metals that contribute to chemical oxygen demand while being resistant to biological degradation. The foul odour and brownish coloration observed further support industrial contamination. The biological impacts documented here—32% weight reduction and 26% condition factor decline—represent sublethal effects that precede and predict the acute mortality events occasionally observed. Chronic exposure to sublethal pollutant concentrations erodes population health, reduces reproductive output, and diminishes fishery productivity even in the absence of overt mortality. The condition factor decline to 0.76 in medium-sized fish suggests that these populations are operating under severe physiological stress, with reduced capacity to withstand additional environmental perturbations.

Conclusion

This study provides empirical evidence that water pollution in river systems of District Shahjahanpur significantly impairs the growth performance and physiological condition of Channa punctatus. Polluted habitats characterized by elevated BOD, COD, turbidity, and reduced dissolved oxygen support fish populations with 32.12% lower body weight and 25.85% reduced condition factor compared to clear water reference sites. The condition factor decline to 0.76 in medium-sized fish from polluted water indicates severe

physiological stress and poor habitat quality. These findings establish clear linkages between water quality degradation and fish health, highlighting the need for urgent interventions to control industrial effluent discharge into river systems. Regular biomonitoring using C. punctatus as a sentinel species, combined with pollution abatement measures, is essential for sustaining fishery resources and protecting the ecological integrity of Shahjahanpur's riverine ecosystems.

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