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Research paper

Population Density of *Pangasius pangasius* in Semi-Polluted and Polluted Ponds of North Bihar, India

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ABSTRACT

The present investigation was conducted to assess the population density of *Pangasius pangasius* in semi-polluted and polluted freshwater ponds of North Bihar. Fish population density was estimated through seasonal sampling conducted over one year in selected ponds representing two levels of pollution. Physico-chemical parameters such as water temperature, pH, dissolved oxygen, free carbon dioxide, total alkalinity, biological oxygen demand (BOD), and nutrient concentrations were simultaneously analyzed. The results revealed significant variations in population density between semi-polluted and polluted ponds. The average density of *P. pangasius* was higher in semi-polluted ponds (124.6 ± 12.8 individuals ha^{-1}) compared with polluted ponds (78.3 ± 10.4 individuals ha^{-1}). Seasonal fluctuations indicated maximum density during post-monsoon and minimum density during summer. Dissolved oxygen exhibited a positive correlation with fish abundance, whereas BOD and nutrient loading showed negative correlations. Reduced population density in polluted ponds was attributed to deteriorated water quality, organic pollution, and habitat degradation. The study highlights the ecological sensitivity of *P. pangasius* populations to environmental stress and emphasizes the need for improved pond management and pollution control measures for sustainable fish production in North Bihar.

1. Introduction

Freshwater ecosystems are among the most productive yet vulnerable ecological systems on Earth, supporting a wide diversity of aquatic organisms and providing essential ecosystem services to human societies. In India, freshwater ponds constitute an important component of inland fisheries, particularly in rural regions where they serve as sources of fish protein, employment, and economic security. However, rapid urbanization, agricultural intensification, industrial development, and population growth have resulted in increasing levels of environmental pollution in freshwater bodies, causing substantial alterations in aquatic biodiversity and fish populations (Dudgeon *et al*., 2006; Reid *et al*., 2013).

The discharge of domestic sewage, agricultural runoff, livestock waste, pesticides, fertilizers, and industrial effluents introduces excessive organic matter and nutrients into aquatic systems, leading to eutrophication, oxygen depletion, habitat degradation, and loss of aquatic biodiversity (Smith & Schindler, 2009). Fish are particularly sensitive to changes in water quality and are therefore widely recognized as reliable biological indicators of ecosystem health (Sarkar *et al*., 2016).

Population density is one of the most important ecological parameters used to evaluate the status of fish populations in natural and managed aquatic ecosystems. Several studies have reported that pangasius can withstand comparatively low dissolved oxygen concentrations and high stocking densities better than many other freshwater fishes (Datta *et al*., 2017; Islam *et al*., 2022). Nevertheless, prolonged exposure to polluted environments may adversely affect physiological functions, reproductive performance, immune responses, and overall population dynamics. The deterioration of water quality can significantly influence fish community composition and population structure (Kumar *et al*., 2021).

Previous investigations have primarily focused on the growth performance, breeding biology, feeding ecology, aquaculture potential, and culture practices of pangasius species (Datta *et al*., 2017; Rahman *et al*., 2019; Hossain *et al*., 2020). However, information regarding the population ecology of *Pangasius pangasius* in natural and semi-natural freshwater ponds subjected to varying degrees of pollution remains limited, particularly in the context of North Bihar.

This study aimed to estimate population density of yellow fish in semi-polluted and polluted ponds, seasonal variation in density, correlates fish abundance with environmental constraints and evaluated pollution impact on fish population.

2. Materials and Methods

The present investigation was carried out in selected freshwater ponds located in different parts of North Bihar, India, during the period from January 2025 to December 2025. For the purpose of the present study, six perennial ponds were selected based on their degree of pollution and surrounding anthropogenic activities. Three ponds were categorized as semi-polluted ponds, receiving moderate agricultural runoff and limited domestic waste inputs, whereas three ponds were classified as polluted ponds due to continuous discharge of domestic sewage, livestock waste, and other organic pollutants. Classification of ponds was based on preliminary water quality assessments and field observations following the guidelines (Wetzel, 2001; APHA, 2017). Fish specimens were collected using cast nets (mesh size 15–25 mm), drag nets, and gill nets of varying mesh sizes. The sampling effort was maintained uniformly in all ponds throughout the study period. Captured fishes were sorted, counted, and identified using standard taxonomic keys provided by Jayaram (2010).

The pollution status of ponds was evaluated using dissolved oxygen concentration, biological oxygen demand (BOD), nutrient concentration, and visible signs of anthropogenic disturbance. Ponds exhibiting higher BOD values (>5 mg L^{-1}), lower dissolved oxygen levels (<4 mg L^{-1}), and substantial organic loading were categorized as polluted, whereas ponds with moderate nutrient levels and acceptable oxygen concentrations were classified as semi-polluted polluted level categorization was adopted to evaluate fluctuations in population density and environmental variables throughout the annual cycle (Jhingaran, 1991). Simultaneously with fish sampling, water samples were collected from each station for physicochemical analysis. Water samples were transported to the laboratory in clean polyethylene bottles and analyzed according to standard procedures described (APHA, 2017).

Population density of *Pangasius pangasius* was estimated using the Catch Per Unit Effort (CPUE) approach commonly employed in freshwater fisheries investigations (King, 2007).

The population density was calculated as: Population Density (individuals ha^{-1}) = Number of *P. pangasius* captured / Effective sampling area, and, Catch per unit effort (CPUE) was expressed as: CPUE = Total number of fish captured / Netting effort (net h^{-1}). The average population density for each pond was estimated by combining monthly observations and standardizing the values to individuals per hectare.

Representative specimens of *P. pangasius* were measured for total length (cm), standard length (cm), and body weight (g). Total length was measured using a measuring board with an accuracy of 0.1 cm, while body weight was recorded using a digital balance with an accuracy of 0.01 g.

Data obtained during the study were expressed as Mean ± Standard Error (SE). Statistical analyses were performed using SPSS (Version 26.0) and Microsoft Excel. Differences in population density between semi-polluted and polluted ponds were analyzed using one-way Analysis of Variance (ANOVA). Pearson's correlation coefficient (r) was calculated to determine relationships between fish population density and physicochemical parameters. The significance level was tested at $p < 0.05$. Graphs and tables were prepared to illustrate seasonal variations and comparative population densities between pond categories.

3. Results and Observations

3.1 Physico-chemical Characteristics of Study Ponds

The physicochemical properties of the selected ponds showed considerable variation between semi-polluted and polluted habitats throughout the study period. Semi-polluted ponds maintained relatively favorable environmental conditions characterized by higher water transparency and dissolved oxygen

concentration, whereas polluted ponds exhibited elevated biological oxygen demand (BOD), nutrient enrichment, and free carbon dioxide concentration (Table 1).

Table 1 Annual Mean (±SE) about environmental factors

Parameters	Semi-polluted ponds	Polluted ponds
Water Temperature (°C)	27.6 ± 0.84	28.1 ± 0.91
Transparency (cm)	48.5 ± 3.12	24.3 ± 2.75
pH	7.42 ± 0.15	7.81 ± 0.19
Dissolved Oxygen (mg L^{-1})	6.24 ± 0.37	3.76 ± 0.42
Free CO_2 (mg L^{-1})	8.56 ± 0.72	15.82 ± 1.34
Total Alkalinity (mg L^{-1})	118.4 ± 5.6	154.7 ± 7.2
Total Hardness (mg L^{-1})	132.6 ± 6.4	171.5 ± 8.1
BOD (mg L^{-1})	3.24 ± 0.41	8.61 ± 0.83
Nitrate (mg L^{-1})	0.48 ± 0.06	1.32 ± 0.11
Phosphate (mg L^{-1})	0.23 ± 0.04	0.76 ± 0.08

Semi-polluted ponds exhibited significantly higher dissolved oxygen and transparency compared with polluted ponds. In contrast, polluted ponds recorded greater nutrient concentrations, BOD, alkalinity, and hardness, indicating higher organic loading and eutrophication.

3.2 Seasonal Population Density of *Pangasius pangasius*

The population density of *Pangasius pangasius* showed significant seasonal fluctuations in both categories of ponds. Semi-polluted ponds consistently supported greater fish abundance than polluted ponds throughout the study period (Table 2).

Table 2 Seasonal Population Density of *Pangasius pangasius* (Individuals ha^{-1})

Season	Semi-polluted Ponds	Polluted Ponds
Winter	126.0 ± 11.8	79.2 ± 8.5
Summer	108.4 ± 9.7	66.5 ± 7.1
Monsoon	121.8 ± 10.9	75.6 ± 8.3
Post-monsoon	142.3 ± 12.4	91.8 ± 9.2
Annual Mean	124.6 ± 11.2	78.3 ± 8.3

The highest density was observed during the post-monsoon season, while the lowest density occurred during summer. The annual mean density in semi-polluted ponds was approximately 59% higher than that recorded in polluted ponds.

3.3 Monthly Fluctuation in Fish Population Density

Monthly observations revealed a clear pattern of abundance variation associated with seasonal environmental changes (Fig. 1).

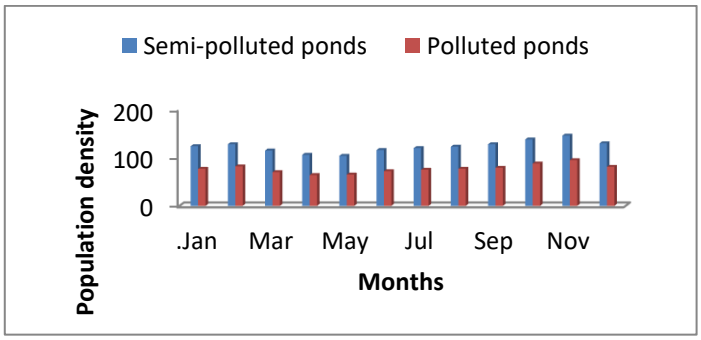


Fig. 1 *Pangassius* density in semi-polluted and polluted (Individuals ha^{-1}) ponds

The maximum population density was recorded in November, whereas minimum abundance occurred during April and May. The decline during summer coincided with elevated water temperature and reduced dissolved oxygen.

3.4 Catch Per Unit Effort (CPUE)

Catch per unit effort reflected the abundance pattern observed in population density estimates (Table 3).

Table 3 Seasonal Catch Per Unit Effort (Fish net^{-1} h^{-1})

Season	Semi-polluted Ponds	Polluted Ponds
Winter	5.6 ± 0.5	3.4 ± 0.3
Summer	4.8 ± 0.4	2.8 ± 0.2
Monsoon	5.2 ± 0.4	3.2 ± 0.3
Post-monsoon	6.4 ± 0.6	4.0 ± 0.4

The highest CPUE was observed during post-monsoon and the lowest during summer. Semi-polluted ponds consistently recorded higher CPUE values.

3.5 Morphometric Characteristics

Fish collected from semi-polluted ponds were larger in size and heavier in weight than those collected from polluted ponds (Table 4).

Table 4 Morphometric Characteristics of *Pangasius pangasius*

Parameters	Semi-polluted ponds	Polluted ponds
Total Length (cm)	38.4 ± 2.6	33.7 ± 2.4
Standard Length (cm)	31.6 ± 2.2	27.4 ± 2.0
Body Weight (g)	712.5 ± 48.6	596.3 ± 42.8

The average body weight of fish from semi-polluted ponds was approximately 19.5% higher than that recorded from polluted ponds.

3.6 Relationship Between Population Density and Water Quality

Correlation analysis indicated that population density was strongly influenced by water quality variables. The strongest positive correlation was observed

between population density and dissolved oxygen (r = +0.84), while BOD showed the strongest negative relationship (r = –0.81) (Fig. 2).

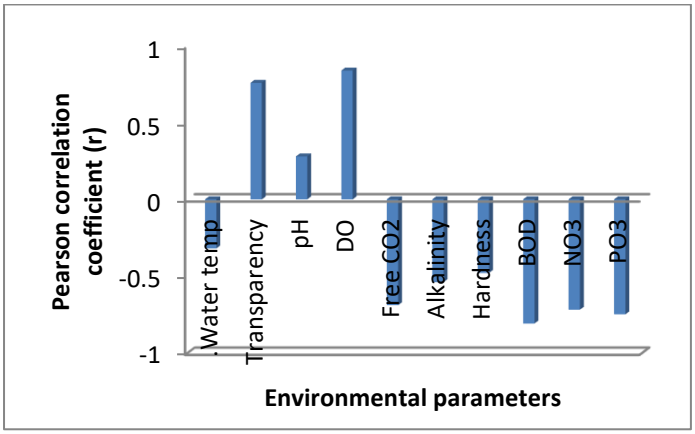


Fig. 2 Pearson's correlation coefficients for population density and environmental variables

3.7 Statistical Analysis

Analysis of variance (ANOVA) demonstrated significant differences in fish population density between semi-polluted and polluted ponds. The observed F-value indicated significant variation in population density between pond categories, suggesting a substantial effect of pollution on fish abundance (Table 5).

Table 5 ANOVA for Population Density of *Pangasius pangasius*

Source of variation	df	Sum of squares	Mean square	F-value	p-value
Between groups	1	5658.4	5658.4	16.84	<0.05
Within groups	22	7389.2	335.9	-	-
Total	23	13047.6	-	-	-

3.8 Relative Reduction in Population Density Due to Pollution

Pollution resulted in an average reduction of approximately 37% in *P. pangasius* population density. The seasonal reduction is near about similar in this study (Fig. 3).

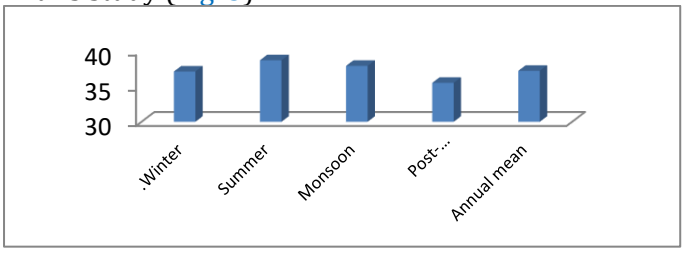


Fig. 3 Percentage reduction of Pangassius fish in polluted ponds

4. Discussion

The present investigation revealed significant differences in the population density of *Pangasius pangasius* between semi-polluted and polluted ponds of North Bihar. The higher abundance of *P. pangasius* observed in semi-polluted ponds indicates that moderate environmental conditions support better survival, growth, and recruitment of the species, whereas excessive organic pollution adversely affects its population structure. Freshwater fish populations are strongly influenced by water quality, habitat conditions, food availability, and anthropogenic disturbances, all of which regulate the carrying capacity of aquatic ecosystems (Reid *et al.*, 2019; Arthington *et al.*, 2023). Similar findings have been reported in tropical freshwater ecosystems where increasing organic pollution and eutrophication resulted in reduced fish diversity and lower population density of commercially important species (Sarkar *et al.*, 2019; Ahmed *et al.*, 2021). The decline in abundance in polluted ponds may be attributed to deterioration of habitat quality, reduced oxygen availability, accumulation of toxic metabolites, and disruption of feeding and breeding activities.

Semi-polluted ponds exhibited significantly higher dissolved oxygen levels compared with polluted ponds, which corresponded with greater abundance of *P. pangasius*. Dissolved oxygen is a critical ecological factor controlling fish metabolism, respiration, feeding efficiency, growth, and reproductive success. Several The previous researches have reported that fish abundance declines markedly when dissolved oxygen concentrations fall below optimal levels (Islam *et al.*, 2022; Boyd & Tucker, 2012).

CPUE is widely recognized as a useful indicator of stock abundance and fisheries productivity (Boyd & Tucker, 2012). Previous studies have demonstrated strong positive relationships between CPUE and fish population density in both natural and managed aquatic ecosystems (Datta *et al.*, 2019; Hossain *et al.*, 2020). The reduced CPUE observed in polluted ponds suggests declining fish stocks and lower fishery potential in these habitats.

Morphometric analysis revealed reduced growth performance in polluted ponds. Similar reductions in fish growth have been reported under degraded water quality conditions in numerous freshwater species (Boyd & Tucker, 2012; Kumar *et al.*, 2021).

The findings of this study are consistent with recent reports highlighting the negative impacts of anthropogenic activities on freshwater fish communities. The reduction about 37% in fish abundance observed in polluted ponds indicates the magnitude of ecological stress imposed by poor water quality (Dudgeon *et al.*, 2020; Kumar *et al.*, 2021). This observation emphasizes the importance of maintaining suitable environmental conditions for sustainable fish production and conservation of aquatic biodiversity.

5. Conclusion

The study demonstrated that population density of *Pangasius pangasius* was significantly higher in semi-polluted ponds than in polluted ponds of North Bihar. Seasonal variation showed peak abundance during post-monsoon months. Effective management of pond water quality and reduction of pollution inputs are essential for maintaining sustainable populations of *P. pangasius* and enhancing inland fisheries productivity in North Bihar.

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