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Impact of Seasonal Water Quality Variations on the Distribution of Gulfam *(Cyprinus carpio)*, Rohu (*Labeo rohita*), and Tilapia (*Oreochromis niloticus*) in the Irrigation Canals of District Larkana, Sindh, Pakistan

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Abstract: *The present study was examined the impact of seasonal water quality conditions on the distribution of three commercially important freshwater fishes namely* Gulfam *(Cyprinus carpio)*, Rohu *(Labeo rohita)* and Tilapia *(Oreochromis niloticus), in the irrigation canals in District Larkana, Sindh, Pakistan). The research was carried out at five canal sites at three seasons: winter, summer and monsoon seasons. On the selected parameters of physicochemical parameters, the water samples were analyzed in terms of temperature, pH, dissolved oxygen (DO), turbidity, electrical conductivity (EC), and total dissolved solids (TDS). Measures of abundance and diversity of fish were done once they had been plotted using the standardized netting and visual census approach with the use of nets to catch the plentiful fish and then their counts were visually enumerated.*

The result meant that this revealed that there were certain seasonal preferences among the target species. Gulfam was highest during the winter season, which is likely to occur due to its

preference of low temperature and cool water. Rohu was the most common during the monsoon season when water movement and connection of the habitat was rife at this time. In summer, Tilapia was the dominant species and this happens to mean that it does not perish due to the high temperatures, or rather low levels of DO. The most important parameter in the water quality parameters was the DO and temperature whereby the DO was positively related to species richness. The results may be compared to the ecological trends of the region but at the same time it indicates the local specific differences that are also needed in the localized fisheries management. The paper sheds some light on the importance of the water quality and species-specific ecological measures, which have to be monitored in an ecological systems of canals. The current study provides a viable background information on planning and conservation of aquaculture sustainability in the semi-arid land of the Pakistani region where the irrigation canals could serve the purpose of providing sources of agricultural life as well as aquatic life in the area.

Keywords: *Seasonal Water Quality, Freshwater Fish Distribution, Irrigation Canals, Sindh, Pakistan, Dissolved Oxygen and Temperature Correlation, Aquaculture Sustainability and Ecology*

Introduction

Water quality of a freshwater ecosystem plays a vital role in determining the structure of biological community since it keeps on varying. Fish are especially susceptible to fluctuation of physicochemical parameters of the environment which makes fish a good indicator of environmental problems. In Pakistan, irrigation canals play an important role in agriculture and fishery inland support. Such canal systems and especially in Sindh province provide critical habitats to several freshwater fish species, most of which are commercially and ecologically important (Hussain and Zafar, 2022). Larkana district is in upper Sindh and it is formed by dams of irrigation canals that support agricultural and waterway flora and fauna. The most common and economically significant species of predatory fish found in such waters include:Gulfam (*Cyprinus carpio*), Rohu (*Labeo rohita*) and Tilapia (*Oreochromis niloticus*). These species differ in their physiological adaptation to the environmental conditions and have different seasonal distributions and abundance (Ali et al., 2023; Ali et al., 2022). To have an effective fishery management system and sustainable development of aquaculture, it is always important to understand the impact of water quality on the occurrence of these species (Fatima et al., 2023). Fluctuations in the seasonal water parameters, including water temperature, dissolved oxygen (DO), turbidity, electrical conductivity (EC) and total dissolved solids (TDS) may have long-standing implications on the behavior of fishes, fish growth and fish survival. As an illustration, the hypoxic stress can be introduced through low levels of DO, and the feeding and breeding processes can be disrupted by high turbidity (Hamayoon et al., 2024; Ahmed and Khan, 2023). It has been pointed out in earlier studies that the parameters influence the formation of fish communities in rivers and lakes yet there have been minimal studies on canals based ecosystems especially in Larkana. This paper sought to fill this gap by focusing on seasonal fluctuation of the water quality and how these fluctuations influence the

distribution of, Gulfam, Rohu and Tilapia in five canal locations in District Larkana. Through the correlation of physicochemical parameters to species abundance, this research was conducted in order to determine the most important environmental factors affecting fish ecology in artificial freshwater. The results should advance the scientific knowledge on interaction among species and their environment as well as offer viable information to policy makers, aquaculturists and conservationists operating on semi-arid regions.

Materials and Methods

Study Area

Five irrigation canals of District Larkana were chosen; and these included the Rice, Dadu, Warah, Saeedpur and Bakrani canals.

Sampling Design

Seasonal sampling was conducted in winter (January), summer (June), and monsoon (September). Water samples were collected in sterilized bottles. Fish were captured using cast and drag nets, and a visual census was conducted.

Water Quality Analysis

Measured parameters:

- Temperature (°C)
- pH
- Dissolved Oxygen (DO) in mg/L
- Turbidity (NTU)
- Electrical Conductivity (EC) in µS/cm
- Total Dissolved Solids (TDS) in mg/L

Standard methods were used (Jhingran 1991; Talwar and Jhingran 1992).

Fish Identification and Diversity Metrics

Fish species were identified using taxonomic key. Diversity indices, such as Shannon-Wiener and Simpson's Index, were calculated.

Statistical Analysis

Quantitative data were analyzed using **SPSS v25**.Descriptive statistics summarized seasonal variations in water quality and fish abundance. Pearson's correlations assessed relationship between physicochemical variables and species abundance, while species-specific linear regressions evaluated predictive effects. Significance was set at $p < 0.05$, with results interpreted in light of ecological relevance and seasonal trends.

Results

Table 1: Seasonal Water Quality Parameters (Average Across Sites)

Parameter	Winter	Summer	Monsoon
Temperature (°C)	18.5	30.2	25.6
pH	7.3	7.6	7.5
DO (mg/L)	6.9	4.5	7.1
Turbidity (NTU)	13.2	21.8	16.4
EC (µS/cm)	410	520	460
TDS (mg/L)	270	340	300

Table 2: Seasonal Abundance of Target Fish Species

Species	Winter	Summer	Monsoon
Cyprinius carpio **(Gulfam)**	High	Moderate	Low
Labeo rohita **(Rohu)**	Moderate	Low	High
Oreochromis niloticus **(Tilapia)**	Low	High	Moderate

Table 3: Correlation Between Water Parameters and Fish Abundance

Parameter	Gulfam (r)	Rohu (r)	Tilapia (r)
DO	+0.82	+0.76	+0.41
Temperature	–0.65	+0.48	+0.79
Turbidity	–0.71	–0.52	–0.33
EC	–0.60	–0.45	–0.58

Discussion

As observed in the current research, the seasonal alteration in the water quality directly and quantifiable affects distribution of *Cyprinus carpio* (Gulfam), *Labeo rohita* (Rohu) and *Oreochromis niloticus* (Tilapia) in irrigation canals of District Larkana. Out of these physicochemical parameters, dissolved oxygen (DO) and temperature were found to be the most critical and that the DO was significantly positively correlated with fish abundance. This is in agreement with other past works in freshwater systems in Pakistan, whereby DO was always found to be a leading force of fish diversity and distribution (Hamayoon et al., 2024; Fatima et al., 2023).

However, significant variation was recorded between our findings and those of previous researches. In our case, Tilapia was the most frequent in summer seasons; alternatively, Zafar and Hussain (2021) found it prevalent in summer in the Punjab canal systems. This difference might be due to differences in the temperature of water, flow regimes and perhaps in the adaptative behavior of tilapia to local level stressors. The conditions in the city of Larkana at high temperatures of summer and low levels of DO may offer the fish a chance to thrive in its physiological tolerance of heat and outcompete other species in the time frame.

Rohu was most abundant in the monsoon, which is consistent with other studies (Naz et al., 2022) who have found Labeo are active when the water flow is large. But again, our data indicated a reduced presence in summer, unlike in their case because Rohu was of moderate presence all year round. This mismatch might be associated with high turbidity and low oxygen concentration in canals of Larkana when the temperature would be higher which might not support the feeding behavior of Rohu and breeding.

Although Nawaz et al. (2021) recorded a dominance of (Gulfam) in spring-fed streams, our research demonstrated significantly different results as the species preferred winter conditions. This disparity is probably caused by habitats type since there are seasonal variations in the canal systems flow and oxygen levels in Larkana, and spring fed habitats are more stable. The abundance of (Gulfam) in our study especially during the winter indicates the possibility that

gulfam prefers cool and oxygenated areas as long as this is the case and it would change its behavior according to the conditions of the habitat.

Bibi and Rauf (2021) also highlighted the importance of the pH and electrical conductivity (EC) to determine fish communities, we found out that those parameters were not significantly associated with species abundance. This is an indication that in relatively stable systems in canal systems, other values, including, but not limited to, DO and turbidity, are more significant in fish distributions.

Overall, the current results support the significance of local ecological evaluations. Inspite of the general tendencies that can be traced in different regions, the behavior and distribution of species are frequently conditioned by the local situation. These facts are important in making particular conservation actions and to give the maximum of the seasonal aquaculture endeavors in the canal based systems such as, those in Sindh.

Conclusion

This study demonstrates that seasonal water quality is a critical factor influencing the distribution of Gulfam (*Cyprinus carpio*), Rohu (*Labeo rohita*), and Tilapia (*Oreochromis niloticus*) within the irrigation canals of Larkana.An important factor was that the dissolved oxygen and temperature: high-DO winter was favored by Gulfam, peak flow of the monsoon was favored best by Rohu and warm and low-oxygen summer waters were dominated by Tilapia. The implication of the findings is to advocate the viability of the local ecological study of the canal fisheries and to enlighten the sustainable planning on aquaculture.

In order to possess good canal ecosystems it is suggested that the future research should dig into the multi-year monitoring of the climate and species throughout the canals. Extended surveillance on the quality of water during the flow is also critical towards the minimization of pollution. Canal margin restoration can also be used to control turbidity and create better habitats by planting vegetation buffers. The species should be stocked in seasons in such a way that they increase survival. GIS habitat mapping would be useful in conservation and space planning. Communities and fishers have to be involved in the management. Seasonal and climatic variability adaptive tactics during disaster seasons need to be included in policies, resilient canal ecosystems.

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