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Impact Of Water Pollution on the Reproductive Biology and Growth Patterns Of Selected Freshwater Fish Species

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ABSTRACT

The presence of water pollution is a serious problem for the freshwater ecosystems as it affects the quality of the water and causes disorder in the biological activities of water organisms. The current research was done in some of the fresh water bodies classified into low, moderate, and highly-polluted sources according to the water quality features. A total of 100 specimens of Catla catla and Ctenopharyngodon idella were collected from Kosam Ghat (confluence of the Narmada and Gour Rivers), Jabalpur, Madhya Pradesh. The water quality parameters measured were pH, dissolved oxygen, nitrate and phosphate; growth parameters measured for fish were body length, body weight and condition factor. The reproductive ability was assessed in the laboratory by gonad weights, Gonadosomatic Index (GSI) and fecundity. The results showed that there was a gradual decline in water quality due to increasing pollution, while the performance of the growth, condition factor, gonadal growth and gonadosomatic index, and fecundity of both species showed significant decreases. The study revealed a strong negative correlation between water pollution and biological health of fish and that the water quality management and conservation programs should be implemented effectively.

Keywords: Water pollution; Freshwater fish; Reproductive biology; Growth patterns

1. INTRODUCTION

Freshwater ecosystems are among the most precious natural resources on earth and are vital to aquatic biodiversity, fisheries production, food security and the livelihoods and wellbeing of millions of people. Freshwater fish play vital roles in these ecosystems, including in nutrient cycling, ecological balance, and economic development through commercial and subsistence fisheries.

Due to the high anthropogenic activities, however, freshwater ecosystems have been highly compromised leading to pervasive water pollution which puts the survival, growth and reproductive potential of fish populations at great risk. The industrial effluents, domestic sewage, pesticides, fertilizers, heavy metals, pharmaceuticals and other pollutants are discharged into rivers, lakes, reservoirs and ponds in large amounts, untreated, and at an accelerated pace due to industrialization, accelerated urbanization, agricultural intensification and population growth. These pollutants change the physical and/or chemical properties of water and result in stressful conditions that negatively impact aquatic organisms.

Fresh water quality is one of the most critical environmental conditions that affects the biological success of freshwater fishes. Fish metabolism, feeding patterns, growth, immune

functioning, and reproductive physiology are directly affected by parameters like dissolved oxygen, pH, temperature, turbidity, salinity, ammonia, nitrate, phosphate and toxic contaminants. Water quality degradation leads to diminished availability of oxygen needed for normal metabolic functions, increased physiological stress and energy expenditure. Repeated exposure to polluted surroundings may cause the function of organs such as the gills, liver, kidneys and endocrine glands to become impaired, which can result in a decrease in growth rate, poorer body condition, higher disease sensitivity, and higher mortality rates. Water pollution has thus emerged as one of the most significant ecological issues that affects the sustainability of freshwater fisheries in the world.

Reproduction is especially sensitive to environmental disturbance among the many processes that are affected by water pollution. A successful reproduction requires the maintenance of favorable environmental conditions that control the activity of the hormones, development of gonads, development of gametes, spawning behaviour, fertilization and the development of the embryo. Chemical pollutants, endocrine disruptive chemicals, heavy metals, pesticides and nutrient enrichment can disrupt reproductive physiology and endocrine regulation and cause delayed sexual maturation, decrease in gonadosomatic index (GSI), decrease in fecundity, poor egg quality, impaired sperm production, decreased hatchability, and abnormal larval development. Exposure to contaminated water over the long term could eventually lead to poor recruitment and jeopardize the survival of natural fish populations.

Another biological indicator of environmental quality in freshwater systems that is reliable is growth performance. The growth of fish is the result of the interaction of nutrition, metabolism, environmental factors and physiological health. Dirty water may reduce the efficiency of feed intake, impair nutrient assimilation, and provoke metabolic needs for detoxification and stress reactions.

Consequently, fish from polluted areas often have a shorter body length, lower body weight, poor condition factor, and decreased physiological fitness when compared to fish from cleaner areas. These reductions may impact both the survival of individual fish and fish productivity as well as the economic value of freshwater resources.

1.1. Objectives of the Study

The study aims to:

• To determine the effect of water pollution on the growth of certain species of fresh water fish.

• To test the impact of water pollution on the reproductive biology of a few species of freshwater fish.

• To investigate the relationship of water quality parameters with fish growth and reproductive performance.

2. REVIEW OF LITERATURE

The growth, reproductive performance, and health of freshwater fishes are heavily influenced by water quality and environmental conditions. In recent years, environmental stressors as well as water pollution have been shown to have a marked effect on physiology, reproductive performance and population sustainability.

Shastak and Pelletier (2023) examined the dietary effects of astaxanthin as a natural antioxidant in fish and found that it could help to alleviate oxidative stress and improve reproduction. They found that by taking precautions to prevent environmental and physiological stress, they were able to improve gamete quality, fecundity and overall reproductive success. The study highlighted that the harmful effects on fish reproductive health due to oxidative stress caused by the deteriorating environmental conditions is an important factor and antioxidant supplementation can have a significant effect in reducing these negative impacts to some extent.

Wagaw et al. (2022) studied the growth and reproductive biology of Oreochromis niloticus from Lake Shala, Ethiopia. The lake's extreme physicochemical conditions influenced the growth pattern, size at first reproduction and periodicity of reproduction, the researchers noted. Changes to water chemistry, nutrients and other environmental stressors had an immediate impact on the reproductive strategy and growth potential, showing how fish adapt to difficult aquatic conditions.

Zhang et al. (2025) presented a general review on water quality effects on fish behaviour in aquaculture. The authors found that the feeding behaviour, stress response, growth and reproductive performance, and development were adversely impacted by poor water quality, which involved exposure to pollutants and/or unfavorable physicochemical conditions. The review also revealed that chronic exposure to poor water quality affects normal physiological and endocrine function and the productivity, survival and sustainability of aquaculture.

Bulbul Ali and Mishra (2022) conducted a thorough review of the significance of dissolved oxygen in freshwater ecosystems and concluded that dissolved oxygen is one of the most important environmental factors that regulate fish metabolism, growth, reproduction, and survival. They discovered that depleting dissolved oxygen levels hinder feeding habits, limit growth rates, interfere with reproductive function, and can lead to more diseases and deaths in fish. Good dissolved oxygen (DO) levels were highlighted as an important aspect of freshwater ecosystem management in the review.

Malik et al. (2020) summarized the impact of water pollution on the freshwater fish species and aquatic ecosystems, emphasizing the harmful effects of industrial effluents, agro-chemicals, heavy metals, pesticides and domestic sewage. The authors said that these pollutants affect water quality, damage the fish's most important organs like gills and liver, weaken the immune system, lower reproduction potential and adversely impact growth and survival of fish populations. They also pointed out that long-term pollution has negative impacts on the biodiversity of fishes, as well as on ecological balance and the sustainability of freshwater ecosystems.

Collectively, these studies have shown that water quality is an intrinsic factor to the health of fish in fresh water, affecting growth, reproduction, physiology and population sustainability. Stresses from changes in the physicochemical environment and dissolved oxygen (DO) levels also negatively affect fish development, but pollution caused oxidative stress and toxicants further reduce reproductive success and ecosystem health. The results of these studies are

highly informative and scientifically support the examination of the effects of water pollution on the reproductive biology and growth of selected species of freshwater fish.

3. RESEARCH METHODOLOGY

In this section the research method, the research procedures that will be used to examine effects of varying levels of water pollution on reproductive and growth behaviour of the chosen freshwater fish species, which are the Indian major carp Catla catla and the Chinese carp Ctenopharyngodon idella are described.

3.1. Research Design

The study is a comparative analytical research design that allows for the comparison of impact of different water pollution levels on the growth pattern and reproductive biology of selected water pollution resistant freshwater fish species. Fresh water bodies are classified as low, moderate and high pollution water bodies based on their physicochemical water quality parameters. This design allows for an orderly comparison of biological responses to fish living in various conditions of pollution and assures the evaluation of the correlation between water quality and fish health.

3.2. Study Area and Sample Size

The study was carried out at Kosam Ghat located at the bank of Narmada River and Gour river in Jabalpur district Madhya Pradesh, India. The study area is composed of interconnected freshwater riverine water bodies that receive different amounts of domestic sewage, agricultural run-off, and other anthropogenic activities. Water quality was roughly analysed from the physicochemical aspects and the sample points were divided into low, moderate and high pollution areas.

A total of 100 Catla catla (Indian major carp) and Ctenopharyngodon idella (grass carp) were collected from these locations using standard fishing method. At the same time, water samples were taken from each location for physicochemical analysis to ascertain the correlation between water quality and the biological response of the selected fish species.

3.3. Data Collection

The fish samples were caught in the nets and brought to the lab alive in ice-boxes and thoroughly examined. All specimens were identified to species in the laboratory and morphometric data were collected such as total length (cm) and body weight (g).

Reproductive biology was evaluated by dissecting each fish on a ventral incision and removing the gonads and weighing them using a digital analytical balance. The Gonadosomatic Index (GSI) was calculated using the formula:

GSI (%) = (Gonad Weight / Total Body Weight) × 100

To estimate fecundity, mature female fishes were preserved in 10% buffered formalin and representative subsamples were taken from the anterior, middle and posterior parts of the ovary, mature oocytes were counted using a stereomicroscope and the counts were extrapolated to estimate the total number of oocytes per ovary. At each sampling location, water samples were taken and analyzed in the laboratory for pH, dissolved oxygen (DO), nitrate, and phosphate concentration in accordance with standard analytical methods

recommended by APHA. These measurements were used to define levels of pollution, and relate the water quality to the growth and reproductive characteristics of fish.

3.4. Study Variables

Water quality parameters, such as pH, dissolved oxygen, nitrate concentration and phosphate concentration are used as independent variables. The dependent variables are body length, body weight, condition factor, gonad weight, Gonadosomatic Index (GSI) and fecundity of fish growth and reproductive parameters, respectively. These variables are used to establish the effect of water pollution on the biological performance of the chosen species of freshwater fish.

3.5. Data Analysis

Data collected is analysed using descriptive and inferential statistical analysis. Water quality, growth and reproductive parameters are summarized by descriptive statistics (mean and standard deviation). Comparative analysis is used to compare pollution levels, correlation analysis and regression analysis are used to assess the relationship between the physicochemical water quality parameters and the growth and reproductive responses of the selected fish species. A p-value of < 0.05 is statistically significant.

4. RESULT AND DISCUSSION

The reproductive biology and growth patterns of Catla catla and Ctenopharyngodon idella were evaluated using field-based water quality assessment and laboratory analysis of growth and reproductive parameters. The results are presented according to pollution level and interpreted in relation to water quality characteristics.

4.1. Water Quality Characteristics Across Pollution Levels

The values of the parameters of water considered such as pH, Dissolved Oxygen, Nitrates and Phosphates were summarized as a mean value with its standard deviation in the bodies of water divided into three groups namely low, moderate and high pollution level to get a comparative view of the status of the waters.

Table 1: Mean Physicochemical Parameters of Water at Different Pollution Levels

Parameter	Low Pollution	Moderate Pollution	High Pollution
pH	7.4 ± 0.2	7.9 ± 0.3	8.5 ± 0.4
Dissolved Oxygen (mg/L)	6.8 ± 0.5	4.9 ± 0.4	3.1 ± 0.3
Nitrates (mg/L)	1.2 ± 0.3	3.6 ± 0.5	6.8 ± 0.7
Phosphates (mg/L)	0.4 ± 0.1	1.1 ± 0.2	2.4 ± 0.3

Table 1 shows the average values of the water's physicochemical properties for low, moderate, and high pollution levels. The results, in general, show a gradual decline in water quality as the level of pollution increases. The pH values ranged from 7.4 ± 0.2 to 8.5 ± 0.4, indicating higher alkalinity in the polluted water. The concentration of dissolved oxygen decreased significantly from 6.8 ± 0.5 mg/L to 3.1 ± 0.3 mg/L, which indicates that the level of oxygen was depleted due to increased pollution. However, the concentrations of nitrate and phosphate rose significantly, from 1.2 ± 0.3mg/L to 6.8 ± 0.7mg/L and from 0.4 ± 0.1mg/L to

2.4 ± 0.3mg/L respectively. The changes suggest nutrient enrichment and poor water quality, which can be detrimental to the growth, physiology and reproductive success of freshwater fish.

4.2. Effects of Water Pollution on Growth Parameters

Table 2 shows summary of growth parameters of total length, body weight and condition factor (K) of Catla catla and Ctenopharyngodon idella under low, moderate and high pollution levels.

Table 2: Growth Parameters of Fish Species at Different Pollution Levels

Pollution Level	Species	Mean Length (cm)	Mean Weight (g)	Condition Factor (K)
Low	*Catla catla*	42.6 ± 3.2	1180 ± 95	1.48
	C. idella	45.1 ± 3.6	1260 ± 110	1.52
Moderate	*Catla catla*	36.8 ± 2.9	920 ± 85	1.31
	C. idella	38.4 ± 3.1	980 ± 90	1.34
High	*Catla catla*	29.5 ± 2.5	610 ± 70	1.09
	C. idella	31.2 ± 2.7	670 ± 75	1.12

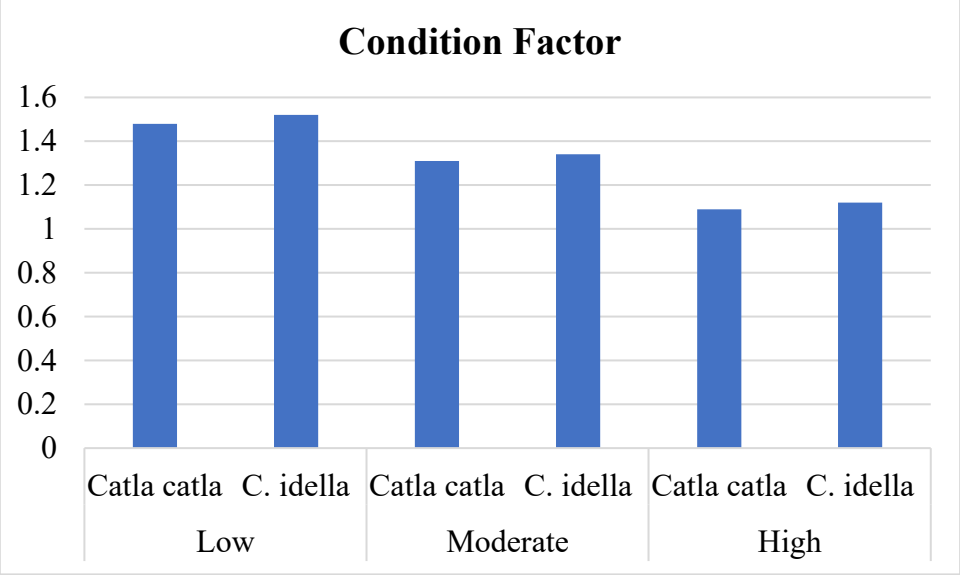

Figure 1: Visual Representation of Growth Parameters of Fish Species at Different Pollution Levels

Table 2 shows the growth parameters of Catla catla and Ctenopharyngodon idella in low, moderate and high pollution conditions. The results show that as water pollution increases, so does the loss of growth performance. In low-pollution water bodies, C. idella exhibited the highest mean length (45.1 ± 3.6 cm), mean weight (1260 ± 110 g), and condition factor (1.52), while Catla catla recorded corresponding values of 42.6 ± 3.2 cm, 1180 ± 95 g, and 1.48. The growth parameters for both species decreased with progressive increase in pollution. The mean length was reduced to 29.5 ± 2.5 cm and 31.2 ± 2.7 cm while the mean weight reduced to 610 ± 70 g and 670 ± 75 g in Catla catla and C. idella respectively under

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highly polluted conditions. Likewise, condition factor of Catla catla and C. idella was found to be 1.09 and 1.12 respectively. The results show that the water quality declines have a negative impact on the growth of the fish, leading to decreased body size, biomass, and physiological status of the fishes, which were freshwater fishes, and thus the results demonstrate the negative impacts of water pollution on the overall health and growth performance of the freshwater fishes.

4.3. Impact of Water Pollution on Reproductive Parameters

The mean (±SD) reproductive indexes gonad weight, gonadosomatic index (GSI) and fecundity of Catla catla and Ctenopharyngodon idella under low, moderate and high pollution levels are presented in table 3.

Table 3: Reproductive Parameters of Fish Species Across Pollution Levels

Pollution Level	Species	Gonad Weight (g)	GSI (%)	Fecundity (eggs)
Low	*Catla catla*	82.4 ± 6.1	6.9	185,000 ± 12,500
	C. idella	88.7 ± 6.8	7.2	192,000 ± 13,200
Moderate	*Catla catla*	61.5 ± 5.4	5.2	142,000 ± 10,800
	C. idella	66.9 ± 5.7	5.6	150,000 ± 11,300
High	*Catla catla*	39.2 ± 4.3	3.4	96,000 ± 8,400
	C. idella	43.6 ± 4.6	3.7	102,000 ± 9,100

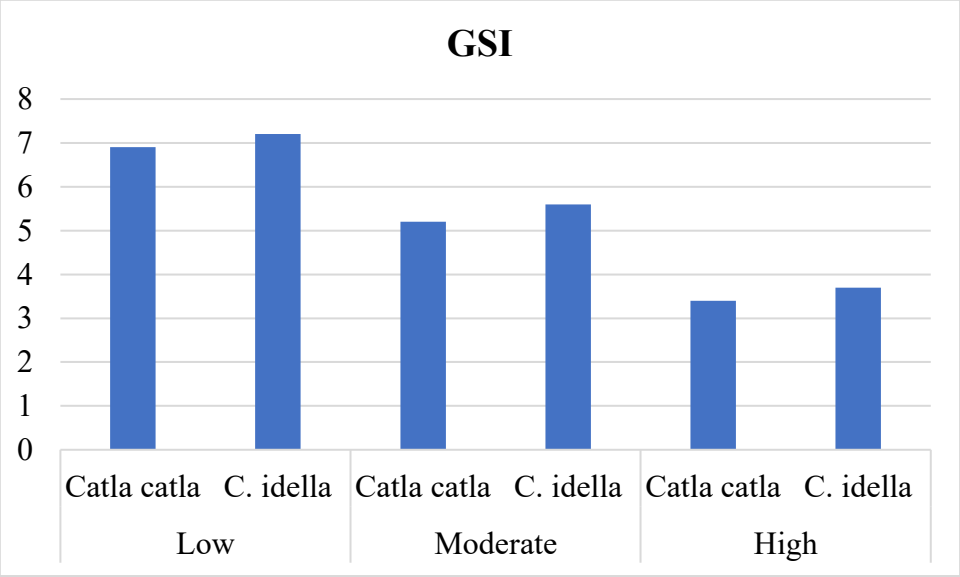

Figure 2: Visual Representation of GSI (%) of Reproductive Parameters of Fish Species Across Pollution Levels

The reproductive parameters of Catla catla and Ctenopharyngodon idella under low, moderate and high pollution are presented in Table 3. The findings show that as water pollution increases reproductive performance decreases significantly. The reproductive performance of C. idella was found to be superior compared to Catla catla under low pollution conditions with gonad weight of 88.7 ± 6.8 g, GSI of 7.2% and fecundity of 192,000 ± 13,200 eggs while in Catla catla it was 82.4 ± 6.1 g, 6.9% and 185,000 ± 12,500 eggs respectively. With

rising pollution, there were successive decreases in gonad weight, gonadosomatic index and fecundity for both species. Under highly polluted conditions, Catla catla recorded a gonad weight of 39.2 ± 4.3 g, GSI of 3.4%, and 96,000 ± 8,400 eggs, whereas C. idella showed 43.6 ± 4.6 g, 3.7%, and 102,000 ± 9,100 eggs, respectively. These results suggest that poor water quality substantially affects gonad development and reproductive capability, thereby decreasing spawning potential and reproductive success. In general, rising pollution has a strong impact on the reproductive health of both freshwater fish species.

5. CONCLUSION

It is found in the present study that high level of pollution of water significantly affects the growth and reproductive biology of freshwater fish species, Catla catla and Ctenopharyngodon idella, clearly. The progressive deterioration of water quality (dissolved oxygen loss and nutrient enrichment) was associated with most of the reductions seen in fish growth performance, condition factor, gonadal development, gonadosomatic index and fecundity. Laboratory examination of gonadal tissues and reproductive indices confirmed that fish from the highly polluted sites had significantly lower gonad weight, Gonadosomatic Index (GSI) and fecundity than fish from the low polluted sites, which suggested that fish collected from the polluted sites had poor reproductive ability under polluted environmental conditions. The fish caught in severely polluted water bodies had a significantly poor physiological state and reproductive ability in comparison with the areas with low pollution levels, which implies chronic environmental pressure. These findings indicate that the quality of the water resource and growth and reproductive parameters are extremely sensitive to water quality changes in freshwater fish and can serve as reliable measures of ecosystem status. The paper emphasizes how the freshwater ecosystems require immediate pollution control measures; continuous monitoring of fresh water resources and sustainable management to safeguard the fish species, and maintaining balance in the ecological condition of fresh water ecosystem.

REFERENCES

1. Aich, U., Polverino, G., Yazdan Parast, F., Melo, G. C., Tan, H., Howells, J., ... & Wong, B. B. (2025). Long-term effects of widespread pharmaceutical pollution on trade-offs between behavioural, life-history and reproductive traits in fish. Journal of Animal Ecology, 94(3), 340-355.
2. Bulbul Ali, A., & Mishra, A. (2022). Effects of dissolved oxygen concentration on freshwater fish: A review. International Journal of Fisheries and Aquatic Studies, 10(4), 113-127.
3. Chen, X., Liu, B., & Lin, D. (2022). Sexual maturation, reproductive habits, and fecundity of fish. In Biology of fishery resources (pp. 113-142). Singapore: Springer Nature Singapore.
4. Hridoy, M. D., Paul, P. B., Rasel, M. A., & Rakib Uddin, K. (2025). Impact of water pollution on physio-chemical properties for fish habitat in the Surma River, Sylhet city, Bangladesh. Water and Environmental Sustainability, 5(1), 12-20.

5. Jan, A., Shah, T. H., & Nissa, N. U. (2022). Impact of aquatic pollution on fish fauna. In Bacterial Fish Diseases (pp. 103-112). Academic Press.
6. Kumar, P., Babita, M., Kailasam, M., Muralidhar, M., Hussain, T., Behera, A., & Jithendran, K. P. (2023). Effect of changing environmental factors on reproductive cycle and endocrinology of fishes. Outlook of Climate Change and Fish Nutrition, 377-396.
7. Malik, D. S., Sharma, A. K., Sharma, A. K., Thakur, R., & Sharma, M. (2020). A review on impact of water pollution on freshwater fish species and their aquatic environment. Advances in environmental pollution management: wastewater impacts and treatment technologies, 1, 10-28.
8. Mariu, A., Chatha, A. M. M., Naz, S., Khan, M. F., Safdar, W., & Ashraf, I. (2023). Effect of temperature, pH, salinity and dissolved oxygen on fishes. Journal of Zoology and Systematics, 1(2), 1-12.
9. Nyirenda, M. S., Katongo, C., Mudenda, H. G., Mbewe, M., & Sinyinza, D. (2024). Aspects of Growth and Reproductive Biology among Three Tilapiines on Lake Kariba. International Journal of Research Publication and Reviews, 5(1), 4294-4299.
10. Parvez, I., Ahmed, S., Tasnim, N., Pervin, R., Alam, M. A., Khan, M. N., ... & Pradit, S. (2025). Heavy metal contamination in freshwater habitats impairs the growth and reproductive health of wild spotted snakehead Channa punctata (Channidae) in Bangladesh. Heliyon, 11(4).
11. Shastak, Y., & Pelletier, W. (2023). Captivating colors, crucial roles: Astaxanthin's antioxidant impact on fish oxidative stress and reproductive performance. Animals, 13(21), 3357.
12. Soler, P., Solé, M., Bañón, R., García-Galea, E., Durfort, M., Matamoros, V., ... & Vinyoles, D. (2020). Effects of industrial pollution on the reproductive biology of Squalius laietanus (Actinopterygii, Cyprinidae) in a Mediterranean stream (NE Iberian Peninsula). Fish physiology and biochemistry, 46(1), 247-264.
13. Swain, S., Sawant, P. B., Chadha, N. K., Chhandaprajnadarsini, E. M., & Katare, M. B. (2020). Significance of water pH and hardness on fish biological processes: A review. International Journal of Chemical Studies, 8(4), 330-337.
14. Wagaw, S., Mengistou, S., & Getahun, A. (2022). Aspects of the growth and reproductive biology of Oreochromis niloticus (Linnaeus, 1758) in a tropical Soda Lake, Lake Shala, Ethiopia. Fisheries and Aquatic Sciences, 25(7), 380-389.
15. Zhang, K., Ye, Z., Qi, M., Cai, W., Saraiva, J. L., Wen, Y., ... & Zhao, J. (2025). Water quality impact on fish behaviour: a review from an aquaculture perspective. Reviews in Aquaculture, 17(1), e12985.