Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.53555/1pzqfe54

COMPARATIVE STUDY TO ANALYZE THE WATER QUALITY PARAMETERS AND TOTAL PROTEIN CONTENT IN MUSCLES OF ROHU (*LABEO ROHITA*) AND MORAKHI (*CIRRHINUS MRIGALA*) IN RIVERS CHENAB AND JHELUM

Umme Habiba[1], Amara Akhtar[1], Muhammad Usman Hayder[1], Rabia Ashiq[1], Saman Khalid[1], Iqra Munir[1], Muhammad Fareed Saeed[1], Muhammad Ahmed Saqib[1] and Jahanzaib Khaliq[2]

[1]Department of Zoology, Wildlife and Fisheries, Punjab, University of Agriculture, Faisalabad, Pakistan
[2]Department of Veterinary Physiology and Biochemistry, Sindh Agriculture University, 70060 Tandojam, Pakistan

***Corresponding Author:** Amara Akhtar
*Department of Zoology, Wildlife and Fisheries, Punjab, University of Agriculture, Faisalabad, Pakistan email: **amara.akhtar47@gmail.com**
ORCID: **https://orcid.org/0000-0002-2636-3112**

ABSTRACT

Background: Water quality of rivers plays an important role in the growth and health of fish. Rohu and Morakhi are commonly eaten fishes, and their muscle protein reflects their nutritional quality.

Objective: to compare the water quality parameters of Rivers Chenab and Jhelum and to evaluate their effect on the total protein content in the muscles of Rohu (*Labeo rohita*) and Morakhi (*Cirrhinus mrigala*).

Methodology: This study assessed water quality and fish meat composition at two sites: Chiniot Bridge (Site A) and Khushab (Site B). Two fish species, *Labeo rohita* (Rohu) and *Cirrhinus mrigala* (Morakhi), and water samples were analyzed using APHA (1998) methods for physiochemical parameters and AOAC standards for proximate composition. Data was analyzed using One-way ANOVA.

Results: Chiniot Bridge showed higher pH (7.00±0.10), dissolved oxygen (7.23±0.26), and chloride (166.00±2.00), while Khushab had higher temperature (32.20±0.60°C), electrical conductivity (378.00±2.00), and total dissolved solids (178.00±2.00). Fish from Chiniot Bridge exhibited higher crude ash, moisture, fat, protein, and fiber compared to those from Khushab

Conclusion: One-way ANOVA revealed significant differences ($p<0.05$) in water and fish quality between sites, indicating environmental impacts on fish health. Pollution at Khushab is likely linked to the nearby atomic site, contributing to poor water quality. These results underscore the urgent need for pollution control and continuous monitoring to protect aquatic ecosystems and public health.

Keywords: Water quality, Total protein, Labeo rohita, Cirrhinus Mrigala, Rivers Chenab and Jhelum

INTRODUCTION

Fish, human life, biodiversity and wellbeing of natural ecosystems require water (Yang et al., 2021). The presence of high traces of water pollutants can disturb the normal patterns of fish species. The gill apertures of some fish species inhabiting turbid water bodies from suspended particles can be clogged and reduce the resistance to parasites and other diseases (Malik et al., 2020). Climate change poses more risks to fish, especially in freshwater that has been polluted where there is stress and injury exacerbated by an increase in both temperature and toxins (Morgan et al., 2001). Contaminated water is a significant problem to fish and other aquatic organisms due to the low oxygen concentration, habitat destruction, biodiversity reduction, and disruption of aquatic life. This indirectly affects aquatic life, and ecosystems are even threatened with extinction (Saxena, 2025).

The pollution is causing adverse impact to the public health and fish by altering the river conditions and consequently harm the food chain, the community structure and represents a health risk to the general (Brraich and Saini, 2015). The warning in the world is caused by high degrees of pollution in the water environment. Another major question in aquatic toxicology is what the negative impact of organic substances is observed in water on fish (Burkina et al., 2018). The primary contributor of river pollution, water eutrophication and the degradation of water ecosystems is agricultural non-point source (NPS) pollution. It has many sources, and it is riskier (Adu and Kumarasamy, 2018). Population growth and industrialization are key contributors to water pollution that leads to the destruction of the ecosystem and the loss of freshwater biodiversity (Bellier et al., 2024).

The Jhelum River water condition is an issue despite the fact that it is required to sustain life. Previous studies on river sections employed spatial analysis as the means to assess the water quality (Bashir et al., 2020; Aziz and Ullah, 2022). Jhelum River has contributed significantly to the economic development of Kashmir. The river is very essential to the lives of the fishing villages. Regrettably, the quality of water in this river has greatly worsened because of the alarming increase of human activity in both banks of this river (Mir et al., 2016). The Chenab River is a major transgressional river in Pakistan, which is encircled by the most fruitful agricultural land in the nation yet a river with the largest pollution (Siddique et al., 2023). Surface water bodies have been promoted to test quality because of the increasing degree of contamination (Sharma et al., 2023).

Fish can not only serve as a source of protein to human beings but also as a source of foreign exchange earnings to numerous people when harvesting, handling and processing schemes are performed in the appropriate way and at the right time (Abraha et al., 2018). As a result of its availability, fish is consumed as a rich source of protein foods in huge amounts by people due to its palatability and taste. The nutritional and biological value of fish protein is high since it includes all the essential amino acids, and those are at the right proportions (Sujatha et al., 2013). Protein, fat and moisture are the primary constituent of fish muscle with lesser quantities of vitamins, carbohydrates and minerals. Thus, the fish muscle contains all the nutritional elements needed to maintain the body of a human being (Begum et al., 2012). The quality of fish meat and proximate composition depend on season, species, sex, age, maturity stage and environmental aspects (Skaalecke et al. 2013).

Labeo rohita is popularly known as Rohu. Rohu is a commonly cultivated crop since it has a high level of protein, grows fast, is resistant to diseases, and the market has high demand (Akhtar and Abdullah, 2021). The labeo rohita is a fish species which is cultured widely in Asia because of its high nutritional value, good taste at low economic value and high market value. This species is in demand, and it is grown in intensive systems using formulated feeds (Khizar et al., 2024). Cirrhinus mrigala also referred to as mrigal is an aquaculture species of great importance in fresh water, and a member of family Cyprinidae. C. mrigala now occupies the position of 1.08 percent of the total freshwater aquaculture production in the global market (Chowdhury et al., 2024).

Animal transportation such as fish is important in freshwater ecosystems, regardless of habitat (Saboret et al., 2024). The global biodiversity in water ecosystem is altering and exhausted heavily due to pollution, habitat destruction, alien species introduction, over exploitation and any other human activity (Prakash and Verma, 2022). The invasion risk does not only concern the alteration of quality and the distribution pattern of native fauna but also impacts the socio-economic parameters of human community that relies on specific aquatic ecosystem to survive (Imran et al., 2021). Urbanization, industrialization, excessive population growth and lack of environmental regulation are causal factors of aquatic contamination. Aquatic species can face extinction due to untreated industrial pollution, deforestation as well as ignorance (Bukola et al., 2015).

MATERIALS AND METHODS

Description of study site

The study was conducted in the Laboratory of the Zoology department, Wildlife and Fisheries at university of Agriculture, Community College PARS. Water and Fish samples were collected from two riverine locations in Pakistan: Khushab (Jhelum River) and Chiniot Bridge (Chenab River).

Collection of water and fish samples

Water and Fish samples were collected on the same day. Water samples were collected in acid-washed 50 mL Falcon tubes from Khushab and Chiniot Bridge following (A.P.H.A 1998) standard procedures. Two species, *Labeo rohita* (Rohu) and *Cirrhinus mrigala* (Morakhi) were captured from both sites using nets with the assistance of fisherman. Each species was collected in duplicate. These collected samples were stored in EDTA tubes with a methylene buffer solution. The specimens were washed, weighed and dissected to extract muscle tissue from the dorsal area. The muscle samples were placed in airtight containers and preserved at -20°C until further laboratory analysis. Both the fish and water samples were sent to the Dx lab Department of pathology faculty of veterinary science at the University of Agriculture Faisalabad for analysis.

Preparation and analysis of water samples

A portion of water sample was vacuum pumped to pass through a Millipore Glass Fiber Prefilter (GFP) for the analysis of dissolved components. The water was analyzed for pH, Temperature, electrical conductivity, dissolved oxygen (DO), total dissolved solids and chloride by using the method (A.P.H.A 1998).

Laboratory analysis of fish samples

Fish samples were subjected to proximate analysis as outlined by the Association of Official Analytical Chemists (AOAC) including dry matter, crude ash, moisture content, crude fat, crude protein and crude fiber.

Fish sample preparation

Fish muscles were thoroughly cleaned, weighed and dried before being tested in the laboratory. To ensure accuracy and prevent contamination, each sample was handled with care.

Determination of dry matter%

Oven-drying at 100–105°C until constant weight. The percentage of dry matter was computed as follows:

$$(\%) Dry\ matter = 100 - Moisture\%$$

Determination of crude ash%

5 g sample incinerated at 550°C in a muffle furnace. The percentage total ash was computed as follows:

$$(\%)\ Total\ Ash = \frac{Weight\ of\ ash}{Weight\ of\ sample} \times 100$$

Determination of moisture content %

Fresh 10 g samples dried under sun (40–42°C) and shade (30–32°C) until constant weight. The percentage moisture content (% MC) was computed as follows:

$$MC(\%) = \frac{M_{fresh-}\ M_{dried}}{M_{fresh}} \times 100$$

Determination of crude fat %

Determined by Soxhlet extraction using diethyl ether. The percentage crude fat was computed as follows:

$$(\%)\ Crude\ Fat = \frac{Weight\ of\ fat}{Weight\ of\ sample} \times 100$$

Determination of crude protein %

Determined by Kjeldahl method (digestion with H_2SO_4, distillation and titration). The percentage crude protein was computed as follows:

$$(\%)\ Crude\ Protein = (\%\ Nitrogen \times 6.25)$$

Determination of crude fiber%

Samples treated with H_2SO_4, NaOH, HCl, dried and ashed at 500°C. The percentage crude fiber was computed as follows:

$$(\%) Crude\ fiber = \frac{W2 - W3}{W1} \times 100$$

Statistical analysis

Data was put into statistical analysis. Results were represented as mean±SD value. Analysis of variance was performed to compare means. Data with normal distribution was evaluated by one way analysis of variance.

RESULTS

Table 1 summarizes the relative water quality characteristics for the Chenab (Chiniot Bridge) and Jhelum (Khushab) rivers. In comparison to the Jhelum River the Chenab River has lower temperatures, TDS and electrical conductivity as well as higher levels of dissolved oxygen. Chenab has slightly more alkaline pH levels. These variations are the result of the two locations differing pollution levels and environmental conditions.

Table 1. *Mean± SD values of Physiochemical Parameters in Water Samples from Chenab (Chiniot Bridge) and Jhelum (Khushab) River*

Parameter	Chenab (Chiniot Bridge)	Jhelum (Khushab)
pH	7.0000±0.1000	6.400±0.200
Temperature	21.300±0.400	32.200±0.600
Electrical conductivity	254.00±6.00	378.00±2.00
Dissolved oxygen	7.230±0.260	5.200±0.400
Total dissolved solids	88.00±2.00	178.00±2.00
Chloride	166.00±2.00	145.00±4.00

Table 2 summarizes the proximate composition of two fish species Rohu and Morakhi from the Chenab (Chiniot Bridge) and Jhelum (Khushab) rivers respectively. In compared to the Chenab River Rohu and Morakhi from the Jhelum have higher dry matter but lower moisture content indicating a more concentrated tissue composition. Furthermore, Chenab fish Morakhi contain higher levels of fat and crude protein indicating improved nutritional quality. Fish from the Chenab River have more diverse biochemical profiles than those from the Jhelum.

Table 2. *Mean± SD values of Proximate composition in Muscle of Rohu and Morakhi in Rivers Chenab and Jhelum*

Parameter	Chenab Rohu	Jhelum Rohu	Chenab Morakhi	Jhelum Morakhi
Dry matter	91.6500±0.020	94.1500±0.0200	92.300±0.200	93.7200±0.0300
Crude ash	1.300±0.450	0.99000±0.01000	2.4800±0.0200	1.4700±0.0300
Moisture	8.3100±0.0200	5.400±0.430	7.4800±0.0200	6.2300±0.0200
Crude fat	6.800±0.200	5.530±0.470	7.540±0.460	6.24000±0.01000
Crude protein	11.526±0.505	10.9347±0.0049	14.2160±0.0020	13.1230±0.0020
Crude fiber	0.24000±0.010000	0.2300±0.0200	0.4800±0.0200	0.3300±0.0200

DISCUSSION

The PH of freshwater ecosystem usually varies according to the environmental conditions although majority of the aquatic organism's species are adapted to the varying PH. PH level in the Chenab River was also higher than in the Jhelum River. This could be attributed to the release of domestic waste, fertilizer run off and industrial effluent of the Paharang Drain that enhanced algal growth and increased pH. This is in line with (Hasan et al., 2021) research revealed that high pH favors metal adsorption and low pH in the downstream regions could enhance the mobility and contamination of metals. In the Jhelum River near Khushab the temperature was higher than the Chenab River. This may be because the climate at district Khushab was harsh because of the hot summers and very cold winters. The site consisted of plateau, plains and desert with the River Jhelum running on the eastern side. The rising temperatures measured in the Jhelum River in the present study are in line with the results of (Nadeem et al., 2024) who indicated that the Jhelum areas increased the temperatures during the summer seasons mainly because of the changes in weather that included the growth of air temperatures and a change in the distribution of precipitation.

The concentration of dissolved ions can be determined by electrical conductivity (EC). The range of electrical conductivity of the Jhelum River in Khushab region was greater than that provided by the Chenab River. This could be because of the proximity in the use of atomic site and fertilizer in the nearby agricultural lands around Khushab City and the high salinity level that is caused by the evaporation of salty soils surrounding the soil. The level of electrical conductivity in the Jhelum River is consistent with the values recorded in the river, when there is low flow, by (Mir and Jeelani, 2015) which suggests lower dilution. This high electric conductivity can cause osmoregulatory stress to fish, which can affect its growth and reproduction. Dissolved oxygen (DO) is a measurement of the quantity of oxygen in water dissolution. The range of dissolved oxygen in the Chenab River was high in respect to the Jhelum River. This may be because of the rugged hills in the vicinity of the Chiniot Bridge, where the furious flow of water enhances aeration and permits a higher oxygen penetration into the water, which promotes the amount of oxygen dissolution in the atmosphere within the Chenab River. The measured dissolved oxygen content of the Chenab River is matched with research performed by (Kausar et al., 2019) who found out that the level of dissolved oxygen of 7.5 to 11 mg/L is adequate to sustain aquatic life. The maximum range of dissolved solids in the Jhelum River were more than the Chenab River. This may be due to both natural and human factors and the geological features of the area surrounding such as salt-rich soil and mineral deposits. The determined content of the total dissolved solids in the Chenab River is compared with the studies by (Charan et al., 2023) who reported that the Chenab River holds a low content of total dissolved solids depicting minimal human interference and natural dilution in the river during this time.

The Chloride range of the Chenab River was larger than the Jhelum River. This could be because the groundwater could have chloride and other dissolved salts of the surrounding geological formations to the river. The indicator chloride concentration content of the Chenab River is correlated with the results of the study by (Kausar et al., 2020) reported chloride content (10-220mg/L) in all locations were within the acceptable ranges but higher levels are usually signs of sewage pollution. The Rohu of Chenab River was lowest in dry matter percentage followed by the Rohu of Jhelum River and the Cirrhinus mrigala (Morakhi) was highest in dry matter percentage than the Morakhi of Chenab River. Extreme summer temperatures, fertilizer runoff toxins, reduce freshwater inflow, stress conditions and fish that is older or spawning may have developed tissue to lose moisture to higher dry matter content hence the highest dry matter content in muscle of Rohu was found in the Jhelum River. The percentage of the dry matter obtained was determined as matching with (Memon et al., 2010), which established that Labeo rohita recorded the highest moisture content during summer (75.65) because of higher water retention. The increased food intake in the spring (72.91) led to increased dry matter and reduced moisture ($p < 0.05$). Rohu of Jhelum River was lowest in the percentage of crude ash followed by Rohu of Chenab River with highest percentage of crude ash than Morakhi of Jhelum River. The muscle of Morakhi of Chenab River may be ranked as the highest in crude ash because of better water quality low electrical conductivity, low total dissolved solids and mineral availability. The value of the crude ash analysis is consistent with the research of the study (ndome et al., 2010) denoted that the species under study are good sources of minerals probably because of their mineral-laden aquatic environment.

Rohu of Jhelum River possessed the least moisture content compared with Rohu of Chenab River whereas Cirrhinus mrigala (Morakhi) of Chenab River possessed the greatest moisture content compared with the Morakhi of Jhelum River. High dissolved oxygen, post-monsoon periods, and low electrical conductivity that confirms a decrease in total ion concentration in the water and consequently reduced the osmotic pressure on the fish, leading to entry of water into the tissues, could be the reason why the highest moisture content was found in Rohu muscle of the Chenab River. The obtained moisture content is compared with (Younis et al., 2021) ascertained that the moisture content of fish muscles varies between 78 and 81 percent owing to some factors such as species, age, season and environmental factors which influence water retention and metabolism. The Rohu of the Jhelum River contained the least amount of crude fat than the Rohu of Chenab River whilst the most amount of crude fat content lay with the Cirrhinus mrigala (Morakhi) of Chenab River followed by the Morakhi of Jhelum River. The most significant amount of crude fat of the muscle of Morakhi of the Chenab River may be attributed to the fact that the healthier metabolism and the higher capability to store energy in the form of body fat are facilitated by the reduced pollution levels and higher natural dilution in the Chenab River as reflected in the lower total dissolved solid translating into higher crude fat. The observed percentage of crude fat is compared to (Ahmed et al., 2022) stating that the fish muscle has a range of 6-20 percent of which depends on several parameters such as salinity, temperatures, species, nutrition and season.

Rohu of the Jhelum River contained the lowest level of crude protein followed by Rohu of Chenab River and then the Cirrhinus mrigala (Morakhi) of Chenab River had the highest level of crude protein. The reason why the maximum amount of protein in muscle of Morakhi of the chenab River was the highest could be attributed to the fact that the dissolved oxygen was more, planktons were more diverse, and food were more to the cleaner water leading to higher percent of crude protein in the water. The percentage of crude protein recorded corresponds with (Afzal et al., 2025) who also found that the content of protein in both species rose during the summer season owing to good temperatures and greater supply of zooplankton, phytoplankton and algal blooms. The lowest was the Crude fiber content of Rohu of the Jhelum River and the highest Crude fiber content of the Cirrhinus mrigala (Morakhi) of the Chenab River. The maximum percentage of crude fiber in Morakhi of the Chenab River could be explained by the fact that more fibrous vegetable matter was consumed by higher quantity of nitrogen load and growth of aquatic plants leading to increase in crude fiber percentage which is dependent on better water quality. The determined percentage of crude fiber is in correspondence to (Ferdousi et al., 2023) who indicated that the levels of crude fiber in fish species found in the Tista and Baral rivers are between 0.46 and 18.30 percent. These differences could have been due to differences in nutrition, size of fish, stage of development, ambient factors and laboratory processing environment.

CONCLUSION

These findings of the research revealed that Chenab River was observed to have a more alkaline habitat compared to the Jhelum River because of the greater nitrogen content through industrial, agricultural and domestic sources through the Paharang drain. High temperatures and atomic sites in Khushab district resulted in thermal stress and low oxygen levels in aquatic species in the Jhelum River. The salinity of the Jhelum River was natural, which accounted for the high conductivity and TDS levels, agricultural runoffs, industrial pollution, and seasonal increases and decreases in flow. The Chenab River indicated increased levels of DO because of low temperatures, turbulence, reduced organic load and good vegetation whereas increased levels of chloride were attributed to leaching of salty soil and contamination. These conditions were seen in the fish muscle composition with improved hydration, fat, protein, and mineral contents in fish at the Chenab River and the occurrence of environmental stress and dehydration in the fish at the Jhelum River. Long-term monitoring and remediation strategies should be considered in future research to enhance the water quality and aquatic health in both rivers particularly around Chiniot bridge and in Khushab District.

Author's contribution

Conceptualization: UH, AK. Methodology: MUH, RA. Formal analysis: SK, IM. Writing reviews and editing: MFS, MAS, JK
All authors have read and agreed to the published version

Conflict of Interest: All authors declare no conflict of interest
Source of Funding: The authors received no financial support for the research, authorship and publication of this article.

REFERENCE

1. Abraha, B., Admassu. h, Mahmud. A, Tsighe. N, Shui. X and Fang. y (2018). Effect of processing methods on nutritional and physico-chemical composition of fish: A review. MOJ Food Processing & Technology, 6 (4),376-382.
2. Adu, J. T., and M.V. Kumarasamy (2018). Assessing non-point source pollution models: a review. *Polish Journal of Environmental Studies*, *27*(5). 10.15244/pjoes/76497
3. Afzal, R., S.A, Fatima, F. Azam, F. Ghazal, S. Anoosh, S. Parveen, ... and T. Shahid (2025). AQUATIC ECOSYSTEM AND FISH: A REVIEW ON ALTERATIONS OF CLIMATE CHANGE IMPACT ON LABEO ROHITA PHYSIOLOGY. *AQUATIC*, *3*(3). https://doi.org/10.5281/zenodo.15354840
4. Ahmed, I., K. Jan, S. Fatma and M.A. Dawood (2022). Muscle proximate composition of various food fish species and their nutritional significance: A review. *Journal of Animal Physiology and Animal Nutrition*, *106*(3), 690-719. https://doi.org/10.1111/jpn.13711
5. Akhtar, A., and S. Abdullah (2021). Effect Of Animal And Plant Based Dietary Lipids On Growth (Weight Gain) And Serum Metabolites Of Labeo Rohita (Rohu). *Webology ISSN*.
6. Aziz, S., and R. Ullah (2022). Assessment and spatial distribution of quality of water of the middle stretch of the river jhelum using multivariate statistical techniques. *Journal of South Asian Studies*, *10*(1), 19-35.
7. Bashir, N., R. Saeed, M. Afzaal, A. Ahmad, N. Muhammad, J. Iqbal, ... and S. Hameed (2020). Water quality assessment of lower Jhelum canal in Pakistan by using geographic information system (GIS). *Groundwater for sustainable development*, *10*, 100357. https://doi.org/10.1016/j.gsd.2020.100357
8. Begum, M., T. Akter and M.H. Minar (2012). Analysis of the proximate composition of domesticated stock of pangas (Pangasianodon hypophthalmus) in laboratory condition. *Journal*

of Environmental Science and Natural Resources, *5*(1), 69-74. https://doi.org/10.3329/jesnr.v5i1.11555

9. Bellier, B., S. Bancel, E. Rochard, J. Cachot, O. Geffard and B. Villeneuve (2024). Assessment of the impact of chemical pollution on endangered migratory fish in two major rivers of France, including spawning grounds. *Science of The Total Environment*, *931*, 172748. https://doi.org/10.1016/j.scitotenv.2024.172748
10. Brraich, O. S., and S.K. Saini (2015). Water quality index of Ranjit Sagar wetland situated on the Ravi River of Indus River system. *International Journal of Advanced Research*, *3*(12), 1498-1509.
11. Bukola, D., A. Zaid, E.I. Olalekan and A. Falilu (2015). Consequences of anthropogenic activities on fish and the aquatic environment. *Poultry, Fisheries & Wildlife Sciences*, *3*(2), 1-12. 10.4172/2375-446X.1000138
12. Burkina, V., G. Zamaratskaia, S. Sakalli, P.T. Giang, V. Kodes, R. Grabic, ... and T. Randak (2018). Complex effects of pollution on fish in major rivers in the Czech Republic. *Ecotoxicology and Environmental Safety*, *164*, 92-99. https://doi.org/10.1016/j.ecoenv.2018.07.109
13. Charan, G., V.K. Bharti, A. Giri, and P. Kumar (2023). Evaluation of physico-chemical and heavy metals status in irrigation, stagnant, and Indus River water at the trans-Himalayan region. *Discover Water*, *3*(1), 3.
14. Chowdhury, L. M., V. Mohindra, R. Kumar and J. Jena (2024). Genome sequencing and assembly of Indian major carp, Cirrhinus mrigala (Hamilton, 1822). *Scientific Data*, *11*(1), 898. https://doi.org/10.1038/s41597-024-03747-6
15. Ferdousi, L., H. Kabir, M.H. Ali, M. Begum, M. Salma, M.M. Sarker ... and M.S. Reza (2023). Biochemical analysis of commonly consumed fishes and shell fishes from the Tista and the Baral River in Bangladesh. *Journal of Agriculture and Food Research*, *14*, 100671. https://doi.org/10.1016/j.jafr.2023.100671
16. Hasan, M. F., Alaam. Nur-E-, Salam. M, Rahman. M. A, H. Rahman H, S.C Paul, A.E. Rak,... and Towfiqul Islam, A. R. M. (2021). Health risk and water quality assessment of surface water in an urban river of Bangladesh. *Sustainability*, *13*(12), 6832. https://doi.org/10.3390/su13126832
17. Imran, M., A.M. Khan, M. Altaf, M, M. Ameen, R.M. Ahmad, M.T. Waseem and G. Sarwar (2021). Impact of alien fishes on the distribution pattern of indigenous freshwater fishes of Punjab, Pakistan. *Brazilian Journal of Biology*, *82*, e238096. https://doi.org/10.1590/1519-6984.238096
18. Kausar, F., A. Qadir, S.R. Ahmad and M. Baqar (2019). Evaluation of surface water quality on spatiotemporal gradient using multivariate statistical techniques: a case study of River Chenab, Pakistan. *Polish Journal of Environmental Studies*, *28*(4), 2645-2657. DOI: 10.15244/pjoes/92938
19. Kausar, F., A. Qadir, S.R. Ahmad, M. Baqar and F. Sardar (2020). Evaluation of River Chenab water quality with respect to its users, using different classification schemes. *Water Supply*, *20*(8), 2971-2987. https://doi.org/10.2166/ws.2020.192
20. Khizar, A., M. Fatima, N. Khan and M.A Rashid (2024). Effects of phytase inclusion in diets containing rice protein concentrate (RPC) on the nutrient digestibility, growth and chemical characteristics of rohu (Labeo rohita). *Plos one*, *19*(5), e0302859. https://doi.org/10.1371/journal.pone.0302859
21. Malik, D. S., A.K. Sharma, A.K. Sharma, R. Thakur and M. Sharma (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.

22. Memon, N. N., F.N. Talpur and M.I. Bhanger (2010). Nutritional aspects and seasonal influence on fatty acid composition of carp (Labeo rohita) from the Indus River, Pakistan. *Polish journal of food and nutrition sciences*, *60*(3), 217-223.
23. Mir, R. A., and G. Jeelani (2015). Hydrogeochemical assessment of river Jhelum and its tributaries for domestic and irrigation purposes, Kashmir valley, India. *Current Science*, 311-322.
24. Mir, R. A., G. Jeelani, and F.A. Dar (2016). Spatio-temporal patterns and factors controlling the hydrogeochemistry of the river Jhelum basin, Kashmir Himalaya. *Environmental Monitoring and Assessment*, *188*(7), 438. https://link.springer.com/article/10.1007/s10661-016-5429-6
25. Morgan, I. J., D.G. McDonald and C.M. Wood (2001). The cost of living for freshwater fish in a warmer, more polluted world. *Global Change Biology*, *7*(4), 345-355. https://doi.org/10.1046/j.1365-2486.2001.00424.x
26. Nadeem, B., M. Dawood, M. Kashif and M. Hashim (2024). Spatio–Temporal Evaluation of Temperature Variability, Trend and Pattern in Jhelum River Basin, Western Himalaya. *OEconomia*.
27. Ndome, C., O. Oriakpono and A. Ogar (2010). Proximate composition and nutritional values of some commonly consumed fishes from the Cross River Estuary. *Tropical Freshwater Biology*, *19*(1), 11.
28. Prakash, S., and A.K. Verma, (2022). Anthropogenic activities and Biodiversity threats. *International Journal of Biological Innovations, IJBI*, *4*(1), 94-103. https://doi.org/10.46505/IJBI.2022.4110
29. Saboret, G., C. Moccetti, K. Takatsu, D.J. Janssen, B. Matthews, J. Brodersen and C.J. Schubert (2024). Glacial meltwater increases the dependence on marine subsidies of fish in freshwater ecosystems. *Ecosystems*, *27*(6), 779-796. http://dx.doi.org/10.1007/s10021-024-00920-1
30. Saxena, V (2025). Water quality, air pollution, and climate change: investigating the environmental impacts of industrialization and urbanization. *Water, Air, & Soil Pollution*, *236*(2), 73. http://dx.doi.org/10.1007/s11270-024-07702-4
31. Sharma, K., S. Dogra and N. Singh (2023). Analysis of Physiochemical Parameters and Heavy Metal Pollution in Chenab River and its Tributaries, Jammu &Kashmir. https://doi.org/10.21203/rs.3.rs-3187470/v1
32. Siddique, S., M.N. Chaudhr, S,R. Ahmad, R. Nazir, Z. Zhao, R. Javed ... and A. Mahmood (2023). Ecological and human health hazards; integrated risk assessment of organochlorine pesticides (OCPs) from the Chenab River, Pakistan. *Science of the Total Environment*, *882*, 163504. https://doi.org/10.1016/j.scitotenv.2023.163504
33. Skałecki, P., M. Florek and A. Staszowska (2013). Effect of fishing season on value in use, intrinsic properties, proximate composition and fatty acid profile of perch (Perca fluviatilis) muscle tissue. *Fisheries & Aquatic Life*, *21*(4), 249-257.
34. Sujatha, K., A.A. Joice and P.S. Kumaar (2013). Total protein and lipid content in edible tissues of fishes from Kasimodu fish landing centre, Chennai, Tamilnadu. *European Journal of Experimental Biology*, *3*(5), 252-257.
35. Yang, D., Y. Yang and J. Xia (2021). Hydrological cycle and water resources in a changing world: A review. *Geography and Sustainability*, *2*(2), 115-122.
36. Younis, E. M., A.W.A. Abdel-Warith, N.A. Al-Asgah, S.A. Elthebite and M.M. Rahman (2021). Nutritional value and bioaccumulation of heavy metals in muscle tissues of five commercially important marine fish species from the Red Sea. *Saudi Journal of Biological Sciences*, *28*(3), 1860-1866. https://doi.org/10.1016/j.sjbs.2020.12.038