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ORIGINAL ARTICLE

Ichthyofaunal diversity of the Malakand division and the climatic and anthropogenic factors responsible for their decline

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Abstract
Knowing ichthyofaunal diversity and distribution models are critical challenges for researchers and fisheries managers who deal with the decline and extinction of freshwater ichthyofauna. The aim of this review is to evaluate the important literature reporting on ichthyofaunal diversity, their distribution and conservation status and also to identify the climatic and anthropogenic threats that are responsible for the decline of ichthyofauna in the three rivers of the Malakand division Khyber Pakhtunkhwa, Pakistan. Peer reviewed articles, published from 2000 to 2023, that described freshwater ichthyofaunal diversity, their distribution and conservation status were carefully selected. In total, 66 freshwater fish which belong to 8 families have been reported at the survey sites. Out of these the dominant family among the three rivers of the Malakand division is Cyprinidae (56%) followed by Nemacheilidae (15%). The conservation status of the studied ichthyofaunal diversity of the Malakand division indicated that 66 % of the species are of least concern, 10% are endangered, 6% are vulnerable, 7% are nearly threatened, 3% are critically endangered while 8% are not evaluated. Published records show that freshwater ichthyofaunal diversity is continuously declining due to anthropogenic factors and climatic changes such as global warming, heat waves, flooding, illegal and overfishing, habitat destruction and water pollution. In conclusion, certain measures such as habitat restoration, banned on illegal fishing and control of water pollution are required to preserve ichthyofaunal diversity in the studied area. Furthermore, a complete survey of the current ichthyofaunal diversity, conservation status and water quality analysis are highly recommended at the studied sites.

Keywords: Fish, Freshwater, Distribution, Conservation, Climate changes.

INTRODUCTION

The earth's climate is constantly changing, posing major threats to biodiversity and the human population. In contrast to the past, climatic changes have occurred more rapidly over the past two centuries. With the progression of industrialization, man-made activities continuously affect the biota and the biosphere. The climatic factors such as temperature, precipitation and atmospheric CO2 concentration have all changed over the last few decades, resulting in glacier melting, droughts, floods, and acid rain. Climate changes creates a significant threat to ecosystems and biodiversity, including freshwater organisms (Hussain et al. 2019). Recent studies have predicted that the effects of climatic changes will be observed on the entire biota, resulting in worldwide consequences. These critical issues require immediate attention and collaborative efforts to reduce risk and minimize possible consequences (Phillips 2018). Global warming is significant factor in climate change that has far reaching impact on ecosystems. According to the Intergovernmental Panel on Climatic Change (IPCC) under the United Nations Scientific Consortium, the impacts of climatic change are predicted to escalate future adverse events, including rise in temperature, which are anticipated to lead to heat waves, thunder storms, increased precipitation in some regions, glacial melting, and catastrophic flooding (Mata et al. 2001).

Global warming is alarming for sensitive species, particularly ectothermic animals, and has a significant impact on organisms, populations, and ecological communities. Aquatic ecosystems are indeed more vulnerable to the effects of climate change and global warming (Deemer et al. 2016). Fish can change their body temperature in response to their environment; therefore, climatic variations alter their physiological responses and limit their tolerance and resilience (Comte & Olden 2017). Global warming and changes in biotic interactions are the primary drivers of species extinction due to global climate change (Cahill et al. 2013). Despite that, about 50 percent of the world's freshwater fish species are affected by the global climate changes (Darwall & Freyhof 2016). Other than climatic changes, anthropogenic activities also play a remarkable role in affecting freshwater biodiversity. These climatic and anthropogenic stressors have synergistic effects that further affect and alter the freshwater ichthyofaunal biodiversity. These combined stressors include water pollution, habitat destructions, water acidification, pesticides, eutrophication, and the introduction of invasive species (Durant et al. 2005, Joã et al. 2007). With an increasing population, the numbers of industries are increasing lead to water pollution and causing serious threats to freshwater biodiversity (Bukola et al. 2015). These anthropogenic activities exert a significant burden on aquatic ecosystems, necessitating further research to investigate the deleterious effects of water pollution on aquatic biota.

The freshwater ichthyofaunal diversity of Pakistan comprises 193 fish species belonging to class Actinopterygii, subclass Teleostei, 3 cohorts, 6 super orders, 13 orders, 30 families, and 86 genera (Rafique & Khan 2012). A researcher conducted a considerable amount of research on the ichthyofaunal diversity of Khyber Pakhtunkhwa, Pakistan, and reported more than 180 species from the river Indus, 11 species from Kohat, and 8 species from the river Swat (Mirza & Mirza 2014). The aim of this review is to highlight the ichthyofaunal diversity in the rivers of the Malakand division of Khyber Pakhtunkhwa, Pakistan and to relate the effects of climate change and anthropogenic activities to the declining fish population.

Country Profile: The average global temperature is expected to rise by 1.5 to 6.5°C and this increase in temperature will drive certain species toward extinction because each species has a fixed temperature range within which it can survive and global warming will also affect biological rhythms and phenology (Gattuso et al. 1998). Pakistan is located in the South Asian subcontinent; it falls within the temperate zone and has hot and dry climate. The annual temperature average in Pakistan has increased by 0.6°C, consistent with the global trend. The average temperature of northern areas of Pakistan is rising by 0.8 °C as compared to southern regions, and due to this, the IPCC predicted an increase in temperature in the northern areas of Pakistan in contrast to other regions (Cheema et al. 2006). Due to this reason, Pakistan is placed 16th among the countries that are vulnerable to the impact of global climate changes and global warming (Khan et al. 2016).

MATERIALS AND METHODS

To constitute a complete and extensive background, peer-reviewed articles and research projects published between 2000 and 2023 were carefully selected and analyzed. The preferred articles were identified using specific key words: such as freshwater fish biodiversity, climate change, climate change and Pakistan, anthropogenic activities connected with freshwater fish biodiversity, habitat degradation, social and economic barriers, and their distribution and conservation status in various databases, such as Science Direct, Google Scholar, Academia, Scopus and ResearchGate. Taxonomic information of the identified ichthyofauna was collected using different databases, including FishBase, Fish Karyome, and Fishipedia and their conservation status was assessed with the help of International Union for Conservation of Nature (IUCN) Red list categories. Malakand Division is geographically spread from 35° 29' 59.99" North to 72° 00' 0.00" East. It consists of nine districts, which include Swat, Shangla, Malakand, Dir Lower, and Dir Upper, Buner, Chitral Upper and Chitral Lower and Bajaur, along with tribal areas (Fig. 1) (Khan et al. 2021). The total area of the Malakand division is 32,007 km^2. The ichthyofaunal diversity

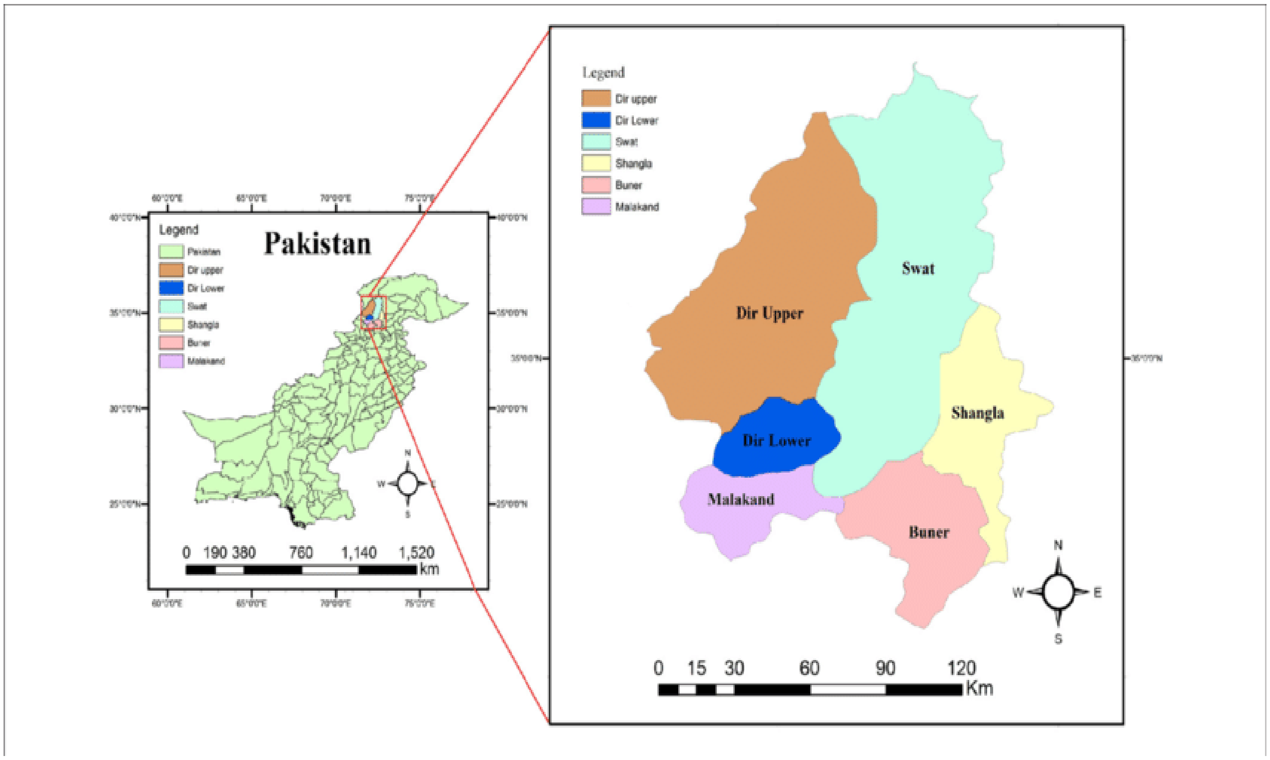

Fig.1. Study map of Malakand division, Khyber Pakhtunkhwa, Pakistan.

faces several major threats, including water pollution, global warming and heatwaves, flooding, habitat destruction and habitat barriers, waste water discharge from hotels and homes, overfishing and illegal fishing, industrial activities, disposal of effluent from marble factories to rivers, and the presence of various contaminants such as pesticides and heavy metals.

RESULTS AND DISCUSSION

The results of icthyofauna of Malakand division are shown in Table 1 and 2. The Barandu River is the largest and most important river in district Buner. It flows through Tehsil Daggar and then into Tehsil Gagra, Tehsil Chagharzi, and finally into river Indus at Kala Dhaka (Haq & Saeed 2012). A survey to study the ichthyofauna of the river Barandu was carried out, in which the river was divided into collection sites and samples were collected from April to September 2012. During this investigation, 11 distinct species of fish were recorded from the Barandu River. These species were categorized into 3 orders and 4 families. The dominant family recorded in the survey was Cyprinidae, which was represented by 6 species: *Barilius pakistanicus, Tor putitora, Crossocheilus latius, Schizothorax plagiostomus, Garra gotyla, Puntius sophore* (Saeed et al. 2013). Another study was conducted from November 2012 to October 2013.

During this investigation, a total of 13 fish species were collected, recognized, and divided into 4 orders and 5 families. The dominant family was Cyprinidae, represented by 8 species. Two new species *Crossochelius deplocheilus* and *Puntius ticto* were also identified in this study (Hasan et al. 2016). The most significant observation concerning the foregoing studies on the Barandu River is that there are no invasive species present in the river. The Swat River originates in Kalam, where the two rivers Ushu and Utror converge, and flows for approximately 106 km passing through the Swat valley. The total length of Swat River is 250 km, beginning in Kalam up to its convergence with the river Kabul near Charsadda. Many small and large streams appeared from various locations and joined Swat River. A study was conducted from 2004 to 2010, and many fish species were collected and analyzed from river Swat and its tributaries.

Table 1. Taxonomy of ichthyofauna of Malakand division, Khyber Pakhtunkhwa, Pakistan.

S. No	Zoological name	Family	Order	Class
1	*Barilius pakistanicus*	Cyprinidae	Cypriniformes	Actinopterygii
2	*Crossocheilus diplocheilus*	Cyprinidae	Cypriniformes	Actinopterygii
3	*Crossocheilus latius*	Cyprinidae	Cypriniformes	Actinopterygii
4	*Puntius ticto*	Cyprinidae	Cypriniformes	Actinopterygii
5	*Puntius sophore*	Cyprinidae	Cypriniformes	Actinopterygii
6	*Garra gotyla*	Cyprinidae	Cypriniformes	Actinopterygii
7	*Schizothorax plagiostomus*	Cyprinidae	Cypriniformes	Actinopterygii
8	*Tor macrolepis*	Cyprinidae	Cypriniformes	Actinopterygii
9	*Schistura punjabensis*	Nemacheilidae	Cypriniformes	Actinopterygii
9	*Triplophysa naziri*	Nemacheilidae	Cypriniformes	Actinopterygii
10	*Glyptothorax punjabensis*	Sisoridae	Siluriformes	Actinopterygii
11	*Channa gachua*	Channidae	Anabantiformes	Actinopterygii
12	*Mastacembelus armatus*	Mastacembelidae	Synbranchiformes	Actinopterygii
13	*Tor putitora*	Cyprinidae	Cypriniformes	Actinopterygii
14	*Danio devario*	Cyprinidae	Cypriniformes	Actinopterygii
15	*Barilius vagra*	Cyprinidae	Cypriniformes	Actinopterygii
16	*Puntius chola*	Cyprinidae	Cypriniformes	Actinopterygii
17	*Ompak pabda*	Suliridae	Siluriformes	Actinopterygii
18	*Carassius auratus*	Cyprinidae	Cypriniformes	Actinopterygii
19	*Acanthocobitis botia*	Nemacheilidae	Cypriniformes	Actinopterygii
20	*Channa punctata*	Channidae	Anabantiformes	Actinopterygii
21	*Puntius sarrana*	Cyprinidae	Cypriniformes	Actinopterygii
22	*Puntius conchonius*	Cyprinidae	Cypriniformes	Actinopterygii
23	*Schizothorax esocinus*	Cyprinidae	Cypriniformes	Actinopterygii
24	*Racoma labiata*	Cyprinidae	Cypriniformes	Actinopterygii
25	*Cyprinion watsoni*	Cyprinidae	Cypriniformes	Actinopterygii
26	*Cyprinus carpio*	Cyprinidae	Cypriniformes	Actinopterygii
27	*Barilius modestus*	Cyprinidae	Cypriniformes	Actinopterygii
28	*Ctenopharyngodon idella*	Cyprinidae	Cypriniformes	Actinopterygii
29	*Schistura lepidota*	Nemacheilidae	Cypriniformes	Actinopterygii
30	*Schistura prashari*	Nemacheilidae	Cypriniformes	Actinopterygii
31	*Schistura macrolepis*	Nemacheilidae	Cypriniformes	Actinopterygii
32	*Triplophysa microps*	Nemacheilidae	Cypriniformes	Actinopterygii
33	*Glyptothorax stocki*	Sisoridae	Siluriformes	Actinopterygii
34	*Glyptothorax sufii*	Sisoridae	Siluriformes	Actinopterygii

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Table 1. Continued.

S. No	Zoological name	Family	Order	Class
35	*Glyptothorax naziri*	Sisoridae	Siluriformes	Actinopterygii
36	*Orienus plagiostomus*	Cyprinidae	Cypriniformes	Actinopterygii
37	*Salmo trutta*	Salmonidae	Salmoniformes	Actinopterygii
38	*Cirrhinus mrigala*	Cyprinidae	Cypriniformes	Actinopterygii
39	*Salmophasia bacaila*	Cyprinidae	Cypriniformes	Actinopterygii
40	*Amblypharyngodon mola*	Cyprinidae	Cypriniformes	Actinopterygii
41	*Labeo rohita*	Cyprinidae	Cypriniformes	Actinopterygii
42	*Salmophasia punjabensis*	Cyprinidae	Cypriniformes	Actinopterygii
43	*Gagata cenia*	Sisoridae	Siluriformes	Actinopterygii
44	*Oncorhynkiss mykiss*	Salmonidae	Salmoniformes	Actinopterygii
45	*Mystus bleekeri*	Bagridae	Siluriformes	Actinopterygii
46	*Rasbora doniconius*	Cyprinidae	Cypriniformes	Actinopterygii
47	*Glytothorax kashmirensis*	Sisoridae	Salmoniformes	Actinopterygii
48	*Schizothorax labiatus*	Cyprinidae	Cypriniformes	Actinopterygii
49	*Glytothorax reticulatum*	Sisoridae	Siluriformes	Actinopterygii
50	*Chanda nama*	Ambassidae	Perciformes	Actinopterygii
51	*Labeo diplostomus*	Cyprinidae	Cypriniformes	Actinopterygii
52	*Xenentodon cancila*	Belonidae	Beloniformes	Actinopterygii
53	*Glyptothorax cavia*	Sisoridae	Siluriformes	Actinopterygii
54	*Clupisoma garua*	Ailiidae	Siluriformes	Actinopterygii
55	*Gagata pakistanica*	Sisoridae	Siluriformes	Actinopterygii
56	*Clupisoma naziri*	Ailiidae	Siluriformes	Actinopterygii
57	*Schizothorax Socinus*	Cyprinidae	Cypriniformes	Actinopterygii
58	*Chela cachius*	Danionidae	Cypriniformes	Actinopterygii
59	*Aspidoparia morar*	Cyprinidae	Cypriniformes	Actinopterygii
60	*Puntis conchoinus*	Cyprinidae	Cypriniformes	Actinopterygii
61	*Naziritor zobensis*	Cyprinidae	Cypriniformes	Actinopterygii
62	*Sistura naseeri*	Nemacheilidae	Cypriniformes	Actinopterygii
63	*Ttiplophysa choprai*	Nemacheilidae	Cypriniformes	Actinopterygii
64	*Eutropiichythys vacha*	Schilbeidae	Siluriformes	Actinopterygii
65	*Colisa fasciata*	Osphronemidae	Perciformes	Actinopterygii
66	*Colisa lalia*	Osphronemidae	Anabantiformes	Actinopterygii

Table 2. Distribution and conservation status of ichthyofauna of Malakand division. (+) means that the specie is present in the specific river while (-) means that the particular specie is absent in that specific river. LC- least concern, NE- not evaluated, VU- vulnerable, EN- endangered, NT- nearly threatened, CE- critically endangered.

S.No	Zoological name	Swat	Panjkora	Bharandu	Conservation status
1	*Barilius pakistanicus*	+	+	+	LC
2	*Crossocheilus diplocheilus*	+	+	+	NE
3	*Crossocheilus latius*	+	-	+	LC
4	*Puntius ticto*	+	+	+	LC
5	*Puntius sophore*	+	-	+	LC
6	*Garra gotyla*	+	+	+	LC
7	*Schizothorax plagiostomus*	+	+	+	VU
8	*Tor macrolepis*	+	+	+	NE
9	*Schistura punjabensis*	-	+	+	NE
10	*Triplophysa naziri*	+	+	+	LC
11	*Glyptothorax punjabensis*	+	+	+	EN
12	*Channa gachua*	+	+	+	LC
13	*Mastacembelus armatus*	+	+	+	LC
14	*Tor putitora*	+	+	+	EN
15	*Barilius vagra*	+	+	-	LC
16	*Puntius chola*	+	-	-	LC
17	*Ompak pabda*	+	-	-	NT
18	*Carassius auratus*	+	+	-	LC
19	*Acanthocobitis botia*	+	-	-	LC
20	*Channa punctata*	+	+	-	LC
21	*Puntius sarrana*	+	-	-	LC
22	*Puntius conchonius*	+	-	-	LC
23	*Schizothorax esocinus*	+	+	-	VU
24	*Racoma labiata*	+	+	-	NE
25	*Cyprinion watsoni*	-	+	-	LC
26	*Cyprinus carpio*	+	+	-	VU
27	*Barilius modestus*	+	+	-	NE
28	*Ctenopharyngodon idella*	-	+	-	LC
29	*Schistura lepidota*	+	+	-	CE
30	*Schistura prashari*	+	+	-	NT
31	*Schistura macrolepis*	-	+	-	EN
32	*Triplophysa microps*	-	+	-	LC
33	*Glyptothorax stocki*	+	+	-	EN
34	*Glyptothorax sufii*	+	+	-	EN
35	*Glyptothorax naziri*	-	+	-	NT
36	*Orienus plagiostomus*	+	+	-	NT
37	*Salmo trutta*	+	+	-	LC
38	*Cirrhinus mrigala*	+	-	-	LC
39	*Salmophasia bacaila*	+	-	-	LC
40	*Amblypharyngodon mola*	+	-	-	LC
41	*Labeo rohita*	+	-	-	LC

Table 2. Continued

S.No	Zoological name	Swat	Panjkora	Bharandu	Conservation status
42	*Salmophasia punjabensis*	+	-	-	LC
43	*Colisa lalia*	+	-	-	LC
44	*Colisa fasciata*	+	-	-	LC
45	*Rasbora daniconius*	+	-	-	LC
46	*Eutropiichythys vacha*	+	-	-	LC
47	*Chanda nama*	+	-	-	LC
48	*Labeo diplostomus*	+	-	-	LC
49	*Xenentodon cancila*	+	-	-	LC
50	*Glyptothorax cavia*	+	+	-	LC
51	*Gagata cenia*	+	+	-	LC
52	*Gagata pakistanica*	+	-	-	LC
53	*Mystus bleekeri*	+	-	-	LC
54	*Clupisoma garua*	+	-	-	LC
55	*Gagata pakistanica*	+	-	-	LC
56	*Glytothorax kashmirensis*	-	+	-	CE
57	*Schozothorax labiatus*	-	+	-	NE
58	*Glytothorax reticulatum*	-	+	-	CE
59	*Clupisoma naziri*	+	-	-	NT
60	*Schizothorax Socinus*	+	-	-	VU
61	*Chela cachius*	+	-	-	LC
62	*Aspidoparia morar*	+	-	-	LC
63	*Puntis conchoinus*	+	-	-	LC
64	*Naziritor zobensis*	+	-	-	EN
65	*Sistura naseeri*	+	-	-	EN
66	*Ttiplophysa choprai*	+	-	-	LC

The collected fish samples were identified using various databases, resulting in the identification of 50 fish species, belonging to 7 orders and 10 families. The dominant family among the 10 recorded family was Cyprinidae (Hasan et al. 2013). A study on the icthyofauna of the river Swat in 2007 collected and identified 50 species. Species such as *Xenentodon cancila, Chupisoma garua, Chela cachius, Aspidoparia morar, Sistura naseeri, Naziritor zobensis, Triplopysa choprai, Eutropiichythys vacha, Colisa fasciata* and *Colisa lalia* were identified in this study (Mirza 2007). However, data on fish collected from the Swat River after the 2010 flood did not show any evidence of the above mentioned species. Following the catastrophic flood of July 2010, another survey was done on water quality parameters and ichthyofaunal diversity of the Swat River at Charsadda. A 35 kilometers long belt of Swat River was covered and analyzed for the distribution and identification of fish species. In this study, 38 fish species were collected, belonging to 6 orders, 9 families, and 24 genera. The dominant family of Cyprinidae was represented by 20 species. Two exotic species, including *Cyprinus carpio* and *Carassius auratus* were also identified. The most significant observation regarding this study was that, 6 species, including *Punitus chola, Sistura naseeri, Punitus conchonius, Glypothorax nazari, Schizothorax esocinus* and *Triplopysa choprai* were absent in this study (Yousafzai et al. 2013). Another study on the ichthyofauna of river Swat from Madayan to Chakdara was done in 2013, and total of eighteen species were collected and identified. The reported species belong to 5 orders and 6 families, and

Cyprinidae was considered the most dominant among them (Ishaq et al. 2014).

In 2017, a preliminary survey of the ichthyofaunal diversity of Swat River in Charsadda was carried out. During the study period from March to July 2017, a total of 13 different species belonging to 4 orders and 7 families were collected and identified. A significant number of species were not reported in this study as compared with previous studies (Waheed et al. 2018). The most important observation regarding this survey was that, *Tor putitora* is considered extinct and was not recorded in this study (Akhtar et al. 2016). Furthermore, *Tor putitora* is regarded an endangered species by IUCN and majority of individuals in genus *Tor* are listed as threatened. Another study conducted in 2016 confirmed the decline of the *Tor putitora* population following the massive flood of 2010. However a final study by Yousaf et al. (2023) confirmed that the species is not extinct, but its population has significantly decreased to a very low level due to the destruction of its habitats. A research was carried out from January to August 2017 regarding the ichthyofaunal of Swat River at Sakhakot stream, Malakand division. 10 species were collected and identified belonging to three orders and four families. Cyprinidae was found to be the most dominant family represented by 7 species (Attaullah et al. 2021).

The Panjkora River flows through district Dir Lower, which is located in the northern areas of Khyber Pakhtunkhwa, Pakistan. The river's name "Panjkora" comes from the confluence of five streams: Kumrat, Kohistan, Lawarri, Barawal, Usherai, and Guldai. The Panjkora River originates from the Hundukush rang at latitudes. It flows through Dir and Timargara, eventually joining the Swat River at Busaq near Qalungai. A survey was conducted to study the diversity of cyprinid fauna in the Panjkora River from January 2012 to December 2015. In total 671 fish, belonging to 7 genera and 10 species were reported and examined. *Schizothorax plagiostmus* is considered the most abundant specie in the study site of the Panjkora river (Yousafzai 2017). Another study especially focusing on the family Sisoridae was done from 2012 to 2105. A total of 115 fish species were collected from six sampling sites, belonging to 2 genera and 5 species. The most important observation in this study is the finding of new fish species, *Glyptothorax kashmirensis* for the first time in the river and also in Khyber Pakhtunkhwa. Furthermore, Cyprinidae was found to be the most dominant family and *Glyptothorix nazari* was found to be the most abundant species (Wahab & Yousafzai 2017). Another study was conducted from November 2012 to May 2013. A total of 11 species belonging to 5 orders and 5 families were reported and identified. Cyprinidae was determined to the most abundant family (Ahmad 2014). A detailed survey of the icthyofauna was conducted from April to September 2012. A total of 781 samples, representing 25 species and belonging to 5 families were collected during this survey. The fish fauna in the study area was dominated by the family Cyprinidae, followed by Nemacheilidae and the dominant specie was *Crossocheilus diplocheilus* (Hasan et al. 2015). According to the above literature, the most abundant family among the three rivers is Cyprinidae, followed by Nemacheilidae, as shown in (Fig. 2). It could be concluded that 66 percent of the species are categorized as least concern, 10 percent considered endangered, and 8 percent were not been evaluated as shown in (Fig. 3).

Some major threats to fresh water fish biodiversity: Major threats to ichthyofaunal diversity are shown in (Fig. 4).

Global warming and heat waves: Global climate change is causing sudden ecological changes and unexpected events. Following the Industrial Revolution, humans have rapidly adapted to using fossil fuels as an energy source. Fossil fuels generate more energy, but they also emit greenhouse gases. Although climate change occurs naturally, and modern anthropogenic activities will exacerbate these changes in the future (Langford 1983). All freshwater fish are poikilotherm, meaning they cannot adjust their body temperature via internal physiological

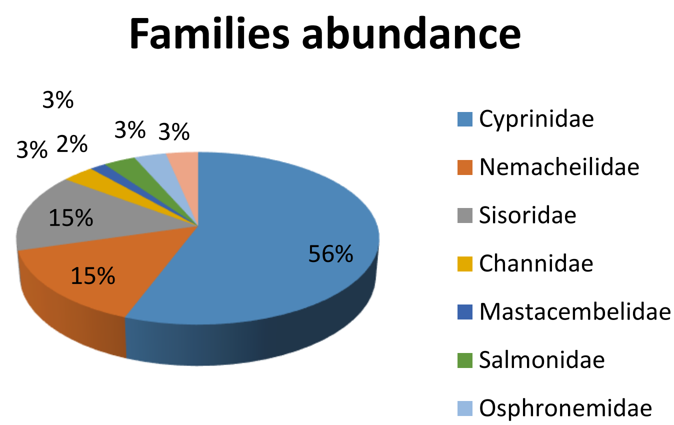

Fig.2. Showing the family's abundance in the three rivers of Malakand division, Khyber Pakhtunkhwa, Pakistan.

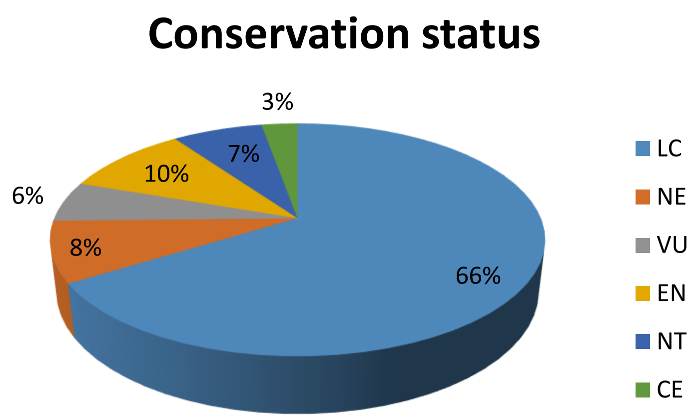

Fig.3. Showing the conservation status of ichthyofauna in the three rivers of Malakand division, Khyber Pakhtunkhwa, Pakistan.

Fig.4. Showing the major threats faced by ichthyofauna in the rivers of Malakand division, Pakistan.

mechanisms. As a result, the body temperature remains identical to that of their external environment to regulate physiological functions such as growth, reproduction, and other hormonal activities. As a result, global warming and heat waves both individuals and populations by modifying their

Fig.5. People washing marble stones in river Swat as major cause of water pollution.

normal physiological functioning in response to the external environment (Fry 1971). As the increase in temperature is inversely related to the solubility of oxygen, so fish exposed to elevated temperature have a high demand for dissolved oxygen because high temperatures decrease the supply of dissolved oxygen in water (Kalff 2002).

Eutrophication is another consequence of global warming. When a heat wave raises the water temperature in the presence of nutrient availability, it results in algal growth and algal blooms, and these blooms cause hypoxia in the fish population (Trolle et al. 2010). Due to the increase in temperature, the toxicity of contaminants in water also increases. Higher temperatures can cause the volatilization of toxic chemicals such as pesticides, persistent organic pollutants (POPs), and heavy metals, releasing them into the water. Warmer water conditions can also convert these toxic compounds into more harmful metabolites, enhancing their toxic effect on fish health (Kibria et al. 2021). These harmful metabolites were then consumed by fish and other aquatic organisms, heightening the risk of disease and impairment. Furthermore, as a result of global warming, the temperature of the biosphere rises, melting glaciers and causing an erratic pattern of rain. As a result, the flow of water in water bodies increased, causing flood and flood swept away anything in their way. Pakistan had two destructive and massive floods in the 21st century: one of them occurred in 2010, which was considered the largest in the history of Pakistan, and the second in 2022. These two floods badly eradicated the biodiversity and economy of Pakistan. The recent flood of 2022 was very devastating and badly affected the fish distribution and water quality of the river Swat and the river Panjkora (Ullah et al. 2023). Floods also cause sudden and substantial changes in other environmental variables, and all these changes in turn influence the organisms inhibiting the reservoir ecosystem from small microorganisms to fish (Yousafzai et al. 2013). Floods also increase the chances of local species extinction by sweeping away eggs, and fingerlings, decrease food availability, and habitat destruction (Zhang et al. 2021).

Industrial and pharmaceutical wastes: Water contamination is significantly affecting the physiology and ecology of the aquatic biota. The discharge of waste from industries into the river results in the alteration of the flora and fauna, thereby impairing the fish population. In Pakistan, a significant number of industries operate without legal registration and continue to discharge their waste effluents straight into the nearby rivers and water bodies (Khanna & Ishaq 2013). Unexpectedly, only one percent of the industrial effluents in Pakistan undergo treatment before it is released into the environment, and the rest contaminate the water bodies. The river Kabul in Khyber Pakhtunkhwa

Fig.6. Pharmaceutical and Industrial wastes at the bank of river Swat.

Fig.7. Extraction of sand from river Swat creating habitat barriers for aquatic organisms.

receives an alarming volume of 80,000 m^3 of effluents every day (Jabeen 2015). Furthermore, Marble industries in district Buner contribute significantly to water pollution in the Barandu River. It is believed that around 70 percent of marble and its resources are processed, cleaned, and polished, resulting in the discharge of effluent into River Barandu and its tributaries, as shown in (Fig. 5). This pollution is considered a significant contributing factor to the declining quantity of fish in the Barandu river (Mulk et al. 2016). In addition, pharmaceutical and personal care goods also contain endocrine-disrupting chemicals that interact with the physiology of fish and disrupt their homeostasis. Over the past few decades, various reports have highlighted the detection of these products in fish tissues. This occurs because pharmaceutical and personal care products often end up in the aquatic environment, with hospitals and domestic discharge, serving as an important source of entry and exposing fish to these potentially harmful substances, as shown in (Fig 6). The parent compounds of these products transform into metabolites, which are typically more toxic than the original compounds and can have an adverse impact on aquatic ecosystems (Bound & Voulvoulis 2005).

Habitat destruction and flow modification: The aquatic ecosystem is also suffering from several other physical threats, including habitat destruction, fragmentation, and degradation. One such concern is the removal of water or sand as shown in (Fig. 7), which can modify water flow and negatively impact fish migratory pattern (Harrison et al. 2015). Another significant threat is the construction of dams and alteration in water flow, which can lead to habitat destruction and fragmentation. These modifications make it difficult for fish to migrate during breeding season. Migration is critical for fish because it allows them to find suitable spawning grounds, feeding areas, and shelter from predators or unfavorable conditions such as flooding or freezing of lakes and streams. Habitat barriers created by dams disrupt the natural migratory patterns of fish, resulting in injury or mortality and leading to the reduction and extinction of fish populations (Meixler et al. 2009).

Illegal fishing: Water pollution and illegal fishing pose significant threats to the decline of fish populations in freshwater bodies. Fishing activities, which bring both the tourists and local people to the rivers, can have detrimental effects when illegal methods of fishing are used. Fishermen utilize destructive techniques such as dynamite, electric currents, and pesticides to capture fish. A study conducted on the Swat and Kabul rivers revealed that dynamite fishing was initially practiced, but the loud noise caused by the blasting can easily be detected by law enforcement authorities (Nafees et al. 2012). As a result, fishermen began to use electric currents and pesticides since these methods were more efficient and took less time and effort. Unfortunately, both pesticides and electric currents have a devastating impact on all fish present in the targeted region. Despite the ban on all these illegal fishing methods, people continue to apply them, resulting in a decline in fish diversity in the rivers of Malakand division, Khyber Pakhtunkhwa (Nafees et al. 2011).

Heavy metals: Heavy metals are defined as "naturally occurring metals having atomic number greater than 20 and an elemental density greater than 5 g cm^{-3}" (Ali & Khan 2018). Hartl (2013) Reported that heavy metals of natural and anthropogenic origin are ubiquitous in the aquatic environment, therefore knowing their behavior and interaction with the aquatic environment. Heavy metals enter the environment from a variety of natural, geological, and anthropogenic sources. Natural resources from which heavy metals are released are weathering of metal-bearing rocks and volcanic eruptions, while manmade activities that release heavy metals into the environment include industries, phosphate fertilizer production and application, mining and the application of metallopesticides on crops, and other agricultural activities (Hashem et al. 2017). Heavy metals get into water bodies via dry and wet deposition, industrial discharge, domestic sewage, and agricultural runoff. Aquatic organisms, particularly fish, are subjected to a mixture of various metals, and their effects can be synergistic, antagonistic, or additive (Sauliutė & Svecevičius 2015). Heavy metals enter the fish body via a variety of mechanisms, including entry from water and sediments, as well as entry through the skin and gills and also the gastrointestinal tract. Usually, metabolically active organs such as the liver, gills, and kidneys acquire excessive concentrations of heavy metals as compared to other tissues and organs (Huang 2016).

Due to industrialization, heavy metal contamination in aquatic ecosystems is a serious pollution problem and has become a global issue. Freshwater pollution has become a serious environmental concern in Pakistan, due to the rapid increase in industrial and economic growth and development. Industrial waste and domestic sewage contain hazardous heavy metals and are often released regularly into rivers and streams without sufficient treatment (Javed & Usmani 2016). Environmental pollution has become as a significant challenge for humanity in the twenty-first century. Among the various forms of pollution, heavy metal contamination has become a significant issue affecting aquatic ecosystems. While heavy metals are naturally present in the environment, human activities have also increased their release into the aquatic environment (Javed & Usmani 2016). Because of their long-term persistence in the environment, heavy metals tend to accumulate in the aquatic biota. Fish are unable to depart from their habitats are particularly vulnerable to the adverse effects of heavy metals (Siraj et al. 2016). Water pollution is believed to be the possible cause of the decline of the fish population, and as a result, *Tor putitora* has been classified as an endangered species in the Kabul river (Yousafzai & Shakoori 2009). Fish act as bioindicators of water pollution, and while some heavy metals are essential for proper bodily functions in small amounts, however, excessive concentrations can cause severe physiological and biochemical alterations in fish. For instance, high concentrations of mercury disrupt fish behavior, impede growth and development, induce reproductive dysfunction, and eventually result in mortality (Pandey & Sharma 2014). The bioaccumulation of methylated forms of mercury occurs in fish, causing neurotoxicity. Studies reported on various fish species have shown that heavy metal accumulation influences the physiology and metabolic processes of exposed fish. Furthermore, cadmium and nickel are carcinogenic and induce cancer in fish, and spotted snakeheads, when exposed to a higher concentration of sodium arsenate, cause death within 2 hours after exposure (Pandey & Madhuri 2014). Heavy metal poisoning causes stressful conditions in fish and changes the glucose contents; glucose indicates the energy requirement and expenditure because stressful conditions use carbohydrates as the primary source of energy (Javed & Usmani 2019). Higher concentrations of heavy metals also cause genotoxicity and DNA damage. A study reported by Baršienė et al. (2013) showed that higher concentrations of copper significantly affect the red

Fig.8. Pesticides used in a single peach garden near river Swat.

blood cells of fish. Heavy metals also cause histological damage, and it has been previously shown that metals accumulate in the gills, liver and kidney; therefore these organs have been the primary targets of environmental pollution. Liver deformation has been observed in fish exposed to higher concentrations of chromium and cadmium (Hughes et al. 1979). It was concluded from the above discussion that heavy metals significantly affect the health status of ichthyofauna and pose serious threats to their diversity.

Pesticides: Pesticides have played a significant role in controlling crop diseases, and the development of synthetic pesticides in the mid-20th century revolutionized pest control in agriculture (Edwards 1993). With a rising population, there is a greater demand for greater agricultural productivity, which has led to the use of pesticides to control pest diseases in crops. After World War II, pesticides were extensively utilized to fulfill the urgent need for food, but the advent of synthetic pesticides from the 1940s onward increased crop and food output (Franco 2015). It has been estimated that 3 billion kg of pesticides are used worldwide, but unfortunately, only one percent of these pesticides reach the targeted sites, and the remaining 99 percent hit the non-targeted sites, posing serious threats to humans and other species (Hernández et al. 2013). Pakistan, an agricultural country, relies significantly on agriculture to support its population and economy. However, disease outbreaks in crops and pests have resulted in a significant economic loss of 85 million US dollars in Pakistan. Unfortunately, Pakistan reported a higher consumption of pesticides than the global average. The amount of pesticide used varies in Pakistan, however, the most widely used pesticides are organochlorines, pyrethriods, carbamates and organophosphates. The most problematic among these pesticides are organochlorines because their metabolites leave residue in the environment and may cross and transport across different media (Rashid et al. 2022).

Pesticides enter freshwater bodies through various routes, including agriculture runoff, industrial waste effluent discharge, and atmospheric deposition (Ali et al. 2014). A study on the usage of pesticides in the Swat Valley reported the significant presence of a large number of pesticides in the region, including the Swat River as shown in (Fig 8). The result of the study indicated that these pesticides were not utilized just for agriculture practices but used for illegal fishing practices in the Swat Valley. All samples observed consist of six pesticides, including Malathion, DDT, Lindane, Deldrine, Parathion- Methyl and Heptachlor. Among these four pesticide Malathion, DDT, Lindane and Deldrine were banned in Pakistan (Nafees et al. 2008). Although endosulfan and cypermethrin are used in agricultura, but they are also misused for killing fish. It killed all the aquatic species present in the applied area of the Swat river and its tributaries, as reported by Mohammad & Rasul (2009). Pesticides also interfere with the olfactory receptors and disrupt olfaction. They also reduce reproductive success and individual mating behavior, thus contribute to increasing the risk of population decline (Tierney et al. 2010).

CONCLUSION

It was concluded from the above discussion that ichthyofaunal diversity is at high risk of decline and extinction. Global warming, habitat destruction, water pollution, heavy metals, illegal fishing, and pesticides are the main threats to freshwater biodiversity in the present era. As shown above, ichthyofaunal diversity is decreasing at an alarming rate in Pakistan. It was concluded from the above discussion that the dominant family among the three rivers of the Malakand division is Cyprinidae, followed by Nemacheilidae. It was also concluded that 66 percent of the species are of least concern and 10 percent are endangered, and 8 percent are not evaluated. The limitation of the study is the yearly wise data of icthyofauna. The Fishery Department and local community have failed to evaluate the ichthyofaunal diversity and conservation status of fish on an annual basis. Furthermore, strict measures should be taken to avoid water pollution and contamination. Habitat barriers and flow modification for social uses should be banned. For the conservation of ichthyofauna, fishing zones will be developed and fishing will be banned during breeding and spawning seasons. The Use of dynamite, electric current, and pesticides to kill fish should be strictly prohibited.

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REFERENCES

Ahmad, L.F. 2014. Icthyofaunal diversity of river Panjkora Upper Dir Khyber Pakhtunkhwa Pakistan. The Journal of Zoology Studies 1: 27-32.

Akhtar, N.; Saeed, K.; Khan, J.; Khan, A.; Akhtar, W. & Akhtar, B. 2016. Tor putitora, the extinct fish species in River Swat Khyber Pakhtunkhwa, Pakistan. World 8: 10-13.

Ali, H. & Khan, E. 2018. What are heavy metals? Long-standing controversy over the scientific use of the term ‘heavy metals’-proposal of a comprehensive definition. Toxicological & Environmental Chemistry 100(1): 6-19.

Ali, U.; Syed, J.H.; Malik, R.N.; Katsoyiannis, A.; Li, J.; Zhang, G. & Jones, K. C. 2014. Organochlorine pesticides (OCPs) in South Asian region: A review. Science of The Total Environment 476-477: 705-717.

Attaullah, M.; Ullah, U.; Ilahi, I.; Ahmad, N.; Rahman, F.; Ullah, J.; Dad, O.; Amin, M.; Hassan, H. & Ullah, R. 2021. Taxonomic, morphometric and limnological assessment of the commercially important ichthyofauna of Sakhakot Stream, Malakand, Pakistan. Brazilian Journal of Biology 82.

Baršienė J.; Rybakovas, A.; Lang, T.; Andreikėnaitė, L. & Michailovas, A. 2013. Environmental genotoxicity and cytotoxicity levels in fish from the North Sea offshore region and Atlantic coastal waters. Marine Pollution Bulletin 68(1): 106-116.

Bound, J.P. & Voulvoulis, N. 2005. Household Disposal of Pharmaceuticals as a pathway for aquatic contamination in the United Kingdom. Environmental Health Perspectives 113(12): 1705-1711.

Bukola, D.; Zaid, A.; Olalekan, E. & Falilu, A. 2015. Consequences of anthropogenic activities on fish and the aquatic environment. Poultry, Fisheries & Wildlife Sciences 3(2): 1-12.

Cahill, A.E.; Aiello-Lammens, M.E. Fisher-Reid, M.C.; Hua X.; Karanewsky, C.J.; Yeong Ryu, H. Sbeglia, G.C.; Spagnolo F.; Waldron, J.B.; Warsi, O. & Wiens, J.J. 2013. How does climate change cause extinction? Proceedings of the Royal Society B: Biological Sciences 280(1750).

Cheema M. A.; Farooq M. Ahmad R. & Munir H. 2006. Climatic trends in Faisalabad (Pakistan) over the last 60 years (1945-2004). Journal of Agriculture and Social Sciences 2(1): 42-45.

Comte, L. & Olden, J.D. 2017. Climatic vulnerability of the world’s freshwater and marine fishes. Nature Climate Change 7: 718-722.

Darwall, W.R. & Freyhof, J. 2016. Lost fishes, who is counting? The extent of the threat to freshwater fish biodiversity. Conservation of freshwater fishes.

Deemer, B.R.; Harrison, J.A.; Li, S.; Beaulieu, J.J.; DelSontro, T.; Barros, N.; Bezerra-Neto, J.F.; Powers, S.M.; Santos, M.A. & Vonk, J. A. 2016. Greenhouse gas emissions from reservoir water surfaces: A new global synthesis. BioScience 66(11): 949-964.

Durant, J.M.; Hjermann, D.Ø.; Anker-Nilssen, T.; Beaugrand, G.; Mysterud, A.; Pettorelli, N. & Stenseth, N. C. 2005. Timing and abundance as key mechanisms affecting trophic interactions in variable environments. Ecology Letters 8(9): 952-958.

Edwards, C.A. 1993. The Impact of Pesticides on the Environment. In: Pimentel, D. & Lehman, H. (eds.) The Pesticide Question: Environment, Economics, and Ethics. Boston, MA: Springer US.

Franco, M.F. 2015. Impact of pesticides on environmental and human health, IntechOpen.

Fry, F.E.J. 1971. 1 The Effect of Environmental Factors on the Physiology of Fish. Environmental Relations and Behavior.

Gattuso, J.P.; Frankignoulle, M.; Bourge, I.; Romaine, S. & Buddemeier, R. W. 1998. Effect of calcium carbonate saturation of seawater on coral calcification. Global and

Planetary Change 18(1): 37-46.

Haq, D.F. & Saeed, K. 2012. Pollution load in industrial effluent and ground water due to marble industries in district buner, khyber pakhtunkhwa, Pakistan. International Journal of Recent Scientific Research 3: 366-368.

Harrison, I.; Blom, E.; Flitcroft, R. & Froend, R. 2015. Managing freshwater, river, wetland and estuarine protected areas. Protected area governance and management pp: 569-608.

Hartl, M.G. 2013. Homeostasis and toxicology of non-essential metals-Edited by CM Wood, AP Farrell & CJ Brauner.

Hasan Z. ; Shuaib, M.; Khan, M.A.; Khan, W. & Naeem, M. 2016. New checklist of freshwater fishes of district Buner, Khyber Pakhtunkhwa, Pakistan..

Hasan Z.; Ullah S.; Rasheed, S.B.; Kakar, A. & Ali, N. 2015. Ichthyofaunal Diversity of River Panjkora, District Dir Lower, Khyber Pakhtunkhwa. Journal of Animal and Plant Sciences 25: 550-563.

Hasan, Z.; Ahmad, I.; Yousuf, M. & Khan, J. 2013. Fish biodiversity of river Swat. Pakistan Journal of Zoology 45(1).

Hashem, M.A.; Nur-A-Tomal, M.S.; Mondal, N.R. & Rahman, M.A. 2017. Hair burning and liming in tanneries is a source of pollution by arsenic, lead, zinc, manganese and iron. Environmental Chemistry Letters 15(3): 501-506.

Hernández, A.F.; Gil, F.; Lacasaña, M.; Rodríguez-Barranco, M.; Tsatsakis, A.M.; Requena, M.; Parrón, T. & Alarcón, R. 2013. Pesticide exposure and genetic variation in xenobiotic-metabolizing enzymes interact to induce biochemical liver damage. Food and Chemical Toxicology 61: 144-151.

Huang, J.-H. 2016. Arsenic trophodynamics along the food chains/webs of different ecosystems: a review. Chemistry and Ecology 32(9): 803-828.

Hughes, G.M.; Perry, S.F. & Brown, V.M. 1979. A morphometric study of effects of nickel, chromium and cadmium on the secondary lamellae of rainbow trout gills. Water Research 13(7): 665-679.

Hussain M.; Butt, A.R.; Uzma, F.; Ahmed, R.; Irshad, S.; Rehman, A. & Yousaf, B. 2019. A comprehensive review of climate change impacts, adaptation, and mitigation on environmental and natural calamities in Pakistan. Environmental Monitoring and Assessment 192(1): 48.

Ishaq M.; Khan, S.; Khan, J.; Akhtar, N. & Saeed, K. 2014. Study on ichthyofaunal biodiversity of River Swat. World Journal of Fish and Marine Sciences 6(4): 313-318.

Jabeen, A.; Huang, X. & Aamir, M. 2015. The Challenges of Water Pollution, Threat to Public Health, Flaws of Water Laws and Policies in Pakistan. Journal of Water Resource and Protection 7: 1516-1526.

Javed, M. & Usmani, N. 2016. Accumulation of heavy metals and human health risk assessment via the consumption of freshwater fish Mastacembelus armatus inhabiting, thermal power plant effluent loaded canal. Springer Plus 5(1): 776.

Javed, M. & Usmani, N. 2019. An Overview of the Adverse Effects of Heavy Metal Contamination on Fish Health. Proceedings of the National Academy of Sciences, India Section B: Biological Sciences 89(2): 389-403.

JoÃ, M.D.; Dag, Ã.Â˜.H.; Geir, O. & Nils Chr, S. 2007. Climate and the match or mismatch between predator requirements and resource availability. Climate Research 33(3): 271-283.

Kalff J. 2002. Limnology. Inland Water Ecosystems. Prentice Hall, Upper Saddle River.

Khan M.A.; Khan, J.A.; Ali Z.; Ahmad, I. & Ahmad, M.N. 2016. The challenge of climate change and policy response in Pakistan. Environmental Earth Sciences 75: 412.

Khan, J.; Basharat, N.; Khan, S.; Jamal, S.M.; Rahman, S. U.; Shah A.A.; Khan, S.; Ali, R.; Khan, S.N. & Ali, I. 2021. Prevalence and molecular characterization of cystic echinococcosis in livestock population of the Malakand division, Khyber Pakhtunkhwa, Pakistan. Frontiers in Veterinary Science 8.

Khanna, D. & Ishaq, F. 2013. Impact of water quality attributes and comparative study of icthyofaunal diversity of Asan Lake and River Asan. Journal of Applied and Natural Science 5(1): 200-206.

Kibria G.; Nugegoda, D.; Rose, G. & Haroon, A.K.Y. 2021. Climate change impacts on pollutants mobilization and interactive effects of climate change and pollutants on toxicity and bioaccumulation of pollutants in estuarine and marine biota and linkage to seafood security. Marine Pollution Bulletin 167: 112364.

Langford, T.E. 1983. Electricity generation and the ecology of natural waters.

Mata, L.; Campos M.; Argenal, F.; Artigas, C.; Basso, E. Cabido, M.; Codignotto, J.O.; Compagnucci, R.; Confalonieri, U.; Fearnside, P.; Magama, V.; Magrin, G.; Marengo, J.; Moreno, A.; Morales, B.; Paz, A.J.; Picado, E.F.; Poveda, G.; Suarez, A. & Orepeza, O. 2001. Intergovernmental Panel on Climate Change (IPCC), Third Assessment Report, Working Group II: Impacts of Climate Change.

Meixler M.S.; Bain, M.B. & Todd Walter, M. 2009. Predicting barrier passage and habitat suitability for migratory fish species. Ecological Modelling 220(20): 2782-2791.

Mirza, M. 2007. A note on the fishes of Swat River, NWFP Pakistan. Biologia Pakistan 53(2): 109-112.

Mirza, M.R. & Mirza, Z.S. 2014. Longitudinal zonation in the fish fauna of the Indus River in Pakistan. Biologia, 60(1): 149-152.

Mohammad, N. & Rasul, M.M. 2009. Residues of cypermethrin and endosulfan in soils of Swat valley. Soil and Environment 28: 113.

Mulk, S.; Korai A.L.; Azizullah, A. & Khattak, M.N.K. 2016. Decreased fish diversity found near marble industry effluents in River Barandu, Pakistan. Ecotoxicology 25(1): 132-140.

Nafees M.; Jan, M.R. & Khan, H. 2008. Pesticide use in Swat valley, Pakistan. Mountain Research and Development 28(3): 201-204.

Nafees, M.; Ahmed, T. & Arshad, M. 2011. A review of Kabul River uses and its impact on fish and fishermen. The Journal of Humanities & Social Sciences 19(2): 73-84.

Nafees, M.; Rasul Jan, M. & Zahidullah, Z. 2012. Community response to ban on fishing and associated environmental problems: lesson learnt from River Swat, North of Pakistan. Interdisciplinary Environmental Review 13 (2-3): 158-169.

Pandey, G. & Madhuri, S. 2014. Heavy metals causing toxicity in animals and fishes. Research Journal of Animal, Veterinary and Fishery Sciences 2(2): 17-23.

Pandey, G. & Sharma, M. 2014. Heavy metals causing toxicity in animals and fishes. Research Journal of Animal, Veterinary and Fishery Sciences 2(2): 17-23.

Phillips, J.D. 2018. Environmental gradients and complexity in coastal landscape response to sea level rise. CATENA 169: 107-118.

Rafique, M. & Khan, N.U.H. 2012. Distribution and status of significant freshwater fishes of Pakistan. Records Zoological Survey of Pakistan 21: 90-95.

Rashid, S.; Rashid, W.; Tulcan, R.X.S. & Huang, H. 2022. Use, exposure, and environmental impacts of pesticides in Pakistan: a critical review. Environmental Science and Pollution Research, 29 (29): 43675-43689.

Saeed, K.; Khan, S. & Haq, D.F. 2013. Diversity and population status of fish fauna of river Barandu district Buner Khyber Pakhtunkhwa Province Pakistan. Journal of Biodiversity and Environmental Sciences (JBES) 3: 83-88.

Sauliutė, G. & Svecevičius, G. 2015. Heavy metal interactions during accumulation via direct route in fish: a review. Zoology and Ecology 25(1): 77-86.

Siraj, M.; Khisroon, M. & Khan, A. 2016. Bioaccumulation of heavy metals in different organs of Wallago attu from river Kabul Khyber Pakhtunkhwa, Pakistan. Biological Trace Element Research 172(1): 242-250.

Tierney, K.B.; Baldwin, D.H.; Hara, T.J.; Ross, P.S.; Scholz, N.L. & Kennedy, C.J. 2010. Olfactory toxicity in fishes. Aquatic Toxicology 96(1): 2-26.

Trolle, D.; Hamilton, D.P.; Pilditch, C.A.; Duggan, I.C. & Jeppesen, E. 2010. Predicting the effects of climate change on trophic status of three morphologically varying lakes: Implications for lake restoration and management. Environmental Modelling & Software 26(4): 354-370.

Ullah, K.; Hayat, A.; Khalil, M.F.; Hasan, Z. ; Sultan, S. & Akram, W. 2023. Assessment of 2022 flood effects on ichthyofauna, water quality parameters and heavy metals level at the confluence of river Swat and river Panjkora, KPK, Pakistan. Journal of Survey in Fisheries Sciences 10(3): 536-541.

Wahab, A. & Yousafzai, A.M. 2017. Quantitative attributes of family Sisoridae (Siluriformes) with a new record of *Glyptothorax kashmirensis* from River Panjkora, District Lower Dir, Khyber Pakhtunkhwa, PakistanThe BPP program for species tree estimation and species delimitation. Journal of Entomology and Zoological Studies 5(2): 741-745.

Waheed, U.; Rehman Ullah, N.; Ullah, F.; Rehman, H.; Usman, K.; Ahmad, W. ; Ahmed, S. Mehmood, A.; Khan, S.; Mazar, S. & Ur, W. 2018. Exploring and identification of fish fauna of River Swat at district Charsadda, KPK, Pakistan. Journal of Biodiversity and Environmental Sciences 13: 154-158.

Yousaf, M.; Hasan, Z.; Zaidi, F. & Rasheed S.B. 2023. An overview of the taxonomic instability of endangered Golden and Zhobi mahseer in Pakistan. Brazilian Journal of Biology 83.

Yousafzai A. W. & Ali M.2017. Cyprinid fauna (Cypriniformes) of River Panjkora, district Lower Dir, Khyber Pakhtunkhwa, Pakistan. Pure and Applied Biology (PAB) 6(4): 1354-1365 .

Yousafzai A.M.; Khan, W. & Hasan, Z. 2013. Fresh records on water quality and ichthyodiversity of River Swat at Charsadda, Khyber Pakhtunkhwa. Pakistan Journal of Zoology 45(6).

Yousafzai, A. & Shakoori, A. 2009. Fish white muscle as biomarker for riverine pollution. Pakistan Journal of Zoology 41: 179-188.

Zhang Y.; Li, Z.; Ge, W.; Chen, X.; Xu, H. & Guan, H. 2021. Evaluation of the impact of extreme floods on the biodiversity of terrestrial animals. Science of The Total Environment 790: 148-227.

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چکیده: آگاهی مدل‌های توزیع و تنوع گونه‌های ماهیان چالش حیاتی برای محققان و مدیران شیلات است که با کاهش و انقراض گونه‌های ماهیان آب‌های شیرین سروکار دارند. هدف از این بررسی، ارزیابی پیشینه مهم گزارش شده در مورد تنوع گونه‌های ماهیان، وضعیت توزیع و حفاظت آن‌ها و همچنین شناسایی تهدیدات اقلیمی و انسانی است که عامل کاهش گونه‌های ماهیان در سه رودخانه مالاکند بخش خیبر پختونخوا، پاکستان است. مقالات بررسی شده، منتشر شده از سال ۲۰۰۰ تا ۲۰۲۳، که تنوع ماهیان آب شیرین، توزیع و وضعیت حفاظتی آنها را توصیف می‌کردند، به دقت انتخاب شدند. در مجموع ۶۶ گونه ماهی آب شیرین متعلق به ۸ خانواده در سایت‌های بررسی شده گزارش شده است. از این میان، خانواده Cyprinidae (۵۶٪) و Nemacheilidae (۱۵٪) در میان سه رودخانه ملکند غالب‌ترین خانواده ها بودند. وضعیت حفاظتی تنوع گونه ماهیان مورد مطالعه در بخش ملاکند نشان داد که ۶۶ درصد گونه‌ها دارای کمترین نگرانی، ۱۰ درصد در معرض خطر، ۶ درصد آسیب‌پذیر، ۷ درصد تقریباً در معرض خطر، ۳ درصد به‌شدت در خطر انقراض و ۸ درصد در طبقه بررسی نشده قرار دارند. سوابق منتشر شده نشان می‌دهد که تنوع گونه ماهیان آب‌های شیرین به‌دلیل عوامل انسانی و تغییرات آب و هوایی مانند گرم شدن کره زمین، گرما، سیل، صید غیرقانونی و بی‌رویه، تخریب زیستگاه‌ها و آلودگی آب به‌طور مداوم در حال کاهش است. در پایان، اقدامات خاصی مانند احیای زیستگاه، ممنوعیت صید غیرمجاز و کنترل آلودگی آب برای حفظ تنوع گونه‌های ماهیان در منطقه مورد مطالعه ضروری است. علاوه بر این، بررسی کامل تنوع ماهیان، وضعیت حفاظت و تجزیه و تحلیل کیفیت آب در سایت‌های مورد مطالعه قویاً توصیه می‌شود.

کلمات‌کلیدی: ماهی، آب شیرین، توزیع، حفاظت، تغییرات آب و هوا.