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Water Quality and Ichthyodiversity of River Kabul at District Nowshera after the 2022 Heavy Flood, Khyber Pakhtunkhwa, Pakistan

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Abstract
The present study investigated the water quality parameters and ichthyodiversity of the River Kabul in the district of Nowshera. The study was conducted from October 2022 to December 2022. For water and fish samples collection, a 20 km river belt was explored for three months, and fish specimens were captured with the assistance of local fishermen using drag nets, cast nets, hand nets, and hooks. Water samples were collected to assess their quality; the water quality parameters were temperature 17- 20 °C, pH 7.75-7.8, velocity 0.5-0.7 m/s, ammonia 0.45-0.9 ppm, nitrite zero ppm, and nitrate 5-6 ppm. All these parameters fall within the limits given by WHO (2011) except ammonia, which is slightly higher than the recommended value. A total of 16 species were identified, which belong to 7 families (Cyprinidae, Siluridae, Schilbiedae, Belontidae, Cichlidae, Bagridae, and Channidae) and four orders (Cypriniformes, Siluriformes, Perciformes, and Channiformes. The Cyprinidae family was found to be the richest family. It is represented by seven species (*Cyprinus carpio, Garra gotyla, Rasbora daniconius, Barilius modestus, Tor macrolepis, Cirrhinus* mrigala, and *Labeo diplostomus*), family Siluridae represented by three species (*Glyptothorax cavia, Ompok pabda, and Wallagu attu*), Family Schilbeidae represented by two species (*Clupisoma naziri* and *Clupisoma garua*). In contrast, the remaining families were represented by a single species: Oreochromis aureus (Cichlidae), *Mystus bleekeri* (Bagridae), *Colisa fasciata* (Belontidae), and *Channa punctata* (Channidae). Throughout the study, *Garra gotyla* was found to be the most abundant fish, while the least abundant is

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Clupisoma Garua. In the present study, four species (*Glyptothorax cavia, Colisa fasciata, Oreochromis aureus,* and *Clupisoma Garua*) are reported for the first time from the river Kabul in the district of Nowshera. This study will help examine future taxonomic and conservation points of view.
Keywords: Biodiversity, flood effects, river Kabul, water quality

Introduction

Biodiversity pertains to the variety of species or organisms living in a particular environment, whereas ichthyodiversity describes the range of fish species in a particular habitat. Ichthyodiversity depends on the fish scale. It can refer to genotypic variation among fish populations, species of life forms, or fish communities across aquatic ecosystems (Burton *et al*., 1992). Aquatic freshwater habitat is one of the most diverse biological habitats (Ward & Tockner, 2001). Fish have a vast diversity and occupy all hydrosphere niches. Fish are present in almost all types of water, like marine, freshwater, and brackish (Usman *et al*., 2018). Fish demonstrate a wide-ranging biodiversity of all the vertebrates, around 22000 species. Of these, 58% live in marine, 41% live in freshwater, while 1% of the fish fauna migrate between marine and freshwater habitats. Marine fishes are expected to show a considerable diversity in contrast to freshwater fishes because they occupy 70% of the Earth's surface. Freshwater covers only 1% of the surface, but this area still harbours 8000 freshwater fish species (Helfrich & Neves, 2009).

Fish encompass 50% of the vertebrates on the Earth's surface and inhabit nearly all types of aquatic habitats. Around 8411 freshwater fish species have been reported from all over the world. Among them, 930 species inhabit the freshwater system of India. India is among those countries representing enormous biodiversity and ranks 9th in aquatic freshwater biodiversity (Shinde *et al*., 2009). Pakistan is blessed with many freshwater bodies and a wide variety of fish. Almost 180 freshwater fish species were reported in Pakistan, including typical vital groups such as catfish, carp, and loaches. Approximately 28 species of fish inhabit the cold water of Pakistan. The eminent game fish of Pakistan are declining in number because of illegal and overfishing, loss of spawning grounds, and some regions are submerged by water reservoirs like Tarbela Dam and Ghazi Barotha (Saeed *et al*., 2013). The freshwater bodies of Pakistan represent 179 species of fish, which belong to 3 Cohorts, 10 Orders, 26 families, and 82 Genera (Mirza & Bhatti, 1999). Many researchers contributed to identifying Khyber Pakhtunkhwa (KP) freshwater fish fauna. Butt (1986) reports 94 fish species from Khyber Pakhtunkhwa, (Butt, 1986).

From River Kabul downstream at Warsak Dam, a total of 22 species were reported, which belong to 4 Orders (Cypriniformes, Channiformes, Siluriformes, and Mastacembeliformes), 8 Families (Cyprinidae, Cobitidae, Chanidae, Siluridae, Sisoridae, Schilbeidae, Heteropneustidae, and Mastacembelidae), (Suleman *et al*., 2016).

Fish farming plays a significant role in the economy of a developing country and its prosperity (Rafiq & Khan, 2012). In Pakistan's freshwater system, 31 fish species have great economic importance; most of these species belong to the worm water fishes and live in the Indus plain region, while eight species inhabit the cold water of the Himalaya, Karakoram, and the Hindu Kush. Some economically important indigenous species, like *Cirrhinus mrigala, Labeo*

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rohita, and *Catla catla,* are harvested in aquaculture. At the same time, some economically important exotic species are also part of the aquaculture in Pakistan (Rafiq & Khan, 2012).

A flood is an overflow of river water from a river channel that submerges the usually dry land. It can cause an unexpected change in all environmental parameters (stream channel morphology and water quality), and such changes affect the organism's native habitat, from microorganisms to vertebrates (Godlewska *et al.*, 2003). Floods can alter or modify stream channel morphology and the abundance of fish in rivers (Ross *et al.*, 1985). Suspended sediment can enter the aquatic environment during a flood and cause an increase in water column respiration and reduce dissolved oxygen concentration in river water (Roozen *et al.*, 2003). The significant input of organic matter entering the river during floods also causes emigration or death of many fish because it reduces dissolved oxygen concentration (Winemiller, 1989). Different species or the same species of different age classes are significantly vulnerable to floods (Harrel, 1978). The juvenile life stage of the life cycle is more vulnerable to floods, and in high-gradient systems, floods can cause a significant loss (Elwood & Waters, 1969). Many young fish die or are lost during moderate seasonal flooding in systems where the time of high flow coincides with fragile stages (Nehring & Miller, 1987). Young fish are more vulnerable to floods because, in this life cycle stage, the fish have poor swimming capability and a small size (Harvey, 1987).

According to past reports, the last comprehensive fish fauna record after the heavy flood 2010 was published in 2015 from the river Kabul at the district of Nowshera. Although other studies have been conducted on river Kabul, (Khattak *et al.*, 2015) and other rivers in the province, (Shams *et al.,* 2023), it is the first attempt after the recent flood of 26th August 2022 in the river Kabul in the district Nowshera, KP when the water discharge of river Kabul at district Nowshera was recorded at 336461 cusecs as compared to the expected average flow of 22334 cusecs. The current study aims to explore the ichthyodiversity and water quality parameters of the river Kabul in the district of Nowshera, KP, and to determine the effects of floods on water quality and ichthyodiversity.

Materials and methods

Study area

The current study assessed the diversity of fish fauna. It determined the effects of floods on water quality and ichthyodiversity of the River Kabul in the district of Nowshera, Khyber Pakhtunkhwa, Pakistan (Figure 1). The River Kabul originates in the Sanglakh range of the Hindukush Mountains in Afghanistan, enters Pakistan at Shalman, the Khyber agency, and finally merges with the River Indus at Attock, Pakistan. District Nowshera is 34.01 N (latitude) and 71.97 E (longitude). District Peshawar surrounds the district Nowshera in the west, District Mardan in the North, District Charsadda in the Northwest, District Sawabi in the northeast, District Attock in the East, and District Kohat in the South.

Collection site

The collection site is divided into Amangarh, Nowshera Cantt, and Pir Sabaq (Figure 2). The length of the river between these three points is 20 Km. From such points, water samples were collected to analyse their quality. Fishes were

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captured to analyse the ichthyodiversity and then compare the water quality parameters and ichthyofauna with past literature to determine their effects on fish fauna.

Physico-chemical parameters of water

Water samples were collected in a clean, sterilised bottle from several river points to assess physico-chemical parameters. The bottle was first washed with distilled water before sample collection. All water parameters were analysed in the laboratory except temperature, measured on the spot at the collection site. The parameters analysed during this study include water temperature, velocity, pH, ammonia, nitrite, and nitrate levels.

Water temperature

Water temperature was measured in degrees Celsius by a digital thermometer. The water temperature was measured by sinking the thermometer to sensor points for two minutes. The procedure was repeated three times, and the average value was selected.

Velocity

The velocity of river water (average flow rate) was determined by flinging a piece of bark in the river at point A and noting the time with the help of a stopwatch. When the bark reached point B again, the time was noted. For the calculation of river water velocity, the following formula was used:

V= S/T

Here,

V Velocity of river water

S Distance travelled by the bark of wood

T= Time taken

pH

The pH of the water sample was measured by using a pH meter.

Ammonia, nitrite, and nitrate

For the analysis of the chemical parameters of water (Ammonia, Nitrite, and Nitrate), the Master Kit of Freshwater Quality Parameters was used.

Fish collection and preservation

The fish were collected twice a month for three months (from October to December 2022). The fish were caught mainly by drag net and cast net, but hand net and hook are rarely used for catching. After collection, the fish were preserved in 10% formalin, and some were preserved in 70% alcohol solution for morphometric measurement and identification. The fishes were identified up to the species level with the help of standard identification keys like Fishes of Punjab, Pakistan, written by Mirza and Sandhu (2007), and The Freshwater Fishes of India, written by K. C. Jayaram.

Results

Physico-chemical parameters of water

Temperature plays a critical role in the persistence of living organisms in a particular habitat, but aquatic organisms are more sensitive, mainly the fishes

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(Mirza & Awan, 1976). In aquatic environments, pH is one of the most restrictive factors. Adult fish can tolerate more acidic water, but young ones have a lower pH tolerance (Davies & Walker, 1986). The current study recorded the average air and water temperature, pH, water velocity, and concentration of ammonia, nitrite, and nitrate at selected points (Table 1).

Table 1: Physico-chemical parameters of the water of the River Kabul at the district Nowshera, Khyber Pakhtunkhwa

Collection point	Air temperature/water temperature	pH	Velocity	Ammonia	Nitrite	Nitrate
Amangarh	20 °C/17.8 °C	7.75	0.55 m/s	0.45 ppm	0 ppm	5.0 ppm
Nowshera Cant	21.6 °C/18 °C	7.8	0.62 m/s	0.24 ppm	0 ppm	6 ppm
Pir Sabaq	22 °C/20 °C	7.8	0.7 m/s	0.9 ppm	0 ppm	6 ppm

Fishes were collected and identified at the species level from the River Kabul in the district of Nowshera, Khyber Pakhtunkhwa. Sixteen species were identified and belonged to 1 Class, 4 Orders, 7 Families, and 15 Genera, as shown in Table 2.

Table 2: A complete list of scientific and local names of ichthyodiversity of the River Kabul at the district Nowshera, Khyber Pakhtunkhwa

S/No	Class	Order	Family	Genus and Species	Local Name
1	Actinopterygii	Crypniformes	Cyprinidae	*Garra gotyla*	Kanesatt
2				*Tor macrolepis*	Mahasher
3				*Rasbora daniconius*	Sowage
4				*Labeo diplostomus*	Torkay
5				*Cyprinus carpio*	China kub
6				*Cirrhinus mrigala*	Torkay
7				*Barilius modestus*	Pepal
8		Perciformes	Cichlidae	*Oreochromis aureous*	Blue tilapia
9			Belontidae	*Colisa fasciata*	-
10		Siluriformes	Siluridae	*Glyptothorax cavia*	Sulamanne
11				*Ompok pabda*	Mountain pafta
12				*Wallago attu*	Malee
13			Schilbeidae	*Clupisoma naziri*	Shermay
14				*Clupisoma garua*	Shermay

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15		Bagridae	*Mystus bleekeri*	Brethu
16	Channiformes	Channidae	*Channa punctata*	Asle katasarre

The current study shows that the most dominant family was Cyprinidae, encompassing 58% of the total collected fishes, followed by Channidae 15%, Cichlidae 11%, Siluridae 6%, Belontidae 6%, Schilbeidae 2% and Bagridae 2%. (Figure 3).

According to species-wise abundance, *Garra gotyla* was found to be the most abundant fish which, comprise 16.26% of the total collected fishes, followed by *Channa punctata* 15.44%, *Cyprinus carpio* 14.63%, *Barilius modestus* 11.38%, *Oreochromis aureous* 10.56%, *Rasbora daniconius* 8.13%, *Colisa fasciata* 5.69%, *Ompok pabda, Wallagu attu, Cirrhinus mrigala, Tor macrolepis* and *Labeo diplostomus* each cover 2.43%, *Clupisoma naziri, Glyptothorax cavia,* and *Mystus bleekeri* comprise 1.62%. In comparison, *Clupisoma garua* comprises 0.81% of the total collection, which is shown in Figure 4.

The morphometric measurements of different parts of the identified fishes, including total length, forked length, standard length, head length, eye diameter, and body depth, are shown in Table 3. The largest fish collected is *Wallagu attu*, whose total length is 40 cm, while the smallest fish is *Barilius modestus*, whose total length is 4.5 cm.

Table 3: Morphometric measurement (cm) of the fish fauna of the River Kabul at the district Nowshera, Khyber Pakhtunkhwa

S/No	Fish species	Total length	Forked length	Standard length	Head length	Eye diameter	Body depth
1	*Garra gotyla*	14.4	12.8	11.5	2.5	0.5	2.5
2	*Tor macrolepis*	17.8	16.2	14.5	3.9	0.8	2.8
3	*Rasbora daniconius*	9.6	8.6	7.4	2.2	0.5	2.7
4	*Labeo diplostomus*	30	27	25	5	0.8	5.5
5	*Cyprinus carpio*	21.3	20	17	4.3	1	5
6	*Cirrhinus mrigala*	21.3	20	17	4.3	0.7	4.9
7	*Barilius modestus*	4.5	4.3	3.5	0.7	0.2	0.8
8	*Oreochrmis aureous*	11	-	9	3.1	0.7	4.2
9	*Colisa fasciata*	7.5	-	5.7	2.1	0.4	2.7
10	*Glyptothorax cavia*	16.9	15.4	14.9	4	0.2	3
11	*Ompok pabda*	14	12.7	11.5	2.7	0.4	2.7
12	*Wallagu attu*	40	37.5	36	9	1.3	9.5
13	*Clupisoma*	21.5	19.1	17.7	4.5	0.4	4

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	naziri						
14	*Clupisoma garua*	19	16.5	15	3.5	1	4
15	*Mystus bleekeri*	12.8	10.8	10.2	2.5	0.5	2.4
16	*Channa punctata*	14.5	-	12	4	0.5	3

Discussion

Recently, the most influential flood ever recorded in Pakistan's River Kabul was on 26th August 2022. The water discharge of the River Kabul reached 336461 cusecs in contrast with the usual average flow of 22334 cusecs in the same month. Floods disturb the aquatic fauna, mostly the fish population and water quality, affecting fish abundance.

The current study was conducted from October to December 2022 to determine the effects of the flood on the water quality and ichthyodiversity of the River Kabul in the district of Nowshera, KP. The water temperature of the River Kabul fluctuates between 17.8 °C and 20 °C during the study period and affects the dispersal and migration patterns of fish (Lagler *et al.*, 1962). Water temperature also affects many limnological phenomena like water stratification, the solubility of gases, the implication of odour and taste, pH, and an increase in the rate of metabolic activities of plants and animals. As a result, oxygen consumption increases, resulting in a decrease in the amount of dissolved oxygen. The pH range was recorded from 7.7 to 7.8. This value falls within the range of WHO recommended values, 7.5-7.9 (Utang & Akpan, 2012). The pH value of water is suitable for fish survival. The average velocity of River water at Amangarh, Nowshera Cannt, and Pir Sabaq was recorded at 0.55 m/s, 0.62 m/s, and 7 m/s, respectively.

In an aquatic system, ammonia is present in ionised form NH4+ and unionised form NH_3. The cell membrane of most organisms is impermeable to NH_4^+, but the unionised form NH_3 can freely diffuse across the tissue barriers. The skin of ammonia-septic fish is light in colour and covered with a thick layer of mucus (Koskivaara & Valtonen, 1992). Ammonia is the final product of the metabolism of nitrogen-containing substances, and mainly, it is excreted through gills into the surrounding water. If the diffusion rate becomes sluggish due to high water pH, oxygen scarcity, and damaged gills, the ammonia concentration will gradually rise in the blood, causing a condition known as autointoxication, which finally leads to toxic gill necrosis (Lewis & Morris, 1986). The ammonia level from the River Kabul was recorded at 0.45-0.9 ppm during the study period. According to WHO (2011), the standard value for ammonia is 0.2 mg/l, WHO (2011).

Nitrites are found together with nitrate and ammonia, but their concentration is usually low because of their instability. They can freely oxidise to nitrate and reduce to ammonia chemically and biochemically by bacterial action. Nitrates are the final product of organic nitrogen compounds' catabolism, and their concentration is low in the aquatic system (Lewis & Morris, 1986). In normal aerobic conditions, ammonia is oxidised to nitrite and then to nitrate by two different bacterial actions. Nitrite concentration increases if the second stage of bacterial oxidation is inhibited by bactericidal chemicals in the water system.

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Nitrite ions enter the fish's body through the chloride cells of the gills. In blood, nitrite ions bind with the haemoglobin, leading to the formation of methaemoglobin and reducing the oxygen-carrying capacity of the blood. The fish generally survive if the amount of methaemoglobin exceeds 50% of the total haemoglobin. If the concentration reaches 70-80%, the fish become torpid, and with a further increase in methaemoglobin level, the fish lose their orientation and become unable to show a response to stimuli. Still, the fish can survive because their blood's erythrocytes contain reductase enzymes that convert methaemoglobin to haemoglobin. This process takes 24-48 hours if the fish are put into nitrite-free water (Lloyd, 1992). The value for nitrite and nitrate in the River Kabul during the study period was recorded as zero ppm and 5-6 ppm, respectively. According to WHO (2011), the standard value for nitrite and nitrate is 3 mg/l and 50 mg/l, WHO (2011.

The current study identified 16 species belonging to 4 Orders, 7 Families, and 15 Genera. The family Cyprinidae was found to be the richest, representing seven species, followed by the family Siluridae, which represented three species, and the family Schilbeidae, which represented two species. In contrast, the family Cichlidae, Channidae, Belontidae, and Bagridae represented only one species each.

A study was conducted in the River Kabul in the district of Nowshera to find its ichthyofauna. A total of 24 species belonging to 4 Orders and 8 Families were recorded. The family Cyprinidae showed 14 species, i.e., Cyprinus carpio, Hypophthalmichthys molitrix, Carassius auratus, Crossocheilus Diplocheilus, Puntius sophore, Puntius ticto, Barilius modestus, Barilius Vagra, Barilius pakistanicus, Tor macrolepis, Labeo Rohita, Oryzias *plagiostomus, Cirrhinus mrigala* and *Garra gotyla*. Family Channidae, Siluridae and Bagridae were represented by two species, i.e., Channa punctata and Channa gachua, Ompok pabda and Wallagu attu, Mystus bleekeri and Sperata sarwari, respectively. In contrast, the remaining families were represented by a single species*: Glyptothorax punjaensis (Sisoridae), Clupisoma naziri (Schilbeidae), Acanthocobitis botia (Nemacheilidae) and Mastacembelus armatus* (Mastacembelidae), (Khattak *et al*., 2015).

Another study was conducted on River Kabul downstream at Warsak Dam, to explore the ichthyodiversity of the area. Twenty-two species belonging to 4 Orders, eight families, and 18 genera were identified. In this survey, the family Cyprinidae was found to be the dominant family and represented by 11 species, i.e., *Barilius vagra, Cirrhinus mrigala, Rasbora daniconius, Punctius sophore, Punctius ticto, Labeo diplostomus, Tor macrolpeis, Crossocheilus doplocheilus, Garra gotyla, Carassius auratus* and *Cyprinus carpio*. Family Sisoridae represents four species i.e., *glyptothorax naziri, glyptothorax punjabensis* and *Glyptpthorax stocki* and *Bagarius bagarius*, family channidae represent two species i.e., *Channa punctata* and *Channa gachua* while all other families represent a single species *Clupisoma naziri* (Schilbeidae), *heteropneustes fossilis* (Heteropneustidae), *Botia birdi* (Cobitidae), *mastacembelus aramatus* (mastacembelidae) and *Wallagu attu* (Siluridae), (Suleman *et al*., 2016).

A previous study on the River Kabul in the district of Charsadda, KP. A total of 16 species were identified, belonging to 4 Orders (Cypriniformes, Siluriformes, Channiformes, and Mastacembeliformes) and eight families (Cyprinidae, Siluridae, Sisoridae, Bagridae, Schilbeidae, Mastacembelidae, Nemacheilidae,

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and Channidae) (Khan *et al.*, 2020). Rauf *et al.* (2015) conducted a study to explore the diversity of fish in the River Kabul at Michini, KP. During the collection period, 23 fish species were recorded, belonging to 6 Orders, 9 Families, and 19 genera (Rauf *et al.*, 2015).

In the current study, 16 species were identified, belonging to 4 Orders, seven families, and 15 genera. It is noteworthy to compare the current diversity report with the previous literature. In the present study, Cyprinidae was found to be the dominant family, but not as rich as in previous literature. Family Siluridae, Schilbeidae, Bagridae, Channidae, and Cichlidae were found in the present study and previous literature, but with several different species. Family Nemacheilidae, Sisoridae, Mastacembelidae, Cobitidae, and Heteropneustidae were found in previous literature but not in the present study. Family Belontidae was found in the present study but not in previous literature. Four species, i-e, Glyptothorax cavia, Clupisoma garua, Oreochromis aureus, and Colisa fasciata are found for the first time in the River Kabul at the district Nowshera.

Results revealed that the water quality parameters (except slightly high ammonia) are within the limits of the World Health Organization Guideline for Drinking Water Quality (2011). Water quality in its present form cannot act as a limiting factor for the inhabitants of the fish population. Still, 14 species are missing in the present study compared to the record of Khattak (2015). These missing species are *Hypophthalmichthys molitrix, Carassius auratus, Crossocheilus diplocheilus, Puntius sophore, Puntius ticto, Labeo rohita, Orienus plagiostomus, Barilius pakistanicus, Barilius vagra, Channa gachua, Sperata sarwari, Glyptothorax punjabensis, Acanthocobitis botia* and *Mastacembelus armatus*. Moreover, Khattak *et al.* have not reported six fish species, but the present study reports: Labeo diplostomus, Rasbora danicunius, Glyptothorax cavia, Oreochromis aureus, Colisa fasciata and Clupisoma garua. The recent flood possibly displaced the fish downstream, or unexpected, immediate changes in water chemistry might have killed the least resistant fishes.

Conclusion

The River Kabul provides a suitable environmental condition for fish fauna and is home to many fish species. The present study reports 16 fish species from the River Kabul, with the addition of four new species. The water quality parameters are suitable for fish life, and water resources are fit for raising commercial fish. The recent flood harshly affected the region and the fish fauna of the River Kabul. However, newly reported species show that the river accommodates new species, and the environmental conditions are suitable, hoping the river will regain its original fish fauna. Also, it is recommended that illegal fishing in the River Kabul should be noted because most of the aquatic fauna is declining, which plays a critical role in the ecological system.

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