Assessment Of 2022 Flood Effects On Ichthyofauna, Water Quality Parameters And Heavy Metals Level At The Confluence Of River Swat And River Panjkora, KP, Pakistan

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Abstract
The present study was designed to investigate the effects of the 2022 flood on fish distribution and water quality at the confluence of River Swat and River Panjkora at Bosaq Malakand, Khyber Pakhtunkhwa, Pakistan from October to March 2023. During the study period, a total of 437 fish specimens were collected belonging to 2 orders, Cypriniformes and Siluriformes, 3 families, Cyprinidae, *Sisoridae,* and Garinidae, 7 genera, and 7 species i.e., *Racoma labiata*, *Orienus plagiostomus, Glyptothorax cavia, Carassius auratus, Garra gotyla, Labeo dyocheilus pakistanicus,* and *Tor putitora*. The family Cyprinidae was the most diverse family represented by 5 species, whereas *Orienus plagiostomus* was the most abundant species. The comparative physico-chemical parameters of water were also studied, which were taken from four different sites. The values for water temperature were 7.7-9°C, pH 6.98-7.42, dissolved oxygen 8.5-8.9 mg/l, alkalinity 215-240 mg/l, electrical conductivity 232-238µs, TDS 91-125 ppm, TSS 200-500 mg/l, Total hardness 116-129.98 mg/l, Calcium hardness 73-99.99 mg/l, Magnesium hardness 23-56.7 mg/l, Sodium 3.2-3.7 ppm, Potassium 30-30.4 ppm, Chlorides 15-32.03 mg/l and turbidity of water ranged from 0 to2-12 NTU. After the flood, 2 fish species were not reported from the studied area i.e. *Mastacembelus armatus* and *Chela cachius*, which means that the flood has swept away their fingerlings as well as adults. All the water parameters were within normal range during the study period except for the values of Alkalinity, Potassium, TSS, and Turbidity, which were higher than the permissible range. This might be due to floods and low water levels during the study period. Analysis: Heavy metals showed that chromium was higher than permissible limits recommended by WHO recommended standards while the other heavy metals were within the permissible limits. Therefore, it can be concluded that the water in the area is suitable for fish and aquatic life, and fish culture could be promoted in the area.

Key words: Bosaq, Cyprinidae, Malakand, Flood, Permissible limit.

INTRODUCTION

Flooding is a major disturbance that impacts aquatic ecosystems and the ecosystem services they provide (Talbot *et al.)*., 2018). Flood is a natural calamity which affects both aquatic and terrestrial life. Pakistan is one of the worst-affected countries in the world from floods and climatic changes in the last few decades. In its simplest form, climate change is the phenomenon by which atmospheric changes take place; leading leads towards alternation in the global eco and bio sphere throw slow natural processes (Shahid and Adnan, 2021).

Due to climate change, the temperature of the biosphere has risen, as a result glaciers are melting down and irregular patterns of rainfall are occurring which have increased the flow of water in water bodies. This increase in water bodies causes floods that sweep away anything in their way. In the 21st century, Pakistan has faced two destructive floods: one in 2010 (the biggest in the history of Pakistan) and the second in 2022, which badly decimated the economy and biodiversity of the country. The 2022 flood was very calamitous and eradicative in the River Swat and River Panjkora, which badly affected fish distribution and water quality. Floods cause a sudden dramatic change in all environmental parameters, and all these changes influence the organisms inhabiting the reservoir ecosystem, from microorganisms to fish (Yousaffzai *et al.*, 2013).

Floods have affected biodiversity both directly and indirectly. The recent flood of 2022 was one of the cataclysmic and fatal events for fish life. Rivers Swat and Panjkora originate from hilly areas and the flow of water downstream with

great speed during flood they become more accelerated with low oxygen levels, soil sediments, and other impurities that affect the fish physically and biologically. The degree of impact depends on many factors, such as e.g., animal characteristics, natural conditions, and flood characteristics (Zhang *et al.*, 2021). After every colossal flood, such 2010 and 2022 in these water bodies raises the chances of local species extinction, because floods swept the egg, fingerlings, decrease food availability, and damage their habitat. Thus, after a flood, some species are eradicated or become extinct from those water bodies. Fish diversity, distribution, composition of population, and characteristics of fisheries depend on many factors, such as water system, size of river system, availability of food, breeding area, depth and speed of water, topography, location of the river basin, and physicochemical factors of water (Hasan *et al.).*, 2015). Flood events can result in the displacement, injury, or mortality of fish populations. The disturbance caused by floodwaters can disrupt the natural habitats and breeding grounds of fish species. Additionally, the rapid changes in water depth, flow, and temperature can limit the survival of certain species and affect their reproductive success. Understanding the composition and abundance of fish species before and after a flood is crucial for assessing the ecological consequences and identifying potential conservation measures (Zhang *et al.*, 2018). Water is one of the essential components for the survival of all living organisms on Earth. Changes in the quality of water are hazardous to living things. Most of these changes occur due to anthropogenic activities. The impurities that pollute the quality of water are brought by floods from mining and 2022, fingerlings, industries, bakeries, hospitals, and farms. Flood events introduce a range of physical, chemical, and biological changes in riverine systems, which can influence water quality parameters. Increased turbidity, sedimentation, and nutrient runoff from adjacent lands are common consequences of floods. These changes can impact water temperature, dissolved oxygen levels, pH, alkalinity, and nutrient concentrations. Assessing these parameters provides insights into the overall health and resilience of the aquatic ecosystem in the aftermath of a flood (Whitehead *et al.*, 2019). Floods affect the water quality by adding heavy metals, sediments, organic and inorganic fertilizers, pesticides, acids, and detergents from different sources and change the water physicochemical parameters like free CO_2, alkalinity, pH, hardness, dissolved oxygen, electrical conductivity, TDS, and TSS. These changes in water affect the health and distribution of fish in the water bodies. In the last two decades, River Swat and River Panjkora have faced two heavy floods. The recent one (2022) was very calamitous. It has immensely disturbed the quality of water; as a result, the fish either migrate or become sick and die. Bad water quality also has adverse effects on aquaculture because the floodwater is not suitable for fish farming and rearing. Floodwaters can carry and distribute heavy metals from various sources, including industrial sites, agricultural runoff, and urban areas. These metals, such as lead, mercury, cadmium, and chromium, pose significant risks to aquatic organisms and human health. Monitoring the heavy metal content in water samples collected before and after a flood event can help identify potential sources of contamination and evaluate the extent of ecological risks associated with heavy metal pollution (Tchounwou *et al.*, 2012). The objectives of the present study are to examine the present status of fishes and water quality.

MATERIALS AND METHODS

River Swat and River Panjkora are two important rivers of KP that confluence at a place called Bosaq, which is situated right at the border of district Malakand, district Bajaur, and district Dir lower. The confluence is located at 34.65° latitude and 71.76° longitude, with an elevation of 604.98±18m and an accuracy of about 1.7 meters.

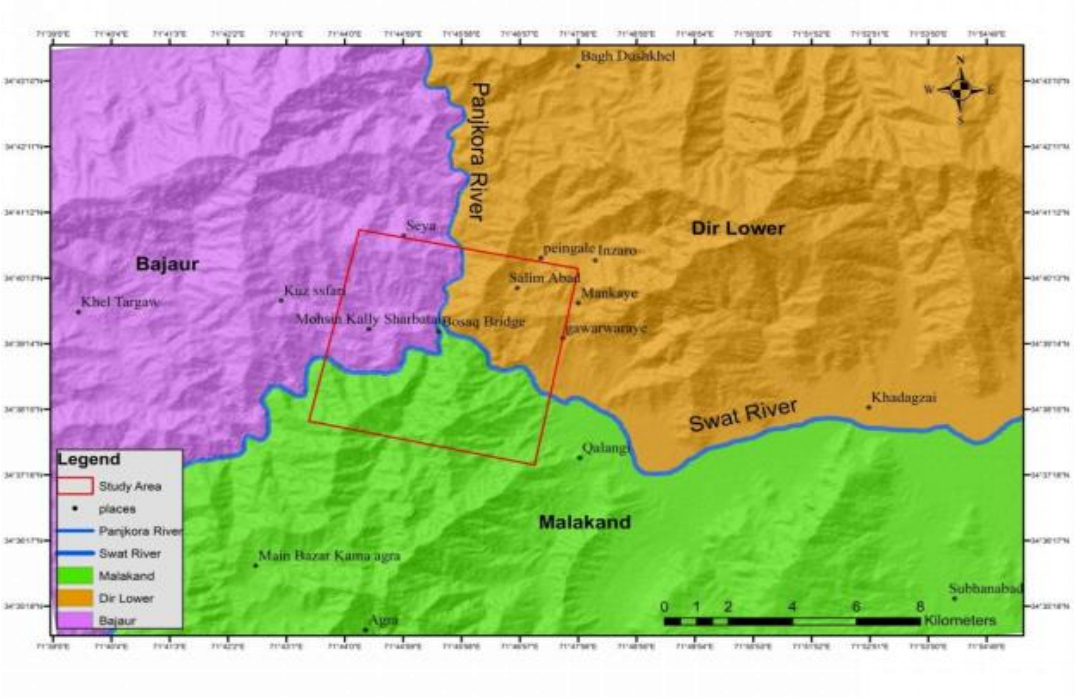

Fig 1.2: 3D Map of the study area

Fish Collection and Water Samples

To evaluate different water parameters, samples were collected from various sites in clean plastic bottles. Before sampling, the bottles were washed with distilled water first and then rinsed three times with river water. Fish then water samples were taken.

Fishes were collected with the help of local fishermen by using wall nets, cast nets, drag nets, rods, and hooks. For lab work and identification, small fish were directly preserved in a 5% formalin solution, while big fish were injected with 10% formalin in their abdomen with the help of syringe before preserving the whole specimen in formalin.

Water temperature was measured at a specific spot using a lab thermometer, DO found through DO meter. PH was measured using a pH meter. Electrical conductivity was found through the help of conductive meter. Alkalinity, total hardness, calcium hardness, magnesium hardness, sodium, potassium, and chloride were found using the titration method. TDS was measured with the help of meter, while TSS was found using the evaporating method. Heavy metals were analyses through Flam Atomic Absorption Spectrometer (Perkin Elmer USA, AA-700).

RESULTS

During the survey of fish fauna after the flood, 437 fish specimens were collected, belonging to 2 orders, 3 families, 7 genera, and 7 species i.e. *Racoma labiata*, *Orienus plagiostomus*, *Glyptothorax cavia*, *Carassius auratus*, *Garra gotyla*, *Labeo dyocheilus pakistanicus*, and *Tor putitora*. The family Cyprinidae was the dominant family, represented by 5 species. The comparative physico-chemical parameters of water values are: water temperature 7.7-9°C, pH 6.98-7.42, dissolved oxygen 8.5-8.9 mg/l, alkalinity 215-240 mg/l, electrical conductivity 232-238µs, TDS 91-125 ppm, TSS 200-500 mg/l, Total hardness 116-129.98 mg/l, Calcium hardness 73-99.99 mg/l, Magnesium hardness 23-56.7°C, sodium 30-30.4 ppm, potassium 3-3.7 ppm, and chlorides 15-32.03 mg/l, and turbidity of water ranging from 0.2-12 NTU (Table 3). Among the heavy metals, chromium was found in all water samples, while the rest of other was in normal range (Table 5).

Table1: Average morphometric measurements (cm) of the fishes collected during the study.

S/No	Fish species	Total length in cm	Standard length in cm	Body height in cm	Head length in cm	Eye diameter in cm	Body width in cm
1.	*Racoma labiata*	34	24.5	5	5.6	1.2	4.7
2.	*Orienus plygiostumus*	36	27.5	6.2	6	1.3	5
3.	*Glyptothorax cavia*	23	15.5	4.3	6	0.8	5
4.	*Carassius auratus*	19	14.5	6.5	4.4	1.3	3.3
5.	*Garra gotyla*	19	12.5	4.3	3.7	1.1	2.7
6.	*Labeo dyocheilus pakistanicus*	30	21	6.5	5	1.3	4.8
7.	*Tor putitora*	22.2	15	3.5	4.5	1.2	2.8

Table2: Scientific and vernacular names of fishes and their number during the studied period

S/No	Order	Family	Genus & Species	Local names	No of species	Percentage composition
1.	Cypriniformes	Cyprinidae	*Racoma labiata*	Chorai	80	18.30%
2.	″	″	*Orienus plagiostomus*	Khoyakai	306	70.02%
3.	Siluriformes	Sisoridae	*Glyptothorax cavia*	Kata mahy	8	1.83%
4.	Cypriniformes	Cyprinidae	*Carassius auratus*	Poplate	26	5.94%
5.	″	Garinidae	*Garra gotyla*	Sodai	6	1.83%
6.	″	Cyprinidae	*Labeo dyocheilus pakistanicus*	Sheen Parshi	8	1.37%
7.	″	″	*Tor putitora*	Sur mahy	3	0.68%

Table 3. Comparative study of Physico-chemical parameters of water

Water sample	From River swat	From River panjkora	From Bosaq (the junction of both rivers	Downstream from the junction.
Water Temperature (°C)	9.0	7.6	7.8	7.9
pH	6.98	7.42	7.15	7.25
DO (mg/l)	7 6.5	7 6.9	7 6.7	7 6.8
Alkalinity (mg/l)	225	220	215	240
Electrical conductivity (µs)	235	238	232	235
Total hardness (mg/l)	129.98	116.65	123.32	129.98
Calcium hardness(mg/l)	129.98	93.32	93.32	99.99
Magnesium hardness (mg/l)	56.57	23.3	30	29.99
Sodium (mg/l)	3.7	3.6	3.4	3.2
Potassium (mg/l)	30.4	30	30.2	30.3
Chloride (mg/l)	30.03	32.03	15.51	26.03
TDS (mg/l)	91	124	125	125
TSS (mg/l)	300	300	200	500

Table 4: Comparisons of water qualities of the two different areas to the present time periods.

S/No	Name of areas (Water parameters)	River Swat at Charsadda by Yousafzai *et al.* (2013)	River Panjkora lower Dir by Hasan *et al.* (2015)	Bosaq junction of Swat and Panjkora present study by Author (2023)
1.	Water temperature in °C	19.8	21.275	7.7-9
2.	pH	7.6	7.325	6.9-7.42
3.	Dissolved oxygen (mg/l)	9.65	7 6.975	7 6.5-8.9
4.	Alkalinity(mg/l)	97	98	214-240
5.	Electrical conductivity mg/l(µs)	199.47	201.675	232-238
6.	Total hardness(mg/l)	118.75	118.75	116-129.98
7.	Calcium hardness (mg/l)	75	77.5	73-99.99
.	Magnesium hardness (mg/l)	43.75	43.25	23-56.7
9.	Sodium (mg/l)	5.325	5.1	3.2-3.7
10.	Potassium mg/l [ppm]	3.175	2.825	30-30.4
11.	Chloride (mg/l)	15.3	15.93	15-30.3
12.	TDS (mg/l)	127.66	127.912	91-125
13.	TSS mg/l[ppm]	93.78	129.857	200-500

Table 5: Concentration of Heavy Metal in Water

S/No	Name of heavy metal	River swat	River Panjkora	Bosaq junction of both Rivers	Downstream from the junction.	Standard Values by WHO for Heavy Metals
1.	Chromium	0.103mg/l	0.079mg/l	0.103mg/l	0.126mg/l	0.05 mg/l
2.	Zinc	0.01mg/l	--	0.004mg/l	0.0.06mg/l	5.00 mg/l
3.	Cobalt	--	0.023mg/l	--	--	0.10 mg/l
4.	Copper	--	--	--	--	1.50 mg/l
5.	Lead	--	--	--	--	0.50 mg/l

DISCUSSION

The confluence of rivers plays a crucial role in shaping the ecology and biodiversity of aquatic systems. These merging points serve as important habitats for various organisms, including fish species. However, natural disasters such as floods can significantly impact the ichthyofauna (fish population) and alter the water quality of these ecosystems. The assessment of flood impacts on ichthyofauna, water quality, and heavy metal content at river confluences provides valuable information for conservation and management strategies. The findings can guide the implementation of measures to restore fish habitats, enhance water quality through appropriate remediation methods, and develop policies for controlling and reducing heavy metal pollution in riverine ecosystems. Additionally, the study contributes to the broader understanding of the ecological resilience of aquatic systems and helps formulate effective strategies to mitigate the impacts of future flood events (Postel and Richter, 2003).

The devastating flood in September 2022 was a tormenting phenomenon not only for human beings but also for the whole ecosystem. The flora and fauna were severely damaged in the flooded areas. The flood has immensely disturbed the quality of water, as a result there was no drinking water and millions of people had limited access to clean drinking clean. According to world water development report 2023 by UNESCO, 1.7 to 2.4 billion people will face water scarcity by the end of 2050. According to NDMA (National Disaster Management Authority, Pakistan), the 2022 flood caused 800 billion (PKR) in damages to the agriculture, food, livestock, and fisheries sectors.

After the 2022 flood, seven fish species were collected from the area, with *Orienus plagiostomus* and *Racoma labiata* being the dominant species (Table 2). The same observation was recorded by Mirza (2004). Two species, *Mastacembelus armatus* and *Chela cachius*, have still not been reported. This observation of the present study was confirmed by showing pictures of the fish to local fishermen who confirmed that the above species have not been found in their catch till now. The accusation for their disappearance may be conferred upon the havoc flood of 2022, as Mastacembelus lives at the gravelly or sandy bottom and is not able to resist speedy water (Hossain *et al.*, 2015).

Chela is so delicate that it cannot sustain in flood water containing a lot of silt and debris. The population of this fish was already low before the flood, as described by the flood, and now it has almost disappeared from the area. According to Akhter *et al* (2016), *Tor putitora* is the extinct fish species in River Swat, but during the present collection, three specimens were collected, which shows the rebirth of the species. Hasan (2020) studied the ichthyodiversity of River Swat and reported 62 species, but *Glyptothorax cavia* was not reported by him, whereas in the present collection, eight specimens of *G. cavia* were collected, which shows the reappearance of the species in the water bodies.

The temperature of water is an important directive influence on the migration and movement of fish (Lager *et al*., 1962). Fish synchronize themselves to water temperature. The temperature plays an important role in the distribution of fish. A sudden drastic change in temperature is often lethal (Love, 1977). Fish display great variability in thermal tolerance, with each species having its own temperature range within which it grows quickly (Ali, 2020). A sudden change in

temperature in a pond produces an egg-bouncy phenomenon. The present temperature is suitable for semi-cold water fish, ranging from 7°C to 9°C.
The Ph of water is an important factor for fish life. The normal pH value of water is 7, but fish can survive up to 9.5, pH values above this range are lethal and unfavorable for fish growth. Fluctuations in pH values are due to adding acids and bases to the water, which have bad effects on fish. The pH water during the study time was 6.9-7.4 which follow in normal range.

Dissolved oxygen in water is the basic need of aquatic life. Factors affecting the availability of dissolved oxygen include atmospheric exchange, mixing of water masses, upwelling, respiration, photosynthesis, ice cover, and physical factors such as temperature and salinity (Davis, 1975). Low or high levels of DO show effects on the fish production of a pond. The present value of DO was 11-11.68 mg/L, which falls within limits. Considered that at DO levels less than 3mg/L fish will die and above 11mg/L may cause gas bubble disease in fish (Arshad, 2013).

Alkalinity of water is due to the presence of carbonate and bicarbonate ions in water. Water with an alkalinity of 50-200ppm is the most productive for fish (Ali, 2020). The present value of alkalinity falls within 215-240 mg/L. The reason for this high alkalinity is the presence of marble factories upstream in Chakdara and a limited volume of water during the collection period. Previous work on River Panjkora and Swat shows that alkalinity was in the permissible range (Yousaffzai *et al.).,* 2013; Hasan *et al.,* 2015).
The ability of water to conduct electric current is termed as electrical conductivity, and it is a good indicator to show ionisable substance dissolves in water. A high conductivity and high TDS indicate a fertile water body. The electrical conductivity of the present water was between, 232-238.

The total hardness of water is due to the presence of Ca and Mg salts or both of them in water. The source of this hardness of water is due to pollution or when water passes through mountain, rock, and plain areas, the organic and inorganic salts are dissolved in the water. The suitable limits of total hardness for aquatic fauna are 20 to 300mg/L (Boyd and Lichtkoppler 1997). The present value of total hardness was 116-129.98mg/L, which falls in the suitable range. The calcium hardness was 73-99.99mg/L and Magnesium hardness was 23-57.7mg/L.

A large number of substances are dissolved in water, and the concentration of these substances in water is called total dissolved solids. These substances may be salts, soil sediments, and small particles of wood, etc. The quality and quantity of DS depend on the nature of the basin, erosion of shoreline, windblown materials, rainfall, decay of organic matter, and anthropogenic activities near the water bodies. TDS of natural water ranges from 15-1300 ppm Welch (1958). The present value of TDS is between 91-125ppm. This value falls in the normal range, and there is no effect of flood on TDS.
There are a large number of substances that float on the water surface and are called total suspended substances (TSS). TSS is inversely proportional to the transparency of water and directly proportional to the turbidity of water. The calculated value for TSS in water samples after the flood was range of 200-500mg/l, while the normal value for TSS is 0-300mg/l.

Potassium is a basic electrolyte and mineral which have vital role in the life of organisms and is required for nervous coordination, osmotic pressure balance, muscle function, and catalyzes different metabolic reactions. The present value of potassium was 30-30.4ppm which is double the standard value.

Chloride is an important component of salt which occurring in water naturally in some cases, at present in combination with potassium or calcium. The values of chloride in water samples were 15-30.03mg/l. The values of other parameters of water, such as sodium and turbidity, Sodium values ranged from 3.2-3.7ppm in water samples.

The values of turbidity of water ranged from 0.2-12NTU. The turbidity of River Panjkora was so high this was due the recent 2022 flood and the basin of the river. Additionally, the river passes through sedimentary rock, causing the soil to water, which raises the turbidity of water.

According to (Whitehead *et al., 2019), heavy* metals are naturally occurring elements that have a high atomic weight and a density at least 5 times greater than that of water. Heavy metals are those with specific weights more than $5g/cm^3$. Accumulation of heavy metals in the body of an organism causes serious problem e.g. displacement of vital minerals and disruption of metabolic function, which affects biological functions of the body. This group of heavy metals contains more than 40 different elements. Heavy metals like Zn and Cu work is a cofactor and activators of enzymes (Maldvain *et al.*, 1970). The water was studied for five heavy metals, but only three of them were found. Copper and lead were absent in the water of both River Panjkora and Swat River. Chromium was analyzed in all water samples, and its values ranged from 0.79-0.126mg/l (Table 5). Zinc was absent in the water of River Panjkora, while in other water samples, it was analyzed, and its values ranged from 0.04-0.011mg/l. Cobalt was present only in the water of River Swat, and its value was 0.023mg/l while in other water samples, it was absent.

Conclusion

It is evident that the flood has left serious effects on the fauna and water quality of the study area. Two species reported earlier are now missing, and some water parameters like alkalinity, turbidity, suspended solids, and potassium levels have increased, crossing the permissible limit. Heavy metals analysis shows that the level of chromium has also exceeded the permissible limit. Further study is recommended in the area after a year to assess whether and how much environmental repair processes have been done.

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