FRESHWATER BIODIVERSITY IN KABUL RIVER

Assessment of fish diversity, distribution & threats to its conservation in Kabul River under Kabul city, Afghanistan

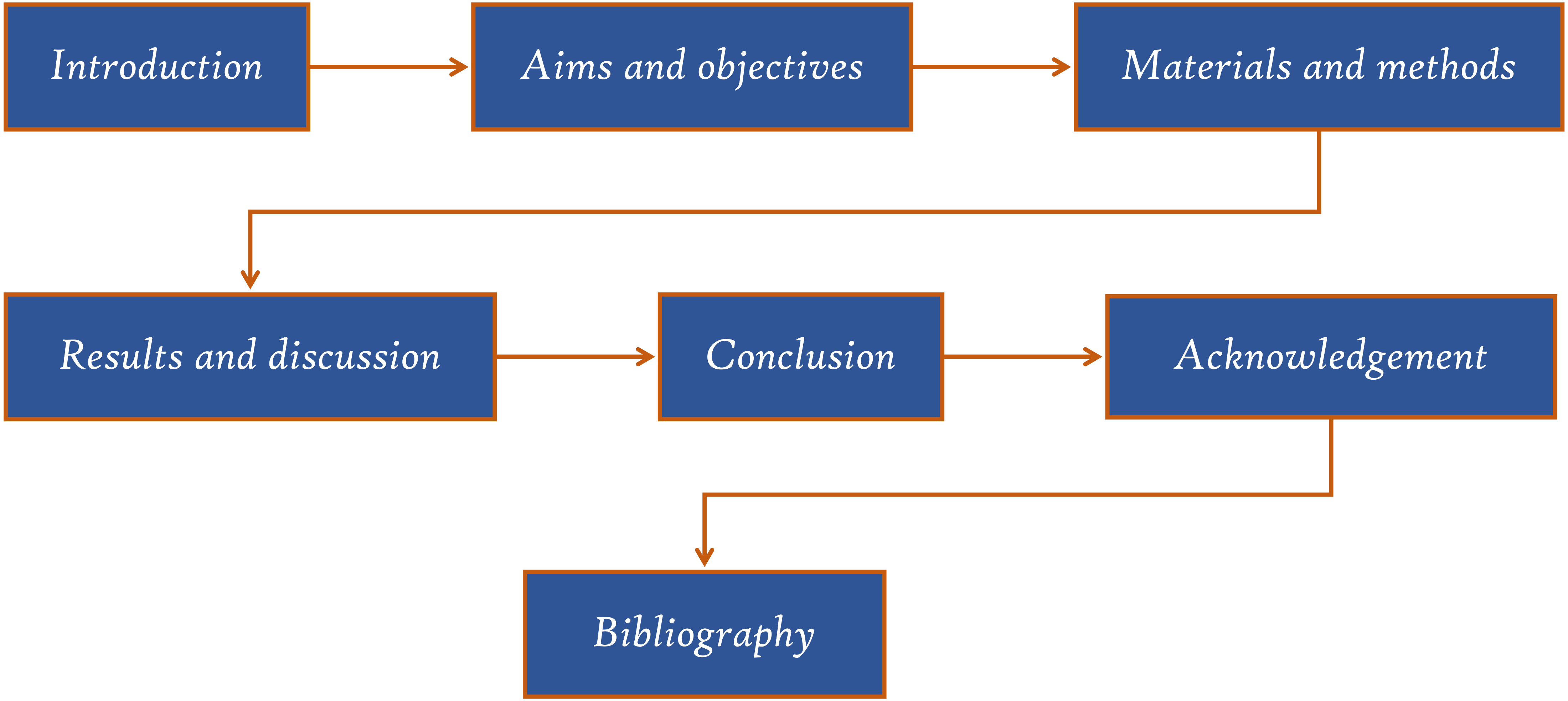
Ahmad Farid Habibi

(Lecturer)

Faryab University, Faryab Province, Afghanistan

Email: ahmadfaridhabibi67@gmail.com

PRESENTATION OUTLINE



INTRODUCTION

1. *What are fish? Why they are important?*
2. *Diversity of fish fauna in the world.*
3. *Threats to the conservation of fish and rationale of the research.*

What are fish? Why they are important?

- **Fish** are vertebrates that have gills and live in water.

(Bagur 2009; Berra 2001, 2008; Keat-Chuan Ng 2017)

- **Fish** are the diverse group of vertebrates in the world.

(Powers 1989; Ravi and Venkatesh 2008)

  - ✓ Fish plays a critical role in functioning aquatic ecosystem (Dudgeon et al. 2006).
  - ✓ Are an indicator to assess the health of an ecosystem (Allan 2004; Wu et al. 2014).
  - ✓ Fishes also contribute to food security in the world (FAO 2014).
  - ✓ Among fishes, freshwater fishes are the most threatened group of vertebrates in the world (Reid et al. 2013)

Diversity of fish fauna in the world

World:

- There are 34,300 species of fish in the world as per the list in FishBase (Froese and Pauly 2019).
- The Himalayan region holds a variety of fish species of which most are cold-water hill stream fishes.

Afghanistan:

- Coad (2015) reported that there are 85 species of fishes belonging to 10 families in the landlocked country of Afghanistan.
- However, 125 species (all freshwater species) are currently present in Afghanistan as of February 2020 per the list in FishBase (Froese and Pauly 2019).

Threats to the conservation of fish and rationale of the research

- Several studies on the fishes have been conducted throughout the world, BUT in Afghanistan, such studies are very much limited.
- Several fishes found in the country are believed to be endemic (UNEP 2003).
- In Afghanistan, water pollution is a significant threat to freshwater ecosystem (Weir 2018), without exception in the study area.
- Pollution of Kabul river in the Kabul city were mainly caused by:
    - The release of industrial effluents,
    - Domestic waste, and
    - development activities

(damaging the aquatic habitat)

(UNEP 2003)

AIMS/OBJECTIVES

Aims/Objectives

The study aims to achieve the following objectives:

- *Assess the diversity of fish composition in the Kabul river under Kabul city;*
- *Study distribution of fish species recorded from the area in different sampling sites along the altitude (downstream to upstream); and*
- *Evaluate abundance of fish fauna in the Kabul River under Kabul city, Afghanistan.*

MATERIALS & METHOD

1. *Study area*
2. *Methods*
   a. *Fish sampling*
   b. *Data analysis*

Study area

- The study was conducted along the stretch of Kabul River within the Kabul City.
- Located at 34°32'33.59"N 68°48'10.79"E.
- **Elevation:** 1,791 meter above sea level (masl).
- **Precipitation:** >312 millimetres (mm) annually.
- Rarer precipitation in summer months (NEPA 2007).
- **Temperature:** Ranges from 4.3°C to 19.6°C.
- The area is densely populated (Mack et al. 2009).
- Kabul River is home to diverse river fish including globally endangered Golden mahseer (*Tor putitora*) (UNEP 2008).
- **Use of river:** Irrigation, effluent and waste disposal, watering livestock, and fishing.

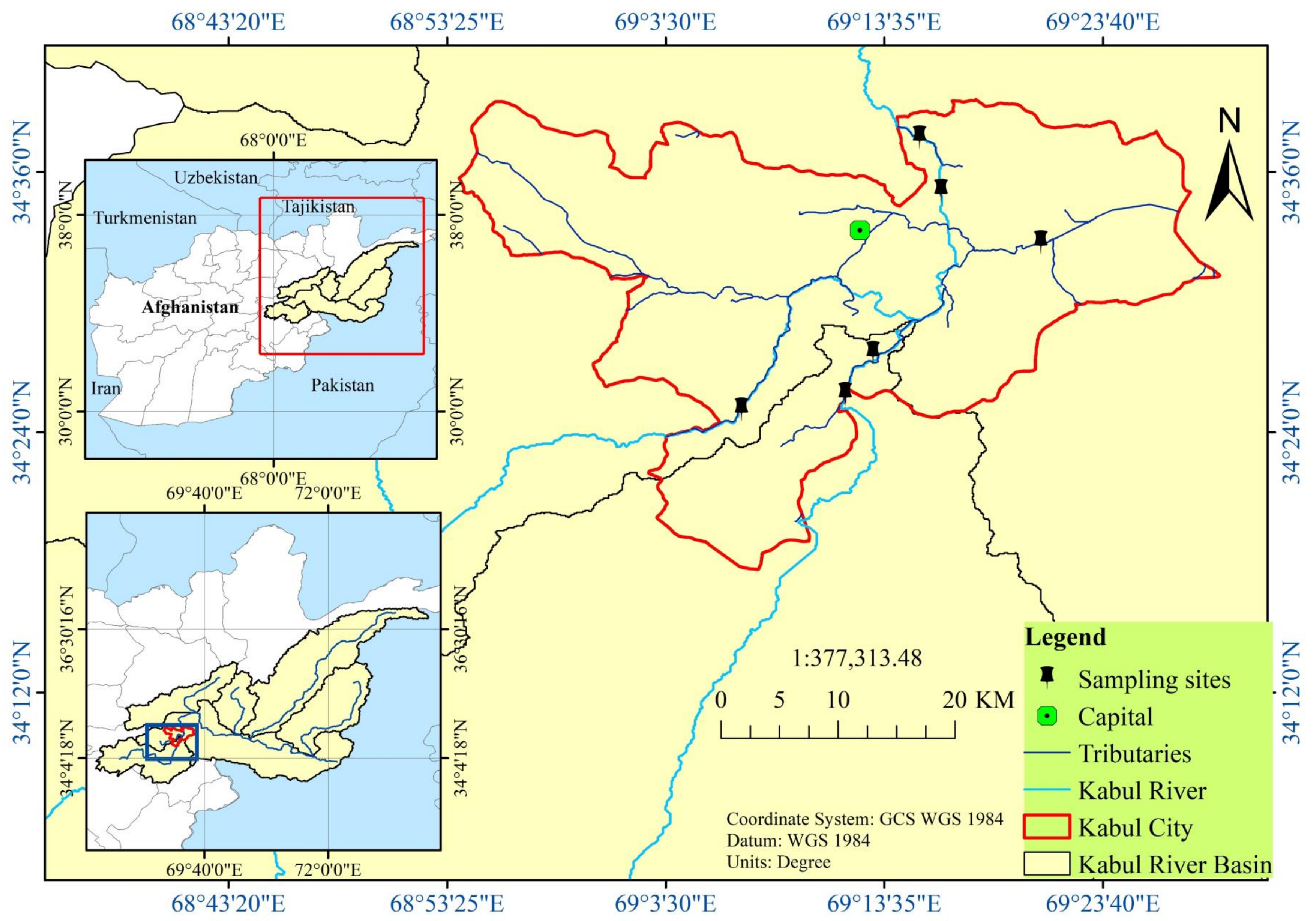


Fig. *Map of study area showing the map of Afghanistan and international boundaries, Kabul river, Kabul city boundary, Kabul river basin, tributaries, and sampling sites*

Study area division:

- Six sampling sites along the altitudinal gradient.
- 3 each sampling sites in Upstream and Downstream.

Sampling stations	Sampling sites	Geographic coordinates		Elevation (m)
		Latitude (D.M.S)	*Longitude (D.M.S)*	
Upstream	S1	34°25'2.86"N	69°6'59.65"E	1919
	S2	34°25'45.24"N	69°11'46.29"E	1814
	S3	34°27'39.25"N	69°13'3.40"E	1797
Downstream	S4	34°37'35.47"N	69°15'12.38"E	1761
	S5	34°35'8.41"N	69°16'12.09"E	1782
	S6	34°32'45.27"N	69°20'48.21"E	1776

Methods

Fish Sampling

- Using the expertise of the local fisherman, ichthyofaunal sampling was done in the selected sampling sites.

- Gill nets and fishing traps were used.

- The fishes were counted and identified to species level on the spot and released back to the river.

- Species that are unable to identify by the project team on the spot were photographed and recorded all the required information in the field for further identification and further study by consulting with experts and referring available literatures.

- Following Mishra (1959), Talwar and Jhingran (1991) Jayaram (1981, 1999), and Coad (2014), taxonomical studies of the fish fauna collected from the study area were performed.

Analysis of Data:

- Statistical analysis like Mann-Whitney U test was performed using IBM SPSS Statistics 23.0:

  - to study the significance of species abundance between upstream and downstream.

- Dendrogram of Bray-Curtis coefficients of similarity (Bray and Curtis 1957) and rank abundance plot of sites were generated using BioDiversity Professional version 2.0 (McAleece 1999).

- Biodiversity indices like Shannon-Wiener diversity index (Shannon and Wiener 1949), Simpson Index (Simpson 1949), Simpson's Diversity (Pielou 1969), Pielou Evenness Index (Pielou 1975), Margalef's Richness Index (Margalef 1958), and Menhinick's Index (Menhinick 1964) and Sorensen's Similarity Coefficient (Dice 1945; Sørensen 1948) were calculated.

RESULTS AND DISCUSSION

1. *Fish composition*
2. *Species abundance*
3. *Diversity and richness of fish species*
4. *Freshwater Ichthyofauna Conservation*

Fish composition

Table: Overall fish species composition in Kabul river under Kabul city

Order	Family	Genus	Species	N	%
Cypriniformes	Cyprinidae	*Alburnoides*	*Alburnoides holciki*	90	7.6
Cypriniformes	Cyprinidae	*Ctenopharyngodon*	*Ctenopharyngodon idella*	54	4.5
Cypriniformes	Cyprinidae	*Cyprinus*	*Cyprinus carpio*	36	3.0
Cypriniformes	Cyprinidae	*Hypophthalmichthys*	*Hypophthalmichthys molitrix*	81	6.8
Salmoniformes	Salmonidae	*Oncorhynchus*	*Oncorhynchus mykiss*	198	16.6
Salmoniformes	Salmonidae	*Salmo*	*Salmo trutta*	18	1.5
Cypriniformes	Cyprinidae	*Schizothorax*	*Schizothorax esocinus*	228	19.2
Cypriniformes	Cyprinidae	*Schizothorax*	*Schizothorax sp.*	420	35.3
Cypriniformes	Cyprinidae	*Tariqilabeo*	*Tariqilabeo diplochilus*	48	4.0
Cypriniformes	Cyprinidae	*Tariqilabeo*	*Tariqilabeo sp.*	12	1.0
Cichliformes	Cichlidae	*Coptodon*	*Coptodon zillii*	5	0.4

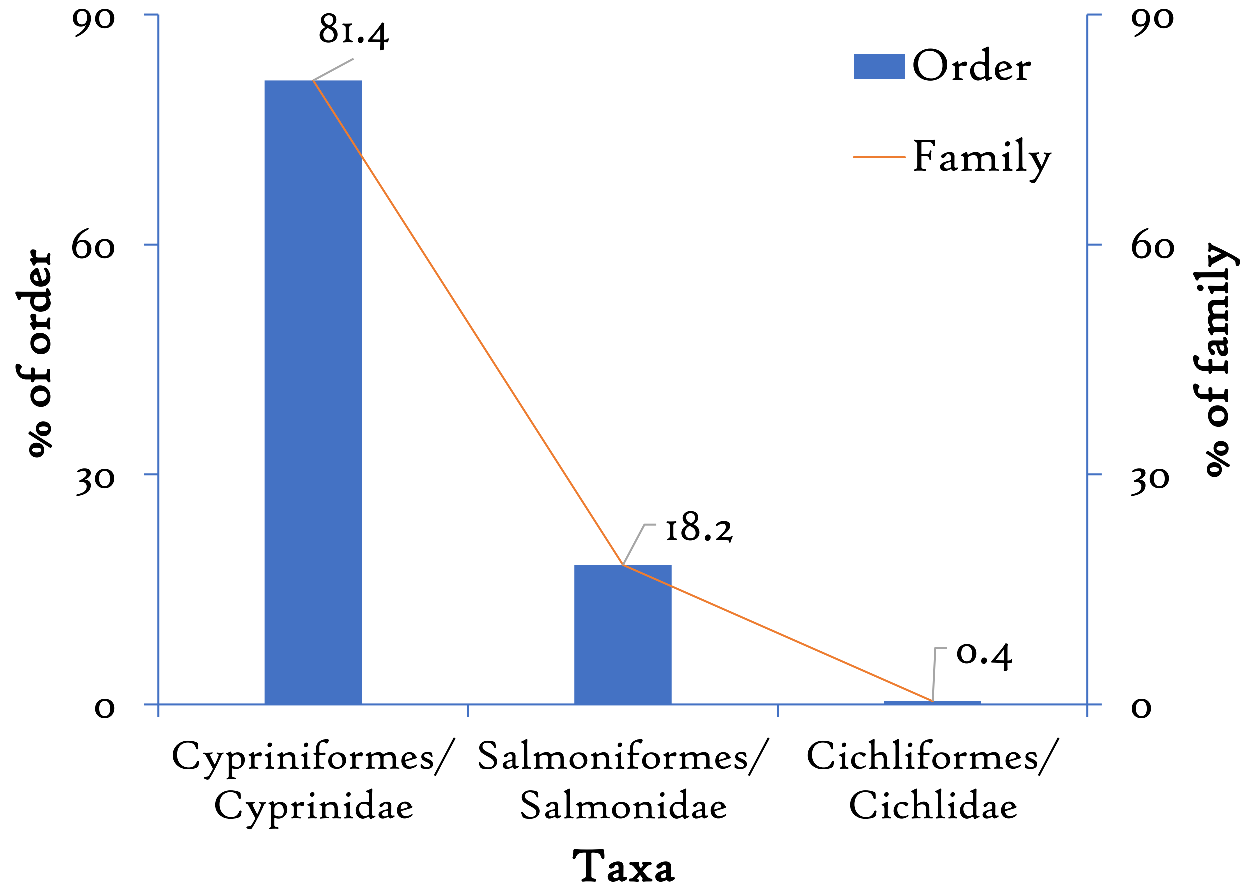


Fig: Composition of fishes based on order and family.

- Total of 1,190 fishes were collected from the study area.

- Order Cypriniformes was most dominant group with 81.4% (n = 969) of total individuals.

- Similar dominance was also reported by Saund et al. (2012), Shendge (2007), Shinde et al. (2009), Vijaylaxmi et al. (2010), Aryani (2015), and Akhi et al. (2020).

- Cyprinids can live in cold waters, can tolerate very low oxygen level, and some feeds on other fish species as well (Royce 1996).

- Cyprinidae was found to be most dominant family.
- Ubharhande and Sonawane (2012), Dau and Parkash (2009), Cunico et al. (2011), Choubey and Qureshi (2013), Mohsin et al. (2013), Verma (2019), Hu et al. (2019), and Herawati et al. (2020) reported the same.
- Cyprinidae in one of the most diverse predominant fish families (Boschung and Mayden 2004; Shen et al. 2016).
- Are also pollution tolerant family with more than 2000 species and 210 genera (Grabarkiewicz and Davis 2008).
- While rating 76 Cyprinidae species, 17% of them are pollution tolerant and 47% of the fish are found to be tolerating pollution intermediately (Barbour et al. 1999; Grabarkiewicz and Davis 2008).
- Their ability to survive in the unclean habitat validates the dominance of Cyprinidae in the most polluted part of Kabul River (Kabul city).

Species abundance

- *Schizothorax sp.* was highly abundant in the sites S2 (n = 76) and S3 (n = 117) followed by *Schizothorax esocinus*.
- In S1, *Oncorhynchus mykiss* (n = 44) was abundant species followed by *S. esocinus* (n = 31)

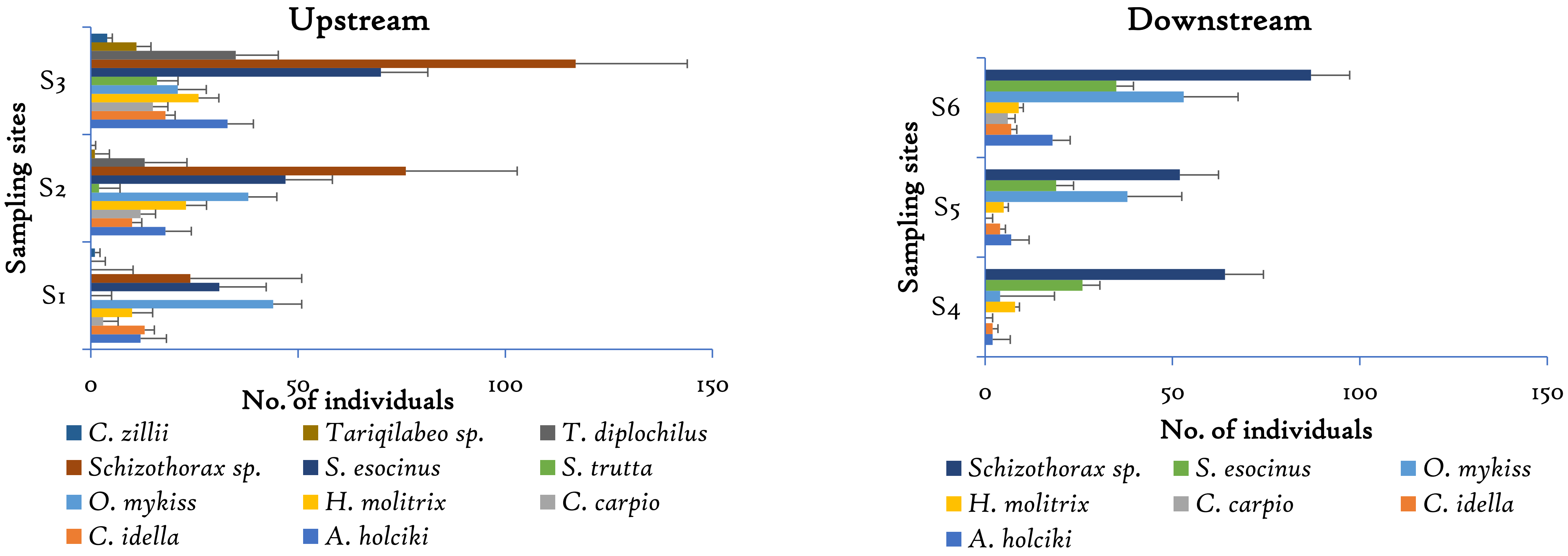


Fig. Species abundance in different sampling sites of upstream and downstream.

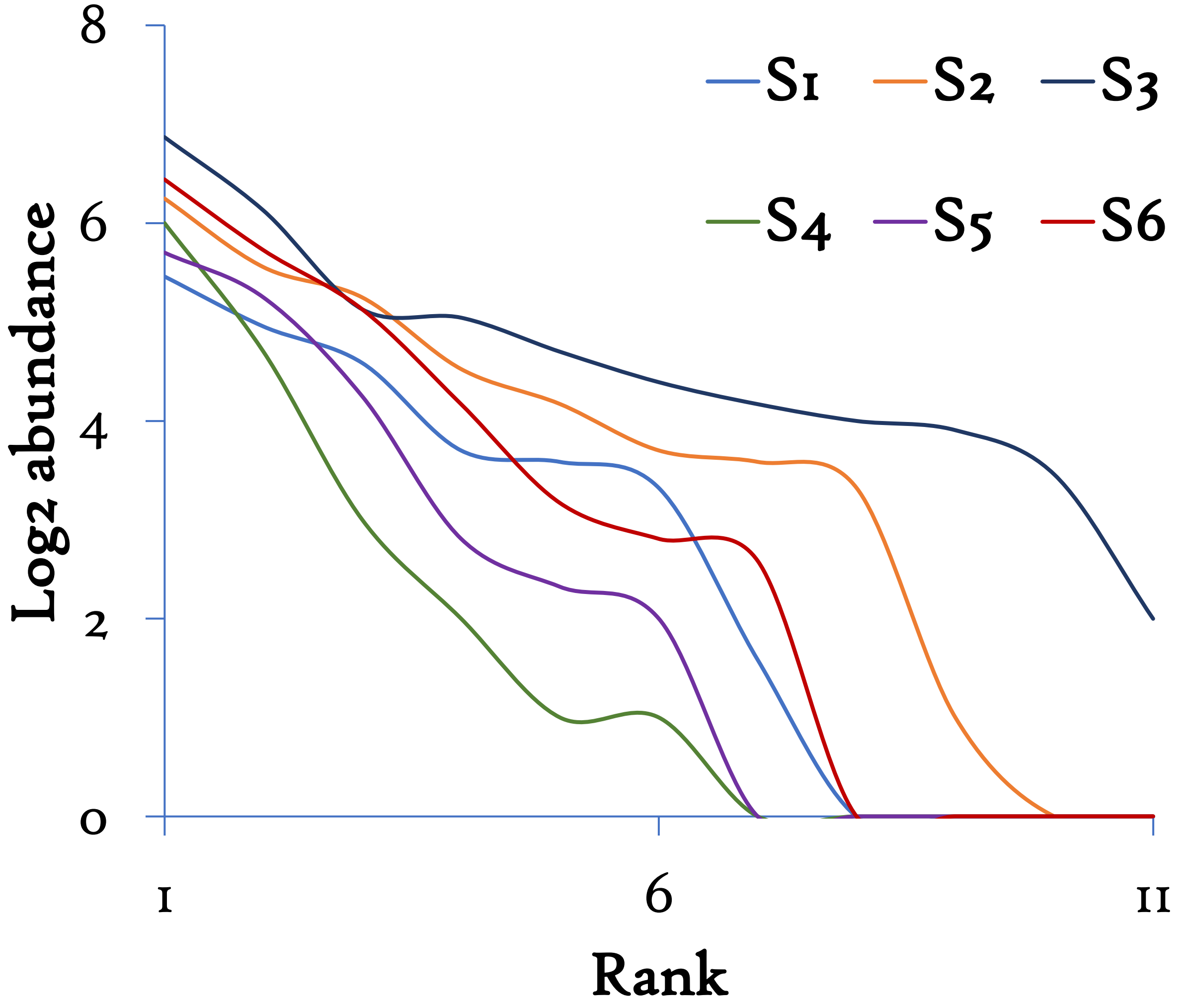


Fig. Rank abundance plot of all the six sites showing species abundance, richness and evenness;

- Almost all species recorded from the area are abundant in S3 and S2.
- The rank abundance curve or Whittaker plot, generated following Whittaker (1965) for Log_2 abundance data of all the six sites also showed high species abundance in S3 followed by S2.

- Overall, in upstream, *Schizothorax sp.* *was abundant* (n = 217, 72.33 ± 46.61).
- *Schizothorax esocinus* (n = 148, 49.33 ± 19.60) and *Oncorhynchus mykiss* (n = 103, 34.33 ± 11.93) were the second and third most abundant species.
- *Coptodon zillii* (n = 5, 1.67 ± 2.08) was least abundant fish species in the upstream.
- In the downstream, *Schizothorax sp.* (n = 203, 67.67 ± 17.79) was *most abundant* and *Cyprinus carpio* (n = 6, 2 ± 3.46) was *least abundant*.
- Pandey et al. (2018) also found abundance and dominance of *Schizothorax sp.* in rivers in Uttarakhand, India.
- Similar report on the abundance of schizothoracines were also reported in Tibetan Plateau (Zhang et al. 2017; Ma et al. 2020).
- Moreover, Kabul is a cold place located at 1,791masl and the lowest temperature recorded at night was -17°C (Aljazeera 2012, February 21).
- Schizothoracines are the cold-water species, living at about 3,323 masl (Petr et al. 2002).
- Thus, abundance of schizothoracines in the Kabul city were mainly correlated with cold weather.

Table: Mean species abundance with standard deviation in upstream and downstream sites

Species	Upstream		Downstream	
	No. of individuals	*Mean ± Standard Deviation*	*No. of individuals*	*Mean ± Standard Deviation*
Alburnoides holciki	63	21.00 ± 10.82	27	9.00 ± 8.19
Ctenopharyngodon idella	41	13.67 ± 4.04	13	4.33±2.52
Cyprinus carpio	30	10.00 ± 6.24	6	2.00 ± 3.46
Hypophthalmichthys molitrix	59	19.67 ± 8.50	22	7.33 ± 2.08
Oncorhynchus mykiss	103	34.33 ± 11.93	95	31.67 ± 25.11
Salmo trutta	18	6.00 ± 8.72	-	-
Schizothorax esocinus	148	49.33 ± 19.60	80	26.67 ± 8.02
Schizothorax sp.	217	72.33 ± 46.61	203	67.67 ± 17.79
Tariqilabeo diplochilus	48	16.00 ± 17.69	-	-
Tariqilabeo sp.	12	4.00 ± 6.08	-	-
Coptodon zillii	5	1.67 ± 2.08	-	-

- Overall, fish abundance in upstream ($n = 744$) was found to be *higher* than downstream ($n = 446$).
- This result is in *contrary* to the findings reported by Tiemann et al. (2004).
- But, Mann-Whitney test reveals that fish abundance in upstream (67.64 ± 64.89) and downstream (63.71 ± 70.28) was *not significantly different* ($U = 35$, $z = -.317$, $p = .751$, $r = -.075$).
- As per the cluster analysis, S2 and S6 had a parallel Bray-Curtis similarity in their species abundance of about 83%. S1, S5, S2, and S3 had a common similarity of about 74%, indicating similarity in species abundance.
- Nevertheless, species present in the upstream like *Salmo trutta, Tariqilabeo diplochilus, Tariqilabeo sp.*, and *Coptodon zillii* were not recorded from the downstream sites.
- This was mainly because of high intensity of ongoing habitat degradation caused by the discharging industrial waste and sewage directly into the river system, construction activities, high density of population and other anthropogenic activities in the downstream area.

Table: Mann-Whitney U test result of species abundance between upstream and downstream

	Group	N	Mean Rank	Mean Sum	*U*	*z*	*p*	*r*
Species abundance	Upstream	11	9.82	108	35	-.317	.751	-.075
	Downstream	7	9.00	63				

U: Mann-Whitney U test; *z*: *z* statistics; *p*: significance value; *r*: effect size

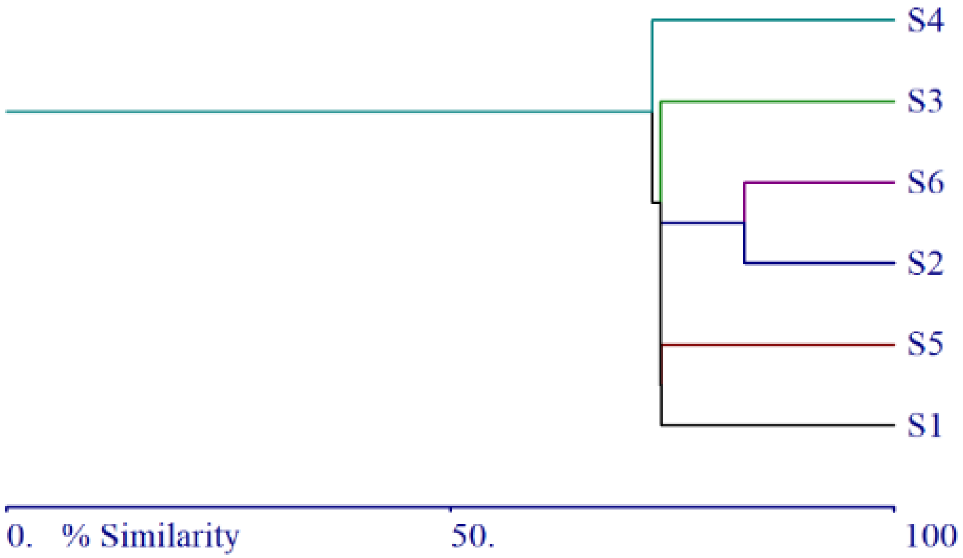
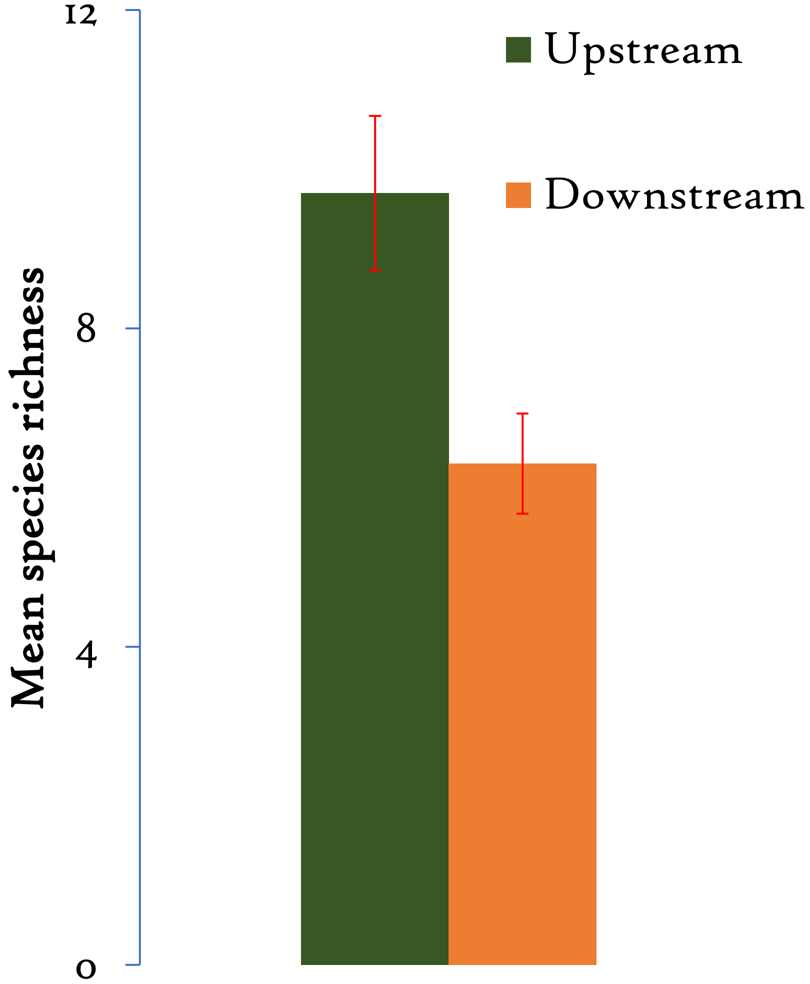


Fig. Cluster analysis (single linkage) based on the Bray-Curtis index of similarity applied to the fish abundance

Diversity and richness of fish species



- **In terms of species richness**, the rank abundance plot illustrated high richness in S3 and S2.
- The high species richness in S3 and S2 were also indicated by Margalef's Diversity Index (D_{Mg}) (1.69 and 1.64 respectively).
- Nevertheless, sampling sites S2 and S3, S1 and S6, S4 and S6, and S5 and S6 indicated having similarity of 95%, 93%, 92% and 92% between them, respectively.
- Sorenson's Similarity Coefficient value between S3, S4 and S5 (CC = 0.71) was the lowest, which also shows 71% of similarity between them.

Table: Sorenson's Similarity Coefficient (whose value ranges from 0 to 1) showing degree of similarity among sampling sites.

	S1	S2	S3	S4	S5	S6
S1	1.00	0.78	0.84	0.86	0.86	**0.93**
S2		1.00	0.95	0.75	0.75	0.82
S3			1.00	0.71	0.71	0.78
S4				1.00	1.00	**0.92**
S5					1.00	**0.92**
S6						1.00

- Altogether, upstream sites recorded 11 species and 7 species for downstream sites.
- High richness in upstream (D_{Mn} = 0.63 ± 0.05, D_{Mg} = 1.59 ± 0.15) was supported by Menhinick's Index (D_{Mn}) and Margalef's Diversity Index (D_{Mg}).
- For downstream, Menhinick's Index and Margalef's Diversity Index were 0.53 ± 0.05 and 1.07 ± 0.04 correspondingly, which was inconsiderably less than upstream.

Table: Mean ± standard deviation of Menhinick's Index and Margalef's Diversity Index for upstream and downstream sites in Kabul city.

Diversity Indices/ Sites	Upstream		Downstream	
	Mean	*SD*	*Mean*	*SD*
Menhinick's Index (D_{Mn})	0.63	0.05	0.53	0.05
Margalef's Diversity Index (D_{Mg})	1.59	0.15	1.07	0.04

- The most diverse site among all was S3 with Shannon-Wiener diversity index (*H'*) of 2.04 and Simpson's Diversity (D_I) of 0.83.

- S4 (*H'* = *1.12*, D_I = *0.57*) was the site with less diversity.

- In the same way, species evenness was also high in S3 with Pielou Evenness Index (*J'*) of 0.85 and less evenness score for S4 (*J'*=0.62).

Table: Different diversity indices showing variation among six sampling sites of Kabul river under Kabul city.

Diversity Indices/ Sites	S1	S2	S3	S4	S5	S6
Total No. of Individuals (N)	138.00	240.00	366.00	106.00	125.00	215.00
Species richness (S)	8.00	10.00	11.00	6.00	6.00	7.00
Menhinick's Index (D_{Mn})	0.68	0.65	0.57	0.58	0.54	0.48
Margalef's Diversity Index (D_{Mg})	1.42	1.64	1.69	1.07	1.04	1.12
Shannon-Wiener diversity index (H')	1.75	1.90	2.04	1.12	1.41	1.56
Pielou Evenness Index (J')	0.84	0.82	0.85	0.62	0.79	0.80
Simpson Index (D)	0.20	0.19	0.17	0.43	0.29	0.26
Simpson's Diversity (D_I)	0.80	0.81	0.83	0.57	0.71	0.74

- All in all, diversity was high in upstream (H' = 1.90 ± 0.15, D_1 = 0.81 ± 0.02).
- Species evenness was also high in upstream (J' = 0.84 ± 0.01).
- Tawari-Fufeyin and Ekaye (2007) also reported high species diversity and evenness in upstream.

Table: Mean ± standard deviation of diversity indices for upstream and downstream sites in Kabul city.

Diversity Indices/ Sites	Upstream		Downstream	
	Mean	*SD*	*Mean*	*SD*
Shannon-Wiener diversity index (H')	1.90	0.15	1.36	0.22
Pielou Evenness Index (J')	0.84	0.01	0.74	0.10
Simpson Index (D)	0.19	0.02	0.33	0.09
Simpson's Diversity D_1)	0.81	0.02	0.67	0.09

- However, all these challenges the universal trend in river system for ichthyofaunal diversity and richness to increase from upstream to downstream.
  (Hermoso et al. 2011; Negi and Mamgain 2013; Bayley and Li 1994; Dey and Sarma 2018; Vannote et al. 1980; Matthews 1998).

- The high species richness and diversity in upstream in the study area may be due to constant flow of river, less modification of land use, less pollution and fewer developmental activities.

- Urban activities like constructions leading to land use change, adding pollution and nutrients to the river system, varying hydro-morphology and hydrologic flow regimes, and unstable flow (as valley remains dry in most of the winter months) will negatively effects fish richness and are found to be MORE in the downstream.
  (Walsh et al. 2005; Booth 2005; Grimm et al. 2000; Wang et al. 2001; Gebrekiros 2016).

- Hence, there was less species diversity and richness in downstream, comparing to upstream.

- Still, 7 out of 11 species were shared between the upstream and downstream with Sorenson's Similarity Coefficient value of 0.78.

Freshwater Ichthyofauna Conservation

- Afghanistan is a dry and landlocked country (Breckle 2007; Wily 2015),
- But, is abundant in water resources (Qureshi 2002).
- However, 80% of water is contaminated and water pollution is a serious threat to the conservation of aquatic biodiversity and human survival (Weir 2018).
- In Kabul city, solid waste, waste water (both domestic and industrial), and open sewers are directly draining into the Kabul river (UNEP 2003);
    - exacerbated by population growth (Mack et al. 2009),
    - modifying the aquatic habitat.
- Habitat environment plays a great role in the fish composition, diversity and distribution in any stream or river system (McClendon and Rabeni 1987; Agarwal et al. 2018).
- Use of agriculture pesticides, and overfishing (Saeed 2018) were other threats to the conservation of the freshwater ecosystem in the Kabul city.

Species	Conservation status
Alburnoides holciki	Not Evaluated
Ctenopharyngodon idella	Not Evaluated
Cyprinus carpio	Vulnerable
Hypophthalmichthys molitrix	Near Threatened
Oncorhynchus mykiss	Not Evaluated
Salmo trutta	Least Concern
Schizothorax esocinus	Not Evaluated
Schizothorax sp.	--
Tariqilabeo diplochilus	Not Evaluated
Tariqilabeo sp.	--
Coptodon zillii	Least Concern

- This study has documented 11 fish species from the area.

- **4 species** of them are listed under IUCN Red List of Threatened Species.

- *Cyprinus carpio* is vulnerable (VU) species (Freyhof and Kottelat 2008) and *Hypophthalmichthys molitrix* is Near Threatened (NT) (Zhao 2011).

- *Salmo trutta* and *Coptodon zillii* are Least Concern (Freyhof 2011; Lalèyè 2020).

- To conserve these species and other associated species in the area, adoption of scientific fishing or sustainable fishing methods, timely monitoring of water quality, and proper management of solid waste and waste water are ***highly recommended***.

CONCLUSION

- Kabul river under Kabul city is threatened by numerous anthropogenic activities.
- Fishes recorded from area were mostly from the upstream sites where the aquatic habitat was least disturbed.
- Species diversity, richness, and abundance tends to decreases as we move from upstream to downstream.
- These were mainly found to be because of intensive agriculture farming, infrastructural development, and ineffective management of waste in the downstream area, which in turn increases sedimentation, contamination, and changes the overall aquatic habitat and their functioning (Pusey et al. 2011).
- Thus, implementation of sustainable development practice was deemed essential, so as to manage the water resources and conserve its biodiversity.
- Moreover, study on physiochemical parameters of the river, aquatic macroinvertebrates and fishes, and their association needs to be carried out to generate baseline information on the aquatic biodiversity of the area and monitor water quality.

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