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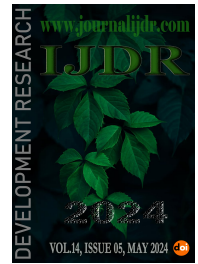
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RESEARCH ARTICLE

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A SURVEY OF RIVER GANDAK, BIHAR (INDIA) TO CHECK THE TYPES OF ANTHROPOGENIC ACTIVITIES IN RIVER THAT AFFECTS FISH BIODIVERSITY

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ABSTRACT

Increasing human population puts intense pressure on the river and uses it as their household dustbin. These are Anthropogenic pollution (are directly associated with the decline of river water quality and the fishes) and become an alarming issue of increasing scientific concern. Bihar is the "land of rivers" and a huge population resides at the bank of the rivers. The present survey was undertaken in Gandak river (Bihar) at Hajipur from Aug 2022 to Sept 2023 to check water quality, fish biodiversity and their IUCN status in summer, winter and rainy season. 39 fish species were identified that belonged to 18 families, 29 genus and 39 species. The Cyprinidae family (31.08%) was dominating, followed by Bagridae family with 14.4%. 79.4% LC, 10.25% VU, 5.12% NT and EN. Physicochemical parameters were analysed that showed variations in river water quality. Anthropogenic activities are very active in these areas. Therefore, all these data will be helpful and very valuable in the future study in the Gandak river with respect to water quality, conservation and sustainable management of the fish biodiversity of river Gandak.

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INTRODUCTION

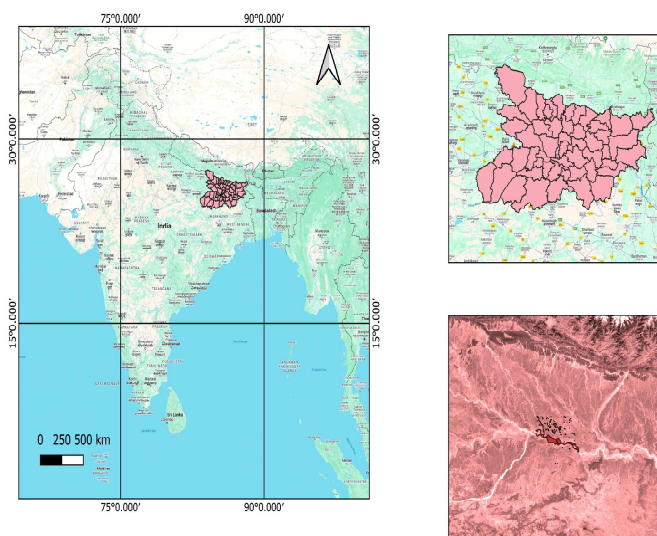
The life flourished and sprayed from water. We get water from various sources like river, pond, sea, ocean, lake, estuaries and many more. Terrestrial life is quite different from aquatic life in many aspects. A river is a nature body and a beautiful creation of great God. River is a naturally flowing watercourse and a new world to the water creatures. It starts from the source point and ultimately joins the ocean as end point. Rivers are flourished with many aquatic flora and fauna especially huge diversity of fishes. "Water is the ultimate solution of life, a source of energy to support life on Mother Earth that is directed to growth, development, and functioning of the Universe", stated in Yajurveda. Fish flesh is blessed with good protein source, vitamin (mainly A, B12) and minerals and Calcium for about one billion human population in the world, beings in different forms from time immemorial. It is considered as the "poor man diet" because it is easily available at very low cost and full of nutrition. Overall, 22% of animal protein consumption are covered by fishes, fish flesh protein composed of approximately 10 essential amino acids (lysine, arginine, histidine, leucine, isoleucine, valine, threonine, methionine, phenylalanine, and tryptophan). It is composed of zero carbohydrate that is good for diabetic patients, contains fully unsaturated fatty acids, that protects against cardiovascular diseases, good than meat. lysine, arginine, histidine, leucine, isoleucine, valine,

threonine, methionine, phenylalanine, and tryptophan. This sector is also a good source of income for a country. Along with these benefits it is an inseparable part of our nature and ecosystem including food web. Bihar is located in Eastern zone of India. It is blessed with many rivers like the Ganga, Gandak, Mahanadi, Son River, Ghaghara, and others. The river Ganga flows almost in the center region of Bihar that seems to be tilted towards center. Bihar has several perennial and non-perennial rivers that originate from the Himalayas in Nepal and River Gandak is one of them. It originates from the Mustang district of Nepal. Gandak River basin drains Nepal's central region and lies between the Koshi and Karnali river basins. It is also called as Narayani or Gandaki river. It crosses Nepal – India border at Bhaisalotan and flows down from districts West Champaran, East Champaran, Muzaffarpur, Vaishali (joins to the river Ganga at Patna then moves downward to Samastipur, Begusarai, Khagaria and Bhagalpur). It is blessed by a huge amount of flora and fauna. River banks are very fertile as it flows down to the plain from the Himalayas ranges and carries an ample amount of silt and soil. Hence Gandak river along with other rivers in Bihar makes it very fertile for the agricultural sector too. Species diversity is found higher in the coastal areas rather than at sea level, due to the presence of the habitat and food. But we know, every coin has two sides. One side it is really a beneficial creature in the world but on the other side due to the drastic rise in population of the world, a huge demand and pressure on the river and fishery sector has also increased. This sector can fulfill the food scarcity and improve malnutrition (E.S. Olaifa et al., 2022).

Approximately 24-24% of people (including young children, women) in Africa, Sub-Saharan Africa (SSA) are malnourished with deficiencies in minerals, vitamins and iron (FAO, 2017; Kassebaum, N.J. et al., 2014). Dependency on natural resources elevated. Along with increased demand various anthropogenic activities are also at a high peak. This vertebrate group is a projected to extinction at the rate of 5 times to the terrestrial fauna and 3 times to the marine mammals (Duncan and Lockwood, 2001). Hence, a survey is very much needed to be carry out to see the river condition and fish biodiversity condition and availability.

MATERIALS AND METHODS

Study area and Duration of sampling: For survey, Gandak river at Hajipur was considered. Hajipur is the heart of the Bihar and is 10 km from Patna. It is very populated and fastly growing city. It flows down into India from Bhaisaloton of West Champaran (Bihar). As Gandak river is situated between Saran district and Vaishali district, two survey sites were selected based on the types of human activities. Site 1 as Konhara Ghat, Hajipur (Lat 25.680792°, Long 85.195927°) Vaishali district and Site 2 as Sonpur Ghat, Saran district (Lat 25.691547°, Long 85.189973°) as shown in Figure 1, adapted from QGIS Software (with coordinates). It joins to the river ganga at Patna (the capital of Bihar).



(Source: adapted from DIVA GIS, using QGIS Software. Maps of India, Bihar and Gandak River)

Figure 1. Study Area where experiments were conducted. India, Bihar, Gandak river

The survey was done from July 2022 to June 2023, twice a month in different seasons (summer, rainy and winter). Fish collection and identification was done between 4 A.M to 6A.M by the help of local fishermen of particular sites. Water sample collected from both the sites between 8:00 A.M to 10:00 A.M, 2cm below the water surface of the river in all three seasons.

Methods for fish and water sample collection: Collection of data from primary and secondary sources were done on the sites and nearby fish market. Fish collection was done by gill nets, cast nets, drag nets, scoop net, mosquito nets and hook and line. Photographs were taken separately. Fishes were released after data evaluation. Fish identification and categorisation was done by their scientific name, vernacular name, IUCN conservative status (2022). by following Molur and Walker's (1998). Further status of taxonomical details was adapted from Talwar and Jhingran (1991). Fishes were categorised on the basis of their family also. Water samples were collected from particular sites in each season and sent to the laboratory for further testing. Various anthropogenic activities were also analysed at both the sites.

Data Analysis: Data of fish composition, physiochemical parameters of different seasons (summer, rainy and winter) were gathered and analysed in Microsoft Excel (2010) by figures, table, pie charts and graphs accordingly.

Species Diversity Index

Shannon- Wiener diversity index (H): The fish diversity indices were calculated by using Shannon - Wiener diversity index (Shannon and Wiener 1949). It shows the characteristics of the species in a given community.

$$H' = - \sum_{i=1}^n \left(\frac{n_i}{N} \right) \log_2 \left(\frac{n_i}{N} \right)$$

Where H' = Shannon-Wiener Index of diversity.

Evenness index (E): Evenness (Pieleu Index, E) expresses evenly distribution of the fishes among different species in a particular time period and climatic condition. It was determined by following Pieleu evenness index (Pieleu, 1966).

$$E = H'_{max} / \log S$$

E = Evenness index, H'_{max} = maximum value of Shannon-Wiener Index, S = total number of species.

If evenness E is less, then diversity is also less and definitely there is some other species which is dominating.

Species richness index (d): The species richness was calculated by using Margalef species richness, d , (Margalef's, 1958). It measure species richness in a particular time zone and area.

$$\text{Margalef diversity index } (R) = S - 1 / \log N$$

R = Margalef's index, S = number of species, N = total number of individuals.

Physicochemical parameters analysis: Water sample of all the three seasons were collected from both sites and preserved for analysis and sent to the laboratory in particular time. Physicochemical parameters such as Temperature, pH, turbidity, TDS, Total Hardness, BOD, COD, DO, Sulphate ion, Chloride ion, Phosphate ions and conductivity were analysed in summer, rainy and winter seasons. pH, conductivity was analysed on the sites. Rest was analysed in the laboratory.

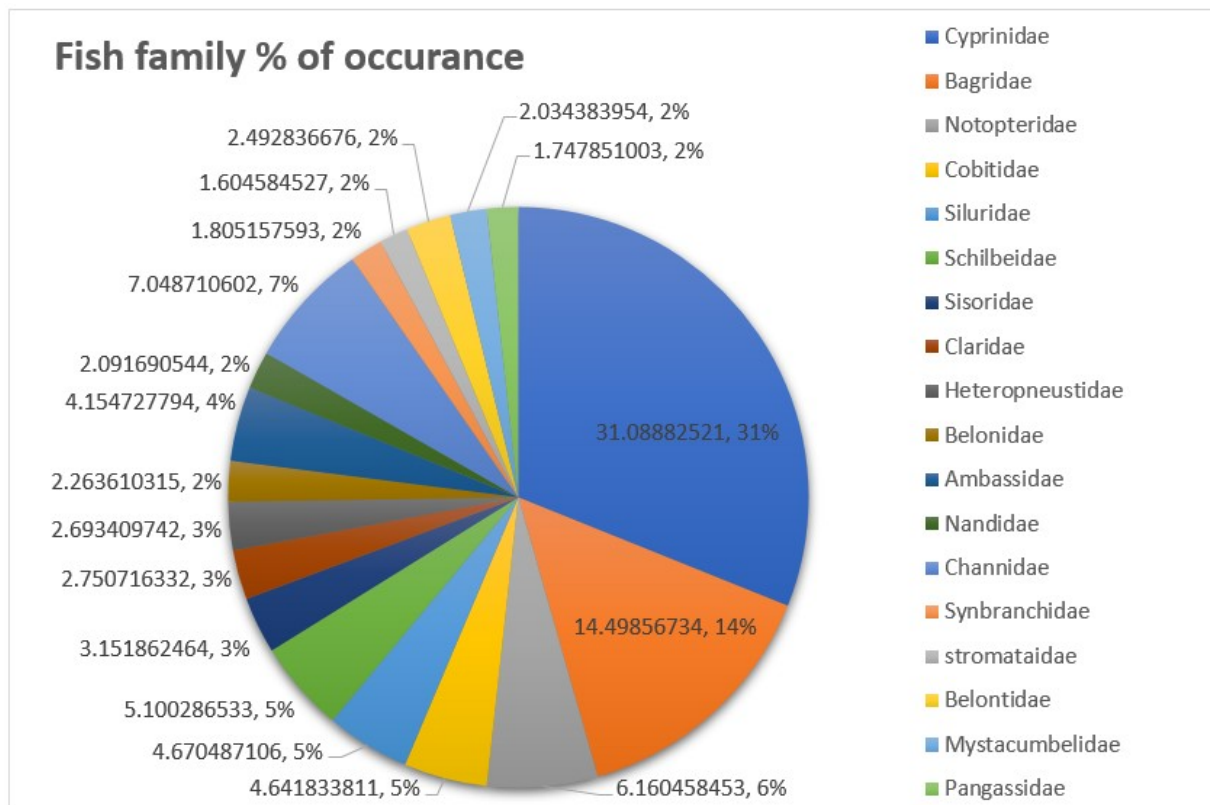
RESULTS AND DISCUSSION

Fish biodiversity: In the present survey, total 39 individual fish species were identified and categorised in different families from two selected sites Konhara ghat (Site 1) and Sonpur Ghat (Site 2) of the Gandak river during July 2022 to June 2023. All were grouped under 18 families, 29 genus and 39 species. The Cyprinidae family found as the most abundant with 11 fish species and family Stromataidae was the least with 1.6% of total families. A list of total available fish biodiversity is provided in Table 1, along with their scientific name, vernacular name, IUCN conservation status of both sites 1 and 2.

Taxonomic status adapted from Talwar and Jhingran (1991): (IUCN= International Union for Conservation of Nature, LC= Least concern, VU= Vulnerable, EN= Endangered, NT= Near Threatened, Site 1= Konhara Ghat of Hajipur, Vaishali, Site 2= Sonpur Ghat of Sonpur, Saran, + = fish found during survey and - = fishes not found during survey). A total of 39 fish species of 18 families and 29 genera were found. Cyprinidae family (31.088%) occupied the most, followed by the Bagridae family (14.49%). Notopteridae family showed 6.16% whether Siluridae family with 4.67%, Cobitidae family with 4.64%. Pie chart 1 showing the family wise fish percentage in Gandak river.

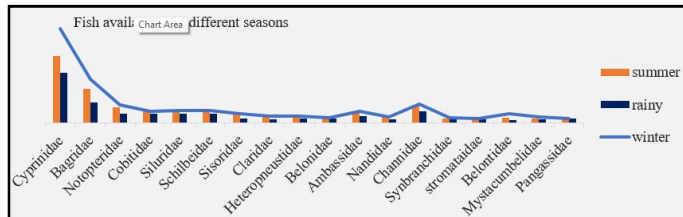
Table 1. Fish biodiversity collected from Konhara and Sonpur ghat in Gandak river, based on Molur and Walker’s (1998).

Family	Scientific Name	Vernacular Name	IUCN Conservation Status	Site 1	Site 2
Cyprinidae	1. <i>Aspidoporia morar</i>	Chippuah	LC	+	+
	2. <i>Catla catla</i>	Catla	LC	+	+
	3. <i>Chela cachius</i>	Chelhawa	LC	+	+
	4. <i>Cirrhinus mrigala</i>	Naini	LC	+	-
	5. <i>Cirrhinus reba</i>	Rewa	LC	+	-
	6. <i>Cyprinus carpio</i>	China rohu	VU	-	+
	7. <i>Labeo rohita</i>	Rohu	LC	+	+
	8. <i>Labeo calbasu</i>	Kala rohu	LC	+	+
	9. <i>Puntius conconius</i>	Sidhari	LC	+	-
	10. <i>Puntius sophore</i>	Sidhari	LC	+	+
	11. <i>Puntius chola</i>	Sidhari	LC	+	+
Bagridae	12. <i>Mystus bleekari</i>	Tengara	LC	+	+
	13. <i>Mystus tengara</i>	Tengara	LC	+	+
	14. <i>Mystus vittatus</i>	Tengara	LC	+	-
	15. <i>Separata seenghala</i>	Tengara	LC	+	+
	16. <i>Separata oar</i>	Dariai tengara	LC	-	+
Notopteridae	17. <i>Notopterus notopterus</i>	Patra	LC	+	+
	18. <i>Notopterus chitala</i>	Moya	LC	+	+
Cobitidae	19. <i>Botia Dario</i>	Baggha	LC	+	+
	20. <i>Lepidocephalus guntea</i>	Nakati	LC	+	-
Siluridae	21. <i>Ompok bimaculatus</i>	Jalkapoor	NT	+	+
	22. <i>Wallago attu</i>	Barari	VU	+	-
Schilbeidae	23. <i>Ailia colia</i>	Patasi	LC	+	+
	24. <i>Eutropichthys vaccha</i>	Banjhoo	EN	-	+
Sisoridae	25. <i>Bagarius bagarius</i>	Goinchi	VU	+	-
Claridae	26. <i>Clarius batracus</i>	Mangur	EN	+	+
Heteropneustidae	27. <i>Heteropneustes fossilis</i>	Singhi	LC	+	+
Belonidae	28. <i>Xenotodon cancila</i>	Kauwa	LC	+	+
Ambassidae	29. <i>Chanda nama</i>	Chanda	LC	+	+
	30. <i>Parambassius lola</i>	Chanari	NT	+	-
Nandidae	31. <i>Nandus nandus</i>	Dhalae	LC	+	+
Belontiidae	32. <i>Colisa fasciatus</i>	Khosti	LC	+	+
Channidae	33. <i>Channa straita</i>	Soura	LC	+	+
	34. <i>Channa orientalis</i>	Changa	VU	-	+
	35. <i>Channa punctatus</i>	Garai	LC	+	+
Mystacumbelidae	36. <i>Mastacumbeus armatus</i>	Belwa	LC	+	+
Synbranchidae	37. <i>Monopterusuchia</i>	Baami	LC	+	+
Pangassidae	38. <i>Pangasius pangasius</i>	Basa	LC	+	-
Stromataidae	39. <i>Pampus argenteus</i>	Rupchand	LC	+	+



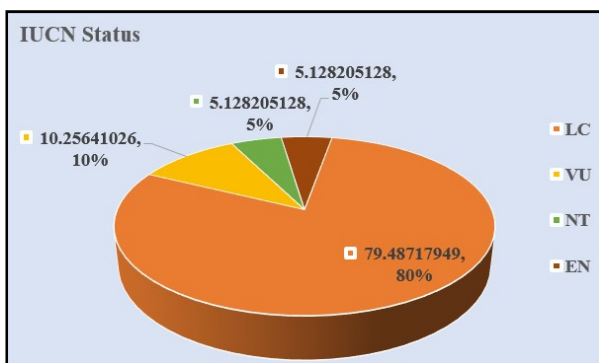
Pie chart 1. showing fish diversity found during the survey (Source- by the Author)

Fish availability in different seasons varies, highest in winter seasons followed by rainy season then summer season. Fish consumption in the rainy season is unfit to consume because rainy season is referred as breeding season (shown above in Graph 1) and during that period fishes underwent many physiological changes in its body.



Graph 1. Showing fish availability in different seasons (source- by the Author)

IUCN Conservation Status: The IUCN website was used to check the conservation status of identified fishes in the Gandak River. LC (least concern) is 79.4%, VU (vulnerable) is 10.25%, EN (endangered) is 5.12% and NT (near threatened) is 5.12%.



(Source – by the Author)
IUCN= International Union for Conservation of Nature, LC= least concern, VU= vulnerable, NT= near threatened, EN= endangered

Graph 2. Shows diversity indices of surveyed fishes in three seasons (source- by the Author)

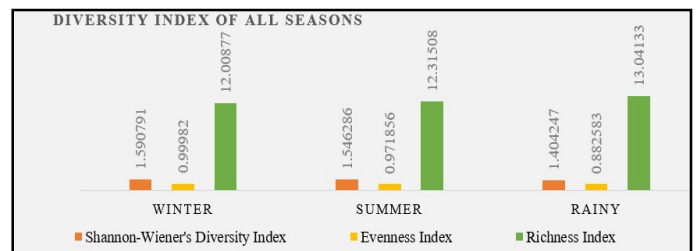


(i) Sperata seenghala eating chippuah (Source – by the Author)

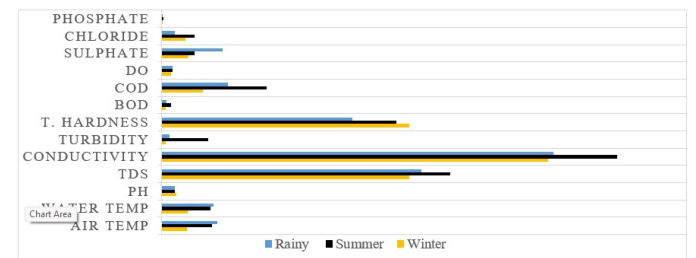
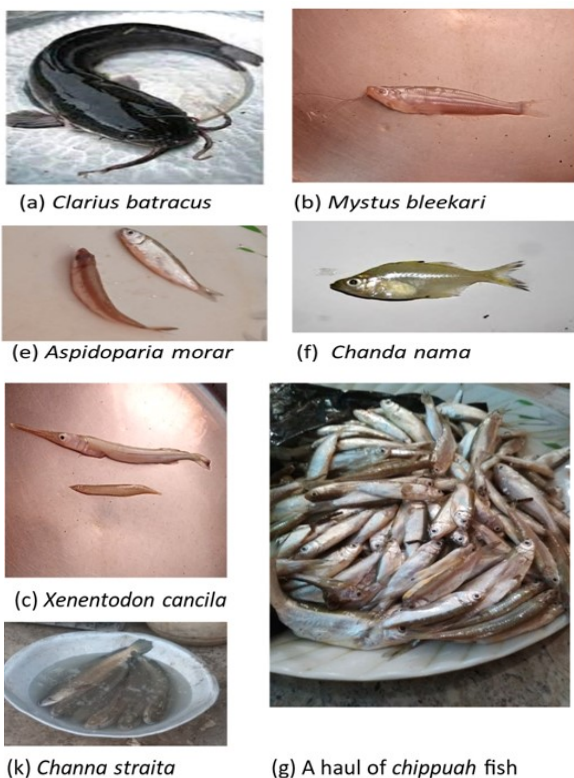
Figure 2. Some of the surveyed fish species of the Gandak river

Data analysis: Diversity indices; Shannon- Wiener Index (H) was found the highest in winter season and the lowest in the rainy season at site 1. Similarly Pielou Index or Evenness (E) was highest in winter season and the lowest in the rainy season. Margalef Diversity Index or Richness (R) was the highest in rainy season and lowest in winter season. Therefore, we could see the difference in availability of fishes in different seasons.

Physiochemical parameters of river water in three seasons: To document the availability of fish biodiversity in the river, it is very important to check the river water condition means its physiochemical parameters. Here in the present survey some parameters were analysed.



(source- by the Author)
(BOD= biochemical oxygen demand, COD= chemical oxygen demand, DO= dissolved oxygen, T.hardness= total hardness, TDS= total dissolved oxygen, pH= potential of hydrogen, Temp= temperature)



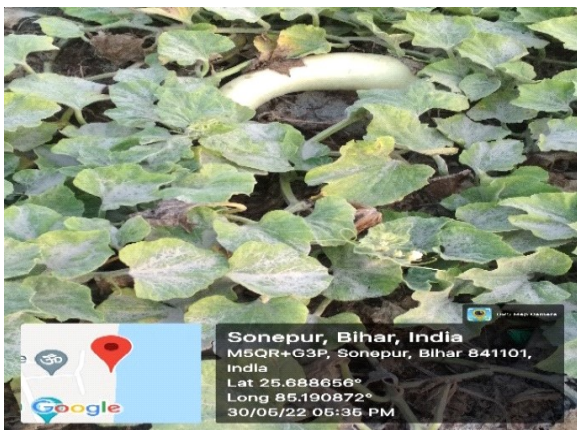
(Source- by the Author)
(BOD= biochemical oxygen demand, COD= chemical oxygen demand, DO= dissolved oxygen, T.hardness= total hardness, TDS= total dissolved oxygen, pH= potential of hydrogen, Temp= temperature)

Graph 2. Variations in water parameters in rainy, summer, and winter season. (Source- by the Author)

Air temperature and water temperature were highest in rainy season during the sample collection and lowest in winter season. Burt et.al.,2011 had revealed the temperature effects on the early life history of fishes. It is defining property of water that very much crucial for fish growth. pH varied from 8.23 in winter to 7.63 in summer season. Total dissolved solids (TDS) was highest in summer and lowest in winter season. Water conductivity varied from 260.65 ms/cm in summer to 221 ms/cm in winter season. Turbidity was extremely high in summer season (26.75 NTU) and lowest in 2.45 NTU only. Total hardness was more in winter season than in rainy season. BOD, COD and DO were the highest in summer season the lowest in winter season.

Sulphate ions were ranged from 15.52 (winter) to 35.01 in rainy season. Chloride ions varied from 7.48 in rainy to 18.89 in summer season. Phosphate ions was the highest in summer season.

Anthropogenic Activities found during survey: It crosses many districts and carry various types of silt, mud, wastes, plastics etc. these all comes under human ill activities to the river for self-comfort. Hence these are called as anthropogenic activities. Some of them were found at the time of survey. Bathing and washing clothes and utensils in a river, draining waste water into the river, overfishing by using small mesh-sized nets, agricultural runoffs into the river (Figure 5), growing invasive species for livelihood disturb the native fishes, overbridge construction, throwing waste, plastics, peels of fruits, and coins into a river (Figure 6), cremation activities and dropping God and Goddess statues in festivals. Ecosystem functions with the set of processes that regulated the energy flaxes and matter in the ecosystem as a consequence of the joint activity of these organisms (Tilman et.al 2014). Water quality of a river includes all physical, chemical, and biological features (involving biotic and abiotic factors).



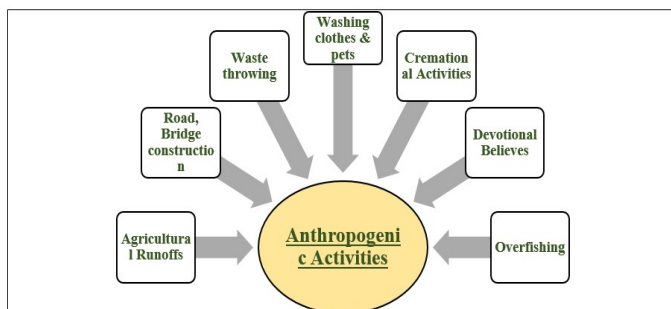
(Source: by the Author, on spot GPS image)

Figure 5. Cucumber cropping on Gandak riverbed



(Source: by the Author, on spot GPS image)

Figure 6. Wastes at the bank of the river



(Source: By the Author)

Figure 7. Showing types anthropogenic activities found at the survey duration

All are interlinked to each other. This leads to altering the actual quality of the river water suitable for proper growth (qualitative and quantitative aspects), nourishment, and development of fish. Human activities along with climatic change impacts disturbs river and fishes (Kalyani, et. al 2024). Most cases of malnutrition in poor family includes growing children, pregnant women, and girls at puberty age, due to lack of nutrition; According to National Health & Family Survey and WHO. Yes, after many efforts India has reduced malnutrition over the past years but still, there is a need to consider and enhance fish production. River management along with fish diversity enhancement is very crucial and need of the hour (Dudgeon, D.2005).

Conservative measures: River is priceless gift of nature. It flourishes life, living and balances ecosystem also. Therefore, it must be clean and free from any human activity. There are various activities that are very much working at the survey site. Site 1 Konhara ghat is known for devotional and cremational activities and Site 2 Sonpur ghat is mostly known for devotional, tourist spot and agricultural activities. Devotional activities, agricultural runoffs, cremational works, overfishing, washing clothes, throwing waste, coins, plastics, and peels must be prohibited. Fishermen should use a proper fishing guide, proper mesh-sized nets and lead-free nets. They should adopt sustainable development in the fishery sector. Government should find these activities and threatened fish species and accordingly work on it to enhance their number. Avoid direct involvement of wastewater in the river. Awareness among fishermen, job-oriented works, training, other facilities should be provided to fishermen because they are very active part of river. Further research can be done in this sector to find other sustainable ways.

CONCLUSION

After survey of the Gandak river, it was found that industrial activities were less but anthropogenic activities were very active. Along with these rapid urbanization, industrialization, spiritual beliefs, riverbed agriculture, global warming, climatic changes, and increasing demand for water and fishes has put immense pressure on the river (Singh *et al.*, 2013) that continuously harsh fishes and hence decline catch from the river. In 1963 David surveyed on the Gandak River and its fisheries; 161 km above and 24 km below the Bhaisalotan barrage, as a pioneer work. Srivastava (2013) documented 54 fish species in the Gandak River (Uttar Pradesh). From previous to recent records, due to changes in morphology and hydrological parameters, fish count has been declined and may continue if strict steps towards its conservation not taken. Collectively all human activities, climatic changes, pollution should be properly considered and prohibited in river area. Illegal activities should be controlled, awareness programs should be conducted effectively. Sustainable development should be enhanced.

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