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Fish diversity and water quality of wetlands in attabira block of Bargarh District, Odisha, India

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Abstract
The State of Odisha is endowed with a number of wetlands which provide many services that contribute to human well-being and poverty alleviation. The present study is focused on the status of fish diversity and water quality in five types of wetlands of Attabira block in Bargarh district, Odisha. The sampling sites selected for study are Site 1: running wetland; Site 2: Stable and protected wetland without anthropogenic interference; Site3: disturbed and unprotected wetland with anthropogenic interference; Site 4: Paddy field wetland; Site5: Swampy wetland. The water quality parameters were studied following standard protocol prescribed by CPCB and APHA (1992). The Shannon Weiner's diversity index was calculated for different fish diversity of above wetlands. The water quality of site 3, 4, and 5 exceeded the permissible limits as prescribed by CPCB. The pollution load could be due to several factors like agricultural runoff, mass bathing and religious activities. The percentage of fish population showed that order Cypriniformes was most dominant constituting 47% followed by order Siluriformes constituting 17%, order Anabantiformes 11.7%. The cultivable and weed and ornamental fishes were also recorded. The highest Shannon Weiner's Diversity Index was recorded in running wetland followed by pond without anthropogenic interference, pond with anthropogenic interference, paddy field wetland and then swampy wetland respectively. As far as biodiversity status (IUCN-2018) is concerned, out of 17 fish species, 9 fish species are categorized in to least concerned, 3 not evaluated, 2 vulnerable, 1 near threatened and 1 endangered. The study thus strongly emphasized that wetland management is highly essential to restore the degraded wetlands. The implementation of different conservation measures could contribute to the increase and sustenance of fish population and water quality standard of these precious wetland ecosystems.

Keywords: wetlands, fishery, fish diversity, water quality, wetland management

1. Introduction

1.1 Wetlands services to human being

Wetland ecosystems, including rivers, lakes, marshes, rice fields, and coastal areas, provide many services that contribute to human well-being and poverty alleviation. Some groups of people, particularly those living near wetlands, are highly dependent on these services and are directly harmed by their degradation. Two of the most important wetland ecosystem services affecting human well-being involve fish supply and water availability. Inland fisheries are of particular importance in developing countries like India, and they are sometimes the primary source of animal protein to which rural communities have access. Wetland resources exhibit significant ecological diversity, primarily because of variability in climatic conditions and changing topography in India. Unfortunately, many such areas have been converted for agriculture, industry or settlements.

Fish diversity comprises of species richness (number of species in a defined area), species abundance (relative number of species) and phylogenetic diversity (relationships between different groups of species) [1]. In the recent year, several broad scale studies have identified modification and loss of aquatic habitat as primary factor threatening the conservation of freshwater fishes and communities [2, 3]. Parameters such as species composition, species richness, abundance have been used in many studies to describe and assess fish community and diversity [4, 5].

1.2 Fish diversity in fresh water wetlands

Wetlands are important study site for biodiversity as a healthy wetland provides a habitat for feeding and breeding for terrestrial and aquatic mammals, birds, reptiles, fish and invertebrates. Hence, wetlands are very productive in nature and contribute a healthier native fish population. The freshwater fish fauna of India is highly diverse in nature and constitute 1027 species [6]. Various freshwater resources of Odisha are blessed with diverse fish fauna constituting about 13.92% of the freshwater fish fauna in India [7]. However, there have been very minimal studies on freshwater fishes in different parts of Odisha. The published literatures reflect works on Ichthyofaunal diversity of Chilika lake [8], river Samuka [9], river Mahanadi [10], and Ansupa lake [11] in Odisha.

1.3 Fish Responses to Water Quality

Fish is highly susceptible to changes in water chemistry due to different anthropogenic activities from their catchments. Water quality is determined by various physicochemical and biological factors, as they may directly or indirectly affect its quality and consequently its suitability for the distribution and production of fish and other aquatic animals [13]. In most of the countries, fishes are cultivated in ponds (lentic water) but unfortunately such breeders are not so aware of importance of water quality management in fisheries.

The very poor of developing countries often rely on fishing as a primary source of income and fish as primary source of animal protein. However, many such areas have been converted for agriculture, industry or settlements. A great number of wetlands have been affected by industrial effluents, discharge of sewage, household wastes thereby directly threatening the fish diversity. It is realized from the literature that very few works have been carried out on fish diversity in small lentic and lotic wetlands of Western Odisha. Thus, it becomes indispensable to evaluate fish diversity and water quality of inland aquatic system for their conservation and sustainable fish production. The present investigation attempts to find out the fish diversity in few wetland types in Attabira block of Bagarh district located in Western Odisha.

2. Materials and Methods

2.1 Study sites

The study areas lie in Bargarh district, Odisha. The area contains different types of wetlands which are used for irrigation and domestic purpose, but is being used today for inland fish culture. The average temperature of study sites was around 28º C during monsoon (July) and around 30ºC during post monsoon (October). The area received good rainfall from south-west monsoon. The mean annual rainfall was 650 mm during June to September. The sampling sites were Site 1, a running wetland (latitude 21° 21' 31.0104" N, longitude - 83° 46' 47.496" E). Site 2: a stable and protected wetland without anthropogenic interference (latitude- 21° 21' 33.6348" N, longitude- 83° 46' 47.1144" E), Site3: a disturbed and unprotected wetland with anthropogenic interference (latitude- 21° 22' 2.37" N, longitude- 83° 47' 6.972" E), Site 4: paddy field wetland (latitude-21° 21' 30.5172" N, longitude- 83° 46' 46.8768" E), Site5: a swampy wetland close to a temple (latitude- 21° 23' 27.168" N, latitude- 83° 48' 40.752" E). The fresh water swamp was dominated by aquatic floating-leaved rooted and submerged plants like *Ipomoea aquatic* and *Eichornea sp* respectively. The paddy field was dominated by *Azolla sps.*

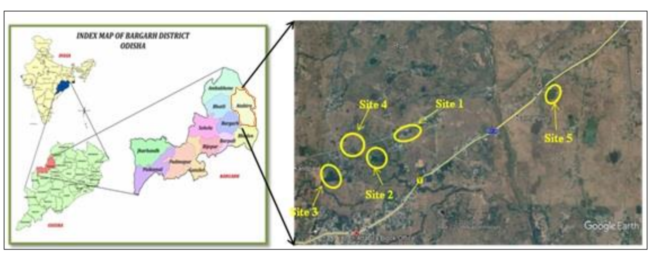

Fig 1: Map showing sampling sites

2.2 Fish samples collection and identification

Fish samples were collected from different selected wetlands during monsoon (July 2019 to September 2019) and during post monsoon (October 2019). Fish samples were collected with the help of local fishermen using cast nets randomly from five points of each wetland. Photographs of fishes were taken immediately after the sampling. The fishes were identified by following Jayaram [14]

2.3 Determination of Diversity Indices

For determination of diversity indices random samples of fish were taken from five nettings from each stations. Total number of species, total number of individuals in a sample and total number of individuals of a species were determined. From these data Shannon-Weiner species diversity index and dominance index were determined using following equations.
Frequency was estimated as per Raunkier [15],

$$Frequency = \frac{No.of\ qudrate\ of\ occurrence\ of\ species}{Total\ no.of\ qudrate\ studied} \times 100$$

Density and Abundance was calculated following Mishra [16] as:

$$Density = \frac{Total\ no.of\ individual\ of\ a\ species}{Total\ no.of\ qudrate\ studied}$$

$$Abundance = \frac{No.of\ individual\ of\ species}{No.of\ qudrate\ of\ occurrence\ of\ species}$$

2.4 Important value index

Important value index (IVI) of each species was calculated by adding relative frequency, relative density and relative abundance of the species (Phillips) [17].

2.5 Species diversity

Species diversity ($\hat{H}$) of the herbaceous species was determined following Shannon and Weiner [18] as $\hat{H}= -\sum (n_i/N) \ln (n_i/N)$
Where n_i=IVI of individual species and N=Total IVI of individual of all species in the area.

2.6 Water sample collection and analysis

For water quality analysis random samples of water were collected from three different locations of each wetland in the morning of the first week of July 2019 (monsoon) and October 2019 (post monsoon). The sampling could not possible during pre-monsoon as water dries up due to excess heat in this area. Water samples were collected from 50cm depth in each collection sites. Different water qualities (TDS, pH, conductivity, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), nitrate content, phosphate content) were studied following the standard methods described by APHA (1992) [19].

3. Results and Discussion

A total of 17 fish species belonging to 8 orders and 10 families were recorded from the study sites (Table 1). The fishes belonging to order Cypriniformes was found to be dominant with 8 species followed by order Siluriformes with 3 species; order Anabantiformes with 2 species; order Gobiiformes, Mastacembeliformes, Perciformes and Clupeiformes with one species each.
As far as biodiversity status (IUCN-2018) is concerned, out of 17 fish species, 9 fish species were categorized in to least concerned, 3 not evaluated, 2 vulnerable, 1 near threatened and 1 endangered.

Table 1: Types of fish species collected from different wetlands with their IUCN status

Common Name	Scientific Name	Order	Family	Iucn Status
Catla	*Catla catla*	Cypriniformes	Cyprinidae	LC
Rohu	*Labeo rohita*	Cypriniformes	Cyprinidae	LC
Mrigal	*Cirrhinus mrigal*	Cypriniformes	Cyprinidae	VU
Common carp	*Cyprinus carpio*	Cypriniformes	Cyprinidae	VU
Grass carp	*Ctenopharyngodon idella*	Cypriniformes	Cyprinidae	LC
Ticto barb	*Puntius ticto*	Cypriniformes	Cyprinidae	LC
Mola	*Amblypharyngodon mola*	Cypriniformes	Cyprinidae	LC
Brilliant rasbora	*Rasbora einthovenii*	Cypriniformes	Cyprinidae	Not evaluated
Sutchi catfish	*Pangasius sutchi*	Siluriformes	Pangasiidae	EN
Long whisker cat fish	*Mystus gulio*	Siluriformes	Bagridae	LC
Cat fish	*Wallago attu*	Siluriformes	Siluridae	NT
Dwarf snake head	*Ophiocephalus gachua*	Anabantiformes	Channidae	LC
Spotted snakehead	*Ophiocephalus punctatus*	Anabantiformes	Channidae	LC
Barrad spiny eel	*Mastacembelus pancalus*	Mastacembeliformes	Mastacembelidae	Not evaluated
Indian river shad	*Gudusia chapra*	Clupeiformes	Clupidae	Not evaluated
Indian glassy fish	*Parambassis ranga*	Perciformes	Ambassidae	LC
Tank goby	*Glossogobius giurius*	Gobiiformes	Gobiidae	LC

(Abbreviation-*LC- Least concern, * NT- Near threatened, *VU- Vulnerable, *EN- Endangered)

The Shannon-Weiner fish diversity index of different wetlands ranged from 1.98 to 0.68 during monsoon and 1.87 to 0.63 during post monsoon (Fig 2).

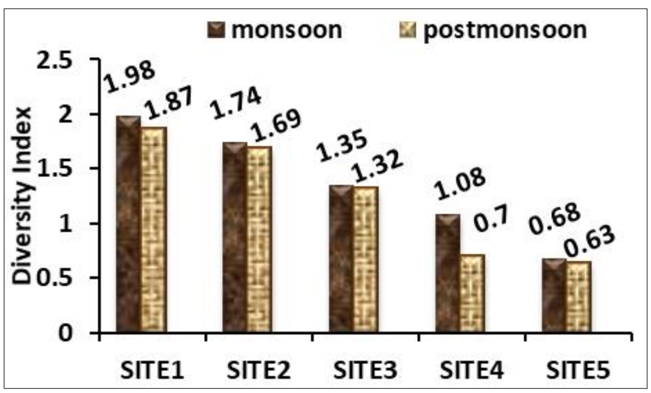

Fig 2: Shannon-Weiner diversity index of fishes in different wetlands

Where, Site 1= Running wetland, Site 2= stable and protected wetland without anthropogenic interference, Site 3= disturbed and unprotected wetland with anthropogenic interference, Site 4= short-term wetland, Site 5= Swampy wetland

Kumar [20] studied the fish diversity in four sites of Mahanadi River. He recorded 56 species belonging to 35 genera, 19 families and 7 orders with Cyprinidae as the most abundant family contributing 37.5% of the total species of all the families found in this region while among the orders, Perciformes topped the list. The calculated diversity indices of the four areas selected along the stretch of Mahanadi River on the basis of the Shannon–Weiner diversity index revealed that they ranged between 1.51 (at Satakosia) and 3.23 (at Hirakud). In the present study Cyprinidae was also found to be the most abundant family contributing to 47.05% of the total species of all the families, followed by Channidae (11.76%). The families Pangasidae, Bagridae, Siluridae, Mastacembelidae, Clupidae, Ambassidae and Gobiidae contributed 5.88% each in different wetlands. The highest fish diversity was recorded in flowing canal water both in monsoon and premonsoon (1.98 and 1.87 respectively). Many studies have revealed seasonal changes in the composition and relative abundance of species in estuarine fish communities and these changes may be influenced by constant fluctuations in environmental factors such as salinity, temperature and dissolved oxygen levels (Griffith) [21]; Moyle and Cech, 2004 [22]; Harrison and Whitefield [23]. A scale of pollution in terms of species diversity (3.0-4.5 slight, 2.0-3.0 light, 1.0-2.0 moderate and 0.0-1.0 heavy pollution) has been described by Staub *et al.* [24].

Out of 6 species obtained from protected wetland which is used only for fishing, one species (*Pangasius sutchi*) was found to be endangered. Basically, this agriculturally based area associated with profuse application of various chemicals, poisons and drugs in agricultural field that largely pollute the protected wet land and ultimately exerting growing pressure on living aquatic resources and driven significant fish biodiversity decline. However, over fishing, chemicals, agricultural runoff and other forms of pollution are most important factors which should be restricted for the conservation of freshwater fish biodiversity. The country demands fish production from inland open water bodies as a promising option for providing high quality protein food, livelihood to the rural populace and doubling the fisher's income as per the ICAR Annual Report 2016-17. However, most of these waters are in a process of degradation due to increasing anthropogenic activities and have lost their pristine characteristics, which in turn affected the ecological services and ultimately natural fish stocks and biodiversity.

3.1 Water Quality Parameters

Water, the most vital resource for all kinds of life on this planet is adversely affected both qualitatively and quantitatively by all kinds of human activities on land, in air or in water. A large number of parameters signify the quality of water. In this study total 3 water samples from different sampling stations: Site 1, Site 2, Site 3, Site 4 and Site 5were analyzed to determine the physicochemical parameters of these five aquatic ecosystems during monsoon and post monsoon. The important physicochemical characteristics for water measured in this study were TDS, pH, conductivity, DO, BOD, COD, Nitrate and Phosphorus.

The values of different parameters of five water bodies are given in the table 2 and 3.

Table 2: Physicochemical parameters (Avg ± SD) of water during monsoon.

	SITE 1	SITE2	SITE3	SITE4	SITE5
TDS (ppm)	146.67± 5.77	162.33± 2.08	201.00± 2.65	258.00± 8.0	302.00± 2.0
pH	7.07± 0.06	6.83± 0.12	6.03± 0.06	5.63± 0.21	5.03±0.15
Conductivity (μ S /cm)	0.11± 0.01	0.11±0.002	0.12± 0.001	0.14±0.002	0.16±0.002
DO (mg L^{-1})	6.23±0.25	4.93±0.404	4.07±0.31	3.36±0.41	3.56±0.11
BOD (mg L^{-1})	5.67± 0.58	10.00± 1.50	14.57± 1.4	16.00±2.0	15.00±3.5
COD (mg L^{-1})	146.67± 8.56	162.33± 5.78	201.00± 9.54	258.00± 8.67	302.00±10.7
Nitrate (mg L^{-1})	15.67± 0.58	13.33± 3.46	103.33± 7.64	161.67± 12.58	117.50±12.0
Phosphorus (mg L^{-1})	0.37± 0.06	0.47± 0.06	0.60± 0.15	2.00± 0.87	2.75±0.43

Table 3: Physicochemical parameters (Avg ± SD) of water during post monsoon

	SITE 1	SITE2	SITE3	SITE4	SITE5
TDS (ppm)	160.33±1.53	195.00±5.57	250.00±20.0	289.67±14.5	346.00±19.31
pH	6.73±0.15	6.40±0.1	5.63±0.31	5.30±0.26	4.43±0.21
Conductivity (μ S/cm)	0.11±0.002	0.12±0.01	0.13±0.002	0.15±0.01	0.16±0.02
DO (mg L^{-1})	5.23±0.25	4.37±0.47	3.63±1.15	3.03±0.15	3.00±0.78
BOD (mg L^{-1})	11.33±0.4	12.27±2.61	15.10±2.06	16.67±2.08	18.33±1.53
COD (mg L^{-1})	20.40±3.21	114.00±3.46	241.33±10.42	310.67±10.07	380.00±20.00
Nitrate (mg L^{-1})	19.33±2.08	15.67±1.53	121.67±9.5	183.33±10.41	183.33±10.41
Phosphorus (mg L^{-1})	0.53±0.06	0.68±0,08	0.75±0.15	3.40±0.38	4.35±0.54

Table 4: Correlation between fish diversity and water parameters during monsoon and post monsoon

Season		TDS	PH	Conductivity	DO	BOD	COD	Nitrate	Phosphate
Monsoon	Diversity	-0.988	0.997	-0.963	0.938	-0.878	-0.963	-0.719	-0.903
Postmonsoon		-0.968	0.948	-0.982	0.955	-0.977	-0.968	-0.773	-0.915

Fish diversity showed positive correlation with dissolved oxygen and pH whereas negative correlation was found between diversity and TDS, conductivity, BOD, COD, PO_4, and NO_3. Fish and other aquatic animals depend on dissolved oxygen (the oxygen present in water) and pH to live. A high content of dissolved solids elevates the density of water; influences osmoregulation of fresh aquatic organisms reduces the solubility of gases and reduces utility of water for drinking purpose and results in to eutrophication of aquatic ecosystem. Electrical conductivity value mainly depends on the ionic concentration or dissolved organic substances. A higher BOD indicates a lower level of dissolved oxygen. This lower concentration of oxygen causes many fish to suffocate, and as they die, the number of oxygen-demanding decomposers increases even more. Nitrates (NO_3^-) are water-soluble (they dissolve easily in water), and are commonly applied to agricultural fields as fertilizer. Once applied, nitrates may leach into groundwater or erode and end up in surface runoff. Eventually, they may enter a lake, river, or stream and contribute to eutrophication. Unlike nitrates, phosphates (PO_4^{3-}) are not water-soluble; they do not usually dissolve in water. However, they do adhere to soil particles, and as such often accumulate in soil and erode along with soil into aquatic environments.

Phosphates also form a major component of most fertilizers, and in conjunction with nitrates, they have made agriculture the largest source of nonpoint water pollution. These explanations justify the negative correlation between fish diversity and TDS, conductivity, BOD, COD, PO_4, and NO_3.

The percentage of fish population showed that order Cypriniformes was most dominant constituting 47% followed by order Siluriformes constituting 17%, order Anabantiformes 11.7%.

The cultivable and weed and ornamental fishes were also recorded. The cultivable fish includes *Catlacatla, Labeorohita, Cirrhinus mrigal, Cyprinus carpio, Ctenopharyn godonidella, Pangasius sutchi*. The weed fish includes *Puntius ticto, Amblypharyn godonmola*, *Rasbora einthovenii, Mystus gulio, Wallago attu, Ophiocephallus gachua, Ophiocephallus punctatus, Mastacembelus pancalus, Gudusia chapra.* Among the weed fish *Mystus gulio, Wallago attu, Ophiocephalus gachua and Ophiocephalus punctatus* are predators. Now a day *Amblypharyn godonmola* belongs to cultivable fish and economically important as its eyes possess a large amount of vitamin E. The fish *Chanda ranga* belongs to ornamental fish.

During study it was found that diversity of fishes was found to be normal in relation to water quality. The maximum number of species was recorded in running wetland followed by pond without anthropogenic interference, pond with anthropogenic interference, paddy field wetland and then swampy wetland respectively.

The species diversity was high in monsoon due to sufficient fresh water and flow of water causes high dissolve oxygen. Ample food sources were high during monsoon. The seasonal and temporal variation of fish species is influenced by hydrological changes, geomorphological process and interaction among the marine organism (Letourneur *et al.*) [25]. Moyle and Leidy [22] divided the proximate causes of fish species' decline into five broad categories: (1) competition for water, (2) habitat alteration, (3) pollution, (4) introduction of exotic species, and (5) commercial exploitation. The running wetland and pond without anthropogenic interference are suitable for fisheries as the level of pH and DO are in desirable limits (according to CPCB the value of DO should be 4 mg/l and pH lies between 6 and 8. Attempts to manage fisheries in developing countries have been much weaker and most often have had little effect (Cowx and Welcomme [26]. A scale of pollution in terms of species diversity (3.0-4.5 slight, 2.0-3.0 light, 1.0-2.0 moderate and 0.0-1.0 heavy pollution) has been described by Staub *et al*. [26]. As per this scale site-1, 2, and 3 is moderately polluted; site-4 and 5 are heavily polluted. To justify this statement a dendrogram was run by hierarchical-agglomerative method in SPSS 22 considering the water quality parameters during monsoon (Fig 3) and post monsoon (Fig 4).

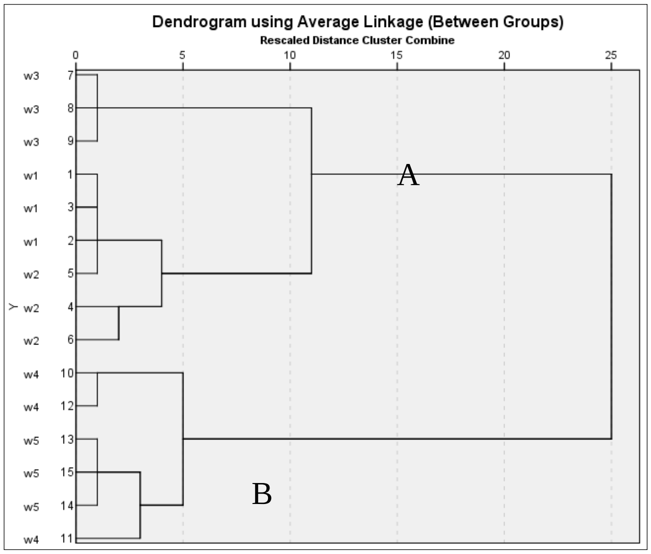

Fig 3: Cluster analysis of the water qualities in the wetlands during monsoon season

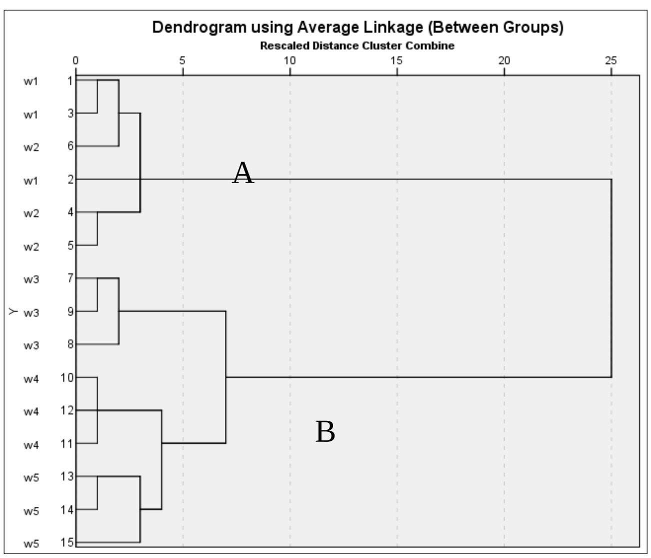

Fig 4: Cluster analysis of the water qualities in the wetlands during post- monsoon season

During monsoon and pre monsoon the eight water quality parameters formed two main clusters A, and B. During monsoon cluster A had two sub–clusters separating 1st wetland from the 2nd and 3rd whereas cluster B includes 4th and 5th wetland. However, in post monsoon cluster B had two sub–cluster separating wetland3 from 4th and 5th wetland. Cluster A includes 1st and 2nd wetlands. The test justifies that the diversity in running water (W1) and that of protected pond (W2) was higher in comparison to that of wetland with anthropogenic activities (W3), temporary wetland (W4) and swampy wetland (W5) as affected by water qualities. This result was in agreement with the opinion of Staub *et al*. [26].

4. Conclusion

The wetlands offer immense scope for biodiversity studies and for gaining new opportunities for sustainable development. The more important physical and chemical qualities of water influencing aquatic productivity are temperature, transparency, pH, dissolved oxygen, free carbon dioxide, and total alkalinity and dissolved nutrients like nitrogen, phosphorus, potassium, calcium, magnesium. Seasonal variability in diversity, richness, and abundance was as a result of varied habitat conditions mediated by environmental disturbances such as farming activities and bush fires. Thus, management must be of priority concern, especially to rural communities whose livelihood largely depends on the availability of fish resource. The implementation of conservation measures could contribute to the increase and sustenance of fish population, which serve as a major source of livelihoods for the rural dwellers. The findings of present communication may serve as baseline information for planning, conservation and management of fish and fisheries resources of inland water resources in Odisha.

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