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Ecology and Partial Restoration of Daha River for Fish Productivity

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Author's contribution

This The sole author designed, analysed, interpreted and prepared the manuscript.

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ABSTRACT

Daha river, a threatened water body of polluted nature in the Gopalganj district of Bihar was studied for its degradation and possible restoration. The study reveals high rate of sedimentation and agricultural activities, changes in water quality and biotic community. Agricultural activities have led to high input of nitrogen (N) and phosphate (P) fertilizers along with pesticides being used by the farmers. The positives response of restoration practices was observed with partial improvement in fish-productivity due to hindrance factors acting upon severe fish species.The mean concentration of phosphate, nitrate and ammonia corresponds about 0.60-1.40 mg/l, 1.30-2.50 mg/l and 23-43 mg/l in polluted river, while after restoration declines to 0.20-0.48 mg/l, 0.60-1.10 mg/l and 14-27 mg/l, respectively indicating more suitable towards fish productivity. The observations on other water parameters also showed similar trend during partial restoration of Daha river. The cause of algal bloom and other macrophytic population is inorganic ammonia, however, organic pollution is also in polluted state observed as more quantity of ammonia than nitrate especially at site II and Site III during the study period. The concentration of nitrate is much higher than the critical value in polluted river which causes algal diversity and macrophytic vegetation. Therefore, partial restoration of the river helped to enhance fish productivity concluded from this study.

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1. INTRODUCTION

Small rivers in Gangetic region serve as water resource for local area. In the last few decades' rapid population growth resulted in pollution of water bodies by domestic, industrial sewage and agricultural effluents containing fertilizers and pesticides [1]. The anthropogenic disturbances can modify physical and chemical quality of water resources. These changes through external loading have direct impact on the biotic component of the water body. Also, the internal loading of pollutants from sediments is expected to further increase eutrophication and delivered continuous pressure on rivers [2]. The study of ecological parameters in such resources may provide clue for appreciating the key relations which are relevant for restoration strategies.

The Daha river is tributary of Gandak originated near Sriram Mathia village in Kushinagar district of UP with disturbed flow in Gopalganj, Siwan and Chapra district of Bihar and lastly emerges in Saryug river. The anthropogenic activities in last two decades polluted this river so exclusively that several places hold water only in flood time during winter.

Restoration requires reconstruction of antecedent physical conditions, chemical adjustment of soil and water; and biological manipulation [3]. A survey of is essential for restoration of any open system like rivers. This means that a functional ecosystem can be constituted from an arbitrary set of species from the species pool that could occupya given site. Restoration practice typically begins with a different goal, which is to accomplish specific objectives. The restoration project needs re-establish a species in a place, reduce rates of within its natural range, re-establish a natural environment, eliminate an invading species, or create vegetation that will provide nesting habitat for a species of interest. Integrated water restoration aims to enhance the coordinated development and management of water, land and related resources in order to maximize economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems. The nutrient cycling especially phosphorus and algal biomass are expected to be valuable resources to promote aquatic ecology [4].

Phosphorus and nitrogen have been recognized as crucial nutrients for harmful algal growth in polluted waters [5]. The phosphorus removal may decrease in pollutant runoff and ultimately minimize algal blooms in polluted rivers, while macro-invertebrate community in river basin may identify primary pollutants that need to be controlled from the perspective of water ecological health protection. The results could be used to control river pollutants, improve river health management and guide ecological restoration. The external loading from point to non-target sources might be minimized with widening of riparian buffers through wetland or grassland zone which are also effective for phosphorus and nitrogen removal as key point of restoration. Dredging is also an option towards ecological balance in small rivers by removing polluted sediments to reduce the internal loading of nutrients. Zhang et al. [2] opined that dredging could be a useful approach for sediment remediation and ecological restoration.

There is also need about post-restoration monitoring in small polluted rivers as Wu et al. [6] introduced artificial aquatic plants into enclosures which reduces algal blooms and growth of submerged macrophytes that are utilized to ecological balance in small rivers. The macrophytes stimulate the growth of phytoplankton and help in the recycling of the organic matter. The submerged species of macrophyte at the margin also act as green manure favorable the abundance of zooplankton and benthic fauna, supported by Bhute and Harne [7] from Nagral lake. Macrophytes serve as a substratum, manure and also provide food and shelter for many aquatic organisms.

The main objective of this research was to determine the ecological status of Daha river prior and after restoration in terms of fish productivity.

2. MATERIALS AND METHODS

The study sites selected as site I near river origin, site II near Mirganj and site III at Chapra town. For analysis of physic-chemical characteristics of water, samples were collected repeatedly one year from March 2018 to Feb 2020.The study estimated in first year under pollution and in second year under restoration period. To cover the variation at sites of the river, water samples were taken from three sites in aid washed bottles of two liter capacity. The temperature, pH, electrical conductivity and

Fig. 1. Daha river in pollution and after restoration during study period

dissolved oxygenwere analyzed immediately after sampling. Various physic-chemical parameters viz. DO, Total hardness, alkalinity, COD, TDS, nitrate and phosphate were determined as per the standard methods described in APHA [8].

This research was conducted to restore functional ecology through water storage with excavation, debris jam removal and rockslide removal. Restoration of spawning site of fishes accomplished with gravel placement and creation of side-channel. The vegetative methods for bank stabilization were applied. The fish assemblage was also determined on the basis of ecological (Schiemer and Weidbacher, 1992) and balance of fish assemblage according to Balon (1975). The biomass of algae, zooplankton and insects were determined followed standard methods [8]. The macrophyte evaluated as abundance and species richness at sites of the river.

The data was collected by employing two methods using observation checklist and investigation of laboratory results. In laboratory analysis each of the tests were done in replicates and the results were checked twice to avoid transcription errors.

3. RESULTS AND OBSERVATIONS

During the field visit, it was observed that the water subsided and dried In general, data on water quality is indicative of pollution prior to restoration with extreme temperature variation is due to differential amount of light incidence over the water surface, in different seasons prior and after restoration (Table 1).

The mean value of total alkalinity gradually decreased from March to July and increased in August. The values are comparatively high in cold months may be possible due to dissolution of calcium carbonates at lower temperature [9] Table 1. Hardness of river water decreased from August to November due to the abundance of floodwater, while higher values in dry months due to the discharge of water through outlets and evaporation (Table 1).TDS value was maximum at station III in June and minimum at station I in July due to large inflow of rainwater (Table 1). Variation in salinity was notable with maximum and minimum value in May and August related with amount of organic deposition at different sites (Table 1). The pattern of variation in dissolved oxygen followed closely with changes in temperature and biomasss of planktons (Table 1; Fig. 5). Total nitrogen and phosphorus values showed higher concentration prior to restoration, while adjusted after restoration (Tables 1 and 2). Less COD value were observed after restoration, perhaps due to low amount of organic compounds in this river (Table 1). Also same trend were visible in the case of total chloride in this river. There is considerable change in all physical parameters after restoration might be adaptive for growth and survival of fishes (Table 2).

The ammonia and nitrate level of the river is also at a level to cause algal bloom at site II and III, while not crucial at site I. Any concentration of inorganic nitrogen greater than 0.3 mg/l can cause algae to grow in abundance [10]. Thus, the river has more than optimum level for growth of algae and other aquatic weeds.

Table 1. Physicochemical characteristics of Daha river prior to restoration at selected sites

Sl. No.	Parameters	Site- I		Site- II		Site – III	
		Min	Max	Min	Max	Min	Max
1.	Water Temp. (°C)	12.6	28.3	11.7	27.6	13.6	29.6
2.	pH	7.4	8.2	7.6	8.4	8.2	8.9
3.	TDS (mg/L)	1230.60	1410.0	1310.0	1520.0	1460.0	1580.0
4.	Hardness (mg/L)	620.30	770.10	660.20	810.10	710.30	840.10
5.	Chloride (mg/L)	470.40	560.10	520.30	610.0	620.10	680.60
6.	Alkalinity (mg/L)	380.10	732.60	410.30	840.20	530.0	910.60
7.	DO (mg/L)	3.10	4.20	3.70	4.80	4.30	6.10
8.	COD (mg/L)	110	170	140	210	170	240
9.	Total Nitrate (mg/L)	1.30	1.70	1.60	2.30	1.80	2.50
10.	Total Phosphate (mg/L)	0.60	0.90	0.70	0.90	1.10	1.40
11.	Ammonia (mg/L)	23	26	37	41	41	43

Table 2. Physicochemical characteristics of Daha river after restoration

Sl. No.	Parameters	Site- I		Site- II		Site – III	
		Min	Max	Min	Max	Min	Max
1.	Water Temp (°C)	13.1	29.4	12.9	28.8	13.3	29.6
2.	pH	6.1	6.3	6.4	6.7	6.5	6.8
3.	TDS (mg/L)	478.10	530.20	524.20	560.10	540.10	570.60
4.	Total hardness (mg/L)	180.20	210.10	200.0	230.0	220.0	240.0
5.	Chloride (mg/L)	470.40	560.10	520.30	610.0	620.10	680.60
6.	Alkalinity (mg/L)	90.60	130.0	110.0	160.10	120.10	168.20
7.	DO (mg/L)	6.10	6.70	5.80	6.40	5.60	6.20
8.	COD (mg/L)	25.20	32.10	26.10	32.60	28.0	34.10
9.	Total Nitrate (mg/L)	0.60	0.90	0.70	1.0	0.80	1.10
10.	Total Phosphate (mg/L)	0.20	0.35	0.25	0.40	0.32	0.48
11.	Ammonia (mg/L)	14	17	21	23	25	27

The assessment of migration barriers was best performed after restoration program in studied river. Barriers to fish migration have evaluated at various flow conditions, and observed that barrier only prevent fish movement during low flow regime of water. The majority of migration barrier was associated with vertical drops in life-stage of target species. In addition, the ability to jump a vertical drop is also related to water depth from which a fish could leap. A pool depth of at least 1.25 times the length of the barrier provides ideal leaping of largest fishes.

The construction of spawning site was primarily a reflection of prevailing hydrological conditions with review of conditions during typical spawning season and peak flow of water to assess habitat stability. Introduced vegetation was cost effective and self-sustainable appliance for improvement of bank stability. However, selected species at studied sites with specific requirements showed hindrance. The plantation was suitable with soil moisture, available sunlight for competing species and potential for food traffic.

The colonization of the adult fish in restored water occurred with restoration in 2019. The fishes were always present in side-channel occasionally connected to the river. Species occurrence varied only as predatory fishes were dominated during summer and followed months. The herbivore species was also occurred during rainy season. The relative abundance increased mainly due to high occurrence of 1^+ and 2^+ fish in assemblage after restoration at different studied sites than polluted state of Daha river (Fig. 2).

In January 2018, the abundance and biomass were 3-4 times higher than river prior to restoration suggested possible adaptive changes of environmental condition after restoration in Daha river and there is great difference in species abundance (Fig. 3). The contribution of herbivore fishes were linked only in flood time. The fish abundance showed seasonal variation in fishes in both cases of pollution and restoration (Fig. 4).

The phytoplankton biomass showed high density at river sites prior to restoration, but optimum zooplanktons were present in all sites caused algal bloom in polluted river (Fig. 5). The biomass value after restoration indicating enriched food medium for fish productivity, however, site I was more suitable than other two sites (Fig. 6) for fishery even to carp culture in limited extent. The macrophyte density is normal in site I, moderate in site II and high in site II prior to restoration, whereas limited density observed after restoration period.

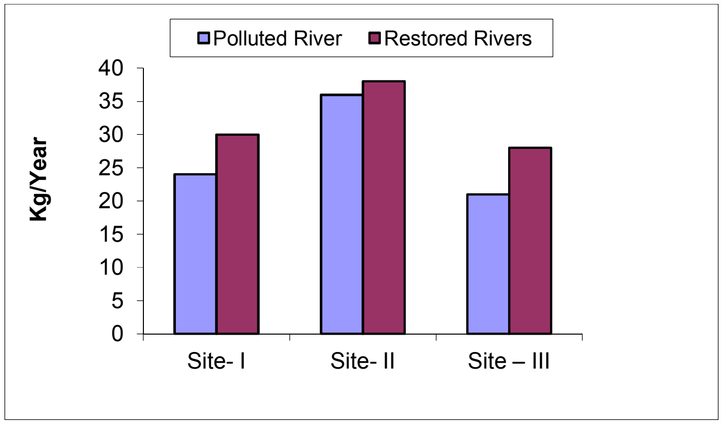

Fig. 2. Fish assemblage on different sites under pollution and restoration period

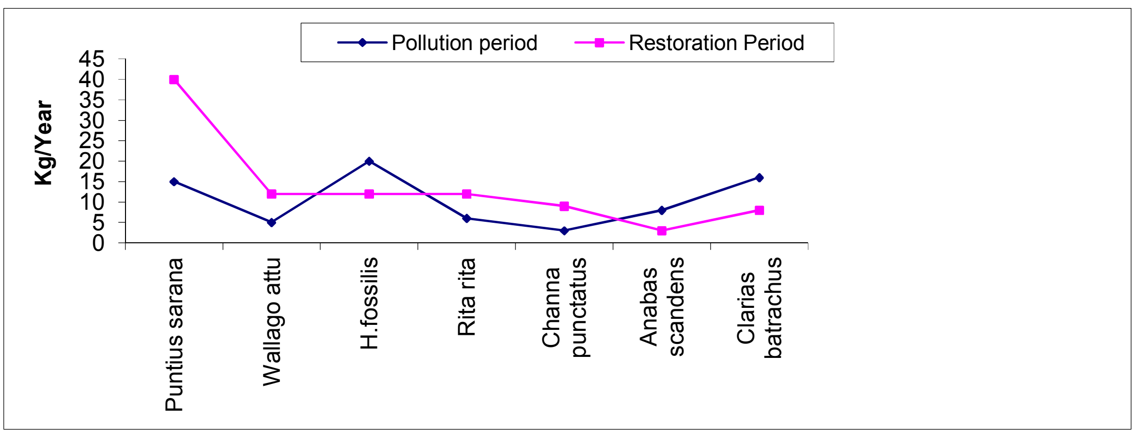

Fig. 3. Species abundance under pollution and restoration period

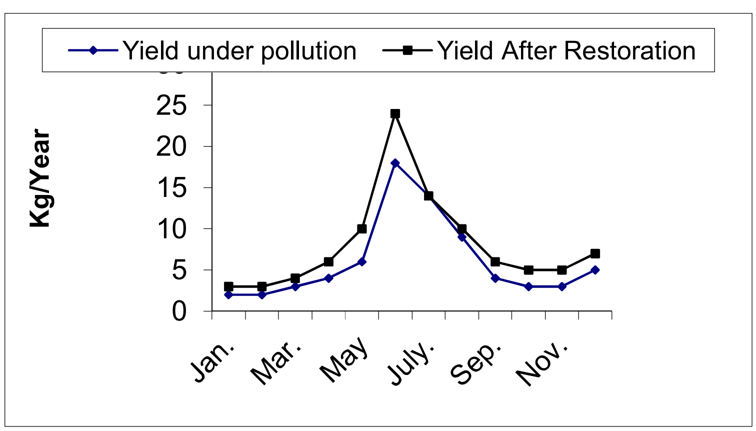

Fig. 4. Seasonal fish catchment under pollution and after restoration period

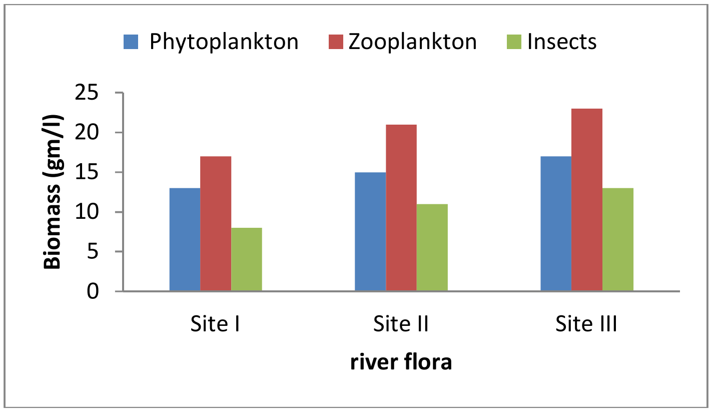

Fig. 5. Estimated biomass under pollution period

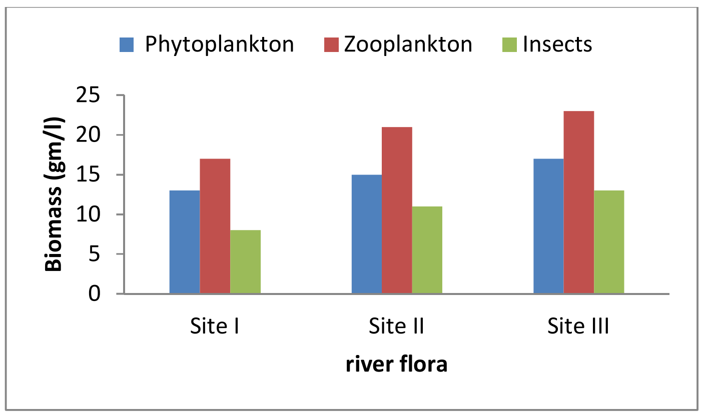

Fig. 6. Estimated biomass after restoration period

However, predatory fish remains dominated in river. Applied vegetative method improved the aesthetic qualities of the riparian zone. The plantation of graminaceous grass and road creeper reduced surface erosion and structural integrity of river bank has enhanced with root spreading in soil. The road creeper was also observed as fish access and spawning site of fishes. The herbaceous ground grasses provide control of erosion during flood time.

4. DISCUSSION

This study is in agreement with Nazneen [11] reported the influence of hydrological factors on the seasonal abundance of dissolved oxygen play an immense role in temporal changes of fish assemblage with seasonal variation. A rise in temperature leads to the fast biochemical reactions and affects upon growth and survival of fishes showed consistency with Harshley et al. [12] who reported close relation between water temperature and fish productivity. The variation in pH was due to presence of free carbon dioxide and carbonate related, and, decreased pH after restoration with low abundance of phytoplanktons. This type of observation has also reported by Das and Srivastava [13]. Also gradual decrease of alkalinity from March to July and after restoration is attributed to low rate of nutrient cycling in Daha river. High concentration of total hardness during summer in polluted state of river and gradual decrease in hardness after restoration is probably related with organic deposition in water as also reported by Singhal et al. [14]. The variation in salinity and TDS as pH was observed and consistent with study of Kumar et al. [15]. Kulshreshtha et al. [16] also reported high COD in polluted river as findings of this study. Natural water generally contains low chloride level as resulted after restoration practice.Amount of chloride prior to restoration as a consequence of macrophyte decomposition is also reported by Sarwar [17]. The present study support findings of Elser et al. [18] as high level of nitrogen resulted with growth of planktons and agricultural effluents. The phosphate amount showed similar trend as nitrogen through fertilizer effluents in river. The concentration of nitrate is too much lower than the ammonia concentration that may be attributed to the decay of dead algae and other aquatic weeds as well as continuing discharge of organic waste to the river both of which can produce ammonia before restoration.

The study about biomass of planktons and insects revealed that imbalance existed in polluted river showed inclination towards optimum value for fish productivity during the study period. Prasad and Das [19] demonstrated that internal sediment loading and environmental factors like as topography, season and rainfall are expected to create several ecological niches, also leads to high diversity of aquatic plants in a polluted river. The findings of this study indicating that the shallow water when enriched with high bottom sediments provide an ideal habitat for luxuriant growth of macrophytes and planktons.

This research hold relation between water quality and fish productivity was consistent with study of Downing et al. [20]. The fish yield was variable for existing species and showed Gaussian curve for productivity. There is effect of unconventional diets on growth and survival of fishes as reported in the case of *Clarias batrachus* as reported by Tiwary et al. [21]. The accumulation of bedload are beneficial in terms of their role in the creation of spawning rearing and over-wintering habitat. Removal of soil from lower surface of river during restoration increases both the water volume and flow rate. The entrapment of spawning gravel was necessary during restoration after clearance of riparian vegetation. The study showed that the restoration supported fish assemblage increment as reported in similar case by Penaz and Jurajda [22]. The fish habitat has been achieved with improvement in water quality. A lower ratio of predatory fishes after project was partly caused by increased occurrence of herbivore than previous years. During the study, initial land limiting fish migration was observed. This study confirms that restoration provide new chances and enriched habitat scale of the river system for local populations as reported by Schiemer and Weidbacher [23] with similar case.

5. CONCLUSION

There is direct relationship between fish yield and water quality. However, restoration of Daha river with limited approach and economy resulted in partial backwater and there are several hindrance factors encountered due to specific need of all fish species. Thus, further researches may be needful during restoration for particular fish species for local population.

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COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Bashir I, Lone FA, Bhat RA, Mir SA, Dar ZA, Dar SA. Concerns and threats of contamination on aquatic ecosystems. In Bioremediation and Biotechnology. Cham. Springer. 2020;1-26.
2. Zhang H, Shang Y, Lyu T, Chen J, Pan G. Switching harmful algal blooms to submerged macrophytes inshallow waters using geo-engineering methods: Evidence from a 15N tracing study. Environ. Sci. Technol. 2018;52:11778–11785.
3. Zedlar JB. Restoring wetland plant diversity: A comparison of existing and ablaptine approaches, wetlands ecology and management. 2005;13(1):5-14.
4. Pan G, Lyu T, Mortimer R. Comments: Closing phosphorus cycle from natural waters: Re-capturing phosphorus through an integrated water-energy-food strategy. J. Environ. Sci. 2018;65:375–376.
5. Lewis W, Wurtsbaugh W, Paerl H. Rationale for control of anthropogenic nitrogen and phosphorus to reduce eutrophication of inland waters. Environ. Sci. Technol. 2011;45:10300–10305.
6. Wu Y, Huang L, Wang Y, Li L, Li G, Xiao B, Song L. Reducing the phytoplankton biomass to promote the growth of submerged macrophytes by introducing artificial aquatic plants in shallow eutrophic waters. Water. 2019;11:1370.
7. Bhute KB, Harney NV. Macrophytes biodiversity of Nagrala lake of Bhadrawati, district- Chandrapur (M.S.), India. Int. Res. J. of Science & Engineering. 2017;6(1):17-19.

8. APHA. Standard methods for the examination of water and waste watershed. Washington, USA; 1998.
9. Cairns A, Yan N. A review to the influence of low ambient calcium concentrations on Freshwater daphniids, gammarids and crayfish. Environ Rev. 2009;17:67-79.
10. Blackwell Science. Freshwater biology, New Zeland. 2001;46:153-156.
11. Nazneen S. Influence of hydrological factors on the seasonal abundance of phytoplankton in Keinjer lake. Ine. Rev. hydrobiol. 1980;65(20):269-282.
12. Harshley DK, Patil SG, Singh DF. Limnological studies on a tropical freshwater fish tank of Jabalpur, India. Geobios. 1982;1(2):98-102.
13. Das SM, Shrivastava VK. Quantitative studies on plankton. Part 2, Correlation between Plankton and Hydrological factors. Proc. Nat. Acad. Sci. India. 1956; 26(4):243-253.
14. Singhel RN, Swarn J, Davis RW. The physico-chemical environment and the plankton characteristics of unregulated rural ponds in Haryana, India. Trop Ecol. 1986;26:43-53.
15. Kumar A, Bohra C, Singh AK. Ecotechnology for limnological project of kawar lake with special reference to biogeochemical cycle, In: Ecology and Ethology of Aquatic biota, Daya Publishing House, Delhi (India). 2002;1:149-199.
16. Kulshreshtha SK, George MP, Saxena R, Johri M, Shrivastava M. Seasonal variations in the limno-chemical characteristics of Mansarovar reservoir of Bhopal, Aquatic Ecology. 1992;7:275-295.
17. Sarwar SG. Species composition and seasonal variation of periphyton on Ceratophyllum demersum in waskur lake, Kashmir, Geobios. 1987;6:114-118.
18. Elser JJ, Marzolf ER, Goldman CR. Phosphorus and nitrogen limitation in the freshwaters of North America: A review and critic of experimental enrichments. Can. J. Fish aquat Sci. 1990;47:1468-1477.
19. Prasad Nami, Das Tapati. Diversity and distribution of aquatic macrophytes with special reference to invasive species in Barak Valley, Assam, Northeast India. NeBIO An International Journal of Environment and Biodiversity. 2018;9(1): 102-108
20. Downing JA, Plante C, Lalonde S. Fish production correlated with primary productivity, not the morpho-edaphic index. Can J. Fish Aquat. Sci. 1990;47:1929-1936.
21. Tiwary CB, Thakur KK, Tiwari SK. Effect of Unconventional diets on Growth and Survival of *Clarias batrachus* (Lin.). Journal of Inland Fisheries Society India. 2013; 45(1):53-56.
22. Penaz M, Jurajda P. Fish assemblage of the Morava river: Longitudinal Zonation and Protection. Folia Zool. 1993;42:317-328.
23. Scheimer F, Waidbacher H. Strategies for conservation of Danubian fish fauna, In:Boon PJ, Calow P and Petts GJ (Eds.): River Conservation and Management. John Wiley Sons Ltd. Chichester. 1992; 363-382.

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