Limnological and Biological Exploitation of the Punpun River at Nabinagar, Aurangabad, Bihar, India in Relation to Fish and Fisheries

A

Thesis

Submitted towards the Requirement for the Award of Degree of

Doctor of Philosophy
in
ZOOLOGY

Under the Faculty of Science
By

Neha Raj
Enrollment No. 161596404559

Under the Supervision of

Dr. Ashish Vishwakarma
Head of the Department (Zoology)
P.K. University, Shivpuri (M.P.)

Year-2024

P.K. University
NH-27, Village. Thanra (P.O. - DINARA),
Shivpuri (M.P.)–473665

www.pkuniversity.edu.in

Limnological and Biological Exploitation of the Punpun River at Nabinagar, Aurangabad, Bihar, India in Relation to Fish and Fisheries

A

Thesis

Submitted towards the Requirement for the Award of Degree of

Doctor of Philosophy

in

ZOOLOGY

Under the Faculty of Science
By

Neha Raj
Enrollment No. 161596404559

Under the Supervision of

Dr. Ashish Vishwakarma
Head of the Department (Zoology)
P.K. University, Shivpuri (M.P.)

Year-2024

P.K. University
NH-27, Village. Thanra (P.O. - DINARA),
Shivpuri (M.P.)–473665

www.pkuniversity.edu.in

P.K. UNIVERSITY

(University established under section 2f of UGC act 1956 vide mp government act no 17 of 2015)
Village- Thanra Tehsil, Karera NH 27 District Shivpuri M.P.}

DECLARATION BY THE CANDIDATE (PARA 26-B)

I declare that the thesis entitled **"Limnological and Biological Exploitation of the Punpun River at Nabinagar, Aurangabad, Bihar, India in Relation to Fish and Fisheries"** is my own work conducted under the supervision of **Dr. Ashish Vishwakarma** (Supervisor) at P.K. University, Shivpuri (M.P.) approved by Research Degree Committee. I have put more than 240 days of attendance with Supervisor at the center. I further declare that to the best of my knowledge the thesis does not contain any part of any work which has been submitted for the award of any degree either in this University or in any other University without proper citation.

Besides this –

1. I have successfully completed the Course Work of one semester as per UGC Regulation 2009 norms.
2. I have also given a pre – Ph.D. presentation and successfully incorporated the changes suggested on the basis of feedback and comments received.
3. I have also published two research papers in an ISSN/ referred journal from the research work of the thesis and have produced an evidence of the same in the form of acceptance letter/ or the reprint.

Neha Raj
Research Scholar (Zoology)
Enroll No. 161596404559

Dedicated To,

Husband

&

All Family Members

P.K. UNIVERSITY

(University established under section 2f of UGC act 1956 vide mp government act no 17 of 2015)

Village- Thanra Tehsil, Karera NH 27 District Shivpuri M.P.}

CERTIFICATE OF THE SUPERVISOR (PARA 26-C)

This is to certify that the work entitled **"Limnological and Biological Exploitation of the Punpun River at Nabinagar, Aurangabad, Bihar, India in Relation to Fish and Fisheries"** is a piece of research work done by **Neha Raj** under my Guidance and Supervision for the degree of Doctor of Philosophy of Zoology in the P.K University (M.P) India, and that the candidate has put an attendance of more than 240 day with me.

To the best of my knowledge and belief the thesis:

I – Embodies the work of the candidate himself/

II – Has duly been completed.

III – Fulfill the requirement of the ordinance relating to the Ph.D. degree of the University.

IV – Is up to the standard both in respect of contents language for being referred to the examiner.

Signature of the Supervisor

Dr. Ashish Vishwakarma
Head of the Department (Zoology)
P.K. University, Shivpuri (M.P.)

Acknowledgement

Laudation to the GOD of majesty and glory! Obedience to him is a cause of approach and gratitude in increase of benefits. Every inhalation of the breath prolongs life and every expiration of it gladdens our nature; wherefore every breath confers two benefits and for every benefit gratitude is due. After several months of hard working, finally my PhD journey got over & this would not have been possible without the tremendous assistance, cooperation & support of others. I would like to use this opportunity to extend my gratitude to all those who contributed in the completion of this dissertation.

It is my pleasure to express my thanks to **P.K. University Hon'ble Chancellor Shri Jagdeesh Prasad Sharma, Hon'ble Vice Chancellor Prof. (Dr.) Shri Yogesh Chandra Dubey, Dr. Jitendra Kumar Mishra (Director Admin)** for their cooperation and also for giving me the opportunity to do the research work at their prestigious University.

I would like to acknowledge deepest sense of gratefulness to guide, **Dr. Ashish Vishwakarma**, for his invaluable guidance, continuous inspiration and timely suggestions which enabled me to complete this thesis as desired. I'm grateful for his contribution and guidance coupled with his unique sense of humor and great personality which were a blessing throughout this journey. I would like to thank the faculty of commerce & business studies who lectured me in the first year of my PhD program & provided me fruitful resources to build this thesis on. I also wish to thank the university staffs for assisting me in many different ways to complete this research.

I would like to thank, **Dr. Deepesh Namdev,** Registrar, **Prof. (Dr.) Jitendra Kumar Malik** Dean of Faculties, **& Dr. Nalla Bhaskar,** Dean of Research, **Dr. Aiman Fatima,** Dean Academics, **Ms. Nisha Yadav,** Librarian and **Mr. Kamlesh Yadav, Mr. Alok Khare,** IT. Cell.

I specially thank to **Dr. Safal Kumar Mishra, Ex. Prof. & HOD, B.R.A. Bihar University, Muzaffarpur (Bihar) & Dr. Ratnesh Mishra, Ex. Registrar of B.R.A. Bihar University, Muzaffarpur (Bihar),** for extending me their moral support to carry research work. I also express my gratitude.

I am profoundly grateful to my loving father **Mr. Rajkishore Singh** and caring mother **Mrs. Shashikala Singh,** my brother & relative who always gave me the confidence to be brave and not to fear the unknown, who gave me wings to explore the world and never held me back to achieving my dreams rather they paved the way for my every success with their trust, support and immense beliefs. I'm thankful for their constructive comments, valuable suggestions and emotional supports without which I could not have accomplished my work. You are my all and I would have never succeeded without your love.

I sincerely thank my friend**,** **Mr. Bipin Kumar Jha** who has always been there with me in every situation.

Last but not the least, I am extremely thankful to my beloved my husband **Dr. Pawan Kumar** and my daughter **Pranavi Singh** for their moral support, patience and encouragement throughout the research work. Above all, I thank to Almighty God for granting me health, strength & the wisdom to commence this research work and enabling me to its completion.

Neha Raj
Research Scholar (Zoology)
Enrol No. 161596404559

"List of Tables"

S.No.	Table	Page No.
1.	**Table-01 :** Salient features of the Punpun river	**14**
2.	**Table-02 :** Salient features of the Nabinagar, Bihar	**14**
3.	**Table-03 :** Climatic data of Nabinagar (Bihar) (January, 2018-December, 2018)	**20**
4.	**Table-04 :** Physico-chemical parameters of water samples of the river Punpun at Nabinagar (January, 2018 to December, 2018) and their permissible limits. All values are in mg/l except temperature and pH.	**21**
5.	**Table-05 :** Showing effect of pH on fish	**22**
6.	**Table-06 :** List of fishes	**29-30**
7.	**Table-07 :** Fishermen Questionnaire	**77-81**

"Tables of Contents"

Chapter	Topic	Page No
Chapter 1	Introduction	**01-07**
Chapter 2	Review of Literature	**08-10**
Chapter 3	Study Area, Materials and Methods	**11-19**
Chapter 4	Observation and Discussion	**20-50**
Chapter 5	Fishing Gears and Crafts	**51-59**
Chapter 6	Exotic Fish Species	**60-72**
Chapter 7	Socio Economic Conditions	**73-81**
Chapter 8	Anthropogenic Impacts on River Ecology and Fisheries, Required Management	**82-90**
Chapter 9	Summary	**91-92**
	References	**93-106**
	Appendix	

ABSTRACT

The present investigation deals with the limnological and biological exploitation of the Punpun river at Nabinagar, Aurangabad, Bihar in relation to fish and fisheries.

The riverine ecosystem of the country in general and state of Bihar in particular have been witnessing serious threats due to anthropogenic interferences which is not only degrading the ecosystems but also declining the fish production of the country.

The Punpun river of Nabinagar (Bihar) in an important right bank tributary of the Ganga river in lower reaches. It originates from Chottanagpur hills of the Palamu district at an elevation of 300m. in Bihar and lies between East longitude of $84^0$10′ to $85^0$20′ and North longitude of $24^0$11′ to $25^0$25′. The river mostly flows in North East direction and finally joins the Ganga River flowing through Chatra, Aurangabad, Gaya and Patna district of the Indian states of Jharkhand and Bihar. It is a 200 km long river bearing a number of tributaries namely, the Butane, the Modar and the Morhar draining the Chottanagpur plateau. The shape of the Punpun river is roughly trapezoidal having a catchment area of about 8530 sq. Km. which is about 1% of the total area of Ganga basin in the country. The Aurangabad district of Bihar is situated on the eastern bank of the river Punpun which flows diagonally from south western corner to north east corner of this district. Water of small rivers of this district falls in Punpun. Rivers are full of valuable raw materials. The agricultural area under the Punpun river basin is about 3000 sq. km. The geology of the area varies from granity gneiss, charnokites in the hills to the recent alluvium in the plains. The Punpun river is leading towards eutrophication due to pollution and anthropogenic activities and the water of the river is not suitable for drinking purposes as well as fish production is declining too. Most of the rivers of Bihar have been explored for fish and fisheries but no attempt has so far been made to study the river Punpun from limnological and biological point of view in relation to fish and fisheries, hence the present research investigation was done.

The objective of this project is also to evaluate the states of this riverine ecosystem and to suggest the issues strategies for proper scientific, rational and sustainable management of this ecosystem.

The structure of studies of this research work was: -

(i) To study the history, origin, hydrology and geomorphology of the river Punpun at Nabinagar.

(ii) Three sampling sites were selected for work i.e. 3 km. Upstream of Nabinagar (site I), Nabinagar town (site II) and 3 km. Downstream of Nabinagar (site III).

(iii) Water samples were collected monthly for a year for their physico-chemical analysis.

(iv) Fishes were collected and preserved.

(v) Different types of fishing gears and crafts and fishing techniques were studied.

(vi) Exotic fish species recorded in the river were studied.

(vii) Socio-economic condition of the fishing community of the Aurangabad district of Bihar were studied with the help of a fishermen questionnaire.

(viii) Anthropogenic impacts on River ecology and fisheries were studied.

(ix) Riverine conservation and management principles were studied.

(x) Finally, recommendations were given for conservation and betterment of fisheries of the river Punpun.

Standard methods prescribed by APHA-AWWA-WEF, 2005, Gopal, 1995; Singh 2008; WHO, 1993 and Welch, 2009, 2010 were followed for physic-chemical analysis of water samples of the river Punpun. Fish specimens were collected with the help of different kinds of fish catching appliances and devices. The specimens were fixed in 8% formalin solution with proper labeling. Identification nomenclature and classification of fishes are based on standard references and recent revisions. The various inland fishing gear and fishing techniques employed in the river was reviewed from available literatures and published data from state fisheries Department.

The study on socio-economic condition of fishermen community of Aurangabad district is based on a household survey with the help of a prepared questionnaire of various aspects of their socio-economic conditions.

Limnological and biological exploitation of the Punpun river at Nabinagar, Aurangabad, Bihar India in relation to fish and fisheries reveals the following facts:-

(i) During course of investigation the minimum and maximum atmospheric temperature ranged between 10.7-28^{0}c and 24-41.9^{0}c respectively. Aurangabad district showed an annual increase of temperature by .0045^{0}c.

(ii) Humidity ranged between 25-84%. There was an insignificant decreasing trend during the period of investigation.

(iii) Rainfall ranged between 3-311 mm. Aurangabad district showed an increasing trend in July whereas all other districts of Bihar, showed decreasing trend (not significant).

(iv) Hydrogen ion concentration ranged between 7.2-8.2. The river water was never found acidic. The pH of the river water was within tolerance limit and suitable for the growth of fishes.

(v) The river water samples showed 700-950 mg/l dissolved solids, which was maximum during rainy season. The dissolved solids caused turbidity and prevents penetration of light through water and affects the photosynthesis of phytoplankton's.

(vi) Total suspended solids varied from 360-380% mg/l which was maximum during winter season. It showed a narrow range of fluctuation.

(vii) Total solids ranged between 1080-1310 mg/l which was within the excessive limit. Silting and soil erosion were obvious, adversely affecting the species diversity and productivity of the river.

(viii) Dissolved oxygen was recorded low in summer season. The value of dissolved oxygen showed a considerable seasonal variation.

(ix) The value of free Carbondioxide fluctuated from .95-1.95 mg/l which is within the tolerance limit.

(x) Chloride ranged between 1.65-2.30 mg/l. The value of chloride never exceeded the permissible value as prescribed by WHO.

(xi) The range of alkalinity was found between 70.8-89.5 mg/l. It showed decreasing trend in rainy season. Water of the river Punpun may be considered as productive especially for the fishes.

(xii) During course of investigation 75 inland fishes belonging to 51 genera, 22 families, 10 order were recorded. Conservation states of the fish's species showed that maximum species comes under vulnerable (28%) and lower risk near threatened (28%) and category, followed by lower risk least concern (6.6%), endangered (5.3%), exotic (5.3%) and threatened (.075%).

(xiii) The physico-chemical parameters of the water samples of the water of Punpun river revealed that the water of the river is fit for industrial as well as irrigational purposes but unfit for bathing and drinking purposes.

(xiv) A large number of fishing gear and tackles are operated in different stretches of the river Punpun which are remarkably primitive type.

(xv) *Ctenopharyngodonidellus, Hypopthalmichthysmolitirx*and *Cyprinus carpio* are the common exotic fishes recorded in the river Punpun.

(xvi) The socioeconomic condition of fishing community of Aurangabad district is not satisfactory and needs improvement.

(xvii) The following most important strategies are required for sustainable effective management/conservation of the Punpun river of Bihar, India:

(i) Introduction of broad-based research.

(ii) Improved procedure for environment assessment

(iii) Long term monitoring

(iv) National and international co-ordination

(v) Public awareness and participation etc.

CHAPTER-I

INTRODUCTION

The term **"Limnology"** derived from the Greek word "**Limne"** was coined by **Swiss Francois Alphonse Forel at the end of 19th century** in his pioneering monograph Le Leman. **Forel** is regarded as the father of limnology. Limnology, a branch of ecology, refers to the study of inland freshwaters, and deals all levels of organization, from individuals, populations, communities to complex ecosystems. Limnological study refers the study of Physics, Chemistry, Biology, Geology and Climatology of water systems. Limnology is a branch of Ecology that covers mostly fresh water system but also includes inland salt and brackish or slightly salty waters. Limnology is the study of both lentic and lotic water bodies covering wetland and ecosystem services too. The inland water resources can be categorized as warm water resources (Rivers & canals, Tanks and Ponds, Reservoirs, Floodplain, Brackish water and Saline Alkaline affected areas) and cold-water resources (River, Lakes and Reservoirs). The extent of Rivers and Canals of warm water and cold-water resources of India are 1,95,210 and 8253 Km respectively. A river is a large body of flowing water constrained in channel and plays a vital role by conserving the precious biodiversity.

Inland waters compromise approximately 0.01% of the total volume of water on earth (Stiassny,1996). From time immemorial rivers are meeting the multifarious demand of society at the expense of its own ecosystem health (Born, 1999). River is a dynamic body of water, which flows from higher ground elevation like hills and mountains, towards lower level, like the sea. In its journey it comes across a varied range of terrain, ranging from pebbly highlands to sand-covered alluvial reaches to silty and sand covered alluvial reaches to silty and clayey stretches of the deltaic plains. The velocity of the river changes from very swift in the hills to placid in the lower plains (Sen, 2006). Rivers are relatively large lotic water bodies, created by natural processes. Hynes (1979) described rivers as a

manifestation of the landscapes that they drain. Rivers perform a vital role in integrating and organizing the landscape, and monitoring the ecological setting of basin. They are the prime factors controlling the global water and the hydrological cycles, they are the most dynamic agents of the transport (Garrels *et al*. 1995). The river water plays an important role in overall developmental programmes of the country serving as a source of water supply for domestic and industrial purposes and agriculture, fisheries and power development too.

The riverine ecosystem is valuable due to their high biological productivity, high potential value of exploitable resources, high biodiversity, multiple alternative livelihood opportunities, high resilience to heavy exploitation level and climate changes, fisheries, agriculture, transport, forestry, water abstraction, water drainage, housing, industry, etc.

Fisheries may be defined as an economic activity which involves harvesting fish or any aquatic organism from the wild or raising them in confinement (capture or culture fisheries). It may be traditional or commercial. Traditional fisheries are small scale fisheries for substance but commercial fisheries are for profit and large scaled. According to the database of the **National Bureau of Fish Genetic Resources (NBFGR) Lucknow, U.P.,** 877 species of fishes from freshwater habitats have been recorded in addition to 291 exotic fish species occurring in India (Uttam K Sarkar *et al*. 2012). Inland fish compromise just about 40% of all fish species and 20% of all vertebrate species (Helfman *et al*. 2009). The inland fisheries of India may be classified as:

1. Lacustrine Fisheries (Lakes and Reservoirs)
2. Riverine Fisheries (Rivers and Streams)
3. Estuarine Fisheries (Estuaries and Backwaters)
4. Flood plain and Wetland Fisheries
5. Coldwater Fisheries
6. Ornamental Fisheries
7. Sport Fisheries
8. Cultural Fisheries (Aquaculture)

Inland fishery resources of Bihar comprise about 3200 km river length of which the **Punpun river of Bihar occupies a length of 200 Km.**

There is a considerable volume of literature on the subject of river hydrology in relation to fisheries. The earliest knowledge of this area was summarized in 2001 by Welcomme, among the relatively recent publication reference may be made to Devid and Closs (2002); Das *et al.* (2014); Freeman *et al.* (2001); Humpires *et al.* (1999); King *et al.* (2003); Montogomery *et al.* (1996); Marchatti and Moiyle (2001); Mukhopadhyay (1996); Mishra (2000); Nath *et al.* (2007); Nath *et al.* (2008); Singh and Gupta (2010), etc.

A number of contribution on the riverine ecosystem are available from India Das (2014); Giri *et al.* (2008); Joshi and Bisht (1993); Joshi and Biswas (2010); Kaur and Joshi (2003); Kumar (2000); Mishra and Tripahi (2003); Mishra and Dwivedi (1994); Mishra (2000); Narain and Chauhan (2000); Pandey *et al.* (2000); Ray (1998); Rajput *et al.* (2004); Srivastava *et al.* (1996); Subramanian (1994); Sinha *et al.* (2000); Sinha (2006); Trivedy (1990); Unni (1996); Zafar and Sultana (2008) etc. however, no information is available on the hydrobiology, fish and fisheries and other related aspects of the Punpun river of Nabinagar, Aurangabad, district of Bihar (India).

Socio economic status is an economic and sociological combined total measure of a person's work experience and of an individuals or family's economic and social position in relation to other, based on income, education and occupation. Data on socio-economic framework of the fisherman community forms benchmark for policy formulation to develop this economically and socially backward community. Lack of authentic information on socio-economic condition of the fishing community is one of the serious impediments in the successful implementation of developmental programmes. In fisheries sector, several micro and macro level socio-economic surveys had been conducted by various agencies and fishery workers of our country to study one or other problem of the fishermen community (Basava Kumar *et al.* 2011; Goswami *et al.* 2002; Kotekar, 2009; Kalita, 2015; Kalita *et al.* 2015; Saxena, 2014; Saxema and Chisti, 2014, etc.). Investigations on social, economic and cultural status as well as

occupational structure of fishes, over time and space, are conducted in Uttar Pradesh and Bihar along the Hardoi- Bhagalpur stretch, of the river Ganges (Central Inland Fisheries Institute, 2006), but no survey has been done particularly in Aurangabad district of Bihar.

Knowledge of fishing gear, craft and fishing methods are very essential for scientific and Judicious exploitation including the management of any capture fishery. Bihar has a network of ephemeral, intermittent and perennial river systems. The inland fishery resources of Bihar are exploited mostly by traditional fishing methods and gears which vary from place to place depending upon target species, fishing ground, climate, current and other hydrobiological conditions. Adoption of unscientific fishing practices, over exploitation of fishing resources along with habitat degradation are the major reasons for depletion of catch.

There are many attempts on the classification of fishing gear based on design, operation and the mode of capturing fish by Burdon (1951), Davis (1958), Hornell (1923), Jhingran (1963), Kolekar (2009), Miyamots (1951), Nayak *et al.* (2000), Ramesan *et al*. (2011), Saxena (1966) and Verma (2006) etc.

An attempt has been made here to present an account of different gears and crafts used in the Punpun river along with their mode of operation.

Several exotic fish species have entered into rivers probably form reservoirs or flooded tanks. Exotic fish species introduction has both advantages and disadvantages. Among exotics 'Common Carp' *(Cyprinus sp.) and* 'trouts' *(Salmo sp.)* are worth mentioning. The Silver carp *(Hypopthalmichthys molitrix)* has been introduced in many countries. Likewise, the Grass carp (*Ctenopharyngodon idella)* have been transplanted worldwide for cultural practices. The spread of Tilapia is a remarkable phenomenon. The introduction of larvivorous fishes to different parts of the world is also interesting. Of the catfish families, Claridae enjoys the widest range of geographical distribution.

The negative aspects of the introduction of exotic fish species are genetic contamination, disease introduction and ecological interactions

leading to native species loss. The entry of exotic fishes in rivers might have increased the biological stress of existing species of fishes. During course of ichthyofaunal investigation some exotic species of fishes were also recorded from the river Punpun.

The riverine ecosystem of the country has been witnessing serious threats due to anthropogenic interferences which do not only degrading the ecosystem but also declining the fish production of the country. It has been found that the area where the study is being carried out the freshwaters have been a direct victim in terms of deterioration. The eutrophication caused due to diffused and point source of pollution in the river Punpun were studied. Anthropogenic impacts on ecology and fisheries of the river Punpun were studied in detail.

Fishery management refers the integrated process of information gathering, planning, decision making, enforcement of fishery regulations, in order to ensure the continued productivity of the living resources.

The basic objective in the riverine fisheries should be to give emphasis to improvement in the water quality and conservation of biological and particularly fishery resources while attempting to optimize the productivity (Dehadrai, 2002). The nature of inland waters and magnitude of their resources vary hence they are managed differently. The objective of the study was to evaluate the status of this riverine ecosystem and to suggest the issues strategies for proper scientific, rational and management of this ecosystem.

OBJECTIVE

In India a substantial amount of research on limnology and inland fish and fisheries have been carried out in past 50 years. Fish production of mostly inland water bodies declined considerably in the past decade. Freshwater species are more in danger throughout the world (McAllister *et al.* 1997; Stein *et al.* 2000).

The economic survey of Bihar has revealed that the people of Bihar in general and study area in particular are suffering from protein deficiency in their diet, hence the state of needs and enormous increase in fish

production. The state of Bihar is land locked but the fisheries development prospects are tremendous because all the factors required for the development of fish farming are in abundance.

Nabinagar has undergone dramatic development at industrial, agricultural and socio-religious front with a simultaneous rise in population. It is utmost important to understand the water quality, fauna, flora, their dynamic and functioning of these ecosystems as well as the impact of increasing human activities on them for management of fresh waters and to keep them in healthy state to sustain the future progress of the region.

The data on water quality, ichthyofauna, anthropogenic interference and management policy is available to improve the conditions of water bodies existing in the country. There is an urgent need of collecting the baseline data on all lotic ecosystems, identifying the kind of and magnitude of human onslaught on them, assessing on them to protect these water bodies for posterity.

The research project intitled "Limnological and Biological Exploitaion of the Punpun river at Nabinagar, Aurangabad, Bihar, India in relation to fish and fisheries" has been undertaken and conducted with a view to achieving the following objectives: -

(1) To study the history, origin and geomorphology of the river Punpun.

(2) To measure the physico-chemical characteristics of the river water.

(3) To determine the fish and fisheries of the river.

(4) To study the different types of fishing gears and techniques employed.

(5) To study the exotic fish species of the river.

(6) To study the socio-economic conditions of the fishing community of the study area.

(7) To study the anthropogenic impacts on the river ecology and fisheries.

(8) To study the riverine conservation and management principles.

The basic objective of this research project is to give emphasis to improvement in the water quality and conservation of biological and

particularly fishing resources while attempting to optimize the productivity. The objective of this research project is also to evaluate to status of this river ecosystem and to suggest the issues strategies for proper scientific, rational and sustainable management of this ecosystem. This research project will provide certain data to the planners, scientists and fishing authorities which will be significant in conservation of this riverine ecosystem as well as fish production and ultimately advantageous for national economy.

CHAPTER-II

REVIEW OF LITERATURE

There is a considerable volume of literature on river limnology in relation to fish and fisheries. The existing literature on inland waters, hydrology and fish and fisheries are reviewed in this chapter.

Srivastava *et al.* (1990) carried out investigation on the zooplankton density of river Ganga between Kalakankar and Phaphamau Allahabad. They observed that the zooplankton density was maximum during summer and minimum during the rainy season.

Khan (1990) studied the significance of limnology in management of manmade Lakes.

Singh (1990) described limnology of a tropical pond with reference to fisheries. He found that plankton population showed bimodal pattern of fluctuation with one peak in winter and other in summer. Most of the planktonic organism showed seasonal variation in density and period of occurrence.

Shukla and Bais (1990) described physico-chemical profile of Bila Reservior during winter season.

Singh and Ali (1991) studied physico-chemical factors and phytoplankton of Pawaputi pond and observed that pH, Dissolved Oxygen, Alkalinity, Chlorides and Phosphate depicted erratic seasonal fluctuations impacting profound impact on the phytoplankton.

Patra lekh (1991) described phytoplankton periodicity in perennial pond of Bhagalpur, India and observed that phytoplankton population exhibited marked fluctuation in different seasons. Its maximum population was recorded in March and minimum was found in August.

Shaji and Patel (1991) studied chemical and biological examination of pollution in river Sabarmati at Ahmedabad.

Singh (1995) studied the physico – chemical and biological factors of the river Ganga at Kanpur. He stated that these factors were directlyaffected the aquatic biota of river Ganga.

Bais and Agarwal (1995) determined the comparative study of Zooplanktonic spectrum in the Sagar Lake and Military engineering Lake. They identified that the Protozoa, Rotifer Cladocera, Ostracoda and Copepoda were the main groups in both the Lakes. They also found that the main limiting factor which hampered the density of Zooplankton population in the Military engineering Lake was a very low population of phytoplankton.

Doctor *et al.* (1998) have worked out physico – chemical and microbial analysis of dye contamination water of river Bhadar.

Chandrasekhar and Jafar (1998) described limnological parameters of a temple pond in Kerala.

Agarwal (1999) described physico-chemical characteristics of river Yamuna water and effects of various pollutants of some aquatic fauna. He found a very poor water quality of river Yamuna.

Ansari and Prakash (1999) studied limnology of Ranital Balrampur, Uttar Pradesh.

Sharma *et al.* (2000) carried out detailed investigation to assess the water quality of major drains entering river Yamuna at Mathura. They discovered the presences of high amount of metallic pollutants in drain water.

Azizul *et al.* (2001) determined limnological parameters of fish pond in Rajshai, Bangladesh.

Sen (2006) defined river a dynamic body of water which flows from higher ground elevation like hills and mountains, towards lower level, like the sea

Bhuiyan and Gupta (2007) reported a comparative hydrobiological study of a few ponds of Barak valley, Assam and their role as sustainable water resources.

Kumar *et al.* (2007) described the ecological status and zooplankton diversity of Sikandarpur Reservoir.

Shekhar *et al.* (2008) described phytoplankton as index ofwater quality with reference to industrial pollution and emphasized the need of phytoplankton community as index of water quality polluted by industrial effluents at the downstream stretch of the Bhadra River.

Raja *et al.* (2008) described evaluation of physical and chemical parameters of river Kaveri.

Hujare (2008) described seasonal variations of phytoplankton in the fresh water tank of Talsande, Maharastra

Padmanabha and Belagali (2008) described that ostracods as anindicator of pollution in the lakes of Mysore. The study revealed highest water quality index and population density of ostracods during summer and lowest during winter.

Saksena *et al.* (2008) determined water quality and pollution status of Chambal River in National Chambal Sanctuary.

Tiwari and Chauhan (2008) determined the periodicity of cyanobacterial bloom in a polluted pond of Agra city.

Singh *et al.* (2009) described the physic - chemical analysis with special reference to phytoplankton of Vijay Sagar Lake, Mahoba District (U.P.).

CHAPTER-III

STUDY AREA, MATERIALS AND METHODS

Study Area:-

The river Punpun is also known as Punah-Punah. It is a holy river following in the defined area of Magadh division of Bihar. The river Punpun originates from the shobhichakra and Saraiya village situated on the northern border of chhotanagpur hills of the Palamu district of Jharkhand state. The rivers emerging from the Indian Saptkul mountains mentioned in our Puranas did not show the river Punpun/Punah-Punah. The river Pishchike mentioned in our Puranas may be considered as the river Punpun. Pind Daan water oblation are done for the deceased demon ancestors in the water of this river hence this river was named as Pishachike. This river became famous as Punah-Punah in a spiritual sense that sins are removed again and again by offering oblations to fore fathers in the river making demon deceased ancestors holy. The river Punpun has been mentioned in the Vau and Padma Puranas.

The river Punpun enters into Aurangabad district of Bihar east of the village Bara lying between $24^0 11' - 25^0 25'$ N longitude and $84^0 10' - 85^0 10'$ E Longitude at 300 metre elevation. The catchment area of this river is about 8530 Sq. Km. The catchment area of Punpun is about 1% of the total area of the Ganga basin in the country. River Punpun having several tributaries is mostly rainfed. It carries little discharges during the non- mansoon period.

The river Punpun is a not large hill stream but fed by several hilly torrents like the Adri, the Balane, the Batre, the Ramrekha, the Madar, the Dhawa, the Kasman etc. Nabinagar is situated 6 Km north from the origin place of the river Punpun. Nabinagar lies at $24^0 62'$ N Latitude and $84^0 12'$ E Longitude. The Punpun flows 27.35 Km in Nabinagar area bearing trapezoidal basin. The agiculture area and gross recharge of Punpun is about 500 Sq. Km. and 1.6 lakh Ha respectively. The area of Nabinagar is dry stony and water deficient. River Punpun is of considerable importance for

possessing valuable building construction raw materials and precious stones. Nabinagar Super Thermal Power Project is also situated near the river.

Inland fishery resources of Bihar comprise of about 3200 Km river length of which the Punpun river occupies a length of 200 Km.

River is a dynamic body of water, which flows from higher ground elevation, like hills & mountains, towards lower level, like the sea. In its journey, it comes across a varied range of terrain, ranging from pebbly highlands to sand covered alluvial reaches of silty and clayey stretches of the deltaic plains. The velocity of the river also changes from very swift in the hills to placid in the lower plains (Sen, 2006).

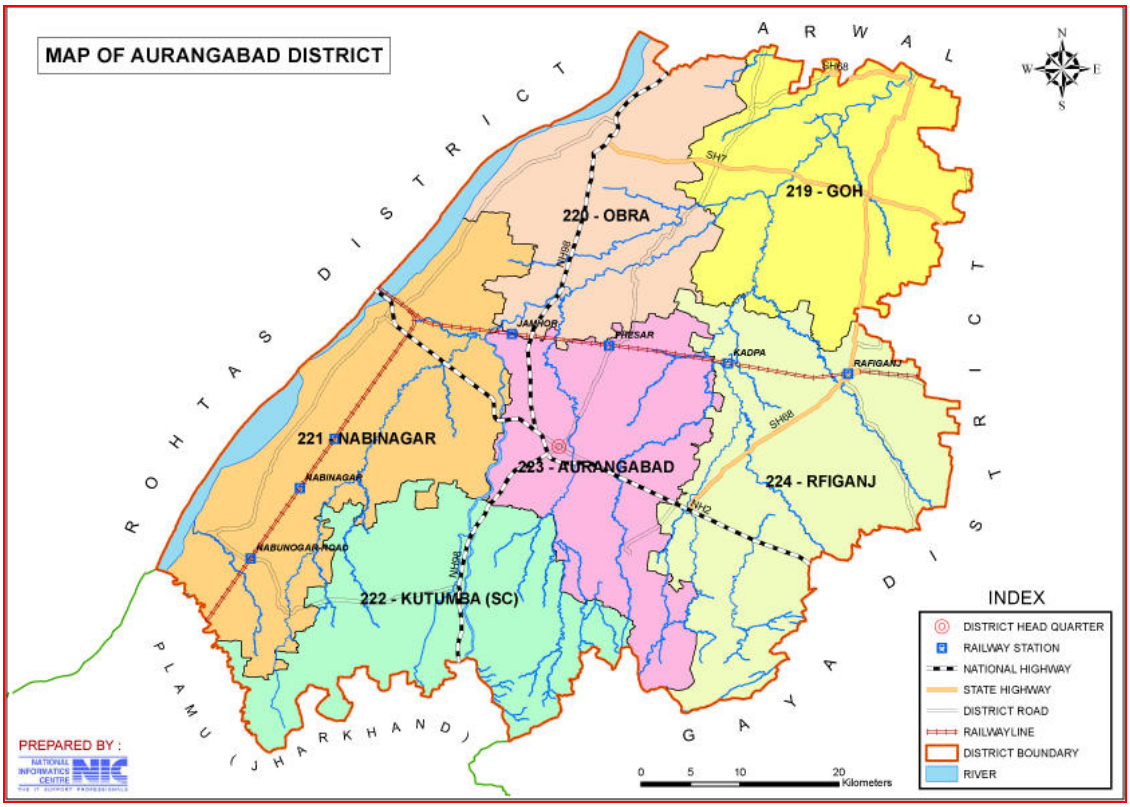


Fig. 01 - Aurangabad District, (Bihar) showing Nabinagar.

Fig. 02 - Satellite View of Punpun River at Nabinagar.

Fig. 03 - Punpun River flowing through Nabinagar Town

Table 01. Salient features of the Punpun river

S.No.	Particular	Area
1.	Length of the inland fishery resources of Bihar	3200 Km
2.	Length of the Punpun river	200 Km
3.	Length of the Punpun river in Nabinagar area	27.35 Km
4.	Catchment area of the Punpun river	8530 sq. Km
5.	Latitude	$24^0$11'-$25^0$25'N
6.	Longitude	$84^0$10'-$85^0$10'E
7.	Elevation of the river Punpun	300 Meter

Tributaries – The Adri, the Batre, the Batare, the Dhawa, the Kasman, the Ramrekh the Madar etc.

Table 02. Salient features of the Nabinagar, Bihar

S.No.	Particular	Area
1.	Latitude	$24^0$62'N
2.	Longitude	$84^0$12' E
3.	Location	6 km north from the place of origin of the river Punpun forming southern portion of Magadh Division.
4.	Elevation	138 Meter
5.	Climate	Warm and temperate
6.	Location of Nabinagar	9 Km from "Nabinagar Thermal Power Project Road" Railway station

Materials and Methods:-

Three sampling sites at Nabinagar area were selected for collection of water samples, fish collection and recording of various physico-chemical parameters.

Site I :- 3 Km upstream of Nabinagar town.

Site II :- Nabinagar town.

Site III:- 3 Km downstream of Nabinagar.

The ombrothermic and physico-chemical parameters of the river water measured followed by :- APHA-AWWA-WEF, 2005; Gopal, 1995; Singh, 2008, Trivedy and Goel, 1986; WHO, 1993; and Welch, 2009.

Water samples were collected from the sites once in a month from **January, 2018 to December, 2018, between 10-11 AM** in acid washed one litre capacity plastic bottles from a depth of 5-10 cms. Immediately after collection, clearly labeled each sample bottle with water proof ink, and recorded the relevant details for each sample. Temperature of water was immediately recorded. Dissolved Oxygen, free CO_2, alkalinity and pH quickly change with time hence their estimation was carried out in the field and water samples were also brought to the laboratory for further estimation of other parameters.

Fish specimens of the river Punpun were collected using different kinds of fish catching appliance and devices with the help of fishermen and some were procured from the local markets. Ecological notes, wherever possible were taken down. The specimens were fixed in 8% Formaline solution. Fixed specimens were kept in containers with proper labeling and the tail pointing upwards for further studies. Identification, nomenclature and classification of fishes collected in the river Punpun are based on standard references (Datta Munshi, 2006; Greenwood *et al*. 1966; Jhingram, 1991; Jayaram, 2010; Mishra, 2003; Mishra, 2012 and Menon 1974; Talwar & Jhingran, 1991 and Yadav, 1997). The nomenclature of various piscine species is based on recent revisions.

The various inland fishing gear and fishing techniques employed in the river have been reviewed from available literatures.

A profilistic study on the socio-economic status of the fishermen community of Nabinagar was conducted during the period 2018-2019. A sample random sampling procedure was applied to 50 respondents from Nabinagar. A structural interview schedule was developed incorporating all the queries to accomplish the objectives set for the study. The data was collected directly from the fishermen families, through personal discussions and interviews regarding the various aspects of socio-economic conditions

like age composition, employment and occupational structure, habits, fishing intensity, income distribution and assets. Simple percentages were calculated and tabular analysis was made for arriving at the results.

OMBROTHERMIC ANALYSIS:-

Atmospheric Temperature

Atmospheric temperature was measured by using a maximum and minimum thermometer.

Humdity

Humidity was recorded by Hygrometer

Rainfall

Rainfall was recorded by Rainfall gauge.

Water Temperature

Water temperature was measured with a good grade mercury thermometer with a precision of 0-1^{0}C.

PHYSICO-CHEMICAL ANALYSIS OF WATER SAMPLES:-

Hydrogen ION Concentration (pH)

Hydrogen ion concentration was recorded with the support of pH paper. The color of the pH paper changed after dropping it into the water sample. The changed color of the pH paper was compared with the provided color chart and the pH values of the samples were recorded.

Total Solids

Total solids were determined as the residue left after evaporation of the unfiltered sample. Total solids were calculated as follows: -

$$\text{Total solids, mg/l} = \frac{A - B \times 1000}{V}$$

Where,

A = Final weight of the dish in gm.

B = Initial weight of the dish in gm.

V= Volume of sample taken in ml.

Total Suspended Solids

It is difference between the total solids and total dissolved solids.

Total Dissolved Solids

Total dissolved solids are residue left after evaporation of the filtered sample. Total dissolved solids were calculated as follows: -

$$\text{Total Dissolved Solids, mg/l} = \frac{\text{A - B X 1000 X 1000}}{\text{V}}$$

Where,

A = Final weight of the dish in gm.

B = Initial weight of the dish in gm.

V = Volume of the sample taken in ml.

DISSOLVED OXYGEN

Reagents

1. Sodium Thiosulphate, 0.025N
2. Alkaline Potassium Iodide Solution
3. Manganous Sulphate Solution
4. Starch Solution
5. Sulphuric Acid

The quantity of liquefy Oxygen in water samples of the river Punpun were measured by Winkler's method. The water samples were taken into the ground glass BOD bottles preventing any bubble. 2ml of saturated solution

of Manganous sulphate ($MnSO_4$) and 2 ml of alkali Iodide Azide solution were added for the settlement of precipitate. Thus, precipitate obtained was melt in concentrated H_2SO_4. Thus, precipitate H_2SO_4 and titrated against 0.025 N Sodium thiosulphate solution ($Na_2S_2O_3$), using starch as indicator until a blue color disappeared. Dissolved Oxygen was calculated as:

$$DO, mg/l = \frac{(ml\ X\ N)\ of\ titrant\ x\ B\ x\ 1000}{V_2 \frac{(V_1 - V)}{V_1}}$$

Where,

V_1 = Volume of sample bottle

V_2 = Volume of part of contents titrated

V = Volume of $MnSo_4$ and Kl added

FREE CARBONDIOXIDE

Reagents

1. Sodium Hydroxide, 0.05N
2. Phenolphthalein Indicator

Free CO_2 was determined tri-symmetrically by using alkali as titrant (such as carbonate free NADH) and Phenolphthalein as an indicator. Free Carbondioxide was calculated as follows:-

$$Free\ CO_2 mg/l = \frac{(ml \times N) of\ NADH \times 1000 \times 44}{ml\ of\ sample}$$

CHLORIDE

Reagents

1. Silver Nitrate, 0.02N
2. Potassium Chromate, 5%

Chloride was determined by titrating the sample against Silver Nitrate (0.2N) using Potassium Chromate as an indicator. At the end point when all

the chlorides get precipitated, free silver ions react with chromate to get silver chromate of Reddish brown in color. Chlorides were calculated as follows:-

$$\text{Chloride, mg/l} = \frac{(\text{ml} \times \text{N}) \text{ of } AgNO_3 \times 1000 \times 35.5}{\text{ml sample}}$$

TOTAL ALKALINITY

Reagents

1. Hydrochloric acid, 0.1N
2. Methyl orange indicator, 0.05%
3. Phenolphthalein indicator
4. Sodium carbonate, 0.1N

Total alkalinity was estimated by titration method using 0.01 N H_2SO_4 or HCl as titration and Phenolphthalein as indicator.

$$\text{Alkalinity, mg/l} = \frac{\text{Vol. of 0.01 NHCl} \times 1000}{\text{ml of sample}}$$

CHAPTER-IV

OBSERVATION AND DISCUSSION

CLIMATIC CONDITIONS:-

Atmospheric Temperature

During course of investigation the minimum and maximum atmospheric temperature ranged between 10.7-28^{0}C and 24-41.9^{0}C respectively. May was recorded as the hottest month of the year; Minimum atmospheric temperature was recorded in the month of January. There was a variation of 17.2^{0}C temperature throughout the year. The lowest and highest average atmospheric temperature were recorded 17.3^{0}C and 34.5^{0}C in the month of January and May respectively. Atmospheric temperature showed fluctuating in different months. The climatic data of Nabinagar (Bihar) have been depicted in Table 03.

Table 03 - Climatic data of Nabinagar (Bihar) (January, 2018-December, 2018)

S.No.	Parameter	Range
1.	Minimum atmosphereic temperature (^{0}C)	10.7 - 28
2.	Maximum atmospheric temperature (^{0}C)	24 - 41.9
3.	Humidity (%)	25 - 83
4.	Rainfall (mm)	3 - 311

Humidity

The range of humidity was between 25-83%.

Rainfall

The rainfall ranged between 3-311mm. The summers were much rainy than the winters. During course of investigation it was observed that maximum rainfall occurred in the month of July, whereas November was the driest month (3mm of rain)

Physico chemical analysis of water samples temperature:

The water temperature of the river Punpun ranged between 12.8^{0}C to 28^{0}C. The minimum and maximum temperature were observed in the month of January and May respectively. Different parameter values have been depicted in Table 0 4.

Table 04- Physico-chemical parameters of water samples of the river Punpun at Nabinagar (January, 2018 to December, 2018) and their permissible limits. All values are in mg/l except temperature and pH.

S.No.	Parameter	Range	Tolerance limit
1.	Temperature	12.8-28^{0}C	10-15.6^{0}C
2.	pH	7.2-8.2	6.5-8.5
3.	Total solids	1080-1310	0
4.	Dissolved solids	7.2-11.8	0
5.	Suspended solids	360-380	0
6.	Dissolved Oxygen	7.2-11.8	3
7.	Free Carbon dioxide	0.95-1.95	6
8.	Chloride	1.65-2.30	200
9.	Total alkalinity	70.8-89.5	0

Table 4(a)

PARAMETERS	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
PH	8.0	7.8	7.4	7.4	7.3	7.2	7.2	7.3	7.4	8.0	8.2	8.2
Total Solids	1310	1280	1240	1160	1085	1080	1080	1090	1184	1245	1300	1310
Dissolved Solids	700	820	856	860	885	946	950	948	910	755	748	740
Total Suspended solids	380	370	368	365	360	362	364	364	368	376	380	380
Dissolved Oxygen	11.8	11.4	11.4	7.2	7.4	7.2	7.2	7.4	10.6	11.0	11.5	11.8
Free Co_2	1.92	1.86	1.80	1.86	1.86	.98	.95	.95	.96	1.76	1.88	1.95
Chloride	2.28	1.80	1.80	2.22	2.30	1.80	1.65	1.68	2.00	2.18	2.22	2.30
Total Alkalinity	78.0	84.0	84.8	88.2	89.5	72	70.8	71	71.08	72	76	80

HYDROGEN ION CONCENTRATION (pH)

Hydrogen ion concentration (pH) of the Punpun river water samples ranged between 7.2-8.2. The pH limit was found within the acceptable range for various purposes. Effect of pH on fish have been shown in Table 05. The water of the river was never found acidic.

Table 05- Showing effect of pH on fish

S.No.	pH	Effect
1.	4	Acidic death point
2.	4-6	Slow growth
3.	6-9	Best growth
4.	9-11	Slow growth, lethal to fish over long period of time
5.	11	Alkaline death point

TOTAL SOLIDS:

Total solids in river water samples ranged between 1080-1310 mg/l.

DISSOLVED SOLIDS:

Total dissolved solids ranged between 700-950 mg/l. This value was minimum during the winter season and maximum during rainy season.

TOTAL SUSPENDED SOLIDS:

Total suspended solids range varied from 360-380 mg/l, which was minimum during rainy season and maximum during winter season.

DISSOLVED OXYGEN:

The value of dissolved oxygen, a critical factor in natural waters, ranged between 7.2-11.8 mg/l. The low value of DO was observed in summer season when the temperature was high and the river flow was slow.

FREE CARBONDIOXIDE:

Free Carbondioxide of the river water fluctuated from 0.95-1.95 mg/l.

CHLORIDE:

Chloride ranged between 1.65-2.30 mg/l in the water samples of the river.

TOTAL ALKALINITY

The Alkalinity ranged between 70.8-89.5 mg/l in the water samples of the river Punpun. It showed decreasing trends in rainy season.

ICHTHYOFAUNA OF THE RIVER PUNPUN AT NABINAGAR (BIHAR):

During course of ichthyofaunal investigation of the river Punpun at Nabinagar (Bihar) Seventy-five species of inland fishes belonging to 51 genera, 22 families and 10 orders have been recorded including 12 vulnerable, 4 exotic and 01 endangered species.

INLAND FISHING GEARS AND FISHING TECHNIQUES OF PUNPUN RIVER SYSTEM OF NABINAGAR (BIHAR):

In the river Punpun fishing is carried out by local fishermen. A large variety of fishing gear and tackles are operated in different stretches of the river for commercial exploitation of the fishery resources. The Punpun riverine fishery resources are exploitated mostly by traditional methods and gears which vary from place to place.

The fishing methods based on the target species, fishing ground, climate, water current other hydrobiological conditions. The existing fishing methods in the river Punpun is conventional type. The main fishing gear is the cast net, made of both nylon and cotton of various dimensions. The other fishing gear includes Bagnets, Scoop nets, Stake nets, Gill nets, Hooks &Lines, Angling, Barriers etc. Fishing crafts includes different types of mechanized and non-mechanized boats but mostly traditional non-mechanized crafts and gears are in vogue.

DISCUSSION

Atmospheric Temperature:

General atmospheric conditions of research area are warm, temperate and typically monsoon type with three distinct seasons (Summer, Winter and Rainy). The atmospheric warmth is one of the most significant physical factors which regulates the natural process of the environment. The atmospheric temperature of the study area was recorded in accordance of the seasonal changes. The minimum and maximum atmospheric temperature ranged between 10.7-28^{0}C and 24-41-9^{0}C respectively. It was excessive in May and June (Summer), medium in July and August (Rainy season) and lower in December and January (Winter season). A hot wind of high temperature referred to as “Loo” is the characteristic of summer season. The climate of Bihar is

greatly affected by the Himalayas and the Ganga plateau because of its geographical status. A various contribution on identifying the trend in the climatic parameters are available from India Rupa Kumar *et. al*. (1994), Pant and Kumar (1997) and Arora *et. al*. (2005). Kumar *et. al*. (1994), reported a countrywide increase as well as decrease in annual mean maximum and annual mean minimum temperature by 0.6^0C and 0.1^0C respectively.

Pant and Kumar (1997) suggest that India has a significant warming trend of 0.57^0C per hundred years. The annual mean temperature for the country as a whole has been increasing by 0.56^0C during the time period of 1901-2009 (IMD annual climatic summary (2009). Tuag and Goswami (2009) and the Attri (2006). There is a significant increasing trend for the annual mean temperature for all the districts of Bihar during the 102 years (1901-2002). Aurangabad district showed an annual increase of temperature by 0.0045^0C (Roy and Kumar, 2016).

HUMIDITY:

Humidity refers the concentration of water vapour in air. Nabinagar has a warm and humid climate. The scope of humidity of the research area varied from 25-84%. There was an insignificant decreasing trend for Relative humidity for Aurangabad district during the period of investigation. The annual relative humidity showed an increasing trend.

RAINFALL:

Bihar lies in the subtropical region of the temperate zone having humid subtropical climate. Monsoon begins in the mid-June but it is unpredictable and erratic. The Indian state of Bihar gets a reasonably good amount of rainfall that contributes greatly to the fisheries, forestry and agriculture sector. The rainy season continues until the end of September in Bihar and rain set in towards the middle of June when the temperature begins to fall and humidity rises. Nabinagar fall in the South Agro-Climatic Zones of Bihar and 88% of rainfall comes during the southwest Monsoon (June to September). During course of study July registered peak rainfall in the year, whereas November was the driest month. The rainfall ranged between 3-311mm throughout the study research. There is a statistically significant diminishing trend of annual rainfall during the period 1901-2002 for all the districts of Bihar (Roy *et al*. 2016). India lies in the tropical monsoon zone and receives plenty of rainfall.

Already there are many studies available on the trends and variability of rainfall and also extreme rainfall events, but all the studies are based on past 100 years (Warwade *et. al*., 2018; Guhathakurta *et. al.* 2011; Guhathakurta & Rajeevan, 2008 etc.). Guhathakuta *et.al*., 2020, observed rainfall variability and changes over Bihar state on recent past thirty years (1989-2018). He observed that the state gets highest rainfall (33%) of south west monsoon in the month of July. In July Aurangabad district have also an increasing trend (not significant) whereas all other districts of Bihar have decreasing trend (not significant). July registered peak rainfall in the year which indicates that the river catchments had a greater influence of the southwest monsoon.

TEMPERATURE:

Water temperature influences several physical properties of water such as viscosity, density, salinity, conductance, dissolved gases solubility etc. It also increases the rate of chemical and biological reactions in water. Water temperature shows diurnal variations. It depends upon climate, sunlight and depth too.

It is minimum during early hours of morning and reaches a maximum value in the afternoon. Temperature increases the rate of biological and chemical reactions in water. The minimum and maximum water warmth of the river Punpun was recorded in the course of January and May respectively. Das (2001) has described that the rise in temperature leads to accentuating growth and feeding rate and decrease in egg development period leading to rise in productivity. Ratan *et.al*. (2017) has described that the rate of chemical and biological reaction is being doubled with every 10^0C increase in temperature. Fish grow the best at a temperature range of 25^0 to 32^0C. The water temperature of the Punpun river ranged between 12-8^0C to 28^0C throughout the course of investigation (January 2018 to December 2018). Water temperature was recorded in accordance with the seasonal changes.

HYDROGEN ION CONCENTRATION (pH):

The presence of Hydrogen ion or pH was introduced by Sorenson in 1909. pH is the negative logarithm of concentration (in moles/litre) of hydrogen ions of a solution. The measure of acidity and alkalinity of a solution is the number of hydrogen and hydroxyl ions present in a solution. The pH of most lotic waters is generally neutral to slightly alkaline (7.0 to 8.5) which changes due to rain and effluents. The pH is affected not only by levels of carbondioxide but also by other organic and inorganic components

of water. Further, any alteration in water pH is accompanied by changes in other physico-chemical parameters (Ratan *et.al*., 2017). Water pH is important for the biotic community because most of the plants and animals survive in a narrow range of pH from slightly acidic to moderately alkaline conditions (Das, 2001). pH is affected by levels of CO_2, organic and inorganic components of water. Hydrogen ion concentration of the Punpun river water ranged between 7.2 to 8.2, never found acidic, and within the acceptable range for various purposes. The pH range between 6.0 to 8.5 indicates medium productive nature, more than 6 low productive (Jhingran & Suganan, 1990).

pH 4 indicates acid death point, 4-6 slow growth, 6-9 best growth, 9-11 slow growth, lethal to fish over long period of time and 11 alkaline death point. The pH of the Punpun river water is within tolerance limit and acceptable for the growth of fishes. Higher pH indicates a higher productivity of water (Khan, 1985).

TOTAL SOLIDS:

It is residue left after evaporation of the unfiltered sample. It is composed of carbonates, bicarbonates, chlorides, sulphates, phosphates and nitrates of Ca, Mg, Na, K, Mn, organic matters, silt and other particles. Silting and soil erosion were obvious in the river which might adversely affect the species diversity and productivity of the river.

Total solids ranged between 1080-1310 mg/l which is within the excessive limit. The permissive and excessive values for total solids in lentic as well as lotic water are 500 mg/l and 1500 mg/l respectively (WHO, 1971).

DISSOLVED SOLIDS:

Total dissolved solids are the residue left after evaporation of the filtered sample. The dissolved solids caused turbidity which prevents penetration of light through water and affects the photosynthesis of phytoplanktons. Total dissolved solids serve as indicator of pollution. Total dissolved solids ranged between 700-950 mg/l. This value was highest throughout rainy season.

TOTAL SUSPENDED SOLIDS:

It is determined as the difference between the total solids and total dissolved solids. Total suspended solids showed a narrow range of fluctuation. Its range varied from 360-380 mg/l, which was maximum in winter season.

DISSOLVED OXYGEN:

There is an increase in dissolved oxygen during day light due to photosynthetic activity of plants but the dissolved oxygen levels continuously decline at night because of the consumption of oxygen both by plants & animals leading to oxygen depletion. Oxygen is dissolved in water due to direct diffusion from air and photosynthesis which depends on water temperature, salinity of water, total dissolved solids and movement of water. Dissolved oxygen is of prime importance for the decomposition of chemical waste and dead organic matter. Dissolved oxygen is a good indicator of aquatic health also. The value of dissolved oxygen showed a considerable seasonal variation during course of investigation, ranging from 7.2 to 11.8 mg/l. The low value of DO was observed in summer season when the temperature was high and the flow of the river was slow.

Atmosphere, solubility and photosynthesis are the sources of oxygen whereas respiration decay by aerobic bacteria and decomposition of dead decaying sediments are the causes of its loss.

FREE CARBONDIOXIDE:

Carbon dioxide plays a vital role in determination of several parameter like hydrogen ion concentration, hardness and total alkalinity of water. The atmosphere contains small amount of CO_2; however, it is relatively abundant in natural water. The sources of CO_2 in inland waters are rain water, water passing through organic soil and streams, from the atmosphere, bacterial decomposition of organic matter and respiration of organisms. Respiration of aquatic organisms, decomposition of organic matter and infiltration through the soil are the chief sources of free CO_2 in water.

Rajput *et. al*., 2004 started that biological oxidation of organic matter and dissolved CO_2 from air increases the level of CO_2 in water. The value of free CO_2 fluctuated from 0.95-1.95 mg/l in the water of the river Punpun. This value is within the tolerance limit. Free CO_2 an important component of the buffer system as well as necessary constituent in an aquatic environment influences carbonate and bicarbonate concentrations in water. Maximum free CO_2 during summer may be due to high decomposition of organic waste by the microbes where they release CO_2 and absorb O_2 during rainy season indicated the influx of free CO_2 during rain water in the form of carbonic acid (Mansoori *et al*., 1995).

CHLORIDE:

Chloride play metabolically important role in photolysis of water and photophosphorylation reactions in autotrophs. Their higher concentration indicate pollution due to sewage as well as industrial wastes. Chloride content increases the degree of eutrophication (Sinha, 1986). It is generally considered as a major factor to equalize cation and anion balance of the aquatic system. Chloride was in the range of 1.65-2.30 mg/l in the water samples of the river under study and never exceeded the permissible value as prescribed by WHO. The permissible value of chloride content in potable water is 250 mg/l (WHO 1983). Similar chloride concentration observation hasbeen reported by Mishra & Tripathi (2003) in Ganga river water.

TOTAL ALKALINITY:

The alkalinity of water is caused by carbonates, bicarbonates and hydroxide. The alkalinity makes water tasteful and helps in coagulation (Hussain, 1987). Alkalinity acts as an index of nutrient status of water body and it is related to availability of CO_2 for primary production. The range of alkalinity was found between 70.8-89.5 mg/l in the river water under study showing decreasing trends in rainy seasons. Alkalinity values showing decreasing trends in rainy season can also be attributed due to the influx of freshwater into the river causing dilution of water. Water with total alkalinity levels of 20 to 150 mg/l generally contains adequate quality of CO_2 *(Boyd, 1984)* and water bodies having total alkalinity above 50 mg/l can be considered productive (Moyle, 1949).

ICHTHYOFAUNA:

The study of ichthyofauna of the river Punpun of Nabinagar, Bihar is based on a collection of 75 inland fishes belonging to 51 genera, 22 families, 10 orders as shown in Table 06.

Table 06- List of fishes

Order	Family	Genus	Species	Feeding Habbit	Status
Clupeiformes	Engraulididae	Setepinna Swainson	*01. Setipinna phasa (Ham.)*	C	V
Osteoglossiformes	Notopteridae	Notopterus Lacepede	*02. Notopterus chital (Ham.)*	C	V
			03. Notopterus Notopterus (Pallas)	C	T
Cypriniformes	Cyprinidae	Catla Valenciennes	*04. Catla catla (Ham.)*	H	V
		Ctenopharyngodon Steinbacher	*05. Ctenopharyngodon idellus (Valenciennes)*	H	Exo
		Crossocheilus Van Hasselt	*06. Crossochelus latius latius (Ham.)*	H	V
		Chela Hamilton	*07. Chela laubuca Bleeker*	E-P	LRIc
		Hyphophthal-michthys Bleeker	*08. Hypophthalmichthys molitrix (Valeniennes)*	Mpp	Exo
		Salmostoma Swainson	*09. Salmostoma bacaila (Ham.)*	O	LRIc
		Esomus Swanson	*10. Esomus danricus (Ham.)*	O	LRIc
		Danio Hamilton Rasbora Bleeker	*11. Danio rerio (Ham.)*	O	
			12. Rasbora daniconius (Ham.)	O	
		Aspidoparia Heekel	*13. Aspidoparia morar (Ham.)*	O	LRnt
		Barilius Hamilton	*14. Barilius bendelisis (Ham.)*	Ppp	LRnt
		Cyprinus Linnaeus	*15. Cyprinus carpio Linnaeus*	O	Exo
		Puntius Hamilton	*16. Puntius chola (Ham.)*	H	V
			17. Puntius conchonius (Ham.)	O	V
			18. Puntius sophore (Ham.)	H	LRnt
			19. Puntius sarana sarana (Ham.)	O	V
			20. Puntius ticto (Ham.)	H	LRnt
			21. Puntius terio (Ham.)	O	LRnt
		Osteobrama Heckel	*22. Osteobrama cotio cotio (Ham.)*	O	LRnt
		Labeo	*23. Labeo angra (Ham.)*	H	LRnt
			24. Labeo boga (Ham.)	D	LRnt
			25. Labeo calbasu (Ham.)	H	LRnt
			26. Labeo dero (Ham.)	H	V
			27. Labeo rohita (Ham.)	H	LRnt
			28. Labeo dyocheilus (Mcclelland)	H-O	V
			29. Labeo gonius (Ham.)	H	LRnt
		Cirrhinus Oken	*30. Cirrhinus mrigala (Ham.)*	O	V
			31. Cirrhinus reba (Ham.)	H	V
		Botia Gray	*32. Botia Dario (Ham.)*	O	V
	Cobitidae		*33. Botia lohachata Chaudhury*	C	En
		Somileptes Swainson	*34. Somileptes Gongota (Ham.)*	C	LRnt
		Lepidocephalus Bleeker	*35. Lepidocephalus guntea (Ham.)*	D	Lc
		Rita Bleeker	*36. Rita rita (Ham.)*	Bp	LRnt

Siluriformes	Bagridae	Mystus Scopoli	*37. Mystus bleekeri & Day*	C	V
			38. Mystus Cavasius (Ham.)	C	LRnt
			39. Mystus tengra (Ham.)	C	
			40. Mystus vitattus (Bloch)	C	V
	Siluridae	Ompok Laeepede	*41. Ompok bimaculatus (Bloch)*	P	nt
		Wallago Bleeker	*42. Wallago attu (Schneider)*	C	nt
	Schilbidae	Clupisoma Swainson	*43. Clupisoma garau (Ham.)*	C	V
		Pseudotropius Bleeker	*44. Pseudotropius atherinoides (Bloch)*	O	En
		Eutropiichthys Bleeker	*45. Eutropiichthys Vacha (Ham.)*	C	En
	Sisoridae	Bagarius Bleeker	*46. Bagarius bagarius (Ham.)*	C	V
		Gagata Bleeker	*47. Gagata Cenia (Ham.)*	O	
		Nangra Day	*48. Nangra viridescens (Ham.)*	C	LRnt
		Erithistes Muller & Troschel	*49. Erethistes pussilus Muller & Troischel*	C	
		Laguvia Hora	*50. Laguvia swai Hora*	O	
		Glyptothorax Blyth	*51. Glyptothorax telchitta telchitta (Ham.)*	O	V
		Sisor Hamilton	*52. Sisor rhabdophorus (Ham.)*	C	En
	Claridae	Clarias Scopoli	*53. Clarias batrachus (Linnaeus)*	C	V
	Heteropncustidae	Heteropneustes Miller	*54. Heteropncustes fossilis (bloch)*	C	V
Antheriniformes	Balonidae	Xenentodon Ragan	*55. Xenentodon cancila (Ham.)*	C	LRnt
	Cyprinodontidae	Aplocheilus McClelland	*56. Aplocheilus panchax (Ham.)*	L	
Channiformes	Channidae	Channa Scopoli	*57. Channa marulius (Ham.*	C	
			58. Channa orientalis (Schneider)	C	V
			59. Channa punctatus (Bloch)	C	LRnt
			60. Channa striatus (Bloch)	C	LRIc
Synbranchiformes	Synbranchidae	Monopterus Lacepede	*61. Monopteres cuchia (Ham.)*	C	
Perciformes	Chandidae	chanda Hamilton	*62. Chanda baculis (Ham.)*	C	
			63. Chanda nama (Ham.)	C	
			64. Chanda ranga (Ham.)	C	
	Nandidae	Nandus Valenciennes	*65. Nandus nandus (Ham.)*	C	
		Badis Bleeker	*66. Badis badies (Ham.)*	C	V
			67. Badis Dario (Ham.)	C-O	
	Gobiidae	Glossogobius Gill	*68. Glossogobius giuris (Ham.)*	C	LRnt
	Anbantidae	Anabas Cuvier	*69. Anabas testudineus (Bloch)*	P	V
	Belontidae	Colisa Cuvier	*70. Colisa fasciatus (Schneider)*	O	LRnt
	Cichliade	Tilpia A. Smith	*71. Tilapia mosambica Peters*	H	Exo
		Macrognathus Lacepede	*72. Macrognathus armatus (Bloch)*	C	
Mastacem Beliformes	Mastacem Belidae	Mastaeembelus Scopoli	*73. Mastaeembelus armatus armatus (Lacepede)*	C	
			74. Mastaeembelus Pancalus (Ham.)	C	
Tetraodontiformes	Tetraodontidae	Tetraodon Linnacus	*75. Tetraodon cutcutia (Ham.)*	C	

C = Carnivorous

H = Herbivorous

D = Detritivorous

O = Omnivorous

L = Larvivorous

P = Predatory

E-P = Euryphagous plaktivorous

Bp = Benthophagous

Mpp = Micro phytoplankton

Mpf = Microplankton feeder

Ppp = Periphytophagous

V = Vulnerable

T = Threatened

En = Endangered

Exo = Exotic

LRlc = Lower risk least concern

LRnt = Lower risk near threatened

SYSTEMATIC ACCOUNT OF THE SPECIES

Order – Clupeiformes

Family – Engraulididae

Genus – Setipinna Swainson

01. *Setipinna phasa* (Ham.)

Setipinna phasa belonging to one of the economically valuable families of fishes Engraulidiae, comprising the anchovies, are quite frequent during the monsoons and appear to be a migrant. This fish is locally known as Phansi. Carnivorous, feeding actively in the surface and littoral zones.

Order – Osteoglossiformes

Family – Notopteridae

Genus – Notopterus Lacepede

02. ***Notopterus chitala*** **(Ham.)**

Members of the family Notopteridae are pedaminantly tropical fresh water fishes of extraordinary diverse body form and size. *Notopterus chitala* is locally known as Cheetal or Moya. This fish is popular for its good taste and rich oil content in the abdominal region. Feeding habits: Carnivorous

Status – Vulnerable

03. ***Notopterus notopterus*** **(Pallas)**

It is frequent both in lentic and lotic watr bodies like *N. Chitala* and locally known as Patara, Moh. This is a very popular food fish all over Bihar, very much known for its dense thick bone.

Feeding habits : Carnivorous

Status : Threatened

Order – `Cypriniformes

Family – Cyprinidae

Genus – Catla Valenciennes

04. ***Catla catla*** **(Ham.)**

Members of the family cyprinidae are most dominant and economically significant group of primary freshwater fishes within its distribution, were the chief contributor to the annual catch composition. *Catla catla* is very popular and an esteemed food fish all over Bihar and largely cultured in ponds throughout the state due to its non-predatory habits and being a quickest growing carp, it is locally named as Bhakur, Katla.

Feeding habits : Herbivorous

Status : Vulerable

Genus - Ctenopharyngodon Steindachner

05. ***Ctenopharyngodon idellus*** **Valenciennes**

Ctenopharyngodon idellus locally called Grass carp is regarded as one of the major popular carps of India. It is popular exotic fish found all over state of Bihar next to Silver carp and Common carp. It originally belongs to China and U.S.S.R. rivers.

In 1959 it was first brought by C.I.F.R.I., Odisha in India for rearing, today it is being cultured all over India. It is moderately liked in Bihar for fresh condition and less price.

Feeding habit – Herbiovorous

Status – Exotic

Genus : Crossocheilus Van Hassett

06. ***Crosscheilus latius latius*** **(Ham.)**

It is principally a hill stream fish morphologically as well as in behavioural aspect much similar to *Garra annandalei*. It behaves very like the Garras adhering to stones in stream, beds (Shaw & Shebbeare, 1937). This fish is locally known as Petphorani,

Genus – Feeding habit – Herbivorous

Status - Vulnerable

Genus : Chela Hamilton

07. ***Chela laubuca*** **Bleeker**

Chela laubuca is not much liked locally as food, taken, mostly by porer sections. Its local name is Dannahrah, Dendula

Feeding habit : Euryphagous planktivorous

Status : Lower risk least concern

Genus : Hypophthalmichthy Bleeker

08. ***Hypophthalmichthys molitrix*** **(Valenciennes)**

It is a carp, native to Asia, introduced around the world for aquaculture as well as controlling excessive growth of phytoplankton in natural waters. It causes damage to

native species. In 1959 it was first of all imported from China and introduced in Indian waters. The common name of this carp is Silver carp which is traditionally sold fresh for human consumption.

Feeding habit **:** Microphytoplankton feeder

Status **:** Exotic

Genus **:** Salmostoma Swainson

09. ***Salmostoma bacaila*** **(Ham.)**

Prefer by people as food, costly fish and tasty. This is used as bait and it is good in eating. It is esteemed as food on account of invigorating qualities of its flesh (Talwar & Jhingran, 1991). This fish is known as Chelliah, Chilwa, Chalhava in Bihar.

Feeding habit **:** Omnivorous

Status **:** Lower risk least concern

Genus **:** Esomus Swainson

10. ***Esomus danricus*** **(Ham.)**

Esomus danricus, widely distributed throughout India, is a small indigenous fish species. It is knwon as Dendua, Dahwiee in Bihar. This flying barb is of less economic importance because of its small size.

Feeding habit **:** Omnivorous

Status **:** Lower risk least concern

Genus **:** Danio Hamilton

11. ***Danio rerio*** **(Ham.)**

Danio rerio, the Zebra fish of aquarists, is popular for its attractive blue bands. Zebra fish bears many valuable characteristics for studying human genetics and disease since the 1960s. This fish has become a model organism for biomedical research.

Feeding habit **:** Omnivorous

Status **:** Least concern

Genus : Rasbora Bleeker

12. *Rasbora daniconius* (Ham.)

Rasbora daniconius, a ray finned fish, occurs in a variety of habitats. It is locally known as Dendua, Gola, Darai. Ths fish is also used as an aquarium.

Feeding habit : Omnivorous

Status : Least concern

Genus : Aspidoparia Heckel

13. *Aspidoparia morar* (Ham.)

Aspidoparia morar, an indigenous fresh water carp, was named by Hamilton in 1822. This fish species is of no interest to fisheries. This is a food fish marketed in fresh condition. It is an ornamental fish and eaten by rural persons as a source of protein and micronutrient substances, It is locally called Chippuah, Kenwachi.

Feeding habit : Omnivorous

Status : Lower risk least concern

Genus : Barilius Hamilton

14. *Barilius bendelisis* (Ham.)

Mostly confined in shallow hill streams with beds bests with rock boulder. Hamiltons Barila and Indian hill trout are the common name of this fish. This fish is called Bhola in Bihar.

Feeding habit : Periphytophagous

Status : Lower risk least concern

Genus : Cyprinus Linnaeus

15. *Cyprinus carpio* Linnaeus

This fish was first of all introduced in the plain Indian districts in 1959, however, now being cultured all over India as well as world. *Cyprinus carpio* (Common carp or

European carp) is native to Europe of Asia, often considered a destructive invasive species, has been introduced to every part of the world.

Feeding habit : Omnivorous

Status : Exotic

Genus : Puntius Hamilton

16. *Puntius chola* (Ham.)

This species is very common in all water-logged areas throughout the state of Bihar. It is closer to *Puntius sophore* differing from it in colour pattern. Gunther (1968) considered this species synonymous with *Leuciscus thermal is Valenciennes (1842)* from Sri Lanka. It is locally called Sidhari in Bihar. It is commercially less important fish.

Feeding habit : Herbivorous

Status : Vulnerable

17. *Puntius conchonius* (Ham.)

Puntius conchonius (Rosy Barn) is very common in waterlogged areas throughout the state of Bihar. This species is close to *P. ticto ticto* (Ham.) (Jayaram 1991). Economically less valued fish due to its less flesh and smaller size. It is locally called Sidhari.

Feeding habit : Omnivorous

Status : Vulnerable

18. *Puntius sophore* (Ham.)

Hamilton (1822) described this species as *Cyprinus sophore* deriving the specific name from Sanskrit meaning “a beautiful little fish”. This species is close to *Puntius chola*, and unique in the sense that it has given rise to several others. Its local names are Pottiah, Sidhari.

Feeding habit : Herbivorous

Status : Lower risk least concern

19. ***Puntius sarna sarana*** **(Ham.)**

This fish is quite frequent among other Puntius species and is considered of economic importance because of its comparatively big size and good oily taste under the genus Puntius Hamilton. It is locally called Durhie, Potah.

Feeding habit : Omnivorous

Status : Vulnerable

20. ***Puntius ticto*** **(Ham.)**

A small, most common fish found all over Bihar. It is liked due to its slightly 'bitter' taste (Tita=Bitter). This species is closely related to *P. Chola.* It shows variations in its major characters. Its local name is Kotree, Sidhari.

Feeding habit : Herbivorous

Status : Lower risk least concern

21. ***Puntius terio*** **(Ham.)**

Puntis terio is popularly called Terio Barb' and used as aquarium minnow due to its attractive colours. It is related to *P. sophore* but differs in several characters (Jayaram, 1991). The male species during its mating turns into beautiful orange instead of red (Sen, 1981). It is locally called Sidhari.

Feeding habit : Omnivorous

Status : Lower risk near threatened

Genus : Osteobrama Heckel

22. ***Osteobrama cotio cotio*** **(Ham.)**

It is ray finned fish threatened by extensive loss of habitat, deforestation and pollution and useful in controlling mosquito larvae. This fish species is marketed in fresh condition and used as food fish. It is said this species supply vitamin A to a greater extent. It is known as Moa, Goordah.

Feeding habit : Omnivorous

Status **:** Lower risk near threatened

Genus : Labeo cuvier

23. ***Labeo angra*** **(Ham.)**

Labeo angra, the carps and minnows, native to Asia, a commonly known as Angra Labeo, is of commercial importance as a food and sport fish. It is cultured and highly growing species of Labeo and vey delicious food supplying a huge amount of protein.

Feeding habit **:** Herbivorous

Status **:** Lower risk near threatened

24. ***Labeo boga*** **(Ham.)**

Labeo boga is an esteemed minor carp of economic importance. This species is distributed in Gengatic provinces. This fish is locally known as Bhagan and presumably Baga is also a name for this species. The common name of this species is violet Gilled Shark.

Feeding habit **:** Detritivorous

Status **:** Lower risk near threatened

25. ***Labeo calbasu*** **(Ham.)**

This Labeo species is very common culturable, esteemed major carp, known for its sweet taste. *L. calbasu* is one of the important foods and game fish of India in general and state of Bihar in particular, being used largely in stocking tanks. It is also known as Kalbasu.

Feeding habit **:** Herbivorous

Status **:** Lower risk near threatened

26. ***Labeo dero*** **(Ham.)**

Labeo dero is popular for its taste, big size and availability. It is locally called Bongsa. It is rarely found.

Feeding habit : Herbivorous

Status : Vulnerable

27. *Labeo rohita* (Ham.)

Labeo rohita is riverine in nature but widely cultured all over India. This species is most economically important fish of north-eastern states of India. Its common name is Rohu.

Feeding habit : Herbivorous

Status : Lower risk near threatened

28. *Labeo dyocheilus* (McClelland)

It is a migratory species and commercially important. This species is also considered suitable for aquaculture. It has minor fishery value. It is cultured in captivity (Uniyal and Kumar, 2006). Adults live in clear active currents of large rivers (Talwar and Jhingram 1991). It is also known as Boalla, Bhola.

Feeding habit : Herbivorous-Omnivorous

Status : Vulnerable

29. *Labeo gonius* (Ham.)

Labeo gonius, an ornamental fish, is advantageous for short duration culture. It is a medium carp also known as 'Kuria labeo' or 'gonus'. This fish is locally called as 'Kursha'.

Feeding habit : Herbivorous

Status : Lower risk near threateneds

Genus : Cirrhinus Oken

30. *Cirrhinus mrigala* (Ham.)

This species is a very popular carp of India of high over the economic importance, cultured all over the state of Bihar. It is an highly esteemed food fish. Though this

species in a hill stream form but also found in streams with sandy and muddy substratum. It's another name is Naini.

Feeding habit : Omnivorous

Status : Vulnerable

31. *Cirrhinus reba* (Ham.)

C. reba is an esteemed food fish. It is famous for its sweet taste. It is found in all kinds of waters and famous amongst minor carps, however, this fish is comparatively of small size. Its common as well as local name is Rewah.

Feeding habit : Herbivorous

Status : Vulnerable

Genus : Botia Gray

32. *Botia dario* (Ham.)

*B.Daria*is a typical hill stream fish and liked for its good flavour. This species is occasionally found in aquarium shops. Its common name is Botya, however, this species of Botia is locally called Baghawa.

Feeding habit : Omnivorous

Status : Vulnerable

33. *Botia lohachata* Chaudhuri

Botia lohachata or Yoyo loach, sometimes referred to as a scaleless fish is an active scavenger. This fish is commercially useful in aquarium trade. Its local name is Bagha.

Feeding habit : Carnivorous

Status : Endangered

Genus : Somileptes Swainson

34. ***Somileptes gongota*** **(Ham.)**

S. gongota is a typical hills stream fish. It is an ornamental fish. It is locally called Baluari. It is of less economic importance.

Feeding habit : Carnivorous

Status : Lower risk near threatened

Genus : Lepidocephalus Bleeker

35. ***Lepidocephalus guntea*** **(Ham.)**

Fishery value of this species is less. A small fish being eaten by the poor people. This species is found most commonly all over the state of Bihar. It is locally called Nakati.

Feeding habit : Detritivorous

Status : Lower risk least concern

Genus : Rita Bleeker

36. ***Rita rita*** **(Ham.)**

It is a strong large sized bony fish next to *Wallago attu.* It is not much liked as food taken by poor people. It survives without water for some time due to its cutaneous respiration *(Jayaram, 1977).* Its common name is Rita. It is locally called Hunna.

Feeding habit : Benthophagous

Status : Lower risk near threatened

Genus : Mystus Scopoli

37. ***Mystus bleekeri*** **(Day)**

This fish is used to eat in the state of Bihar. It is locally called Tengra.

Feeding habit : Carnivorous

Status : Vulnerable

38. ***Mystus cavasius*** **(Ham.)**

This species is economically important. It is locally called kavasi.

Feeding habit : Carnivorous

Status : Lower risk near threatened

39. ***Mystus tengra*** **(Ham.)**

Mystus tengra is commonly known as tiger zebra eat fish and locally known as tengara or tenger. It is a very delicious food supplying a higher calorific value.

Feeding habit : Carnivorous

40. ***Mystus vitattus*** **(Bloch)**

It is a broadly distributed most popular Mystus species in spite of its small size. *Mystus tengara* (Ham.) and *Mystus vitattus* (Bloch) resemble each other. Hora stated *M. Tengara* is probably synonymous with *M. Vittatus. M. Vitattus* is locally called as tengra.

Feeding habit : Carnivorous

Status : Vulnerable

Genus : Ompok Lacepede

41. ***Ompok bimaculatus*** **(Bloch)**

It is a good eating fish, called the "Butter fish" by the Europeans. It is a popular costly fish. It is locally called Jalkapoor.

Feeding habit : Predatory

Status : near threatened

Genus : WallagoBleeker

42. ***Wallago attu*** **(Schneider)**

It is most frequent amongst the catfishes found in rivers. It is very distructive to all other kinds of fishes as it is predatory by nature. It is highly esteemed for its food value chiefly by poorer classes. Its local name is Boyari.

Feeding habit : Carnivorous

Status : Near threatened

Genus : Clupisoma Swainson

43. ***Clupisoma garua*** **(Ham.)**

This species is considered good eating and is generally favoured by the needy people. Its local name is Batchwa.

Feeding habit : Carnivorous

Status : Vulnerable

Genus : Pseudotropius

44. ***Pseudotropius atherinoides*** **(Bloch)**

It is considered to be an inferior kind of economic value as a food fish, despite its wide distribution. Its bright colour and small size attract the attention of aquarists (Jayaram, 1977b). Its local name is Barusa.

Feeding habit : Omnivorous

Status : Endangered

Genus : Eutropiichthys Bleeker

45. ***Eutropiichthys vacha*** **(Ham.)**

It is found in abundance during monsoon months. It local name is Bachwa.

Feeding habit : Carnivorous

Status : Endangered

Genus : Bagarius Bleeker

46. ***Bagarius bagarius*** **(Ham.)**

This fish is one of the largest known fresh water fish and is a favourite of anglers, and also called the fresh water shark. This fish is mainly an inhabitant of rapids and

rocky pools. This fish is locally known as Goonch. It is not a good for eating purpose because of its due stiff and fibrous yellowish red flesh.

Feeding habit **:** Carnivorous

Status **:** Vulnerable

Genus **:** Gagata Bleeker

47. ***Gagata cenia*** **(Ham.)**

This species of sisorid catfish is found in the Ganges delta. Its common name is clown cat fish. This fish is most attractive at its smaller size suited to the aquarium. This fish is locally known as Tinkatia.

Feeding habit **:** Omnivorous

Status **:** least concern

Genus **:** Nangra Day

48. ***Nangra viridiscens*** **(Ham.)**

It is known as Huddah nangra.It is harmless, commercial species of cat fishes.

Feeding habit **:** Carnivorous

Status **:** Lower risk near threatened

Genus **:** Erithistes Muller & Troschel

49. ***Eristhistes pussilus*** **Muller & Troschel**

E. Pussilus s mostly found in hill streams. It is known from Bihar in Ganga drainage. Its common name is giant Moth cat fish. It is rare in aquarium trade.

Feeding habit **:** Carnivorous

Genus **:** Laguvia Hora

50. ***Laguvia shawi*** **Hora**

It is small fresh water hill stream fish. This fish is called Shaw stone cat fish is English.

Feeding habit : Omnivorous

Genus : Glyptothorax Blyth

51. ***Glyptothorax telchitta telchitta*** **(Ham.)**

This fish is quite frequent in the sandy muddy and rocky environment. This fish is locally known as *Telliah*, no interest to fisheries.

Status : Vulnerable

Genus : Sisor Hamilton

52. ***Sisor rhabdophorus*** **(Ham.)**

It is a modified cat fish confined to some of the tributaries of north Indian rivers.

This fish is locally called Bistuiya. This fish possesses a long filamentous extension of the uppermost caudal finray hence it is called rabdophorus (Gk. Rod and phorus).

Feeding habit : Carnivorous

Status : Endangered

Genus : Clarias Scopoli

53. ***Clarias batrachus*** **(Linnaeus)**

It is most frequent amongst 'live' fishes. This species is highly esteemed as food amongst the 'live' cat fishes, frequently sold in the fish market. This species survives for a long time out of water due to possession of accessory respiratory organs. It is a high-priced fish for it believe rejuvenating vigor. Its local name is Magur.

Feeding habit : Carnivorous

Status : Vulnerable

Genus : Heteropneustes Miller

54. ***Heteropneustes fossilis*** **(Bloch)**

Most common siluroid fishes found throughout India. This fish is able to breathe air and can survive out of water for some time. This fish is highly esteemed as food and extensively on account of the reported invigorating qualities of its flesh. Its local name is Shinghi.

Feeding habit : Carnivorous

Status : Vulnerable

Genus : Xenentodon Regan

55. ***Xenentodon cancila*** **(Ham.)**

It occurs in rivers, canals, lakes and beds, commercially not so important fish. It is locally called Kawwa.

Feeding habit : Carnivorous

Status : Lower risk near threatened

Genus : Aplocheilus McClelland

56. ***Aplocheilus panchax*** **(Ham.)**

It is one of the significant indigenous lavivorous species. Many Zoologists certifiedthis of great utility for malaria control. Its local name is Dendula.

Feeding habit : Larvivorous

Genus : Channa Scopoli

57. ***Channa marulius*** **(Ham.)**

The species is known for its giant size. It is commercially less important. It is locally called Sauri.

Feeding habit : Carnivorous

58. ***Channa orientalis*** **(Schneider)**

It is commercially less important. Its local name is Chanaga. Menon (1974) synonymised Channa gachua (Ham.) with this species.

Feeding habit : Carnivorous

Status : Vulnerable

59. *Channa punctatus* (Bloch)

This fish is sold in the market and also useful for aquarium. Its local name is Garai.

Feeding habit : Carnivorous

Status : Lower risk near threatened

60. *Channa striatus* (Bloch)

It is most popular fish all over Bihar. This fish is commercially important and liked by all in Bihar. It is locally known as Sauri.

Feeding habit : Carnivorous

Status : Lower risk least concern

Genus : Monopterus lacepede

61. *Monopterus cuchia* (Ham.)

People reluctant to take it because of its snake lie appearance. It is locally knwon as Anhaya Baam/Bami.

Feeding habit : Carnivorous

Genus : Chanda Hamilton

62. *Chanda baculis* (Ham.)

The common name of this species is Himalayan glassy perchlet. It is found in Himalayan and Indo-gangetic plains. Its local name is Chanari.

Feeding habit : Carnivorous

63. *Chanda nama* (Ham.)

It is not commercially important because of its strong spines. It is locally known as Chanari. A very good fish for home aquaria.

Feeding habit : Carnivorous

64. *Chanda ranga* (Ham.)

C.nama and *C. ranga* both resembles one another morphologically but can be distinguished on the basis of several characters. *C. ranga* is not important economically because of its spines and scanty flesh. Its local name is Channa/Chanari and highly esteemed as an aquarium fish.

Feeding habit : Carnivorous

Genus : Nandus Valenciennes

65. *Nandus nandus* (Ham.)

N. nandus is a very popular fish throughout Bihar and highly esteemed as an aquarium fish. Its local name is Dhebari, however, it is commonly called Nandus/Chamariya. This fish is useful as an aquarium fish.

Feeding habit : Carnivorous

Genus : Badis Bleeker

66. *Badis badis* (Ham.)

Rarely found in Bihar. This fish is useful as an aquarium fish. Its vernacular name is Sumha.

Feeding habit : Canivorous

Status : Vulnerable

67. *Badis dario* (Ham.)

It is a tropical smallest known percoid fresh water fish species. In aquarium trade this fish is sold under a variety of names.

Feeding habit : Carnivorous

Genus : Glossogobius Gill

68. ***Glossogobius giuris*** **(Ham.)**

This species usually shares a common habitat with Channa spp. This fish has much fishery value. The vernacular name of this fish is Bulla.

Feeding habit : Carnivorous

Status : Lower risk near threatened

Genus : Anabas Cuvier

69. ***Anabas testudineus*** **(Bloch)**

This fish is caught from beels and marshy areas and abundantly found in the market immediately after the rainy season. This species is a very popular food and known for its delicious taste. Its local name is Kawai.

Feeding habit : Predatory

Status : Vulnerable

Genus : Colisa Cuvier

70. ***Colisa fasciatus*** **(Schneider)**

This species was regarded as larvivorous fish by Hora & Mukherjee (1938). Its local name is Khosti.

Feeding habit : Omnivorous

Status : Lower risk near threatened

Genus : Tilapia A. Smith

71. ***Tilapia mosambica*** **Peters**

It is an oreochromine cichlid fish native to Africa and popular for aquaculture. This species has been introduced for a wide variety of reasons (e.g., to control mosquitoes, commercial fish and as a food etc.)

This species is an invader of aquatic ecosystem. It is most popular farm raised fish, much loved for its cheap cost and delicious taste.

Feeding habit : Herbivorous

Status : Exotic

Genus : Macrognathus Lacepde

72. *Macrognathus aculeatus* (Bloch)

M. aculeatus lesser spiny eel lives in ditches, tank, beels, bheries, ponds, tributaries. This species is not much important for its small size. Its local name is Pataya.

Feeding habit : Carnivorous

Genus : Mastacembelus Scopoli

73. *Mastacembelus armatus armatus* (Lacepede)

It is a most popular species for its long size, good girth and oily taste. This is a good eating hardy fish and can withstand extreme drought by keeping itself inside the mud and silt months together till the onset of the monsoon rains. Its local name is Bami.

Feeding habit : Carnivorous

74. *Mastacembelus pancalus* (Ham.)

This species is commercially not much important due to its small size. It is locally called Gaincha.

Feeding habit : Carnivorous

Genus : Tetraodon Linnaeus

75. *Tetraodon cutcutia* (Ham.)

This fish is not eaten locally due to its poisonous effect, only poors take it as fish occasionally out of extreme poverty.

Feeding habit : Carnivorous

CHAPTER-V

FISHING GEARS AND CRAFTS

A large number of fishing gear and tackles are operated in different stretches of the river Punpun for its commercial exploitation. The fishing methods and gears are of mostly traditional type, depending on the target species, fishing ground, climate, current and several hydrobiological conditions. The methods of fishing vary from place to place. It was observed that they are remarkably primitive when compared to those employed elsewhere and are more or less common methods. The major reasons for depletion of catch in the river Punpun are adoption of unscientific fishing practices, over exploitation, habitat degradation and anthropogenic activities. The knowledge of fishing gear, crafts and fishing methods are very important for scientific, judicious exploitation and management of any capture fishery. Methods ranging from catching fish with the hands to the operation of large and indigeniously designed nets are adopted for fishing in the river Punpun due to its highly diverse nature. The fishing equipments have been described under the following heads. Fishing boats, Nets, Traps, Angling and Hunting

The various fishing implements nets, traps etc. used in this river were remarkably primitive and more or less common methods. Ordinarily fishing is carried out in this river throughout the year but the main period of fishing is from October to June which varies in accordance with varying hydrographical conditions, prevailing in different sites and parts of the year, the fishing methods also vary. The fishing equipments have been described under the following heads:

FISHING BOATS, NETS, TRAPS AND HUNTING

FISHING BOATS

Fishing craft in use throughout the river Punpun are locally built, mostly non-mechanized and indigenous. Fishing boats are locally known as

"Nav" and are small to medium size plank-built canoes (Fig. 04). These canoes are hollowed trunk of Sal trees, designed to carry one to ten persons. The cost of a canoe comes to Rs. 10000 To 80000 presently. The total number of boats during peak season were about 25 at Nabinagar Boats of different sizes were found in the river.

Type	Total Length	Breadth	Depth	
			Front	Back
1.	12'	1.5'	1'	1.5'
2.	25'	1.5'	1.5'	3'
3.	30'	3'	2'	4'

The fishing methods vary in accordance of the prevailing hydrographical conditions. Chauhan (1947) has described smaller boats in detail:

Fig. 04: Wooden Boat

FISHING NETS

Different types of nets are used in the river Punpun for fishing.

1. Cast net: - This net is locally known as Fekajal or Maghali (Fig. 05 & 06). This net is operated in shallow water by single person either standing on the bank of the river or standing on a small boat. This net is thrown over the surface of water in a way that is spreads out in the air before it sinks into the water, hence this net is also called throw net or feka jal. It is a umbrella shaped conical net bearing a strong cord on the apex of the cone and heavy sinkers of solid iron beads on its peripheral rim. The number of the sinkers varies from 100 to 200 which settles at the bottom. The net is thrown to cover the fish and hauled slowly with the help of long strong cord connected to the apex. Cast net is prepared from silk or nylon threads and the mesh diameter is about 20-25 mm. Cast nets were originally developed in India (Brandt, 1972) and has been in use for thousands of years with various modifications. Three types of cast nets are common in India viz. fixed peripheral pockets, without peripheral pockets and stinged cast nets. Since small varieties of fishes are caught by this net, the returns are so poor, that fishermen can no longer depend on this fishing method for them livelihood.

Fig. 05: Cast Net

Fig. 06: Cast Net

2. Baghjal:- This is a type of sein (a fishing net) hanging vertically in the water having sinkers on one edge and floats on the other and its ends are drawn ashore. Seines are very popular in the Ganges system. It is extensively used in the Ganges system for large scale fishery. Its length and width generally depend upon the depth of the water body. Baghjal of varying dimensions and mesh size are used for fishing. It is made of silkcords or nylon cords having generally a length of about 10-25 meters and its width depends upon the depth of the water body where fishing has to be carried out. The net bears strong ropes on its four corners for pulling. The whole net is dragged for distances with the help of 6 to 10 persons. Three persons on each side hold the ropes attached to the upper margin of the net, while two on each side hold ropes attached to the lower margin of the net. This net is used in the lake fishery also in Bihar. Sometimes boats of various sizes are also pressed into services depending upon the depth of the water body. The fishermen drag the net to the bank of the river when sufficient amount of fishes is trapped.

3. Bhasajal:- This is a specialized type of large cotton silk or nylon seine net. This net is used in deep water having sufficient width. Its length depend upon the width of the river and the width of the net is about 1-1.5 metre. The net is fixed vertically with the help of bamboo sticks in the river bottom. The upper margin of the net bears floats/light pieces of woods of

low specific gravity which keeps net erect/vertical without sinking. The floats are fixed at an interval of about half meter. The mesh size of the net varies from 30-50 mm. The net is fixed in the river water and fishes travelling get trapped in the mesh, finally the net is taken out and the fishes are hand-picked.

4. Sipuli:- Sipuli is manufactured locally with strong and straight stem of *Saccharum fascum* (Roxb) and *S. spontaneum* (L) and used where fishes are ascending the stream. Sipuli is a mat like structure with three raised sides (Fig. 07). It is fixed in a manner that the stream has to fall through it. The raised three sides of the Sipuli does not allow any fish to jump and the stream enter into the Sipuli from the fourth side which has no raised margin. The length of the Sipuli ranges from 2. To 3 meters or even more. The length is generally two or more times of the width. The Sipuli is fixed with the help of bamboo sticks. The number of bamboo sticks varies according to its length and requirement. The water filters through the Sipuli and the fishes are trapped on the mat. The Sipuli is fixed at a point where there is a steep fall in the stream. The knitting of the Sipuli is done with the help of strong thin threads of nylon or grass ropes. Generally small sized fishing like Puntius spp., Channa spp. etc. are trapped on the Sipuli.

Fig. 07 : Sipuli

5. Khokha:- It is an umbrella shaped net fixed on six bamboo poles (Fig. 08 & 08A). Length of the bamboo stick generally varies from 1 to 1.5 meter. One pole of all the bamboo poles are tied together at one place and after some distance all the poles are tied internally separately with an iron ring with plastic ropes. The outer margin of the net is tied with the last poles of the six bamboo sticks tightly with the help of nylon ropes. Thus, it becomes umbrella shaped net operated by a single person in shallow water. This trap is utilized where surface floating fishes are common. The trap is dropped inside the water and suddenly lifted, so the fishes come trapped inside the net.

Fig. 08 Khokha

Fig. 08A

Fig. 08 & 08A: Khokha and its operation

6. Jalbans:- Jalbans is a triangular net to be used by one person for trapping surface floating fishes during summer season (Fig. 09). It is prepared by two bamboo sticks. Each bamboo pole is about 4 feet in length. Both the poles are tied together at one end in a way that their ends remain one foot apart. The basal ends of two poles are connected by a rope and the basal end of each pole is connected to the distal pole of another pole which keep the net in fixed position. A sac like net is stitched on the bamboo poles so that the upper open mouth is fixed with the poles, while the lower end is hanging down. This trap is put inside the water and when fishes come above the trap, it is lifted suddenly and fishes are trapped inside the net. Generally small and medium sized fishes are trapped.

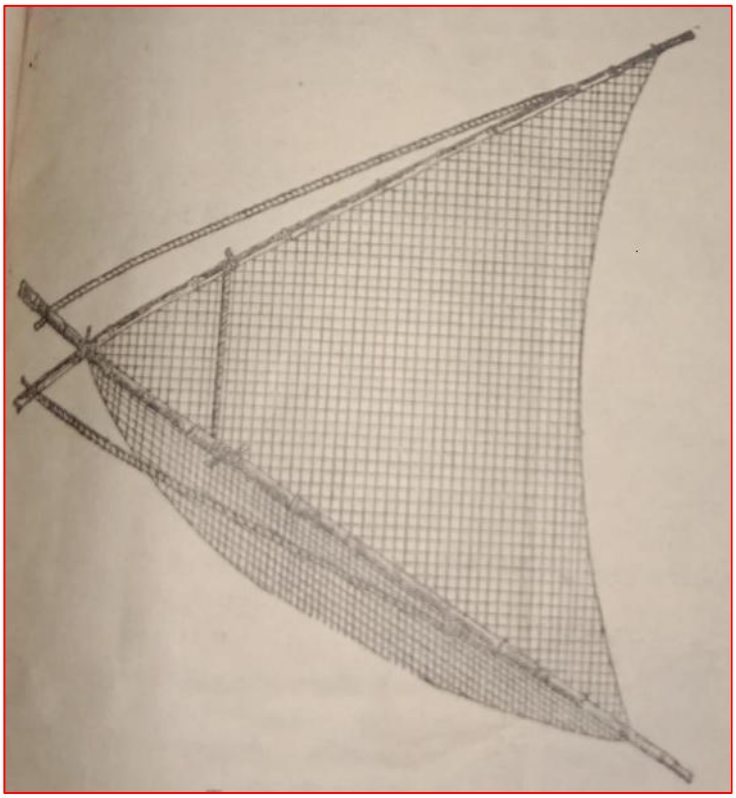


Fig. 09: Jalbans

Traps:- Traps are impounding devices into which an organism is lured and from where escape is made difficult because of the non-return device fixed at the entrance (Job and Pantulu, 1953) Different types of traps are in operation in inland waterbodies of India, however, the principles of operation of fish traps, is same in the country. Different types of traps are in operation in inland water bodies of India like box traps, filter traps,

tubular traps, plunge baskets, pound traps etc. Traps, the highly selective gear is made of natural materials bearing low capital investment.

1. Jhap: – This trap is also known as Top and Ottal in Travancore, Thapa in Orissa and Tappu and Polui in Bengal (Sen, 1972). This trap is used in the soft mud of the river bank. The trap is conical in shape and made of split bamboo pieces (Fig. 10), It bears a circular opening at the top. It is used in shallow water. The trap is dropped in water and the wide mouth pressed into the soft mud. The fishermen insert his hand through the opening of the trap and catches smaller and medium sized fishes present in the mud like Mystus spp., Channa spp., *Heteropneustes fossilis*, Puntius spp. etc.

Fig. 10: Jhap

2. Stakenet: - It is a conical bag net. It is set against current of water and filters small fishes. It is set in the water body with the help of bamboo poles erected to the bottom. Floats and anchors are also used to suspends the net.

ANGLING:

1. Line and hooks: Hook and line fishing is the simplest fishing method. It can be practiced by anyone with minimum skills. Different types of hooks depending on target species are available in market and different types of

artificial, plant or animal origin, dead or alive baits are used in hook and line fishing. Similarly, various types of lines are also in operation like hand line, long line, drop line etc. The principle of the line fishing is to offer bait and entice the fish so that it can be lifted from the water together with the bait.

HUNTING WITH WEAPONS:

1. Spear: – This is also called Sharhad. This weapon is used during winter season, when the depth of water is high, for hunting medium to large sized fishes. This weapon consists of a bamboo shaft of 3.5-5' length. This distal end of this weapon bears 10-15 securely tied separate split bamboo. Each spear bears a conical hollow iron point. When thrown on a fish the spears fan out which increases the chance of hitting the fish.

2. Topa: – This is also called a spear. This weapon is used for hunting the medium size fishes. It consists of a long bamboo shaft of about 6'. The distal end of this weapon consists of about 10-15 country made iron spears which are tied.

MISCELLANEOUS METHODS

1. Filtering with the basket: Women and children's of fishing community occasionally collect fishes with the help of baskets. Small fishes like Puntius, Colisa, Channa etc. are trapped in the basket by filtering the water.

2. By hands: During summer season the water level falls sufficiently low and a portion of the river shore is enclosed by muds. The fishes found in mud are picked up by hands. Fishes hiding in floating vegetation like Puntius sp, *Amphipnouscuchia* etc. near the shore are also caught by hand.

CHAPTER-VI

EXOTIC FISH SPECIES

Exotic fishes are non-indigenous having their origin in another country. Exotic fishes have been introduced in different Indian regions for various purposes like augmented fish production, ornamental purpose, sport fishery and weed/mosquito control etc. A fish species intentionally or accidently transported and released into an environmental outside its present range by man is called exotic fish species. The seeds, eggs, spores or other biological material which are capable of propagating that species, not native to that habitat, is called an exotic species. Exotic fish, an alien species, is species, subspecies of lower taxon brought in from strange, abroad or foreign in an ecosystem or area due to anthropogenic activities. Exotic fishes are species occurring outside of its natural range. In Indian waters the history of exotic fish's introduction dates back to a century when the country was under the British rule and such fisheries were probably introduced as a means for recreation only. In 1863 Sir Francies Day, the author of the classical work on the Fish fauna of Indian region, was probably the first person who tried to introduce the brown trout, *Salmo trutta fario* in the Nilgiri water, but his attempt was unsuccessful (Jhingran 1975). Game or Sports fishes and Larvicidal fishes. The post-independence India witnessed introduction of eight exotic fish species viz.

(i) *Cyprinus carpio* Linnaeus

(ii) *Ctenopharyngodon idella* Valencinnes

(iii) *Hypophthalmichhys molitrix* Valencinnes

(iv) *Puntius Javanicus* Bleeker

(v) *Tilapia mossambica* Peters

(vi) *Salvelinus fontinalis* Mitchill

(vii) *Onchorhyncus nerka* Walbaum and Artedi

(viii) *Salmo salar* Linnaeus

India has vast and varied inland fisheries resources perhaps richest in the world, in which several indigenous variety of fish services. The fish culture in India was mainly dependent upon the culture of some most common carps like Labeo, Catla and Mrigal but due to the introduction of the foreign breeds of fishes to Indian freshwater ponds, lakes and reservoirs and their culture with the Indian counter parts yields a higher production.

The riverine resources of India comprise of about 29,000 km river length. The Indian riverine resources have been divided into five systems viz.

Ganga River System *(29%)*

East Coast River System (40%)

West Coast System (12%)

The Brahmaputra System (75%) and

The Indus River System (12%)

River in India constitute the backbone of capture fisheries. There are 113 major and minor rivers along with their principle tributaries. India is one of the largest fishes producing nations in the world and ranks ninth among all the nations (Jhingran, 1991). The Gangetic system is home for more than 265 species of fishes, which form the source of culturable fishes in the country.

During course of ichthyofaunal investigation of the river Punpun at Nabinagar, Bihar (India) 75 species of inland fishes were recorded dominated by Cypriniformes followed by Siluriformes, Perciformes, Channiformes, Mastacembeliformes, Osteoglossiformes, Symbranchiformes and Tetraodontiformes belonging to 51 genera, 22 families and 10 orders. The trophic composition revealed abundance of carnivorous species (46.6%), followed by omnivorous (22.6%), herbivorous (18.6%), detritivorous (2.6%), predatory (2.6%), euryphagous planktivorous (1.3%), microphytoplankton feeder (1.3%), benthophagous (1.3%), periphytophagous (1.3%) and larvivorous (1%). Cypriniformes dominated with 32 species. The trend of dominance of Cyprinids in the river Punpun

agrees with the observation in tropical Indian rivers (Das MK *et. al.*, 2013 and Sarkar UK *et al.,* 2009). Cyprinids are the most dominant and economically significant group of primary fresh water fishes within its distribution, were the chief contributor to the annual catch composition. *Ctenopharyngodon idellus* (Valenciennes) *Hypophthalmichthysmolitrix* (Valenciennes) and *Cyprinus carpio* (Linnaeus) are common exotic fishes, recorded in the river Punpun also, now cultured all over India.

***Ctenopharyngodon idellus* (Valenciennes):**

The common name of this carp is Grass carp (Fig. 11). This carp is a native of China and river Amur in Russia. In India Grass carp was first of all introduced in 1959 at Cuttak (Orissa) for the sole purpose as food fish and secondarily for controlling sulmerged vegetation. Grass carp due to its fast growth rate became an integral part of composite fish culture in India. It is a voraciferous herbivorous fish, feeding on selected macrophytes such as Hydrilia, Najas and Vallisneria sp. but do not consume floating hydrophytes such as Pistia, Eichhornia and Salvinia sp. which are abundant in lakes, reservoirs, ditches, ponds all over India. Grass carp has diversified food habits bearing specialized pharyngeal teeth for aquatic vegetation and its daily food requirement is as much as its body weight. Its head is bigger than body and do not bred in stagnant water. The fish attains a weight of 4.5-7 kg or more in about four years. Its fries feed upon both zoo and phytoplanktons but adults are strictly herbivorous and it is a problem to provide it large quantity of preferred weeds. Grass carp has both positive and negative impact on the indigenous species of fishes.

(i) It controls the weeds.

(ii) It brings in circulation the nutrients locked up by the weeds

(iii) It produces valuable proteins.

The negative impact of grass carp on the indigenous species of fishes includes:

(i) It impacts the survival of fishes and prawns hidden in the weeds.

(ii) It alters the water quality.

(iii) It increases turbidity.

(iv) It reduces dissolved oxygen and there is an increase in plant nutrients.

(v) Influence species abundance and fish composition.

Fig. 11: *Ctenopharyngodon idellus* (Grass Crap)

***Hypophthalmicthys molitrix* (Valenciennes):**

Its common name is Silver carp. The Silver carp was introduced to India in the year 1959. The fingerlings of Silver carp were brought from Japan. Silver carp originated from China, Amur, Basin and Russia too. It has been introduced and cultured in many countries of the world like China, Taiwan, Thailand, Malaysia, Japan, Sri Lanka, India, Pakistan, Nepal, Philippines, Russia, Myanmar, Hongkong, Singapore, UAR, Israil etc. Silver carp is a fast growing planktivore fish feeding mainly on small phytoplankton. It does not spawn in confined water and easy to harvest.

The body of silver carp is oblong, compressed with pointed head, small eyes and a little protruding lower Jaw. Body is covered by small scales and possess abdominal keel. It is pelagic and planktophagus.

Its fry feed on phytoplankton and post larvae on zooplankton, however, adult subsist on protozoa, rotifers, decayed macrovegetation and detritus. It has been reported that Silver carp survive well on artificial food like rice bran, bone meal etc. during culture and in wild it attains sexual maturity in 2-6 years. There are some disadvantages also in Silver carp culture. Silver carp competes with Catla and a special care is needed for long distance transportation of its fry. There are also problems in its stocking. The genetically eroded Silver carp increased danger to biodiversity because its competition for food to endemic species in high. Its wide use can contribute to increase aquaculture production by utilizing vacant niches as aquatic plants, benthos and phytoplankton, Silver carp fully utilizes nutrients in the water during November to February. Because the metabolism of endemic species is affected in cold period, hence growing period can be extended full year, significantly contributing food security of the nation. This exotic fish species has adopted well in the reservoir ecosystem and yielding high in Gobindsagar reservoir of Himanchal Pradesh too.

***Cyprinus carpio* (Linnaeus):** The common name of *Cyprinus carpio* (Linnaeus) is common carp or European carp. It is a native of China, generally found at an altitude over 304msl or above. There are three categories of common carp recognized on the basis of their body scales which are distributed world over tropical as well as temperate regions now.

1. *Cyprinus carpio* var. communis (Scale carp)
2. *Cyprinus carpio* var. specularis (Mirror carp)
3. *Cyprinus carpio* var. nudus (Leather carp)

The body of *C.carpio* var *communis* is covered completely with smaller scales, hence called scale carp. The body of *C. carpio* var. *specularies* is covered with large shiny scale, hence called Mirror carp. The body of *C. carpio* var. *nudus* has a leathery appearance without scales. In India *C. carpio* var. *specularies*, german stock was introduced in 1939 fro Ceylon. Scale carp was brought to India (Cuttak) from Bangkok in August 1957 because the German stock of the common carp does not breed freely in Indian tropical waters. The German stain of common carp was introduced in

Uttrakhand in 1946 and later the Dal lake was invaded and heavily infested causing exclusion of all other local species, specially the schizothoracids. This species showed a lucrative fishery in Himanchal Pradesh despite of dominating silver carp. It competes with indigenus *Cirrhinus mrigala, Clarias batrachus* both for the space as well as for food due to its bottom habitat.

This species is burrowing in nature. It makes the water turbid and reduces phytoplankton production as well as natural productivity. Due to overflowing of ponds and reservoirs it has been recorded from all the Indian major rivers. This species is not easily harvestable due to their slow movement in water and bottom dwelling habit. The population of Common carp has been increased along the stretches of Ganga whereas the availability of Gangetic carps has been decreased. *C. carpio* is omnivorous. It grows very fast and convert food into flesh efficiently. Naturally this carp breeds in confined water, in shallow, marginal and weed infested areas, breeding twice a year, January to March and July to August. This fish breeds upto five years of age after attaining maturity.

Fig. 12: *Cyprinus Carpio* (Common Crap)

This fish is found in a variety of habitats and environmental conditions having a wide range of food habits. Primarily the young feed on zooplankton and later chiefly on bottom invertebrates. They also feed algae, detritus, decaying plant matter, etc.

A large number of exotic species of fishes have entered into the major rivers of India from flooded tanks and reservoirs, which have increased the biological stress of existing fish species. The history of fish culture dates back to ancient geological time in India. The evidence of fish culture in Indian subcontinent comes from the writings of Kautilya's ARTHSHASTRA (321-300 B.C.). Someswara of Chanakya Dynasty described the methods of fattening the fish in ponds in 'MANSOLTARA". In Bengal, Bihar and Orissa traditional fish culture developed by the end of 19th century, which spreaded in other Indian states too. India is the second largest fish producing country, with about 9% of the world's total aquaculture. Inland aquaculture fish producing system in India produces about 1.7 million t/yr. Carp accounts for over 80% of farmed fish. West Bengal is the largest fish producing states in India. The following major fish species are cultured in India:-

Labeo rohita

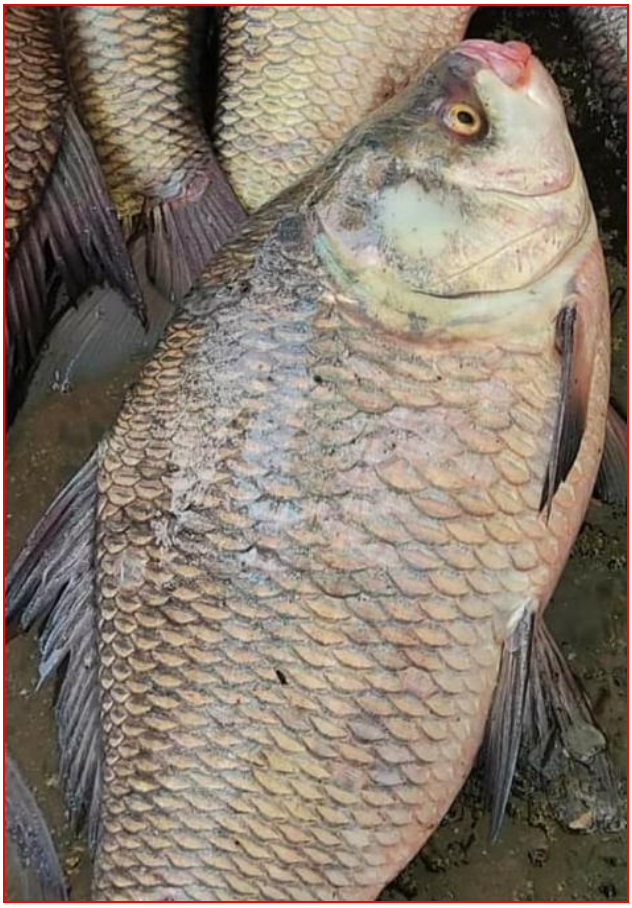


Fig. 13: *Labeo rohita* (Rohu)

Catla catla

Fig. 14 :*Catla catla* (Bhakur)

Ctenopharyngodon idellus

Cyprinus carpio

Fig. 15 : *Cyprinus carpio*

Hypophthalmichthys molitrix

Fig. 16: *Hypophthalmichthys molitrix* (Big head)

Clarias batrachus

Fig. 17: *Clarias batrachus*

Heteropneustes fossilis

Fig. 18: *Heteropneustes fossilis*

Salmo gairdnerii

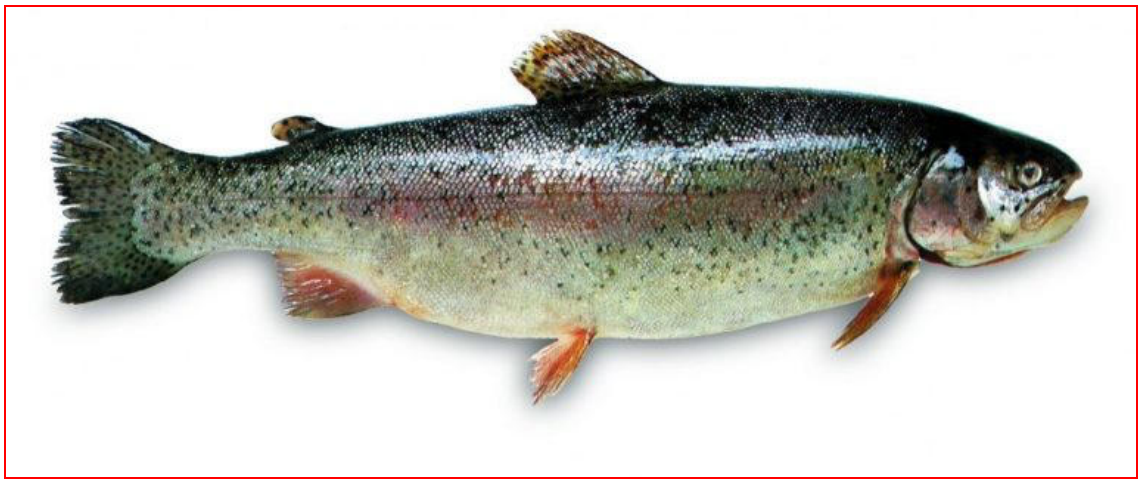


Fig. 19: *Salmo gairdnerii*

Macrobrrachium rosenbergii

Fig. 20: *Macrobrrachium rosenbergii*

In 1899 brown trout eyed eggs were brought from England into India, which hatched successfully at Harwan in Kashmir, thus brown trout aquaclutre started in himalayas and elsewhere. Later on, this species was transported to Jammu, Gilgit, Uttar Pradesh, Himanchal Pradesh, North Bengal, Arunchal Pradesh, Meghalaya, Nagaland and southern Peninsula. Similarly rainbow trout was also brought from England which has not been established in streams and rivers of the Indian Himalayas. Indian major carps along with the exotic carps form the backbone of Indian freshwater aquaculture.

"Among numerous reasons for introduction of exotic aquatic animals into countries, aquaculture development is said to be a main motive (Welcomme, 1998 and FAO DIAS). Exotic fish species affects indigenous biodiversity leading to potential dominance of the introduced species, disease transmission on contamination of local genetic pools. Maximum exotic fish introductions have been done in the later part of the last century as new species and genetic variants or strains of a particular species.

Exotic Species Introduction Purpose

The reasons of exotic species introduction vary with time, space and requirements from country to country. The following are the main purpose of introduction of exotic fish species in India:-

(i) Exotic fish species have played a significant role in the development of aquaculture and aquaculture products trade. The fisheries sector has an important role in overall development of the country because aquaculture is a similar activity as that of agriculture.

(ii) Management of inland waters is also the purpose of introduction of exotic fishes. Till 1988 seventy-eight species were introduced for sport purposes all over the world. Salmonids were also introduced in India for the development of sport fisheries.

(iii) There are several reasons for introduction of fish species like establishment of new food fishes, filling vacant niches, providing forage for predators, restoration of fisheries, wild stock establishment and control of stunted species etc. Silver carp or Common carp were introduced for intensive fish culture.

(iv) Exotic fish have been also widely distributed outside its natural range for ornamental purpose. Flourishing aquarium trade and global demand of colourful fishes (viz. Gold fish *Carassius auratus* small fishes are the main reasons for its wide dispersal.

(v) Introduction of exotic fish species are very significant in biological control. Small larvivorous fish species was very effective in control of mosquito larva by replacing insecticides. Twelve exotic fish have been introduced in India for mosquito control of which three species *Poecilia latipinna, Poecilia reticulate* and *Gambusia affinis* were most extensive, however, exotic molluskivorous fishes were also introduced for controlling the aquatic snail. The number of exotic species increases under favourable conditions. They require enough food and their elimination in rare. Majority of exotic fish species have been introduced in India during the last century.

Effects of introduction of exotic fish species: Positive impacts of introduced fish species:

The following positive impacts have been identified as benefits of introduction of exotic fish species

(i) Easy to breed and culture.

(ii) Fast growth, high production and high survival rate.

(iii) Seeds can be produced by small scale farmers.

(iv) Source of foreign exchange earnings due to high market value.

(v) Source of alternative income.

(vi) Improves fish farmers income and employment opportunities.

(vii) Can integrated with rice farming or can grow in upland areas.

(viii) Offers opportunities to develop hybrids and in country brood stock development of aesthetic and some ornamental species of social value.

(ix) Improves nutrition of poor and their livelihood.

(x) Disease resistance and beneficial in weed and some vectors control.

Identified Negative Impacts:

(i) The price of induced species is cheaper which causes price drop of indigenous species.

(ii) The demand of exotic fish species is low which causes it low market price.

(iii) Creates completion for habitats and natural food.

(iv) Potential negative environmental impacts and for disease contaminations.

(v) Common carp causes water turbidity.

(vi) Grass carp resulted in decline in local species with same feeding regime. Environmental fish stock quantity deteriorates through stunting.

(vii) Introduction of Tilapia or other exotic fishes reduces catch of indigenous species like *Notoptenus notoptenus* etc.

(viii) Tilapia escapes to natural waters due to over breeding.

(ix) Introduced fish species imparts parasites, pathogens and diseases.

(x) Introduction of exotic fish species also affect socio-economic factors directly or indirectly.

Exotics and International Organisations:

Food and Agricultural organization (FAO) code for responsible fisheries emphasizes to minimize the harmful effects on the wild and culture stocks associated with the introduction of exotic fish species. FAO further suggested that international trade in fish and fishery products should be conducted as per the international agreements.

India is one of the founder member of world Trade organization. Most of the countries avoid the entry of exotic pathogens. NACA (Network of Aquaculture Centres in Asia –Pacific) and FAO has developed technical guidelines to suit the respective situations.

The National Bureau of Fish Genetic Resources (NBFGR), Department of Animal Husbandry, Dairying and Fisheries (DAHD & F) and Government of India has documented "Aquatic Exotics and quarantine Guidelines" for exotic aquatic organisms introduction into India.

CHAPTER-VII

SOCIO ECONOMIC CONDITION

Socio economic condition of fishing community of Aurangabad district of Bihar, India:

The Aurangabad district lying between 84-35^{0}E longitude and 24.70^{0}N latitude is one of the thirty-eight districts of Bihar state of India.

This district falls in the Punpun river sub basin. The river Punpun forms the major drainage and other drainages are namely Adri, Batre, Batane, Dhawa, Karman, Madar and Ramrekha etc. which merge with the river Punpun at different places within the district. Fish and fishing business are an important sector from the standpoint of income and employment generation in India. about 60 million are exclusively depending on it for livelihood in India. Fisheries related activities provide important sources of livelihood for nearly 7 million people in India. Bihar has vast potential for inland fishes and a major fish contributing state (8.71%). Bihar is the fourth largest inland fish producing state in India, Bihar is a land locked state having immense freshwater and aquatic resources. The state of Bihar cultivates farming of fishes and captures fishes from river system. The greatest fish potential development lies in culture of fishes. Fisheries have a significant impact on the overall Indian economic scenario contributing to the national income, employment and foreign exchange.

Socio-economic status is an economic and sociological combined total measure of a person's work experience and of an individuals or family's economic and social position in relation to others, based on income, education, and occupation. Although fishery is the oldest about 2000 years old but its importance has been realized recently due to scarcity of animal protein for ever increasing human population. The state of Bihar is indowed with aquatic wealth in the form of rivers, resources, wet lands, derelict water bodies, tanks and ponds.

In the fisheries sector of India various socio-economic surveys of fishing communities had been conducted by various agencies and research workers to study the different problems of the fishermen community (Mukunda *et,al*., 2002; Basava Kumar *et.al*., 2011; Saxena, 2012; Saxena *et.al*., 2014; Kalita *et.al*., 2015 etc.)

Hence the present study was an attempt to evaluate the socio-economic conditions of fishing community of Aurangabad district of Bihar in detail.

In the fisheries sector, socio-economic status of fishermen plays a key role in production activities. Fishing was their primary and secondary source of income. A household survey was conducted with the help of the prepared questionnaire to evaluate the socio-economic conditions of the fishermen of Aurangabad district of Bihar. The interaction of personal psychological and situational factors always influences the earning and the adoption of scientific fish farming, information on socio-economic frame work of the fish farmer community forms a benchmark for policy formulation to develop this economically backward sector. In fisheries sector socio-economic status of fishermen play a key role in production activities.

There are 2335 registered fish farmers in Aurangabad district which were classified as full time, part time and occasional fishermen respectively. The present study was undertaken in three places (Obra, Aurangabad and Nabinagar) of Aurangabad district covering a total fishermen population of fifty. The general picture pertaining to the social status of the fishermen community is presented in Table 07. The results of the study revealed that the male population constituted about 60% indicating the dominance of males in the fisheries. The percentage of fisher women involved in fisheries sector was 40% only. The caste structure of the fishing community showed that the majority of the members were from general caste (48%) followed by OBC (42%) and SC (10%). The study points out that 44% of fishermen population falls under younger age group followed by 20% middle and 8% older age group respectively. The age is of great importance in determining levels of economic and social participation.

The data reveals that 80% fishermen had small size of family, however only 20% respondents had large family. Housing pattern is one of the significant factors for assessment of economic well-being of any community. On an average 64% fishermen community were still living in huts, where as 30% and 6% were living in Katcha and Pucca houses respectively. Education is an important socio-economic factor which plays a role in income. Higher levels of education are associated with better economic and psychological outcomes. It was observed that only 12%; of the respondents were educated above secondary level, while 88% were educated below secondary level in which the percentage of illiterate fishers were high. It was observed that a greater number of illiterate farmers were involved in fish culture practices. Male literacy rate was more as compared to females in the research area. Low level experience category of fishers was represented by 60% of the total followed by medium (30%) and high (5%) level fishers in the study area. Fish Farmers Development Agencies and other organizations organizes training programmers for the transfer of technology among fishermen community but majority of the fishers did not receive training on fish culture practices, however, training is an effective tool of transfer of technology. The percentage of trained and untrained fishers were 10 and 90% respectively in the district. Majority of fish farmers did not receive training on fish culture practices due to several reasons like fear of wage loss, lack of time, lack of incentives and lack of knowledge. Majority of fish farmers of the district have low level of social participation. This is followed by medium and high-level categories with percentage of 20 and 10 respectively. Women play a vital role in all fishing activities. Net repairing is generally done by women and they spend their maximum time at home. The major occupation of the fishing community was fishing but occasionally agriculture and business too. Women also take part in the marketing of fish and business. On an average 60% of fishers were engaged in fishing followed by agriculture (10%), business (20%) and services (10%) as other occupations. Majority of the fishers had fishing as a primary occupation along with business as one of the secondary activities.

The study revealed that smoking, tobacco taking, betal nut chewing, pan chewing and other Narcotics were the common habits among maximum adult fishermen and fisherwomen. Income is an important factor for determination of the living standard of any community and enhances the social harmony among different sections of human population. The majority of fish farmers had annual income in the range of Rs. 30,000-50,000 (70%) followed by Rs. 10000-30,000, Rs. 50,000-100,000 and above Rs. 100,000. The income of majority of fish farmers was not sufficient to maintain their normal livelihood. The low-level income reflects their poor economic condition. The transportation of fish was carried by Bicycle (50%), Motorcycle (30%) and Load carrier (320%) in the bucket along with the ice. Different types of nets and taps were used for fishing in the district, viz. different sized plank-built canoes, Cast net, Baghjal, Bhasajal, Sipuli, Khokha, Jalbans, Jhap, Stake net, hunting weapons, basket etc. Most commonly used gears by all the fishermen were cast net (70%), followed by gill/Dragnet (20%) and others (10%) of various mesh sizes.

The fish caught by the fishermen are bought and sold in the different fish market of the district. When fish is caught in abundance the fishermen sell fish to whole sellers. During course of study it was observed that 80% fish were sold in local markets while only 20% of their catches were exported to other places. It was also observed that women fisher also takes the responsibility of marketing fish in local markets and the fisher folk move in group to dispose of their catch in the local markets. The transportation of fish is either carried out in ice boxes (60%) or in open bags (Tokaries) (40%). During course of survey, it was found that the fishermen caught upto 5-20 kg fish individually daily. Majority of fish farmers (60%) uses mobiles followed by TV (20%) and two wheelers (20%).

The present survey highlights some factors for the poor socio-economic condition and low standard of living of fishermen community of Aurangabad district.

Maximum numbers of fishermen were unable to fulfill their minimum requirements and were less perceptive about modern capture fisheries techniques. There are 49 lakhs of fishermen in India which socio-economic

condition improvement is quite essential. The people of Aurangabad district are suffering from protein deficiency in their daily diet, hence Bihar needs an enormous increase in fish production. Bihar is a land locked state and water bodies can be easily used for the culture of fishes. The prospects of fisheries development in the study area are tremendous. The study indicated that the general socio-economic status of fishermen community could be improved by the adoption of improved fishing and fish farming methods by imparting education. It is essential to aware the fishermen about threat by adopting various activities eg. Seminars, posters, mass communication, advertising, environmental education programs, etc.

Table 07: Fishermen Questionnaire

Places: Obra, Aurangabad and Nabinagar

Number of households studied: 50

Gender:

S.No.	Gender	Numbers	%age
(a)	Male	30	60%
(b)	Female	20	40%
	Total	**50**	**100%**

Caste:

S.No.	Caste	Numbers	%age
(a)	SC	5	10%
(b)	OBC	21	42%
(c)	General	24	48%
	Total	**50**	**100%**

Age groups:

S.No.	Age Groups	Numbers	%age
(a)	Younger (<30)	22	44%
(b)	Middle (<30-50)	20	40%
(c)	Older (>50)	8	16%
	Total	**50**	**100%**

Average size of family:

S.No.	Average Size of Family	Numbers	%age
(a)	Small	40	80%
(b)	Big	10	20%
	Total	**50**	**100%**

Housing Pattern:

S.No.	Housing Pattern	Numbers	%age
(a)	Hut	32	64%
(b)	Katcha	15	30%
(c)	Pucca	3	6%
	Total	**50**	**100%**

Literacy rate:

S.No.	Literacy Rate	Numbers	%age
(a)	Educated above secondary level	6	12%
(b)	Educated below secondary level and illiterates	44	88%
	Total	**50**	**100%**

Experience:

S.No.	Experience	Numbers	%age
(a)	Low	30	60%
(b)	Medium	15	30%
(c)	High	5	10%
	Total	**50**	**100%**

Training:

S.No.	Training	Numbers	%age
(a)	Trained	5	10%
(b)	Untrained	45	90%
	Total	**50**	**100%**

Social participation:

S.No.	Social Participation	Numbers	%age
(a)	Low	35	70%
(b)	Medium	10	20%
(c)	High	5	10%
	Total	**50**	**100%**

Major occupation:

S.No.	Major Occupation	Numbers	%age
(a)	Agriculture	5	10%
(b)	Fishery	30	60%
(c)	Business	10	20%
(d)	Service	5	10%
	Total	**50**	**100%**

Annual Income level (Rs.):

S.No.	Annual Income Level	Numbers	%age
(a)	10,000-30,000	5	10%
(b)	30,000-50,000	35	70%
(c)	50,000-100,000	5	10%
(d)	>100,000	5	10%
	Total	**50**	**100%**

Transportation mode:

S.No.	Transportation Mode	Numbers	%age
(a)	Bicycle	25	50%
(b)	Motorcycle	15	30%
(c)	Load carrier	10	20%
	Total	**50**	**100%**

Which net is used for fishing?

S.No.	Type of Fishing	Numbers	%age
(a)	Cast net	35	70%
(b)	Gill/dragnet	10	20%
(c)	Others	5	10%
	Total	**50**	**100%**

Where the fish is sold?

S.No.	Fish is Sold	Numbers	%age
(a)	In local market	40	80%
(b)	Export to other cities	10	20%
	Total	**50**	**100%**

How the fish is transported?

S.No.	Fish is Transported	Numbers	%age
(a)	In ice boxes	30	60%
(b)	In open bags (tokaries)	20	40%
	Total	**50**	**100%**

What the amount you catch daily? 5-20 kg

Electronics used by the fishermen:

S.No.	Electronics used by the fishermen	Numbers	%age
(a)	Mobiles	30	60%
(b)	TV	10	20%
(c)	Two wheelers	10	20%
	Total	**50**	**100%**

CHAPTER-VIII

ANTHROPOGENIC IMPACTS ON RIVER ECOLOGY AND FISHERIES, REQUIRED MANAGEMENT

The human activity is closely related to fish and fisheries. The Indian riverine ecosystems have been witnessing serious threats due to anthropogenic activities. It is degrading the ecosystems and declining the fish production also. The anthropogenic activity is perhaps closely related to fishes and affects different aspects of their biology and ecology is that of fishing. Rivers provide a wide range of ecosystem goods and services to society and fisheries production particularly depend upon the biodiversity and ecological integrity of aquatic ecosystems. Riverine biodiversity is threatened by pollution, climate change, agricultural and urban land use, deforestation, loss of habitat and habitat connectivity, introduced species, channel modifications, interbasin transfers of water, modified flow regimes and fishing pressure. The riverine ecosystem may be considered as the mirrors of environmental degradation. There are several sources of anthropogenic stress impeding fisheries development in India such as domestic waste, industrial waste, agricultural run-off, abstraction of water, siltation, river training, construction of dams, climate change etc. Two types of water pollution exist.

Domestic Waste:

Pollution in the form of organic material enters as sewage etc. in the riverine ecosystem, which are break down by natural bacteria and protozoas using dissolved oxygen in the water. When levels of dissolved oxygen drop below two to five parts per million, different types of fishes and bottom dwelling aquatic organisms are killed in large numbers loading to disruptions in the food chain. Municipal sewage is mainly accompanied by trade waste synthetic detergents and heavy metals. The domestic sewage is mainly polluted by microorganisms and organic matter. Rivers running around the city and industrial belts are under the stress of severe water pollution (Gupta *et al*., 2002).

The river Punpun running around the Nabinagar town is direct victim in terms of deterioration due to anthropogenic activities like domestic waste disposal causing severe damage to this riverine system in nationally as well as globally.

Industrial Waste:

Industrial waste is a principal pollutant that is discharged directly into almost all the rivers causing severe damage to the riverine ecosystem. The rapid industrialization has created a serious problem of industrial pollutants viz. thermal power station, sugar mills, distilleries, paper mills, dye factories, rice factories, etc., are being discharged directly into the riverine ecosystem without any treatment, causing severe damage. It has been found that many of these effluents produce hazardous effects on aquatic ecosystem (Ghatak and Konar, 1992). In India about 10 billion cubic meter of freshwater is consumed annually and same amount is returned as little or untreated waste water by different industries. Types of industries prevailing in Aurangabad district of Bihar has been given in table 08.

Showing type of industries prevailing in Aurangabad district of Bihar.

S. No.	Name of district	Type of industries prevailing in Aurangabad district of Bihar
1.	**Aurangabad**	Agro based, cotton textiles, woolen, silk and artificial thread-based clothes, Readymade garments and Embriodery, wood/wooden based furniture, Metal based (Steel fabricated) Engineering units and Transport equipment Repairing and servicing, Rice Mills, Sugar mills, Thermal power project Industrial wastes and sewage, important pollutants, are being discharged directly into the river without any treatment, has created an acute problem causing severe damage to the riverine system. It has been found that many of these effluents produce hazardous effects on aquatic ecosystem (Singh, 1997). The Indian riverine

		ecosystem has been witnessing serious threats due to increasing input of sewage & industrial effluents.

Agricultural runoff:

Agriculture is the important source of many organic and inorganic pollutants in rivers. These contaminants chiefly include compounds of phosphorus and nitrogen and sediment from erosion cropland. These contaminants partly originate in animal wastes and commercial fertilizers. Animal wastes harbor pathogenic organisms and are high oxygen demanding material as well as nitrogen and phosphorus, the animal farm runoff carrying nutrients, organic matter, bacteria and irrigation water containing heavy load of silt are degrading the water body. The magnitude of agricultural runoff is very fast causing severe water pollution in rivers. India is third largest consumer of pesticides in the world, however, only 25-30% of the total cultivated area is under pesticide cover. The uses of increased quantities have serious ecological consequences on the aquatic ecosystem. Mass mortality of fishes have also been recorded due to run off pesticides and fertilizers.

Erosion and abuse of river bank:-

The river banks are used for several purposes like soil lifting, brick fields etc. These activities cause soil erosion both by winds and runoff water actions which directly or indirectly affects the fish habitats.

Siltation of the river bed:-

There is a gradual increase of silt load in most of the Indian rivers. Silting causes lowering of depth of river and losing its water holding capacity. Thus, flood occurs usually in these rivers. The rivers are gradually becoming narrower due to silting. The reduced depth holding lesser volume of water is not conductive to support fishes living in the water bodies.

Construction of dams:-

The dams, barrages etc. constructed on riverine ecosystem are obstacles in pathway of migratory fishes. Some migratory fishes move upstream and downstream to complete their life cycles. Many fishes are also killed during downward movement through the dam to the river below. They also encounter high level of nitrogen gas at the base of the dam.

Water abstraction:-

The load bearing capacity of downstream water is reduced by large scale abstraction. Due to urbanization along the bank of river ecosystem are facing a huge stress.

Climate warming:-

The ten warmest years since 1880 were in the last 15 years with 1990s being the warmest decade and 1998 the warmest year.

Entry of exotic fishes:-

The exotic fishes might have increased the biological stress of existing fish species. The negative impacts of exotic fish species are due to genetic contamination, diseases introduction and ecological interactions leading to native species loss. Riverine eco-systems were severely affected by illegal introduction of exotic species (Konar *et al*., 1997).

The Indian riverine ecosystem has been witnessing serious threats due to anthropogenic activities. Due to anthropogenic interferences the riverine eco-systems of the country are degrading as well as fish production declining.

Compared to the terrestrial and marine organisms, freshwater species are more in danger throughout the world (Stein *et al*., 2000). Approximately 30% of the freshwater fishes included in the Red List of IUCN are threatened (IUCN species survival commission 2000). In a global analysis of fishes, it has been estimated that 71% of extinctions were related to habitat alteration, 54% of exotic species, 26% of pollution and the rest to hybridization, parasites and diseases, or intentional eradication (Harrison and Stiassny, 1999). The human activities damaging and degrading river

systems include (1) supra catchment effects such as inter-basin transfers of water, acid deposition, climate change (2) catchment land use change, (3) river corridor engineering and (4) instream impacts (Junk, 2002). Fish production of most of the rivers of Bihar declined considerably in the past, decade as revealed from the investigation. The river Punpun of Nabinagar was productive water body in the recent past, but due to continuous abuse the present production declined.

75 fish species belonging to 51 genera, 22 families and 10 orders were recorded from the Punpun river of Nabinagar. Riveine eco-systems was affected by illegal introduction of exotic species. The climate of Nabinagar is warm and humid. Maximum annual rainfall comes during the southwest monsoon (June to September). The months July and August register peak rainfall in a year. The main source of water in the basin is direct seasonal rainfall. Fish landing have declined sharply both quantitatively and qualitatively. The main causative factor for low yield fish may be the reduction of spawning grounds in the river due to changes in river morphology, extraction of water resulting in reduction of flow and water development activities. The man induced environmental stresses have a direct bearing on the biological production processes. Low river velocity physiologically upset the fluvial communities adopted for the lotic condition. The river catchment is characterized by a prolonged dry season followed by a turbulent monsoon and flood discharge, causing high rate of natural sedimentation. Moreover, erosion of top soil and removal of vegetative cover of the catchment area are other problems. The fishes are killed by industrial effluents in an addition to destruction of habitat or benthic and planktonic communities and toxicity. Mixed organic wastes cause depletion of dissolved oxygen and enhancement of BOD level. Domestic sewage effluents cause deoxygenetion, high BOD load, rapid eutrophication and heavy metals accumulation in the environment. Pesticides from agricultural runoff cause accumulation of chlorinated hydrocarbons in the aquatic ecosystem. The industrial and municipal effluents cause death of fishes. The river Punpun running around the

Nabinagar town is under the stress of severe water pollution and negative impact of anthropogenic activities.

River Punpun has been subjected to considerable anthropogenic activities due to developmental activities like urbanization, industrial activity, tourism, road network, construction and simultaneous rise in population. It has been found that the area where the study was carried out the fresh waters have been a direct victim in terms of deterioration. The kind of human activity to which the river is subjected in the decreasing order of importance in terms of population are human bathing, cloth washing, cultural activities, sewage disposal, open defaecation, agriculture and deforestation in the catchment area, industrial waste disposal and reaction. The river Punpun of Bihar is leading towards eutrophication.

REQUIRED MANAGEMENT

Required Management/Conservation/Recommendations

India is countries of the world that is under developing weak ecological policy framework for the protection of whole river system (e.g. Ganga, Brahmputra, Krishna, Narmada, Godavari river) (Vass *et al*., 1997). Human needs, particularly for irrigation, still govern river management priorities and objectives for most rivers in inland regions of the world (Doppelt, 1993). Management of riverine resources has much been focused in parts of India where there is already considerable damage but it is still to develop in less developed parts of Indian continent. Riverine resource management includes river conservation. Even though Bihar has vast potential for augmenting its fish production but a number of issues concerning fisheries development and management need to be studied because various technical and socio-economic issues are responsible for this state of affairs. The rivers are managed traditionally as a common property resource which have multiple uses for riparian area population. The Indian rivers play a vital role by conserving the precious biodiversity in addition to fisheries perspectives. The fisheries sector besides providing cheap and nutritional food also play vital role in the national economy. This sector

also plays a significant role in the socio-economic development of the fishermen community of the country.

Ecological management and resource evaluation need more importance, in contrast to traditional mode of resource management and exploitation, due to growing stresses and declining resources. Particularly in India the rapid population growth is the greatest strain on aquatic resources, hence it is essential to develop an understanding about problems related to riverine management. Bihar has vast potential for augmenting fish production but many issues constraining fisheries development and management yet need to be resolved technically and scientifically. The following are the required strategies for sustainable effective management/ conservation of riverine fisheries: -

(i) There is a need of immediate change with introduction of broad-based research projects for environmental factors. The fish production from inland water resources their potential, simply due to low priority given to this sector.

(ii) There should be an improved procedure for environmental assessment before initiation of any project in the rivers or the catchment.

(iii) Unwanted interferences in rivers like reservoir releases, water abstraction need be used for future advantage.

(iv) In absence of proper knowledge of healthy habitat requirements, management of some important species failed to achieve desired result, hence studies on riverine biota habitat is quite essential to know the ecologically habitat requirements of the targeted species.

(v) Application of theoretical ecology to river conservation are beneficial for river management/conservation.

(vi) Proper taxonomic feedback is essential for conservation and management of riverine biodiversity and potential harvestable crop.

(vii) A long term monitoring on ecological studies on riverine variability is quite essential.

(viii) An effective liaisoning on national and international level is quite necessary between NGO, developmental and research organizations

(ix) To achieve the goal effective river management/conservation public awareness and participation is a must.

(x) In case of flowing through four states the exploitation policies are at variance depending upon the importance of riverine fisheries. There is a definite need for taking up stock assessment studies and allied aspects. An interstate Riverine Fisheries Board should be considered for the formulation of a rational and ecologically sound exploitation policy for inter state fisheries.

(xi) Inland fisheries should be included in the concurrent list of the Indian constitution so that the union Government can also frame laws.

(xii) Indian fisheries leasing policy needs revision by all the states. Leasing periods of water should not be for a shorter period.

(xiii) Inter-state river management conflicts effect fisheries development. There should be a uniform regulation of fisheries.

(xiv) Fishers need financial assistance because they belong to the poor communities of the country. Procedures for obtaining loans/financial assistance from the banks/departments needs to be simplified.

(xv) The inland fisheries have one great advantage of having production sites in close proximity of the consuming centres, leading to lower selling costs in terms of preservation and distribution. Inland fishes do not have a high market value at their production sites.

(xvi) The traditional sale of whole fish from the production centre is the main cause of low remuneration to the producer. It needs organized sale of processed fish through a chain of retail outlets. It will enhance income and generate large scale employment.

(xvii) The Fisheries Extension Officers and other associated members should be trained in proper identification of the fishes upto the

species level and in methods of soil/water analysis too at research institutes. A small laboratory could be established at each district headquarters also.

(xviii) Training in pacing, handling, transport and marketing of fish should also be provided.

(xix) The anthropogenic activities affecting most aspects of the biology and ecology is that of fishing should be minimized.

(xx) Biodiversity of the river Ganges is threatened by climate change, deforestation, agricultural and urban land use, pollution, channel modifications, inter basin transfer of water and modified flow regimes, loss of habitat and habitat connectivity, introduced species and fishing pressure.

Inter basin transfer is under serious consideration of the Govt. of India. Fishery scientists should also suggest the ameliorative measures to the Government.

Management of riverine fisheries resets with state Government. Commercial exploitation systems followed in different states can be grouped under: -

a. Department fishing

b. Lease by auctioning

c. Issue of license to co-operative societies or individual and

d. Fishing on a royalty basis

e. Establishment of a riverine conservation authority with participation from various user organizations like Irrigation, Fisheries, Municipal corporation and Drinking water establishment.

SUMMARY

The present investigation deals with the limnological and biological exploitation of the Punpun river at Nabinagar, Aurangabad, Bihar, India in relation to fish and fisheries. During course of study history, origin, hydrology and geomorphology of the river Punpun were studied. Different changing physico-chemical parameters of water samples were studied like temperature, rainfall, pH, total solids, dissolved solids, suspended solids, dissolved Oxygen, free Carbondioxide, Chloride and alkalinity. The physico-chemical parameter of water samples indicated that the water of the Punpun river is fit for industrial as well as irrigational purpose but unfit for bathing and drinking purposes. Biodiversity of the river Punpun is threatened by climate change, deforestation, agricultural and urban land use, pollution, channel modifications, inter basin transfer of water and modified flow regimes, loss of habitat and habitat connectivity, introduced species and fishing pressure.

During course of investigation 75 species of inland fishes were recorded from the river Punpun dominated by Cypriniformes (32 species) followed by Siluriformes (19), Pericofmes (10), Channiformes (04), Mastacembeliformes (03), Osteoglossiformes(01), Symbranchiformes (01) and Tetraodonliformes (01). Among these fishes 21 were vulnerable, 04 exotic, 04 endangered, 01 threatened, 05 lower risk least concern and 21 lower risk near threatened. Positive and negative impacts of introduced exotic fishes have been studied. A large number of fishing gear and tackles operated in different stretches of the river Punpun for its commercial exploitation have been identified. The method of fishing was mostly of traditional type depending upon the target species, fishing ground, climate, current and several hydrobiolgoical conditions. The major reason for depletion of catch in the river Punpun are adoption of unscientific fishing practices, over exploitation, habitat degradation and anthropogenic activities. Methods ranging from catching fish with the hands to the operation of large and indigeniously designed nets are adopted for fishing in the river Punpun due to its highly diverse nature. The various fishing

implements nets, traps etc. used were remarkably primitive and more or less common methods. The fishing equipments included fishing boats, nets, traps and hunting etc.

The survey of socio-economic condition of fishermen community of Aurangabad district highlighted some factors responsible for the poor socio-economic condition and low standard of living fishermen community. Maximum number of fishermen were unable to fulfil their minimum requirements and were less perceptive about modern capture fisheries techniques. The study indicated that the general socio-economic status of fishermen community could be improved by the addition of improved fishing and fish farming methods by imparting education.

River Punpun has been subjected to considerable anthropogenic activities due to developmental activities like urbanization, industrial activity, tourism, road network, construction and simultaneous rise in population. It has been found that the area where the study was carried out the freshwater have been a direct victim in terms of deterioration.

The kind of human activity to which the river is subjected in the decreasing order of importance in terms of population are human bathing, cloth washing, cultural activities, sewage disposal, open defaecation, agriculture and deforestation in the catchment areas, industrial waste disposal and reaction. The river Punpun is leading towards eutrophication. There are several sources of anthropogenic stress impeding fisheries development such as domestic waste, industrial waste, agricultural runoff, abstraction of water, siltation, construction of dams, climate change etc.

In view of the growing stresses and declining resources, more importance needs to be given to ecological management in contrast to the traditional mode of resource management and exploitation. Required strategies for sustainable effective management/ conservation of fisheries of river Punpun have been suggested in detail....

REFERENCES

- Anonymous, (1982). District Statistical Report. 1981-82. Dharwad district at a glance, Dharwad.
- APHA-AWWA-WEF, (2005). Standard method for the examination of water and waste water. 21st Edition, Washington, DC.
- Arora, M., Goel, N. K., and Singh, P. (2005). Evaluation of temperature trends over India. Hydrobiologial Sciences Journal, 50 : 81-93.
- Attri, S.D .and Tyagi, A. (2010). Climate profile of India. Met. Monograph Environmental Meterology No.1, pp. 122.
- Badola, S.P. and Singh, H.R. (1984). Spawning of some important cold-water fish of the Garhwal Himalaya. Bombay Nat. Hist. Soc. 81(1): 54-58
- Bartley DM, De Graaf GJ, Valbo-Jorgen Sen, J, Marmulla, G-2015.Inland Capture fisheries: status and data issues, Fish, Manage Ecol.22(1):71-77 cross ref.
- Basava kumar, K.V., Devendrappa, S. and Srinivas, S.T., (2011). Astudy on profile of fishing community of a village in Karnataka. J.Agri. Sci., 24(5): 684-687.
- Basava Kumar, K.V., Devendrappa, S. and Srenivas, S.T., (2011). A study on profile community of a village in Karnataka,J.AgricSci.,24(5):684-687.
- Born, B. (1999). Overview of in land fishery enhancements from a global perspective, FAO Aquaculture NewsletterNo.21:pp.10-18.
- Boyd,C.E. (1984). Water quality management for pond fish culture. Elsevier Sci. Publ. Co. Amsterdom, pp.318.
- Brandt, A.V, (1972). Fish Catching Methods of the World. Fishing News (Books) Ltd. London. 240 p.
- Bunn, S.E. and Arthington A.H. (2002). Basic principles and ecological consequences of altered flow regimes for aquatic biodiversity. Environmental Management, 30 : 492-507.48 session 3 Review.

- Burdon, T.W. (1951). A consideration of classification of fishing gears and methods. IPFC Proc 3(3): 143-165.
- Central Inland Fisheries Research Institute (CIFRI), (2006). Preliminary finding of project Techno socio-economic status of fishers of river Ganga".
- Chaudhary, N. (1985). Ganga needs clean up by all of us. Key noteaddressin Ganga basin conference and exposition. Calcutta. Nov.28-30. (1985). Journal, Indian Cent. Pub. Hlth. Environ. (Splissue).
- Chauhan, B.S. (1949). Fish and fisheries of Patna state, Orissa. Rec. Indian Museum, 45(2&3) (1947), 267-282
- Cooke SJ, Lapointe NWR, Martins E9, Thiem JD, Raby GD, Taylor MK, Beard TDJr, Cowx1G; 2013. Failure to engage the public in issues related to inland fishes and fisheries :strategies for building public and political will to promote meaningful conservation. J. Fish Birl 83(4): 997-1018 Medline.
- Das M.K., Samanta, S.,Mitra, K., Bandyopadhyaya, M.K. and Bhowmick, S., (2014). Assessment and fishery and ecological integrity of the anthropogonically stressed river Churni, India, Inland Fish, Soc. India. 46(1): 9-28.
- Das, A.K. (2001). Abiotic features in reservoir fisheries. In proceeding of a national agricultural technology project workshop fisheries management in lentic water systems: stocking of reservoirs with fish seed, Barrackpore, India, CIFRI, pp.15-72.
- Das, M.K., Sharma, A.P., Vass, K.K., Tyagi, R.K., Suresh, V.R., Naskar, M. and A Kolkar, A.B. 2013. Fish diversity, community structure and ecological integrity of the tropical river Ganges, India. Aquatic Ecosystem health and Management. 16(64): 395-407.
- Datta Munshi, J.S. and Srivastava M.P. (2006). Natural History of Fishes and Systematics of Freshwater Fishes of India, Fishes of India, Narendra Publishing House, Delhi.
- David B.O. and Closs, G.P. (2002). Behaviour of a stream dwelling fish before, during and after discharge events. Transactions Amer Fish.

Soc, 131: 762-771.

- Davis, F.M. (1958). An account of the fishing gears of England and Wales. Fishery Invest. Land., (2), 21(8): 1-165.
- Dehadrai, P.V. (2002). Open Water Capture Fisher is; Development, Strategies and Policies. pp. 461-483. In Indistutionalising common Pool Resources. Marothia, D.K. (ed). Concept Publishing Co., New Delhi.
- Deka, P. and Kalita, P., (2015). Socio economic condition and livelihood status of fisher around the landing sites of Motapung-Maguri Beel of Tinsukia district of Assam, India. Int. J. Fish. Aquatic studies., 3(2): 55-57.
- Doppelt, R. (1993). The vital role of the scientific community in new river conservation strategies. Journal of the North American Bentho logical Society, 12(2): 189-193.
- Dudgeon D, Arthington AH, Gessner MO, Kawabata Z-11, Knowler DJ, Leveque C, Naiman RJ, et al. (2006). Freshwater biodiversity: importance, threaets, status and conservation challenges. Biol, Rev. 81(2):163-182 cross ref, Medline.
- Freeman, M.C., Bowen, Z.H., Bowee, K.D. and Irwin, E.R. (2001). Flow and habitat effects on Juvenile fish abundance in natural and altered flowregimes. Ecological applications, 11: 179-190.
- Garrels, R.M., Mackenzie, F.R. and Hunt, C. (1995). Chemical cycle and the global Environment. Willian Kaufman, New York. P. 260.
- Ghaghra and Ganga due to anthropogenic pressures. Pollution Research, 21(3): 261-263.
- Ghatak, D.B. and Konar, S.K. (1992). Field studies on the effect of various industrial effluents of Damodar river ecosystem, West Bengal, Environ. Ecol. 10: 767-773.
- Giri, S., Pradhan, P. and Chakraborty, S.K. (2008). studies on hydrobiological status of Kansai and Dwarkeshwar rivers in West Bengal, India. J. Inland Fish Soc. India 40(1): 59-64.
- Goessling W. North TE (2014). Repairing quite swimmingly: advances

in regenerative medicine using Zebrafish. Dis. Models Mech. 7(7): 769-776 Cross ref, Medline.

- Gopal, B. (1995). Limnology in Developing countries, Vol. I. Narendra Publishing House, Delhi.
- Goswami, M., Sathiadhas, R., Goswami, U.C. and Ojha, S.N. (2002). Socio-Economic Dimension of Fish Farming in Assam. J. Indian Fisheries Assoc. 29, 103-110.
- Greenwood, P.H., Rosen, D.E., Weitzmann, S.H. and Myers, G.S. (1966). Phylictic studies of the teleostean fishes with a provisional classification of living forms. Bull. Amer. Mus. Nat. Hist. 131: 33-456.
- Guhathakurta, BL Sudeep Kumar, Menon, Prasasd, A.K., Sangwan, N. and Advani, S.C. (2020). Observed rainfall variability and changes over Bihar state. Met Monograph No.: ESSO/IMD/HS/Rainfall Variability/ 04 (2020)/28. India Metrological Department, Pune – 411005
- Gunther, A. (1868). Catalogue of the fishes in the British Museum. 7, XX+512 pp.
- Gupta, A.K. and Raghubansi, A.K. (2002). Comparative study of enrichment of nutrients and heavy metals in rivers waters of Ghaghra and Ganga due to anthropogenic pressures. Pollution Research, 21(3): 261-263.
- Gupta, G.P. (1975). Sediment production status report on data collection and utilization Soil cons. Digest 3(2): 10-1.
- Harrison, I.J. and Staissny, M.L.J. (1999). The quiet crisis. A preliminary listing of the fresh water fishes of the world that are extinct or "missing in action". pp. 271-352. In Macphee, R.D.E. (ed). Extinctions in near time: causes, contexts, and consequences, New York: Kluwer Academic/Plenum Publishers.
- Hart, J.S. (1944). The circulation and respiratory tolerance of some Florida fresh water fishes. Proc. Acad Sci. 7: 221-246.
- Hasnain, S.I. (2002). Himalayan Glacier melt down: impact on South Asian Rivers. IAHS Pub. No. 274, 1-7.

- Helfman, G.S., Collette, B.B., Facey, D.E. and Bowen, B.W. (2009). The diversity of fishes: Biology, Evolution and Ecology. Wiley-Blackwell, Hoboken, NJ.
- Helfman, G.S., Collette, U.C. and Ojha, S.N. (2002). Socio-economic dimension of fish farming in Assam. J. Ind. Fish. Assoc. 29: 103-110.
- Hemingway J, Ranson H (2000). Insecticide resistance in insect vector of human disease. Annu. Rev. Entomol 45: 371-391. Cross ref. Medline.
- Hora, S.L. and Mukerje, D.D. (1938), Table for identification of Indianfresh water fishes, with description of certain families and observations on the relative utility of the probably larvivorous fishes of India. Health Bulletin No. 12. Malaria Bureau No. 4. Ed. 3: 1-47, Delhi.
- Hornell, J. (1923). The methods of fishing in Ganges. Mem. Asiatic. Soc. Beng., 8(3): 199-237.
- Humphries, P. Kochn, J.D. and King, A.J. (1999). Fishes, flows and flood plains: links between Murray-Darling freshwater fish and their environment. Environmental Biology of Fishes, 56: 129-151.
- Hussain, S. (1987). Water supply and sanitary engineering. Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi.
- Hynes, H.B.N. (1978). The biology of polluted water, Liverpool Uni. Press, Liverpool, pp. 200-204.
- IMD, (2009). Annual Climate Summary, 2009. National Climate Centre, Pune. Jayaram, K.C. 1977. An aid to identification of Siluroid fishes. Rec. Zool. Surv. India, Occ. Paper no. 8, pp. 1-41.
- Jayaram, K.C. (2010). The freshwater fishes of Indian Region, 2nd Ed. Narendra Publishing House, Delhi, pp. 616.
- Jhingran, A.G. and Sugunan, V.V. (1990). General guidelines and planning criteria for the small reservoir fisheries management. P. 18 In: Jhingran Arun G. and V. Unnithan (eds). Reservoir Fisheries in India, Proc. Of the Nat. workshop on Reservoir Fisheries, 3-4 January 1990. Special Publication 3, Asian Fisheries Society, Asian Branch, Mangalore, India.

- Jhingran, V.G. (1963). Report on the fisheries of the Chilka Lake, 1957-1960.
- Jhingran, V.G. (1991). Fish and Fisheries of India, Hindustan Publishing Corporation (India) Job, T.J. and Pantelu, V.R. 1953. Fish trapping in India. J. Asiat. Soc. Sci., 19(2): 175-196.
- Joshi, B.D. and Bisht, R.E. (1993) Some aspects of Physico-chemical characteristics of western Ganga canal near Jwalapur, Haridwar, Himalayan Jr. Env. Zool. 7(1): 76-82.
- Joshi, K.D. and Biswas, B.K. (2010). Piscine diversity and fisheriesin the river Ken, proposed for inter river linkihng. J. Inland Fish. Soc. India, 42(2): 25-31.
- Junk, W.J. (2002). Long term environmental trends and the future of tropical wetlands. Environmental conservation, 294 : 414-435.
- Kalita, G.J., Sarma, P.K., Goswami, P. and Rout, S., (2015). Socio-economic status of fishermen and different fishing gear used in Beki River, Barpeta, Assam. J. Entomology and Zoology studies 3(1): 193-198.
- Kalita, GJ, Sarma, P.K. Goswami, P. and Rout, Srustidhar, (2015). Socio economic satus of fisherman and diffrent fishing gear used in Beki river Barpeta, Assam. J. Entomology and Zoology studies. 3(1): 193- 198.
- Kalita, P. and Deka, P. (2015). Socio-economic condition and livelihood status of fish around the landing sites of Motapung – maguri Beel of Tinsukia District of Assam, India. International J. Fisheries and Aquatic Sciences. 3(2): 55-57.
- Kaur, S. and Joshi, B.D. (2003). Seasonal variation in some physico-chemical conditions of the river Ganga in and around Haridawar. Him. J. Zool. 17: 45-55.
- Kennedy, G. Nantel G, Shetty P. (2003). The scourge of "hinder hunger". Global dimensions of micronutrient deficiencies. Food Nutr. Ag. 32: 8-16.
- Khan I.A. and Khan, A.A. (1985). Physiochemical conditions in Seikha Jheel at Aligarh. Environment and Ecology, 3(2) : 269-274.

- King, A.J., Humphries, P. and Lake, P.S. (2003): Fish recruitment on flood plains; the role of patterns of flooding and life history characteristics. Can. J. Fish Aquat Sci., 60(7) : 773-786.
- Kolekar, V. (2009). An account of observations on fishing gear and crafts of Mandovi estuary of Goa. J. Inland Fish. Soc. India, 41(1): 41-46.
- Konar, S.K., Paria, T., and Das, M.C. (1997). Habitat degradation as threat to piscine abundance, p 8-14. In Vass, K.K. and Sinha, M. (eds.). Changing perspectives of Inland Fisheries. Proc. Nat. Sem. IFSI, Barrackpore, India.
- Kumar, A. (2000). A quantitative study of the pollution and physico-chemical condition of the river Mayurakshi in Santhal
- Paragna, Bihar, in: (Trivedy, R.K. Edited). Pollution and Biomonitoring of Indian Rivers, ABD Pub. Jaipur. 246-251.
- Lacey LA, Lacey CM (1990). The medicinal importance of Riceland mosquitoes and their control using alternative to chemical insecticides. J. Am. Mosq, control Assoc. Supplement 2: 1-93 Medline.
- Mansoori, H.A. Lavania, R.K. and Tiwari, R.K. (1995). Hydrological study of Lakshmital Lake, Jhansi with special reference to plankton productivity. Flora and Fauna 1(1): 39-42.
- Mc Allister, DE, Hamilton, A.L. and Harvey, B. (1997). Global freshwater biodiversity, striving for the integrity of freshwater ecosystems. Sea Wind, 11: 1-140.
- Menon, A.G.K., (1974). A checklist of Fishes of the Himalayan and the Indo-Gangetic plain. Spl. Publ. No. 1 Inland Fish. Soc. India, Barrackpore, West Bengal, India.
- Merchetti, M.P. and Moyle, P.B. (2001): Effects of flow regime on fish assemblages in a regulated California stream. Ecological Applications, 11: 530-539.
- Mishra, K.S. (2003), An aid to the classification of the Common Commercial Fishes of India and Pakistan, Narendra Publishing House, Delhi.

- Mishra, B. P. and Tripathi, B.S. (2003). Seasonal variation in physico-chemical characteristics of Ganga water as influenced by sewage discharge. Indian J. Ecol. 30: 27-32.
- Mishra, B.P. and Tripathi, B.S. (2003). Seasonal variation in physico- chemical characterisitics of Ganga water as influenced by Sewage discharge. Indian J. Ecol. 30: 27-32.
- Mishra, B.P. and Tripathi, B.S. (2003). Seasonal variation in physico- chemical characteristics of Ganga water as influenced by sewage discharge. Indian J. Ecol. 30: 27-32.
- Mishra, S.K. (2000). Comparative evaluation of the water quality of two rivers of Narkatiaganj, Bihar (India) with reference to Pollution, Fisheries and Diseases (Trivedy, R.K. Edited). Pollution and Bio-monitoring of Indian Rivers. ABD Publ. Jaipur, 159-167.
- Mishra, S.K. (2012), Hill Stream fishes along the Indo Nepal Border, Mittal Publicatoins, New Delhi pp. 126.
- Mishra, S.K. amnd Dwivedi, R. (1994). Fish and Fisheries of the river, Pandai, West Champaran, Bihar. Geobios new reports, 13: 125-128.
- Montogomery, D.R., Buffington, J.M., Peterson, N.P., Schuett- Hames, D. and Quinn, T.P. (1966). Stream bed Scour egg buria depths and the influence of Salmonid spawning on bed surface mobility and embryo survival. Can. J. Fish. Aquat Sci., 53: 1061-1070.
- Mookerje, H.K. (1945). Factors influencing the spawning of principal carps in India. Symposium on the factors influencing the spawning of Indian Carps. Proc. Nat. Inst. Sci. India 71: 312-315.
- Moyle, J.B. (1949). Some indices of lake productivity. Trans. Amer, Fish Soc., 76: 322-334.
- Mukhopadhyay, S.K. (1966). Limnological investigations in lotic and lentic freshwater bodies in an around Darjeeling, West Bengal, India, Geobios. 23(2): 101-1016.
- Mukunda Goswami, R. Sathiadhas, U.G. Goswami and Ojha, S.N. (2002). Socio economic dimension of fish farming in Assam. J. Indian Fish

Association 29: 103-110.

- Narain, S. and Chauhan, R. (2000). Water quality status of river complex Yamuna at Panchnada (Etwah, U.P.). An integrated management approaches. J. Poll. Res. 19(3): 357-364.
- Nath, D., Misra, R.N., Jha, B.C. and Mukhopadhyay, M.K., (2007). Hydrobiological investigation in river Damadar with special reference to aquatic pollution. J. Ind. Fish. Soc. India 39(1):45-50.
- Nath, D., Shrivastawa, N. P. and Mondal, S. (2008). Water pollution at river, Narmada in Madhya Pradesh. J. Inland Fish. Soc. India 40(2): 74-77.
- Nayak, A.K., Mukhi, S.K., Behera, B.K., Samantha, B., Mishra, C. and Kohli, M.P.S. (2000). A survey on various gears, crafts and fishing methods adopted by the fishermen of Chilka lake. Fish Food Securily (Abstracts). First Indian Fisheries Science Congress, Indian Society of Fisheries Professionals. P. 22.
- Pandey, B.N., Gupta, A.K. Mishra, A.K., Das, P.K.L. and Jha, A.K. (2000). Ecological Studies on River Panar of Araria (Bihar) with Emphasis on its Biological components. Pollution Bio-monitoring of Indian Rivers, ABD, Pub. Jaipur.
- Pandey, B.N., Gupta, A.K., Mishra, A.K., Das, P.K.L. and Jha, A.K. (2000). Dams on the Mekong River: Lost fish protein and the implications for land and water resources. Global Enviorn. Change 22(4): 925-932. Crossref.
- Pant, G.B. and Rupa Kumar, K. (1997). Climates of South Asia, John Wiley & Sons. Raj, B.S. 1916. Notes on the freshwater fishes of Madras, Rec. Indiasn Mus., 12: 249-294.
- Rajput, S.I., Wahgulade, G.P. and Zambare, S.P. (2004). A study of physico-chemical characteristics of water from regent canal of Hatner Reservoir of Jalgaon, Maharasthra State. Ecol. Env. & Cons. 10(2): 171-173.
- Rajput, S.I., Wahgulade, G.P. and Zambare, S.P. (2004). A study of physic-chemical characteristics of water from regent canal of hatner Reservoir of

Jalgaon, Maharasthra State, Ecol. Env. & Cons. 10(2): 171-173.

- Ramesan, M.P., Pravin, P. and Kumari, M. (2011). Inland Fishing Gear and Fishing Techniques of India J. Inland Fish Soc.India, 43(2): 55-72.
- Ratan, N., Srivastava S., Pathak, A. and Singh, U.N. (2017). Water quality of Parichha Dam reservoir in relation to fisheries in Jhansi (U.P.) India. Flora and Flora, Vol. 23, No.1, pp. 95-98
- Ray, (1998). Ecological imbalance of the Ganga river system. Its impact on aquaculture. Daya Publishing House, Delhi.
- Ross N, Waheb MA, Chamnan C, Thilsted SH. (2007). The role of Fish in Food-Based strategies to combat Vitamin A and Mineral Deficiencies in Developing Countries. J. Nutr. 137(4): 1106-1109 Medline.
- Roy, L.B., Bhusan, M. and Kumar, R. (2016). Climate Change in Bihar India: A case study. J. Water Resources and Hydraulic Engineering. Vol. 5, Iss. 3. pp. 140-146.
- Rupa Kumar K., Krishan Kumar and Pant, G.B. (1994). Diurnal symmetry of surface tempereature trends over India, Geophysics, Rcs. Lett., 21, 677-680.
- Sarkar, U.K., Gupta, B.K. and Lakra, W.S. (2009). Biodiversity, ecohydrology, threat status and conservation priorty of the fresh water fishes of river Gomati, a tributary of river Ganga (India). Environmentalist, 30: 3-17.
- Saxena Shriparna, (2014). Study on socio-economic status of fishermen community of upper lake Bhopal: Preliminary study International J. Sci. Res., 3(8): 2047- 2048. www.ijsr.net
- Saxena, A, Singh, R.N. and Chisti, A. (2014). The Socio-Economic Status of Fishermen of district Rampur, Uttar Pradesh. 3(3): 1-4.
- Saxena, A., Singh, R.N. and Chisti, A. (2014). The Socio-economic status of fishermen of District Rampur, Uttar Pradsh, 3(3): 1-3.
- Saxena, R.K. (1966). The fishing nets and traps in a section of the middle reach of Ganga river system of India. Proc. Indo-Pacific Fish. Coun., 2(2):

250-271.

- Saxena, S., Study on Socio-Economic status of Fisherman community of Upper Lake Bhopal. Preliminary Survey. International J. Sci. Res. (IJSR), 3(8); 2047-20048; www.ijsr. Net.
- Sen, D. (2006). River Dynamics River Fisheries in India Issues and Current Status (In K.K. Vass, K. Mitra, V.R. Suresh, P.K. Katiha, N. P. Srivastava Ed.) Inland Fisheries Society of India, Barrackpore-700120, West Bengal 13-24.
- Sen, T.K. (1981). The minnows of India. Zoologiana, No. 4, Z5I. 99. pp. 95-100.
- Sen, V. (1972). Methods of fishing in Rarh region of Bengal Indian Mus. Bull., 7(2): 37-52.
- Shaw, G.E. and Shebbeare, E.O. (1937). The Fishes of Northern Bengal.
- J. R. Asiat. Soc. Beng. Sci, 3: 1-137, 6 pls. 130 text-figs. Singh, (2008). Advances in Limnology, Narendra Publishing, House, Delhi.
- Singh, M.R. and Gupta, A. (2010). Seasonal variation in certain physico-chemical parameters of Imphal. Iril and Thoubal river from Manipur River System. India. Eco. Env. & Cons. 16(2): 197-207.
- Sinha, A.K., Singh, V.P. and Srivastava, K. (2000). Physico-chemical studies on river Ganga and its tributaries in Uttar Pradesh the present status. In Pollution and Biomonitoring of Indian Rivers (ed.), Dr. R.K. Trivedy Ed., ABD Publishers, Jaipur, 1-29.
- Sinha, M.P. (1986). Limnobiotic study on trophic status of a polluted fresh water reservoir of coal field area. Poll. Res. 5(1): 13-17.
- Sinha, R.K. (2006). Ecological basis for management and conservation of riverine fisheries with special reference to the Ganga river system (In K.K. Vass, K. Mitra, V.R. Suresh, P.K. Katiha, and N.P. Srivastava Ed.). River fisheries in India issues and current s tatus. Inland Fish. Soc. Of India, Barrackpore, 700120, West Bengal, 83- 97.
- Srivastava V.K., Srivastava, G.K. and Srivastava, J.K. (1966).

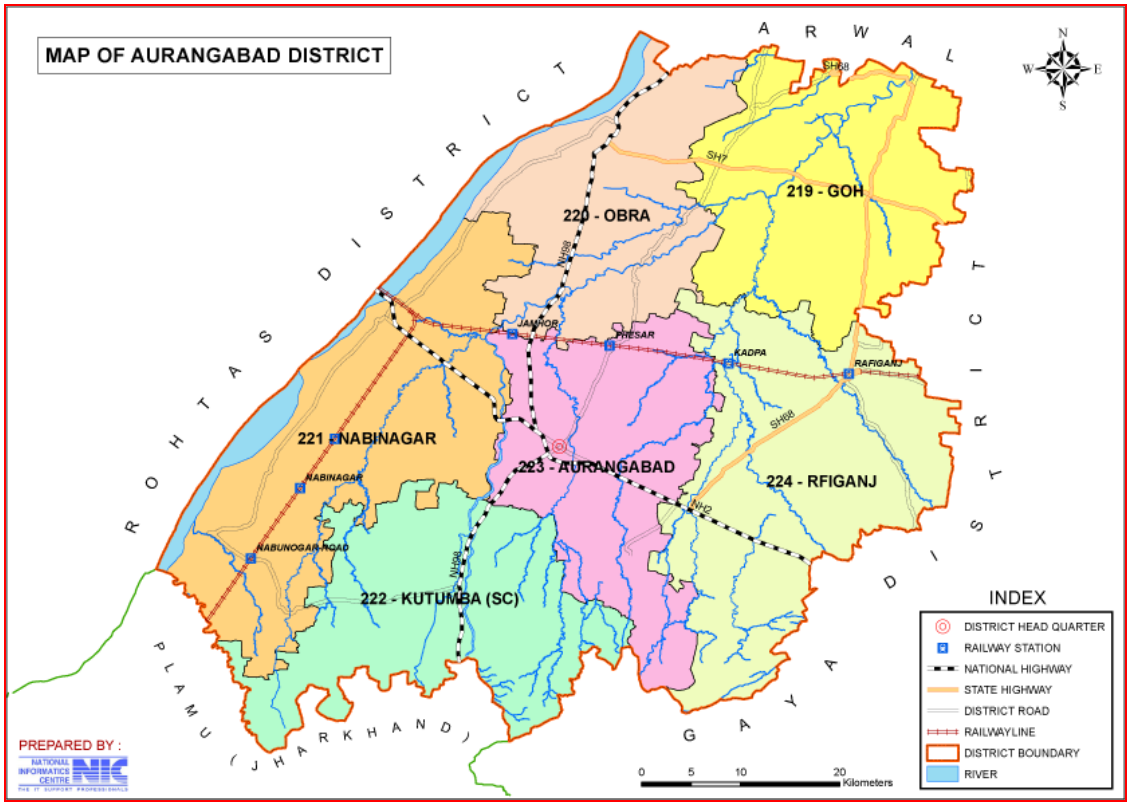
Phytoplankton productivity and physico-chemical properties of Rapti River. Ecol. Env. & Cons. 2: 183- 185.

- Stein, B.A., Kutner, L.S. and Adams, J.S. (eds.), (2000). Precious heritage. The status of biodiversity in the United States/. New York. Oxford University Press. pp. 416.
- Stiassny, MLJ 1996. An overview of Freshwater Biodiversity: With some Lessons from African Fisheries 21(9): 7-13 crossref.
- Subramanian, S. (1994). Inland fisheries potential and its development in Goa, pp. 20-27. In Das, M.K. and Chkrabarty, P.K. (eds.) contribution to the fisheries of inland open water systems in India. Part II. Cental Inc. Fish. Research Inst. Barrackpore
- Talwar, P.K. and Jhingran, A.G. (1991). Inland Fishes of India and Adjacent countries. Oxford and IBH Publication Co. Pvt.Ltd. New Delhi. Vols. 1 & 11.
- Thilsted SH, Roos, N, Hasan N. (1997). The role of small indigenous fish speices in food and nutrition security in Bangladesh. NAGA 20 (3-4): 82-84
- Trivedy, R.K. (1990). Studies on Biological characteristics of the river Krishna in Maharasthra with reference to human activity and pollution. Final technical report (1985- 1988). Ministry of Environment, Forest and Wild Life, Govt. Of India.
- Trivedy, R.K. and Goel, P.K. (1986). Chemical and Biological Methods for Water Pollution Studies. Environmental Publication, Karad (India).
- Tyagi, A. and Goswami, B.N. (2009). Assessment of climatic change and adaptation in India. Climate Sense, 68-70.
- Uniyal, D.P., and Kumar, A. (2006). Fish diversity in the selected streams of Chakrata and Shiwalik Hills (District Dehradun, Uttarnchal,), India. Records of the Zoological Survey of India, Occasional paper 253.
- Unni, K. Shankaran, (1996). Ecology of river Narmada. A.P.H. Publishing Corporation, New Delhi, pp.371.

- Uttam K Sarkar, J.K. Jena, Shri Prakash Singh, A.K. Singh and SC Rebello (2012). Documenting Coastal Fish Biodiversity of India: Status, Issueses and challenges, conference paper, International Day for Biological Diveristy, Marine Biodiversity, 22 May, 2012, Uttar Pradesh State Biodiversity Board, Lucknow, 22-28.
- Vass, K.K., Mukhopadhyay, M.K., Mitra, K., Bagchi, M.M. and Bandhopahdyay, S. (1997). Fish as biomonitoring tool for environmental impact assessment in Ganga river system pp. 15-23. In vass, K.K. and Sinha, M (eds.) Changing Perspective of Inland fisheries. Proc. Nat. Sem. IFSI, Barrackpore, India.
- Verma, A.M., (2006). On a fishing device posing threat to rare fish fauna in North Bihar. J. Inland Fish. Soc. India, 38(2): 85-87.
- Verpoorter C, Kutser T, Seckell DA, Tranvik L J, (2014). A global Inventory of Lakes Based on High-Resolution Satellite Imagery Geophys Res. Lett. 41 (18): 6396-6402 Cross ref.
- W.H.O. (1971). International standards of Drinking water, 111rd Edition, Geneva W.H.O. 1983. International standards for drinking water. World Health Organization, Geneva, p. 1-7.
- Welch, P.S. (2009). Limnological Methods, McGraw Hill, New York. Welcomme RL, Cowx 1G, Coates D, Bene C, FungeSmith S, Halls A, Lorenzen K. 2010. Inland capture fisheries. Phil-
- Trans R. Soc. Lond Ser-B, Biol-Sci 365 (1554): 2881-2896 crossref, Medline.
- Welcomme, R. (1998). Evaluation of stocking and introduction as management tools, pp. 397-413. In stocking and introduction of Fish (ed.)., Cowx, 1G. Fishing News Books, A division of Blackwell science Ltd. 456 pp.
- Welcomme, R. and Vidthayanon, C. (2000). The impacts of introductions and stocking of exotic fish species in the Mekong basin and policies for their control Management of Reservoir Fisheries in the Mekong Basin, MRC Vientiane. 70 pp.
- Welcomme; R.L. (2001). Inland fishereies ecology and management. Oxford

UK, Blackwell science Ltd. Fishing News Books.pp.358.

- World Health Organizaiotn, (1993). Guidelines for drinking water quality-1. Recommendations 2nd Ed. Genera WHO, www.lenntech.com/drinking water standard. htm.
- Yadav, B.N. (1997). Fish and Fisheries, Daya Publishing House, Calcutta, p. 320.
- Youn SJ, Taylor WW, Lynch AJ, Cowx 1G, Beard TD, Bartley D, WuF, (2014). Inland capture fishery contributions to global food security and threats to their future. Global Food Secur 3(3-4): 142-148 crossref.
- Zafar, A. and Sultana, N. (2008). Seasonal analysis in the water quality of river Ganges, J. Curr. Sci. 12(1): 217-220.



Map - Aurangabad District, (Bihar) showing Nabinagar.

Acta Scientific Veterinary Sciences (ISSN: 2582-3183)

Volume 4 Issue 2 February 2022

Research Article

Ichthyofauna of the River Punpun of Nabinagar, Bihar (India) and its Fisheries

Neha Raj[1], Kumari Priyanka[2] and Safal Kumar Mishra[2]*

[1]*Department of Zoology, P. K. University, India*

[2]*Department of Zoology, B. R. A. Bihar University, India*

***Corresponding Author:** Safal Kumar Mishra, Department of Zoology, B. R. A. Bihar University, India.

Received: September 04, 2021

Published: January 13, 2022

Abstract

The paper deals with the fish and fisheries of the river Punpun of Nabinagar, Bihar (India). During course of investigation 75 species of inland fishes were recorded dominated by Cypriniformes (32 species) followed by Siluriformes (19), Perciformes (10), Channiformes (04), Mastacembeliformes (03), Osteoglossiformes(01), Symbranchiformes (01) and Tetraodontiformes (01). Among these fishes 21 were vulnerable, 04 exotic, 04 endangered, 01 threatened, 05 lower risk least concern and 21 lower risk near threatened. The existing fishing methods were of conventional type.

Keywords: Ichthyofauna; Punpun; Nabinagar; Bihar (India); Fishes

Abbreviations

C: Carnivorous; H: Herbivorous; D: Detritivorous; O: Omnivorous; L: Larvivorous; P: Predatory; E-P; Euryphagous plaktivorous; Bp: Benthophagous; Mpp: Micro Phytoplankton Feeder; Mpf: Microplankton Feeder; Ppp: Periphytophagous; V: Vulnerable; T: Threatened; En: Endangered; Exo: Exotic; LRlc: Lower Risk Least Concern; LRnt: Lower Risk Near Threatened

Introduction

Bihar is one of the most significant and interesting state in India ichthyologically owing to its diverse ichthyofauna. The Punpun flowing in North - East direction is fed by a number of hilly torrents, namely, the Adri, the Batre, the Batane, the Dhawa, the Kasman, the Ramrekha, the Madar etc., joins the river Ganga at Fatawh, 25 Km downstream of Patna, the capital of Bihar state. Inland water comprise approximately 0.01% of the total volume of water on earth [24]. Inland fish comprise about 40% of all fish species and 20% of all vertebrate species [9]. Inland fish serve as a major source of protein, essential fats and micronutrients for hundreds of millions of people, particularly in rural communities [20,27,29]. More than 60 million people in low income countries rely upon inland fisheries as a source of livelihood and women represent half the individuals in inland fisheries society chains [5]. During financial year 2018, the fish production amounted to around 650 thousand metric tons in Indian state of Bihar. Thus fisheries sector has an important role in overall development of state of Bihar.

A perusal of literature reveals that since Day's time (1878 -1889) ichthyofaunal work of Bihar has been extremely fragmented, however, Indian state of Bihar has many major rivers, rivulets and streams, offering diverse habitat. The most important contributors on Bihar inland Ichthyofauna are Hamilton [8], Srivastava [25]; Mishra., *et al.* [18]; Hasan [7]; Mishra [16]; Payne [19]; Datta Munshi., *et al.* [3]; Sinha [23]; Mishra [17] and Sinha., *et al.* [22] but no attempt has been done on the ichthyofauna of the river Punpun of Nabinagar, Bihar (India) hence the present study was undertaken.

Materials and Methods

The Punpun river of Nabinagar, Bihar (Figure 1) lying between 84^0: 0′ - 85^0: 20′ E Longitude and 24^0: 1′ - 25^0 25′ N Latitude is a right bank tributary of the river Ganga having a catchment area of about 8530 sq. km., which is about 1% of the total Ganga basin area in the country.

Figure 1: Location map of study area.

Figure 2: The river Punpun flowing through the Nabinagar town.

Figure 3: A view of the river Punpun upstream at Nabinagar town.

Figure 4: The river Punpun downstream at Nabinagar town.

Fish specimens were collected using different kinds of fish catching appliances and device with the help of fishermen while some were procured from the local market. Ecological notes, wherever possible were taken down. The specimens were fixed in 8% formaline solution. Fixed specimens were kept in containers with proper labeling and the tail pointing upwards for further studies. The identification of fishes are based on Day [4]; Jayaram [12]; Talwar., *et al*. [26] and Yadav [28]. Classification of fishes followed here are that of Greenwood., *et al*. [6] from Menon [15] cheek list. The nomenclature of various species are based on recent revisions and ICUN status of fishes were prepared based on CAMP, categorisation and IUCN category [1,10,11].

Results, Discussion and Conclusion

The river Punpun (Figure 2) has been surveyed within a stretch of 6 Km (3 Km upstream and 3 Km downstream of Nabinagar town) (Figure 3,4). The ichthyofauna of the river Punpun flowing through Nabinagar (Bihar) is based on a collection of 75 species of inland fishes belonging to 51 genera, 22 families and 10 orders as presented in table 1.

Order	Family	Genus	Species	Feeding habbit	Status
Clupeiformes	Engraulididae	Setipinna Swainson	(01) *Setipinna phasa* (Ham.)	C	
Osteoglossiformes	Notopteridae	Notopterus Lacepede	(02) *Notoperus chitala* (Ham.)	C	V
			(03) *Notopterus notopterus* (Pallas)	C	T
Cypriniformes	Cyprinidae	Catla Valenciennes	(04) *Catla catla* (Ham.)	H	V
		Ctenopharyg-odon Steinbachner	(05) *Ctenopharyngodon idellus* (Valenciennnes)	H	Exo
		Crossocheilus Van Hasselt	(06) *Crossocheilus latius* (Ham.)	H	V
		Chela Hamilton	(07) *Chela laubuca* (Bleeker)	E-P	LRlc
		Hypophthalmi-chthys Bleeker	(08) *Hypophthalmichthys molitrix* (Valen-ciennes)	Mpp	Exo
		Salmostoma Swainson	(09) *Salmostoma bacaila* (Ham.)	O	LRlc
		Esomus swainson	(10) *Esomus danricus* (Ham.)	O	LRlc
		Danio Hamilton	(11) *Danio rerio* (Ham.)	O	
		Rasbora Bleeker	(12) *Rasbora daniconius* (Ham.)	O	
		Aspidoparia Heckel	(13) *Aspidoario morar* (Ham.)	O	LRnt
		Barilius Hamilton	(14) *Barilius bendelisis* (Ham.)	Ppp	LRnt
		Cyprinus Linnaeus	(15) *Cyprinus carpio (*Linnaeus)	O	Exo
		Puntius Hamilton	(16) *Puntius chola* (Ham.)	H	V
			(17) *Puntius conchonius* (Ham.)	O	V
			(18) *Puntius sophore* (Ham.)	H	LRnt
			(19) *Puntius sarana sarana* (Ham.)	O	V
			(20) *Puntius ticto* (Ham.)	H	LRnt
			(21) *Puntius terio* (Ham.)	O	LRnt
		Osteobrama Heckel	(22) *Osteobrama cotio cotio* (Ham.)	O	LRnt
		Labeo Cuvier	(23) *Labeo angra* (Ham.)	H	LRnt
			(24) *Labeo boga* (Ham.)	D	LRnt
			(25) *Labeo calbasu* (Ham.)	H	LRnt
			(26) *Labeo dero* (Ham.)	H	V
			(27) *Labeo rohita* (Ham.)	H	LRnt
			(28) *Labeo dyocheilus* (McClelland)	H-O	V
			(29) *Labeo gonius* (Ham.)	H	LRnt

		Cirrhinus Oken	(30) *Cirrhinus mrigala* (Ham.)	O	V
			(31) *Cirrhinus reba* (Ham.)	H	V
	Cobitidae	Botia Gray	(32) *Botia dario* (Ham.)	O	V
			(33) *Botia lohachata* (Chaudhuri)	C	En
		Somileptes Swainson	(34) *Somileptes gongota* (Ham.)	C	LRnt
		Lepidocephalus Bleeker	(35) *Lepidocephalus guntea* (Ham.)	D	Lc
		Rita Bleeker	(36) *Rita rita* (Ham.)	Bp	LRnt
Siluriformes	Bagridae	Mystus Scopoli	(37) *Mystus bleekeri* (Day)	C	V
			(38) *Mystus cavasius* (Ham.)	C	LRnt
			(39) *Mystus tengra* (Ham.)	C	
			(40) *Mystus vitattus* (Bloch)	C	V
	Siluridae	Ompok Lacepede	(41) *Ompok bimaculatus* (Bloch)	P	nt
		Wallago Bleeker	(42) *Wallago attu* (Schneider)	C	nt
	Schilbeidae	Clupisoma Swainson	(43) *Clupisoma garua* (Ham.)	C	V
		Pseudotropius Bleeker	(44) *Pseudotropius atherinoides* (Bloch)	O	En
		Eutropiichthys Bleeker	(45) *Eutropiichthys vacha* (Ham.)	C	En
	Sisoridae	Bagarius Bleeker	(46) *Bagarius bagarius* (Ham.)	C	V
		Gagata Bleeker	(47) *Gagta cenia* (Ham.)	O	
		Nangra Day	(48) *Nangra viridescens* (Ham.)	C	LRnt
		Erithistes Muller and Troschel	(49) *Erithistes pussilus* (Mulller & Troschel)	C	
		Laguvia Hora	(50*) Laguvia shawi* (Hora)	O	
		Glyptothorax Blyth	(51) *Glyptothorax telchitta telchitta* (Ham.)	O	V
		Sisor Hamilton	(52) *Sisor rhabdophorus* (Ham.)	C	En
	Claridae	Clarias Scopoli	(53) *Clarias batrachus* (Linnaeus)	C	V
	Heteropneustidae	Heteropneustes Miller	(54) *Heteropneustes fossilis* (Bloch)	C	V
Atheriniformes	Belonidae	Xenentodon Regan	(55) *Xenentodon cancila* (Ham.)	C	LRnt
	Cyprinodontidae	Aplocheilus McClelland	(56) *Aplocheilus panchax* (Ham.)	L	

Channiformes	Channidae	Channa Scopoli	(57) *Channa marulius* (Ham.)	C	
			(58) *Channa orientalis* (Schneider)	C	V
			(59) *Channa punctatus* (Bloch)	C	LRnt
			(60) *Channa striatus* (Bloch)	C	LRlc
Symbranchiformes	Synbranchidae	Monopterus Lacepede	(61) *Monopterus cuchia* (Ham.)	C	
Perciformes	Chandidae	Chanda Hamillton	(62) *Chanda baculis* (Ham.)	C	
			(63) *Chanda nama* (Ham.)	C	
			(64) *Chanda ranga* (Ham.)	C	
	Nandidae	Nandus Valenciennes	(65) *Nandus nandus* (Ham.)	C	
		Badis Bleeker	(66) *Badis badis* (Ham.)	C	V
			(67) *Badis dario* (Ham.)	C-O	
	Gobiidae	Glossogobius Gill	(68) *Glossogobius giuris* (Ham.)	C	LRnt
	Anabantidae	Anabas Cuvier	(69) *Anabas testudineus* (Bloch)	P	V
	Belontidae	Colisa Cuvier	(70) *Colisa fasciatus* (Schneider)	O	LRnt
	Cichlidae	Tilapia A. Smith	(71) *Tilapia mosambica* (Peters)	H	Exo
		Macrognathus Lacepade	(72) *Macrognathus aculeatus* (Bloch)	C	
Mastacembiliformes	Mastacembelidae	Mastacembelus Scopoli	(73) *Mastacembelus armatus armatus* (Lacepede)	C	
			(74) *Mastacembelus pancalus* (Ham.)	C	
Tetraodontiformes	Tetradontidae	Tetraodon Linnaeus	(75) *Tetraodon cutcutia* (Ham.)	C	

Table 1: List of fishes of the river Punpun of Nabinagar (Bihar).

In the river Punpun out of 75 species Cypriniformes dominated with 32 species followed by Siluriformes (19), Perciformes (10), Channiformes (04), Mastacembeliformes (03), Osteoglossiformes (02), Atheriniformes (02), Clupeiformcs (01), Symbranchiformes (01) and Tetraodontiformes (01). The trend of dominance of Cyprinids in the river is in agreement with the observations in tropical Indian rivers [2,21].

Evaluation of the conservation status of the fish species showed that maximum species comes under vulnerable (28%) and lower risk near threatened (28%) category, followed by lower risk least concern (6.6%), endangered (5.3%), exotic (5.3%) and threatened (0.75%) (Table 01). The trophic composition revealed abundance of carnivorous species (46.6%) followed by omnivorous (22.6%), herbivorous (18.6%), detritivorous (2.6%), predatory (2.6%), euryphagous planktivorous (1.3%), microphytoplankton feeder (1.3%), benthophagous (1.3%), periphytophagous (1.3%) and larvivorous (1%).

Engraulidiae, one of the economically valuable families of fishes, comprising the anchovies are quite frequent during the monsoons and appears to be a migrant. Members of the family Notopteridae are predominantly tropical freshwater fishes of extraordinary diverse body form and size. Cyprinids are the most dominant and economically significant group of primary freshwater fishes within its distribution, were the chief contributor to the annual catch composition. *Ctenopharyngodon idellus* (Valenciennes), *Hypophthalmichthys molitrix* (Valenciennes) and *Cyprinus carpio* (Linnaeus) are common exotic fishes now cultured all over India. Cobitids are bottom dwellers, mostly of small size (upto 30 cm), having no interest to fisheries. Fishes of the family Bagridae are not much liked locally as food, taken, mostly by poorer sections. Among

Siluriids *Ompok bimaculatus* (Bloch) is considered a very tasty fish and is highly priced. *Wallago attu* (Schneider) a good sport and is very destructive to other more valuable food fishes. Schilbiidae is a family of cat fishes. These fish tend to swim in open water. Sisorids are eaten by poorer classes and of no interest to fisheries. Clarids, commonly named air breathing of walking catfishes, are a group of catfishes naturally occurring in the Indian sub continent. *Clarias batrachus* (Linnaeus) is of great economic importance as food fish and have been introduced, generally without through considerable threat to the biodiversity of local species. The threatened stinging catfish *Heteropneustes fossilis* (Bloch) is a nutritionally valuable food in Asian countries. The fish is mostly preferred for its tender flesh, delicious taste and low fat content, where as it is also appreciated in traditional medicine. Its natural populations have declined due to over exploitation, habitat loss and pollution, thus deserving high conservation importance for the remaining isolated, wild population of *Heteropneustes fossilis* (Bloch) in Asian countries. Belonids are elegant surface – living fish and of no interest to fisheries. *Aplocheilus panchax* (Ham,) is an important larvivorous fish. Snake head fishes of the family Channidae are predatory freshwater important food fish and have been introduced widely. Symbranchidae or Gangetic mud eels or swamp eels occur in both freshwater and occasionally in brackish water. Fishes of the family Channidae are not important due to its spines and scanty flesh. *Badis badis* (Ham.) is not commercially important due to its spinous small body with less flesh. *Glossogobius giuris* (Ham.) is commercially not important due to its 'bloodless' flesh and tastelessness, locally consumed when freshy caught and sold in the local fish markets. Anabantids are traditionally known for its excellent taste. *Colisa fasciatus* (Schineider) is very much popular for its good taste. *Tilapia mosambica* (Peters) is reported to be unsuitable for fish culture along with major Indian carps, because of its depradation on carp fry. *Macrognathus aculeatus*(Bloch) commercially not important due to its small size and less flesh. *Mastacembelus armatus* (Laceede) and *M. pancalus* (Ham.) are most popular for good girth and oily taste. *Tetraodon cutcutia* (Ham.) are not eaten locally due to its poisonous effects.

During field study the fishing method were studied. Fishing is carried out by local fishermen. A large variety of fishing gear and tackles are operated in different stretches of the river for commercial exploitation of the fishery resources. The fishery resources are exploited mostly by traditional methods and gears. depending upon the target species, fishing ground, climate, current and other hydrobiological conditions. The methods of fishing vary from place to place. The existing fishing methods in the river Punpun are conventional type. The main fishng gear is the castnet, made of both nylon and cotton of various dimensions. The other method employed are Bag nets, Scoop nets, Stake nets. Gill nets, Hooks, Angling, Barriers etc. Fishing crafts includes different types of boats. Mostly traditional non – mechanized crafts and gears are in vogue since long.

Bibliography

1. CAMP. "Report on the Workshop on conservation assessment management plan (CAMP) for freshwater fishes of India". Zoo Outreach Organisation and NBFGR, Lucknow, 22-26 September (1997): 156. www.books.google.cv.in

2. Das MK., *et al*. "Fish diversity, community structure and ecological integrity of the tropical river Ganges, India". *Aquatic ecosystem Health and Management* 16.4 (2013): 395-407. www.researchgate.net

3. Datta Munshi JS., *et al*. "Natural History of Fishes and Systematics of freshwater Fishes of India". Narendra Publishing House Delhi (2006). www.abebooks.com

4. Day F. "The Fishes of India : being a natural history of the of the fishes known to inhabit the seas and freshwaters of India, Burma, and Ceylon". Taylor and Francis, London: (1875-1878) (1986). www.indianculture.gov.in

5. FAO. "CWP "Handbook of fishery Statistical Standards". Section G: Fishing Areas Genefal. Rome, Italy (2014b). www.fao.org

6. Greenwood PH., *et al*. "Phylectic studies of Teleoteam fishes, with a provisional Classification of living forms". *Bulletin of the American Museum of Natural History* 131 (1966): 339-456. www.digitallibrary.amnh.org

7. Hassan SS. "The Current Status of the Fish Stock of Commercial Importance in River Ganga in and around Patna Region". Ph.D. Thesis, Patna University (1999).

8. Hamilton F. "An account of the fishes found in the river Ganges and its branches". Edinburgh and London: VIII (1822). www.openlibrary.org

9. Helfman GS., *et al*. "The Diversity of Fishes: Biology, Evolution and Ecology". Wiley - Black well, Hoboken, NJ (2009). www.books.google.co.in

10. IUCN. "International Union for Conservation of Nature and Natural Resources" (2011). www.iuenredlist.orgj.1523/1739.2008,00953.x

11. IUCN. "The IUCN Red List of Threatened Species". Version 2015. 2. IUCN, Gland, Switzerland and Cambridge, UK (2015). www.ivemredlist.org.290October:(2015)

12. Jayaram KC. "The fresh water fishes of India". A Handbook. Zoological Survey of India, Calcutta, 1-VIII (1981). www.faunaofindia.nic.in

13. Lakra WS., *et al*. "Threatened Freshwater Fishes of India". NBFGR, Lucknow (2010). www.nbfgr.res.in

14. Menon AGK. "Threatened Fishes of India and Their Conservation". Zoological Survey of Indi, Kolkata., (2004). www.faunaofindia.nic.in

15. Menon AGK. "A cheek list of fishes of the Himalayan and the Indo -Gangetic plains". *Journal of the Inland Fisheries Society of India* (1974). www.catalogue.nla.gov.au

16. Mishra KS. "An Aid to the Identification of the Common Commercial Fishes of India and Pakistan". Narendra Publishing House, Delhi (2003). www.worldcat.org

17. Mishra SK. "Hill Stream Fishes along the Indo – Nepal border". Mittal Publication, New Delhi (2012). www.mittalbooks.com

18. Mishra SK., *et al*. "Fish and Fisheries of the river Pandai, West Champaran, Bihar". *Geobios New Report* 13 (1994): 125-128.

19. Payne A I., *et al*. "A review of the Fisheries". In welcome R. and T. Peter, (eds.) Proceeding of the Second International Symposium on the Management of large Rivers for fisheries Volume 1. FAO Regional office for Asia and the Pacific, Bangkok, Thailand, RAP Publication 16 (2004/16): 229-251. www.LARS2.org/proceeding Vol.1/A Review of the Ganges Basin.pdf

20. Roos N., *et al*. "The Role of Fish and Food – Based Strategies to Combat Vitamin A and Mineral Deficiencies in Developing Countries". *Journal of Nutrition* 137.4 (2002): 1106-1109. www.pubmed.nlm.nih.gov

21. Sarkar UK., *et al*. "Biodiversity, ecohydrology, threat status and conservation priority of the freshwater fishes of river Gomti, a tributary of river Ganga (India)". *Environmentalist* 30 (2009): 3-17. www.researchgate.net

22. Sinha A., *et al*. "Freshwater Ornamental fish of Bihar". Central Inland Fisheries Research Institute, Barrackpore, Kolkata 191 (2015). www.researchgate.net

23. Sinha RK. "Ecological basis for management and conservation of riverine fisheries with special reference to the Ganga river system". (In K.K. Vass, K. Mitra, V.R. Suresh, P.K. Katiha and N.P. www.cifri.res.in Srivastava Edited). River fisheries in India Issues and Current Status. Inland Fisheries Society of India. Barrackpore- 700120, West Bengal (2006).

24. Stiassny MLJ. "An Overview of Freshwater Biodiversity; with Some Lessons from African/Fishes". *Fisheries* 21.9 (1996): 7-13. www.afspubs.onlinelibrary.wiley.com

25. Srivastava GJ. "Fishes of U.P. and BIHAR". Vishwavidyalaya Prakashan, Varanasi (1980). www.abebooks.com

26. Talwar PK., *et al*. "Inland Fishes of India and adjacent Countries". Oxford and IBH Publication Co. Pvt. Ltd. New Delhi 1.2 (1991). www.booksgoogle.co.in

27. Thilsted SH., *et al*. "The role of small indigenous fish species in food and nutrition security in Bangladesh". 20.3-4 (1997): 82-84. www.researchgate.in

28. Yadav BN. "Fish and Fisheries". Daya Publishing House, Calcutta (1997). www.books.google.co.in.

29. Youn SJ., *et al*. "Inland capture fishery contributions to global food security and threats to their future". *Global Food Security* 3.3-4 (2014): 142-148. www.pubs.er.usgs.gov

Acta Scientific Veterinary Sciences (ISSN: 2582-3183)

Volume 3 Issue 10 October 2021

Research Article

Fishery and its Management of Sugaon Lake of East Champaran District of Bihar, India

Kumari Priyanka[1], Neha Raj[2] and Safal Kumar Mishra[1]*

[1]*Department of Zoology, B. R. A. Bihar University, India*

[2]*Department of Zoology, P. K. University, India*

***Corresponding Author:** Safal Kumar Mishra, Department of Zoology, B. R. A. Bihar University, India.

Received: August 27, 2021;

Published: September 23, 2021

Abstract

A remarkable physical feature of East Champaran district of Bihar is a chain of lakes, running through the centre of the district. These lakes of which the largest one at Chaknaha, Piprapakri, Bakaya, Kararia, Motijheel, Turkaulia, Sugaon, Phulwari, Sirsa, Chilraon, etc., evidently mark an old bed of the river Great Gandak. Lakes are of natural origin and because of their magnitude as well as production potential occupy important position in Indian inland fisheries. There is a high rate of primary production in the lakes of plains which suggests that if scientifically managed, the fish production can be augmented to a greater extent.

Ichthyologically the condition of Sugaon lake has been deteriorating under the impact of anthropogenic pressure, global warming and fast pace of development and if proper conservative measures are not taken the lake is likely to further deteriorate.

Keywords: Fishery; Management; Sugaon Lake; East Champaran; Bihar

Abbreviation

Sq.: Square; N: North; E: East; ha: Hectare; spp: Species

Introduction

The word 'Lake' comes from the Greekword 'Lakkos' meaning hole or pond (a basin), formed on the surface of earth due to various natural mechanisms. The lakes are variously termed as 'Jheel'; 'Beel'; 'Bellabongs' in Australia; 'Lores' in France and 'Altwasser' in Germany. In study area lakes are termed as 'Maun' and 'Jheel' respectively. Lakes has been classified on the basis of chemistry, physical form, size, geographical position, depth, phytoplankton, zooplanakton, macrophytes, invertebrates, fish, human use etc. A. Forel (1901) Father of Limnology, gave the first generally accepted systems of classification on the basis of thermal characteristics and recognized three types of lakes viz. Polar, Temperate and Tropical lakes. This system was modified by G. C. Whipple (1927) by subdividing the three main types into three orders. In 1936 S. Yoshimura improved the classification of Forel and recognized five types of lakes on the basis of thermal characteristics (Tropical, Subtropical, Temperate, Subpolar and Polar lakes). G. E. Hutchinson [1] considered the variation in latitude, altitude and depth of basin and recognized five categories of lakes (Amictic, Monomictic, Dimictic, Oligomictic and Polymictic). Lakes are often classified on the basis of availability of nutrients and productivity into three categories viz. Eutrophic, Oligotrophic and Dystrophic.

India occupying 9th position in terms of freshwater biodiversity is a megadiverse in ichthyofauna.

In North Bihar Gandak basin, a total water spread area of more than 7000 ha are available of which 80% fall under old Champaran (East and West) district.

East Champaran district is situated in the plains of river Gandak, Burhi Gandak and Baghmati and came into existence as one of the district of State of Bihar in 1971. It occupies an area of 3968.0 km^2. Nepal forms its northern boundary, Muzaffarpur southern while

Sitamadhi and Sheohar eastern and West Champaran with part of Gopalganj bounds it in western side.

The history of lakes of Champaran district dates back of more than hundred years. The origin of lake is a complex phenomenon and they have been originated after the great flood of 1867 A.D. in Burhi Gandak, involving many natural and human forces, which inundated the entire basin, leaving a few isolated islands. The Gandak basin comprises a number of 'U' shaped natural impoundments, originated due to fluviatile activity of Burhi Gandak and its tributaries.

The Champaran district is bestowed with many perennial rivers, originating from Nepal and among them the Gandiki river also famous as the Gandak and Narayani is most significant. The main stream of river Gandiki enters into Nepal through Mustang canyon located in the Himalaya. Burhi Gandak (Sikrahana) is the most significant river associated in the creation of lakes in Gandak basin. Prior to the construction of embankment on either side of the river Burhi Gandak, it changed its courses invariably leading to the formation of meanders, which cut off partially or fully from the original rivers and assumed the shape of lakes.

Lakes have been the subject of numerous investigation all over the world, however, comparatively few studies are available from India in general [3-5] and North Bihar in particular [6,7]. This report is the first detailed ichthyofaunal study of a natural threatened lake of East Champaran district of North Bihar.

Materials and Methods

The Sugaon lake lies between $26^0$16' N Latitude and $84^0$30' to $85^0$10' E Longitude. It is located about 19.5 km south of Motihari town the headquarter of East Champaran district. During course of investigation fish specimens were collected using different kinds of fish appliances and devices with the help of local fishermen. The identification of fishes are based on Day [14], Talwar., *et al.* [8] and Mishra [9]. The nomenclature of various species are based on recent revisions. Fishing methods were observed and different informations related to lake, fishery and its management were gathered through various sources.

Results and Discussion

Man has exploited lakes from time immemorial. Lakes are formed on the surface of earth due to various natural mechanisms. Lakes differ widely in their origin, shape, size, depth, hydrobiology and other characteristics. Lakes has variously been defined (Table 1) by different scientists [2,15].

Scientists	Definition
F. A. Forel	A Body of standing water occupying a basin and lacking continuity with sea
R. A. Muttkowskii	Those bodies of standing water which are considerable expanse and deep enough to stratify thermally
P. S. Welch	All large bodies of standing water
Johnes., *et al*	Bodies of water, both natural and man-made greater than two hectare in area

Table 1: Definition of Lakes.

The East Champaran district has a chain of 28 lakes running through the centre of the district. It occupies a water area of 7486 acres and shows a large potential for fishery development. Distribution and area of some important existing lakes in Gandak basin of East Champaran has been given in (Table 2).

Name of Lakes	Area in ha
Chaknaha	400
Pipra pakri	400
Bakaya	160
Kararia	120
Motijheel	100
Turkaulia	100
Sugaon	80
Phulwaria	80
Sirsa	80
Chilraon	80

Table 2: Distribution and area of some important lakes of East Champaran.

Sugaon lake occupies an area of 80 ha (Figure 1-3). Its depth varies from 3 to 20 feet and sufficient quantity of water remains in the lake throughout the year, never entirely dries up.

During course of investigation altogether 41 species of inland fishes belonging to 24 genera, 15 families and 8 orders have been recorded (Table 3).

Figure 1: A general view of the Sugaon Lake.

Figure 3: A temple for cultural activities on the margin of the lake.

Figure 2: Aquatic macrophytes along the margines of the Sugaon Lake.

The fishery of this lake is dominated by medium sized fishes (40%) like *Mystus cavasius* (Ham.), *Clarias batrachus* (linnaeus), Notopterus spp., Channa spp., and *Mastacembelus armatus* (Lacepede) and big fishes like *Wallago attu* (Schneider) followed by miscellaneous fishes (55%) like *Chela laubuca* (Ham.), *Esomus danricus* (Ham.), Barilius spp., Puntius spp., *Xenentodon* cancila (Ham.),*Chanda nama* (Ham.), *Anabas testudineus* (Bloch), *Colisa fasciatus* (Schneider). Miscellaneous fishes of less economic value have occupied the niche on a large scale, provided the basis for survival to the fishermen community of the area. The availability of the economic valued prized fish like *Catla catla* (Ham.), *Aspidoparia morar* (Ham.), Labeo spp., Cirrhinus spp., *Clarias batrachus* (Linnaeus) and *Heteropneustes fossilis* (Bloch) is much low about

Order	Family	Genus	Species	Common Name
Clupeiformes	Engraulidae	Setipinna Swainson	*Setipinna phasa* (Ham.)	Phansi
Cypriniformes	Cyprinidae	Catla Valenciennes	*Catla catla* (Ham.)	Bhakur
		Chela Hamilton	*Chela laubuca* (Ham.)	Chelwa
		Esomus Swainson	*Esomus danricus* (Ham.)	Dendua
		Aspidoparia Heckle	*Aspidoparia morar* (Ham.)	Chippuah
		Barilius Hamilton	*Barilius bola* (Ham.)	Dhawai
			Barilius bendelisis (Ham.)	
		Puntius Hamilton	*Puntius ticto* (Ham.)	Kotree
			Puntius sarana sarana (Ham)	Durhi
			Puntius chola (Ham.)	Sidhari
			Puntius conchonius (Ham.)	Sidhari
			Puntius sophore (Ham.)	Potiah
		Labeo Cuvier	*Labeo bata* (Ham.)	Bata
			Labeo reba (Ham.)	Reba
			Labeo calbasu (Ham.)	Kalbasu
			Labeo gonius (Ham.)	Kursha
			Labeo rohita (Ham.)	Rohu
		Osteobrama Heckel	*Osteobrama cotio cotio* (Ham.)	Goordah

		Cirrhinus Oken	*Cirrhinus reba* (Ham.)	Rewa
			Cirrhinus mrigala (Ham.)	Naini
	Cobitidae	Lepidocephalus Bleeker	*Lepidocephalus guntea* (Ham.)	Nakati
Siluriformes	Bagridae	Mystus Scopoli	*Mystus bleekeri* (Ham.)	Tengra
			Mystus cavasius (Ham.)	Tengra
			Mystus tengra (Ham.)	Tengra
			Mystus seenghala (Ham.)	Tengra
	Siluridae	Wallago Bleeker	*Wallago attu* (Schneider)	Boyari
	Claridae	Clarias Scopoli	*Clarias batrachus* (Linnaeus)	Mangur
	Heteropneustidae	Heteropneustes Miiller	*Heteropneustes fossilis* (Bloch)	Singhi
Osteoglossiformes	Notopteridae	Notopterus Lacepede	*Notopterus chitala* (Ham.)	Moya
			Notopterus notopterus (Pallas)	Golhi
Atheriniformes	Belonidae	Xenentoden Regan	*Xenentoden cancila* (Ham.)	Kawwa
Channiformes	Channidae	Channa Scopoli	*Channa striatus* (Bloch) Channa punctatus (Bloch) *Channa gachua* (Ham.) *Channa marulius* (Ham.)	Sauri Gauri Chanaga Sauri
Perciformes	Chandidae	Chanda Hamilton	*Chanda nama* (Ham.)	Chanda
	Gobiidae	Glossogobius Giil	*Glossogobius giuris* (Ham.)	Bulla
	Anabantidae	Anabas Cuvier	*Anabas testudineus* (Bloch)	Kawai
	Belontidae	Colisa Cuvier	*Colisa fasciatus* (Schneider)	Kotra
Mastacembiliforms	Mastacembelidae	Mastacembelus Scopoli	*Mastacembelus armatus* (lacepede)	Bami

Table 3: Fish fauna of Sugaon lake.

5% only. Overall species composition of the lake showed the dominance of predatory and weed fishes. These fishes compete with major carps for food [10,11]. Inspite of the fact that lake of plains have a high rate of primary production, the present investigation showed a tremendous decrease in the ichthyofaunal diversity of the lake. Fishing is carried out by local fisherman of the primary fisherman Co-operative society. The fishing craft used were medium sized plank – built canoes. The gear employed were drag and cast nets. The lakes of Gandak basin are largely public properties brought under the state Department of fisheries and are auctioned annually to the local fisherman Co-operative societies. There is no export of fish from any of the fish markets of East Champaran district. This lake is subjected to considerable human pressure. Surrounding settlements are totally dependent on this lake for bathing , cloth washing, open defecation, cultural activities etc. Fishing is the greatest simple economic activity depended upon by the communities surrounding the lake and it is one of the greatest threats to biodiversity.

Lake management objectives includes maintenance of water quality, reduction of erosion, protection from flood, a buffer zone between human settlement and the lake, maintenance of a gene pool of plants and animals, controlled insect pest population, produced renewable resources and provided aesthetic support for human beings [12]. Various conservation measures as management tools for lakes includes reforestation, control of grazing on the slopes which are prone to soil erosion, to change the agriculture practice, to reduce the non- point pollution from the source [13]. The specific goals of the management of the lake may be listed as follows: Control of encroachments in the lake area and to stop large scale reclamations of the foreshore by filling and land leveling, sewerage system, control of siltation and sedimentation, increase of water circulation, over exploitation/fishing, law enforcement, public awareness, regular environment monitoring and making the fisheries co-operatives viable, eradication of predatory and weed fishes, measures to prevent entry of different riverine fish along with their spawn into the lake and strengthening of the mechanism of technology transfer.

Conclusion

The condition of Sugaon lake, in terms of fish and fisheries, is gradually becoming critical under the impact of anthropogenic

pressures, fast pace of development, global warming, eutrophication, exotic species and subsequent modification of the river basins. Fish production from this lake could be modestly enhanced upto 3-4 times, if managed on the line of culture based capture fishery techniques with rational stocking of suitable species, size, density, and proper harvesting.

Conflict of Interest

No.

Bibliography

1. Hutchinson HE. "A tretise on Limnology, Geography, Physics and Chemistry". John Wiley and Sons, New York 1: (1957): 1015.

2. Gupta SK., *et al*. "General and Applied Ichthyology (Fish and Fisheries)". S. Chand and Company Ltd. Ramnagar. New Delhi. (2006): 559-588.

3. Pati DK. "Status of fish and fisheries of Ansupa lake, Orissa". *Journal of the Inland Fisheries Society of India* 40 (2008): 83-84.

4. Prakasam, V.R., et. al., "Water quality of Sasthamkotta Lake, Kerala". In Nair C.K.G.: (ed.). Proceeding of the National Seminar on Ecology and Conservation of Wetlands. Limnological Association of Kerala, Kerala (2002): 59-63.

5. Wani OA., *et al*. "A study on ichthyofaunal diversity of Sagar Lake, Madhya Pradesh, India". *International Journal of Biodiversity and Conservation* 7.3 (2015): 126-129.

6. Sinha M., *et al*. "Ecology and Fisheries of Ox-Bow lakes (Maun) of North Bihar – A threatened ecosystem". Central Inland Capture Fiseries Research Institute (ICAR), Barrakpore, W. Bengal. 74 (1997): 65.

7. Chaudhary SK., *et al*. "Hydrobiological studies of the Bahandei reservoir of Basopati, Madhubani district of Bihar, India with references to its management". *Ecology, Environment and Conservation* 16:4 (2010): 513-517.

8. Talwar PK., *et al*. "Inland Fishes of India and Adjacent countries". Oxford and IBH Publication Co. Pvt. Ltd., New Delhi., 1 (1991): 2.

9. Mishra SK. "Hill Stream Fishes Along the Indo-Nepal Border". Mittal Publication, New Delhi (2012).

10. Nataranjan AV., *et al*. "The food Spectrum of trash fishes in relation to major carps in Konar and Tilaiya reservoir (Bihar)". *Journal of the Inland Fisheries Society of India* 7 (1975): 65-75.

11. Kumar, D. "study on abundance and behavious of weed fishes in Ravishankar reservoir (Madhya Pradesh)". In Vass K.K. And Sinha, M. (Eds). Changing Perespective of Inland Fisheries, Inland Fish, Soc. India, Barrackpore (1997): 143-149.

12. Pandik AK. "Dal Lake Ecosystem in Kashmir Himalaya, Ecology And Management". In Ecology and Pollution of Indian Lakes and Reservoir. Mishra, P.C. and Trivedi, R.K. (ed.) Ashish Publishing House, New Delhi. (1993): 131-202.

13. Jorgensen SE. "Introduction of Guidelines of Lakes Management. Lake Shore Management" (ed. S.E. Jorgensen and H. Loffler) International Lake Environment Committee Foundation and UNEP, Japan. 3: (1990).

14. Day F. "The Fishes of India: being natural history of the fishes known to inhabit the seas and freshwaters of India, Burma and Ceylon". Taylor and Francis, London (1875-1878): 778.

15. Johnes PB., *et al*. "Lakes – classification and Monitoring". Environment Agency, R and D Note 253, Environment Agency, R&D Note 253, Environment Agency, Bristol (1994).

Volume 3 Issue 10 October 2021

Best Journals
Knowledge to Wisdom

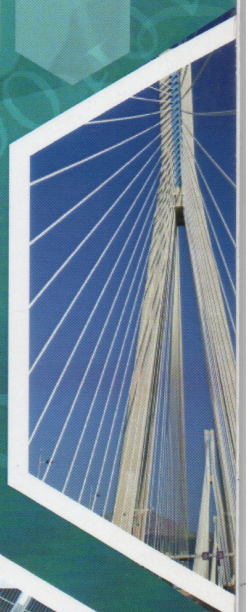
ISSN(P) 2348-0521

BEST : International Journal of Humanities , Arts, Medicine and Sciences (BEST : IJHAMS)

VOLUME: 8, ISSUE: 4, APR, 2020

JCC Impact Factor(2019): 4.3241

Index Copernicus Value (ICV): 44.78



editor.bestjournals@gmail.com

www.bestjournals.in

BEST: International Journal of Humanities, Arts, Medicine and Sciences (BEST: IJHAMS)

Volume 8, Issue 4, Apr – 2020

ISSN (P): 2348–0521

TABLE OF CONTENTS

S.NO	TITLE	AUTHOR(S)	PAGE NO
1.	Blockchain for Human Awareness and Response to Health	Nour Elamal Ahmed Elashhab	1-4
2.	Assessing the Implications of Linguistic Relativity in Maithili Speakers (A Preliminary Perception Study)	Sanjay Kumar Jha	5-8
3.	Health and Ability of the Punpun River of Nabinagar (Bihar) with Special Reference to its Conservation	Neha Raj	9-14
4.	Differences Between Boys and Girls in Learning English Language at Under Graduate Level	Dr. M. Rajitha	15-20

BEST: International Journal of Humanities, Arts,
Medicine and Sciences (BEST: IJHAMS)
ISSN (P): 2348–0521, ISSN (E): 2454–4728
Vol. 8, Issue 04, Apr 2020, 9-14

HEALTH AND ABILITY OF THE PUNPUN RIVER OF NABINAGAR (BIHAR) WITH SPECIAL REFERENCE TO ITS CONSERVATION

NEHA RAJ

Madani Lane, Club Road, Mithanpura, Ramna Muzaffarpur, Bihar, India

ABSTRACT

Limnological investigations in the Punpun river of Nabinagar (Bihar) were conducted for one year i.e. January 2018 to December 2018, to study the changing physico – chemical parameters in the river water due to natural and man-made activities. The study revealed that the river water is fit for industrial as well as irrigational purposes but not safe for bathing and drinking purposes. The required management and conservation strategies of river were also studied.

KEYWORDS: Health, Ability, Punpun River, Nabinagar & Conservation

INTRODUCTION

Inland fishery resources of Bihar comprise of about 3200 Km river length of which the Punpun river occupies a length of 200 Km. The river plays a significant role in the biodiversity conservation as well as economic development of the state, in particular and country in general.

River is a dynamic body of water, which flows from higher ground elevation, like hills and mountains, towards lower levels, like the sea. In its journey, it comes across a varied range of terrain, ranging from pebbly highlands to sand – covered alluvial reaches to silty and clayey stretches of the deltaic plains. The velocity of the river also changes from very swift in the hills to placid in the lower plains. (Sen,2006).

Rivers are relatively large lotic water bodies, created by natural processes. Hynes (1979) described rivers as a manifestation of the landscapes that they drain.

The Punpun river is also known as Punah – punah is a holy river of Magadh Division of Bihar. It is famous for Pind Daan and oblation of water to the manes in honour of deceased ancestors. The Punpun takes its rise in the Shobichak and Saraiya village situated on the northern border of Palamu district of Jharkhand State and enters into the district of Aurangabad of Bihar, east of the village Bara. It lies geographically between 24°11′ - 25°25′N latitude and 84°10′ - 85°10′E longitude at 300 meter elevation, having a catchment area of about 8530 square Km. The Punpun is a hilly stream and during its course through the Aurangabad district of Bihar, it is fed by a number of hill torrents, namely the Adri, the Batre, the Batane, the Dhawa, the Kasman, the Ramrekha, the Madar etc. Nabinagar is situated on the left side of the river Punpun, 6 Km north from the place of its origin, forming the southern portion of the Magadh Division which geographically lies at 24°62′ N latitude and 84°12′E longitude. The Punpun after flowing one Km in Palamu district of Jharkhand flows 27.35 Km in Nabinagar area. The Punpun is famous for valuable raw materials for building construction and precious stones like Gomed, Garnet, Sfatick, Mariyam etc. Nabinagar Super Thermal Power Project is also situated near the river.

The study of river has gained immense importance of multiple use of river water. From time immemorial rivers are meeting the multifarious demand of society at the expense of its own ecosystem health (Born, 1999). In recent years

aquatic resources are subjected to increasing anthropogenic stress. Pollution strongly affects the life of aquatic organism depending on physical and chemical characters of aquatic environment. The changes in physico – chemical composition of water may lead to drastic change in the community of aquatic biota, some of which, the others may diminish. Such changes in structure and function of biota form the basis of water quality assessment.

A good number of work has been carried out by many Indian scientists on the ecology of various rivers of India in general and Bihar in particular (Bairoliya, P. K. et al 2010; Das, M. K. et al. 2014; Gopal, 1995; Giri, S. et al. 2008; Joshi, B. D. and Bisht, R.E. 1993; Kaur, S. and Joshi, B.D. 2003; Kumar, A. 2000; Mishra, S.K. 2000; Mishra, B.P. and Tripathi, B.S. 2003;Mukhopadhyay, S.K. 1996; Nath, D. et al. 2007; Nath, D. et al. 2008; Narain, S. and Chauhan, R. 2000; Sinha, R.K. 2006; Singh, M.R. and Gupta, A.2010; and Zafar, A. and Sultana, N. 2008 etc.), but no work has been done on the health and ability of the Punpun river with special reference to its conservation, hence the present studies was mainly confined to provide a baseline data for further advancement in studies. In this respect, the physico – chemical features of the river were studied.

MATERIALS AND METHODS

Water samples were collected during morning (10 – 11 AM) in plastic containers at monthly intervals for a year (Jan, 2018 – Dec, 2018) and taken to laboratory for various physico – chemical analysis. Temperature, pH, Total dissolved solids were chemically fixed on spot. Standard methods prescribed by APHA – AWWA – WEF, 2005; Trivedy and Goel, 1986; WHO, 1993 and Welch, 2009, 2010; were followed for physico – chemical analysis of water samples.

RESULTS AND DISCUSSIONS

The minimum maximum value of various geographical and abiotic parameters of the river Punpun of Nabinagar from January 2018 to December 2018 and their permissible limits is given in Table 1.

Table 1: Various Geographical and Abiotic Parameters of the River PUNPUN of Nabinagar (Jan.2018 – Dec. 2018) and their Permissible Limits All values are in mg L^{-1} except Temperature, Rainfall and pH.

1	Length of the inland fishery resources of Bihar	3200Km
2	Length of the Punpun river	200 Km
3	Length of the Punpun river in Nabinagar area	27.35 Km
4	Catchment area of the Punpun river	8530 Sq. Km
5	Elevation of the river Punpun	300 Meter
6	Elevation of Nabinagar	138 Meter

		Range	Tolerance Limit
7	Min. Temerature (°c)	10.7 –28	10-15.6 (Ave. Temp)
8	Max. Temperature (°c)	24 – 41.9	
9	Rainfall (mm)	3 – 311	
10	pH	7.2 – 8.2	6.5 – 8.5
11	Total solids	1080 – 1310	
12	Dissolved solids	700 – 950	
13	Suspended solids	360 – 380	
14	DO_2	7.2 – 11.8	3
15	Free CO_2	0.95 – 1.95	6
16	Chloride	1.65 2.30	200
17	Total alkalinity	70.8 - 89.5	

Nabinagar geographically lies between 24.62° latitude and 84°12°E longitude at an elevation of 138 meters and from the southern portion of the Magadh Division of Bihar. The climate of Nabinagar is warm in temperature. The summers are much rainy than the winters. During course of investigation, the minimum and maximum temperature ranged between 10.7 – 28 and 24 – 41.9°c respectively. Rainfall ranged between 3 and 311 mm. Maximum rainfall was recorded in the month of July. The water of the river Punpun was found slightly alkaline (7.2 – 8.1). It is obvious that pH 7 is considered to be the most standard for various reaction as well as human beings. The pH limit was found within the acceptable range for various purposes (ISI). Solids (Suspended, dissolved, total) present in water were within the tolerance limit. Suspended and dissolved solids cause turbidity in water. During investigation, it was observed that selting and rainfall increases the turbidity causing less transparency. The value of DO_2 ranged between 7.2 and 11.8 mg L^{-1}. Dissolved Oxygen is a general indicator of water quality which shows the health and ability of the water body. It is source of Oxygen for respiration of aquatic organisms. Organisms have specific requirement of Oxygen. A minimum concentration of 5 mgL^{-1} was considered necessary to maintain the ichthyofauna of the waterbody. During summer, the value of dissolved Oxygen was found to be low while the river flow was slow and the temperature was high. During the course of investigation, free CO_2 ranged between 0.95 and 1.95 mg L^{-1}. The chief source of carbon is free CO_2 of atmosphere and that dissolved in water. Plants and animals also return carbon to the atmosphere as free CO_2. The presence of free CO_2 during course of investigation indicates that the free CO_2 was not utilized by the phyloplanktons. Chloride value ranged between 1.65 and 2.30 mgL^{-1}. Chlorides play metabolically active role in photolysis of water and photophosphorylation reaction in autotrophs. The high concentration of chlorides is an indicator of water pollution that is caused by organic wastes of animal origin or industrial effluents. Chloride concentration was within the permissible limit. Rivers running around the city and industrial belts are under the stress of severe water pollution (Gupta etal. 2002). During course of investigation soil erosion, silting, sewage disposal, industrial wastes disposal, human bathing, cloth washing, cultural activities, open defecation, agriculture and deforestation were observed, thus making an impact of human activities, which were obvious. Sinha (2006) noticed that the Ganga river system is also facing many such challenges, which are likely to intensify in future. Total alkalinity ranged between 70.8 and 89.5 mgL^{-1} which showed decreasing trends in rainy season (July – October). Thus, it may be concluded that the water of the Punpun river is fit for industrial as well as irrigational purpose but unfit for bathing and drinking purpose.

REQUIRED MANAGEMENT / CONSERVATION

There is no doubt that renewable resource like rivers have been damaged to the extent that the vital characteristics of their renewability have become vulnerable. In view of the growing stresses and declining resources, more importance needs to be given to ecological management and evaluation of the resource. The following most important strategies are required for sustainable effective management / conservation of rivers:

- Introduction of broad based research.
- Improved procedure for environment assessment.
- Long term monitoring.
- National and international Coordination.
- Public awareness and participation etc.

REFERENCES

1. APHA – AWWA – WEF, 2005. Standard method for the examination of Water and Waste Water, 21st Edition,Washington, DC.

2. Bairoliya, P. K., Mishra, S. K., Chaudhary, S. K. and Jalan Kumari Neelam. 2010. Physico – Chemical – Characteristics ofRiver Kamla at Jainagar, Bihar, India, 2008- 2009 Ecol. Env. & Cons. 16(4): 617 – 619.

3. Born. B. 1999, Overview of Inland fishery enhancements from a global Perspective. FAO Aquaculture Newsletter, No. 21 pp. 10 – 18.

4. Das, M. K., Samanta, S., Mitra, K., Bandyopadhyay, M. K. and Bhowmick, S., 2014. Assessment and fishery and ecological Integrity of the anthropogenically stressed river Churnic, India. J. Inland Fish. Soc. India. 46(1): 09-28.

5. Davis. B. R. et al. 2008. A comparison of the cathments sizes of rivers, Streams pands, ditches and lakes: implications forProtecting aquatic biodiversity in an agricultural Landscape. Hydrobiologia. 597 : 7-17.

6. Gopal, B. 1995. Limnology in Developing Countries, Vol.1. Narendra Publishing House, Delhi.

7. Giri, S., Pradhan, P. and Chakraborty, S. K. 2008 Studies on Hydrobiological status of Kansai and Dwarkeshwar Rivers in West Bangal, India. J. Inland Fish Soc. India. 40(1): 59-64.

8. Gupta, A. K. and Raghubanshi, A. K. 2002, Comparative study of Enrichment of nutrients and heavy metals in river Waters of Ghaghra and Ganga due to Anthropogenic pressures. Pollution Research, 21(3): 261–263.

9. Joshi, B. D. and Bisht, R. E. 1993. Some aspects of physico – chemical Characteristics of Western Ganga canal nearJwalapur, Hardwar Himalayan Jr. Env. Zool. 7(1): 76–82.

10. Kaur, S. and Joshi, B. D. 2003. Seasonal variation in some physico – Chemical conditions of river Ganga in and aroundHaridwar Him. J. Zool. 17: 45-55.

11. Kumar, A. 2000. A quantitative study of the pollution and physico –chemical condition of the river Mayurakshi in

11. Santhal Paragna, Bihar, In : (Trivedy, R. K. Edited) Pollution and Biomonitoring of Indian Rivers, ABD Pub. Jaipur. 246–251.

12. Mishra, S. K. 2000. Comparative evaluation of the water quality of two Rivers of Narkatiaganj, Bihar (India) with reference toPollution fisheries and diseases. In: (Trivedy, R. K. Ed.). Pollution and Biomonitoring of Indian Rivers. ABD Publ. Jaipur. 159-167.

13. Den, D. 2006. River Dynamics. In: River fisheries in India – Issues And Current status. Ed. K. K. Vass et al., Inland Fish. Soc. Of India, Barrackpore, Kolkata – 700120, West Bengal 13–24:

14. Sinha, A. K., Singh, V. P. and Srivastava, 2000. Physico – chemical on river Ganga and its tributaries in Uttar – Pradesh – the present status. In : Pollution and Biomonitoring of Indian Rivers (ed.) R. K. Trivedy, ABD Publishers, Jaipur, 1–29.

15. Mishra, B. P. and Tripathi, B. S. 2003. Seasonal Variation in physico – chemical characteristics of Ganga water as influenced By sewage discharge Indian J. Ecol. 30: 27–32.

16. Mukhopadhyay, S. K. 1996. Limnological investigations in lotic and lentic freshwater bodies in and around Darjeeling, West Bengal, India. Geobios. 23(2): 101 -106.

17. Nath, D., Mishra, R. N., Jha, B. C. and Mukhopadhyay, M. K. 2007. Hydrobiological investigation in river Damodar with special reference to aquatic pollution. J. Inland Fish. Soc. India, 39(1): 45 – 50.

18. Nath, D., Shrivastava, N. P. and Mandal, S. 2008. Water pollution at river Narmada in Madhya Pradesh. J. Inland Fish. Soc. India. 40(2): 74 – 77.

19. Narain, S. and Chauhan, R. 2000. Water quality status of complex Yamuna at Panchnada (Etwah, U.P.). An IntegratedManagement approach. J. Poll. Res. 19 (3): 357 – 364.

20. Pandey, B. N., Gupta, A. K., Mishra, A. K., Das, P. K. L. and Jha, A. K. 2000. Ecological studies of River Panar of Araria (Bihar) with Emphasis on its Biological Components, Pollution and Biomonitoring of Indian Rivers. ABD Pub. Jaipur.

21. Sinha, R. K., 2006. Ecological basis for management and conservation Of riverine fisheries with special reference to the Ganga river System(In: K. K. Vass et al Ed.). River Fisheries in India Issues Current Status Inland Fish. Soc. Of India, Barrackpore, 700120, West Bengal 83 – 97.

22. Singh, H. R. 2008. Advances in Limnology, Narendra Publishing House, Delhi.

23. Singh, M. R. and Gupta, A. 2010. Seasonal variations in certain physico – chemical parameters of Imphal, Iril and Thoubal rivers From Manipur river system, India. Eco. Env. & Cons. 16(2): 197 – 207.

24. Tripathi, H. 1998. Dakhchir Bihar Ki Nadiya, Dhar aur Kachar, Bihar Granth Academy, Patna. 182 – 230.

25. Trivedy, R. K. and Goel, P. K. 1986. Chemical and Biological Methods For Water Pollution Studies. Environmental Publications, Karad (India).

26. World Health Organization. 1993. Guidelines for drinking Water Quality – 1, Recommendation 2nd Ed. Geneva WHO,www. lenntech.com/drinking water –standard.htm.

27. Welch, P. S. 2009. Limnological methods Mc. Graw Hill, New York.

28. Welch, P. S. 2010. Limnology, Narandra Publishing House, Delhi.

29. Zafar, A. and Sultana, N. 2008. Seasonal analysis in the Water Quality Of River Ganges. J. Curr. Sci. 12(1): 217 – 220.

Forum for Interdisciplinary Research Methods

1st Annual International Conference of Forum for Interdisciplinary Research Methods

on

September 08-09, 2019

Certificate

This is to Certify that Dr. /Mr. /Mrs /Prof. Neha Raj, Research Scholar, Dept. Of Zoology, P.K. University Jhansi *participated in the 1st Annual International Conference of Forum for Interdisciplinary Research Methods organized by Dept. of Economics & Dept. of Sociology, A.S.College Deoghar in collaboration with P.G. Dept. of Economics, S.K.M. Univrsity Dumka, Jharkhand, India on September 08-09, 2019 and deliverd a Guest lecture/ chaired a session / presented a paper entitled* 'Sustainable Development and Natural Resources Managment: Special Reference to Biological Exploitation of Pun, Pun Rever.'

09.09.2019

Dr. Anil Thakur
Organizing Secretary
(Dept. of Economics, A.S.College Deoghar)

Dr. S. S. Mahto
Convenor
(Dept. of Sociology, A.S.College Deoghar)

Prof (Dr) Manoj Kumar Mishra
Secretary & Treasurer
(Forum for Interdisciplinary Research Methods)

Best Journals
Knowledge to Wisdom

Certificate of Publication

(Paper ID: IJHAMSAPR202003)

Awarded to

Neha Raj

In recognition of the publication of the paper titled

Health and Ability of the Punpun River of Nabinagar (Bihar) with Special Reference to its Conservation

Published in BEST: IJHAMS Journal,
ISSN(P): 2348-0521; ISSN(E): 2454-4728; Impact Factor(JCC): 4.3241; ICV: 44.78

Volume 8, Issue 04, Apr 2020

Date: 28.04.2020

Managing Editor

Publication Certificate

Acta Scientific Veterinary Sciences (ASVS), is delighted to award you for publishing your eminent Research Article entitled

FISHERY AND ITS MANAGEMENT OF SUGAON LAKE OF EAST CHAMARAN DISTRICT OF BIIHAR, INDIA

Authored by "**Kumari Priyanka, Neha Raj and Safal Kumar Mishra***" that has undergone double blinded peer review and the article is published in Volume 3 Issue 11 (Page No: 62-66).

We heartily congratulate you for the successful publication!

Acta Scientific Publications Hyderabad

With Kind Regards,
Mr. Sanjay Kumar,
Acta Scientific Publications
Contact: +91-9182824667

ACTA SCIENTIFIC

A S

Indian Association of Scientific Research

Prestige Institute of Management, Gwalior

UGC NAAC ACCREDITED 'A' GRADE AUTONOMOUS INSTITUTE

11th National Research Methodology Workshop

August 21-25, 2019

CERTIFICATE

This is to certify that Prof./Dr./Mr./Ms. Neha Raj, Ph.D Scholar

of P.K. University has Participated / Volunteered in

11th National Research Methodology Workshop during 21-25 August 2019, organized by **Prestige Institute of Management, Gwalior.** He/She has developed & presented research paper titled Impact of Image Conciousness, Neuroticism And Materialism On Compulsive Buying: A Study On Mobile Phones

Dr. Nandan Velankar
Organizing Secretary

Dr. S.S. Bhakar
Director

33rd Annual Function of NESA

National Virtual Conference on

TECHNO-SCIENTIFIC CHALLENGES AND SUSTAINABLE SOLUTIONS FOR LIVING BEINGS DURING CHANGING ENVIRONMENT (TCSE-2021)

29-30, January, 2021

Organized by:

National Environmental Science Academy (NESA), New Delhi
ICAR-Indian Agricultural Statistics Research Institute (IASRI)

Co-organized by:

School of Chemical and Life Sciences (SCLS) Jamia Hamdard (Deemed University), New Delhi
Asian Biological Research Foundation (ABRF), Prayagraj (U.P.) India | RAS BIO, Moradabad, Uttar Pradesh
Al-Falah University, Dhauj, Faridabad, Haryana | National Agricultural Higher Education Project, New Delhi
Indian Society of Horticultural Research and Development (ISHRD), Dehradun, Uttarakhand
Jai Narain Vyas University, Jodhpur, Rajasthan

Certificate

This is to certify that

Neha Raj

Department of Zoology, P.K. University, Shivpuri, M.P., India

actively participated as a delegate and presented paper
in the 2 days National Conference on **Techno-scientific Challenges and Sustainable Solutions for Living beings during Changing Environment (TCSE-2021).**

Prof. Javed Ahmad
President, NESA

Dr. Sushil Kumar Singh
Convener - TCSE-2021
General Secretary-NESA

Dr. Prabhat Kumar
Organising Secretary
Convener - TCSE-2021

International Conference on

AGRICULTURE SCIENCE AND TECHNOLOGY: CHALLENGES AND PROSPECTS (AST-2022)

6-8, May, 2022

Organized by:

Rani Lakshmi Bai Central Agricultural University, Jhansi, UP. | National Environmental Science Academy (NESA), New Delhi
ICAR-Indian Grassland and Fodder Research Institute, Jhansi, U.P. | ICAR-Central Agroforestry Research Institute, Jhansi, U.P.

In Association with:

Bundelkhand University, Jhansi | Central Ayurveda Research Institute, Jhansi
Indian Society of Agroforestry, Jhansi, U.P. | U.P. Council of Agricultural Research, Lucknow
Range Management Society of India, Jhansi, U.P. | ICAR-National Agricultural Higher Education Project, Delhi
The Society for Science of Climate Change and Sustainable Environment (SSCE) Delhi
Society for Plant and Agricultural Sciences, Pune | Jan Parivartan Sansthan, Gwalior

Certificate of Participation

This is to certify that

Neha Raj

Department of Zoology
P.K. University, Shivpuri, M.P., India

has participated in the in the 3 days International Conference on **Agriculture Science and Technology: Challenges and Prospects (AST-2022)** as **PARTICIPANT.**

Prof. Javed Ahmad	**Dr. A. Arunachalam**	**Dr. A. Chandra**	**Dr. Shakeel Ahmad Khan**	**Dr. R.S. Tomar**
President	Director	Director	Organizing Secretary	Co-Organizing Secretary
NESA	ICAR-CAFRI, Jhansi	ICAR-IGFRI, Jhansi	AST 2022	AST 2022

NATIONAL WEBINAR
O N
"IMPACT OF GLOBAL PANDEMIC (COVID-19) ON INDIA"

ORGANISED BY:
DEPARTMENT OF ECONOMICS AND DEPARTMENT OF COMMERCE
A.S COLLEGE, DEOGHAR
IN COLLABORATION WITH
UNIVERSITY P.G. DEPT. OF ECONOMICS, S.K.M.U. DUMKA,
JHARKHAND, INDIA
JUNE 2, 2020

CERTIFICATE OF APPRECIATION

This is certified that Mr./MS./Dr./Prof. **Neha Raj** has presented a paper *in National Webinar :* ***"Impact of Global Pandemic (COVID-19) on India"*** *held on 2nd June 2020. We wish to acknowledge your presence which productivity enhance the stream of Discussion. We hope you had a fruitful experience.*

Chair Person (Principal)	***Secretary***	***Convener***
Prof. Anil Kumar Jha	Dr. Anil Thakur	Dr. Dileep Kumar Varma
A.S.College	A.S. College	A.S. College
Deoghar	Deoghar	Deoghar