ABSTRACT

The study presents the status of fish diversity, abundance and habitat structure of Surha Lake, which is a perennial and natural lake fed by the river Ganga. The study was conducted between 2011 to 2013 covering pre and post-monsoon seasons. In total, 4,852 individual fish specimens were collected representing 66 fish species belonging to 23 families. The species diversity comprised 65 species in pre-monsoon and 60 species in post-monsoon seasons (p<0.05). The highest species diversity was recorded for the family Cyprinidae (22), followed by Bagridae (7). An assessment of conservation status of 66 fish species as per IUCN Red List 2019 criteria listed 6 species under near threatened (NT), 54 under least concern (LC) and 2 species under vulnerable (VU) category. The study reports several commercially important species under near threatened (Chitala chitala, Labeo pangusia, Ompok bimaculatus, Ompok pabda, Ailia coila and Bagarius bagarius) which makes Surha Taal an important natural lake from fishery management point of view. The study also prioritised different habitat types important for different species. The slow water in the mid-channel areas of the lake were categorised as important habitats for near threatened and vulnerable fish species like C. chitala, B. bagarius and Wallago attu, which can be prioritised for population level management.

Keywords: Conservation status, Fish diversity, Ganga River basin, Surha Taal
entry of aquatic weeds mainly *Eichhornia crassipes*. The lake encompasses an area of 3,422 ha at full storage level (FSL) and 1,260 ha at dead storage level (DSL) with an average area of approximately 2,000-2,200 ha. The lake expands consequent to the incursion of water from the inlet and annual precipitation, and inundates vast low lying areas. During the late winter and summer, the lake becomes a chain of discontinuous water patches with intermittent islands. A sizeable quantity of water is drawn for irrigating the rabi crops in the district. The water fowls that feed on the small forage fishes contribute to the nutrient enrichment of the lake through the droppings.

Fish sampling in the lake was conducted at monthly intervals during pre-monsoon (January to April) and post-monsoon (September to December) seasons. Collections were made with the help of cast net, gillnet and other indigenous nets in the shoreline and middle areas of the lake. Voucher specimens of the collected samples were preserved and identified following Jayaram (2010) and Talwar and Jhingran (1991) and the species names were further validated with reference to Catalogue of Fishes (Fricke et al., 2020). The threat assessment of the identified fishes was done as per IUCN Red List criteria 2019.

For water quality assessments, a total of four sampling surveys were done, two each in pre and post-monsoon seasons. The water quality measurements were carried out in the field with the help of multi-parameter kit (YSI EX03). The data on 19 physico-chemical parameters including pH, water temperature (°C), water depth (cm), dissolved oxygen (mg l⁻¹), free carbon dioxide (mg l⁻¹), carbonate (mg l⁻¹), bicarbonate (mg l⁻¹), hardness (mg l⁻¹), calcium (mg l⁻¹), magnesium (mg l⁻¹), chloride (mg l⁻¹), iron (mg l⁻¹), silicate (mg l⁻¹), phosphate (mg l⁻¹), nitrate (mg l⁻¹), dissolved organic matter (mg l⁻¹), TDS (mg l⁻¹) and specific conductance (µmhos cm⁻¹) were recorded.

Species diversity was assessed using four different indices viz., species richness, Shannon-Wiener diversity, Evenness and Dominance indices. Shannon-Wiener diversity index (Shannon and Weaver, 1949; Ramos et al., 2006) considers both the number of species and the distribution of individuals among species. The Shannon-Wiener diversity was calculated using the formula:

\[ H = \sum_{i=1}^{S} P_{i} \times \log P_{i} \]

where, S is the total number of species and Pi is the relative cover of iᵗʰ species.

Margalef index (d) (Margalef, 1968) was used to measure species richness using the formula:

\[ d = (S/1) = \log (N); \]
where, S is the total no. of species and N is the total no. of individuals.

Buzas and Gibson’s evenness (Harper, 1999) was measured using the formula:

\[ E = e^{H/S} \]

where, E is the measure of evenness or equitability, H is the diversity measure and S is species richness.

The dominance index (Harper, 1999) was measured to determine whether or not a particular fish species dominate in a particular aquatic ecosystem, and can be a useful index of resource monopolisation by a superior competitor, particularly in communities that have been invaded by exotic species. This index was determined using the formula:

\[ D = \sum \left( \frac{n_i}{n} \right)^2 \]

where \( n \) is the number of individuals of \( i^{th} \) species.

Fish habitats were categorised as open river, slow water, fast water, mid channel, deep pool and lateral scour pool as per the description by Bain and Stevenson (1999). After sampling, the fish diversity was categorised based on segregation of data under different habitat categories.

The average values of water quality parameters are given in Table 1.

A total of 4,852 individual fishes were collected, that represented 66 fish species belonging to 21 families (Table 2). A total of 2,937 individuals representing 65 species were collected in pre-monsoon and 1,915 individuals representing 60 species were collected in post-monsoon. Maximum number of individuals was recorded for *Amblypharyngodon mola* (355 individuals) and minimum for *Tariqilabeo latius* (1 individual) and *Ophichthys cuchia* (1 individual).

Results of the data analyses showed higher species diversity (65 species) in pre-monsoon compared to post-monsoon season (60 species) (Table 3). The Shannon-Wiener diversity index, Margalef richness, dominance index and evenness index for pre and post-monsoon seasons are presented in Table 3.

An assessment of conservation status of the 66 species as per IUCN Red List 2019 indicated 6 species under near threatened (NT), 2 under vulnerable (VU), 54 under least concern (LC), 3 under not evaluated (NE) and one under data deficient (DD) category (Table 2).

Habitat of the Surha Lake was classified into seven micro habitat categories viz., open river, slow water, fast water, mid channel, deep pool and lateral scour pool. The slow water habitats of the lake showed maximum species richness (28) whereas, deep pools were assessed to have minimum species richness (5) (Fig. 2).

The present study highlights that physical habitat variables play an important role in the distribution of freshwater fishes in the lake. A total of 66 species belonging to 21 families were recorded from the lake which is higher than the previous reports (Srivastava and Srivastava, 2009). Among all the families, Cyprinids dominated, with varied species structure including threatened as well as economically important species. Some of the important species which were not reported during the

| Parameters                          | Values (Mean±SD) |
|-------------------------------------|------------------|
| Water temperature (°C)              | 22.85 ± 0.64     |
| Depth (cm)                          | 222.5 ± 3.53     |
| Transparency (cm)                   | 81.5 ± 2.12      |
| pH                                  | 8.3 ± 0.14       |
| Dissolved oxygen (mg l⁻¹)           | 10 ± 0.28        |
| Carbonate (mg l⁻¹)                  | 19.1 ± 0.85      |
| Bicarbonate (mg l⁻¹)                | 80.75 ± 0.64     |
| Hardness (mg l⁻¹)                   | 80.95 ± 0.49     |
| Calcium (mg l⁻¹)                    | 39.5 ± 0.14      |
| Magnesium (mg l⁻¹)                  | 41.55 ± 0.35     |
| Chloride (mg l⁻¹)                   | 20.8 ± 0.85      |
| Iron (mg l⁻¹)                       | 0.6 ± 0.14       |
| Silicate (mg l⁻¹)                   | 2.6 ± 0.28       |
| Phosphate (mg l⁻¹)                  | 0.13 ± 0.01      |
| Nitrate (mg l⁻¹)                    | 0.31 ± 0.02      |
| Dissolved organic matter (mg l⁻¹)   | 2.39 ± 0.16      |
| TDS (mg l⁻¹)                        | 76.5 ± 1.77      |
| Conductivity (µmhos cm⁻¹)           | 153.8 ± 0.85     |

Fig. 2. Diversity of fish species (species richness) recorded in different habitats of the lake.
Table 2. List of species with number of individuals caught in pre and post-monsoon seasons

| Sl. No. | Fish species         | Total | Pre-monsoon | Post-monsoon | Conservation status* (IUCN) |
|---------|----------------------|-------|-------------|--------------|----------------------------|
| 1       | *Chitala chitala*    | **5** | **4**       | **1**        | NT                         |
| 2       | *Notopterus notopterus* | **6** | **4**       | **2**        | LC                         |
|         | **Clupeidae**        |       |             |              |                            |
| 3       | *Gudusia chapra*     | **238** | **138**   | **100**      | LC                         |
| 4       | *Setipinna phasa*    | **249** | **109**   | **140**      | LC                         |
|         | **Cyprinidae**       |       |             |              |                            |
| 5       | *Amblypharyngodon mola* | **355** | **225**   | **130**      | LC                         |
| 6       | *Cabbyo morar*       | **60**  | **40**     | **20**       | LC                         |
| 7       | *Labeo catla*        | **42**  | **30**     | **12**       | LC                         |
| 8       | *Salmostoma bacaila* | **35**  | **27**     | **8**        | LC                         |
| 9       | *Labuka labuca*      | **30**  | **20**     | **10**       | LC                         |
| 10      | *Chagunius chagunio* | **22**  | **14**     | **8**        | LC                         |
| 11      | *Cirrhinus cirrhosus*| **40**  | **21**     | **19**       | VU                         |
| 12      | *Cirrhinus reba*     | **136** | **86**     | **50**       | LC                         |
| 13      | *Tariqilabeo latius* | **1**   | **1**      | **0**        | LC                         |
| 14      | *Labeo bata*         | **143** | **83**     | **60**       | LC                         |
| 15      | *Labeo calbasu*      | **77**  | **55**     | **22**       | LC                         |
| 16      | *Labeo dyocheilus*   | **2**   | **2**      | **0**        | LC                         |
| 17      | *Labeo pangusia*     | **5**   | **5**      | **0**        | NT                         |
| 18      | *Labeo rohita*       | **71**  | **42**     | **29**       | LC                         |
| 19      | *Osteobrama coto*    | **50**  | **36**     | **14**       | LC                         |
| 20      | *Systomus sarana*    | **124** | **84**     | **40**       | LC                         |
| 21      | *Puntius sophore*    | **300** | **200**    | **100**      | LC                         |
| 22      | *Pethia ticto*       | **225** | **164**    | **61**       | LC                         |
| 23      | *Puntius puntio*     | **19**  | **11**     | **8**        | NE                         |
| 24      | *Rasbora daniconius* | **100** | **66**     | **34**       | LC                         |
| 25      | *Securicula gora*    | **136** | **90**     | **46**       | LC                         |
| 26      | *Raiamas bola*       | **4**   | **4**      | **0**        | LC                         |
| 27      | *Botia lohachata*    | **10**  | **8**      | **2**        | NE                         |
| 28      | *Botia dario*        | **3**   | **0**      | **3**        | LC                         |
|         | **Bagridae**         |       |             |              |                            |
| 29      | *Mystus cavasius*    | **200** | **114**    | **86**       | LC                         |
| 30      | *Mystus tengara*     | **140** | **85**     | **55**       | LC                         |
| 31      | *Mystus vittatus*    | **190** | **105**    | **85**       | LC                         |
| 32      | *Mystus bleekeri*    | **10**  | **7**      | **3**        | LC                         |
| 33      | *Rita rita*          | **10**  | **3**      | **7**        | LC                         |
| 34      | *Sperata aor*        | **30**  | **20**     | **10**       | LC                         |
| 35      | *Sperata seenghala*  | **90**  | **60**     | **30**       | LC                         |
|         | **Siluridae**        |       |             |              |                            |
| 36      | *Ompok bimaculatus*  | **8**   | **6**      | **2**        | NT                         |
| 37      | *Ompok pabdha*       | **7**   | **5**      | **2**        | NT                         |
| 38      | *Wallago attu*       | **46**  | **25**     | **21**       | VU                         |
earlier studies, but observed in good abundance include *C. chitala, N. notopterus, C. chagunio, L. dyocheilus, R. rita, S. seenghala, O. pabda, B. bagarius, M. cuchia* and *P. pangasius*. Sarkar et al. (2007) reported a total of 46 species from a protected area *i.e.* Samaspur Bird Sanctuary and showed 28.26% of species under threatened category as per the IUCN. However, our study in Surha Lake provides different results as compared
Table 3. Species diversity, dominance, evenness and richness for pre and post-monsoon seasons

|                          | Pre-monsoon | Post-monsoon |
|--------------------------|-------------|--------------|
| Taxa                     | 65          | 60           |
| No of individuals        | 2937        | 1915         |
| Dominance index (D)      | 0.03281     | 0.03389      |
| Shannon Diversity index (H) | 3.688    | 3.634        |
| Evenness index (E)       | 0.6146      | 0.6313       |
| Margalef richness (M)    | 8.015       | 7.807        |

to a study conducted in Rihand Dam which reported 42 fish species (Khan 2000).

An assessment of conservation status of the species as per IUCN Red List criteria 2020 indicated 6 species under near threatened and 2 species under vulnerable category in the Surha Lake. Therefore, there is need for implementing better management strategies for protection of threatened fish species like C. chitala, L. pangusia, O. himaculatus, O. pabda, A. coila, B. bagarius, W. attu, and C. cirrhosus.

The result on fish diversity structure in different habitats of the lake provides a better understanding for habitat management. The slow water in the mid-channel areas of the lake showed highest fish diversity of large species which can be considered important for sustenance of those fishes. Studies conducted on large tributaries of Ganga also showed importance of these areas for large river fishes like C. chitala, W. attu and B. bagarius (Dubey et al., 2012). Since the lake was reported to be susceptible for exotic species invasion, managing the local fish diversity in the lake should be given priority.

The physico-chemical parameters recorded during the study appeared conducive for good biological productivity. A comparison on the diversity and species richness between pre and post-monsoon season was found to vary slightly, which might be due to impact of climatic and seasonal variations.

The present study reports a rich fish diversity of 66 species belonging to 23 families in the Surha Lake which include several threatened as well as economically important species. The lake provides a good habitat for fishes; however, there are several challenges such as invasion by exotic species and water abstraction activities. The water quality of the lake was found favourable for the living aquatic biota. The study provides a range of diversity indices which would be important in quantifying any changes amongst the common and rare species and also for better management of natural fish populations for biodiversity conservation.

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