International Scholars Journals

African Journal of Fisheries Science ISSN 2375-0715 Vol. 9 (2), pp. 001-006, December 2021.
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Research Article

Assessment of limnological parameters, fish species composition and gear selectivity in Belbella Reservoir

Abera Hirpo L*

Oromia Agricultural Research Institute, Batu Fish and Other Aquatic Life Research Center, P.O. Box 229, Batu, Ethiopia.

Accepted 09th December, 2021

Limnological parameters, fish species composition and some biology of *Oreochromis niloticus* in Belbella Reservoir was studied during the period between July 2018 to June 2021 using different limnolgical kits and fishing gears. The result obtained for conductivity and pH as the mean ± SE values were 377 ± 5.7 µS cm^{-1} and 8.4 ± 0.7, respectively. Among the phytoplankton taxa, Blue green algae with 11 genus, followed by green algae and diatoms with six and four genus respectively. Rotifers were the most species-rich zooplankton group with seven genus. The second most important zooplankton group was the *cladocerans*. The copepods were, poorly represented, with only two genus, in the zooplankton community of Belbela reservoir. *Oreochromis niloticus* was the dominant fish species in the reservoir and Length-weight relationship of the fish was curvilinear, show isometric growth and statistically highly significant (P<0.05). Sex ratio was not significantly different from 1:1 for all sampling months. The 50% maturity length (L50) of *O.niloticus* was estimated to be 18 cm total length for females and 17.5 cm total length for males. The current gill net mesh size (10 cm) used in the reservoir was captured the fish with the range of length class between 16-20 cm that coincide with at their L50 of both sexes of the fish. Hence, care should be taken based on the length at first maturity that immature fish will not be affected by the waterbodies.

Key words: Belbella reservoir, fishes, fishing gear, physico-chemical parameters, planktons

INTRODUCTION

Ethiopia has a number of lakes and rivers with substantial quantity of fish stocks. Many artificial water bodies including reservoir have also been stocked with fish for fishery. Reservoirs are water bodies that are formed by humans for purposes of drinking and municipal water supply, industrial cooling water supply, power generation, irrigation, river regulation, flood control, fisheries, recreational uses and waste disposal (Chapman, 1996). Reservoirs show many of the same basic hydrodynamic, chemical and biological characteristics as the natural lakes. Like natural lakes, reservoirs harbor phytoplankton and zooplankton, which form integral parts of the aquatic food web and influence other aspects of the lake including color and clarity of the water and fish production (Tansakul, et al. 2008).

Belbela reservoir is one of the dams that constructed in 1980 by a Cuban Civil Mission in collaboration with Ethiopian Water Resources Authority. The protection works, canals, and on-farm structures for the dam were later constructed by the Ethiopian Water Works Construction Authority, with an objective of irrigating land area to be used by State Farms for fruit production. The other storage dam (Wadecha dam) through hydrological catchments transfers recharges the reservoir.

Limnological information and fishery activities on Belbela reservoir are almost non-existent. Thus, the physico-chemical and biological limnology of this reservoir remains to be explored. The reservoir serves as the primary source of drinking water for both local inhabitants and livestock. The reservoir water at the shores is also used for swimming and washing clothes by people living near the reservoir including irrigation.

Although some studies were conducted on the reservoir, the change on the liminological parameters of the water body is fast and hence the information on the reservoir gets outdated quickly. Therefore, regular updating, monitoring and control are essential and this study becomes important and relevant for better management and sustainable use of the resources for fishery development. Hence, this paper attempts to assess some

*Corresponding author. Abera Hirpo L, Email: negrofarm@gmail.com.

physico-chemical factors of the reservoir; to assess fish species composition and the biology of the fish in the reservoir; and finally to identify appropriate fishing gear to enhance the fish production of the water body.

METHODOLOGIES

Description of the study area

Belbela Reservoir established in Ada'a district in East Showa zone of the Oromia region by damming wodecha river. It is located 17 km east of Bishoftu town and about 64 km southeast of Addis Ababa along the road to Chafe Donsa town. It found between 380 01'- 400 04' E longitude and 080 47'- 090 00' N latitude. The reservoir situated on a highland with an average elevation of 2,300 m.a.s.l (Figure 1).

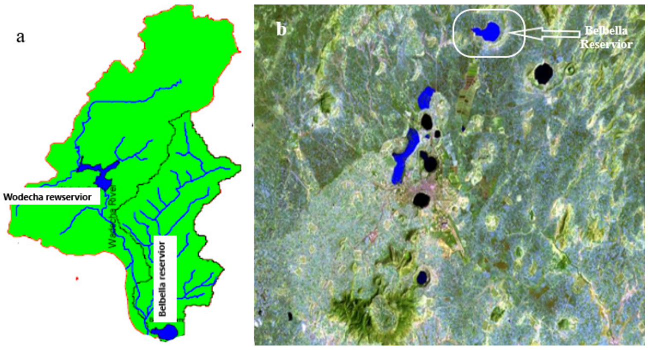

Figure 1. (a) Map showing the drainage system and (b) google map of Belbela Reservoir.

Some of the physical characteristics described in Table 1 and, agriculture is the major source of employment, revenue, export earnings and a means for ensuring food security in the reservoir. As a result, there has been an ever-increasing expansion of irrigation-agricultural development practices in the area although workable management and exploitation strategies are not yet in place.

Table 1. Physical characteristics of Belbela Reservoir (Wakena Totoba, 2006).

Description	values
Catchment area	85 Km^2
Outlet-pipe diameter	0.76 m
Maximum discharge	3.87 m^3/sec
Mean discharge	2.4 m^3/sec
Maximum depth	6 m

The climatic condition of the reservoir area is wet to sub-humid, the wet season (March-September) with mean monthly rainfall varying from 65-239 mm. The rainfall of the study region is unimodal with the highest amount of rainfall occurring between June and August and accounting for about 76% of the mean annual precipitation in the catchment areas of the reservoir.

Site selection and sampling procedure

Physico-chemical parameters: To assess the physico-chemical factors that influence the fish community structure of the reservoir, four sampling sites were selected based on geographical proximity and/or habitat similarity, their distance from anthropogenic effects. Samples were collected monthly with a Van Dorn bottle sampler from the pre-selected sampling station during the period spanning from July 2018-June 2021. Samples were collected from selected depths distributed within the euphotic zone and mixed in equal proportions to produce composite samples. The composite samples were used for the analysis of inorganic nutrients, identification of phytoplankton taxa, and estimation of phytoplankton biomass as Chlorophyll a (Chl-a) production. For the identification and enumeration of zooplankton, separate samples were collected by towing upward using a tow net (55 µm)

Fish parameters: Parallel to the physico-chemical sampling, every month the fishes were collected at all sites using variety of fishing gears, which included gill nets of various mesh sizes (6, 8, 10 and 12 cm stretched mesh size), monofilament nets with various stretched mesh sizes (5 mm-55 mm stretched mesh size) and multiple long-lines with hooks of different size (9, 10, 11 and 12 cm). The gears were set in the afternoon (4:00 pm) and were collected in the following day (7:00 am). Immediately after capture, some morphometric measurements were measured and the fish samples were put in plastic jars containing 10% formalin and labeled with all necessary information. Then the preserved specimens were soaked in tap water for many days to wash the formalin away. Then, the samples were transferred to 75% ethanol before species identification was conducted. The specimens were identified to species level using taxonomic keys of Golubtsov, et al.1995; Witte, et al. 1995; Stiassny, et al. 2007; Redeit Habteselassie, 2012 and figures from fish base.

Data analysis

Plankton and fish species composition were presented as a numerical contribution by each species. This was determined by calculating the percentage of each species represented in the total catch for each station. Descriptive statistics were also used to analyze the remaining collected data using SPSS software (SPSS V.19.0).

RESULTS AND DISCUSSIONS

Physico-chemical parameters of the reservoir

Some of the parameters that affect the quality of water in the reservoir, which is indicated in Table 2. The result obtained for conductivity and pH as the mean ± SE values were 377 ± 5.7 µS cm^{-1} and 8.4 ± 0.7, respectively, were comparable with the values (410 µS/cm and 8.5, respectively) reported by (Elizabeth Kebede, et al.1994) and very recently by (Girum Tamire, et al. 2012) with similar water system. Hence, the pH values of the lake water, it is suitable for normal biological activity set as 6.5-8.5 by the European Economic Community (EEC, 1980).

Table 2. Pooled mean and standard error values of physico-chemical variables of the reservoir (from July 2018-June 2021).

Parameters	Values
Secchi depth (m)	0.23 ± 0.9
Temperature (°C)	21 ± 0.5
pH	8.4 ± 0.7
Dissolved oxygen (mg L^{-1})	5.4 ± 0.1
Conductivity (µS cm^{-1})	277 ± 5.7
Nitrate (µgL^{-1})	148 ± 1.5
Ammonium (µg L^{-1})	96 ± 9.4

SRP (µg L^{-1})	82 ± 0.5
Chl-a (µgL^{-1})	57.8 ± 0.4

The mean nitrate value (148 ± 1.5 µg^{-1}) was higher than previously reported values for the same lake (Feyisa Girma, 2011), indicating an eutrophication trend with time. However, nitrate varied more than soluble reactive phosphate suggesting that it may be a limiting factor for phytoplankton growth in addition to siltation in the reservoir. Talling, et al. 1965 highlighted that nitrogen was the limiting nutrient for phytoplankton growth in tropical African lakes. The high concentration of dissolved oxygen was satisfactory for fish production (EEC, 1980). Dissolved oxygen content has higher values in the area and suitable for the production of fish. High circulation of water in the reservoir is the possible reason for such high oxygen values. Offem, et al. 2009 reported similar findings in reservoir, Nigeria. Although the nitrate concentrations in the reservoir are comparable to those reported for an offshore station in Koka reservoir (Hadgembes Tesfay, 2007), they are much lower than the values recorded for *Geffersa* (10 to 300 µg^{-1}, Nigatu Ebisa, 2010) and *Legedadi* (240 to 1850 µg^{-1}, Adane Sirage, 2006). This was probably reflecting the differences among the reservoirs in the extent of application of fertilizers and external loading of the nutrient through runoff. The concentrations of Soluble Reactive Phosphate (SRP) and Chl a were 82 ± 0.5 µg L^{-1} and 57.8 ± 0.4 µgL^{-1} respectively. Despite the fact that phosphorous is regarded as an extremely important element in controlling the trophic status of some tropical lakes (Kalff, 1983) and chlorophyll a was found to be strongly coupled to measured concentrations of phosphorus (Schindler, 1977; Praire, et al. 1989), the correlation between SRP and Chl a biomass of phytoplankton was poor in Belbela reservoir.

Plankton species composition

Phytoplankton: The phytoplankton community was constituted by 25 genus (Table 3) belonging to six algal families. These were *Cyanophyceae* (Blue-green algae), *Chlorophyceae* (Green algae), *Bacillariophyceae* (Diatoms), *Euglenophyceae* (Euglenoids), *Cryptophyceae* (Cryptomonads) and *Dinophyceae* (Dinoflagelates) (Table 3).

Table 3. List of phytoplankton taxa identified in Belbella reservoir.

Family	Genus
Chlorophyceae (Green algae)	*Actinastrum spp.*
	Elakatothrix spp.
	Closteridium spp.
	Pediastrum spp.
	Scendesmus spp.
	Tetrastrum spp.
Cyanophyceae (Blue-green algae)	*Anabena spp.*
	Aphanocapsa spp
	Aphanothece spp.
	Arthrospira spp.
	Chroococcus spp.
	Coelosphaerium spp.
	Cylidrospermopsis spp.
	Dactylococcopsis spp.
	Microcystis spp.
	Planktothrix spp.
	Pseudoanabaena spp.
Bacillariophyceae (Diatoms)	*Nitzschia spp.*
	Opephora spp.
	Pleurosigma spp.
	Synedra spp.
Dinophyceae	*Peridinium spp.*
Euglenophyceae	*Euglena spp.*
	Trachelomonas spp.
Cryptophyceae	*Cryptomonas spp.*

Species composition of phytoplankton communities were observed in the reservoir (Figure 2). Among the phytoplankton taxa, Blue green algae with 11 genus, followed by green algae and diatoms with six and four genus respectively. Other taxonomic groups of phytoplankton were relatively poorly represented in the phytoplankton community of the study reservoir (Figure 2). The overwhelming dominance of blue-greens algae constituted primarily by *Cylinderospermopsis*. The dominance of algal groups enhanced by one or several environmental conditions such as light, temperature, water column mixing and availability of nutrients in the reservoir depending on the particular algal groups (Reynolds, 2006). High turbidity (Smith, 1986) and temperature (Shapiro, 1990) and high total phosphate (Watson, et al. 1997) were among the physico-chemical factors known to initiate and enhance cyanobacterial dominance. Blue-green algae can regain their vertical position quickly owing to their effective buoyancy mechanism associated with gas vacuoles (Reynolds, 1987). Consequently, mixing of the water column in this reservoir can affect the blue-green algae only temporarily. Owing to the same adaptive feature of blue-green algae, the poor underwater climate of the reservoir would not be a factor of overriding importance. In fact, positive buoyancy gives blue-green algae a competitive advantage over other algal groups as other algae like diatoms lack an effective mechanism of maintaining their vertical position in the water column.

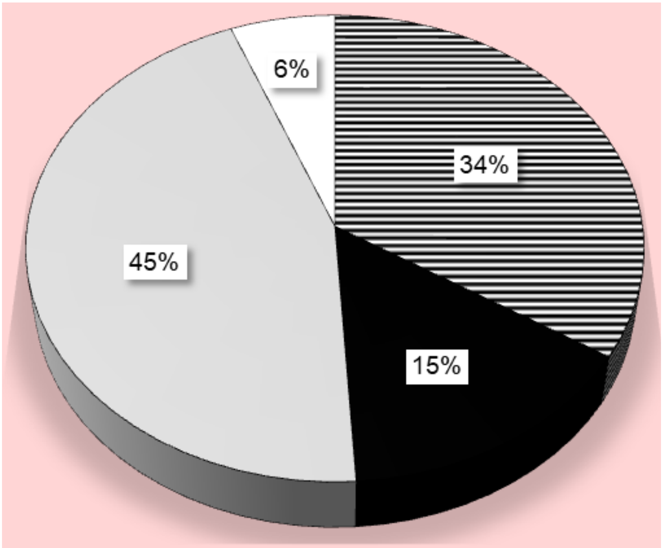

Figure 2. Composition of phytoplankton in Belbella reservoir.
Note: ( )Green algae, ( )Diatoms, ( )Blue-green algae, ( )Others

Zooplankton: The major zooplankton species identified in the reservoir were summarized in Table 4. Rotifers were the most species-rich zooplankton group with seven genus. The second most important zooplankton group was the *cladocerans*. The copepods were, poorly represented, with only two genus, in the zooplankton community of Belbela reservoir. The zooplankton community of the reservoir was reflective of tropical African freshwater systems modified by altitude and salinity-alkalinity series (Green, et al. 1991). The major species of rotifers (Figure 3), which were responsible for the dominance of the group included *Brachionus* and *Filinia*. Green, et al. 1991 also asserted that the zooplankton of Ethiopian lakes exhibit high rotifer diversity with Branchionus dominance.

Table 4. List of zooplankton taxa identified in Belbella reservoir.

Family	Genus
Copepoda	*Thermocyclops*
	Eucyclops
Cladocera	*Daphnia barbata*
	Diapohanosma
	Moina
	Ceriodaphnia
Rotifera	*Barchionus*
	Asplanchna
	Lecane
	Polyarthra
	Hexarthra
	Filinia
	Trichocerca

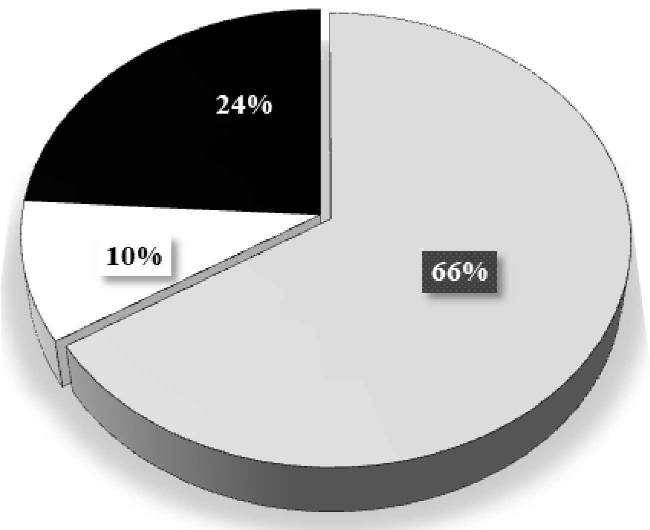

Figure 3. Composition of zooplankton.
Note: ( )Rotifera, ( ) Copepda, ( ) Cladocera

Composition of fish species

A total of 857 fish specimens were recorded from the three families during the study period (Figure 4). The species was *Oreochromis niloticus* from the family *Cichilidae* (86%) and the remaining was *Cyprinus carpio* and *Labeobarbus intermedius* from the family *Cyprinidae* 4% and 10% respectively (Figure 4).

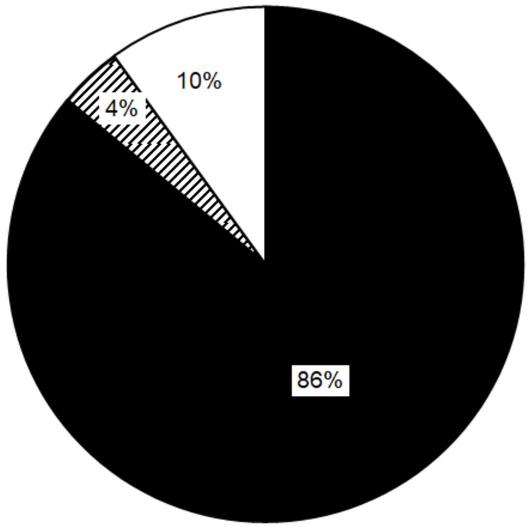

Figure 4. Composition of fish species in the waterbodies.
Note: ( )*Oreochromis niloticus*, ( ) Cyprinus carpio, ( ) Labeobarbus intermedius

Some biology of the dominant fish species

Length-weight relationship of *Oreochromis niloticus*: The Length-weight relationship of *O.niloticus* in the reservoir was curvilinear, show isometric growth and statistically highly significant (P<0.05) (Figure 5).

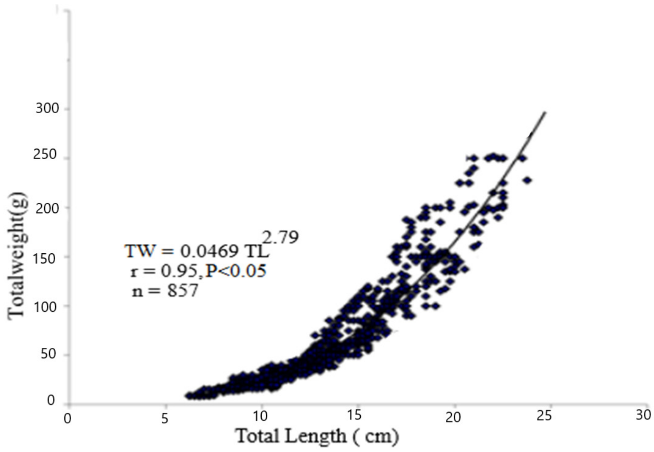

Figure 5. Length-weight relationship of *O.niloticus* in the reservoir.

Sex ratio, length at maturity and fishing gears selectivity of *Oreochromis niloticus*: Sex ratio results of *Oreochromis niloticus* were presented in Table 5.

Table 5. Pooled sex ratio of the *O.niloticus* (from July 2018 - June 2021).

Month	F	M	F:M	X^2
Sep	73	57	1:0.78	0.086
Oct	47	31	1:0.65	0.071
Nov	36	24	1:0.66	0.072
Dec	16	10	1:0.63	0.069
Jan	11	7	1:0.64	0.070
Feb	14	9	1:0.64	0.070
Mar	17	13	1:0.76	0.084
Apr	21	18	1:0.86	0.096
May	42	25	1:0.59	0.062

Jun	48	51	1:1.06	0.59
Jul	73	59	1:0.8	0.214
Aug	94	61	1:0.65	0.072
Total	**492**	**365**	**1:0.74**	**0.081**

The ratio was not significantly different from 1:1 for all sampling months (Table 4). In addition, the overall sex ratio (1:0.74) was also not significantly different from 1:1 (Table 4). The 50% maturity length (L50) of *Oreochromis niloticus* was estimated to be 18 cm total length for females and 17.5 cm total length for males (Figure 6). On the average, males appeared to attain sexual maturity at a relatively smaller size than females. As reported for both temperate and tropical aquatic ecosystems, males attain maturity at a smaller size than females (Tempero, et al. 2006; Britton, et al. 2007). Size at first sexual maturity of *Oreochromis niloticus* in Rift Valley Lakes (Lake Ziway, Koka and Langano). This might be due to the high fishing pressure and productivity of the water body.

The catch size frequency distributions of the fish caught by the gillnet was indicated in Figure 7. The current mesh size (10 cm) used in the reservoir was captured the fish with the range of length class between 16-20 cm that coincide with at their L50 around 18 cm and 17.5 cm respectively for female and male (Figures 6 and 7). Hence, care should be taken not to lower the mesh size any further to the immature fish will be affected by the fishery. The results of gill selectivity show that the use of recommended gillnets with mesh sizes that select fish below the size at first maturity (L50) of the target resources for the fish that reduced the spawning stock (Figure 6 and 7).

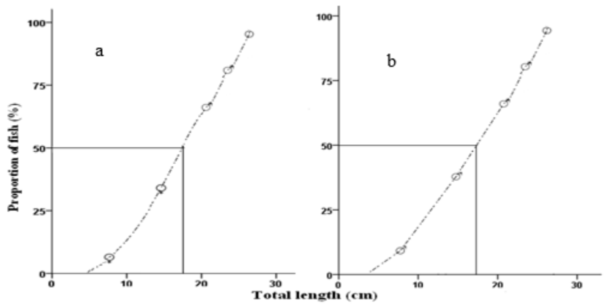

Figure 6. (a) The proportion of fish in different length groups of females and (b) males of O. niloticus in Belbella reservoir.

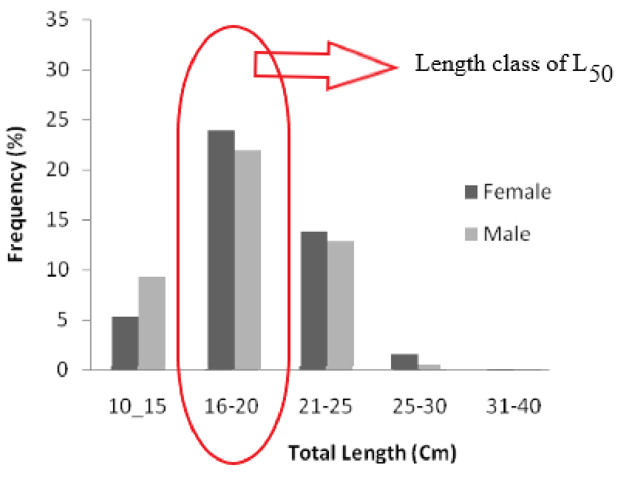

Figure 7. Number of fish catch per length class of O.niloticus using 10 cm mesh size gill net.

CONCLUSION AND RECOMMENDATIONS

Belbela reservoir is a very low salinity turbid eutrophic body of water that supports phytoplankton community, which is primarily constituted by cyanobacteria, green algae and diatoms. The reservoir water is suitable for human and animal consumption in light of the levels of aggregate chemical parameters and such physical variables as turbidity. The acceptability of the water from Belbela reservoir for human consumption is, however, questionable in light of cyanotoxins and heavy metals as the reservoir harbors potentially toxic cyanobacteria of high levels of abundance and is found in the proximity of floriculture industries that use a variety of chemicals.

The family *Cichilidae* dominates the fish fauna of Belbella Reservoir. *Oreochromis niloticus* was the most abundant and commercially the most important fish species under the family in the reservoirs. Based on percentage composition, *O.niloticus* was relatively the most dominant fish in the reservoir, which contributed to 86% of the total catch. Among the *Cyprinids, C. carpio and L. intermedius* contributed 4% and 10%, respectively, of the total fishes catch. From the length-weight relationship, it can be stated that the only one dominant fish species (*O. niloticus*) show isometric growth and the length-weight relationships were also curvilinear. The smallest sexually mature male *O. niloticus* was 17.5 cm TL and the female was 18 cm TL.

Fishing technology on Belbella Reservoir was not modern in its nature and only makes use of traditional boats of wooden manual boat. Gillnets of not recommended mesh size was practiced on the water body that decreased the fish resources of the reservoir. Hence, as recommendation, with increase in nutrients and more degradation in the catchment, fish species composition may continue changing in the future. Therefore, monitoring of fishes and management of nutrient inputs should be carried out on regular basis. The shore of reservoir should be restored with macrophytes and protected in order to control external nutrient loading.

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