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Research Article

Evaluation of Limnological Status of Jagadishpur Reservoir, Kapilvastu District, Nepal

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Abstract

The aim of this research was to analyze physical and chemical characteristics of low altitude lake of Jagadishpur Reservoir, a Ramsar site in central Nepal lies about 197 m altitude. The reservoir water was studied for three seasons (rainy, winter and summer) to compare the changes in the parameters. Water quality in reservoir was found less favorable to aquatic organisms, with low pH and transparency, low dissolved oxygen (DO), and high nutrient concentrations (Nitrogen). The reservoir was found eutrophic in nature by nitrogen concentration and transparency criteria. The findings created a database for present status of low land water reservoir of Nepal, which can be used for the management of lakes as well as to study the impact on water quality.This study provided useful information for decision makers aimed to the conservation and sustainable management of the reservoir.

Keywords: Ramsar site; Physico-chemical parameter; Eutrophic; Lowland

Introduction

Wetlands are interface between terrestrial and aquatic communities and the most productive ecosystem on the earth. They occur only where the water table is at or near the surface of the land or where the land is covered by shallow water. They have significant role in conservation of biodiversity and genetic resources. They play a great role in providing wildlife habitat, shelter for migratory birds, regulating water quality, flood control, production of organic material and conservation of rare and endangered species (*Oli et al*., 2013).

Wetlands in Nepal are exclusively fresh water in nature. They occupy approximately 5% of the total area of the country mainly in the form of rivers, lakes, reservoirs, village ponds, paddy fields and marshes (HMG/N 1992). Nowadays fresh water has become a rare commodity due to over exploitation and pollution (Talwar *et al*., 2014). Most water bodies are contaminated due to incorporation of different pollutants (Pani and Mishra, 2005).

Nepal's wetlands are facing degradation primarily due to eutrophication and land reclamation. These are critically threatened by the effects of anthropogenic activities such as deforestation, unregulated hunting, dam construction, and increased pollution due to discharges of untreated effluents and runoff from agricultural fields (Joshi *et al*., 2001). Monitoring water quality parameters is very important to determine the actual limnological status of wetlands (Pradhan, 1998). Water quality parameter provides the basis for judging the suitability of water for its different uses

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(Bajpai *et al.* 2001). Therefore, it has become obligatory to analyze the important water parameters of water bodies in regular interval of time. Keeping in view the above facts, an attempt has been made to examine the suitability of lower lake water for drinking and irrigation purposes. Therefore, the present investigation has been conducted to find out the limnological status of Jagadishpur reservoir for evaluating the potential risk of water quality deterioration of this economically important aquatic resources.

Study Area

Jagdishpur Reservoir (27° 35' N and 83° 05' E) lies in the Niglihawa Village Development Committee of Kapilvastu district of Nepal (Fig. 1), about 10 km north-west to the district headquarters Taulihawa. It lies at low elevation (197 m asl) with a tropical monsoon climate of hot rainy summer and cool, dry winter. The reservoir is the main source of water for irrigation of at least 406 ha land in the Kapilbastu district. The water level in the reservoir fluctuates from a maximum of 5-7 m to a minimum of 2-3 m. This site is considered as paradise for birds. It provides shelter to at least 18 species of mammals, 8 species of reptiles, 42 species of indigenous and migratory birds and 25 species of fishes (Baral and Inskipp, 2005). Similarly, several plant species occur in the reservoir and the adjoining areas. The major aquatic plant species are *Ageratum conyzoides, Ceratophyllum emersum, Cyperus spp.,Hygrorhiza aristata, Typha elephantina, Ipomoea carnea* ssp. *fistulosa, Leersia hexandra, Nelumbo nucifera, Nymphoides hydrophyllum, Oryza rufipogon, Ottelia alismoides, Paspalum distichum, Polygonum hydropiper, Vetiveria zizanioides, etc.Plantation of Dalbergia sissoo* is common along the embankment. The associated species in the plantation areas mainly consist of alien taxa, such as *Cassia occidentalis, C. tora, Chromolaena odorata ,Croton bonplandianum, Hyptis suaveolens, Parthenium hysterophorus, Xanthium strumarium,* etc. It is currently managed under the Reservoir Management Committee involving local community. The Committee has leased this Reservoir for commercial fish culture. Some southwest part has been used for recreation (boating) purpose. Based on the following criteria the Jagdishpur eservoir has been designated as Ramsar site in 2003.

Materials and Methods

To determine the water quality and limnological parameters, water samples were collected during winter (December), pre-monsoon (April) and mid-monsoon (August). A triplicate water samples from each sampling sites were collected in standardized PET (polyethylene terephthalate) bottles, which were thermo stated bottles. The PET bottles of 1.5 liter capacities and 0.5 liter capacity with stoppers were used for sample collection. The bottles were washed thoroughly with 2 % nitric acid and subsequently rinsed with distilled water. Before collecting the water samples, all bottles were rinsed with sample water 2-3 times. All the sampled bottles were made watertight by air tightening it inside water. Precaution has been taken to remove any air bubble present. Each container was clearly marked with the name and date of sampling. All the samples were preserved at 4^{o}C till analysis.

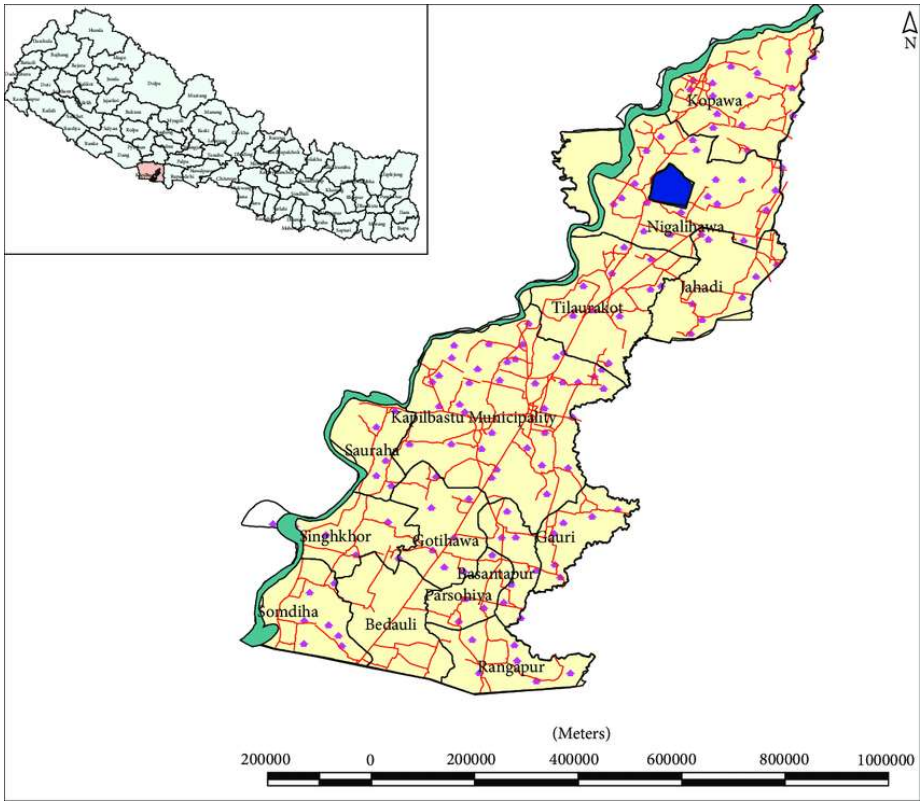

Fig 1: Location map of study site

The water temperature of each site was measured with mercury thermometer, transparency was measured by Secchi disc method, and pH and conductivity were determined by pH meter (692 pH/ion meter) and Conductivity meter (inoLab Cond Level L. WTW) respectively. The other physio-chemical parameters such as total alkalinity, total hardness, dissolved oxygen and were carried out in the laboratory of Central Department of Botany, TU for the analysis of different parameters. Analysis of phosphorous and total nitrogen was carried out in the laboratory of NARC Khumaltar, Lalitpur. All the samples were kept in refrigerator at 4ºC in the laboratory and before analysis samples were allowed to gain normal water temperature.

Results and Discussion

The average temperature of reservoir was observed low during winter (19.45± 0.065) and higher during summer (29.28± 0.452) (Table 1). This may be due to mature leaves of floating species such as *Nelumbo nucifera*, *Nymphaea nouchali*, *Nymphoids indica*, *Hygrorhyza ariatata* etc., which formed a thick and dense cover over the water surface and does not allow a direct contact or penetration of light to lake water (Mishra *et al.,* 1996). The increase in temperature was followed by pH (Hussainy, 1967) and conductivity (Bhatt *et al.,* 1999). Generally, the amount of dissolved oxygen decreased with an increase in water temperature. Seasonal change in water temperature was found to be related with corresponding change in atmospheric temperature (Kundanger *et al.,* 1996).

pH is one of the most important parameter which is used in measuring water quality in chemical and biological system of natural water. The average pH value of the reservoir was slightly alkaline (7.10 ± 0.352) during summer, whereas in rainy season it was recorded higher (7.50 ±0.124). High pH favors the better macrophytes growth which showed positive correlation with species diversity index (Mishra *et al.,* 1996). The fluctuation in pH can be attributed to the combined effect of temperature, carbon dioxide balance, and liberation of ions and buffering capacity of water. Generally, water with low levels of carbonates, bicarbonates and phosphates has low buffering capacity (Agrawal 1999). The range of pH value (6.9- 7.5) of present study site is similar to that of Begnas and Rupa Tal (6.6-7.5) as reported by Lohman *et al*. (1988). The pH range 6 to 9 for open lakes was considered slightly alkaline in nature and falls under the categories of Wetzel (1983). Similar results were found by Fisheries Research Centre(1994) in Lakes of Pokhara valley; Phewa, Begnas and Rupa.

Transparency of water of Jagadishpur reservoir was minimum (0.51±0.035) during rainy season and maximum (0.72±0.21) during summer revealed that eutrophic nature of the reservoir on the basis of criteria proposed by Yashimura (1993), lakes with transparency value 1.5 m or less depict higher trophic level i. e. eutrophic. Transparency value inversely related with the amount of total solid present. The minimum transparency during rainy season of present study due to allochthonous material from outside along with monsoon rain made turbid to reservoir water. This result is comparable with the results of Bhatt *et al.* (1999) in Taudaha and Mishra *et al.* (1996) in Bihar lake.

Dissolved oxygen is one of the most important parameter in water quality assessment. Its presence is essential to maintain varieties of forms of life. During present study minimum value of DO (5.90 ±0.242) was recorded during summer and maximum during winter season (7.20± 0.212). This could be due to dissolved oxygen decrease exponentially with increase in temperature and vice versa (Agrawal 1999). During summer low value of DO might be due to the decomposition of autochthonous and allochthonous organic matter brought in by the inflowing streams and respiration of microbes (Cole 1975). Low content of oxygen is the indication of organic pollution, so tolerant limit of dissolved oxygen should not be less than 6 mg/l (Kudesia 1985).

Acidity of water is due to presence of strong acid , weak bases and different minerals. The value of acidity was lower (12.32±0.12) during winter season and it attains maximum during summer season (17.24±o.112). This result was supported by the result of Singh *et al.* (1982) in Naukuchi tal of Kumaon, where watershed water during winter was also acidic. Generally, the maximum amount of CO_2 combines with water and forms higher amount of carbonic acid during summer than other seasons, might be due to amount of CO_2 concentration was higher and dissolved oxygen lower in summer season. The value of acidity strongly correlated positively with free CO_2 and temperature, and negatively with dissolved oxygen in present study (Table 2). Acidic water is not so good for aquatic macrophytes and organisms as well.

Alkalinity is the ability to neutralize acids and is generally caused by the presence of water soluble radicals like carbonate, bicarbonate, hydroxide, phosphate, nitrate and silicate. pH value ranged from 4.5 to 8.3. has practically observed no carbonate (Jhingram,1975), showed bicarbonate alkalinity in present study site. The value of total alkalinity was higher during winter season (275.2±59.620) and least (85.65±8.622) during summer season (Table 1). Higher value of bicarbonate alkalinity, due to large number of aquatic animals, zooplankton, phytoplankton and microorganisms, during respiration process produced large amount of CO_2 which dissolve in water and increase total amount of bicarbonate at the season. Higher ratio of bicarbonate over carbonate can be used as an index of higher productivity (Khan and Qyajjym 1996).More than 60 mg/l average value of bicarbonate alkalinity categories in nutrient rich categories by Kundanger *et al*.(1996) found in Wular Lake similar to present study. Annual total alkalinity value of present study

was similar to the value of Kawar Lake of Bihar reported by Sharma (1996). The suspended and dissolved materials, microorganisms like phytoplankton and zooplankton present in the lake water were considered as total solid matter. The present study showed that total solid matter was highest during rainy season (386±10.182) due to the addition of sediment by flooding and it was lowest during winter season (Table 1). The annual value of total solid matter was found slightly higher in Gaindahawa Lake (Simkhada, 2003) than present study. Due to low value of total solids, the population of benthos and planktons might be positively affected (Welch, 1952; Roy, 1955). The negative correlation occurred between total solids and submerged species may be due to low penetration of light and surface accumulation of particulate matter (Shrestha 2002)

Free carbon dioxide is also important physico-chemical characteristics of water. The source of free CO_2 in an aquatic environment is atmospheric diffusion, respiration by aquatic organisms and microbial decomposition. Free CO_2 content in water increases with increase in temperature (Agrawal, 1999). During present study minimum value of free CO_2 (12.24±2.23) was recorded in winter which increase in rainy and attained maximum value (22.70 ±0.92) in summer (Table 1). Low free CO_2 in winter season might be due to higher macrophytic diversity used maximum CO_2 in photosynthetic activity (Mishra *et al*., 1996). From present study it was found that the free CO_2 correlated negatively with dissolved oxygen i.e. with increasing free CO_2 decrease in dissolved oxygen, due to an enhancement activity of aerobic microbes (Table 2). The high free CO_2 content in winter indicates the overall eutrophication of the watershed.

Total hardness value of water was higher (214 ±16.190) during summer and least (185 ± 12.062) during winter season. The higher concentration may be due to decrease in water level by evaporation which increase the salts of Ca^{++} and Mg^{++} (Dangol and Lacoul, 1996). Lower concentration of total hardness during winter might be due to effect of low temperature, probably decrease in release of calcium and magnesium.

Table 1: Average Limnological value in three seasons of Jagadishpur Reservoir (n=3)

Parameters	**Winter**	**Summer**	**Rainy**	**Average**
Temperature(°C)	19.45± 0.065	29.28± 0.452	25.83 ±0.723	24.83±4.422
pH	6.90 ± 0.092	7.10 ± 0.352	7.50 ±0.124	7.17 ±0.325
Transparency	0.58±0.018	0.72±0.210	0.51±0.035	0.60±0.106
Dissolved Oxygen (mg/l)	7.20± 0.212	5.90 ±0.242	6.40± 0.325	6.50± 0.528
Acidity (mg/l)	12.32±0.120	17.24±o.112	13.22±0.214	`4.26± 2.726
Total Alkalinity (mg/l)	275.2±59.620	85.65±8.622	134.82±30.246	165.22 ± 96.245
Total Solid matter (mg/l)	302 ±12.632	332±6.285	386±10.182	340± 40.510
Free CO2 (mg/l)	12.24 ±2.235	22.70 ±0.920	14.05 ± 3.092	16.33 ± 4.852
Total hardness (mg/l)	185 ± 12.062	214 ±16.190	192 ±8.526	197 ±14.453
Total Nitrogen (mg/l)	4.26±0.086	7.02 ±0.620	5.26 ± 0.256	5.51 ± 1.321

Table.2.: Correlation between Limnological characteristics of water of Jagadispur reservoir

	pH	**Trans.**	**DO**	**Acidity**	**TA**	**TSM**	**F.CO2**	**TH**	**TN**
pH	_	-0.500	-0.499	-0.017	-0.568	1.000*	-0.028	0.043	0.175
Trans.	_	_	-0.549	0.875	-0.428	-0.477	0.879	0.844	0.765
DO	_	_	_	-0.885	0.990	-0.473	-0.881	-0.912	-0.958
Acidity	_	_	_	_	-0.813	0.009	1.000**	0.998*	0.981
TA	_	_	_	_	_	-0.590	-0.807	-0.847	-0.910
TSM	_	_	_	_	_	_	-0.001	0.070	0.201
F.CO2	_	_	_	_	_	_	_	0.997*	0.979
TH	_	_	_	_	_	_	_	_	0.911

*Correlation is significant at the 0.05 level; **Correlation is significant at the 0.01 level

Table 3: Drinking Water standards

PARAMETERS	UNIT	WHO*	EC**
Temperature	^{o}C	-	25 – 25
Turbidity	NTU	5	1 – 10
Total Dissolved Solids	mg/l	1000	1500
P^{H}		6.5 - 8.5	6.5 - 8.5
Conductivity	µs/cm	-	400
Total Hardness as CaCO3	mg/l	500	-
Nitrogen – Ammonia	mg/l	-	0.04 - 0.4
Nitrogen – Nitrite	mg/l	1.0	-
Nitrogen – Nitrate	mg/l	1.0	5 – 10
Ortho- Phosphate	mg/l	-	0.4 - 5.0

* World Health Organinization, 1984

** European Community, Directive 80/778/EEC

The value of total nitrogen may be due to abundant microbial activities and higher excretory products by aquatic animals, was higher (7.02 ±0.620) during summer whereas, lower aquatic biomass decomposition rate with inactiveness of microbes showed low value (4.26±0.086) during winter season (Table 1). While comparing tropic state criteria proposed by Forsberg and Ryding (1980), the present study falls under the category of eutrophic level. Lower value of total nitrogen (0.76 mg/l) was recorded from Gaindhawa Tal (Mc Eachern 1996). Similarly, the value of total nitrogen (8.85 mg/l) was higher than present study also recorded by Jones *et al.*(1989) in Nagpokhari, Kathmandu .

The average of pH was found to be more or less similar in all three seasons and within the EC, WHO standard (6.5 - 8.5). Temperature of water in study sites was found within the EC standards (i.e 12-25^{0}C) set for the surface water used for potable abstractions (Table 3).

Conclusion

The limnological parameters of the lake, in terms of temperature, pH, transparency, dissolved oxygen, acidity, total dissolved solid, total alkalinity, total nitrogen , etc. were determined. Seasonal variation in physico-chemical characteristics in the lake occurs due to fluctuation of water level, limited sources of water. On the basis of turbidity and total nitrogen content, this reservoir was found to be eutrophic category. Due to sedimentation, eutrophication, encroachment,growth of invasive species and lack of awareness among locals, the condition of reservoir was found to be degrading day by day.This problem can be overcome by proper conservation and management.

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