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Physico-chemical conditions at Watlab ghat in Wular lake, Kashmir

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Abstract

The present limnological investigations include analysis of various physico- chemical parameters at the selected site in Wular lake, Kashmir (a Ramsar site) from March, 2007 to February, 2008. The aim of current study was to evaluate the status of the Wular lake water on the basis of different physico-chemical conditions. The water depth ranged from 1.35 (m) to 2.60 (m). The pH of the water was on alkaline side throughout the study period. The lake depicted the usual cation progression: Ca > Mg. The lake can be categorized as calcium rich after Ohle (1934). Specific conductance was found low in spring and summer. High values of transparency were recorded in winter. The lake water is typical hard water type. The alkalinity was due to bicarbonates only. High values of both NO_3–N (338 µg/L) and PO_4–P (203 µg/L) were recorded during summer. Statistical analysis was also carried out to find out the degree of relationship between various abiotic factors. Dissolved oxygen showed significant negative correlation with water temperature ($r = –0.839$), whereas significant positive correlation with pH ($r = 0.854$) at the selected site. pH showed significant negative correlation with water temperature ($r = –0.777$) and CO_2 ($r = –0.854$) respectively, at the selected site.

Keywords: *Abiotic factors, alkalinity, calcium rich, correlation, water quality parameters, limnological*

Introduction

In the western Himalaya, the picturesque high altitude valley of Kashmir abounds in diverse type of freshwater bodies like rivers, streams, lakes, springs, wetlands which are of great ecological and economic interest. As a result of growing anthropogenic pressure, mainly due to widespread urbanization and reclamation of land for agriculture, the water bodies of valley are not only shrinking in size but its waters are becoming more and more polluted, thereby posing a regular threat to human health also. In recent years many of these water bodies have started showing the signs of instability and in some of them even the red euglenoid blooms, a rare phenomenon in freshwater lakes, were evinced. Although the increased fertility of lakes with ageing is a natural phenomenon, but the rate at which the lakes of this part of the Himalayas have shown this phenomenon clearly indicates that human interference in the catchment area as well as within the basins of the aquatic system has greatly increased. Although a lot of literature is available on the limnological aspects of urban lakes of Kashmir, yet very little information is available on rural lakes like Wular lake. In this backdrop, limnological investigation on Wular lake was undertaken to provide a base line data on physico-chemical characteristics of water and also to find the main source of pollution. A perusal of literature shows that a large number of reports are available on the water chemistry of Kashmir lakes. The important contributions are those of Qadri and Yousuf (1979), Zutshi *et al.* (1980 a and b), Khan and Zutshi, (1980); Singh *et al.* (1982), Trisal, (1987), Pandit (1993 and 1999), and Ganai *et al.* (2010).

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Material and Methods

The Wular Lake (34° 15´– 34° 28´N longitude and 74° 30´ – 74° 45´E latitude) is the largest freshwater lake of India and in Asia (Fig. 1), situated at an altitude of 1580 m above mean sea level. The lake is situated in newly carved district of Bandipore which is about 34 km away from Srinagar city of Kashmir valley. The lake is mainly fed by river Jhelum besides various bubbling springs as well as streams like Erin, Madhumati, Pohru, Harbuji, Arrah and the famous Ningal Nallah. The river Jhelum flows into the lake near the village 'Banyar' on its south-east side and leaves the lake near

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Sopore from its south-west corner. The lake has now shrinked down from 20,000 hectares to 2400 hectares due to continued silt deposition brought by its various tributaries, exceptionally high human interference in and around this lake in the form of agriculture, industrialization and urbanization. An area of 11,853 kanal and 14 malras of land has been illegally encroached from Bandipora side alone with 92 illegal constructions raised over the encroached land (Rashid, 2008). Further, due to large quantities of organic matter brought by river Jhelum, flowing through several towns of the valley, add and deposit organic and inorganic matter to the lake and as a result of this nutrient concentration has increased. This has resulted in the production of large number of rooted and free floating plants. Due to human interference, there has been severe depletion of some endemic and endangered fauna and flora.

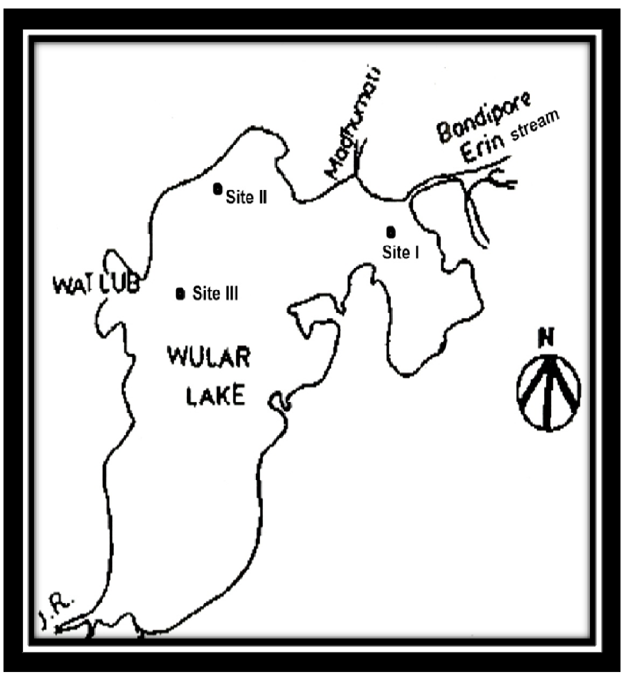

Fig. 1: Map of Wular lake showing sampling station station

The sampling was carried out on monthly basis from March, 2007 to February, 2008 at the selected site between 9-10 am. The different physico-chemical characteristics were analysed following the works of Theroux *et al.* (1943), Trivedy and Goel (1984) and APHA (1998).

Results and Discussion

The physico- chemical analysis has a great bearing in the elucidation of any aquatic ecosystem and is essential to bring out various aspects of pollution and also for complete understanding of the biological phenomenon. Water quality monitoring has thus, become high priority for the determination of current conditions and long term effective managements. The monthly variation in various physico-chemical parameters of the lake at the selected site is depicted in Fig. 2-5 whereas the statistical briefs of various physico - chemical parameters and their correlation and mean and standard error are presented in Table 1-2. Temperature of water depends upon water depth besides solar radiations, climate and topography. No, other single factor has so much profound influence on physico- chemical, biological and psychological behaviour of aquatic ecosystems than temperature. Water temperature showed a very characteristic annual cycle, with minimum value of 6^{o}C in the month of January, 2008 to a maximum of 27^{o} C in the month of July, 2007 (18.6 ^{o}C ± 2.0).The distribution of temperature followed a seasonal trend, showing an ascending pattern during summer and decreasing pattern during winter with moderate temperature during spring. Maximum values were recorded during summer, which is due to high ambient temperature and long photoperiods. Minimum temperature was recorded during winter season, which is related to short photoperiods and low temperature during this time. Water level plays an important role in governing the water quality. Shallow waters get heated up and thus, increase their temperature and consequently affect the biological and chemical reactions taking place. Depth of the selected site showed great fluctuation from a minimum of 1.35 (m) in Oct, 2007 to a maximum of 2.60 (m) in March, 2007 (1.87 m ± 0.12). High values of depth were recorded in spring due to heavy rains, whereas it declined quite fastly in summer and then slowly in autumn. Transparency of water allow more light penetration which has far reaching effects on all aquatic organisms including their development, distribution and behaviour. The value of transparency fluctuated from a minimum of 20 cm in the month of March, 2007 to a maximum of 120 cm in January, 2008 (74.6 cm± 10.5).

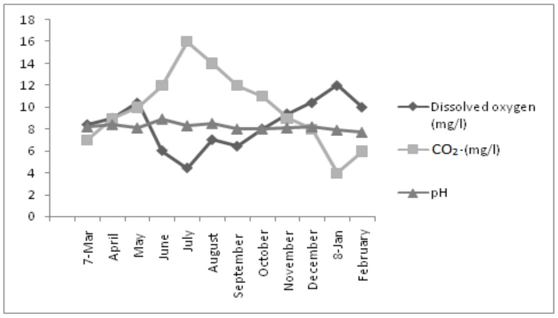

Fig.2. Monthly variations in dissolved oxygen, CO_2 and pH from March, 2007 to February 2008

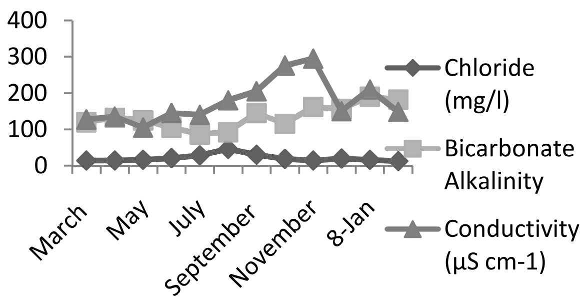

Fig. 3. Monthly variations in conductivity, alkalinity and chloride from March, 2007 to February 2008

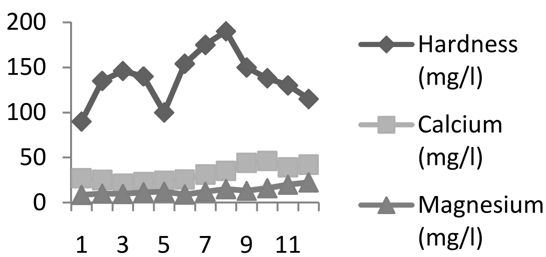

Fig. 4. Monthly variations in hardness, calcium and magnesium from March, 2007 to February 2008

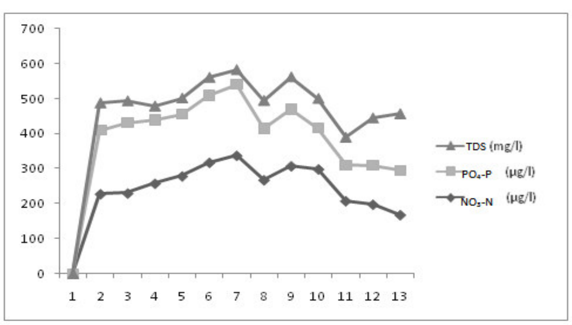

Fig.5. Monthly variations in NO_3-N, PO_4-P and TDS from March, 2007 to February 2008.

The high transparency during winter season might be attributed to the decreased silt, low biological activity and low input of organic matter at this time, while decline in transparency values during spring is due to heavy rains during this season. Statistically a positive correlation was found between transparency and TDS at the selected site (r=0.397- Table 1). Conductivity is the measure of capacity of a substance or a solution to conduct electric current. Conductivity is an important factor which gives an indication of total salt concentration. The conductivity values are the indication of the total nutrient status of the water bodies; therefore, this parameter is used to indicate the trophic status. A well marked seasonal pattern of specific conductivity in water body under study was noted. Conductivity values fluctuated from a minimum of 105 μScm^{-1} in the month of May, 2007 to a maximum of 295 μScm^{-1} in the month of November, 2007 (176.3 μScm^{-1} ±17.1). The maximum electrolytic conductivity was recorded in autumn against minimum in spring which could be related to the death and decomposition of organic matter during fall. Decline in conductivity values in spring could be related to increase in phytoplankton and macrophyte population leading to increase in the uptake of nutrients.

The total dissolved solids (TDS) in water comprise mainly of organic salts and small amount of organic matter. Generally, carbonate, bicarbonate, chloride, sulphate, nitrate, sodium, potassium, calcium and magnesium contribute total dissolved solids. TDS varied from a minimum of 39.0 mg/l in the month of March, 2007 to a maximum of 162 mg/l in February, 2008 (79.17 mg/l ±10.6). The higher values of TDS during winter might be due to less utilization by plankton and macrophytes, whereas lower values in summer can be attributed to their active utilization by plankton and other aquatic plants in addition to loss of nutrients to the sediment.The dissolved oxygen (DO) plays a very important role in regulating metabolic activities of almost all the organisms. Dissolved oxygen is one of the most reliable parameter in assessing the trophic status and the magnitude of eutrophication in aquatic ecosystems (Brazin and Saunders, 1971). Dissolved oxygen varied from a minimum of 4.40 mg/l in July, 2007 to a maximum of 12.0 mg/l in

January, 2008 (19.1 mg/l ±2.71). Decrease in dissolved oxygen in summer was observed due to increased rate of oxidation of organic matter. Consequently the high dissolved oxygen during winter is the result of low biological activity (Qadri *et al.* 1981, Ganai *et al.*, 2010) and high oxygen holding capacity of water at low temperature. Statistically DO showed a significant negative correlation with water temperature (r=-0.839) whereas with pH, correlation was significant positive(r = +0.814) (Table 1). The free carbon dioxide contributes to the fitness of natural waters as it serves to buffer the environment against the rapid shifts in the acidity or alkanity. It also regulates biological processes in the aquatic communities and can form many compounds. The concentration CO_2 fluctuated from a minimum of 4.0 mg/l in the month of January, 2008 to a maximum of 16.0 mg/l in July, 2007 (11.0 mg/l ± 0.75). The higher concentration of CO_2 during summer in present study is attributed to shallow depth, higher microbial decomposition and more respiratory activities of aquatic plants and animals. pH of natural waters is an important environmental factor, the variation of which, among other causes are linked with the chemical changes, species composition and life processes of animal and plant communities inhabiting them. pH between 6.7-8.4 are suitable, while below 5.0 and above 8.3 are detrimental (Klein, 1957). pH of water remained on alkaline side throughout the period of investigation and varied from a minimum of 7.7 in February, 2008 to a maximum of 8.9 in June, 2007 (8.19 ± 0.09). Higher values of pH were recorded during summer which could be related to enhanced photosynthesis, thereby, removing free CO_2, leading to increase in pH. However, no significant change in pH was observed during most of the period of study, thereby showing that lake water is well buffered. pH showed significant negative correlation with water temperature (r= - 0.777) and carbon dioxide (r= - 0.854) and significant positive significant with the alkalinity (0.899) (table-1). The total alkalinity was solely due to bicarbonates of calcium and magnesium as carbonates were never recorded. The values of alkalinity varied from a minimum of 86.0 mg/l in the month of July, 2007 to a maximum of 190.0 mg/l in the month of January, 2008 (155.5 mg/l ± 10.6). The maximum values of alkalinity were recorded during winter. The minimum values of alkalinity were recorded during spring and summer which could be related to absorption of bicarbonates by macrophytes in these seasons.Total hardness, is governed by the content of calcium and magnesium salts largely combined with bicarbonates and carbonate (temporary hardness) and with sulphates, chlorides and other anions of mineral acids (Permanent hardness).The values of hardness varied from a minimum of 90.0 mg/l in the month of March, 2007 to a maximum of 190.0 mg/l in October, 2007 (77.8 mg/l ±13.5). High values of hardness were registered in autumn season which is related to inflowing sewage and high anthropogenic activities. No significant change in hardness values were noticed during rest of the seasons. Water with hardness values more than 180 mg/l is very hard. However, water of Wular Lake can not categorized into very hard category as values of hardness recorded were lower than the prescribed values almost during whole period of investigation. Calcium is an important micronutrient which influences the growth and population dynamics of fresh water flora and fauna. It was recorded to be the most dominant cation of the lake water and follow the cation progression Ca>Mg. The values of calcium fluctuated from a minimum of 21.0 mg/l in the month of May, 2007 to a maximum of 46.0 mg/l in December, 2007 (31.8 mg/l ± 2.59). The lake can be categorized as calcium rich as per the classification given by Ohle (1934). This also agrees with findings of Pandit (1991) who categorized lake waters of Kashmir as "Calcium rich". Magnesium occurs in all kinds of natural water with calcium but its concentration remains generally lower than the calcium. It is required universally by chlorophyllous plants for the magnesium porphyrin complex, and a micronutrient in enzymatic transformation especially in transphosphorylation by algae, fungi and bacteria (Wetzel, 1983). The depletion of magnesium acts as a limiting factor for the growth of phytoplankton and reduces the number of phytoplankton. The values of magnesium fluctuated from a minimum of 8.50 (mg/l) in the month of March, 2007 to a maximum of 22.50 (mg/l) in the month of February, 2008

(13.2 mg/l ± 1.27). In present investigation magnesium showed no definite seasonal trend, however, higher values were registered in winter which is related to its least uptake by aquatic vegetation for the formation of chlorophyll magnesium porphyrin complex and its role in enzymatic transformation (Wetzel, 1983) and lower decomposition rates. Large content of chloride in fresh water is an indication of organic pollution.

Increased concentration of chloride is always regarded as indication of eutrophication. The chloride values varied from a minimum of 12.0 mg/l in February, 2008 to a maximum of 46.0 mg/l in August, 2007 (20.5 mg/l ± 2.8). Low values of chloride were recorded throughout the period of investigation. However, a high value of chloride in summer is due to large amount of sewage and organic matter carried into it. Thresh *et al.* (1944) and Ganai, (2011) suggested high chloride concentration of water as indicative of pollution of animal origin.

Table. 1. Statistical briefs of various water quality parameters at Watlab Ghat in Wular lake, Kashmir from March, 2007 to February, 2008.

Parameter	Parameters	Coefficient of correlation	Significance at ($p \leq 0.05$)
Transparency	TDS	0.397	-
Dissolved oxygen	Water temperature	-0.839	✓
	pH	0.814	✓
pH	Water Temperature	-0.777	✓
	Carbon dioxide	-0.854	✓
	Alkalinity	0.899	✓

Table. 2. Mean and standard error of various water quality parameters at Watlab Ghat in Wular lake, Kashmir from March, 2007-February, 2008)

Parameter	Mean ± SE
Water temperature (^oc)	18.6 ± 2.0
Depth (m)	1.87 ± 0.12
Transparency (cm)	76.6 ± 10.5
Conductivity ($\mu S\ cm^{-1}$)	176.3 ± 17.1
TDS(mg/l)	79.17 ± 10.6
D. Oxygen (mg/l)	19.1 ± 2.71
CO_2 (mg/l)	11.0 ± 0.75
Alkalinity (mg/l)	155 ± 10.6
pH (mg/l)	8.19 ± 0.09
Hardness (mg/l)	77.8 ± 13.58
Calcium (mg/l)	31.8 ± 2.59
Magnesium (mg/l)	138.5 ± 8.2
Chloride (mg/l)	20.5 ± 2.8
NO_3 - N (µg/l)	25.8 ± 2.8
PO_4 -P(µg/l)	158.9 ± 10.4

The importance of nitrate and phosphate in plankton ecology has been emphasized by (Fitzgerald, 1970). Nitrogen and phosphorus can be considered as two major elements limiting primary production. According to Mc. Caull and Crossland (1974) the most important factors responsible for eutrophication of freshwater lakes are phosphorus (PO_4–P) and Nitrogen (NO_3–N). High concentration of nitrates are useful in irrigation but their entry into water resources increase the growth of nuisance algae and trigger eutrophication and pollution (Trivedy and Goel, 1984). A wide range of variations in the concentration of nitrate nitrogen have been reported from Indian waters. The values of NO_3–N in present study varied from a minimum of 168 µg/l in February, 2008 to a maximum of 338 µg/l in August, 2007 (258.8 µg/l ± 15.2). High values of NO_3–N during summer and autumn in present study are attributed to increased rate of decomposition of organic matter at high temperature and entry of nitrogen fertilizers from the catchment area.

Phosphorus is regarded as key element in eutrophication process (Vollenweider, 1972). The values of PO_4–P fluctuated from a minimum of 103 µg/l during the month of December, 2007 to a maximum of 203 µg/l during the month of August, 2007 (158.9 µg/l ± 10.7). In present study, PO_4–P content exhibited distinct seasonal variations, with highest concentration in summer which is again related to decomposition of organic matter at high temperature and increased anthropogenic pressure in and around the lake. This finding are is in line with the findings of Ganai *et al*. (2010).

Toerrin and Walmsley (1974) suggested that 25-30 µg/l of total phosphorus can be regarded as border line for eutrophy. Ganapati (1960) pointed out that the concentration of NO_3–N beyond 0.15 mg/l is an indicative of eutrophication. As per this criterion, Wular lake can be categorized as highly eutrophic. However, despite the increasing cultural influences and input of sewage and other effluents, the concentration of NO_3–N and PO_4–P are lower in Wular lake than other valley lakes and could be attributed to; (i) locking up of the phosphates and nitrates in dense macrophytic vegetation and (ii) that the lake is drained by mighty river Jhelum which greatly reduce the water retention period and as such prevent high accumulation of the nutrients.

Conclusions

Based on the investigation of Phosphate-phosphorus and nitrate-nitrogen, the lake can be classified as hypereutrophic. In addition to river Jhelum, point and non-point sources of pollution, other inflowing streams; fishing and boating activities were also among the major sources responsible for lake water quality deterioration. Interventions should be made to reduce anthropogenic discharges in the lake basin through their diversions; otherwise, high levels of pollution will greatly influence biodiversity directly and indirectly and will invite socio-economic disasters. These results should be considered for future planning in the lake's conservation and management.

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