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**Research Article**

# PHYSICO-CHEMICAL ANALYSIS OF AN URBAN LAKE OF KASHMIR VALLEY

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**ABSTRACT**

The Srinagar city in the past used to have a network of water bodies in the form of lakes, wetlands and streams but due to subversive urbanization and overpopulation the expanse of water bodies has decreased as well as their condition has deteriorated. The present study deals with Khushalsar lake which has reduced in area due to encroachment and water quality has also degraded. The analysis of different physico-chemical parameters showed the nutrient enrichment of the lake to be greater than Dal lake.

**Keywords:** Srinagar, Khushalsar, Encroachment, Physico-chemical parameters, Nutrient enrichment.

## INTRODUCTION

From the very beginning mankind has been curious about the nature and in fact the earliest civilizations emerged near water bodies. Since living near water bodies satisfied almost every basic human need, with this started the overuse and mismanagement of freshwater resource and today it comes out to be burning issue which is affecting millions of people across the world. Global warming, pollution, global rise in freshwater demand, over harvesting of water bodies, has disturbed the functioning of freshwater sources so much that today they have became a limited resource. For long term sustainability of aquatic resources principles of ecosystem science can be incorporated into planning and management of freshwater resources. These ecosystems need to be protected and conserved not only for freshwater but also for invaluable services they provide. It has been observed that those lakes and rivers which support rich diversity of different species are less likely to be altered by human interferences and climate changes. In order to protect and conserve any ecosystem it becomes imperative to understand the various interactions occurring among different variables.

The capital city of Srinagar located within the geographical coordinates of 340 0'N to $34^0$ 15' N latitude and $74^0$ 45' E to $74^0$ 0' E longitude amidst the Kashmir valley is famous for its lakes. The city has been growing at an alarming rate and is thus heavily urbanized. It supports an estimated population figure of 1.6152 million (India population, 2018). Higher the population more intensively the natural resources are used especially freshwater which forms the basis of life on earth. The city in the past used to have a network of water bodies in the form of lakes, wetlands and streams. But unfortunately today about 50% of water bodies of Srinagar city have disappeared (Rashid & Naseem, 2007). The natural vegetation has also considerably decreased over the period of last fifty years (Bhat *et al*., 2012). The reason being urbanization, unplanned expansion of Srinagar city increased demand for fresh water, construction of roads, disposal of solid waste, reduction of catchment area of lakes and wetlands, blocking of inflow or outflow channels of water bodies for construction purposes not to mention about tourism pressures. All these factors jointly have resulted in the deterioration of urban aquatic ecosystems in the valley.

According to Birch & McCaskie (1999) urban lakes provide a number of services and are more vulnerable to changes in water quality due to nutrient enrichment than rural lakes. Besides meeting the demands for drinking water, disposal of sewage, production of food and fodder,

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recreation, they help in maintaining the hydrological balance of the area by regulating the microclimate and retaining water to control floods. Keeping in view all these facts physico-chemical analysis of an urban lake was carried out in order to provide insight into the present condition of the water body.

The ecological science such as limnology got attention by different workers during 17th and 18th century but it was Forel 1901 who for the first time published his preliminary work on Lake Geneva, Switzerland. In India hydrobiological research was well developed in the beginning of this century but due to growing realization of problem of water pollution after independence all kinds of aquatic habitats were investigated intensively. Prasad's work on seasonal conditions governing pond life in Punjab (1916) can be considered as one of the pioneering works on limnology in India. The pioneers of limnology in Kashmir with regards to lake morphometry and succession can be considered the works of (Mukerjee, 1921, 1926).

## MATERIALS AND METHODS

### Description of study area

Khushalsar Lake, this water body is located towards the north west of Srinagar city at a distance of about 8.5 km from city centre, at an elevation of 1589 m.a.s.l having an average depth of 3.0 meters. Once known for its crystal clear waters the lake appears in highly deteriorated state today on visual assessment. It is under immense anthropogenic pressure with surroundings having dense human habitation and vegetable gardens for commercial marketing. The water body stinks during the autumn and winter period causing a number of respiratory problems in people living in the vicinity. The lake water is so much polluted that it sometimes causes many allergic reactions to the skin. The main water body is used for cultivation of Lotus stems (nadroo) by the local people on commercial scale. The marshy area of the lake is a feeding and nesting site for the Moor hens. It has become garbage dumping site for locals and lots of Polythene bags, plastic bottles and other trash material can be seen floating on the lake surface (Table 1).

According to locals this water body in the past occupied the whole area from Aali masjid to Zoonimar but due to illegal Encroachments the main water body of the lake today occupies approximately 647 kanals and the marshy area covers about 949 kanals (Recent updates of LAWDA, 2018). The inlet of lake receives water from Nigeen basin of Dal lake by a channel or nallah dug by an Afghan governor (Amir Khan) known by his name (Nallah Amir Khan) via Gilsar. There is no known source of underground springs feeding this lake till date. The outlet is again a channel which drains its water in Anchar Lake. Another channel (Mar khol) used to connect this lake to Brarinambal lagoon but this channel was filled and converted to a road which is known today by the name of Nallah Mar road thus further deteriorating the condition of this water body. Though relatively small it still has got its own importance by providing livelihood to local people, acting as source of groundwater recharge, feeding, nesting and breeding site for many bird species. The pathetic condition of this lake is highlighted in various local dailies by a number of environmentalists which has urged the Government agencies to take action against landfilling practices taking place at various sites on the banks of this lake. During the present study three sites were selected and these sites differed in their ecological conditions.

**Table 1**. Followed parameters and standard methods.

| S.No. | Parameters | Method |
|---|---|---|
| 1 | Air temperature | APHA,1998 |
| 2 | Water Temperature | APHA,1998 |
| 3 | Transparency | Welch,1948 |
| 4 | pH | Digital pH meter (Model 335 Systronics) |
| 5 | Specific conductivity | Digital Conductivity meter (Systronics DB-104) |
| 6 | Dissolved Oxygen | Modified Winkler's method |
| 7 | Free Carbon Dioxide | Titrimetric method (APHA,1998) |
| 8 | Total Alkalinity | Titrimetric method (APHA,1998) |
| 9 | Chloride | Argentometric method (APHA,1998) |
| 10 | Ammonia | Phenate method (APHA,1998) |
| 11 | Nitrate | Sodium Salicylate method (CSIR,1974) |
| 12 | Nitrite | Sulphanilamide method (APHA,1998) |
| 13 | Total Phosphorus | Stannous Chloride Method (APHA 1998) |

**Figure 1.** Site 1st (K1) this is the site where water from Nigeen (one of the basins of Dal lake) enters Khushalsar via Gilsar. Only few macrophytic associations were found here. On both sides of this channel emergent species of macrophytes like Polygonum, Phragmites and Typha sp could be seen.

**Figure 2.** Site 2nd (K2) this is the open water area of the lake which is mainly used for nadroo cultivation by the locals. Floating leaf type macrophytes like *Nelumbo nucifera*, *Nymphoides peltatum* and submergents like Potamogeton species could be observed.

**Figure 3.** Site 3rd (K3) through this site water leaves the lake and the depth of this site is least of all the sites with few plants of *Lemna* sp floating on the surface.

## RESULTS AND DISCUSSION

The physico-chemical parameters of the water body were studied for a period of twenty two months. The three selected sites showed marked differences in their surroundings while the inlet and outlet can be seen with a lot of garbage on the banks, the site in the middle of the lake is used for cultivating lotus plants. The inlet and the outlet have less depth as compared to the central site. All the three sites were visited monthly and thirteen physico-chemical parameters were analysed. Global warming is affecting flora and fauna worldwide either directly or indirectly. Since water has relatively high specific heat or heat capacity due to which it can maintain more even temperature. Water temperature is a critical component which can affect all the biochemical processes of any aquatic system Slight increase in water temperature can alter ecological functioning and geographical distribution of various aquatic species (Table 2 and 3). Some aquatic species show alteration in behavioural characteristics with inconsiderable change in water temperature. Species composition and ecosystem productivity can also be altered by changes in seasonal pattern of precipitation which affects the hydrological characteristics of a water body. During the investigation period water temperature was found to follow the air temperature. Average water temperature didn't show significant variation among different sites during the whole study period.

Water transparency determines the depth to which the sunlight can reach and aid in the process of photosynthesis. It shows seasonal variations as well as varies among different kinds of freshwater sources. In general lakes have more transparent waters than rivers since the latter carries lot of eroded material and therefore the water appears muddy. Sediments from surrounding land especially the area which has low vegetation cover and agricultural fields, are brought in high quantity during the rainy season in lakes. Plankton or any kind of minute biota, detritus and a number of salts reduce the transparency of water body. It was found to be low at all the three sites but the overall average was higher at site 2 as compared to the other two. This may be due to the rich growth of macrophysics both submerged and floating leaf type, which provide surface for the settling down of different kinds of suspended materials at this site. (Falås, 2007) was also of the same view. pH of any water body depends on the eroded and waste material which it receives from the surroundings besides the bedrock of that region. (Verma *et al*., 2006) specified that a number of biochemical processes in the water body are controlled by pH. It even controls the chemical state of certain dissolved gases, likewise phosphorus and nitrates (Beutel *et al*., 2001).The pH of the three sites was always on alkaline side but value as low as 7.4 was also observed at site 3 in January (2013). Usually low pH values were observed during winter period which tended to increase towards summer season. The increase in pH value during summer may be attributed to high photosynthetic activity of phytoplankton and aquatic vegetation in which CO2 molecule is taken up (Table 4 and 5).

**Table 2**. Physico-chemical parameters at site 1st (K1) during 2012-2013.

| PC Parameter | Range | Average | S.D. |
|---|---|---|---|
| Air Temperature ($^{o}$C) | 4.5-32 | 17.4 | 10.1 |
| Water Temperature ($^{O}$C) | 2.1-26.8 | 13.8 | 9.1 |
| Transparency (m) | 0.23-1.1 | 0.53 | 0.23 |
| pH (units) | 7.9-8.3 | 8.0 | 0.1 |
| Specific conductivity (µS/cm) | 342.5-441 | 397.3 | 32.3 |
| Dissolved Oxygen (mg/l) | 5.2-8.5 | 7.3 | 0.7 |
| Free $CO_2$ (mg/l) | 13.4-25.2 | 20.5 | 3.6 |
| Total Alkalinity (mg/l) | 205.6-344 | 285.6 | 39.7 |
| Total Chloride (mg/l) | 23.6-47.2 | 31.8 | 7.5 |
| Ammonia (µg/l) | 132.3-388.6 | 323.5 | 72.8 |
| Nitrate (µg/l) | 323.9-445.7 | 400 | 46.6 |
| Nitrite (µg/l) | 14.8-45 | 34.8 | 8.6 |
| Total Phosphorus (µg/l) | 432.7-574.5 | 510.7 | 44.7 |

**Table 3**. Physico-chemical parameters at site 1st (K1) during 2013-2014.

| PC Parameter | Range | Average | S.D. |
|---|---|---|---|
| Air Temperature ($^{o}$C) | 4.8-30.3 | 16.8 | 10.1 |
| Water Temperature ($^{O}$C) | 2.1-27.5 | 12.8 | 10.0 |
| Transparency (m) | 0.31-1.0 | 0.61 | 0.26 |
| pH (units) | 7.7-8.6 | 8.3 | 0.3 |
| Specific conductivity (µS/cm) | 316-426 | 370.3 | 40.1 |
| Dissolved Oxygen (mg/l) | 6.4-8.5 | 7.9 | 0.6 |
| Free $CO_2$ (mg/l) | 14.2-25.8 | 22.0 | 4.1 |
| Total Alkalinity(mg/l) | 208.5-348.5 | 273.9 | 50.2 |
| Total Chloride (mg/l) | 23.4-42 | 32.5 | 6.4 |
| Ammonia (µg/l) | 294.5-384.5 | 336.7 | 25.2 |
| Nitrate (µg/l) | 378.9-456.8 | 433.0 | 27.1 |
| Nitrite (µg/l) | 24-46.8 | 38.6 | 8.3 |
| Total Phosphorus (µg/l) | 438.7-578.7 | 524.1 | 37.9 |

**Table 4.** Physico chemical Parameters at Site 2nd (K2) during 2012-2013.

| PC Parameter | Range | Average | S.D. |
|---|---|---|---|
| Air Temperature ($^{o}$C) | 5-32 | 17.5 | 10.0 |
| Water Temperature ($^{O}$C) | 2.2-27.1 | 14.2 | 9.4 |
| Transparency (m) | 0.3-1.3 | 0.60 | 0.34 |
| pH (units) | 7.5-9.1 | 8.1 | 0.4 |
| Specific Conductivity (µS/cm) | 326.4-444 | 388.7 | 447.0 |
| Dissolved Oxygen (mg/l) | 6.3-8.5 | 7.3 | 0.8 |
| Free $CO_2$ (mg/l) | 14.4-28 | 23.2 | 3.8 |
| Total Alkalinity (mg/l) | 192-322.1 | 285.6 | 39.7 |
| Total Chloride (mg/l) | 23-47 | 34.4 | 6.5 |
| Ammonia (µg/l) | 218-382.4 | 317.3 | 51.8 |
| Nitrate (µg/l) | 312.4-436.5 | 371.0 | 48.0 |
| Nitrite (µg/l) | 18-48.4 | 33.8 | 10.2 |
| Total Phosphorus (µg/l) | 440.5-602.5 | 531.7 | 45.9 |

**Table 5** . Physicochemical Parameters at Site 2nd (K2) during 2013-2014.

| PC Parameter | Range | Average | S.D. |
|---|---|---|---|
| Air Temperature($^{o}$C) | 4.6-30.4 | 16.7 | 10.4 |
| Water Temperature($^{O}$C) | 2-27 | 12.6 | 9.9 |
| Transparency (m) | 0.56-1.2 | 0.93 | 0.22 |
| pH (units) | 7.9-9.1 | 8.6 | 0.4 |
| Specific Conductivity (µS/cm) | 322-452 | 396.6 | 39.0 |
| Dissolved Oxygen (mg/l) | 5.2-9.2 | 7.3 | 1.2 |
| Free $CO_2$ (mg/l) | 19.5-31.5 | 24 | 3.9 |
| Total Alkalinity (mg/l) | 208.6-364 | 258.8 | 80.7 |
| Total Chloride (mg/l) | 24-43 | 29.8 | 6.2 |
| Ammonia (µg/l) | 296.5364.8 | 315.4 | 34.7 |
| Nitrate (µg/l) | 321.5-442.8 | 383.9 | 43.2 |
| Nitrite (µg/l) | 25-48 | 35.7 | 7.8 |
| Total Phosphorus (µg/l) | 458.6-564.8 | 523.4 | 39.2 |

**Table 6**. Physico chemical Parameters at Site 3rd (K3) during 2012-2013.

| PC Parameter | Range | Average | S.D. |
|---|---|---|---|
| Air Temperature($^{o}$C) | 4.6-32.9 | 17.6 | 9.8 |
| Water Temperature($^{O}$C) | 2-26.5 | 13.9 | 9.3 |
| Transparency (m) | 0.21-0.80 | 0.43 | 0.17 |
| pH (units) | 7.4-8.4 | 7.9 | 0.2 |
| Specific Conductivity (µS/cm) | 345-448 | 399.4 | 41.7 |
| Dissolved Oxygen (mg/l) | 5-8.9 | 6.3 | 1.3 |
| Free $CO_2$(mg/l) | 19.5-28.5 | 24.1 | 2.8 |
| Total Alkalinity (mg/l) | 234-364.5 | 287.9.2 | 43.7 |
| Total Chloride (mg/l) | 25-46 | 34.4 | 7.6 |
| Ammonia (µg/l) | 312-385 | 334.4 | 26.3 |
| Nitrate (µg/l) | 328.9-445.6 | 394.3 | 42.8 |
| Nitrite(µg/l) | 30-46 | 39.7 | 5.4 |
| Total Phosphorus(µg/l) | 414.6-665 | 522.9 | 70.1 |

**Table 7**. Physico chemical parameter at site 3rd (K3) during 2013-2014.

| Pc Parameter | Range | Average | S.D. |
|---|---|---|---|
| Air Temperature($^{o}$C) | 4.8-30.2 | 17.0 | 10.4 |
| Water Temperature($^{O}$C) | 2-28 | 12.9 | 10.2 |
| Transparency (m) | 0.31-0.99 | 0.59 | 0.22 |
| pH (units) | 8-8.8 | 8.3 | 0.2 |
| Specific Conductivity (µS/cm) | 332.6-468.8 | 419 | 49.8 |
| Dissolved Oxygen (mg/l) | 5.3-8.2 | 6.9 | 1.0 |
| Free $CO_2$ (mg/l) | 22-30.3 | 26.4 | 2.7 |
| Total Alkalinity (mg/l) | 172.6-350.4 | 281.0 | 56.2 |
| Total Chloride (mg/l) | 22-46.2 | 33.6 | 8.2 |
| Ammonia (µg/l) | 231.7-384 | 315.4 | 34.7 |
| Nitrate (µg/l) | 324.5-460.6 | 421.8 | 42.8 |
| Nitrite (µg/l) | 26.6-43.7 | 35.2 | 6.4 |
| Total Phosphorus (µg/l) | 502.7-645.8 | 545.8 | 52.1 |

The dissolved oxygen concentration is maintained by photosynthetic activity of aquatic plants and respiration of both plants and animals in any lake. Its concentration showed decrease towards the autumn season when it reached the lowest of 5.0 mg/l in October (2013).Spring season was marked with highest dissolved oxygen content of 9.2 mg/l in March 2014. The high DO content in spring may be due to dilution of water body with water coming from Dal lake which has comparatively (seasonal comparison) higher levels of water in spring. The Dal lake itself receives snow melt water in spring which on mixing with the water of Khushalsar enhances its capacity to dissolve more oxygen due to the decreased water temperature. The abundance of free carbon dioxide exerts certain specific effects on aquatic biota. The average free $CO_2$ content was high at site K3 (26.4 mg/L) in 2014 which is the outlet of the lake. During the summer months free $CO_2$ was low at all the sites which may be due to the utilization of this molecule in the process of photosynthesis by phytoplankton and macrophytes. Winter and autumn season showed the highest values which may be attributed to the decomposition process going on in the depths of this water body. The stink from Anchar Lake and the water body under study becomes very troublesome for the locals during these seasons causing serious respiratory ailments, nausea, headache etc.

Alkalinity is important for aquatic life as it considered as a buffering agent against pH changes (Capkin *et al*., 2006). Aquatic organisms need a certain optimum range of pH in which they can thrive well. Alkalinity resists the spatio-temporal changes in pH so as to stabilize the aquatic environment. Total Alkalinity was found to be high in winter season which gradually started to decrease towards the other seasons. The monthly average value was highest at K3 (287.9 ± 43.7 mg/L) in 2012-2013 while as the lowest value was obtained at site K2 (255.8 ± 45.4 mg/L) again in 2012-2013. Chloride is the one of the most important anions in water bodies. Small concentration of this ion is necessary for the growth and development of aquatic organisms. It originates from the dissociation of certain salts such as calcium and magnesium chlorides in the water column. But the increase in freshwaters worldwide is attributed to human caused factors, the main among them being the sewage contamination. Some workers concluded that crustaceans are more sensitive to high chloride concentrations than fish (Evans & Frick, 2001). Hale & Groffman (2006) while working on forested and suburban stream debris dams found that high chloride concentration interferes with the processes by which bacteria breakdown nitrogen. The highest monthly average chloride content of 34.4 mg/L was observed at sites K2 and K3 (2012-2013). However during the second year of study chloride concentration was slightly lower than first year. This may be due to frequent rainfall during the second year which could have led to decrease in the chloride concentration (Table 6 and 7).

The lake is highly enriched with nutrients i.e., ammonia, nitrate, nitrite and phosphorus etc. The surface leaching of these ions from the surrounding area into the water body may be the cause, since fertilizers are used in the cultivation of vegetables in and around the lake. Not only allocthonous but autochthonous beneficiation of nutrients leads to their high concentration in the water body. Fish excrete mostly ammonia and urea although in small concentrations, being the byproducts of protein biosynthesis. Ammonia is then taken up by algae and other forms of plant life. Urea get hydrolysed in ammonia and carbon dioxide. Some of this ammonia is rapidly oxidized to nitrates and nitrites. The mean ammonical-nitrogen concentration in the water body during the first year was obtained as 325.9 ±10 µg/L and in the second year it was 320.4 ± 14.4 µg/L. No well marked seasonal variations were observed.

Nitrate-nitrogen in the water body is due to the use of nitrogen rich fertilizers on the surrounding land which enter the lake by the process of leaching and surface run off including the municipal sewage and decaying plant and other debris at the bottom. The highest monthly average was obtained at K1 (433.0±27.1 µg/L) in 2013-2014. The inlet receives water from Dal lake via Gilsar, both of them are progressively atrophying, therefore conditions in the receiving water body become still worse. However annual mean showed increase during the second year. Nitrites have very less residence time in water and therefore occur naturally in a very low concentration. The highest monthly mean of 39.7 µg/L was obtained at site K3 in 2012-2013. Total phosphorus concentration in the lake depicts the trophic status of the water body. Although phosphorus is utilized in living systems in small quantities but it is excessively used in fertilizers without taking into consideration the requirement of the crop under cultivation. If the farming practices are done keeping in view the sustainable development and according to scientific lines nutrient enrichment of water bodies can be controlled under such circumstances. It was highest (monthly average value) 545.8 ± 52.1 µg/L at the outlet (K3) of the lake in 2013-2014. However the overall average value of the water body was highest in the second year for which surface runoff from the surrounding area can be considered the reason due to the frequent rainfall during that period.

## CONCLUSION

Physico-chemical analysis of water revealed comparatively higher chlorides, nitrates, nitrites and total phosphorus than Dal lake. After going through the literature it is concluded that only sporadic studies have been conducted on this water body. For the restoration of this lake it is therefore suggested that frequent analysis of physico-chemical parameters and biotic communities is required. Fertilizers application should be carried out in accordance with the needs and demands of soil and crop under cultivation, so that lake does not get excess nutrients from the surrounding vegetable gardens. Construction around the lake should be restricted. Moreover the natural inlets and outlets of the lake should be made functional again so that proper flushing and dilution of the lake takes place. People should be discouraged to throw garbage directly into the lake by imposing fines. Government agencies and people should

work in coordination with each other in order to protect this natural asset.

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