



## STATISTICAL REVIEW ON CHANGE IN WATER QUALITIES OF DAL LAKE

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### Abstract

The issues with sewage disposal and surface water contamination are getting worse quickly due to urbanization, modernization, and a rise in population in Dal Lake. The water quality of Dal Lake has drastically changed over the past 40 years, making it unusable for home usage and aesthetic purposes. A lake's land usage might be expanded, which could result in a rise in fertilizer consumption and the eutrophication issue. The paper makes an effort to describe the lake's water quality situation. Several metrics, such as PH, nitrate, calcium, alkalinity and chloride have been used to evaluate the quality of water. The findings of the study have revealed that weeds cover the majority of lake water surfaces as a result of increasing nitrate and phosphorus concentrations, which cause siltation of lake water. Lower levels of dissolved oxygen in the lake water as a result of greater BOD and COD values directly endanger the lake ecosystem. Heavy metals including lead, chromium, iron, and mercury, among others, are particularly dangerous because they contaminate water or induce chronic poisoning in aquatic species. Across the world, harmful algal blooms are growing more frequent in freshwater environments. Plastic scrap pollution of water bodies, which impacts open water, shorelines, and habitats, is a growing environmental problem.

**Keywords:** Aesthetic, Contamination, Pollution, Sewage, Urbanization

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## 1. Introduction

Water holds the prime position to stand the survival of human existence. Not only water, but the water bodies including lakes and rivers also hold greatest recreational value in the economic perspective. These water bodies are vital in terms of maintaining ecological balance that provide habitat to the aquatic flora and fauna. Any unwarranted episode including unplanned urbanization, industrialization and illegal encroachment of these water bodies affects their ecology and sustainability into the negative mode (Singh *et al.*, 2002). The cited factors have inherent potential to negatively affect the quality of water and make it unfit for human consumption and marine life. The seasonal changes in precipitation, surface runoff, groundwater flow, interception, and abstraction have a significant impact on lake volume, which in turn affects the amount of contaminants present in a body of water.

Furthermore, the surface water quality is largely affected by human inducted activities, including air pollution, effluent discharges, and use of agricultural chemicals, degraded soils, and injudicious land use. Dal Lake, has witnessed extreme loss in water quality during the last four decades because of environment changes by people directly and indirectly (Kumar *et al.*, 2022). In the above context, the Kashmir valley, in India is known for its scenic view including rivers, high altitude grass lands, snow clad mountains and fresh water lakes. The picturesque view of Kashmir valley is scattered uniformly in rural and urban habitations. Dal Lake is one of the urban lakes that hold greatest importance in the tourism profile of Jammu and Kashmir. The Dal Lake offers a wide array of scenic view under the shadow of *Zabarwan Hills* and Green lush meadows. However, there are certain inherent factors that have altered the ecological balance of Dal Lake. The emerging challenges include encroachment, contamination and degradation. The 18<sup>th</sup> and 19<sup>th</sup> centuries human induced growth of Srinagar city towards the Dal Lake have radically far reaching consequences upon its water quality and surrounding (Abu-Bakr & Kundangar,

2005). Therefore, to manage these aquatic resources sustainably, monitoring and planned changes are crucial.

In the above background, the present study has been undertaken to delve deep into the water quality of Dal Lake. Moreover, the analysis of water quality in terms of PH, alkalinity, calcium, chlorine and nitrate has been presented under the appropriate themes. Additionally, the impact of deteriorating water quality upon humans and other aquatic life has been presented followed by the scope of study.

## 2. Research Methodology of the Study

To quantify the stated objectives of study, it becomes important to adopt the appropriate research methodology. The present study is an exploration into the water quality of Dal Lake in the heart of Srinagar city of Jammu and Kashmir. The study has adopted qualitative approach and analytical cum descriptive research technique to garner greater insights into the subject matter. The study is based on secondary data. The methods employed to generate long-term information about the changes in the water quality within and in the vicinity of the lake made use of data from various secondary sources including pieces of literature, research articles, and newspaper publications. Primarily a set of ten research journals have been selected to draw the precise inferences with respect to PH, alkalinity, calcium, chlorine and nitrate content in the Dal Lake water. All the subject matter has been presented under appropriate themes subjected to coherency and synchronization.

## 3. Review of Literature

The present section will explore the review of previous ten studies under which five parameters including Ph, Alkalinity, Calcium, Chloride, and Nitrate will be explored and analyzed in systematic approach. Before delving deep into the subject matter, it is important to know the normal ranges of these parameters for drawing the precise inferences. The normal ranges are presented in below table.

**Table 1: Normal Range of Water Contents**

Content	Normal Range	Impact on Water
PH	6.5-8.5	High pH causes bitter water taste and depresses effectiveness of disinfection of chlorine.
Alkalinity	20-200 mg/L	Increase in Alkalinity prevents pH changes that are harmful to aquatic life.
Calcium	1-35 mg/L	Higher calcium content makes water unfit for consumption, therefore frequent urination.
Chloride	4 mg/L	High chloride content gives salt taste to water and affects sewage pipelines.
Nitrate	10 mg/L	High nitrate causes nitrate poisoning among living creatures and blue coloration of skin.

Table 1 presents an exploration into the five principle parameters that will be analyzed under appropriate themes. The water quality of Dal Lake will be analyzed on the basis of analysis of five major factors including pH, alkalinity, calcium, chloride and nitrate contents. The stated

parameters will be analyzed by comparing the values with normal parameters as presented in subsequent tables. The comparative analysis between the normal value will define the water quality of Dal Lake.

**Table 2: Observations from Review of Literature**

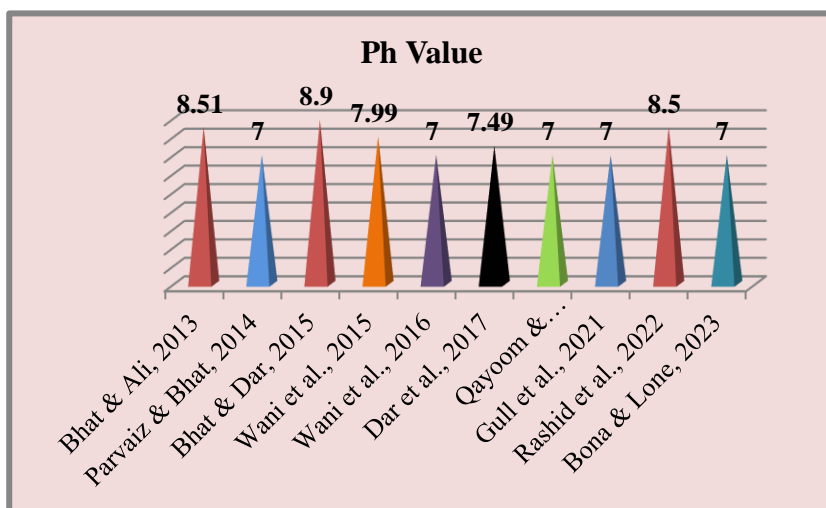
Study	Observations
Bhat & Ali, 2013	Spatial and Monthly Variations in salinity, but higher values lie near houseboats in Dal Lake.
Parvaiz & Bhat, 2014	Water quality varies from basin to basin in Dal Lake
Bhat & Dar, 2015	Seasonal variations in water quality, but Nehru Park is more vulnerable to water pollution
Wani et al., 2015	Using Pearson's chi square test to ascertain co-relation: Water pollution is major problem
Wani et al., 2016	Using Arithmetic Index, It was observed that Water is unfit for human consumption
Dar et al., 2017	Higher quantity of Nitrates, Phosphorus and other constituents
Qayoom & Tanveer, 2018	Geology and Anthropogenic activities are prime reasons for deteriorated water quality
Gull et al., 2021	Urbanization and Anthropogenic Activities are responsible for low transparency & higher concentration of nutrients
Rashid et al., 2022	Higher Phosphorus concentration leads to larger presence of weeds
Bona & Lone, 2023	There is influence of spatiotemporal & environmental factors on poor water quality

The five most important parameters that were observed in the study include pH, alkalinity, calcium, chloride and nitrate level. The prime observations of the study have revealed that Dal Lake is fully loaded with unwarranted and excessive nitrate, chloride and calcium content. Majority of the excessive inflow of these contents drains from the Srinagar city that affects the water quality and ecosystem thereby. The excessive presence of nitrates and phosphates has paved way for excessive Azolla that cover majority of Dal Lake and causes eutrophication. Higher concentration of BOD directly hampers the growth of aquatic life. Due to the lake's high turbidity, there are visible colour changes, odours, and a resistance to light penetration that prevents additional dissolved oxygen from being produced through photosynthesis. Either directly or indirectly, the turbidity poses a greatest hazard to the ecosystem of the Dal Lake.

By using GIS, we can quickly and easily visualize the effects of different parameters and their concentration effects across catchments of Dal Lake. Nearly all of Dal Lake's basins exhibit the same characteristics, and according to the aforementioned figures, every basin is severely polluted with nitrate and phosphate. Furthermore the review has stated that water quality of Dal Lake is significantly deteriorated since last four decades. PH, alkalinity, calcium and chloride have witnessed an upward trend that poses the greatest challenge to the aquatic ecosystem. Presence of excessive CO<sub>2</sub> product as an outcome of decomposition process mixing with sewage and residential waste amplified the alkalinity levels during summer peak. The huge amount of run-off, arising pollution from tourism and unplanned sewage disposal has largely affected the water quality of Dal Lake (Bhat & Dar, 2015).

**Table 3: PH Value of Dal Lake Water Using PH Meter**

Study	Ph Value
Bhat & Ali, 2013	8.51
Parvaiz & Bhat, 2014	6.8-8.5
Bhat & Dar, 2015	7-8.9
Wani et al., 2015	7.99
Wani et al., 2016	6.5-8.5
Dar et al., 2017	7.49
Qayoom & Tanveer, 2018	6.5-8.5
Gull et al., 2021	6.2-8.1
Rashid et al., 2022	8.5
Bona & Lone, 2023	6.71-8.18



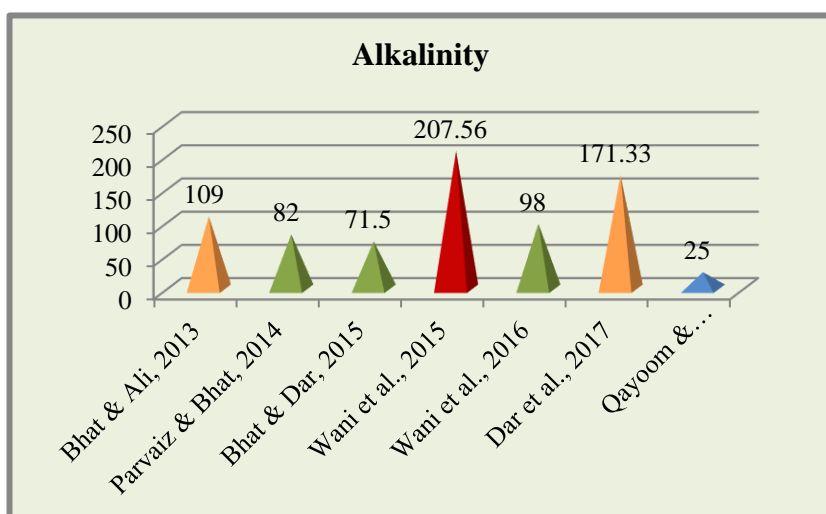
**Figure 1:** PH Value of Dal Lake Water Using PH Meter

PH is known as “potential of hydrogen” is a scale that that specifies the acidity and basicity of an alkaline solution. The pH scale ranges from 0-14 where 0 represents very acidic, 14 as very basic and 7 as neutral. Water is termed as a neutral aqueous solution having pH value of 7. It is normal for water to have a range between 6.5 and 8.5 as its fluctuations are inherently affected by environmental and other socio-economic factors. In the background of above data, the statistics have revealed that pH level of Dal lake water greatly varies from 6.5-8.5. Therefore, the pH

level normally lies within the framework of neutral aspect. In few studies, the pH value of Water in Dal Lake is about 8 and the lake's water is mostly alkaline. However, the variations among the ten noted readings depict that minor changes in temperature, air, seasonal effect and human induced factors are prime reasons for pH fluctuations of Dal lake water. Even the pH fluctuations are being by day/night temperature and summer/winter temperature variations.

**Table 4:** Alkalinity Value of Dal Lake Water Using Titrimetric Method

Study	Alkalinity
Bhat & Ali, 2013	109
Parvaiz & Bhat, 2014	82
Bhat & Dar, 2015	71.5-96.9
Wani et al., 2015	207.56
Wani et al., 2016	98-180
Dar et al., 2017	171.33
Qayoom & Tanveer, 2018	25-313



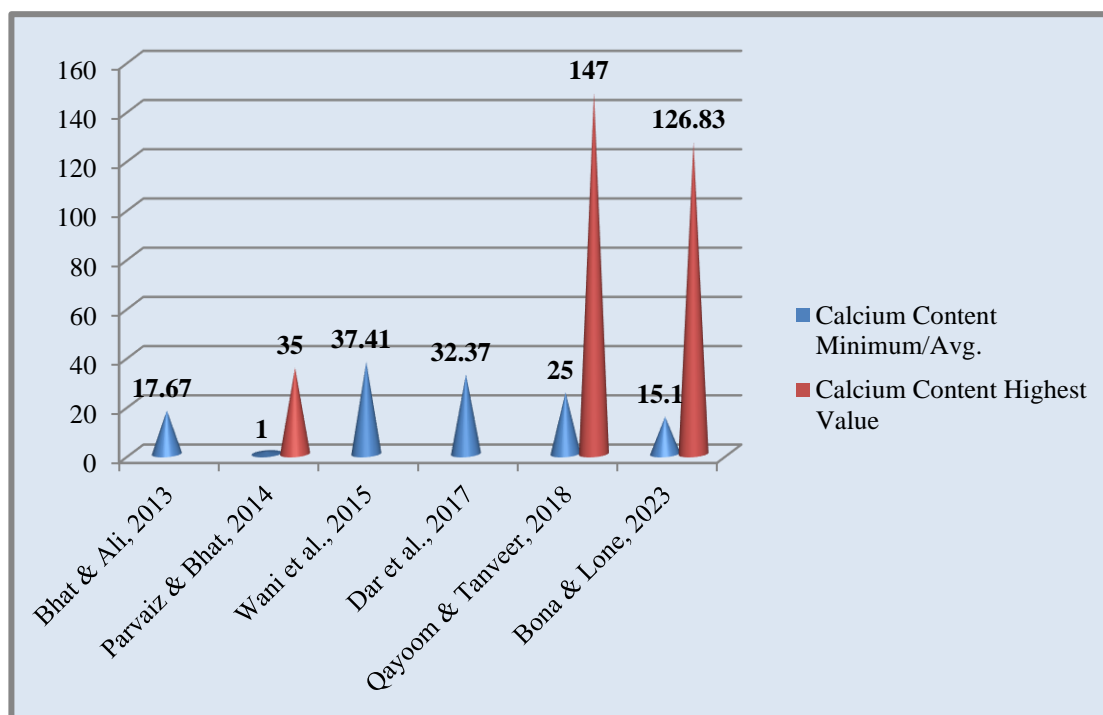
**Figure 2:** Alkalinity Value of Dal Lake Water Using Titrimetric Method

Alkalinity is the water's capacity to resist changes in pH that would make the water more acidic. In other words, alkalinity is the capability of water to neutralize the acid. The average alkalinity that should be in our water is 20-200 mg/L. The average total alkalinity is 116.16 mg/L, indicating that the lake's moderate to high alkalinity has a good buffering capability. While as the total alkalinity values vary from 60 to 230 mg/L (Wurts and Durborow, 1992). A high quantum of alkalinity is generally termed as good in drinking water as it keeps the water safe for drinking. In

this background, out of ten reviews, eight have shown that alkalinity of Dal lake water ranges from 25 to 207. There is variation in range of alkalinity in terms of habitations in north/south and east/west side of Dal Lake. There is no uniformity in alkalinity in Dal Lake water across seasons or geographical locations. Therefore, the alkalinity of Dal lake water is quite impressive; however, there are other contents that have negatively affected the water quality and make it unfit for human consumption at large.

**Table 4:** Calcium Content Value of Dal Lake Water Using EDTA Titatmetric Method

Study	Calcium
Bhat & Ali, 2013	17.67
Parvaiz & Bhat, 2014	Normal: 1-35mh/L
Wani et al., 2015	37.41
Dar et al., 2017	32.37
Qayoom & Tanveer, 2018	25-147
Bona & Lone, 2023	15.1-126.83



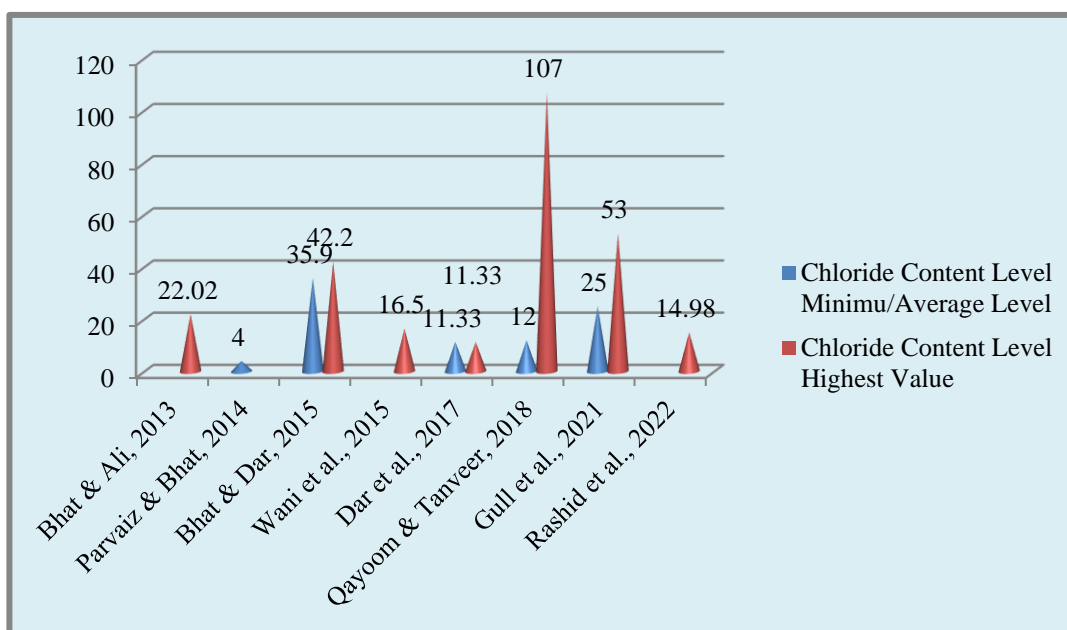
**Figure 3:** Calcium Content Value of Dal Lake Water Using EDTA Titatmetric Method

The calcium concentration of water greatly varies from 1 to 35 mg/L across USA and other northern hemisphere countries. A good amount of calcium makes kidneys work harder to filter it. Excessive calcium content causes excessive thirst and frequent urination. Calcium is integral part of metabolism and physical process of all living creatures. Typical lake water contains 4 to 100 mg/L calcium content. In this framework, the review has suggested that calcium content in Dal

Lake greatly varies from 15.1 to 147 mg/L. The calculated average of the calcium content from selected studies has been attributed at 31.88 mg/L. In this background, it can be inferred that calcium content in Dal Lake lies at average level, however certain studies have suggested that there is excessive calcium content in Dal Lake that affects the aquatic life and water quality thereby.

**Table 6:** Chloride Content Level of Dal Lake Water Using Argentometric Method

Study	Chloride
Bhat & Ali, 2013	22.02
Parvaiz & Bhat, 2014	Normal
Bhat & Dar, 2015	35.9-42.2
Wani et al., 2015	16.5
Dar et al., 2017	11.33
Qayoom & Tanveer, 2018	12-107
Gull et al., 2021	23-53
Rashid et al., 2022	14.98



**Figure 4:** Chloride Content Level of Dal Lake Water Using Argentometric Method

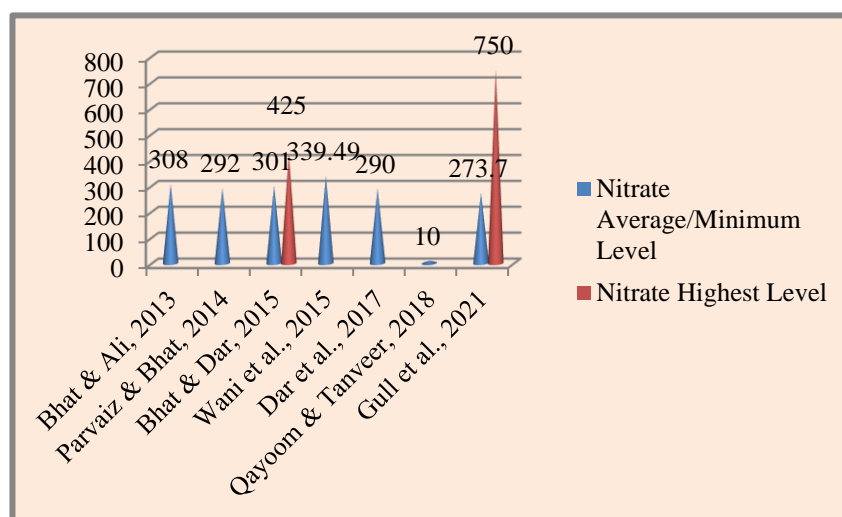
Excessive chloride ions impart a salty taste in the drinking water and its presence serves as an indicator of sewage pollution in the water. In the present study the chloride range was found between 12 to 107 mg/L in Dal Lake. According to the set of standard value system, the permissible chlorine content in drinking water should be 4 mg/L; however the mean value of the chloride in Dal Lake water is 19.40 mg/L that signifies the water is not safe for human

consumption and aquatic survival. The review has further stated that Hazratbal and Nigeen basins have significant levels of chloride ions, that is the clear demarcation of the human induced pressure brought by human activities. As the lake's deepest basin, the Nigeen's high chloride contents are explained by the basin's considerably longer water retention time (Trisal and Kaul, 1983).

**Table 7:** Nitrate Value of Dal Lake Water using Spectrophotometric Method

Study	Nitrate
Bhat & Ali, 2013	308
Parvaiz & Bhat, 2014	292
Bhat & Dar, 2015	301-425
Wani et al., 2015	339.49
Dar et al., 2017	290
Qayoom & Tanveer, 2018	<Normal
Gull et al., 2021	273.7-750





**Figure 5:** Nitrate Value of Dal Lake Water using Spectrophotometric Method

Nitrates are termed as essential plant nutrients; but excessive presence causes significant water quality problems. The excessive presence of nitrates and phosphorus causes eutrophication that significantly causes dramatic increase in aquatic plant growth and changes in types of plants and animals that live there. High nitrate level can be an outcome of runoff or leakage from fertilized soil, waster water, septic system or urban drainage. The United States Environmental Protection Agency (EPA) has marked 10 mg/L nitrate as permissible in drinking water. However, the review has suggested that nitrate level in Dal Lake water varies from 273-750 mg/L. The excessive presence of nitrates affect the aquatic species and makes the water unfit for human consumption. Moreover, the abundant presence of Ortho-phosphate phosphorus and nitrate nitrogen are clear signs of human activity (Turner *et al.*, 2003). The lake's nitrate nitrogen values range from 200 to 750 mg/L, with the interior of the lake and areas of the Nigeen and Gagribal basins having the highest concentrations due to their proximity to populated areas. On the other hand, the Nishat and Hazratbal basins displayed low levels of nitrate nitrogen (Mushtaq *et al.*, 2013).

#### 4. Significance of the Study

The water bodies hold greater importance in terms of economy and tourism in the Kashmir valley. Water bodies such as fresh water rivers, springs and lakes have inherent aesthetic and recreational value in the socio-economic setting of Kashmir region. Therefore, it becomes imperative to add value, protect and promote the water bodies in Kashmir. Dal Lake being at the centre of Srinagar city also holds the greater importance in terms of ecological balance and tourism. However, there are certain intrinsic factors that have negatively affected the water quality of Dal Lake. In this

context, the present study holds greater importance to suggest ways and means for value recreation and water conservation of Dal Lake. The study will call for awareness among the local populace for the protection of Dal Lake and the water thereby. Additionally, the suggested means for improving the water quality will guide the policy measures in the positive orientation. Systematic exploration of subject matter will guide the future researchers to take a lead into the concerned field. Moreover, the study will act as a reference point for researchers to garner the in-depth exploration into the subject matter. Lastly, the study has explored various challenges associated with water quality and suggested the reforms thereby.

#### 5. Conclusion

The survey of literature has presented an opportunity to garner an exploration into the water quality of Dal Lake. The review has indicated that water quality of Dal Lake is declining rapidly. The increase in pollution and human induced pollutants has increased BOD in a given lake region that minimizes dissolved oxygen in water and affects aquatic species. Unmatched pH level and interrupted alkalinity has negatively affected the quality of water at large. In this context, following measures could be a reformative cum innovative measure/s to protect and maintain the recreational and ecological value of Dal Lake and the water quality thereby:

- Systematic and appropriate urban planning for disposal of garbage and other waste.
- Need specific plan for revitalization, ecosystem survival and ecological balance.
- Public private partnership and holistic approach for water management.
- Adjacent basin/s should be prevented from draining waste into the Dal Lake water.

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