

A REVIEW OF THE BACTERIAL CONTAMINATION OF HIGH-ALTITUDE DAL LAKE, KASHMIR

MONISA MALIK¹, ADNAN ABUBAKR², SAMREEN ISAQ³,
ADNAN AMIN¹ AND IMTIYAZ QAYOOM⁴

Division of AEM, Faculty of Fisheries, SKUAST-K, J&K., India

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Abstract—A study was conducted to determine the bacterial load of Dal Lake, Kashmir over a period of 7 years to understand the changes in the contamination levels due to anthropogenic or natural factors. Lake showed a considerable increase in viable bacterial counts when compared with previous data suggesting deterioration in water quality over the years. Dalgate area of the Lake recorded maximum increase in bacterial load of about 7.1 cfu log₁₀ /ml in 2017-18. Heavy tourist influx leading to greater pollution was suggested to be a major cause of the increased bacterial load, thereby leading to incidence and risk from water borne diseases.

INTRODUCTION

Dal Lake is an urban lake situated in the heart of the Srinagar city of union territory of Jammu and Kashmir. It is a scenic and fascinating site which forms a major tourist attraction for the city of Srinagar. The lake has been named variously due to its beauty like “Lake of Flowers”, “Srinagar’s jewel” and “Jewel in the crown of Kashmir”. The beauty of this lake is further enhanced by a magnificent Mughal Garden on its opposite side, inviting people from all over the world to visit this pristine site.

Dal Lake is among the most famous water bodies of the Kashmir valley, providing portable water, fish, vegetable foods and fodder besides recreation. The lake lies at 1584 m ASL and has a catchment area of 316 km² (Qadri and Yousuf, 2008). This urban lake is the second largest freshwater lake in the state of Jammu and Kashmir. The geographical position of the lake is about 34°07’N Latitude and 74°52’E Longitude, with an average altitude of 1584 m ASL, catchment area of 316 km² and a maximum depth of 5.4m. The lake covers an area of 11.4 sq. kms and comprises of four basins namely Bod-Dal, Lokut-Dal, Nigeen and Gagribal (Qadri and Yousuf, 2008).

Dal Lake is surrounded by densely populated human establishments which are at higher levels than the Dal body. Besides, large number of house

boats are also floating in Dal with good number of inhabitants and tourists. The Dal is used for a number of economic activities related to tourism, sightseeing, recreation, fisheries, harvesting of food and fodder plants, and irrigation of vegetable fields which have grown in number and extent in recent years. The lake’s floating gardens on rafts make it one of the valley’s biggest vegetable producing areas (Malik *et al.*, 2017). These activities along with the day-to-day actions of locals like washing of clothes, use of fertilizers in the floating gardens, direct discharge of waste from households into the lake have proven to be the reason for proliferation of microbes in excessive numbers. Further, the increase in cultural eutrophication of Dal Lake over the years has only worsened the state of its water. The increase in numbers of the harmful microbes along with excessive enrichment of lake water can cause diseases in aquatic organism as well as humans who are directly or indirectly associated with it.

Due to ecological stress from human activities the lake system is not only shrinking in surface area but its water quality has also deteriorated as large quantity of untreated sewage and garbage are received by the lake from human settlements as well as business settlements (Saleem *et al.*, 2011). In order to get an idea about the present state of the contamination in Dal Lake, a study was conducted

using bacterial populations as the indicators of organic load. Bacteria have been considered as reliable indicators of contamination time and again by various scientists (Saleem *et al.*, 2011, Malik *et al.*, 2017) because of their ability to respond quickly to any change in the environmental conditions. The main objective of the study was to compare the bacterial population levels at different sites of Dal Lake over a period of 7 years so as to get an understanding of contamination especially via organic pollution.

MATERIALS AND METHODS

A total of three sites were studied for comparing the level of bacterial contamination. These sites were:

- The inlet station where the canals and streams open into the Dal lake at Telbal,
- The main body of the lake i.e. Hazratbal
- The outlet station where the excess Dal water is flooded into the river Jhelum at Dalgate.

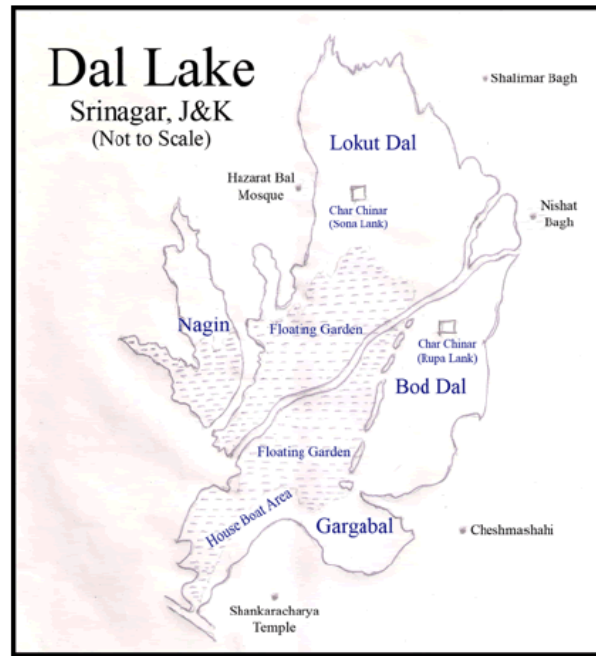
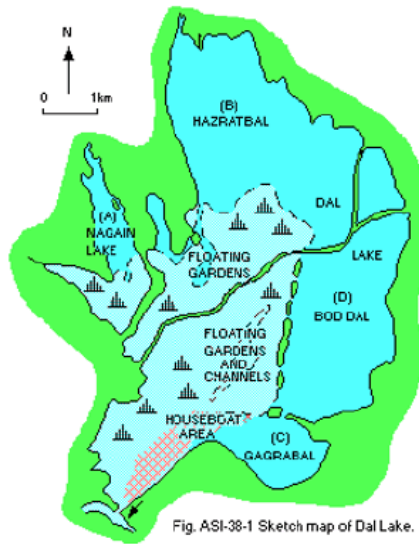


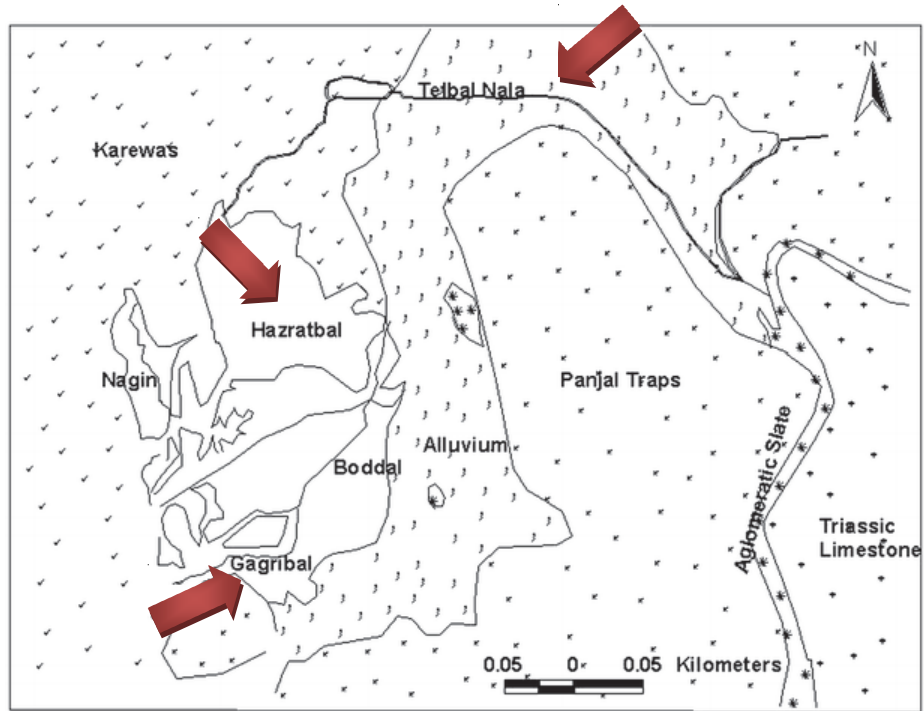
Figure 1: Map not to scale.

RESULTS

Using preliminary data of researchers Saleem *et al.*, (2011), Malik *et al.*, (2017), and Khan, J.A. (2017), a study was carried out to assess the total bacterial load of Dal Lake over a period of 7 years i.e. from 2010 to 2017. Table 1 represents the TVC in (cfu log 10 /ml) recorded at different sites of the Lake. During the year 2010-11, the mean TVC values recorded were 5.63, 5.97 and 4.84 cfu log 10 /ml respectively at Dalgate, Hazratbal and Telbal Nallah sites of Dal Lake by Saleem *et al.*, 2010. However, a reduction in levels of TVC was recorded by Malik *et al.*, (2017) during the year 2011-12 at the same sites. They observed values of 4.4, 3.0 and 3.1 cfu log 10 /ml at Dalgate, Hazratbal and Telbal Nallah respectively while the same authors reported elevated counts i.e. 5.89, 6.26 and 5.60 cfu log 10 /ml respectively during the year 2013-14. Khan (2017) further reported increase in the bacterial counts at Dalgate, Hazratbal and Telbal Nallah to be 7.1, 6.6 and 6.3 cfu log 10 /ml during the year 2016-17.

Table 1. Table representing the Total Viable Bacterial Load at different sites of Dal Lake in different years.

Site	TVC in (cfu log 10 /ml) in different years			
	2010-11	2011-12	2013-14	2017-18
Dalgate	5.63	4.4	5.89	7.1
Hazratbal	5.97	3.0	6.26	6.6
Telbal Nallah	4.84	3.1	5.60	6.3



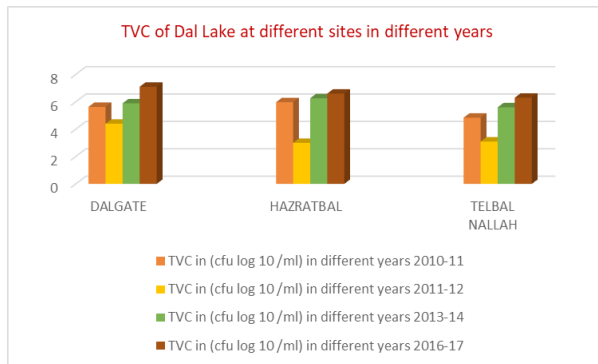
(Picture taken from: Jeelani and Shah, 2006)

On comparing the bacterial load documented at Dalgate during the years 2010, 2012, 2014 and 2017, it was found that the TVC showed an overall increasing trend from 5.63 to 7.1 (cfu log 10 /ml). Similar findings were observed for Hazratbal area where the TVC showed an increase from 5.97 to 6.6 (cfu log 10 /ml) during the study period. However, the TVC was found to be comparatively low during the year 2012 for both Dalgate and Hazratbal regions. Comparable observations were recorded at the Telbal nallah where the highest count was observed in 2017 as 6.3 cfu log 10 /ml and the lowest was recorded during 2012 as 3.1 cfu log 10 /ml. On comparing the data between sites, it was found that the highest bacterial load amongst all sites was present at Dalgate in 2017 (7.1 cfu log 10 /ml) while the lowest was recorded at Hazratbal in 2012 (3.0 cfu log 10 /ml).

DISCUSSION

The total bacterial count in 2010-11 at Dalgate, Hazratbal and Telbal were recorded as 5.63, 5.97 and 4.84 cfu log 10 /ml respectively. The highest load at Hazratbal can be attributed to input of detergents into the lake at Dhobi ghat site which is one of the main areas for washing of clothes in the city by locals who earn their living out of the same. Malik *et*

al., 2017 attributed high bacterial counts in Hazratbal basin to the presence of pilgrims in those areas who visit Hazratbal shrine and use the lake water for washing etc. The comparatively lower values in Telbal Nallah may be due to the fact that it brings snowmelt water from the high altitude Marsar lake which may not have been contaminated as much as the other sites. The TVC observed at Dalgate, Hazratbal and Telbal Nallah during 2011-12 was 4.4, 3.0 and 3.1 cfu log 10 /ml respectively. This year recorded the minimum TVC values for all the sites when compared with the other years of study. During the year 2013-14, almost comparable values of TVC were recorded at Dalgate and Telbal Nallah regions (5.89 and 5.60 cfu log 10 /ml). As counts exceeding 5.00 cfu/mL in log₁₀ scale are considered indicative of pollution with organic matter (Cruickshank *et al.*, 1975), the water in both Dalgate and Telbal Nallah areas was clearly rich in organic matter throughout the study period. The water at Hazratbal area showed the maximum TVC during 2013-14 which may be attributed to the surface runoff and pollutants brought by flood waters of 2014 into the Dal Lake. Further the direct discharge of domestic waste and sewage from the adjacent residential areas enhance the already elevated organic pollution. Trisal and Kaul (1983) reported peak levels of planktons in Hazratbal area of Dal



Lake which were attributed to untreated human excreta discharging directly in to the lake thereby making nitrogen and phosphorus available for the growth of plankton. Abubakr and Kundangar (2005) reported high values of total and fecal coliforms in Hazratbal basin of Dal Lake and linked it to direct intervention by human activities which lead to the increase in bacterial contamination. During the study period, maximum TVC values were recorded at Dalgate site in the year 2016-17 as compared to Hazratbal and Telbal Nallah. This may be attributed to the high tourist influx in this area resulting in the increased movement of Shikaras (tourist boats) with no subsequent disposal system for the night soil leading to water quality deterioration coupled with outburst of bacterial counts. Extension of tourist season as a goal to improve the tourist industry by the State Government may partly be responsible for higher bacterial counts since the latter is directly related to contamination with human and animal wastes. Furthermore, continuous use of fertilizers and manures etc. in the floating gardens also contribute to the elevated bacterial fauna in this part of the lake. Abubakr (2003) also reported higher total coliform and faecal coliform counts in Nehru Park Basin of Dal Lake due to higher human settlements and increased number of house boats discharging human waste directly into the Dal. On comparing the data of Dal waters over a period of seven years, it is clearly visible that there has been significant increase in the bacterial contamination during this time. This is an alarming situation since the Lake holds a significant importance in terms of being a tourist attraction and needs to be conserved by proper planning and management strategies. There is a need to question the functioning of the treatment plants located at the Lake's periphery for their proper working since the data clearly indicates a deterioration in the water quality.

CONCLUSION

The study suggests that water quality in the various sites of Dal Lake has deteriorated which is clearly indicated by the increased bacterial populations from 2010 to 2017. The authorities need to take proper measures to improve the condition of this Lake since it holds much importance in economy as well as ecology of this Valley.

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