Water quality assessment of Dal Lake, Kashmir using the coliforms as indicator bacteria

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ABSTRACT

Polluted water contains pathogenic bacteria that are usually involved in disease transmission and are referred to as "indicator bacteria". The most common indicators used are the coliform bacteria. In present study an assessment of this indicator group of bacteria was carried out in Dal Lake at sixteen (16) different sites. The seasonal and spatial variation of the total coliform outbursts showed the influence of water temperature, sewage influx, intervention of human activities from within and outside the lake. Coliforms were enumerated using multiple-tube fermentation (MTF) technique with lactose broth as the presumptive medium, Brilliant Green Bile broth for completed test and EMB medium as the confirmatory medium. All the samples tested were positive with respect to the coliform occurrence, though the count was variable. The coliform count at all sites ranged between a MPN/100ml value of 3 to 1100 and the overall coliform load observed in the water samples was lowest in winter season compared to the summer season. It was further observed that none of the samples was fit for drinking purpose with respect to this particular parameter as it does not meet requirements of World Health Organization (WHO) standards. 89.07% of the water samples obtained from the lake were having a good or fair quality and 10.93% were having poor quality hence unfit for any use.

Key Words: Dal Lake; coliforms; indicator bacteria; water quality

INTRODUCTION

There has been growing concern about the needs to protect the environment from various forms of pollution caused by growing population, industrialization and by modern agricultural methods (Hunt & Wilson 1986). Water and land based anthropogenic activities within the system and in the catchment including the release of nutrients, organic matter, toxic chemicals and water borne pathogens have a negative effect on water quality. Bacterial contamination in particular accelerates when human activities are augmented, jeopardizing the safe use of water for drinking and recreational purposes. Bacteria often play a vital role in determining the extent of pollution (Higgins & Burns 1975) and the presence of faecal coliform is considered as presumptive evidence of faecal pollution (Mara 1978). The density of coliform bacteria in water is a significant criterion of degree of pollution in aquatic ecosystems (Odum 1985). It is well established that a large number of infectious diseases are transmitted primarily through water supplies contaminated with human and animal excreta particularly faeces (WHO 1993). Outbreaks of water borne diseases continue to occur throughout the world but especially serious in developing countries (Jones *et al.* 2007). The human pathogens that present serious risk of disease whenever present in drinking water include *Salmonella* spp., *Shigella* spp., *Yersinia enterocolitica*, *Campylobacter* spp. and so on (Geldreich 1992; Pommervilli 2007). But it is not practicable to monitor drinking water for every possible pathogen. Therefore, normal intestinal organisms including coliform group of organisms (Covert *et al*., 1989) are used as indicator of faecal pollution (WHO 1984; Cartwright *et al.* 1993). They are considered as suitable indicators because they are easy to detect and enumerate in water. Considering the reality about the coliforms, present work was undertaken to determine total coliform count to the context of biological pollution level to reveal the overall status of water quality in Dal Lake.

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MATERIAL AND METHODS

Location and site description

Dal Lake, lying between geographical coordinates 34° 07′ N, 74° 52′ E, 1584 m a.s.l in Srinagar, Jammu and Kashmir, a multi-basined lake with Hazratbal, Bod Dal, Gagribal and Nageen as its four basins, having two main inlets as Boathall Nallah and Tailbal Nallah and two main outlets as Dal Lock Gate and Pokhribal Nallah, was taken up for the current study. Sixteen (16) sites viz., Hazratbal Open, Hazratbal littoral, Nageen Open, Nageen near Houseboats, Gagribal Open, Gagribal near Houseboats, Nishat Open, Near Centeur, Boathall Nallah-I, Boathall Nallah-II, Tailbal Nallah-I, Tailbal Nallah-II, Dal Lock Gate-I, Dal Lock Gate-II, Pokhribal Nallah-I and Pokhribal Nallah-II with 8 sites from the 4 basins, 4 sites from two inlets and 4 other sites from two outletswere selected.

Collection of water samples

Water samples were collected on seasonal basis in white plastic containers, which were previously sterilized with 70% alcohol and rinsed with distilled water. At the lake, the containers were rinsed thrice with the lake water before being used to collect the samples. The samples were transferred immediately to the laboratory for analysis within 24 hours (APHA 1998).

Multiple tube fermentation technique

The technique used for enumerating coliforms was multiple-tube fermentation (MTF) technique (Rompre *et al*. 2002). The method consisted of inoculating a series of tubes with appropriate decimal dilutions of the water sample. Production of gas, acid formation or abundant growth in the test tubes after 48 h of incubation at 35°C constituted a positive presumptive reaction. Lactose broth was used as presumptive media (Collins & Lyne 1976; Bakare *et al*. 2003) and all tubes with a positive presumptive reaction were subsequently subjected to a confirmation test. The formation of gas in a brilliant green lactose bile broth fermentation tube (Coyne & Howell 1994) at any time within 48 h at 35°C constitutes a positive confirmation test. The results of the MTF technique were expressed interms of the most probable number (MPN) of microorganisms present. This number is a statistical estimate of the mean number of coliforms in the sample.

RESULTS

The data revealed that all the samples collected for different sites of the lake were positive with respect to the coliform occurrence, though the count was variable. All the samples tested showed coliform counts above the permissible limits. The coliform count at all the sixteen sites (Table 1) ranged between a MPN/100ml of 3 to 1100. The overall coliform count in the open water sites of different lake basins ranged between a minimum of 3 MPN/100ml to a maximum of 1100 MPN/100ml. While drawing a comparison between the different open water sites of these basins highest count of these indicator organisms was observed in Nigeen followed by the Gagribal basin, Hazratbal basin and Nishat basin. In the littoral sites of these basins again a highest count of coliform bacteria was found in the Nigeen lake followed by the Gagribal basin, Hazratbal basin and Nishat basin Here it ranged between a minimum of 4 MPN/ 100ml to a maximum of 1100 MPN/100ml. However, the count was higher in the group of littoral sites and lower in the group of open water sites as in case of the littoral sites 11 (34.37%) observation showed the coliform count above 200 MPN/100ml while as in case of the open water sites the observation with such higher coliform count was only 7 (21.87%). The coliform count of all the inlet sites with 9 (28.12%) observations having the MPN count >200 was comparatively higher than those of the outlet sites with 96.87% (31) observation having the MPN/100ml of coliform bacteria <100. In both inlets the coliform count was higher towards the outer ends (TBN2 and BHN2) as compared to the end connected with the lake (TBN1 and BHN1). But in case of the outlet sites the count was higher towards the extreme exit points (DLG2 and PKB1) compared to the near outlets (DLG1 and PKB2). The data further reveals a great deal of seasonal and spatial variation in coliform bacterial count in the lake water as the overall coliform load observed was lowest in winter season compared to summer season. Furthermore the load was higher in the second year of study compared to the first year of study throughout the lake.

The category wise distribution of coliform count (Table 2) into four categories with MPN range of 0 (zero) for category I, 4-50 MPN/100ml for category II, 51-400 MPN/100ml for category III and 401-1100 MPN/100ml for category IV shows that 50% water samples lie in category III, followed by 39.06% samples in category II, 10.93% samples in category IV and 0% sample in category I. The perusal of the data indicates that none of the samples was fit for drinking purpose with an excellent water quality with respect to this particular parameter.

Table 1: MPN index of water samples collected from Dal Lake

S.No	Site code	Spring		Summer		Autumn		Winter	
		2010	**2011**	**2010**	**2011**	**2010**	**2011**	**2011**	**2012**
Open sites	HB1	7	14	39	120	94	39	14	3
	NO	7	14	39	75	43	28	14	3
	GB1	75	150	150	460	93	120	43	64
	NL1	240	460	1100	1100	240	460	150	210
Littoral sites	HB2	9	15	43	120	75	43	15	4
	NC	9	15	43	93	64	39	15	4
	GB2	93	210	210	460	150	240	64	75
	NL2	240	460	1100	1100	240	460	150	210
Inlet sites	TBN1	64	93	150	240	210	460	120	43
	BHN1	64	93	120	460	93	150	39	64
	TBN2	75	120	210	460	150	240	150	64
	BHN2	75	120	210	460	150	240	43	75
Outlet sites	DLG1	20	28	43	75	39	23	14	9
	PKB2	28	39	64	93	75	64	43	21
	DLG2	21	39	64	93	43	28	21	11
	PKB1	23	43	75	120	93	64	39	20

Table 2: Category wise distribution of coliform count (MPN/100ml)

Categories	MPN range	% age	Usage	Grade
Category I	0	0	Drinking	Excellent
Category II	4-50	39.06	Bathing , swimming	Good
Category III	51-400	50		Fair
Category IV	401-1100	10.93	Unfit	Poor

DISCUSSION

The principal coliforms are *Escherichia coli*, *Enterobacter aerogenes*, *Klebsiella* spp. and *Citrobacter* spp. *E.coli* is abundantly found in the gastro intestinal tracts of humans, birds and animals, but rarely found in water or soil that has not been subjected to faecal pollution. Thus presence of coliforms in Dal lake indicates the extent of faecal pollution in it (Godfree *et al*. 1997; Mossel 1958). The presence of classified indicator (*E. coli*) in water suggests the presence enteric pathogens (Nwadiaro 1982) and there is a direct relationship between the numbers of *E. coli* and the extent of faecal pollution. The higher its number, the more polluted is the sample (Akoleowo 2002). The count of total coliform bacteria was significantly higher at all littoral sites in all basins and the possible reason for this was that these sites in each basin are more prone to direct impact from human activities and also from point and non-point sources of sewage. As human activities increase so does the bacterial contamination as found in all the sites which are directly susceptible to interventions taking place within and outside the lake. Kundangar *et al.* (2003) also has attributed increase in total coliform count of Dal Lake to environmental variables such as low dissolved oxygen and human influence at inshore sites. The polluted nature of these sites is further clarified by the findings of various studies (Rai & Hill 1978; Ramadhan 1971; Clark & Pagel 1977) reporting that the total coliforms indicate degree of pollution and are a reliable indicator of contamination or pollution. Seyfried (1995) while investigating the effect of various site characteristics on bacterial levels, found a positive correlation between the bacterial number, number of boats and the amount of organic carbon in the sediments. The occurrence of coliforms in the sample is also confirmed by a local study conducted by Latief *et al*. (2003) reporting high coliform count in fifteen springs of Kashmir valley.

The coliform count in the lake water showed considerable seasonal and spatial variation with highest coliform load in summer season and lowest in winter season that could be related directly to the water temperature. With the increase in water temperature from spring onwards there was a corresponding increase in coliform count indicating that it governs the coliform dynamics in the lake, which is in conformation with various other studies (Sastry *et al*. 1970; Hadas 1988; Verma & Paul 1996; Hadas *et al*. 2000). The present observation is also favoured by the study carried out by Wetzel (1975) reporting that the lower bacterial biomass during winter and higher during summer in temperate lakes can be correlated to low winter temperature and reduced loading of particulate and dissolved organic substrates from allochthonous sources and the vice versa in summer. Moreover the higher load of coliform bacteria in the summer seasons could also be attributed to tourist influx resulting in the increased movement of house boats in the Lake, where there is no proper disposal system for the night soil, thus resulting is water quality deterioration coupled with the outburst of bacterial counts.

The MPN index observed for water samples revealed that the maximum samples were crossing the permissible limits set by WHO (2003) indicating gross pollution of the lake and its transition to eutrophic status. Water source used for drinking or cleaning purpose should not contain any organism of faecal origin (Sabongari 1982; Fonseca *et al*. 2000). The World Health Organization (WHO 1984) suggested that treated water entering the distribution system should contain no coliform organisms. Thus in accordance to the WHO limits and the work of Pandey and Sharma, 1999 it was observed that most of the water samples obtained from the lake were fit for bathing and swimming with a good or fair quality while as some areas of the lake were having very much poor quality, hence unfit for any use.

CONCLUSION

The density of total coliform bacteria in the lake water indicates that the lake water is deteriorated and is not fit for drinking purposes. It is further visible that the heavy influence of human activities has resulted in elevated levels of total coliforms as compared to natural conditions. Inadequate sanitary system, poor land use pattern in the immediate catchment and the discharge of waste water continues to jeopardize the water quality of the lake for human use. Therefore, control must be implemented to minimize bacterial transport to such natural systems.

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