Advanced Research Journal of Microbiology Vol. 1 (3), pp. 051-055, November, 2013. Available online at www.advancedscholarsjournals.org © Advanced Scholars Journals

Full Length Research Paper

Coliform bacterial estimation: A tool for assessing water quality of Manasbal Lake of Kashmir, Himalaya

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Accepted 12 October, 2013

Total coliform count is commonly used to assess contamination level of drinking and swimming waters, especially with pathogenic bacteria of intestinal origin. The common sources of coliforms in Kashmir Himalayan lakes include point source discharges (raw sewage, combined sewer overflows, effluents from wastewater treatment plants, industrial sources) and non-point source discharges (agriculture, forestry and urban run-off). In the present study, total coliforms were enumerated using a multiple tube fermentation technique with lactose broth as the presumptive medium, eosine-methylene-blue (EMB) agar medium as the confirmatory medium and brilliant green bile broth for completed test. All the samples obtained from the lake were positive with respect to the coliform occurrence, though the count was variable ranging between 4 and 460 MPN/100 ml. Highest proportion of indicator coliforms was found in the water samples collected at the site surrounded by residential hamlets (site II) in comparison to the other three sites. The results allow us to conclude that none of the studied water samples was fit for drinking in view of high coliform count, though most of the water samples (95%) obtained from the lake with a good or fair quality could be used for bathing and swimming. These results have important implications for lake managers and local inhabitants that use the water of this lake for various purposes.

Key words: Total coliform, bacteria, Manasbal Lake, Himalaya.

INTRODUCTION

Aquatic environments act as a natural habitat of diverse range of microorganisms, with both beneficial and pathogenic characteristics. Pathogenic bacteria are considered as etiological agents of infectious diseases to human and marine animals (Baker-Austin et al., 2006; Pereira et al., 2007). Microbial indicators are used to determine whether or not water is safe for use. Recently, concerns have been raised about the appropriate use of microbial indicators to regulate recreational uses of water bodies (Solo-Gabriele, 2005).

Microorganisms are widely distributed in nature, their diversity and density may be used as an indicator for the suitability of water (Okpokwasili and Akujobi, 1996). Use of bacteria as water quality indicators can be viewed in two ways. First, the presence of such bacteria can be taken as an indication of faecal contamination of water and second it can be taken as an indication of the potential health risk that faecal contamination poses. The higher the level of indicator bacteria, the higher is the level of faecal contamination and greater the risk of water-borne diseases (Pipes, 1981). Determining the source of fecal contamination in aquatic environments is essential for estimating the health risks associated with pollution, and identifying likely measures to remediate polluted waterways (Malakoff, 2002).

Recreational waters are susceptible to a variety of

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sources of microbial pollution, which can contain pathogenic microorganisms that cause infections in gastrointestinal tract, upper respiratory tract, ears, eyes, nasal cavity and skin (WHO, 2003). The potential public health threats posed by waterborne microbial pathogens have attracted renewed attention, both within the scientific community and among the public (Theron and Cloete, 2002). Once thought to be under control, they are now referred to as “emerging or re-emerging” pathogens.

The source of microbiological pollution is often inadequately treated human sewage or runoff from animal husbandries into streams or lakes along with many other factors including:

1. Wastes from wild animals,
2. Variations in turbidity or water chemistry, and
3. Algal blooms which increase bacterial abundance in the water bodies (Geldreich et al., 1991).

In absence of proper management, serious problems may arise in availability and quality of water (Subba and Subba, 1995).

Freshwater bodies of Kashmir Himalaya are contaminated with various types of pollutants resulting from disposal of domestic and municipal wastes causing undesirable change in them. Manasbal Lake is no exception, despite the fact that it acts as an important source of water to inhabitants around and offers facilities for navigation and transportation, fisheries, harvesting of economically useful plants, sightseeing, tourism and recreation. The anthropogenic pressures have affected the water quality of the lake to a great extent and monitoring the quality of lake water using microbial indicators is of pivotal importance in combating the problems associated with public health. The objective of present study was therefore to investigate the incidence of coliform bacteria as indicators of contamination level in this typical Kashmir Himalayan lake ecosystem.

MATERIALS AND METHODS

Location and site description

Manasbal Lake (Figure 1) is located at an altitude of 1,583m a.s.l. about 30 km north of Srinagar, the summer capital of Jammu and Kashmir State. It has predominantly rural ambience with three villages namely, Kondabal, Jarokbal and Gratbal in its surroundings. Although, the lake has no major inflows and its water supply is chiefly derived from internal springs and precipitation, it is the deepest lake of the valley fed by groundwater. The volume of water has been estimated as 12.8×10^6 m^3 (Yousuf, 1992). The lake serves as an important natural water reservoir for the local population and its water is used for drinking and agricultural purposes (Zutshi and Vass, 1976; Dewan, 2004). Four different sites were selected for the present study:

Site I: Located near Laar Kul, a small irrigational stream which takes off from Sindh Nallah and irrigates the agricultural fields throughout its course, drains into the lake on its eastern side.

Site II: A site surrounded by residential hamlets, exposed to myriad of interference, such as emission of domestic sewage and washing of clothes and other activities.

Site III: The central site represents the open water zone with a maximum depth of 12.5 m and relatively a lesser density of macrophytic vegetation, the water at this site is relatively clear with a greater degree of visibility.

Site IV: Represent the lake outlet characterized by more turbid water due to the sediment loading. The water comes out of the lake through this outlet and enters into river Jhelum through Nunyar Nalla near Sumbal village.

Sampling

Water samples were collected from the selected sites on monthly basis for ten months from March 2011 to December 2011 in plastic (100 ml) bottles which were previously carefully cleaned, rinsed thoroughly with distilled water (APHA, 1998). During collection of samples, extreme care was exercised to avoid contamination.

Coliform count

Water quality was determined by the standard multiple tube fermentation technique. Coliforms were detected by inoculation of samples into tubes of lactose broth. The three-tube procedure using lactose broth (Collins and Lyne, 1976; Bakare et al., 2003) was used to detect the coliform and determine the most probable number (MPN) of coliform bacilli (Collins and Lyne, 1976). 10 ml, 1 ml and 0.1 ml of water samples were inoculated into tubes with 10 ml of lactose broth and incubated at 35 ± 0.5°C. Gas formation after 24 h of inoculation indicated positive presumptive test. The productions of gas (a bubble filling the concavity of Durham’s tube) were considered presumptive positive growths of coliforms. Cultures showing no production of gas in 48h were considered negative. The tubes showing gas were inocula-ted on endo or eosine-methylene-blue agar; and one or more typical colonies are picked off into Brilliant Green Bile broth (Coyne and Howell, 1994) and studied microscopically to see whether the contained organisms have the morphological and staining properties of coliform bacilli.

RESULTS

All the water samples collected during the study were positive with respect to the coliform occurrence well above the permissible limits, though the counts were variable (Figure 2). The data also reveals that the highest proportion of these indicator organisms was present at at the site surrounded by residential hamlets (Site II). Distribution of coliforms was highly variable with significant differences existing between the sampling sites and the concentration ranged between 4 and 460 MPN/100 ml.

For the site I, maximum coliform count (460 MPN/100 ml) was observed in December, followed by 93 MPN/100 ml in March and April each, 43 MPN/100 ml in June, 21 MPN/100 ml in July and October, 9 MPN/100 ml in August and November each, 4 MPN/100 ml each in September and May. For site II, maximum coliform count (240 MPN/100 ml) was observed in March and September each, 75 MPN/100 ml in June, 43 MPN/100 ml in April, July and August, 28 MPN/100 ml in October, 23 MPN/100 ml in November, 20

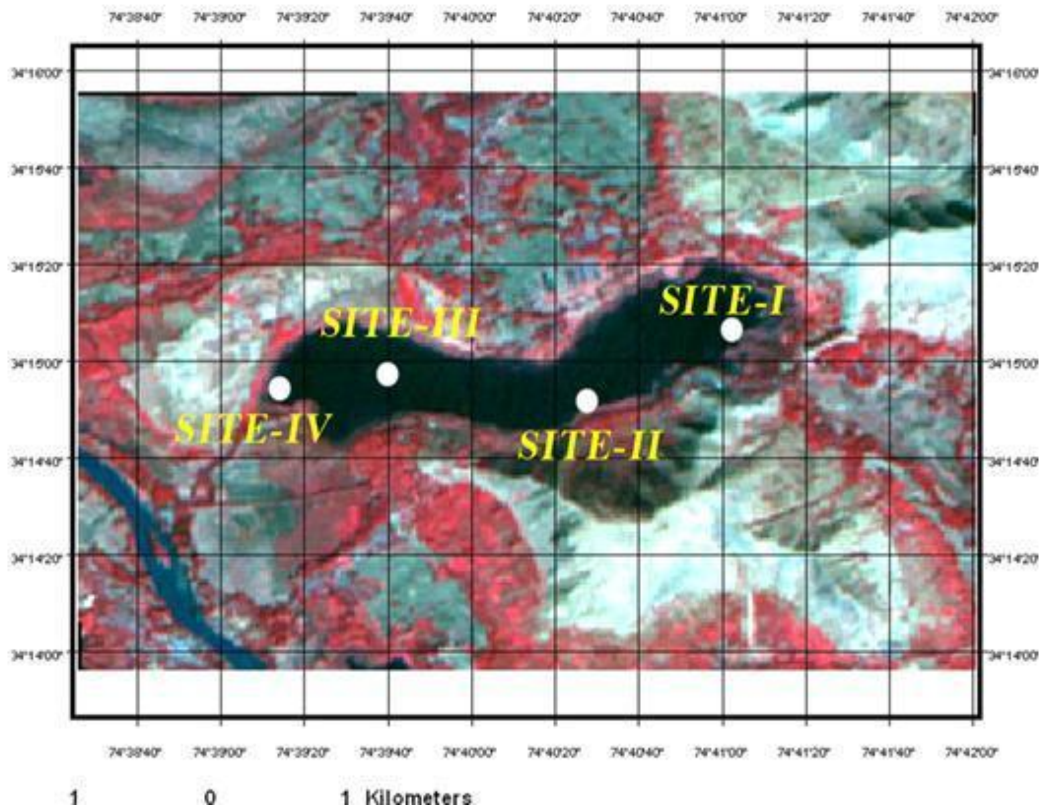

Figure 1. Satellite imagery depicting Manasbal Lake and various study sites.

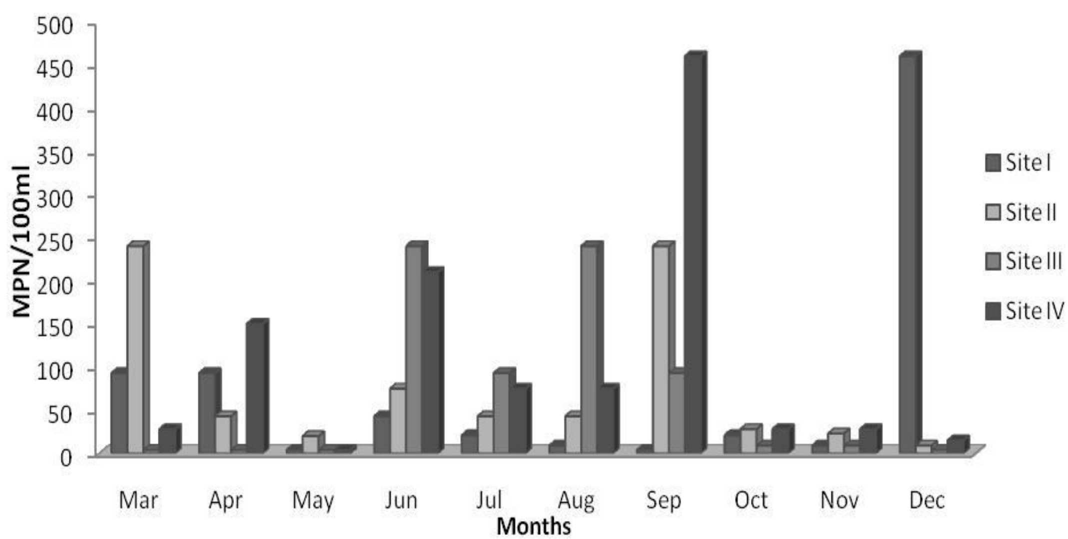

Figure 2. Total coliform count of different water samples (MPN/100 ml).

20 MPN/100 ml in May and 9 MPN/100 ml in December. For site III, the maximum coliform count 240 MPN/100 ml was observed in June and August followed by 93 MPN/100 ml in September and July, 9 MPN/100 ml in October and November, 4 MPN/100 ml in March, April, May and December. For site IV, the maximum concentration of 460 MPN/100 ml was observed in September followed by 210 MPN/100 ml in June, 150 MPN/100 ml in April, 75 MPN/100

Table 1. Category wise distribution of coliform count (MPN/100 ml) in Manasbal Lake with respect to its usage and quality.

Category	MPN range	Percentage	Usage	Grade
Category I	0	0	Drinking	Excellent
Category II	4-50	62.5	Bathing and swimming	Good
Category III	51-400	32.5		Fair
Category IV	401-1100	5	Unfit	Poor

ml in July and August, 28 MPN/100 ml in March, October and November, 15 MPN/100 ml in December and 4 MPN/100 ml in May.

The category wise distribution of coliform count (Table 1) into four categories with MPN range of zero for category I (excellent water quality), 4 to 50 MPN/100ml for category II (good), 51 to 400 MPN/100ml for category III (fair) and 401 to 1100 MPN/100ml for category IV (poor) shows that the most of the water samples (62.5%) lie in category II, followed by 32.5% samples lying in category III, 5% samples in category IV and 0% sample lying in category I. The results indicate that none of the samples was fit for drinking purpose. Most of the water samples (95%) obtained from the lake were fit for bathing and swimming with a good or fair quality. However, some patches of the lake were of poor quality and hence unfit for any use.

DISCUSSION

The water quality of Manasbal Lake showed significant deterioration in quality in view of global standards. All the samples were contaminated with coliform bacteria, resulting mainly from anthropogenic activities, especially discharging of domestic and agricultural wastes directly into the lake as some recent studies (Sharma et al., 2010; Sadat et al., 2011) revealed that coliform count has positive relation with anthropogenic activities. Feng et al. (2007) suggested that *Escherichia coli* is a faecal bacterium which is found in the intestinal canal of man and warm-blooded animals and is discharged with faeces. Enterotoxigenic *E. coli* (ETEC) is a common cause of "traveler's diarrhea" in developing countries infecting only humans and transmission occurs through water and food contaminated with human waste. The MPN index observed for the water samples revealed that maximum of samples were crossing the permissible limit of WHO (2003) indicating gross pollution of the lake and its transition towards eutrophic state. The high MPN values in the lake water samples analyzed can be attributed to the agricultural runoff and sewage drained into the lake from the catchment area via laar kul. The results are in agreement with the findings of Geldrich (1972) who observed an increase in the total coliform count of water bodies due to increased use of animal wastes as manure in the agricultural fields. The occurrence of coliforms in the samples is also confirmed by a local study conducted by Lateef et al. (2003) reporting high coliform counts in the spring water of Kashmir valley. Due to change in agricultural methods, diminishing of livestock farms, intensive farming operation increased concentration of animal wastes results in an increased pollution of rivers and streams (Gelt, 1998). The results of the present study draw support from the findings of Sharma et al. (2010) who worked on the bacterial indicators of faecal pollution and physiochemical assessment of North Indian lakes and reported that the places with greater anthropogenic pressure experience a comparatively higher bacterial load. Manasbal Lake can be categorized into category III and designated as satisfactory for the purpose of bathing (Pandey and Sharma, 1999). Therefore, control measures must be implemented to minimize bacterial transport to natural systems like Manasbal Lake.

Conclusions

Density of total coliform bacteria in the lake water indicates that the water quality has deteriorated and is not fit for drinking purposes. It is further visible that anthropogenic activities have resulted in elevated levels of total coliforms. Inadequate sanitary system, poor land use pattern in the immediate catchment and 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.

ACKNOWLEDGEMENT

The authors are thankful to the Centre of Research for Development, University of Kashmir for providing the necessary laboratory facilities to carry out this work.

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