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Bacteriological quality of Mirik lake waters, Darjeeling district, West Bengal

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Abstract
A study was conducted on Mirik Lake to assess the bacteriological quality of the lake water during the period of March 2009 through February 2010. Water samples were collected from five different sites of the lake and analysed for bacteriological study to enumerate the seasonal distribution of total bacterial count, total coliform, faecal coliform bacteria and faecal streptococci. Total heterotrophic bacterial count per 100 ml (cfu/100 ml) was found to be $0.2x10^6$-$0.3x10^6$ in monsoon, 1.0×10^6- $6.7 x10^6$ in summer and 4.75×10^6 -10×10^6 in winter. The range of total coliform was observed to be 1100 - 1750 / 100 ml, 1100 – 2400/ 100 ml and 1750 – 2400 /100 ml in winter, summer and monsoon seasons, respectively. Faecal coliform was recorded to be 49 – 1245 / 100 ml in winter, 1320 – 2400 /100 in summer and 780 – 2400 / 100 ml in monsoon. The range of faecal streptococci was found to be 43-125 /100 ml in winter, 87 -1100 /100 ml in summer and 87 - 1340 /100 ml in monsoon.
The study indicated that the lake water was polluted by faecal contaminants of human origin to the extent that water was unsafe to be used for domestic as well as recreational purposes, also the total bacterial load exceeded the standard prescribed level (WHO, 1983) and both parameters showed variation according to the sampling sites and season.

Keywords: coliforms, faecal, streptococci

Mirik is a small town in the Darjeeling Hills, located at 26°54'N, 88°10'E/26.9°N,88.17°E with average elevation of 1495 metres (4904 feet) above msl. It has a pleasant climate all the year round with temperatures of maximum 30°C in summer and a minimum of 2°C in winter. Lake is man made, 1.25 km long, spread over an area of 110 ha. The lake gets water from several springs in its surrounding hilly catchment area. A dense coniferous forest lies on the southwest of the lake whereas the hills on the northern side experience extensive erosion. Sewage from the human settlements and tourist activities in its catchment directly enters the lake through several drains and solid wastes are also dumped into it. Washing and bathing activities too impinge upon the lake water quality.

Microorganisms are widely distributed in nature and their abundance and diversity may be used an indicator for the suitability of water (Okpokwasili and Akujobi, 1996). The 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 the water and thus as a signal to determine why such contamination is present, how serious it is and what steps can be taken to eliminate it; second, their presence can be taken as an indication of the potential danger of health risks that faecal contamination posses (Baghel *et. al.*, 2005).The higher the level of indicator bacteria, the higher the level of faecal contamination and the greater the risk of water-borne diseases (Pipes, 1981). The faecal pollution indicator organisms can be used to a number of conditions related to the health of aquatic ecosystems and to the potential health effects among individuals using aquatic environments (McLellan *et. al.*, 2001). A wide range of pathogenic microorganisms can be transmitted to humans via water contaminated with faecal material. These include enteropathogenic agents such as *salmonellas*, *shigellas*, *enteroviruses*, and multicellular parasites as well as opportunistic pathogens like *Pseudomonas aeruginosa, Klebsiella, Vibrio parahaemolyticus and Aeromonas hydrophila* (Hodgekiss, 1988). The most widely used indicators are the coliform bacteria, which may be the total coliforms that got narrowed down to the faecal coliforms and the faecal streptococci (Kistemann *et. al.*, 2002, Pathak and Gopal, 2001; Harwood *et. al.*, 2001; Vaidya *et. al.*, 2001). The contamination of lakes and rivers by faecal material increases the risk to the populations due to water borne diseases (Rajakumar *et. al.*, 2006; Scott *et. al.*, 2003). Typhoid fever, cholera, infectious hepatitis, bacillary and amoebic dysenteries and many varieties of gastrointestinal diseases can all be transmitted by water (Rajakumar *et. al.*, 2006).

The study was undertaken to determine water quality of the lake water in terms of enumeration of total bacterial load, coliform bacteria, faecal coliforms, and faecal streptococci; their periodicity and pattern of distribution during March 2009 to February 2010.

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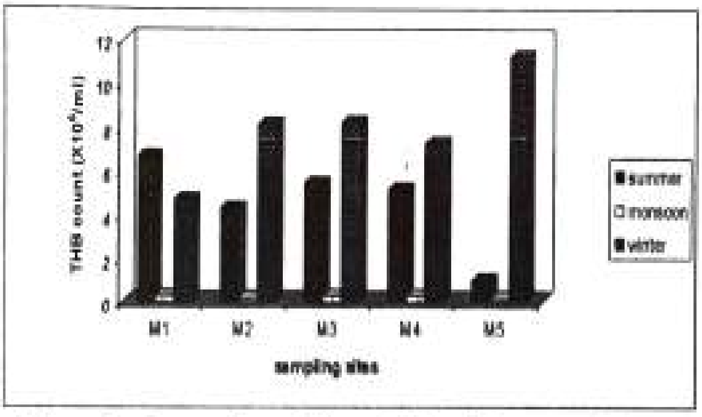


Figure 1 : Seasonal variation of Total Heterotrophic Bacteria (THB) count of Mirik Lake waters

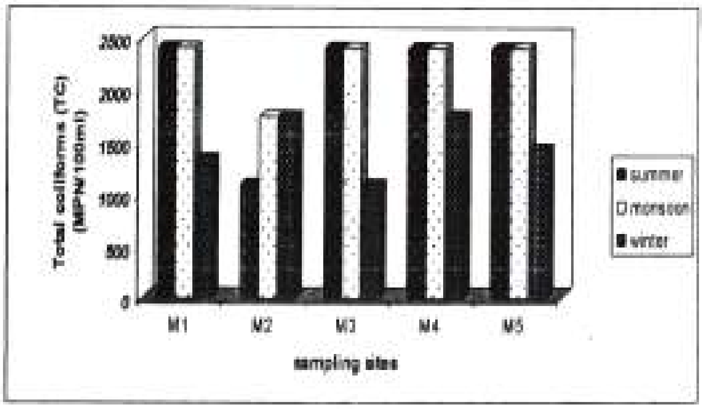


Figure 2: Seasonal variation of Total Coliform count of Mirik Lake waters (MPN /100 ml)

Materials and methods

Samples were collected from five different sites of the lake, sewage inlet (M1), area near human influence (M2), outlet (M3), boat house (M4) and the centre of the lake (M5), during three seasons i.e., summer, monsoon and winter, from March 2009 to February 2010. The samples were collected in pre sterilized stopper glass bottles and transported to the laboratory in an ice box and processed within 6 hours of collection.

The microbiological quality of water was determined by the standard most probable number (MPN) method and the data is represented as MPN/100ml. The total coliform and faecal coliform density were determined by inoculating the samples in Lauryl Sulphate Lactose Broth (LSLB) followed by their incubation at 37°C and 44°C respectively for 48 hours. Faecal streptococci density was determined by inoculation of samples in Glucose Azide Broth and incubated at 37°C for 24 - 48 hours (APHA, 1998).The total heterotrophic bacterial (THB) count was determined by serial dilution agar plate method on nutrient agar and represented as colony forming units per ml (cfu/ml).

All the culture media except otherwise stated were obtained from Hi Media Pvt. Ltd., Bombay, India.

Result and Discussion

THB count (THB/ml) were observed in the range of 5×10^6 to 11×10^6 in winter, 1×10^6 to 7×10^6 in summer and 0.2×10^6 to 0.3×10^6 in monsoon (Fig. 1).

An average of total coliforms in the five sites of the lake was found in the range of 1100 – 2400/100 ml in summer, 1750 – 2400/100ml in monsoon and 1100 – 1750/100ml in winter. The counts of faecal coliform observed during summer and monsoon and winter was in the range of, 1320 – 2400/100ml^{-1} and 780 – 2400/100 ml, 49 – 1245/100ml respectively. Faecal streptococci were in the range of 87 – 2400/100 ml in summer, 87 – 1340/100 ml in monsoon and 10 – 125/100 ml in winter (Table 1).

Total coliform count was the highest in sampling site M4 during all seasons i.e., 2400/100 ml in summer, 2400/100 ml in monsoon and 1750/100 ml in winter (Fig.2). The highest count of faecal coliform was also found in the site M4, i.e., 2400/100 ml, 2400/ 100 ml and 1245/100 ml in summer, monsoon and winter seasons respectively (Fig.3). The highest faecal streptococcal count was observed in the monsoon season in M3 showing the highest count of 1340/100 ml (Fig. 4).

Discussion

The study showed the variation in bacterial counts with season and the time of collection and sampling sites which was in agreement to other similar studies (Badge and Varma, 1982; 1991; Badge and Rangari, 1999; Rajakumar *et al.*, 2006). The bacteriological analysis revealed that water samples collected from five different sites of the lake were heavily loaded with coliforms, faecal coliforms and faecal streptococci. The highest and the lowest coliform population were observed in the monsoon and the winter season, respectively. The monsoon population was closely followed by the summer population; the pattern which was reported in earlier studies (Badge and Varma, 1982; Badge and Rangari, 1999, Rajakumar *et. al.*, 2006). The increase in

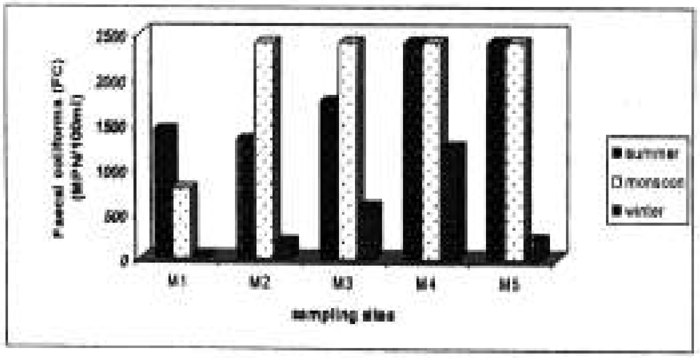
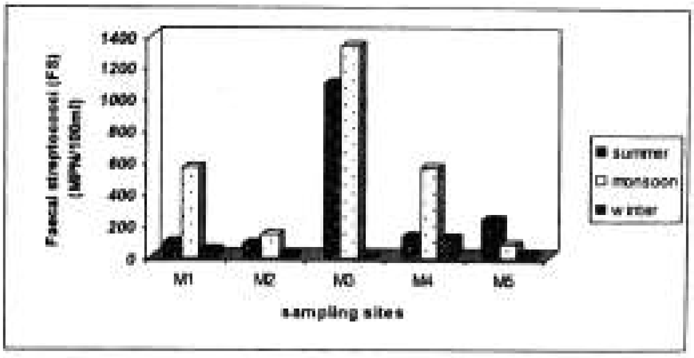


Figure 3: Seasonal variation of Faecal Coliform count of Mirik Lake waters (MPN/100 ml)



4: Seasonal variation of Faecal Streptococcal count of Mirik Lake waters (MPN/100ml)

Table 1: Range of total heterotrophic bacterial count, total coliforms, faecal coliforms and faecal streptococci in all the sampling sites of Mirik Lake during different sampling seasons

Indicator organisms	Sampling seasons (MPN/ 100 ml)		
	Summer	Monsoon	Winter
Total coliform	1100-1750	1100-2400	1750-2400
Faecal coliform	49-1245	1750-2400	780-2400
Faecal streptococci	10-125	87-1100	87-562
THB/ml ($x10^6$)	4.8 -8.3	01-6.8	0.2 -0.3

coliform population in monsoon may be due to the rain water that washed the faecal matter into the lake, as it was the major source of bacterial population in the lake water as observed by Quereshi and Dutka (1979). High population of coliforms during summer may be due to less available dilution (Badge and Varma, 1982) and also due to tourism activities in and around the lake. The lowest count during winter may be explained on the basis of lower multiplication rate and poor growth of bacteria due to low temperature during the season (Rajakumar *et. al.,* 2006). The fluctuations in the number of coliforms in different water samples can be attributed mainly to the intensity and age of pollution in addition to temperature and runoff waters (Badge and Varma, 1982). The highest faecal streptococci count was observed on the onset of .monsoon followed by summer and winter which may be due to runoff of human excreta as open air defecation is also common around the lake. Open air defecation and pouring of sewage pipes into the lake from the nearby vicinity around the site M3 may have contributed to the highest count of faecal streptococci at the site. Monsoon water samples showed highest population of faecal streptococci which may be due to drainage of sewerage pipes of the nearby habitation into the lake at the site. In the case of rainfall, the microbial loads of runoff water may suddenly increase and reach the lakes very quickly (Kistemann *et. al.,* 2002). Most strains of *E. coli* are harmless, but it is typically associated with more harmful bacteria that can cause illness. Therefore abundance of considerable population of faecal coliforms as well as faecal streptococci throughout the sampling periods indicates the continuous input of intestinal microorganisms of human origin warranting the population from outbreak of enteric diseases.

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