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Total Coliform and Fecal Coliform Bacterial Estimation Assessing Water Quality of Lake Saheb Bandh

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Abstract : Manmade urban lakes are potential tourism site as well as a source of livelihood. urban lake Saheb Bandh in Purulia district were being used by the local communities residing nearby for various purposes such as fishing purposes, ecotourism, waste disposal, idol immersion, swimming, bathing and drinking purposes. Thus, Saheb Bandh Lake situated between 23º29'42"N latitude and 86º21'37"E longitude of Purulia district, West Bengal, India was assessed to study bacteriological characteristics of the lake water for quality assessment of drinking and recreational purposes. Studies on the abundance and distribution of heterotrophic bacterial communities of Total Coliform (TC) bacteria and Fecal Coliform (FC) bacteria revealed a distinct seasonal variation of their population with relatively higher values in summer and monsoon season and lower during winter. All the samples obtained from the lake were positive with respect to the coliform occurrence, though the count was variable ranged between 0.05×103 MPN/100 ml. and 8.75×103 MPN/100 ml. in TC whereas in FC it was ranged between 0.01×104 MPN/100 ml. and 5.65×104 MPN/100 ml. Highest proportion of indicator coliforms was found in the water samples collected from the littoral zone where anthropogenic disturbances taken place. The results showed that the most of the water samples lying in category III and category IV and 0% sample lying in category I. The results allow to conclude that none of the studied water samples was fit for drinking purposes in view of high coliform count, could be used for bathing, swimming and recreational purposes. This result has important implications for municipality and local inhabitants that use the water of this lake for various purposes.

Keywords: Total coliform, Fecal coliform, water quality, Lake Saheb Bandh

1. INTRODUCTION

Aquatic environment is vital for survival of any form of life which constitute 75% of the earth's surface [1] and the well-being of all people acts as an important natural resource useful for domestic as well as developmental purposes. The quality of the water sources greatly impacts on the health status of the consumers [2,3]. Unfortunately, only about 0.3 % is usable by humans that comprise of freshwater and lakes (0.009%), inland seas (0.008%), soil moisture (0.005%), atmosphere (0.001%), rivers (0.0001%), groundwater (0.279%) and other composed of ocean (97.2%), glaciers and other ice (2.15%) [3-5].

The surface water from lakes, ponds, rivers, streams are vital resources of water necessary for subsistence of all living organisms [3]. The vast majority of people living in undeveloped countries still rely on surface waters as their primary sources of water and simultaneously, as their means of waste disposal. A majority of this population depends on unprotected or contaminated water sources as a means of drinking water which can cause outbreaks of waterborne diseases [5-10] to human and other animals [11-13].

Lakes provide fisheries, flood plains, agriculture, natural services and products like aquifer replenishment, water quality improvement and biodiversity [2,14-15] as well as support transportation, recreation and other cultural amenities [16]. Although these water sources serve a great benefit to the communities, they are usually under threat as a result of anthropogenic activities in some of the communities surrounding the lake and the streams [10].

Microbial indicators are useful to determine whether the water is safe or unsafe for use. Recently, concerns have been raised about the appropriate use of microbial indicators to regulate recreational uses of water bodies [11,17] whereas their diversity and density may be used as an indicator for the suitability of water [11,18].

A large variety of pathogenic forms may occur, including indigenous and external microorganisms, usually with considerable fecal content [19]. Majority of microbial pathogens in water are coming from feces of human and other mammals can enter waters either from a point source, non-point sources or both. Rainwater surface run-offs, storm sewer spillages or overflow cause non-point microbial pollution of waters, while point-source pollution comes from discharge of untreated or partially treated effluents from wastewater treatment plants [1,20-21].

A variety of sources of microbial pollution susceptible to recreational waters can contain pathogenic microorganisms that cause infections in gastrointestinal tract, upper respiratory tract, ears, eyes, nasal cavity and skin [11,22]. In order to ensure and maintain good health, water should be of good quality meeting local and WHO recommended standards [23]. In absence of proper management, serious problems may arise in availability and quality of water [11,24).

Pathogenic microorganisms contaminate the water, is now a major global problem. The main causes of bacteria in the aquatic environment are the disposal of human waste and municipal waste water through sewage and drainage ditches systems. Human pathogenic bacteria, particularly members of the coliform can inhabit on fishes and aquatic environment [25]. Feces of warm-blooded animals can harbor fecal coliforms and they are the most commonly used indicators of fecal pollution in water and food. Increased levels of fecal coliforms provide a warning of failure of the water distribution system and possible contamination with other pathogens [26]. Water become unsafe for human consumption or usage when it contains pathogenic or diseases causing microorganisms. The consumption of unhygienic drinking water and uses of unsafe water for daily purposes lead to the prevalence of diseases among the population [27].

The maintenance of good water quality is essential for healthy survival of aquatic organisms and people's good health those who are exposed to this water. However, there are only a few published data on the microbiological quality of wetland water of these microorganisms in few areas around the country. Microbial communities play vital roles in decomposition of organic matter, remineralization of nutrients, and biogeochemical cycling in terrestrial and aquatic environments. Wetlands are unique ecosystems, and can act as ecotones between terrestrial and aquatic systems [28-29].

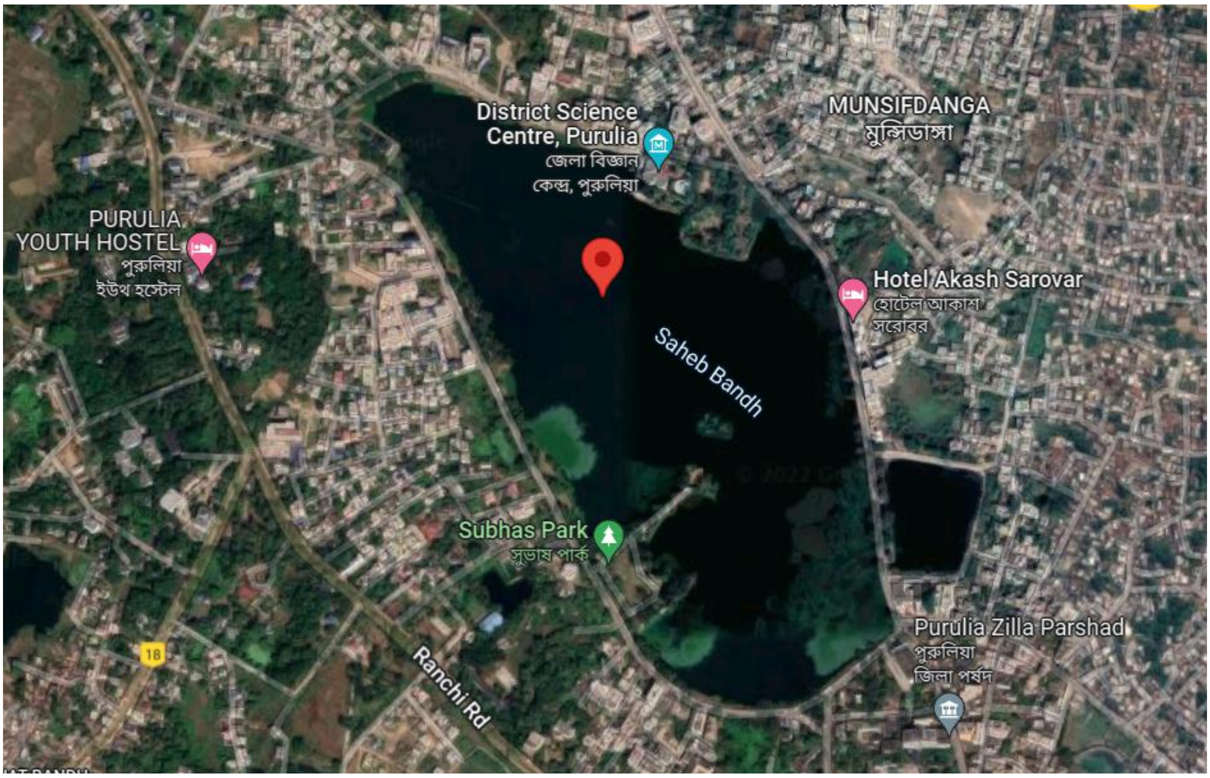
A few previous studies indicated that microbial community structure in wetlands was dependent on soil type [30-31), soil depth [30], carbon and nitrogen sources [32], vegetation

[33], and successional stage [34]. These previous studies focused on soil microorganisms in wetlands.
Bacteria acts as water quality indicators where it can be taken as an indication of fecal contamination of water and as an indication of the potential health risk that fecal contamination poses. The higher the level of indicator bacteria, the higher is the level of fecal contamination and greater the risk of water-borne diseases [11,35]. Aquatic environments determine the source of fecal contamination and essential for estimating the health risks associated with pollution, and identifying likely measures to remediate polluted waterways [8,11]. Inadequately treated human sewage or runoff from animal husbandries into streams or lakes along with many other factors including wastes from wild animals, variations in turbidity or water chemistry, algal blooms which increase bacterial load in the water bodies [11] are the sources of microbiological pollution.
For domestic as well as recreational purposes untreated surface water are still commonly used in many areas in developing countries [36], and the communities in the urban town Purulia and surrounding areas of the Lake Saheb Bandh are not exceptional one in West Bengal, India. It acts as an important source of drinking water to inhabitants of town Purulia 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. Sources of contamination in the water resource may involve direct rainfall, disposal of domestic wastes, municipal and medical wastes, and seepage from broken septic tanks, pit latrines and surface runoff water containing fecal matter causing undesirable change. Some communities surrounding the lake use it as a tourist center and for recreational purposes.
The objective of present study was therefore to investigate the incidence of coliform bacteria as indicators of contamination level in this typical urban lake ecosystem to establish if seasonal changes in climate affect these quality issues.

2. MATERIALS AND METHODS

2.1. Location and site description

The freshwater lake Saheb Bandh (Nibaran Sayar) is located at 23º29'42"N latitude and 86 º 21’37” E longitudes (Fig 1) situated at the center of the Purulia town in West Bengal. The land and water area of lake covers an area of ~ 110 acres [37] with mean depth of 4.8 ± 2 m [38]. The water is mainly used for domestic as well as drinking purposes under the administrative control of Purulia Municipal Corporation (PMC), and also being used for fishing, sports, recreational and cultural purposes throughout the year. It is an important wetland ecosystem for its biological diversity, aesthetic beauty and multipurpose features like bathing, washing, fishing, boating, swimming etc. Apart from the water spread area, its surrounding open landmass is also an integrated part of this lake ecosystem, which provides several cultural and recreational activities. Unfortunately, in spite of its environmental, recreational and aesthetic values it has received little attention in the past. The most noticeable threats to the wetland are domestic sewage from surrounding houses and nearby shops. There are small islands at the center of the lake and Subhas Park that plays an important role as the shelter and breeding ground of many migratory water birds and local non-migratory bird species.
Figure1. Lake Saheb Bandh (Nibaran Sayar) In Purulia District, West Bengal, India (Courtesy Google Earth)



2.2. Collection of Sample

Samplings were carried out at monthly intervals from March 2017 to February 2018, from ten selected spots (Figure 2) during morning hours, covering the entire water area of the lake. The entire study period was classified into three seasons representing summer (March 2017 – June 2017), monsoon (July 2017 – October 2017) and winter (November 2017 – February 2018). Water sample for bacteriological studies were collected in sterilized plastic (100 ml) bottles which were previously carefully cleaned, rinsed thoroughly with distilled water [39].

Figure 2. Map Showing Sampling Points/Locations

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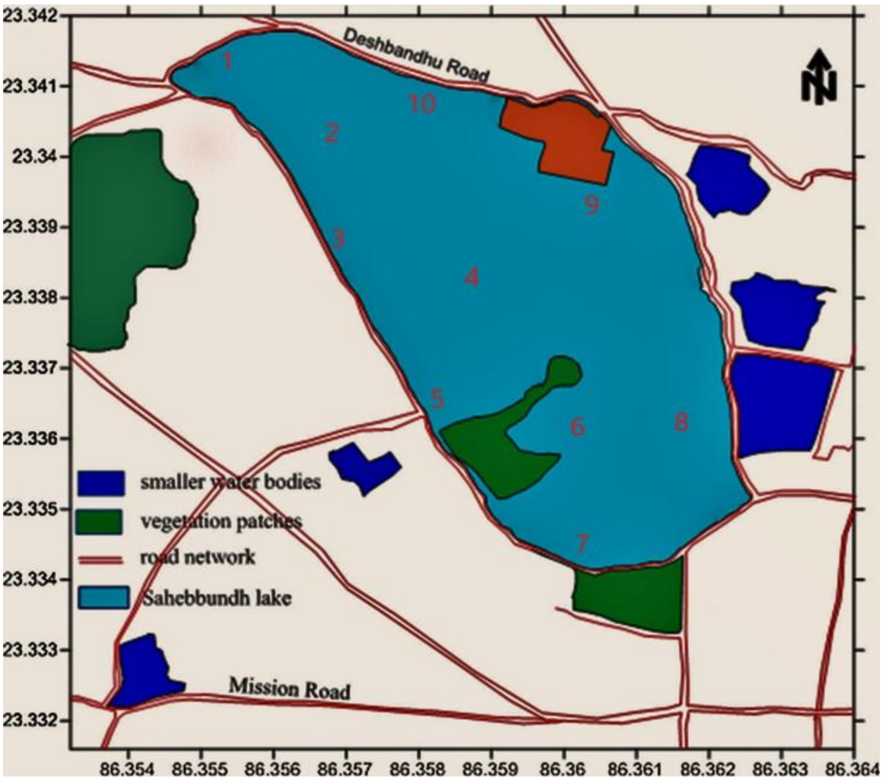


2.3. Coliform Count

Total aerobic and facultative bacteria were assessed by Standard Plate Count Method (SPC) using agar medium and inoculated at 37˚C. The enumeration of total coliform bacteria (TC) was done using multiple tube method. This method determines the presence of bacteria as well as most probable number (MPN) of total coliform by planting a series of measured quantities of water into test tubes containing culture media.

For fecal coliform, the measured amount of water samples was inoculated in lactose broth in similar way to total coliform and after incubation at 37˚C, positive tubes were later incubated at 44˚C for 48 hours. The probable number of fecal coliforms was calculated with a MPN table were followed as per standard method [39].

3. RESUTS

Table 1. Monthly variation of Total Coliform ($\times10^3$ MPN/100 ml) in different Station.

St. No.	Mar-17	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan-18	Feb
Stn.1	3.5	4.3	8	5	8.75	7.4	6.5	5	3	2.2	2	4.6
Stn.2	2.5	0.7	0.5	0.5	0.65	3.95	2	0.2	0.1	0.4	0.2	0.3
Stn.3	3.6	4	0.9	4	8.2	3	5	3	3	1.3	0.4	2.1
Stn.4	1.5	1.8	0.6	0.3	0.2	0.4	2.35	1.8	0.3	0.2	0.1	0.4
Stn.5	3	7.5	4.1	6	8.5	1.3	3.5	6.5	4	2.4	0.3	2.4
Stn.6	0.5	0.5	1.5	2.5	0.25	0.3	1.75	0.7	1.5	0.2	0.3	0.2
Stn.7	2.6	3.6	1.3	3.5	0.55	7	1.5	0.9	1.2	0.6	0.3	0.1
Stn.8	3.8	2	0.7	0.5	4	0.6	4	3	0.8	0.2	0.05	1.1
Stn.9	1.5	2.5	0.5	0.5	0.6	6	5	3.6	0.4	0.5	0.3	1.5
Stn.10	2	3	0.6	0.7	0.9	5	2	0.4	0.6	0.4	2.5	1.2

Table 2. Monthly variation of Fecal Coliform (×10^4 MPN /100 ml) in different Station.

St. No.	Mar-17	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan-18	Feb
Stn.1	1.3	0.2	1.1	0.2	0.35	1.5	0.5	0.2	0.65	0.7	0.1	0.05
Stn.2	0.1	0.2	0.05	0.1	0.05	0.05	0.15	0.05	0.075	0.1	0.01	0.03
Stn.3	1	0.2	0.15	0.2	0.1	0.2	1.4	0.1	0.08	0.15	0.01	0.04
Stn.4	0.1	0.1	0.15	0.01	0.15	0.1	0.25	0.01	0.08	0.01	0.01	0.02
Stn.5	0.4	0.1	0.05	0.05	0.05	1.3	0.2	0.6	0.05	0.1	0.1	0.1
Stn.6	0.2	0.1	0.01	0.01	0.1	0.05	0.1	0.3	0.01	0.01	0.01	0.02
Stn.7	0.05	0.2	0.05	0.05	1.3	0.1	0.6	0.05	0.05	0.1	0.3	0.03
Stn.8	0.2	0.4	0.1	0.2	0.5	0.2	0.9	0.15	0.15	0.15	0.3	0.01
Stn.9	0.75	0.8	0.2	0.2	0.2	1.25	0.4	0.1	0.2	0.25	0.05	0.8
Stn.10	0.34	0.55	0.15	0.3	0.2	0.4	0.7	0.2	0.225	0.3	0.2	0.1

Table 3. Analysis of bacteriological water quality originating from Saheb Bandh Lake using criteria given by Shafi *et al.*, 2013.

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

Figure 3. Seasonal variations of Total Coliform in Lake Saheb Bandh

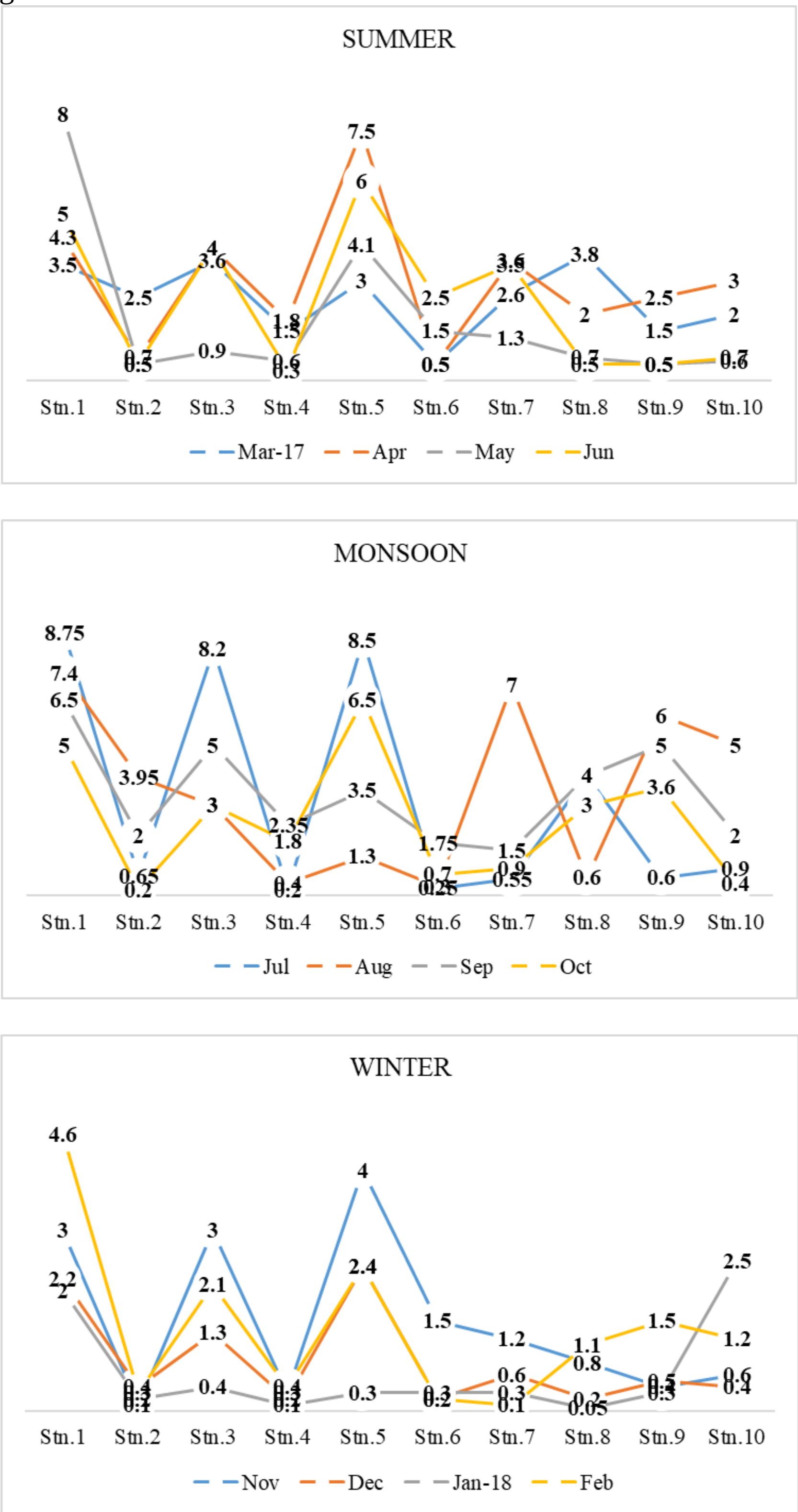
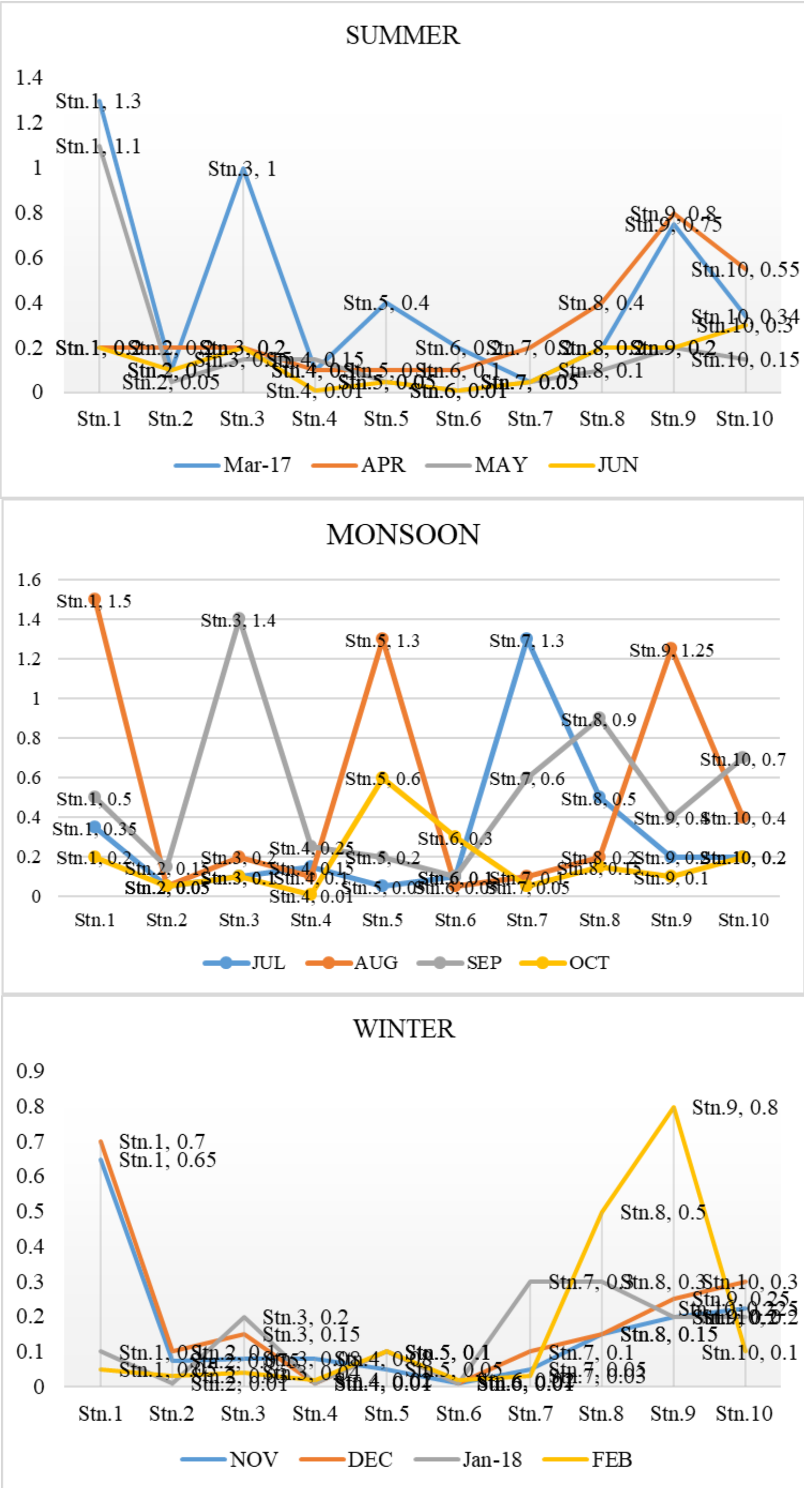


Figure 4. Seasonal variations of Fecal Coliform in Lake Saheb Bandh



All the water samples collected during the study period were showed positive results with respect to the coliform occurrence well above the permissible limits, though the counts were variable (Table 1 and 2). The data also reveals that the highest proportion of these indicator organisms was present at littoral site where anthropogenic activities taken place (Stn.1,3, 5, 7, 8, 9 and 10). Distribution of coliforms was highly variable with significant differences existing

between the sampling sites and the concentration ranged between 0.05×10^3 MPN/100 ml. and 8.75×10^3 MPN/100 ml. in TC whereas in FC it was ranged between 0.01×10^4 MPN/100 ml. and 5.65×10^4 MPN/100 ml.
For the Stn.1, maximum TC count (8.75×10^3 MPN/100 ml) was observed in July 2017, followed by minimum in January 2018 (2×10^3 MPN/100 ml) whereas, FC count maximum in month August 2017(1.5×10^4 MPN/100 ml) and minimum in February 2018(0.05×10^4 MPN/100 ml).
For Stn.2, maximum and minimum TC was observed in August 2017(3.95×10^3 MPN/100 ml) and November 2017 (0.1×10^3 MPN/100 ml) whereas FC count maximum in month April 2017(0.2×10^4 MPN/100 ml) and minimum in Jan 2018(0.01×10^4 MPN/100 ml).
For Stn.3, maximum TC was counted as 8.2×10^3 MPN/100 ml in July 2017 whereas minimum in January 2018(0.4×10^3 MPN/100 ml). FC count was maximum in the month September 2017(1.4×10^4 MPN/100 ml) but minimum (0.01×10^4 MPN/100 ml) during January 2018.
For Stn.4, maximum and minimum TC was observed in September 2017(2.35×10^3 MPN/100 ml) and January 2018 (0.1×10^3 MPN/100 ml) whereas FC count maximum in month September 2017(0.25×10^4 MPN/100 ml) and minimum (0.01×10^4 MPN/100 ml) during June, October, December and January 2018.
For Stn.5, maximum TC was counted as 8.5×10^3 MPN/100 ml in July 2017 whereas minimum January 2018(0.3×10^3 MPN/100 ml). FC count was maximum in the month August 2017(1.3×10^4 MPN/100 ml) but minimum (0.05×10^4 MPN/100 ml) during May, June, July, Nov 2017.
For Stn.6, maximum and minimum TC was observed in June 2017(2.5×10^3 MPN/100 ml) and December 2017 and February 2018 (0.2×10^3 MPN/100 ml) whereas FC count maximum in month October 2017(0.3×10^4 MPN/100 ml) and minimum in May, June, November, December and January 2018(0.01×10^4 MPN/100 ml).
For Stn.7, maximum TC count (7×10^3 MPN/100 ml) was observed in August 2017, followed by minimum in February 2018 (0.1×10^3 MPN/100 ml) whereas, FC count maximum in month July 2017(1.3×10^4 MPN/100 ml) and minimum in February 2018(0.03×10^4 MPN/100 ml).
For Stn.8, maximum TC was counted as 4×10^3 MPN/100 ml in July and September 2017 whereas minimum in January 2018(0.05×10^3 MPN/100 ml). FC count was maximum in the month September 2017(0.9×10^4 MPN/100 ml) but minimum (0.01×10^4 MPN/100 ml) during February 2018.
For Stn.9, the maximum concentration of TC (6×10^3 MPN/100 ml) was observed in August 2017 followed by minimum 0.3×10^4 MPN/100 ml in January 2018. FC count was maximum in the month August 2017(1.25×10^4 MPN/100 ml) but minimum (0.05×10^4 MPN/100 ml) during January 2018.
For Stn.10, the maximum and minimum TC was observed in August 2017(5×10^3 MPN/100 ml) and October and December 2017 (0.4×10^3 MPN/100 ml) whereas FC count maximum in month September 2017(0.7×10^4 MPN/100 ml) and minimum in February 2018(0.1×10^4 MPN/100 ml).
It was also found that counts of both TC and FC were highest during monsoon and summer months. It almost remained in same level throughout monsoon period and later dropped during winter season (Fig. 3 and 4).

4. DISCUSSION

In this study, total coliform (TC) and fecal coliform (FC) bacteria in freshwater Saheb Bandh Lake subjected to different levels of tourist disturbances, coupled with tourism industry, including sewage discharge from municipality, household discharge, runoff water from catchment area, and local activities, are the main anthropogenic perturbations.

Generally, coliform bacteria in the fresh water lake are not alarming for aquatic organisms but disease-causing bacteria which are pathogenic might pose a health threat to humans [40]. Extreme variations in bacterial count were found in all of the water samples collected from the Saheb Bandh Lake at the same time indicative for presence of variable population of coliform bacteria at different stations. However, comparatively higher counts were recorded at the littoral zones of the lake maybe due to interaction of autochthonous and terrigenous origin [41] and infiltration of water laden with organic matter [9].

Total coliforms can be indirectly associated with fecal pollution are used as indicators of microbiological water quality and are very important of treatment efficiency as well as indicators of decay bacterial after treatment [9,42-44]. Total coliforms which are used to evaluate the general quality of water, exceeded the WHO recommended acceptable limit in all of study sample [45]. The observed differences in the values of water quality indicators result from differences in the type of land use and intensity of touristic activity within the examined catchments [46-47]. The main source of water contamination may include either effluents from illegal discharge of untreated sewage from households or surface runoff carrying bacteria [47,48].

Smoroń and Twardy [46] reported that the effect of variable intensity of tourist movement on the quality of waters were significantly characterized by higher contamination with the concentration of fecal coliforms. According to Lenart-Boroń *et al*. [47], significant deterioration of water quality due to increased tourist traffic, resulting in growing number of illegal sewage discharge. Another important source of water contamination in the catchment area is related to natural processes, such as surface runoff and soil leaching [49].

Saheb Bandh Lake water quality showed significant deterioration in quality in view of global standards. All the samples of this lake water were contaminated with coliform bacteria, resulting mainly from anthropogenic activities, especially discharging of domestic wastes directly into the lake whereas some recent studies revealed that coliform count has positive relation with anthropogenic activities [11,49-50]. According to Shafi et al. [11] and Feng et al. [51], fecal bacterium which is found in the intestinal canal of man and warm-blooded animals is discharged with feces. "Traveller’s diarrhoea" causing by Enterotoxigenic *E. coli* (ETEC) in developing countries infecting only humans and transmission occurs through water and food contaminated with human waste [11]. The water samples revealed that maximum of samples was crossing the MPN index beyond permissible limit [22] indicating gross pollution of the lake and its transition towards eutrophic state of lake Saheb Bandh [52]. In the lake water samples high MPN values can be attributed to the surrounding runoff and sewage drained into the lake from the catchment area increasing the total coliform count of water bodies due to increased animal wastes [11,53]. The results of the present study draw support from the findings of Shafi et al. [11] and Sharma et al. [49] who worked on the bacterial indicators of fecal pollution of North Indian lakes and reported that the places with greater anthropogenic pressure experience a comparatively higher bacterial load.

High-water runoff and accelerated growth of microbes during summer are responsible for higher degradation of organic matter, which eventually reduced the dissolved oxygen concentration, thus making some water bodies more polluted. During monsoon, samples showed highest number of coliform organisms in the lake water may be due to initial monsoon runoff directing towards the lake from the surrounding areas [54]. Comparatively lower bacterial composition during winter is probably related to low water temperature, reduced loading of organic substrate from autocanthous and allocanthous sources reported by Saha et

al. [41]. During summer season increasing trends of organic substrate along with rising temperature might also play a great role to initiate bacterial population [41].
According to Shafi et al. [11], the category wise distribution of coliform count (Table 3) 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 lying in category III and 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. However, some patches of the lake were of poor quality and hence unfit for any use. Therefore, control measures must be implemented to minimize bacterial transport to natural systems.

5. CONCLUSION

Density of total coliform and fecal coliform bacteria in the lake water indicates that the water quality has deteriorated and is not fit for drinking purposes. Fecal contamination observed in the lake water may be due to open defecation practices followed as well as cattle wastes in the neighboring localities eventually finding their way into the wetland. It is further observed 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. However, the recent climate change for last five to six years have been changing the time of monsoon onset and duration in the region to a great extent which ultimately has also resulted in the change of seasonal bacterial population pattern in wet lands. Therefore, control must be implemented to minimize bacterial transport to such natural systems.

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