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Pollution Status with Reference to Microbiological Aspects of Upper Lake, Bhopal, India

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The most common problem associated with pollution of groundwater is due to the mixing of sewage resulting in the presence of pathogenic organisms and bacteria in groundwater. Bacteria are considered to be present every where in most of the biotic and abiotic components of atmosphere including under ground strata. Natural commodities such as air, water, soil and raw food items, essential for life, are usually contaminated with variety of bacterial species and some of which are pathogenic to human beings and other animals. Eight sampling station of Upper Lake were chosen of the year 2011 for the microbiological studies. The results reveal that the water of Upper Lake(Bhopal) is polluted in some stations and requires suitable measures to check it.

Key Words: Upper Lake, sewage, Bacteria, Biotic and Abiotic, Pathogenic, Human beings, Microbiological studies.

Water is the important natural source, which is abundant in nature and cover about 2/3rd of earth surface. However, only 1% of the water resource is available as fresh water (i.e., surface water, rivers, Lakes, streams, and ground water) for human consumption and other activities Water as already said is the basic and primary need of all vital life processes and it is now well established that the life first arose in aquatic environment. Ever since the pre-historic times man has been intimately associated with water and the evidences of past civilization that all historic human settlements were developed around inland freshwater resources have conclusively proved it. Even today it is the major consideration for all socio-economic cultural, industrial and technological developments. Besides drinking, water is also used for fish and aquaculture, irrigation hydropower generation etc. but these days water the elixir of life is becoming more and more unfit and dearer to mankind due to unwise use, neglect and mismanagement. Today water resources have been the most exploited natural systems. Pollution of water bodies is increasing steadily due to rapid population growth, industrial proliferation, urbanization, increasing living standard and wide share of human activities. The rapid urbanization has caused population explosion in urban centers and the generation of wastes both liquid and solid has grown to commendable proportions. The pace of development of waste disposal schemes could not match the rapid rate of urbanization in these urban centers during the last few decades. As a result the waste not properly disposed reaches the water sources and therefore our water sources like river, Lakes and reservoirs that are in close proximity of these urban centers are highly polluted.

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Most of our cities developed without proper development plan. Consequently sewage systems of these cities are not well planned. Therefore wastes of homes and industries mixed with the catchment areas of water by the fault sewage system.

Due to increase in generation of wastewater in the urban centers in Madhya Pradesh, only few class-1 cities have partial sewage collection and proper disposal facilities. Consequently, more than 90% of domestic wastewater is discharged through natural drainage, which pollutes the water bodies. It is estimated that more than 2/3rd of run-off available through rainfall is polluted by wastewater, rendering water unfit for various uses. Most of Lakes, tanks, ponds etc. are in the state of eutrophication. Thus availability of the utilizable water has declined sharply.

Bhopal city, the capital of the state of Madhya Pradesh, is endowed with several man-made Lakes created through the centuries.

The two Lakes (Upper and Lower Lake), that lie at the foot of the old city of Bhopal, are with notable features. There was originally only one Lake, which was held by the great dam that now separates the two Lakes built by a minister of Raja Bhoj of Dhar. The second dam which holds up the water of the Lower Lake was built in about 1794 by Chhote Khan, the minister of Nawab Hayat Mohammed Khan. The Kaliasote River also feed this Lake. Out of two Lakes, water from the Upper Lake is supplied for drinking purposes.

The Upper Lake, created in 11th century AD, and Lower Lake, created in the late 18th century AD, are by far the most important. The Upper Lake has special significance since it has been a source of piped water supply to the city of Bhopal for over 75 years. Even now, the Lake accounts for some 40% of the city's water supply. Until 1947 the water quality of Upper Lake was so good that it did not require any treatment before being supplied to the public. However, tremendous population growth of the city (about 70,000 in 1951 to about 1.4 million in 2001) and rapid urban development around Lower Lake and on the eastern and northern fringes of Upper Lake (especially during second half of the last century) subjected both the Lakes to various environmental problems resulting in deterioration of their water quality mainly due to inflow of untreated sewage. The Bhoj Wetlands of Bhopal comprises of the Upper Lake and the Lower Lake. These Lakes are of immense importance since they are inseparably linked with the socio, economical and cultural aspects of the people of Bhopal and are referred as lifelines of the city.

The Bacteriological study includes comparison of water quality parameters in different stations of the Upper Lake in various months in surface and Bottom waters during the year 2009.

East of the Lake	Fategarh
	Kamla Park
West of the Lake	Bhainsakheri
North of the Lake	Bairagarh
	Khanugaon
South of the Lake	Bhadbhada
	Sewania gond
Central point of the Lake	Takia Shah Ali Shah (Island)

Review of literature

Although the bacteriological studies of Lakes and rivers are a century old but researches in this aspect are very limited all over the world and microbiological or bacteriological studies of fresh water bodies with reference to water quality have received some attention in the last few decades, Panicker *et al*[1]., Lonsane *et al*[2]., Jones[3], Sastry *et al*.[4], Rai and Hill[5], Bagde and Verma[6], Kumar and Saha[7], Bhatnagar[8], Iqbal *et al*.[9-17]., Suratman[18], Husain *et al*.[20], Nazmul *et al*.[21], Kalkar *et al*.[22], Mahalakshmi *et al*.[25], Buhani[27], Kataria *et al*.[29], and Nighat *et al*.[30], Khasbage[31] have studied bacteriological periodicity, seasonal fluctuations and effects of some factors on their occurrence and pollution status of a water body.

According to Rai and Hil a high count of coliform bacteria is sufficient to condemn water for drinking and bathing purposes. Similarly, Crohurst[32] conducted bacteriological examinations of river Mississippi with special reference to pollution and suggested that under certain conditions it may be possible, in the absence of additional pollution to have actual measurable increase in bacteria between points on a stream due to an altered relationship between inhibitive and destructive forces and growth factors.

Taylor[33], Keller[34], Clark[35], Sastry *et al*. (loc cit), Agrawal *et al*[36]., Bagde and Varma (loc cit), Bhatnagar (loc cit), Kumar and Saha (loc cit) and several other bacteriologists have identified the coliform as indicators as indicators of pollutions

and eutrophication and dangerous for human health.

Kumar and Saha (*loc. cit.*) while working on the quality of water, being supplied for drinking purpose at Bhagalpur city, observed M.P.N. of coliform beyond the permissible limits and found it responsible for several water borne disease.

Bacteria are considered to be present every where in most of the biotic and abiotic components of atmosphere including under ground strata. The degree of bacterial contamination in air, water, soil and food including any liquid, solid, swab, biological and clinical samples can be determined by enumeration of test bacteria by several methods.

Since bacteria are microscopic organism these can be enumerated by microscopic and culture methods. Culture techniques require selective solid or liquid medium, incubation period, temperature and standard laboratory conditions, instruments and facilities necessary for the microbiological work. There are following commonly used culture methods for the enumeration of bacteria in different types of samples.

Methodology

Collection of sample

The sample should be collected in pre-sterilized bottles without rinsing, and with the stopper replaced immediately. Then aluminum foil wrapping should be there to protect the sample from contamination.

The multiple-tube method depends on the separate analysis of a number of volumes of the same sample. Each volume is mixed with culture medium and incubated. The concentration of microorganisms in the original sample can then be estimated from the pattern of positive results by means of statistical tables that give the "most probable number" per 100mL of original sample.

Table 1. Microbiology of Upper Lake, Bhopal (YEAR 2009)

Parameters Station	Month	Depth	Total Coliform	Fecal Coliform	Fecal streptococci
(West of the lake) Bhainsakheri	Jan	Surface	1500	750	430
		Bottom	2400	930	750
	Feb	Surface	2100	930	640
		Bottom	4400	1700	930
	Mar	Surface	2400	1200	640
		Bottom	3800	1700	750
	Apr	Surface	2100	1200	430
		Bottom	3800	1500	750
	May	Surface	1200	750	390
		Bottom	2400	930	640
	June	Surface	2400	1200	750
		Bottom	4400	2100	930
	July	Surface	1700	930	430
		Bottom	3800	1500	930
	Aug	Surface	1200	750	390
		Bottom	2400	1200	750
	Sep	Surface	1200	640	430
		Bottom	930	430	390
	Oct	Surface	1500	750	640
		Bottom	750	430	200
	Nov	Surface	640	390	210
		Bottom	930	750	430
	Dec	Surface	930	640	390
		Bottom	750	390	200

Table 2. Microbiology of Upper Lake, Bhopal (YEAR 2009)

Parameters Station	Month	Depth	Total Coliform	Fecal Coliform	Fecal streptococci
North of the lake (Bairagarh)	Jan	Surface	4600	2400	2100
		Bottom	4400	2100	1500
	Feb	Surface	4700	2400	2100
		Bottom	2400	1200	930
	Mar	Surface	3800	1700	1200
		Bottom	3800	1700	1200
	Apr	Surface	4600	2400	2100
		Bottom	11000	4400	2400
	May	Surface	24000	4700	3800
		Bottom	2400	1200	930
	June	Surface	2100	930	750
		Bottom	4700	2400	2100
	July	Surface	2400	1500	1200
		Bottom	2100	1200	640
	Aug	Surface	4700	1700	1500
		Bottom	3800	1700	1200
	Sep	Surface	2400	1200	930
		Bottom	4600	2100	1700
	Oct	Surface	4600	2400	1700
		Bottom	3800	1700	1200
	Nov	Surface	4700	2400	2100
		Bottom	11000	4400	2100
	Dec	Surface	3800	2100	1200
		Bottom	11000	4400	3800

Table 3. Microbiology of Upper Lake, Bhopal (YEAR 2009)

Parameters Station	Month	Depth	Total Coliform	Fecal Coliform	Fecal streptococci
North of the Lake (Khanugaon)	Jan	Surface	24000	24000	24000
		Bottom	4600	3800	1700
	Feb	Surface	11000	4600	2400
		Bottom	4700	2400	2100
	Mar	Surface	11000	4400	2400
		Bottom	4400	2400	1200
	Apr	Surface	11000	4600	1500
		Bottom	3800	2100	1200
	May	Surface	4600	2400	2100
		Bottom	4400	2100	1500
	June	Surface	4700	2400	2100
		Bottom	2400	1200	930
	July	Surface	3800	1700	1200
		Bottom	3800	1700	1200
	Aug	Surface	4600	2400	2100
		Bottom	11000	4400	2400
	Sep	Surface	24000	4700	3800
		Bottom	2400	1200	930
	Oct	Surface	2100	930	750
		Bottom	4700	2400	2100
	Nov	Surface	2400	1500	1200
		Bottom	2100	1200	640
	Dec	Surface	4700	1700	1500
		Bottom	3800	1700	1200

Table 4. Microbiology of Upper Lake, Bhopal (YEAR 2009)

Parameters Station	Month	Depth	Total Coliform	Fecal Coliform	Fecal streptococci
East of the Lake (Fategarh)	Jan	Surface	2400	1200	930
		Bottom	4600	2100	1700
	Feb	Surface	4600	2400	1700
		Bottom	3800	1700	1200
	Mar	Surface	4700	2400	2100
		Bottom	11000	4400	2100
	Apr	Surface	3800	2100	1200
		Bottom	11000	4400	3800
	May	Surface	24000	24000	24000
		Bottom	4600	3800	1700
	June	Surface	11000	4600	2400
		Bottom	4700	2400	2100
	July	Surface	11000	4400	2400
		Bottom	4400	2400	1200
	Aug	Surface	11000	4600	1500
		Bottom	3800	2100	1200
	Sep	Surface	4600	2400	2100
		Bottom	4400	2100	1500
	Oct	Surface	4700	2400	2100
		Bottom	2400	1200	930
	Nov	Surface	3800	1700	1200
		Bottom	3800	1700	1200
	Dec	Surface	4600	2400	2100
		Bottom	11000	4400	2400

Table 5. Microbiology of Upper Lake, Bhopal (YEAR 2009)

Parameters Station	Month	Depth	Total Coliform	Fecal Coliform	Fecal streptococci
East of the Lake (Kamla Park)	Jan	Surface	24000	4700	3800
		Bottom	2400	1200	930
	Feb	Surface	2100	930	750
		Bottom	4700	2400	2100
	Mar	Surface	2400	1500	1200
		Bottom	2100	1200	640
	Apr	Surface	4700	1700	1500
		Bottom	3800	1700	1200
	May	Surface	2400	1200	930
		Bottom	4600	2100	1700
	June	Surface	4600	2400	1700
		Bottom	3800	1700	1200
	July	Surface	4700	2400	2100
		Bottom	11000	4400	2100
	Aug	Surface	3800	2100	1200
		Bottom	11000	4400	3800
	Sep	Surface	24000	24000	24000
		Bottom	4600	3800	1700
	Oct	Surface	11000	4600	2400
		Bottom	4700	2400	2100
	Nov	Surface	11000	4400	2400
		Bottom	4400	2400	1200
	Dec	Surface	11000	4600	1500
		Bottom	3800	2100	1200

Table 6. Microbiology of Upper Lake, Bhopal (YEAR 2009)

Parameters Station	Month	Depth	Total Coliform	Fecal Coliform	Fecal streptococci
South of the Lake (Bhadbada)	Jan	Surface	2100	750	430
		Bottom	2400	930	640
	Feb	Surface	3800	1200	750
		Bottom	1500	750	430
	Mar	Surface	2400	930	750
		Bottom	2100	930	640
	Apr	Surface	4400	1700	930
		Bottom	2400	1200	640
	May	Surface	3800	1700	750
		Bottom	2100	930	390
	June	Surface	4400	2100	930
		Bottom	1500	750	430
	July	Surface	3800	1700	1200
		Bottom	2100	1200	640
	Aug	Surface	3800	2100	930
		Bottom	2100	930	430
	Sep	Surface	4400	1700	1200
		Bottom	2100	930	640
	Oct	Surface	2400	1200	930
		Bottom	1500	930	390
	Nov	Surface	2400	1200	640
		Bottom	2100	930	390
	Dec	Surface	4400	2100	930
		Bottom	1500	750	430

Table 7. Microbiology of Upper Lake, Bhopal (YEAR 2009)

Parameters Station	Month	Depth	Total Coliform	Fecal Coliform	Fecal streptococci
South of the Lake (Sewania Gond)	Jan	Surface	3800	1700	1200
		Bottom	2100	1200	640
	Feb	Surface	3800	2100	930
		Bottom	2100	930	430
	Mar	Surface	4400	1700	1200
		Bottom	2100	930	640
	Apr	Surface	2400	1200	930
		Bottom	1500	930	390
	May	Surface	2400	1200	640
		Bottom	2100	930	750
	June	Surface	3800	1700	1200
		Bottom	2100	1500	930
	July	Surface	4400	2100	1700
		Bottom	2100	1200	640
	Aug	Surface	3800	1500	750
		Bottom	930	640	200
	Sep	Surface	640	430	110
		Bottom	930	750	240
	Oct	Surface	930	750	110
		Bottom	750	430	100
	Nov	Surface	1200	930	240
		Bottom	750	390	210
	Dec	Surface	640	240	200
		Bottom	930	430	390

Table 8. Microbiology of Upper Lake, Bhopal (YEAR 2009)

Parameters Station	Month	Depth	Total Coliform	Fecal Coliform	Fecal streptococci
Central Point of the Lake	Jan	Surface	4700	2400	2100
		Bottom	2400	1500	1200
	Feb	Surface	2100	1200	640
		Bottom	4700	1700	1500
	Mar	Surface	3800	1700	1200
		Bottom	2400	1200	930
	Apr	Surface	4600	2100	1700
		Bottom	4600	2400	1700
	May	Surface	4700	2400	2100
		Bottom	11000	4400	2400
	June	Surface	4400	2400	1200
		Bottom	11000	4600	1500
	July	Surface	3800	2100	1200
		Bottom	4600	2400	2100
	Aug	Surface	4400	2100	1500
		Bottom	4700	2400	2100
	Sep	Surface	2400	1200	930
		Bottom	11000	4400	2400
	Oct	Surface	24000	4700	3800
		Bottom	2400	1200	930
	Nov	Surface	2100	930	750
		Bottom	4700	2400	2100
	Dec	Surface	2400	1500	1200
		Bottom	2100	1200	640

DISCUSSION

Station - 1 (Bhaisakheri)

This sampling station has a major inflow channels. Prominent fluctuation in different parameters has been observed during monsoon and winter seasons. The western part of the Lake has a wide spread catchment area, which accumulates the water in the Lake through Kolans River.

Microbiological Aspects

Moderately high count for total coliform was recorded in the year 2009 indicative of a better situation than the previous year. On the other hand low count was recorded in the summer season showing the killing effect of high temperature of the surface bacteria.

Station - 2 (Bairagarh)

This station is located near the Sehore Nalla, which has one of the major inlets that remain active through out the year.

Microbiological Aspects

Throughout the year 2009 the counts recorded were maximum indicative if a highly polluted station, which is further supported by a high value of BOD, phosphate and nitrate at the station.

Station - 3 (Khanugaon)

Alike to station-2, this station is also grossly polluted with domestic sewage which is being added to the Lake through adjoining *nallas*. This area is also affected by the cattle activities (particularly buffaloes) and anthropogenic interference, which disturb Lake ecosystem.

Microbiological Aspects

In the year 2009 comparably a moderately high count was recorded. No remarkable changes were observed.

Station - 4 (Fategarh)

Microbiological Aspects

A high count was recorded in the month of February, March, April and August in both the years. The higher count in the summer season is the indicative of the anthropogenic activities during this season. In rest of the months of the year a low count was recorded.

Station - 5 (Kamla Park)

This station is subjected to maximum exposure of anthropogenic activities. High density of algal biomass (particularly Microcystis

aeruginosa) is recorded at this station. This is the major site of Idol immersion activities. Recently, the idol immersion activity at this site has been reduced after developing Prempura Ghat particularly for immersion activity. However, the accumulated silts and nutrients have their impact over the years.

Microbiological Aspects

Throughout the year 2009 the counts were high. The highest counts were recorded in the month of September, October and November indicative of the anthropogenic disturbances during these months due to the Idol Immersion activity. In rest of the months, a moderately high count on the other hand is the indicative of the bathing activity on the catchment area and the disposal of the worshiping material.

Station - 6 (Bhadbhada) –

At this station, the water quality parameters depicted considerable fluctuations in various parameters.

Microbiological Aspects

The high count of the coliform in the monsoon period can be correlated to the higher concentration of phosphate, nitrate and BOD.

Station - 7 (Sewania Gond)

This station is highly influenced by anthropogenic and cattle activities. The run-off from the catchment area adds of nutrients to the Lake. The region is covered with high density of emergent / submerged macrophytes.

Microbiological Aspects

The presence of higher values of total coliform may be because of animal activities since the area is influenced by cattle activities (Buffaloes). During the year 2007 a high count was recorded in the month of January which is supported by the high BOD and phosphate concentration during this period.

(Central Part of the Lake)

The deeper zone of the Lake depicted almost similar characteristics in various water quality parameters.

Microbiological Aspects

These zones being the reference zone are least disturbed by the anthropogenic activity a low count of coliform was recorded throughout the tears 2009. A moderately high count was recorded during the monsoon period.

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