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Microbiological status of Dal-Nigeen Lake, related to organic loading

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Abstract

The Research and monitoring division of lakes and waterways development Authority is working in the field of research in terms of Physico-chemical, biological, microbiological, and hydrological studies carried for different basins viz Nehrupark, Nishat, Hazrat Bal, and Nigeen basins. It also carries the study on the sediment load of inflows into the lake. The study regarding the microbiological status of the Dal Lake was carried by this division to know the effects of sewage going into the lake.

Keywords: - *Eutrophication, Fecal coliform, Total coliform, fecal matter, E.Coli.*

Introduction

Location= Srinagar, Jammu and Kashmir
Coordinates= *34.07'N, 74.52'E, 34.117.N, 74.867.E*
Lake type= Warm monomictic
Primary inflows= Inflow Channel Telbal, Bota kul, pishpaw, Meerakshah Nallah. **Primary outflows=** Regulated, two channels (Dal Gate and Nalla Amir Khan) - 275.6 MCM
Catchment area= 316 square kilometres (122 sq mi)
Max. Length= 7.44 km (4.62 mi)
Max. Width = 3.5 km (2.2 mi)
Surface area = 18 to 22 square kilometres (6.9 to 8.5 sq mi)
Average depth = 1.42 metres (4.7 ft)
Max. Depth = 6 m (20 ft) Nigeen centre
Water volume = 983 MCM
Residence time = 22.16 days
Shore length1 = 15.5 km (9.6 mi)
Surface elevation = 1,583 m (5,190 ft)
Frozen = during severe winter
Islands = Two (Sona Lank and Rupa Lank (or CharChinari)

Settlements = Hazratbal, Srinagar

Summery

The lake is a natural wetland, covers 21.1 square kilometers (8.1 sq mi), with floating gardens or otherwise 18 square kilometers (6.9 sq mi). Floating gardens are known as Rad in Kashmiri, which flower with lotus blooms during July and August, provides a delightful setting to the lake. It is divided by causeways into four basins, called Nehru park, Nishat, Hazratbal, and Nagin, though Nagin is also considered an independent lake. Nishat and Hazratbal basins have an island each in the center, known as Rup Lank (or Char Chinari) and Sona Lank, respectively.

The lake is in the foothill formations of the catchment of the Zabarwan mountain valley, a subsidiary of the Himalayan range, which surrounds it on three sides. It lies to the east and north of Srinagar city and is integral to the city. The catchment area drained by the basin is 316 square kilometers (122 sq mi). The surface area of the lake is 18 square kilometers (6.9 sq mi) normally, but with floating gardens of lotus blooms, it is 21.2 square kilometers (8.2 sq mi) (an estimated figure of 22 to 24 square kilometers (8.5to9.3 sq mi) is also mentioned).

The main basin draining the lake is a complex of five interconnected (with causeways) basins, namely, the Nehru Park basin, the Nishat basin, the Hazratbal basin, the Nagin basin, and the Barari Nambal basin. Navigational channels provide transportation links to all five basins.

The average elevation of the lake is 1,583 meters (5,190 ft). The depth of water varies from 6 meters (20 ft) at its deepest in Nagin lake to 2.5 meters (8.2 ft), the shallowest at Gagribal. The depth ratio between the maximum and minimum depths varies with the season between 0.29 and 0.25, which is interpreted as a flat bed slope.

Hydrology

The lake is categorized as shallow, and an open-drainage is fed by Dachigam-Telbal Nallah (with the perennial flow), Dara Nallah (Nallah means stream), and many other small streams. Based on its thermal behavior, the lake has been typing cast as warm monomictic under the sub-tropical lake category. Spring sources are also mentioned as contributors to the flow though no specific data is available to quantify its contribution. The complex land use pattern of the valley is reflected in the urbanized Srinagar in its north, rice fields, orchards and gardens in the lower slopes, and barren hills beyond steep sloping hills. Flat topography also accentuates the drainage conditions. It receives an average annual rainfall of 655 millimeters (25.8 in) in the catchment that occurs during summer and also in the winter season. During the summer, snowmelt from the higher ranges of the catchment results in large inflows into the lake. The flow assessments have been made by water balance studies with an approximation of the discharge contributed by the springs in the lake bed. The maximum flood discharge is of Telbal Nallah, a crucial parameter for hydraulic design has been assessed as 141.5 m3/s for a one in hundred return period; the 1973 observed flood in Telbal Nallah has been estimated as 113 m3/s. The average annual flow, as per actual discharge measurements, has been estimated as 291.9 million cubic meters (MCM), with Telbal Nalah accounting for 80% contribution and the balance 20% is contributed by other sources. There are two outlets from the lake, namely, Dalgate and Amir Khan Nallah (that connects Nagin and Anchar lakes); Dal gate is controlled by a weir and lock system. The outflow from these two outlets has been estimated as 275.6 MCM. Further, the silt load has been estimated at 80,000 tonnes per year with 70% contribution from the Telabal nallah, out of which the amount that settles in the lake is assessed to be 36,300 tonnes.

Encroachments of water channels and consequent clogging resulted in reduced circulation Inflow into the lake has reduced Extensive weed growth and the consequent change in the bio-diversity in the lake on account of Nutrient enrichment of the lake water and the sediment deposit.

Study area

The biological quality of water is determined by testing it for the coliform group of bacteria. These organisms are found in the intestinal tract of warm-blooded animals and in soil. Their presence in water indicates pathogenic contamination, but they are considered pathogens. The standard for coliform in drinking water is “less than one coliform colony in 100ml of sample” (<1/100ml).

The presence of total coliform and fecal coliform at different sites shows the contamination of lake waters and reflects the poor hygienic practices by the local residents, fishermen, and farmers. The possible source of contamination is men, other animals, and the environment, the man playing a major role. Surface runoff from the catchment area also accounts for the input of coliform into the lake.

Most of the inhabitant colonies within the lake do not have proper toilet systems, and even some colonies (Fisherman colony Hazrat Bal) have their latrines falling directly into the lake, thus adding to the fecal contamination of the lake.

No doubt, the in-depth microbiological study is needed to study the behavior of the lake ecosystem, but it is strongly recommended that proper steps should be taken to educate the people living within the lake and on the periphery of the lake regarding their hygiene and sanitation of their homes and surroundings.

It is also recommended that lake waters should get proper flushing through its different exits throughout the year.

These recommendations are based on the fact as observed from the samples analyzed from the lake. The results clearly show a greater influx of bacterial contamination where the population density was found to be higher (Mir mohalla) or where the human influence was more in some or the other way, which includes washing of clothes on the banks of the lake (Dhobi ghat Hazratbal) or the inflow of tourists like Charchinari. Due to the tourist houseboat at charchinari microbial count has risen as the boat throws its waste directly into the lake, thus adding organic waste to the lake.

Mir mohalla, which represents the backwaters of the lake, is the most polluted site of the lake as far as bacterial contamination is considered.

It should be noted that the total coliform includes species that may inhabit the intestines of warm-blooded animals or occur naturally in soil, vegetation, and water. They are usually found in fecally polluted waters and are often associated with disease outbreaks. E.coli. one of the species of the coliform group, is always found in feces and is, therefore, a more direct indicator of fecal contamination and the possible presence of enteric pathogens.

Keeping the above facts in consideration, the inflow of fecal contamination into the lake should be stopped.

Methodology

Scope and Application

This test method describes a sensitive and differential membrane filter (MF) medium, using MFC broth and M ENDO broth, for the simultaneous detection and enumeration of both total coliforms (TC) and Escherichia coli (E. coli) in water samples in 24 hours or less on the basis of their specific enzyme activities.

Total coliforms include species that may inhabit the intestines of warm-blooded animals or occur naturally in soil, vegetation, and water. They are usually found in fecally-polluted water and are often associated with disease outbreaks. Although they are not usually pathogenic themselves, their presence in drinking water indicates the possible presence of pathogens. E. coli, one species of the coliform group, is always found in feces and is, therefore, a more direct indicator of fecal contamination and the possible presence of enteric pathogens. Since a wide range of sample volumes or dilutions can be analyzed by the MF technique, a wide range of E. coli and TC levels in water can be detected and enumerated.

Summary of Method

An appropriate volume of a water sample (100 mL for drinking water) is filtered through a 47-mm, 0.45-µm pore size sterilized cellulose ester membrane filter that retains the bacteria present in the sample. The filter is placed on a 1-2 mL plate of MFC broth and on an absorbent pad for fecal coliform and with 1-2 ml of M-endo broth for total coliform, and the plate is incubated at 35°C for up to 24 hours. The bacterial colonies that grow on the plate are inspected for the presence of blue color and pink color for fecal coliform and total coliform colonies, respectively.

Definitions

Fecal coliforms: - In this method, FC is those bacteria that produce fluorescent colonies upon exposure to long-wave ultraviolet light (366nm) after primary culturing on MFC broth. The colonies formed are blue in color.

Total coliforms: - In this method, TC colonies are produced after culturing on M endo Broth, and the colonies formed are pink in color.

Interferences and Contamination.

Water samples containing colloidal or suspended particulate material can clog the membrane filter, thereby preventing filtration or cause the spreading of bacterial colonies, which could interfere with the identification of target colonies. However, the blue E .coli colonies can often be counted on plates with heavy particulates or high concentrations of total bacteria.

The presence of some lateral diffusion of blue color away from the target E .coli colonies can affect enumeration and colony picking on plates with high concentrations of E .coli. This problem should not affect filters with low counts, such as those obtained with drinking water or properly diluted samples.

Tiny, flat, or peaked pinpoint blue colonies (# 0.5-mm in diameter on filters containing # 200 colonies) may be due to species other than E .coli. These colonies occasionally occur in low numbers and should be excluded from the count of the

E .coli colonies, which are usually much larger in size (1-3-mm in diameter). The small colonies have never been observed in the absence of typical E .coli, but if such should occur, the sample should not be considered E .coli -positive unless at least one colony has been verified by another method.

Safety

The analyst/technician must know and observe the normal safety procedures required in a microbiology laboratory while preparing, using, and disposing of cultures, reagents, and materials and while operating sterilization equipment.

Mouth-pipetting is prohibited.

Avoid prolonged exposure to longwave or germicidal ultraviolet light.

Autoclave all contaminated plates and materials at the end of the analysis.

Equipment and Supplies used.

1. Incubator set at 35°C ± 0.5°C, with approximately 90% humidity, if loose-lidded Petri dishes are used.
2. Stereoscopic microscope, with a magnification of 10-15x, wide-field type.
3. A microscope lamp producing diffuse light from cool, white fluorescent lamps adjusted to give maximum color.
4. Pipette container of stainless steel, aluminum, or Pyrex glass, for pipettes.
5. Graduated cylinders (100-mL for drinking water), covered with aluminum foil or kraft paper and sterilized.
6. Membrane filtration units (filter base and funnel), glass, plastic, or stainless steel. These are wrapped with aluminum foil or kraft paper and sterilized.
7. Line vacuum, electric vacuum pump, or aspirator is used as a vacuum source. In an emergency, a hand pump or a syringe can be used. Such vacuum-producing devices should be equipped with a check valve to prevent the return flow of air.
8. Forceps, straight (preferred) or curved, with smooth tips to permit easy handling of filters without damage.
9. Alcohol, 95% ethanol, in small wide-mouthed vials, for sterilizing forceps.
10. Bunsen or Fisher-type burner or electric incinerator unit.
11. Membrane Filters (MF), white, grid-marked, cellulose ester, 47-mm diameter, 0.45 µm ± 0.02-µm pore size, pre-sterile or sterilized for 10 minutes at 121°C (15-lb pressure).
12. Indelible ink marker for labeling plates.
13. Petri dishes, sterile, plastic, 9 x 50 mm, with tight-fitting lids, or 15 x 60 mm, glass or plastic, with loose-fitting lids; 15 x 100 mm dishes may also be used.

Reagents and Standards

Purity of Reagents: Reagent-grade chemicals shall be used in all tests. Unless otherwise indicated, reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society. The media/broth used for the particular studies were of Hi-Media, which are mentioned as below:

1. MFC Broth for fecal coliform is culturing.
2. M Endo Broth for total coliform is culturing.

Sample Collection, Preservation, and Storage

Water samples are collected in sterile polypropylene sample containers with leak-proof lids.

Storage Temperature and Handling Conditions: Ice or refrigerate water samples at a temperature of 1-4°C during transit to the laboratory. Use insulated containers to assure proper maintenance of storage temperature. Take care that sample bottles are not totally immersed in water from melted ice during transit or storage.

Holding Time Limitations: Analyze samples as soon as possible after collection. Drinking water samples should be analyzed within 30 h of collection. Do not hold source water samples longer than 6 h between collection and initiation of analyses, and the analyses should be complete within 8 h of sample collection.

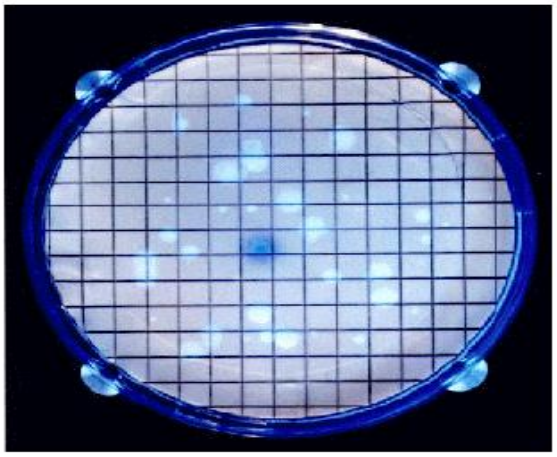
Calculate the final values using the formula:

E. coli/100 ml =

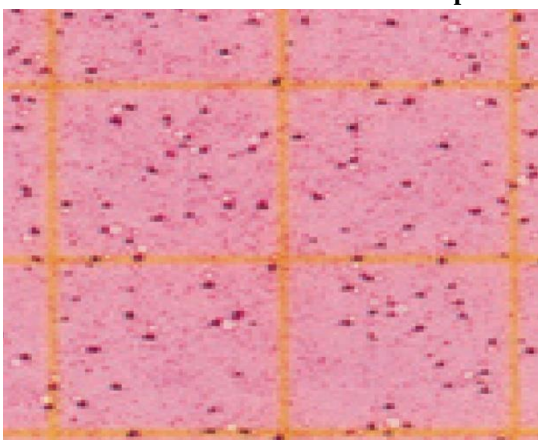
$$\frac{\text{Number of blue colonies}}{\text{Volume of sample filtered (ml)}} \times 100$$

Total coliform /100ml=

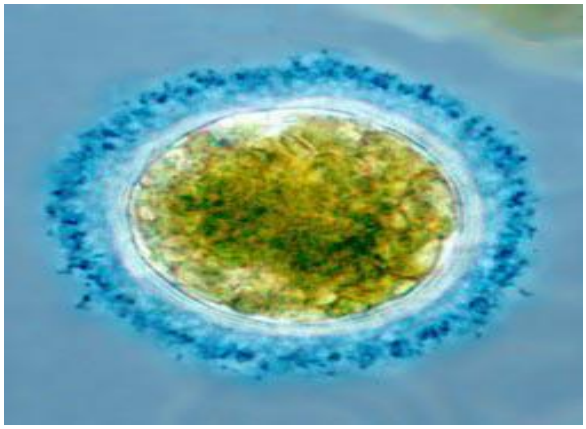
$$\frac{\text{Number of Pink colonies}}{\text{Volume of sample filtered (ml)}} \times 100$$



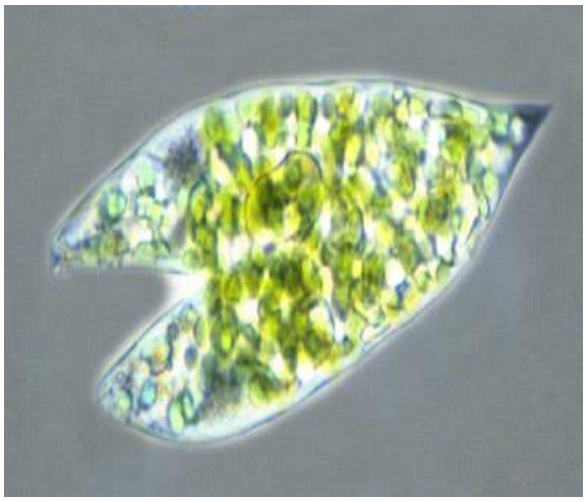
Cultured fecal coliform colonies on a plate



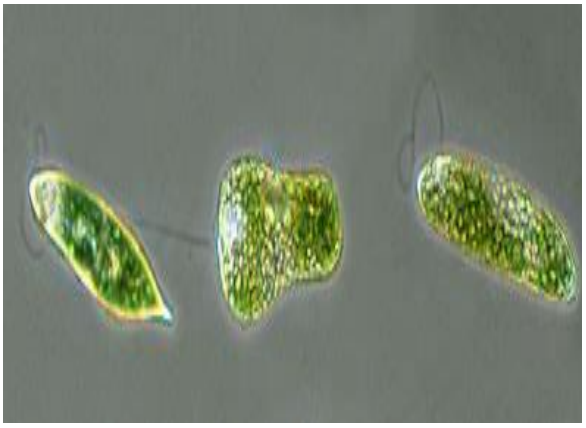
Cultured total coliform colonies on plate.



EUGLENA IN DORMANT STAGE UNTIL IT GETS SUITABLE ENVIRONMENT



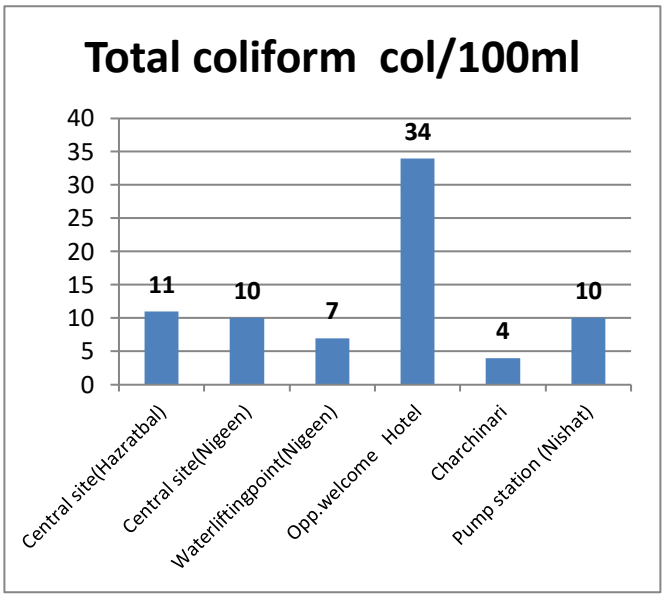
Dividing bacteria (Euglena)



Photographs showing how easily bacteria can alter their shape

Average microbiological status of selected sites from Dal and Nigeen Lake for the year 2010.

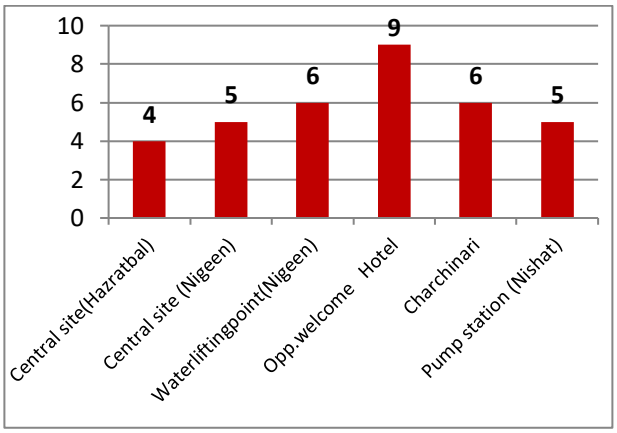
Year→►	**2010**	
Site↓	**Fecalcoli form** col/100ml	**Total coliform** col/100ml
Central site(Hazratbal)	**4**	**11**
Central site(Nigeen)	**3**	**10**
Waterliftingpoint(Nigeen)	**4**	**7**
Opp.welcome Hotel	**22**	**34**
Charchinari	**2**	**4**
Pump station (Nishat)	**8**	**10**



Graphical representation of total coliform count Col/100ml for the year 2010.

Average microbiological status of Dal and Nigeen Lake for the year 2019.

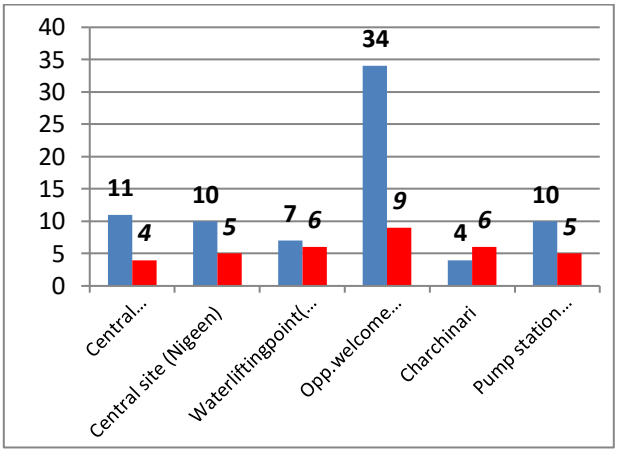
Year→▶	2019	
Site↓	Fecal coli form col/100ml	Total coliform col/100ml
Central site(Hazratbal)	2	4
Central site (Nigeen)	3	5
Waterliftingpoint(Nigeen)	8	6
Opp.welcome Hotel	6	9
Charchinari	2	6
Pump station (Nishat)	2	5



Graphical representation of total coliform count Col/100ml for 2019.

Comparison of microbial status of Dal and Nigeen Lake for the years 2010 and 2019.

Site	2010 (T.C)	2019 (T.C)
Central site(Hazratbal)	11	4
Central site (Nigeen)	10	5
Waterliftingpoint(Nigeen)	7	6
Opp. Welcome Hotel	34	9
Charchinari	4	6
Pump station (Nishat)	10	5

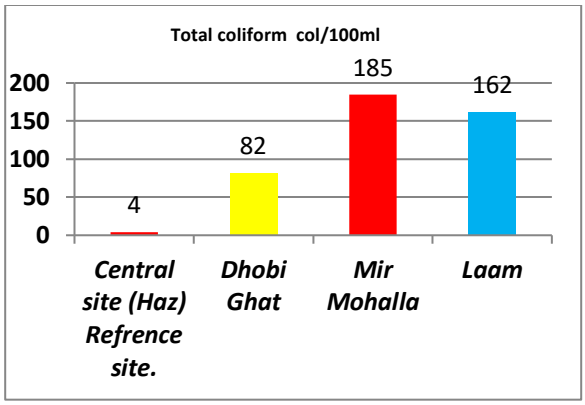


Graphical representation of total coliform count for the years 2010 and 2019.

In addition to the above sites, which mostly represent the health of the lake few sites which are under tremendous pressure of eutrophication due to the population residing inside the lake and their sewage load, which directly goes into the lake, were put under observation. The sites selected for knowing the bacterial load are Dhobi Ghat, Mir Mohalla, and laam. Out of the above three sites, laam is the site that is often hit by blooms.

Average Microbiological comparison of the sites which are under pressure of sewage with reference site (Hazratbal central) for the year 2019.

Year→▶	2019	
Site↓	Fecalcoli form col/100ml	Total coliform col/100ml
Central site (Haz) Reference site.	2	4
Dhobi Ghat	52	82
Mir Mohalla	125	185
Laam	102	162



The above graph shows a clear difference in the coliform count of pressured sites when compared with the Reference site. Thus indicating the organic as well as the fecal load at the particular pressured sites.

CONCLUSION

The above study revealed that Dal Lake is free from industrial waste but has a good amount of domestic waste load. The main representative sites of the lake, i.e., open water expanse, were selected as reference sites. Usually, the microbial count in the reference sites is well within the accepted norms, whereas at other sites, the data shows fluctuations with the increase and decrease in temperature. This shows that the lake is threatened by the high influx of organic waste, rapid shallow-up, and pathogenic contamination. In order to control the problems of eutrophication, Lake shallowing, and microbial contamination, health education and training programs for fishermen and dwellers in general on proper hygienic practices should be emphasized. The government should enforce Laws on proper land-use practices, particularly for lakeshore inhabitants, to avoid farming and livestock rearing in the vicinity of the lake.

Recommendations

1. Connectivity of houseboats within the Nigeen Lake to the nearest IPS.
2. Removal of fisherman colony from Hazratbal basin of the lake near NIT.
3. Stopping of washing activity from Dhobi ghat Hazratbal.
4. Diversion of the outfall of Hazratbal STP to nearest wetland. The site, which is at the immediate outfall of the STP Hazratbal, is showing an alarming increase in the microbial count.

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