The use of microbiological monitoring to assess the impact of the anthropogenic influence on the ecosystem of Lake Baikal

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Abstract. We present the data on the assessment of the hygiene microbiological state in the water area of Lake Baikal and the estuaries of its tributaries in 2016, 2017 and 2018 based on the standards adopted in the Russian Federation. Deep Baikal water, in general, meets the standards applied to assess the water to be used as drinking water supply. Monitoring of the surface layer has shown the most favourable quality of the water from the pelagic zone of the lake in 2017 with the minimum abundance and occurrence of hygiene indicator bacteria. The pelagic water meets the standards adopted in the Russian Federation for surface waters. Assessment of water quality has identified the maximum number of the opportunistic bacteria at the estuaries of the Baikal rivers. The non-standard samples are from the estuaries of the rivers Snezhnaya, Goloustnaya, Buguldeika, Anga, Kuchulga, Sarma, Turka, Barguzin, and Kichera. In 2018, the Snezhnaya River had the greatest anthropogenic load. Monitoring the Angara source by hygiene bacteriological characteristics showed maximum values in July and August 2019 for all groups of microorganisms.

1. Introduction
The problem of clean water resources is increasingly relevant each year. Currently, ecological conditions of freshwater bodies, the main sources of drinking water, are deteriorating worldwide due to anthropogenic impact, which leads to the disruption of the evolutionary microbiocenoses as well as the development of pathogenic and opportunistic bacteria [1-4]. Lake Baikal, one of the world’s largest freshwater body (23000 km²) with 20% of the world’s water reserves, has a diverse flora and fauna, 60% of which are endemic. In 1996, it was listed as a UNESCO World Heritage Site. The lake water is low mineralized (~ 96 mg/l), with low concentration of organic matter (total phosphorus is 5-15 µg/l and nitrate nitrogen is 0.06-0.14 mg/l) and high oxygen concentration (9.5-14.5 mg/l) [5]. The researchers from Institute of Geochemistry have been monitoring the chemical composition of the water from the Angara source for more than 70 years [6]. In the coastal areas of Lake Baikal, allochtonic microorganisms, including those potentially hazardous to human health enter the water body [7-10]. Since 2011, there are large-scale changes in the littoral zone of Lake Baikal, among which mass death of sponges, intensive development of filamentous algae and toxic cyanobacterial bloom are the most evident [11-14]. Notably, there is a many-fold increase in the number of tourists on the shore of Lake Baikal, which reached 2.2 million people in 2015, due to the active development of the infrastructure, in particular, the hotel sector. Now, on the lakeshore, there are more than 40
zones of recreational use, accumulating the bulk of tourist accommodation facilities [15]. In this regard, it is important to conduct microbiological monitoring of the waters that the population uses as sources of domestic, recreational and drinking water supply.

In the Russian Federation (RF), the standard SanPiN 2.1.5.980-00 “Hygienic requirements for the protection of surface waters” regulates the quality of surface waters. The mandatory characteristics are as follows: coliform bacteria (CB, less than 500 CFU/100 ml) – an indicator of the water quality; thermotolerant coliform bacteria (TCB, less than 100 CFU/100 ml) and coliphages (CPh, less than 10 PFU/100 ml) – indices of the faecal contamination degree. If a water sample does not comply with at least one characteristic, it is considered non-standard. The recommended characteristics according to the instructions MUK 4.2.1884-04 are as follows: enterococci (Ent, less than 50 CFU/100 ml) and self-cleaning coefficient (SCC, more than 4). SCC less than 4 indicates a low self-cleaning ability of a water body and pollution from domestic wastewater. The Ent abundance above the norm suggests the influx of fresh faecal contamination and potential epidemiological risk. Directive 2006/7/EC strictly regulates the number of enterococci in bathing waters.

This study is aimed to assess the quality of pelagic waters in Lake Baikal, its tributaries and the Angara source by hygiene microbiological indicators from 2016 to 2018.

2. Models and methods
The water samples were taken during fieldworks onboard research vessels of the Limnological Institute fleet equipped with a microbiological laboratory and a modern the bathometer rosette sampler (SBE 32 Carousel Water Sampler, Sea-Bird Electronics, Inc., USA). Sampling was carried out in May-June 2016-2018. Sampling, research and analysis of the results were performed according to the regulations for surface waters of the water use category II according to SanPiN 2.1.5.980-00, MUK 4.2.1884-04, GOST 24849-2014. The study included 34 pelagic stations and 13 river ones. Since August 2017, at a station of the Angara source, monthly sampling of surface water was started at a distance of 1 m from the coast opposite the Shaman Stone, from a depth of 0.4–0.5 m. In total, 290 samples were investigated at 47 stations. Figure 1 shows the sampling map.

Hygiene microbiological methods. According to regulations, in all samples, the number of CB, TCB and Ent, as well as SCC, were determined.

Total and thermotolerant coliform bacteria. Three portions of polluted water 100, 50, 50, 10 and 10 mL each were filtered through three membrane filters (0.45 μm pores, 47 mm in diameter). The filters were then put on Endo medium and incubated at 37°C for 18-24 h. Dark red mucous colonies with the metallic luster of lactose-positive bacteria were taken into account. After the oxidase test, the oxidase-negative and gram-negative colonies were reinoculated in duplicate on Hiss medium with lactose. The first replicate was incubated at 37°C for 48 h. The colonies were considered positive for the total coliforms when gas and acid were detected. The second replicate was incubated at 44°C for 24 h. The colonies were considered positive for the thermotolerant coliform bacteria when gas and acid were detected.

Enterococci. Three portions of polluted water 100, 50, 50, 10 and 10 mL each were filtered through three membrane filters (0.45 μm pores, 47 mm in diameter). The filters were then placed on medium Slanetz&Bartley Agar and incubated at 37°C for 48 h. Then, the filter was put on a plate with a medium Bile Esculin Azide Agar at 44°C for 2 h (HiMedia, M493-500G, Lot 0000303373, India). The first replicate was incubated at 37°C for 48 h. The colonies were considered positive for the Enterococci when black color was detected.

The total microbial count (TMC). 1 mL of polluted water was inoculated to the Petri dishes with nutritive agar (peptone –10 g, beef extract – 500 g, NaCl – 5 g, agar – 25 g, water – 1 L, NICF, Saint Petersburg, Russia). This was done in triplicate, and then three Petri dishes were incubated at 37°C for 24 h, and the other three Petri dishes at 22°C for 72 h. The plate counts of each dish were added together and divided by water volume in mL inoculated into the dishes. The self-cleaning coefficient is the ratio of the TMC 22°C:TMC 37°C values, which can assess the activity and state of self-cleaning processes in natural water bodies.
Figure 1. Sampling map.

In the samples from the Angara source, the number of oligotrophs and psychrophiles was additionally determined. Oligotrophic microorganisms: 1 mL of polluted water was inoculated to the Petri dishes with 10-times diluted R-2A agar. This was done in triplicate, and then three Petri dishes were incubated at room temperature for 5-7 days. Psychrophilic microorganisms: 1 mL of polluted water was inoculated to the Petri dishes with R-2A (Sigma Aldrich, 17209-500G, Lot BCCB0054, USA). This was done in triplicate, and then three Petri dishes were incubated at 4°C for 14 days.

3. Results and discussion

In the pelagic zone of Lake Baikal during the study period from 2016 to 2018, water samples met the RF standards for surface waters.

In 2016, the occurrence of hygiene indicator microorganisms during the autumn was higher than in the spring and was 65.4% and 29.4%, respectively (Table 1). In the spring, the number of CB varied from 1 to 128 CFU/100 ml, with an average value of 27 CFU/100 ml, and in the autumn – from 1 to 73 CFU/100 ml, averaging 9.3 CFU/100 ml. We found TCB at six stations during the spring, ranging from 1 to 62 CFU/100 ml, and at nine stations in the autumn, numbering from 2 to 40 CFU/100 ml (table 1). In May, only in one sample did we detect bacteria of the genus Enterococcus, in 7 km from Nizhneangarsk (1 CFU/100 ml), but in September – at five stations: 3 km from Cape Tonkiy (5 CFU/100 ml), Barguzin Bay (2 CFU/100 ml), Kotelnikovsky–Ammundakan (2 CFU/100 ml), Elokhin–
Davsha (12 CFU/100 ml), as well as in 3 km from Elokhin (1 CFU/100 ml) and the Tyya River–the Nemnyanka River (6 CFU/100 ml) (table 1).

In 2017, during the spring and autumn, we found CB at nine and eight stations, respectively, and TCB – at three stations. We did not detect Ent in any of the seasons. During the spring and summer, the CB number varied from 1 to 47 CFU/100 ml, averaging 11.8 CFU/100 ml, and during the autumn – from 1 to 26 CFU/100 ml, averaging 8.1 CFU/100 ml. In the spring, CB prevailed in the southern basin of the lake, and we found TCB at the stations Krasny Yar–Kharauz (9 CFU/100 ml), Boldakova–Malye Olkhonskie Vorota (47 CFU/100 ml) and in 3 km from Turali (2 CFU/100 ml). In the autumn, the TCM number was lower, and we found them at the stations: in 12 km from Kultuk (1 CFU/100 ml), Maritui–Solzan (4 CFU/100 ml) and Khoboi–Krestovyi (2 CFU/100 ml) (table 1).

Table 1. Hygiene microbiological indicators in the pelagic water zone (data on May-June, September 2016, 2017 and 2018), CFU/100 ml.

| № St. | May-June 2016<sup>a</sup> | September 2016 | May-June 2017<sup>b</sup> | September 2017<sup>b</sup> | May-June 2018 | September 2018<sup>c</sup> |
|-------|--------------------------|----------------|--------------------------|--------------------------|----------------|--------------------------|
| CB    | CB | SCC | CB | SCC | CB | SCC | CB | SCC | CB | SCC | CB | SCC |
| 15    | 1  | 0  | 4  | 11 | 6  | 0   | >4 | 2  | 0  | >4 | 1  | 1   | >4 | 0  | 0  | 0  | 0  | 0  | >4 |
| 16    | 0  | 0  | 4  | 1  | 6  | 3   | 1  | 1  | 4  | 0  | >4 | 0  | 0   | >4 | 3  | 0  | 0  | >4 | 0  | >4 |
| 17    | 0  | 0  | 4  | 1  | 0  | 0   | 2.6| 1  | 0  | >4 | 4  | 4   | >4 | 5  | 0  | 0  | 0  | 0  | >4 |
| 18    | 0  | 0  | >4 | 0  | 0  | 0   | >4 | 0  | 0  | >4 | 4  | 0   | >4 | 4  | 0  | 0  | >10| 0  | >4 |
| 19    | 0  | 0  | >4 | 1  | 0  | 1   | 2.1| 0  | 0  | >4 | 0  | 0   | >4 | 1  | 1  | 0  | 2  | >4 |
| 20    | 0  | 0  | >4 | 0  | 0  | 0   | >4 | 0  | 0  | >4 | 7  | 0   | 0   | >4 | 0  | 0  | >4 |
| 21    | 0  | 0  | >4 | 4  | 0  | 0   | >4 | 0  | 0  | >4 | 0  | 0   | >4 | 1  | 0  | 0  | 0  | >4 |
| 22    | 0  | 0  | 4  | 0  | 0  | 0   | >4 | 1  | 0  | >4 | 0  | 0   | >4 | 0  | 0  | 0  | >4 |
| 23    | 0  | 0  | >4 | 3  | 0  | 0   | 0.9| 0  | 0  | >4 | 0  | 0   | >4 | 0  | 0  | 0  | >15| >4 |
| 24    | 8  | 4  | 0  | 0  | 0   | 1.4| 4  | 4  | >4 | 0  | 0   | >4 | 0  | 0  | 1  | 0  | >4 |
| 25    | 4  | 1  | >4 | 0  | 0  | 0   | 2.3| 1  | 0  | >4 | 0  | 0   | >4 | 0  | 0  | 0  | >4 |
| 26    | 0  | 0  | >4 | 1  | 0  | 0   | 1  | 0  | 0  | >4 | 0  | 0   | >4 | 0  | 0  | 0  | >4 |
| 27    | 0  | 0  | >4 | 10 | 0  | 5   | >4 | 0  | 0  | >4 | 3  | 0   | >4 | 1  | 1  | 0  | >4 |
| 28    | 0  | 0  | >4 | 2  | 0  | 2   | >4 | 0  | 0  | >4 | ND | ND   | ND | 0  | 0  | 0  | >4 |
| 29    | 0  | 0  | >4 | 4  | 0  | 0   | 2.8| 0  | 0  | >4 | 2  | 2   | >4 | 1  | 0  | 0  | >4 |
| 30    | 0  | 0  | >4 | 1  | 0  | 2   | 3.3| 0  | 0  | >4 | 0  | 0   | >4 | 1  | 7  | 8  | >4 |
| 31    | 0  | 0  | >4 | 0  | 0  | 0   | >4 | 0  | 0  | >4 | 1  | 0   | >4 | 0  | 0  | >4 |
| 32    | 0  | 0  | >4 | 73 | 0  | 0   | >4 | 1  | 0  | >4 | 0  | 0   | >4 | 1  | 0  | 0  | >4 |
| 33    | 0  | 0  | >4 | 0  | 0  | 0   | >4 | 0  | 0  | >4 | 3  | 0   | >4 | 0  | 0  | >4 |
| 34    | 0  | 0  | >4 | 6  | 0  | 0   | >4 | 0  | 0  | >4 | 8  | 0   | >4 | 0  | 0  | >4 |
| 35    | 0  | 0  | >4 | 10 | 1  | 1   | 0.2| 0  | 0  | >4 | 18  | 0   | >4 | 4  | 0  | 0  | 3.5 |
| 36    | 0  | 0  | >4 | 2  | 0  | 12  | 2  | 0  | 0  | >4 | 0  | 0   | >4 | 3  | 0  | 0  | 3.4 |
| 37    | 0  | 0  | >4 | 13 | 3  | 0   | >4 | 0  | 0  | >4 | 26  | 0   | >4 | 0  | 0  | 1  | 4  |
| 38    | 0  | 0  | >4 | 2  | 0  | 1   | 3.8| 0  | 0  | >4 | 0  | 0   | >4 | 3  | 1  | 6  | >4 |
| 39    | 128 | 0  | >4 | 0  | 0  | 0   | 3.1| 0  | 0  | >4 | 6  | 0   | >4 | 4  | 0  | 0  | 3.4 |
| 40    | 0  | 0  | >4 | 0  | 0  | 0   | 2.1| 0  | 0  | >4 | 0  | 0   | >4 | 1  | 1  | 1  | 1.8 |
| 41    | 3  | 2  | >4 | 10 | 3  | 0   | 0.6| 3  | 2  | >4 | 0  | 0   | >4 | 7  | 0  | 2  | 3.6 |
| 42    | 0  | 0  | >4 | 46 | 4  | 6   | >4 | 0  | 0  | >4 | 0  | 0   | >4 | 0  | 1  | 3.1 |
| 43    | 62 | 6  | >4 | 3  | 0  | 0   | 0.6| 0  | 0  | >4 | 0  | 0   | >4 | 2  | 0  | 0  | 1.9 |

<sup>a</sup> 2016, <sup>b</sup> 2017, <sup>c</sup> 2018.

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The elagic zone of Lake Baikal was the most favourable in 2017, with the minimum abundance and occurrence (CB 44 times, TCB 2.4°C decreased by 40% and 42%, and the abundance decreased in 2 and 1.6 times, respectively. In May-June, we detected Ent at eight stations, numbering from 1 to 14 CFU/100 ml, and in September – at four stations, numbering from 1 to 10 CFU/100 ml (table 1).

Therefore, during the study period (2016-2018), we did not identify the group of opportunistic bacteria in the samples from deep layers, and the content of organotrophs did not exceed their natural background. At the same time, in the surface layer, the occurrence of hygiene indicator microorganisms was maximum in spring 2018. In May-June 2016-2017, we detected them at 29% of the stations, and in 2018 – at 79% of the stations. A distinctive feature of the results obtained in September 2016 is a low SCC (77%), which indicates the anthropogenic impact on the ecosystem of the water body and its low recovery ability. SCC during spring 2018 was lower than normal at 40% of the stations of the northern basin, and during the autumn – at three stations, whereas in 2017 SCC was normal in all seasons (table 1).

In comparison with previous data on the period from 2010 to 2015 [8] the occurrence of CB and TCB in 2016 and 2017 reduced by 40% and 42%, and the abundance decreased in 2 and 1.6 times, respectively. Since 2010-2015, Ent were found in 15% of the samples. Therefore, according to the hygiene microbiological indicators, the quality of waters in the pelagic zone of Lake Baikal was the most favourable in 2017, with the minimum abundance and occurrence (CB – 26.1%, TCB – 9.2% and no Ent found). The 2018 data is close to those previously obtained in 2010-2015 [8].

Perhaps the observed fluctuations in abundance and occurrence of opportunistic microorganisms are associated with climate change that contributes to changes in the temperature regime of the lake. For example, the summer water temperature in the southern basin of Lake Baikal has increased by 2.4°C over the past 60 years [16].

Rivers that flow into Lake Baikal undoubtedly have an anthropogenic impact on the ecosystem of the lake. The waters of the investigated rivers contained opportunistic bacteria whose abundance 17 times exceeded that in the lake waters. We identified non-standard samples at the estuaries of the rivers Snezhnaya, Goloustnaya, Buguldeika, Anga, Kuchulga, Sarma, Turka, Barguzin, and Kichera (table 2).

In May 2016, Ent 3 times exceeded the standard (152 CFU/100 ml) in the Buguldeika, and in September – 1.4 times (706 CFU/100 ml) in the Kichera. In the autumn, SCC did not meet the standards in five of the eight rivers (table 2).

In 2017, we found non-standard samples in the rivers Kuchulga, Sarma, Turka, and Barguzin. Water samples from the rivers Sarma, Turka and Barguzin exceeded the CB standards where their abundance was 1099 CFU/100 ml, 600 CFU/100 ml and 712 CFU/100 ml, respectively. In the June samples from the Kuchulga, all studied characteristics exceeded the standards in 1.6 times for CB (797 CFU/100 ml), 1.4 times for TCB (135 CFU/100 ml) and 2.9 times for Ent (145 CFU/100 ml); SCC
was 3.9. In September, CB in this river exceeded the standard in 1.1 times (564 CFU/100 ml). Notably, in the spring, we found Ent only at two stations (table 2).

Table 2. Hygiene microbiological indicators in the tributaries of Lake Baikal (2016 and 2017), CFU/100 ml.

| Indicator | May-June 2016 | September 2016 | May-June 2017 | September 2017 | May-June 2018 | September 2018 |
|-----------|---------------|---------------|---------------|---------------|---------------|---------------|
| T,°C      | 5.2 11.0 9.6 | 7.7 6.2 8.2  | 12.6 7.9 11.6 | 12.1 8.0 13.5 | 6.6 13.9 13.7 | 5.2 6.9 6.1  |
| CB        | 6 28 48     | 134 202 452  | 7 0 8         | 12 148 70     | 60 4 18      | 134 4 70     |
| TCB       | 2 18 36     | 134 202 452  | 7 0 8         | 12 148 70     | 60 4 18      | 134 4 70     |
| Ent       | 1 152 32    | 134 202 452  | 7 0 8         | 12 148 70     | 60 4 18      | 134 4 70     |
| SCC       | >4 >4 >4    | >4 >4 >4     | >4 >4 >4 >4   | >4 >4 >4 >4   | >4 >4 >4 >4   | >4 >4 >4 >4   |
| Goloustnaya | Baguderra | Anga | Kuchulga | Sarma | Turka | Barguzin | Tompuda | Rel | Tyya | Kichera | Upper Angara |
| SCC       | >4 >4 >4    | >4 >4 >4     | >4 >4 >4 >4   | >4 >4 >4 >4   | >4 >4 >4 >4   | >4 >4 >4 >4   |

T – temperature; CB – coliform bacteria; TCB – thermotolerant coliform bacteria; Ent – enterococci; SCC – self-cleaning coefficient; CFU – colony-forming unit; ND – No data; Gray color indicates exceeding the norm.

In 2018, we identified five non-standard samples: in May – in the Turka (Ent 70 CFU/100 ml), in August I – in the Snezhnaya (CB 12000 CFU/100 ml, TCB 12000 CFU/100 ml and Ent 160 CFU/100 ml) and in September – in the Goloustnaya (TCB 136 CFU/100 ml and Ent 86 CFU/100 ml), the Anga (Ent 78 CFU/100 ml) and the Barguzin (CB 594 CFU/100 ml). In the samples of September 2018 from the rivers Tompuda and Upper Angara, we did not find the investigated groups of bacteria (table 2).
In 2005, there was an excess in Ent in the rivers Upper Angara, Barguzin and Goloustnaya [17]. The monitoring from 2010 to 2015 showed faecal pollution of waters in 2011, 2012 and 2015 [8]. A dangerous situation was in 2011 and 2012 when the samples from the eight rivers were non-standard. The number of polluted rivers in terms of microbiological indicators did not reduce by 2018 and amounted to five rivers.

All exceeded standards indicate the influx of fresh faecal contamination and a potential epidemiological risk for the population that uses the water from rivers for drinking, recreational and domestic purposes.

In the surface water of the Angara source, we found the opportunistic bacteria in 18 from the 23 samples. No hygiene indicator microorganisms were found in the samples taken in November 2017, from January to March 2018 and January 2019. The CB number was 1-4 CFU/100 ml in ten samples, and in August 2017 it was 88 CFU/100 ml, March 2019 – 50 CFU/100 ml, July 2019 – 72 CFU/100 ml, and August 2019 – 154 CFU/100 ml (figure 2). TCB was 1-4 CFU/100 ml in eight samples, the highest values were in August 2017 (12 CFU/100 ml), March (27 CFU/100 ml), July (27 CFU/100 ml), and August 2019 (76 CFU/100 ml) (Figure 2a). We detected Ent in 10 of the 23 samples, with the maximum values 60, 66 and 37 CFU/100 ml in May 2018, July and August 2019, respectively; in other samples, the Ent number was less than 5 CFU/100 ml. Monitoring the Angara source by hygiene bacteriological characteristics showed maximum values in July and August 2019 for all groups of microorganisms (figure 2). In 5 samples from the 23 ones, we detected allochtonic organotrophs cultured at 37°C, with the maximum number 1412 CFU/ml in February 2019, and their number in December 2018, as well as March and August 2019, was 133, 72 and 141 CFU/ml, respectively.

Organotrophs and oligotrophs cultured with MPA and R2A decompose organic matter. A distinctive feature of these groups is the preference of different concentrations of organic matter in the nutrient medium used. With MPA, bacteria grow with an optimum growth rate and the concentration of organic matters of 21.6 g/l, and with R2A – 2.5 g/l. The number of oligotrophs is predominantly more than organotrophs (figure 3). The number of psychrophiles in the samples from the Angara source either higher or equal, except for the warmest month August in 2017, 2018 and 2019 (figure 3).
A distinctive feature of the water from the Angara source is the presence of the microscopic moulds, which are active destructors. The presence of moulds is most likely due to the proximity of the source to the coast.

Figure 3. Distribution of groups of microorganisms in the Angara source from August 2017 to August 2019 (TMC, 37°C and TMC, 22°C – organotrophic bacteria cultured with nutritive agar at 37°C and 22°C, Olig, 22°C and Ps, 4°C – oligotrophs and psychrophiles cultured with R2A at 22°C and 4°C).

It should be noted that every year the problem of faecal contamination of water bodies becomes increasingly urgent worldwide. Thus, in America over the past decade, the waters of the Great Lakes have been considered dangerous for bathing due to high numbers of CB and Ent [4, 18]. Constant faecal contamination of freshwater bodies has become one of the priority problems in European countries. Monitoring the sanitary state of lakes and rivers in Lithuania and Belgium revealed a low microbiological quality of waters [19, 20]; in Lake Geneva (Switzerland), there was a high abundance of opportunistic microflora, including salmonella [3].

4. Conclusion
Therefore, the study conducted in the pelagic zone of the lake has shown that deep Baikal water, in general, meets the standards applied to assess the water to be used as drinking water supply. This indicates the high quality of the Baikal water. Monitoring of the surface layer has shown the most favourable quality of the water from the pelagic zone of the lake in 2017 with the minimum abundance and occurrence of hygiene microbiological indicators. Assessment of water quality has identified the maximum number of the opportunistic bacteria at the estuaries of the Baikal rivers. In 2018, the Snezhnaya River had the greatest anthropogenic load, exceeding the standards in 24 times for CB, 1200 times for TCB and 800 times for Ent. The source of this pollution is insufficiently treated wastewater from settlements. Monitoring of microbiological indicators of Lake Baikal and its tributaries is crucial for developing the strategy to preserve Lake Baikal and, hence, the decision-
making on the implementation of environmental measures focused on control and a decrease in the water pollution.

It is necessary to monitor annually tourist sites, settlements and beaches for meeting the standards of the environmental legislation when the liquid municipal and domestic sewage is discharged into tributaries, onto the coast and into waters of Lake Baikal.

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