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Analysis of the Presence of Escherichia coli on Prainha Beach in Caraguatatuba – SP

Análise de presença de Escherichia coli na Praia Prainha em Caraguatatuba – SP

Análisis de la presencia de Escherichia coli en la Playa Prainha de Caraguatatuba – SP

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Abstract:
The microbiological quality of coastal waters is an important indicator of the environmental and sanitary conditions of recreational areas. The presence of Escherichia coli is widely used as an indicator of recent fecal contamination, allowing for the assessment of potential public health risks associated with contact with contaminated water. This study aimed to analyze the presence of Escherichia coli in the water of Prainha Beach, located in the municipality of Caraguatatuba, on the northern coast of the state of São Paulo, using the Compact Dry® EC chromogenic medium as a microbiological detection tool. Four weekly collections were carried out during the month of April 2026, on the 8th, 15th, 22nd, and 29th, maintaining the same sampling point. During the collections, environmental and physicochemical parameters were recorded, including tide, wind speed and direction, rainfall, water temperature, ambient temperature, relative humidity, pH, salinity, and water density. Microbiological analyses were performed by direct inoculation of samples onto Compact Dry® EC plates, followed by incubation at 35 ± 2 °C for 24 ± 2 hours. The results demonstrated the presence of Escherichia coli and total coliforms in all samples analyzed. E. coli concentrations ranged from 600 CFU/100 mL to values exceeding 10,000 CFU/100 mL, while total coliforms ranged from 2,200 CFU/100 mL to values exceeding 10,000 CFU/100 mL. The highest contamination levels were observed on April 15th and 29th. The results suggest the influence of environmental factors such as precipitation, tidal dynamics, and salinity, although it was not possible to establish definitive causal relationships. It is concluded that Prainha Beach presented recurrent fecal contamination during the study period, reinforcing the need for continuous monitoring of water quality for bathing purposes and protection of public health.

Keywords:
Escherichia coli; Suitability for bathing; Compact Dry EC; Water quality; Fecal contamination.

Resumo:
A qualidade microbiológica das águas costeiras é um importante indicador das condições ambientais e sanitárias de regiões destinadas à recreação. A presença de Escherichia coli é amplamente utilizada como indicador de contaminação fecal recente, permitindo avaliar potenciais riscos à saúde pública associados ao contato com águas contaminadas. O presente estudo teve como objetivo analisar a presença de Escherichia coli na água da Praia Prainha, localizada no município de Caraguatatuba, litoral norte do estado de São Paulo, utilizando o meio cromogênico Compact Dry® EC como ferramenta de detecção microbiológica. Foram realizadas quatro coletas semanais durante o mês de abril de 2026, nos dias 08, 15, 22 e 29, mantendo-se o mesmo ponto de amostragem. Durante as coletas foram registrados parâmetros ambientais e físico-químicos, incluindo maré, velocidade e direção do vento, índice pluviométrico, temperatura da água, temperatura ambiente, umidade relativa do ar, pH, salinidade e densidade da água. As análises microbiológicas foram realizadas por meio da inoculação direta das amostras em placas Compact Dry® EC, seguidas de incubação a 35 ± 2 °C por 24 ± 2 horas. Os resultados demonstraram a presença de Escherichia coli e coliformes totais em todas as amostras analisadas. As concentrações de E. coli variaram entre 600 UFC/100

mL e valores superiores a 10.000 UFC/100 mL, enquanto os coliformes totais variaram entre 2.200 UFC/100 mL e valores superiores a 10.000 UFC/100 mL. Os maiores índices de contaminação foram observados nos dias 15 e 29 de abril. Os resultados sugerem influência de fatores ambientais, como precipitação, dinâmica da maré e salinidade, embora não tenha sido possível estabelecer relações causais definitivas. Conclui-se que a Praia Prainha apresentou contaminação fecal recorrente durante o período estudado, reforçando a necessidade de monitoramento contínuo da qualidade da água para fins de balneabilidade e proteção da saúde pública.

Palavras-chave:
Escherichia coli; Balneabilidade; Compact Dry EC; Qualidade da água; Contaminação fecal.

Resumen:
La calidad microbiológica de las aguas costeras es un importante indicador de las condiciones ambientales y sanitarias de las zonas destinadas a la recreación. La presencia de Escherichia coli es ampliamente utilizada como indicador de contaminación fecal reciente, permitiendo evaluar los posibles riesgos para la salud pública asociados al contacto con aguas contaminadas. El presente estudio tuvo como objetivo analizar la presencia de Escherichia coli en el agua de la Playa Prainha, ubicada en el municipio de Caraguatatuba, en la costa norte del estado de São Paulo, utilizando el medio cromogénico Compact Dry® EC como herramienta de detección microbiológica. Se realizaron cuatro muestreos semanales durante el mes de abril de 2026, los días 8, 15, 22 y 29, manteniendo el mismo punto de muestreo. Durante las colectas se registraron parámetros ambientales y fisicoquímicos, incluyendo marea, velocidad y dirección del viento, precipitación, temperatura del agua, temperatura ambiente, humedad relativa del aire, pH, salinidad y densidad del agua. Los análisis microbiológicos se realizaron mediante inoculación directa de las muestras en placas Compact Dry® EC, seguidas de incubación a 35 ± 2 °C durante 24 ± 2 horas. Los resultados demostraron la presencia de Escherichia coli y coliformes totales en todas las muestras analizadas. Las concentraciones de E. coli variaron entre 600 UFC/100 mL y valores superiores a 10.000 UFC/100 mL, mientras que los coliformes totales variaron entre 2.200 UFC/100 mL y valores superiores a 10.000 UFC/100 mL. Los mayores índices de contaminación se observaron los días 15 y 29 de abril. Los resultados sugieren la influencia de factores ambientales, como la precipitación, la dinámica de las mareas y la salinidad, aunque no fue posible establecer relaciones causales definitivas. Se concluye que la Playa Prainha presentó contaminación fecal recurrente durante el período estudiado, reforzando la necesidad de un monitoreo continuo de la calidad del agua con fines de balneabilidad y protección de la salud pública.

Palabras clave:
Escherichia coli; Balneabilidad; Compact Dry EC; Calidad del agua; Contaminación fecal.

Introduction

The bacterium *Escherichia coli* (*E. coli*) belongs to the *Enterobacteriaceae family* and is widely used as a microbiological indicator of fecal contamination in water intended for recreation and human consumption. Its presence suggests recent contamination by human or animal feces, and is associated with the possibility of the occurrence of other pathogenic

microorganisms capable of causing gastrointestinal diseases, hepatitis, and various infections (CONAMA, 2000).

In addition to its sanitary importance, *E. coli* has become one of the main parameters used in monitoring programs for the suitability of Brazilian beaches for bathing. According to CONAMA Resolution No. 274/2000, waters intended for primary contact recreation can be classified as suitable or unsuitable according to the amount of indicator bacteria present in 100 mL of water. For waters considered satisfactory, the acceptable limit is up to 800 units of *E. coli* per 100 mL in at least 80% of the samples collected in the last five consecutive weeks. Values above 2,000 *E. coli* /100 mL in the last sampling make the beach unsuitable for bathing (CONAMA, 2000).

The municipality of Caraguatatuba is located on the north coast of the state of São Paulo and has significant tourist importance due to its beaches and activities related to coastal tourism. Among its beaches is Praia da Prainha, a small cove located near the central region of the municipality, characterized by low hydrodynamic circulation due to its bay-like shape. This characteristic favors the retention of debris and the accumulation of organic matter, which can contribute to changes in the microbiological quality of the water (São Paulo State Tourism and Travel Secretariat, 2024).

Historically, Prainha Beach has consistently received classifications of unsuitability for swimming from CETESB (Environmental Company of the State of São Paulo), frequently receiving a red flag during monitoring periods. The red flag indicates a health risk to bathers and is used when microbiological parameters exceed the limits established by current environmental legislation. The frequent occurrence of this condition may be associated with the irregular discharge of domestic sewage, contaminated urban drainage, and seasonal population growth resulting from tourism. (G1 VALE DO PARAÍBA E REGIÃO, 2026).

Microbiological analysis of water is generally performed by culturing samples in selective media capable of allowing the growth and identification of bacterial colonies. After incubation, the bacteria present form visible clusters called Colony Forming Units (CFU), used as a quantitative measure of the microbiological contamination of the sample. CFUs represent the estimated number of viable microorganisms capable of multiplying under certain laboratory conditions (APHA; AWWA; WEF, 2023).

Compact stands out. Dry EC is a ready-to-use chromogenic medium intended for the simultaneous detection of total coliforms and *Escherichia coli* . The method offers advantages such as operational ease, reduced risk of cross-contamination, ease of transport, room temperature storage, and rapid interpretation of results through color differentiation of bacterial

colonies. Furthermore, the Compact Dry EC reduces the need for preparation of traditional media, making it an efficient alternative for environmental and food microbiological analyses (NISSUI PHARMACEUTICAL, 2023).

Therefore, the present study aims to analyze the presence of *Escherichia coli* on Prainha Beach, located in the municipality of Caraguatatuba – SP, using the Compact chromogenic medium. Dry EC as a tool for microbiological assessment of water quality.

2. Materials and Methods

2.1 Study area and sample collection

This study is characterized as an experimental research project with a quantitative approach, carried out at Prainha Beach, located in the municipality of Caraguatatuba, on the northern coast of the state of São Paulo.

Seawater samples were collected weekly on April 8, 15, 22, and 29, 2026, always in the afternoon, around 2 PM. The sampling point was kept standardized throughout the experimental period to minimize interference from spatial variations on the beach.

Samples were collected in sterile containers and transported for subsequent microbiological analysis. During each collection, environmental and physicochemical parameters considered relevant to water quality were recorded, including tidal conditions, wave intensity, wind speed, and rainfall index, obtained using the Windy application . Hydrogen ion potential (pH) was also measured using a Kasvi digital pH meter ; water density/salinity using an ATC refractometer; sample water temperature using a TP300 digital thermometer; as well as ambient temperature and relative humidity at the time of collection.

3.2 Microbiological analysis

The detection and quantification of total coliforms and Escherichia coli were performed using the Compact chromogenic method. Dry ® EC. The procedure consisted of inoculating 1 mL of the sample directly onto the plate, followed by incubation at 35 ± 2 °C for 24 ± 2 hours, according to the manufacturer's recommendations (NISSUI PHARMACEUTICAL, 2023).

After the incubation period, the Colony Forming Units (CFU) were counted. Blue-colored colonies were considered positive for Escherichia coli, while magenta-colored colonies were classified as total coliforms. The results were expressed in CFU per plate.

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3.3 Photographic record

After incubation, the Compact plates Dry® EC were photographed individually under standardized lighting conditions for visual recording of the developed colonies. The images were identified as A, B, C, and D, corresponding to the collection dates of April 8, April 15, April 22, and April 29, 2026, respectively.

3.4 Data processing and analysis

Microbiological and environmental data were organized into spreadsheets for descriptive and comparative analysis between collection dates. The results obtained were compared with the microbiological limits established by CONAMA Resolution No. 274/2000 for evaluating the suitability of waters intended for primary contact recreation for bathing. Subsequently, possible relationships between the occurrence of total coliforms, Escherichia coli, and environmental variables recorded during sampling were investigated, including tide, waves, wind, precipitation, temperature, humidity, pH, and water density.

3. Results and Discussion

The results of microbiological analyses carried out at Praia da Prainha during the month of April 2026 showed significant variations in total coliform and Escherichia coli counts between the different collection dates (Table 2).

In the sample collected on April 8th, concentrations of 1,400 CFU/100 mL of Escherichia coli and 4,100 CFU/100 mL of total coliforms were observed. On April 15th, the highest microbiological growth recorded during the study occurred, with values exceeding 10,000 CFU/100 mL for both bacterial groups. In the sample collected on April 22nd, a significant reduction in counts was observed, registering 600 CFU/100 mL of Escherichia coli and 2,200 CFU/100 mL of total coliforms. However, on April 29th, a new increase in contamination was observed, with values again exceeding 10,000 CFU/100 mL .

The monitored environmental variables showed fluctuations throughout the experimental period. Water temperature ranged from 26.5 °C to 31.1 °C, while salinity ranged from 30 to 38‰. pH values ranged from 5 to 6, and wind speed varied from 4 to 8 km/h. Rainfall recorded 15 mm in the first collection, no precipitation in the collections of April 15 and 22, and 10 mm in the last collection. Relative humidity ranged from 67% to 86%.

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Images of Compact license plates Dry® EC (Figure 1) visually evidenced the differences in colony density between the evaluated dates, corroborating the quantitative results obtained in the microbiological counts.

Figure 1 – Growth of total coliforms and *Escherichia coli on* Compact plates Dry® after incubation

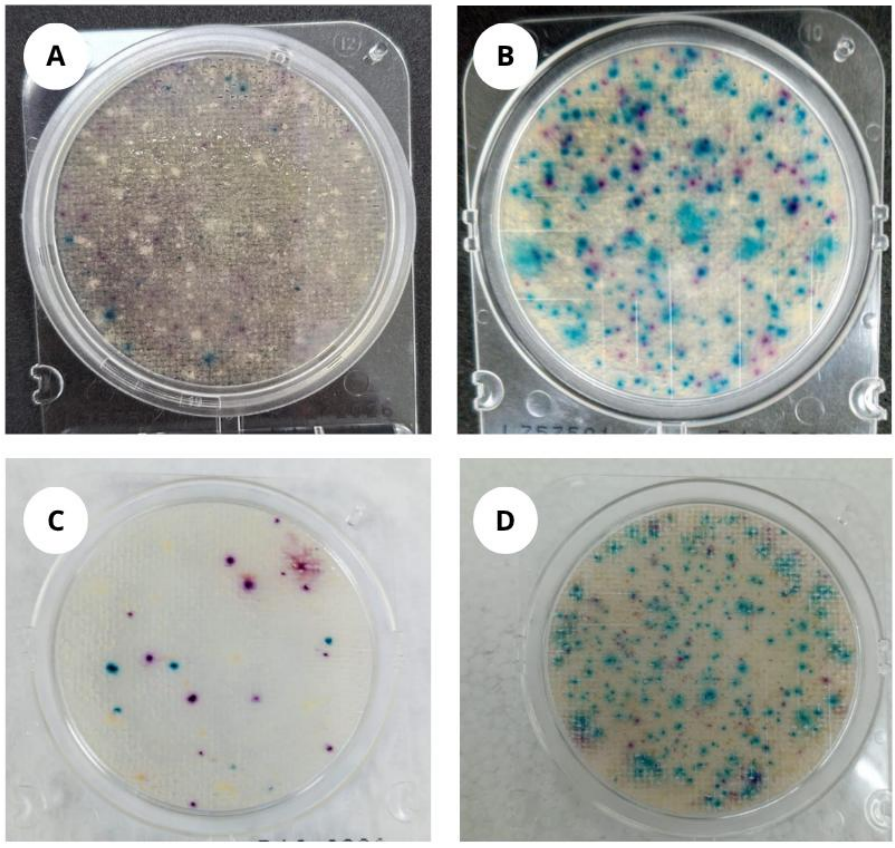


Figura 1 – Placas Compact Dry® utilizadas para detecção de coliformes totais e Escherichia coli em amostras de água do mar: (A) Coleta realizada em 08/04 (B) Coleta realizada em 15/04; (C) Coleta realizada em 22/04; (D) Coleta realizada em 29/04.As colônias azuis indicam presença de Escherichia coli e as colônias magenta indicam coliformes totais. As placas foram incubadas a 35 ± 2 °C durante 24 ± 2 horas.

Table 1 – Environmental variables monitored at Prainha Beach during the month of April 2026.

Date	H	M (m)	Ond	pH	VV (km /h)	DV	Salt (%)	DA (kg/m³)	TA (°C)	TAmb (°C)	IP (mm)	U (%)
08/04	14:43	0.9	going up	5	4	East	30	1023	31.1	33.5	15	67
15/04	14:30	1.1	downloading	6	8	Southeast	32	1024	26.5	27	0	69

22/04	14:55	0.7	going up	6	8	East-Southeast	38	1025	27.4	27.6	0	78
29/04	14:21	1.1	going down	5	8	Southeast	32	1023	26.5	29.2	10	86

Legend: H = time of collection; M = tide; Ond = tide condition (MS = rising tide; MB = falling tide; MD = ebb tide); VV = wind speed; DV = wind direction; Sal = salinity; DA = water density; TA = water temperature; TAmb = ambient temperature; IP = rainfall index; U = relative humidity

Source: Data obtained by the authors (2026).

Table 2 – Microbiological variables monitored at Prainha Beach during the month of April 2026.

Date	EC (CFU/100 mL)	CT (CFU/100 mL)
08/04	1400	4100
15/04	>10000	>10000
22/04	600	2200
29/04	>10000	>10000

Legend: EC = *Escherichia coli* count ; CT = total coliform count; CFU = colony forming units.

Source: Prepared by the author (2025)

The results obtained indicate the presence of significant microbiological contamination at Prainha Beach throughout the study period. The high counts of total coliforms and Escherichia coli suggest the influence of fecal pollution sources in the coastal environment, which may be associated with the discharge of domestic sewage, urban drainage, the contribution of watercourses, or the transport of organic matter from rainfall. According to CONAMA Resolution No. 274/2000, the presence of Escherichia coli in natural waters is directly related to the occurrence of recent fecal contamination and is widely used as an indicator of the sanitary quality of aquatic environments (BRASIL, 2000).

The highest values were observed on April 15th and 29th, when the counts exceeded the maximum quantification limit of the method used (>10,000 CFU/100 mL). These results may indicate isolated contamination events or environmental conditions favorable to the persistence and dispersion of microorganisms in the water column. Studies on microbiological quality in coastal environments demonstrate that the concentration of fecal bacteria can vary significantly depending on environmental and anthropogenic factors, including sewage discharges and local hydrological dynamics (GRBČIĆ et al., 2021).

The rainfall observed on April 8th and 29th may have contributed to the transport of contaminants to the coastal region, a phenomenon frequently associated with an increase in the microbial load in marine waters. Research conducted in coastal regions demonstrates that surface runoff caused by rainfall can carry organic matter and microorganisms of fecal origin into bodies of water, raising levels of microbiological contamination (YOU et al., 2022).

However, the high contamination levels recorded on April 15th, even without rainfall, suggest that other factors may also be involved, such as continuous sources of pollution, effluent discharge, or the influence of ocean currents, winds, and tidal dynamics. The literature indicates that the microbiological quality of coastal waters can be influenced by multiple environmental and hydrodynamic variables, regardless of recent precipitation (GRBČIĆ et al., 2021).

An interesting result observed in this study was the reduction in microbiological counts in the sample collected on April 22, 2026, a period close to the long weekend when the municipality of Caraguatatuba registered intense tourist flow. It was expected that the temporary increase in population could result in higher levels of fecal contamination due to the greater generation of domestic sewage and pressure on urban infrastructure. However, the lowest values of Escherichia coli (600 CFU/100 mL) and total coliforms (2,200 CFU/100 mL) were recorded among all the samples analyzed. This result suggests that the increase in the number of visitors, in isolation, was not sufficient to cause an increase in microbiological contamination in the studied area. In addition, the collection coincided with the absence of precipitation and higher water salinity (38%), factors that may have contributed to the reduction in the survival or dispersion of indicator microorganisms. Studies conducted in estuarine and coastal environments demonstrate that high salinity concentrations tend to reduce the survival of bacteria indicative of fecal contamination, accelerating their decay in the aquatic environment (BORDALO; ONRASSAMI; DECHSAKULWATANA, 2002).

Additionally, recent research points to salinity as one of the most important environmental variables in determining Escherichia coli concentrations in coastal waters (GRBČIĆ et al., 2021). Thus, the results indicate that the microbiological quality of Prainha

Beach seems to be more related to the interaction between multiple environmental factors and specific sources of contamination than exclusively to the seasonal increase in population.

Another factor that may have influenced the observed results is the intense movement of people and recreational vessels at Prainha Beach. Activities such as swimming, water sports, banana boat rides , jet skiing, and boat traffic can promote the resuspension of bottom sediments, temporarily increasing water turbidity and releasing bacteria previously deposited in the sediments into the water column, as well as dispersing these bacteria . Studies demonstrate that microorganisms indicative of fecal contamination, including Escherichia coli, can remain accumulated in coastal sediments and be reintroduced into the water through resuspension caused by waves, tides, boat traffic, and the movement of bathers (WALTERS et al., 2014; WYNESS et al., 2019). Furthermore, research in recreational waters indicates that the very increase in user density and nautical activity can contribute to a temporary rise in fecal bacteria concentrations due to the disturbance of surface sediments (Graczyk TK et al., 2007). Therefore, the dynamics of recreational beach use should be considered as a possible additional factor in the microbiological variability observed throughout the study.

According to CONAMA Resolution No. 274/2000, Escherichia coli is considered one of the main microbiological indicators of fecal contamination in waters intended for primary contact recreation. Furthermore, values exceeding 2,000 CFU/100 mL characterize conditions unsuitable for bathing when considering current regulatory criteria (BRAZIL, 2000). Considering that in two of the four samples the values exceeded 10,000 CFU/100 mL , the results suggest a potential risk to public health, especially due to the possibility of bathers being exposed to pathogenic microorganisms associated with fecal pollution.

The prevailing wind direction observed during sampling also ties into an aspect that deserves attention. The highest levels of microbiological contamination were recorded on April 15th and 29th, when the winds were from the southeast. Conversely, the sampling on April 22nd, which showed the lowest counts of Escherichia coli and total coliforms, was observed to be from the east-southeast, associated with the highest salinity recorded during the study. In coastal environments, winds influence surface water circulation, pollutant dispersion, and water renewal in inlets. Depending on the orientation of the coast and the local geographical configuration, persistent winds can favor both the dispersion and concentration of contaminants in certain areas. Considering that Prainha Beach is characterized by a relatively protected inlet with less hydrodynamic circulation, it is possible that the southeast winds contributed to the retention or transport of water with a higher microbial load to the sampling area. However, this hypothesis cannot be confirmed solely with the data obtained in this study; complementary

analyses involving ocean currents, hydrodynamic modeling, and monitoring on a larger time scale are necessary (GRBČIĆ et al., 2021).

Despite the relevance of the results, the study has limitations related to the small number of samples collected and the short monitoring period. Future investigations involving longer time series, different seasonal periods, and more robust statistical analyses could provide more detailed information on the microbiological dynamics of the studied area.

Final Considerations

Microbiological monitoring carried out at Prainha Beach during the month of April 2026 showed the presence of total coliforms and Escherichia coli in all samples analyzed, indicating recurrent fecal contamination at the site.

The highest counts occurred on April 15th and 29th, when values exceeded 10,000 CFU/100 mL , while the lowest contamination was observed on April 22nd. The variations recorded suggest a possible influence of environmental factors, such as precipitation, salinity, and tidal dynamics, although it was not possible to establish definitive relationships due to the limited number of samples.

The results reinforce the importance of continuous monitoring of the microbiological quality of coastal waters, contributing to the assessment of suitability for bathing and the protection of the health of beach users. Future studies with a broader temporal scope and the inclusion of statistical analyses could expand the understanding of the factors that influence microbiological contamination in the region.

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