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The Impact of Seasonality on Escherichia coli Bacteria Concentration and Water Quality: A Literature Review

The impact of seasonality on the concentration of Escherichia coli bacteria and water quality: a review of the literature

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Summary

Microbiological contamination in coastal environments, especially by Escherichia coli, has become a growing concern for public health and environmental preservation. This study presents a literature review on the impact of seasonality on the concentration of this bacterium in beach waters. E. coli is widely used as an indicator of fecal pollution, being associated with various pathologies, such as gastrointestinal, dermatological, and urinary infections. The presence of the bacterium is related to natural factors, such as rainfall and tidal variation, as well as anthropogenic impacts, such as the inadequate disposal of sewage and solid waste.

The methodology involved analyzing scientific articles published between 2020 and 2025, resulting in 12 selected studies. The results reveal that beach sand is also an important reservoir of pathogenic microorganisms, frequently neglected by health regulations. International studies demonstrate that environmental variables significantly influence contamination levels, making it possible to predict bathing suitability through predictive models with machine learning and rapid molecular techniques, such as PCR and metagenomic sequencing (Nanopore). Furthermore, the effectiveness of purification methods in contaminated seafood and the viability of alternative biomarkers, such as fecal sterols, to expand monitoring were highlighted. The analysis reinforces the need for integrated approaches involving the monitoring of water, sand, and marine organisms, as well as the adoption of new technologies to prevent public health risks, ensure food safety, and promote the sustainable use of coastal environments. Seasonality, therefore, is a key factor in managing water quality on beaches.

Keywords: Escherichia coli, Water quality, Seasonality, Bathing suitability, Fecal pollution, Coastal environments.

Abstract

The Microbiological contamination in coastal environments, especially by Escherichia coli, has become a growing concern for public health and environmental preservation. This study presents a literature review on the impact of seasonality on the concentration of this bacterium in beach waters.

E. coli is widely used as an indicator of fecal pollution, being associated with various pathologies, such as gastrointestinal, dermatological, and urinary infections. The presence of the bacterium is related to natural factors, such as rainfall and tidal variation, as well as anthropogenic impacts, such as the inadequate disposal of sewage and solid waste. The methodology involved the analysis of scientific articles published between 2020 and 2025, resulting in 12 selected studies. The results reveal that beach sand is also an important reservoir of pathogenic microorganisms, frequently neglected by sanitary legislation. International studies demonstrate that environmental variables significantly influence contamination levels, and it is possible to predict bathing suitability through predictive models with machine learning and rapid molecular techniques, such as PCR and metagenomic sequencing (Nanopore). In addition, the effectiveness of purification methods in contaminated seafood and the viability of alternative biomarkers, such as fecal sterols, to expand monitoring were evidenced. The analysis reinforces the need for integrated approaches involving the monitoring of water, sand, and marine organisms, as well as the adoption of new technologies to prevent risks to public health, ensure food safety, and promote the sustainable use of coastal



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environments. Seasonality, therefore, is a key factor in water quality management on beaches.

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Summary

Microbiological contamination in coastal environments, especially by *Escherichia coli*, has become a growing concern for public health and environmental preservation.

This study presents a bibliographical review on the impact of seasonality on the concentration of this bacteria in beach waters. *E. coli* is widely used as an indicator of fecal contamination, associated with various pathologies, such as gastrointestinal, dermatological and urinary infections. The presence of bacteria is related to natural factors, such as the variation in precipitation and tides, as well as anthropogenic impacts, such as the inadequate disposal of wastewater and solid waste. The methodology involved the analysis of scientific articles published between 2020 and 2025, resulting in 12 selected studies. The results reveal that the beach arena is also an important reservoir of pathogenic microorganisms, often ignored by health legislation. International studies demonstrate that environmental variables significantly influence contamination levels, and it is possible to predict the suitability for the bath using predictive models with automatic learning and rapid molecular techniques, such as PCR and metagenomic sequencing (Nanopore). and the feasibility of alternative biomarkers, such as fecal sterols, to expand monitoring. The analysis reflects the need for integrated approaches that include monitoring water, sand and marine organisms, as well as the adoption of new technologies to prevent risks to public health, guarantee food safety and promote sustainable use of coastal environments. Therefore, seasonality is a key factor in the management of water quality on the beaches.

Keywords: *Escherichia coli*, Water quality, Seasonality, Bathing suitability, Fecal contamination, Coastal environments.

1. Introduction

The beaches of the Brazilian coast are gaining importance in environmental and health studies. public. Studies conducted using official government indicators allow for an evaluation of Bathing conditions affect the population's perception of bacteria presence through coliform counts. Fecal matter present in the water can be a source of contamination by pathogenic microorganisms for bathers. According to (VELONAKIS et al., 2014) due to the presence of pathogens in both the sand and the water This poses a threat to the health of the population and bathers, who may be subject to diseases caused by it. caused by viruses, bacteria, and fungi. Studies conducted in recent years have shown an increase in pathologies related to fungal infections and bacterial infections contracted by bathers who frequent The beaches are being used for recreation. This has led to increased concerns about microbial contamination. (PINTO et al., 2011).

Therefore, the objective of this work is to conduct a literature review with the aim of to assess the presence of clinically important bacteria in beach water and the risks associated with human exposure, which can promote pathologies in people who use these beaches.



2 theoretical frameworks

According to (VALDEZ and GROSBELLI, 2012; ANDRAUS et al., 2006) the beaches and their suitability for bathing is related to the microbiological quantity of pathogens present in the water. However, growing concerns about beach contamination have increased in recent years. due to improper disposal of garbage, animal waste, untreated domestic sewage, and Pollutants that are carried by rainwater through rivers to the beaches. (VALDEZ and (GROSBELLI, 2012; ANDRAUS et al., 2014) Thousands of people acquire diseases (conjunctivitis, Ear infections, dermatological and gastrointestinal problems) can occur during a simple swim in the sea or even when lying on contaminated beach sand (ARAÚJO et al., 2014).

According to Castro (2003), among the microbiological indicators of fecal pollution, the group coliform is the most commonly used, with *Escherichia coli* being the most clinically significant for humans. due to its role as an opportunistic pathogen, causing infections in the blood, wounds, and tract. Urinary tract. Among the main pathogenic microorganisms, species of bacteria stand out. found in the gastrointestinal tract of both humans and other warm-blooded animals. (*Escherichia coli*), as well as non-enteric bacteria (*Citrobacter* spp., *Klebsiella* spp. and *Serratia* spp.) (SILVA et al. 2011). The water and sand of the beach become a medium for the cultivation of microorganisms and the spread of diseases caused by them. Due to the suitability for bathing of Given the fragile state of preservation of beaches, biological monitoring is necessary. which could reduce the health impacts on exposed bathers, as well as being a a way to subsidize actions that reduce risks to public health and promote preservation and Restoration of the coastline and rivers that carry their waters to the sandy beach and sea.

3 methodology

A systematic literature review was conducted using the following keywords: *Escherichia coli*, bacteria on beaches, water quality, bacteria concentration, microbiology. using the PubMed, SciELO, and Google Scholar databases. The criteria for... Exclusion criteria: articles published between January 2020 and September 2025 were selected.

4. Results and discussion

During the database search, 39 were found. After using the After applying the exclusion criteria, 12 articles remained, as shown in the table below.

Table 1 – Articles selected after applying the exclusion criteria.

Author /year	Objective	Variables of Study	More Results impactful	Conclusion	Points of Emphasis
Lescre coli and	Evaluate the microbiological quality of Enterococcus in sandy beaches Santos (SP).	Quality of E. coli and Enterococcus (CFU/100g).	Values varied. First study to 2,700,000 in the Santos reservoir; comparison of microorganisms; with specific CFU/100g (E. coli), above national and international limits.	Standards.	the sand from 40,000 pathogenic and the need for international.
three not Itacaré (BA). 2023	Monitoring water quality. All beaches are part of the Carval program. Microbiological analysis of the concentration of E. coli recommended; certification; risks parameter; al., urban membrane.	E. coli classified as monitoring ho et dry sand of urban beaches of Praia da Concha for tourism and health comparison between beaches.	less impacted.	Need for Use of RJ Legislation public.	as and health comparison between beaches.
salinity reduced	Identify predictors of rainfall, E. coli and predictive models. Use of Bayesian models; T reduced specific factors of long-term data. 2024 Vancouver (Canada).	E. coli increased environmental factors with rainfall of Bayesian models; T reduced specific factors of long-term data. 2024 Vancouver (Canada). coli (2013-2021).	concentrations.	each beach.	concentration of E. coli on beaches, salinity, E. coli term (9 years).
accuracy machine.	Modeling coastal water quality using E. coli classifiers and variables such as Meteorological systems with E. coli algorithms (ISO Decision Tree 9308-1) predict and may aid performance in machine. (2009-2021).	Forest and Boosted ML are efficient for monitoring meteorological conditions. E. coli algorithms (ISO Decision Tree 9308-1) predict coastal bathing suitability; high learning of climate data had >99% accuracy. (2009-2021).	accuracy.	quick decisions.	AI Application in models.
of conditions.	Studying water quality at classified beaches - Monitoring Fernan Four beaches are excellent conditions, but continuous sand; use of al., based on total Total coliforms.	beaches are in good environmental condition, and Fernando de Noronha Porto had peaks coliforms 5,000 MPN/100g should be included in rapid methods 2021 (NMP/100g).	During peak season.	analyses.	(3M Petrifilm).
2021	Analyze the influence of on tides, rainfall, and intense E. Natural factors have a large impact on the suitability of bathing water for coliforms in Itapoá (SC).	changes in unsuitable conditions; rainfall, initial methods, and the influence of natural factors have a large impact on the suitability of bathing water for coliforms in Itapoá (SC). (NMP/100ml).	Summer brought more beaches. Valent application. Contamination increased.	Suitability for bathing.	rain and tides.
mussels. Debugging in Rio de Janeiro.	Evaluate Guima's Evaluation High E. coli contamination in food. Culture water, frogs microbiological in winter; purification. Purification is effective, and Perna coli, reduced control evaluation, Perna spp., before and after. Salmonella spp., still safety 2022 but significantly lower the levels. Environmentally necessary, to feed.	AND. Enterococcus.	significantly lower the levels.	Environmentally necessary.	and to feed.
Araujo, Miche 2021	Using fecal sterols High correlation Ile as indicators of sterols Sterols between Steps contamination by Fecal sterols fecal et al. (coprostanol, contamination by pollution in mangroves sewage and focus of E. coli; effective markers in mangroves. in Brazilians.	in coprostanol, contamination by pollution in mangroves sewage. (epicoprostanol).	sewage.	coastal environments.	Alternative method to the use of E. coli; effective markers in Brazilians.

		Presence of concentration of viable bacteria. High precision on between workflow methods (E. coli, Vibrio spp.), methods of rapid and accurate absolute estimates of expected culture cells; 1 Gb of viable cells in water. Workflow potential for metagenomics, sequences in 2 h. Methano-viable beach sequencing using sufficient quantity for QMRA and holistic sequencing to detect species risk assessment (2023). Yang et al.			
	Nanopore and PMA	necessary.	~10 cells/mL.	resistome.	microbial.

Source: Author

The combined analysis of the studies shows that microbiological contamination on beaches and Coastal environments are a global problem, with different methodological approaches to their treatment evaluation. In Brazil, studies such as those by Lescreck et al. (2016) and Carvalho et al. (2023) highlight Sand is an important reservoir of microorganisms, a fact often overlooked in legislation. sanitary. Research in Fernando de Noronha (Fernandes et al., 2021) and Itapoá (Valentini et al., Studies from 2021 show that, even in preserved areas, seasonal and natural factors, such as rainfall and tides, They exert a significant influence on contamination levels.

Internationally, studies by Desta et al. (2024) reinforce the relationship between variables environmental factors (rain, temperature, tides) and levels of E. coli or coliforms, while Tselemonis et al. (2023) and Guo & Lee (2021) demonstrate the potential of machine learning for prediction. quick and accurate assessment of bathing suitability. Similarly, Yang et al. (2023) brings innovation by applying Next-generation metagenomics (Nanopore) for absolute quantification of viable microorganisms. representing an advance for quantitative risk analysis.

In food production environments, as in the study by Guimarães Filho et al. (2022) with mussels, microbiological contamination and its reduction through purification demonstrate the interrelationship. between the coastal environment and food security. Furthermore, Araujo et al. (2021) suggest alternatives of biomarkers, such as fecal sterols, to increase sensitivity in wastewater monitoring. in coastal ecosystems.

Finally, studies on beaches in the United States (Cyterski et al., 2022; Lane et al., 2020) They reinforce the reliability of rapid molecular methods (PCR), capable of supporting decisions of Public health in a timely manner.

5. Conclusion

Based on the analysis of the studies, it is concluded that microbiological contamination in environments Coastal erosion is a multifactorial reality, influenced by both environmental conditions and... anthropogenic impacts. The need to broaden the scope of monitoring is evident, including sand and marine organisms, in addition to water, and incorporating innovative methodologies, such as Machine learning, metagenomics, and alternative biomarkers.



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This integrated approach is essential to strengthen public health and ensure safety.

To support and promote the sustainable recreational and economic use of coastal areas.

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