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BEACH QUALITY: LET'S NOT OVERLOOK FUNGAL SAND CONTAMINATION

Qualidade das praias: Não esqueçamos a contaminação da areia por fungos

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ABSTRACT

Fungi are eukaryotic organisms found worldwide, exhibiting rich enzymatic activity that enables their survival in diverse ecological conditions and various environmental niches. The objective of this study was to conduct a comprehensive review of research on fungi contamination in beach sand. Key aspects investigated included organism diversity, factors influencing occurrence and quantity, and a comparison of commonly used methods for sand sample collection. To evaluate beach sand contamination by fungi, a literature search was conducted in June 2022. A wide variety of fungi is present in beach sands, including potentially pathogenic species, with many belonging to the genera *Candida* and *Aspergillus*. Several environmental variables were found to be associated with fungi presence. While sampling methodologies varied among studies, a degree of standardization was observed, with minimal variation. Continuous monitoring and disseminating information are crucial for ensuring the safety of beachgoers and aiding public managers in decision-making processes.

Keywords: urban beach, beach sand, environmental parameters, fungi sampling methodology, mycological contamination.

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RESUMO

Os fungos são organismos eucarióticos encontrados em todo o mundo, que apresentam uma atividade enzimática rica que lhes permite sobreviver em diversas condições ecológicas e em vários nichos ambientais. O objetivo deste estudo foi realizar uma revisão exaustiva da investigação sobre a contaminação por fungos na areia da praia. Os principais aspectos investigados incluíram a diversidade de organismos, os fatores que influenciam a ocorrência e a quantidade, e uma comparação dos métodos habitualmente utilizados para a recolha de amostras de areia. Para avaliar a contaminação da areia da praia por fungos, foi realizada uma pesquisa bibliográfica em junho de 2022. Existe uma ampla variedade de fungos presentes nas areias das praias, incluindo espécies potencialmente patogênicas, muitas das quais pertencentes aos gêneros Candida *e* Aspergillus*. Verificou-se que diversas variáveis ambientais estão associadas à presença de fungos. Embora as metodologias de amostragem tenham variado entre os estudos, observou-se um grau de padronização, com variações mínimas. O monitoramento contínuo e a divulgação de informações são fundamentais para garantir a segurança dos frequentadores das praias e auxiliar os gestores públicos nos processos de tomada de decisão.*

Palavras-chave: *praia urbana, areia de praia, parâmetros ambientais, metodologia de amostragem de fungos, contaminação micológica*

INTRODUCTION

No other natural environment receives more visitors than beaches. Beach quality has been highlighted as a very important factor in attracting tourists (Cabioch & Robert, 2022; Semeoshenkova *et al*., 2017), but according to Araújo & Costa (2008), the recreational use of a beach can have both direct and indirect effects. Where and when coastal environments are used by human populations, the natural conditions tend to be disturbed, and the degree of disturbance ranges from nearly imperceptible to serious.

Beaches can become contaminated by solid wastes (including food scraps), animal dejects or wastewater discharged directly onto the sand. These problems can favour the appearance of pathogenic microorganisms and parasites. The pathogenic organisms found in sand come from many groups, including bacteria, viruses, protozoa, helminths (worms) and fungi (Solo-Gabriele *et al*., 2016). Environmental fungi are widespread in nature, and spores are dispersed by water and air, but some fungi are pathogenic and cause many infections (Romão *et al*., 2015).

Worldwide, beach water is often monitored for microbiological quality to detect the presence of indicators of human sewage contamination to prevent public health outbreaks associated with water contact. Monitoring the water quality of recreational beaches is only one-step toward understanding microbial contamination (the primary cause of beach closings). The surf zone sediment reservoir is typically overlooked and may also be important (Lee *et al*., 2006).

Considerable evidence exists that sand can serve as a reservoir of microorganisms (often in concentrations greater than the beach water), which can be vehicles of disease transmission at beach sites (Brandão *et al*., 2021; Frenkel *et al*., 2020; Leonard *et al*., 2015; Sabino *et al*., 2014; Walker & Robicheau, 2021). Current policies worldwide give scant regard to the impact of sands on the health of users of beaches (Solo-Gabriele *et al*., 2016). However, a standard method does not yet exist to microbiological analysis to sand beach (Whitman *et al*., 2014).

Among the studies that evaluate the presence of microorganisms in sand, the vast majority consider only bacteria, especially those of the coliform group, normally used as environmental indicators for determining the quality of beaches. Data on fungi in beach sand are scarce but they also occur very frequently, being associated to the same sources responsible for the presence of coliforms in coastal environments (Frenkel *et al*., 2020; Walker and Robicheau, 2021).

The goal of the present study was to carry out a survey of studies addressing fungi beach sand contamination, involving questions such as diversity of organisms; parameters that interfere in its occurrence and quantity, and comparison of the most used methods for collecting sand samples to be evaluated.

MATERIAL AND METHODS

Bibliographic search

In order to assess the sand beach contamination by fungi, a literature search was performed in the following platforms in June 2022: Google Scholar; Scopus; PubMed; ScienceDirect and SpringerLink. The keywords "*fungi in beaches*", "*sand contamination*", "*beach sand quality*"and "*microbiota in beach sand*" were used, without any temporary intermittence. The review consisted of assessing publications in English and their respective references for possible additional citations.

Exclusion and inclusion criteria

Three procedures were used for exclusion and inclusion criteria, namely: (1) removal of duplicate articles; (2) selection only of publications that met the objective and purpose of the present study (contamination of sand beach by fungi); and (3) inclusion of articles only, with the removal of proceedings, conference abstracts, editorials, and book chapters.

RESULTS

Most common fungi in the sands

A wide variety of fungi is present in the sand beaches. The diversity of fungal species was high to species considered as potentially harmful especially to immune compromised persons. Most of them have been assigned to the genus *Candida* and *Aspergillus* (Table 1).

Table 1 - Main types of fungi found on sand beaches in the literature

Main types of fungi found on beaches	References
Acremonium sp.	Salvo & Fabiano, 2007; Pereira *et al*., 2013; Abreu *et al*., 2016
Alternaria sp.	Frenkel *et al*., 2020; Mancini *et al*., 2005
Anixiopsis sp.	Chabasse *et al*., 1986
Aphanoascus sp.	Babic *et al*., 2022
Arthroderma sp.	Chabasse *et al*., 1986
Arthrographis sp.	Echevarría, 2019
Aspergillus sp.	Mancini *et al*., 2005; Salvo & Fabiano, 2007; Soussi Abdallaoui *et al*., 2007; Sabino *et al*., 2011; Pereira *et al*.,

	2013; Sabino *et al*., 2014; Romão *et al*., 2015; Abreu *et al*., 2016; Solo-Gabriele *et al*., 2016; Echevarría, 2019; Frenkel *et al*., 2020; Babic *et al*., 2022; Brandão *et al*., 2021; Echevarría, 2022; Frenkel *et al*., 2022; Özkan, 2022
Aureobasidium sp.	Solo-Gabriele *et al*., 2016; Frenkel *et al*., 2020
Bisifusarium sp.	Babic *et al*., 2022
Beauveria sp.	Özkan, 2022
Candida sp.	Sanches *et al*., 1986; Mariño *et al*., 1995; Vieira *et al*., 2001; Sato *et al*., 2005; Soussi Abdallaoui *et al*., 2007; Sabino *et al*., 2011; Shah *et al*., 2011; Pereira *et al*., 2013; Romão *et al*., 2015; Abreu *et al*., 2016; Solo-Gabriele *et al*., 2016; Zuza-Alves *et al*., 2016; Zuza-Alves *et al*., 2019; Brandão *et al*., 2021; Frenkel *et al*., 2020; Echevarría, 2022; Frenkel *et al*., 2022
Collariella sp.	Frenkel *et al*., 2020; Frenkel *et al*., 2022
Cephaliophora sp.	Echevarría, 2019
Chaetomium sp.	Salvo & Fabiano, 2007
Chrysosporium sp.	Chabasse *et al*., 1986; Soussi Abdallaoui *et al*.; 2007; Sabino *et al*., 2011; Romão *et al*., 2015; Solo-Gabriele *et al*., 2016.
Cladosporium sp.	Salvo & Fabiano, 2007; Pereira *et al*., 2013; Abreu *et al*., 2016; Solo-Gabriele *et al*., 2016; Özkan, 2022
Cryptococcus sp.	Brandão *et al*., 2021; Frenkel *et al*., 2022
Curvularia sp.	Pereira *et al*., 2013; Abreu *et al*., 2016;
Dendryphiella sp.	Salvo & Fabiano, 2007
Dokmaia sp.	Echevarría, 2019
Drechslera sp.	Özkan, 2022
Emericellopsis sp.	Frenkel *et al*., 2020
Exophiala sp.	Romão *et al*., 2015
Geotrichum sp.	Abreu *et al*., 2016; Pereira *et al*., 2013
Humicola sp.	Özkan, 2022
Epidermophyton sp.	Sabino *et al*., 2011
Exophiala sp.	Solo-Gabriele *et al*., 2016
Fusarium sp.	Mancini *et al*., 2005; Salvo & Fabiano, 2007; Sabino *et al*., 2011; Pereira *et al*., 2013; Romão *et al*., 2015; Abreu *et al*., 2016; Solo-Gabriele *et al*., 2016; Frenkel *et al*., 2020; Brandão *et al*., 2021; Özkan, 2022
Gliomastix sp.	Echevarría, 2019

Kadamea sp.	Frenkel *et al.*, 2022
Lignicola sp.	Salvo & Fabiano, 2007
Malassezia sp.	Echevarría, 2019
Metarhizium sp.	Frenkel *et al.*, 2020
Microascus sp.	Echevarría, 2019
Microsporum sp.	Salvo & Fabiano, 2007; Sabino *et al.*, 2011; Pinto *et al.*, 2012; Romão *et al.*, 2015; Solo-Gabriele *et al.*, 2016
Mucor sp.	Mancini *et al.*, 2005; Pereira *et al.*, 2013; Abreu *et al.*, 2016; Solo-Gabriele *et al.*, 2016; Frenkel *et al.*, 2020
Neoscytalidium sp.	Romão *et al.*, 2015
Paecilomyces sp.	Pereira *et al.*, 2013; Abreu *et al.*, 2016;
Papulospora sp.	Salvo & Fabiano, 2007
Paramicrosporidium sp.	Echevarría, 2019
Penicillium sp.	Mancini *et al.*, 2005; Soussi Abdallaoui *et al.*, 2007; Salvo & Fabiano, 2007; Pereira *et al.*, 2013; Abreu *et al.*, 2016; Solo-Gabriele *et al.*, 2016; Frenkel *et al.*, 2020; Babic *et al.*, 2022; Echevarría, 2022; Özkan, 2022
Phoma sp.	Salvo & Fabiano, 2007; Özkan, 2022
Rhizopus sp.	Babic *et al.*, 2022
Rhodotorula sp.	Solo-Gabriele *et al.*, 2016; Frenkel *et al.*, 2022
Scedosporium sp.	Soussi Abdallaoui *et al.*, 2007; Sabino *et al.*, 2011; Romão *et al.*, 2015; Solo-Gabriele *et al.*, 2016.
Scopulariopsis sp.	Sabino *et al.*, 2011; Romão *et al.*, 2015; Solo-Gabriele *et al.*, 2016; Özkan, 2022
Stachybotrys sp.	Solo-Gabriele *et al.*, 2016 ; Özkan, 2022
Scytalidium sp.	Soussi Abdallaoui *et al.*, 2007; Sabino *et al.*, 2011; Solo-Gabriele *et al.*, 2016
Talaromyces sp.	Frenkel *et al.*, 2020; Babic *et al.*, 2022
Trichoderma sp.	Salvo & Fabiano, 2007; Frenkel *et al.*, 2020
Trichophyton sp.	Chabasse *et al.*, 1986; Soussi Abdallaoui *et al.*, 2007; Sabino *et al.*, 2011; Pereira *et al.*, 2013; Romão *et al.*, 2015; Abreu *et al.*, 2016; Solo-Gabriele *et al.*, 2016; Özkan, 2022
Trichosporon sp.	Chabasse *et al.*, 1986
Verrucaria sp.	Nokes *et al.*, 2020

Environmental parameters associated with fungi

Fungi are eukaryotic organisms with a global distribution and rich enzymatic activity. In this way, their survival is allowed under different ecological conditions, thus being found in various environmental niches (Frenkel et al., 2020; Whitman et al., 2014; Brandão et al., 2022). The development of fungi in the beach sand can be favoured by different variables, the most studied being: sand humidity (Soussi Abdallaoui et al., 2007; Velonakis et al., 2014; Whitman et al., 2014), number of bathers or users (Brandão et al., 2021), seasons (Abreu et al., 2016; Brandão et al., 2021; Chabasse et al., 1986; Moura Sarquis and Oliveira, 1996; Sato et al., 2005; Soussi Abdallaoui et al., 2007), urbanization level (Stevens et al., 2012; Walker and Robicheau, 2021), latitude (Brandão et al., 2021; Romão et al., 2015; Solo-Gabriele et al., 2016; Walker and Robicheau, 2021), grain size (Abreu et al., 2016; Soussi Abdallaoui et al., 2007), sewage exposure (Abreu et al., 2016; Brandão et al., 2021; Sabino et al., 2011), temperature (Soussi Abdallaoui et al., 2007), UV radiation, rainfall events, chemical nature of the sand, organic load and presence of animals and birds (Brandão et al., 2021).

Sand humidity favours the formation of fungi in the sands beach (Soussi Abdallaoui et al., 2007). However, Indicator microbes in the dry sand always resulted in the highest compared with the wet and inundated sand samples (Vieira *et al*., 2001; Shah *et al*., 2011).

In the archipelago of Madeira, it was evaluated whether there was an influence of the type of sediment of the sandy beaches (basaltic, natural calcareous and artificial calcareous) and the type of beach (natural or artificial) in relation to the occurrence of fungi (Abreu *et al*., 2016; Pereira *et al*., 2013). These studies showed that there was no influence of the type of grain on the occurrence of fungi and that the entry of sewage under the coast facilitates this occurrence, especially in climatic events of extreme rainfall. When it comes to the evaluation of sand contamination by fungi, a direct relationship with the level of faecal pollution of sand and/or seawater was not observed (Marino *et al*., 1995).

Artificial beaches, for presenting rigid structures of protection and support that break the coastal dynamics, favour the permanence of sources of contamination to bathers, being these in number/diversity of fungi in the sand more contaminated (Abreu *et al*., 2016; Pereira *et al*., 2013). Differences in the diversity and quantity of fungi were also found when comparing coastal and continental beaches, with dermatophytic fungi being more frequent on coastal beaches. *Candida parapsilosis*, *C. tropicalis* and *C. dubliniensis* species were reported only on coastal beaches (Brandão *et al*., 2021; Dunn and Baker, 1984; Stevens *et al*., 2012; Walker and Robicheau, 2021).

The influence of the presence of bathers on the number/diversity of fungi in the sand suggests a greater number of fungi on urban beaches (Abreu *et al*., 2016; Brandão *et al*., 2021; Mancini *et al*., 2005; Soussi Abdallaoui *et al*., 2007). For example, *Candida albicans*, C. *parapsilosis* and *Cryptococcus* spp. were detected only in the sand of urban beaches (Brandão *et al*., 2021; Dunn and Baker, 1984; Stevens *et al*., 2012; Walker and Robicheau, 2021; Zuza-Alves *et al*., 2019). The presence of bathers will mainly influence fungal species such as *Candida* spp. On the other hand, the species *C. dubliniensis* appeared in higher concentrations in the sands of non-urban beaches. This can be explained by the fact that this species is associated with more natural and non-urban environments (Brandão *et al*., 2021; Dunn and Baker, 1984.; Stevens *et al*., 2012; Walker and Robicheau, 2021; Zuza-Alves *et al*., 2019).

There is a seasonal preference for the development of fungi, being the main meteorological condition to define the fungal load in the beach sand (Moura Sarquis & Oliveira, 1996). The autumn/winter seasons are preferred for the development of fungi regardless of the species, when compared to the spring/summer period (Brandão *et al*., 2021). In the sands of beaches in Brazil, the highest number of filamentous fungi was isolated during the winter and the lowest number in the summer (Moura Sarquis & Oliveira, 1996).

The exposure of microorganisms to ultraviolet radiation (UV) causes denaturation of proteins and damage to their genetic material. High summer sand temperatures can inhibit the growth or destroy fungi, and this combined with prolonged exposure to UV rays (Brandão *et al*., 2021; Pereira *et al*., 2013; Solo-Gabriele *et al*., 2016). Sand particles exposed to the sun can get very hot (Solo-Gabriele *et al*., 2016). Dunn and Baker (1984) reported for Hawaiian sands with high temperature (51°C) that the number of fungi was significantly lower, than on beaches with a sand temperature of 30-35 ° C.

Cases where fungal populations have peaked outside the bathing season have been attributed to pollution events such as a sewer rupture, black tongues, where the sandy habitat is severely influenced by environmental changes; particularly temperature and exposure to UV light (Brandão *et al*., 2021; Chabasse *et al*., 1986; Pereira *et al*., 2013; Solo-Gabriele *et al*., 2016; Zuza-Alves *et al*., 2016). The enrichment of beach sand with large amounts of human keratin may eventually lead to favourable conditions for an increase in the number of keratinophilic fungal pathogens. Therefore, these developing natural areas seem to require microbiological surveillance, especially when subjected to the type of environmental pressure described (Chabasse *et al*., 1986).

The existence of a large number of facilities such as tents, kiosks, toilets, among others, on the beach can play an important role in the quality sand (Pinto *et al*., 2012). Coastal management measures and organization of the coast must provide for sanitary measures in order to prevent/improve the quality of the sand, minimizing risks to the health of users (Pinto *et al*., 2012).

Sampling methodology adopted

Sampling methodologies observed in the literature are different, but tend to show a certain level of standardization, with little variation (Table 2). There is a tendency for sampling to be made in dry sand and up to 15 cm depth.

Table 2 - Sampling methodology used, available in the literature

References	Sampled Beach Area	Weight (g)	Depth (cm)	Sampling Frequency
Abdallaoui *et al*., 2007	Three levels.	Approximately 100 g.	On the surface and 5 cm from depth.	Sand samples were taken twice a week (Mondays and Fridays - before and after the weekend) during a summer month.
Abreu *et al*., 2016	Dry sand.	Approximately 200 g.	At a depth from 5 to 15 cm.	Monthly throughout the bathing season – June to September in 2010, 2011, 2012 and 2013 (4 months in each year).
Babic *et al*., 2022	Dry sand.	Approximately 200 g.	At a depth from 5 to 15 cm.	Sampling of the quartz sand was performed monthly between 9 am and 10

				am, from October 2018 to September 2019.
Brandão *et al*, 2020	Dry sand.	Not specified.	Depth of about 10 cm.	Twice during a summer month.
Brandão *et al*., 2021	Dry sand.	Between 100 and 200 g.	At a depth from 5 to 15 cm.	Single sampling.
Chabasse *et al*., 1986	Not specified.	Between 1500 and 2000 g.	Surface sand (< 5 cm depth).	Sampling was carried out quarterly, over a year.
Echevarría, 2019	Dry sand.	100 g.	Not specified.	One sample per month from three equidistant points was acquired every month for a year in each beach to dry (December- April) and humid (May-November) seasons.
Echevarría, 2022	Dry sand.	100 g.	Not specified.	The samples were taken from February to March 2021 (three weeks).
Frenkel *et al*., 2020	Dry sand.	Not specified.	At a depth from 5 to 15 cm.	During one year, involving 3 sampling rounds (during bathing season, prebathing season and postbathing season).
Frenkel *et al*., 2022	Dry sand.	40 g.	Depth of about 10 cm.	Sampling was performed during the bathing season and pre/post-bathing season and collected 3 times at each beach.
Mancini *et al*., 2005	Dry sand.	Approximately 240 g.	Surface sand (< 5 cm depth).	Single sampling.
Mariño *et al*, 1995	Not specified.	Not specified.	Surface sand (< 5 cm depth).	Single sampling.
Pereira *et al*., 2013	Dry sand.	Approximately 200 g.	At a depth from 5 to 15 cm.	Once a month during the bathing season - June to September

				2010 (4 months) and April to September 2011 (6 months).
Pinto *et al.*, 2012	Wet and dry sand.	Approximately 500 g.	Surface sand (< 5 cm depth).	Monthly, on Sundays, during one year.
Sabino *et al.*, 2011	Dry sand.	Not specified.	Depth of about 10 cm.	Monthly for 4 years.
Salvo; Fabiano, 2007	Wet sand.	Not specified.	Surface sand (< 5 cm depth).	During the summer of one year.
Sanchez *et al.*, 1986	Dry sand.	Approximately 500 g.	Surface sand (< 5 cm depth).	Monthly during 19 months.
Sato *et al.*, 2005	Wet and dry sand.	Approximately 500 g.	Surface sand (< 5 cm depth).	Dry season (September, October and November and rainy season (January, February and March).
Shah *et al.*, 2011	Three levels.	Not specified.	Surface sand (< 5 cm depth).	Six different days, 1 h after high tide.
Vieira *et al.*, 2001	Wet and dry sand.	100 g.	Surface sand (< 5 cm depth).	Weekly.

Risk of contracting diseases with use of the beach

The sand contamination can promote direct human contact with a great diversity of pathogens that cause the most diverse diseases to their users (Pond, 2005; Solo-Gabriele *et al.*, 2016). Some of the yeasts and mould species found in sand are known opportunistic pathogens, or respiratory allergens (Frenkel *et al.*, 2020).

Although a direct relationship was not observed between the number of pathogens in the water and in the sand (Marino *et al.*, 1995), sand can behave both as a source of contamination for water (Abreu *et al.*, 2016) and as a reservoir for pathogens (Velonakis *et al.*, 2014).

Infections of the eyes, skin, ears, nose and throat are the most common diseases caused by fungi in these environments (Costa & Costa, 2020; Romão *et al.*, 2015; Solo-Gabriele *et al.*, 2016). In more contaminated sites, there is also a risk of more serious diseases, such as pulmonary aspergillosis and fungal meningitis (Pond, 2005; Solo-Gabriele *et al.*, 2016). Children, seniors and people with compromised immune systems are more susceptible to acquiring these types of diseases (Romão *et al.*, 2015; Solo-Gabriele *et al.*, 2016).

In the literature, the genera most frequently observed are *Trichophyton* (Abreu *et al*., 2016; Chabasse *et al*., 1986; Romão *et al*., 2015; Sabino *et al*., 2011), *Cladosporium* (Abreu *et al*., 2016; Pereira *et al*., 2013; Salvo & Fabiano, 2007; Solo-Gabriele *et al*., 2016; Soussi Abdallaoui *et al*., 2007), *Aspergillus* (Abreu *et al*., 2016; Brandão *et al*., 2021; Frenkel *et al*., 2020; Mancini *et al*., 2005; Pereira *et al*., 2013; Romão *et al*., 2015; Sabino *et al*., 2014, 2011; Salvo & Fabiano, 2007; Solo-Gabriele *et al*., 2016; Soussi Abdallaoui *et al*., 2007) and *Candida* (Abreu *et al*., 2016; Brandão *et al*., 2021; Frenkel *et al*., 2020; Marino *et al*., 1995; Pereira *et al*., 2013; Romão *et al*., 2015; Sabino *et al*., 2011; Sanchez *et al*., 1986; Sato *et al*., 2005; Solo-Gabriele *et al*., 2016; Soussi Abdallaoui *et al*., 2007; Vieira *et al*., 2001) all of great clinical relevance.

Trichophyton and *Cladosporium* genus mainly bring together species of pathogenic fungi that grows on skin, mucous membranes, hair, nails, feathers, and other body surfaces, causing ringworm and related diseases (Abreu *et al*., 2016; Chabasse *et al*., 1986; Pereira *et al*., 2013; Romão *et al*., 2015; Sabino *et al*., 2011; Salvo & Fabiano, 2007; Solo-Gabriele *et al*., 2016; Soussi Abdallaoui *et al*., 2007). Clinical manifestations of *Aspergillus* species include subcutaneous infections, hypersensitivity reaction and pulmonary aspergillosis (Abreu *et al*., 2016; Brandão *et al*., 2021; Frenkel *et al*., 2020; Mancini *et al*., 2005; Pereira *et al*., 2013; Romão *et al*., 2015; Sabino *et al*., 2014, 2011; Salvo & Fabiano, 2007; Solo-Gabriele *et al*., 2016; Soussi Abdallaoui *et al*., 2007).

Infections caused by *Candida* sp. are among the most common fungal infections in humans, covering several forms of candidiasis (Pereira *et al*., 2013). Species of the genus most often affect the mucosal surfaces on which the agent is found (nails, areas of skin folds, oral area, genital and anal area). They cannot survive long-term in contaminated sand, indicating that when their presence is reported, it is due to recent contamination (Abreu *et al*., 2016; Brandão *et al*., 2021; Frenkel *et al*., 2020; Marino *et al*., 1995; Pereira *et al*., 2013; Romão *et al*., 2015; Sabino *et al*., 2011; Sanchez *et al*., 1986; Sato *et al*., 2005; Solo-Gabriele *et al*., 2016; Soussi Abdallaoui *et al*., 2007; Vieira *et al*., 2001; Zuza-Alves *et al*., 2019).

As reported in the literature, the beach environment has a great diversity of fungi, due to the present contamination (Abreu *et al*., 2016; Solo-Gabriele *et al*., 2016; Soussi Abdallaoui *et al*., 2007). Critical points are mainly associated with the flow of people passing through the site, sewage discharges and sources of garbage present in the sand (Abreu *et al*., 2016; Solo-Gabriele *et al*., 2016). These factors associated with environmental factors such as incidence of winds, temperature and sand humidity; contribute to the dissemination and maintenance of atypical species in this environment (Abreu *et al*., 2016; Solo-Gabriele *et al*., 2016).

CONCLUSION

This work gathered information from the literature about the sand quality in the world. The most observed species and genus, associated environmental parameters, sampling methodologies and the risk of contracting diseases with use of the beach were surveyed. Fungi (pathogenic and non-pathogenic) are often found in sand and survive longer compared to other microorganisms in this environment. Therefore, greater attention to the beaches sands is suggested, not only for the water zone, but also for the dry and wet zones.

Despite a certain standardization of the methodologies used in the field in recent years, the abundance of fungi is greatly influenced by different environmental factors: organic load in sand strip, number of bathers, seasons, meteorological factors (temperature, UV, tides) and sand granulometry. All these factors influence the results and need to be considered in the analyses.

Estimating, monitoring and disseminating information related to their presence on beaches is essential for beach users to be able to guarantee the safety of their leisure, as well as for public managers to make decisions, mainly of a sanitary nature.

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