Beach sand quality – a recent concern

João Brandão, PhD

Water and Soil Unit, Dept of Environmental Health, National Institute of Health Dr. Ricardo Jorge

Research Centre for Environmental and Marine Studies (CESAM) – Integrated researcher

https://orcid.org/0000-0001-7553-227X
Email: joao.brandao@insa.min-saude.pt

National representative to the European Confederation of Medical Mycology and to the European Microbiology Experts sub-Group (for the European Bathing and Drinking Water Directives) & WHO expert member of the Guidelines development group

Contents of this presentation

1. Information about Sand (9 slides)
2. The case study of Porto Pim Beach, Faial, Azores, Portugal (8 slides)
3. The Mysosands initiative (6 slides)
4. Way forward (1 Slide)
5. Acknowledgements (1 slide)

Beach need-to-knows/concepts

- Coastal sand composition of beaches varies from volcanic to silica-carbonated and other minerals and in granulometry[1]
- Beaches can be natural or man-made/renourished with sand from other locations, possibly carrying pathogens along[2]
- Inland beaches may have sand, sediment, or mixtures of both, in different composition ratios[1]
- Beach sand is divided in two areas: The wet area or swash zone and the dry area or supratidal zone[2]

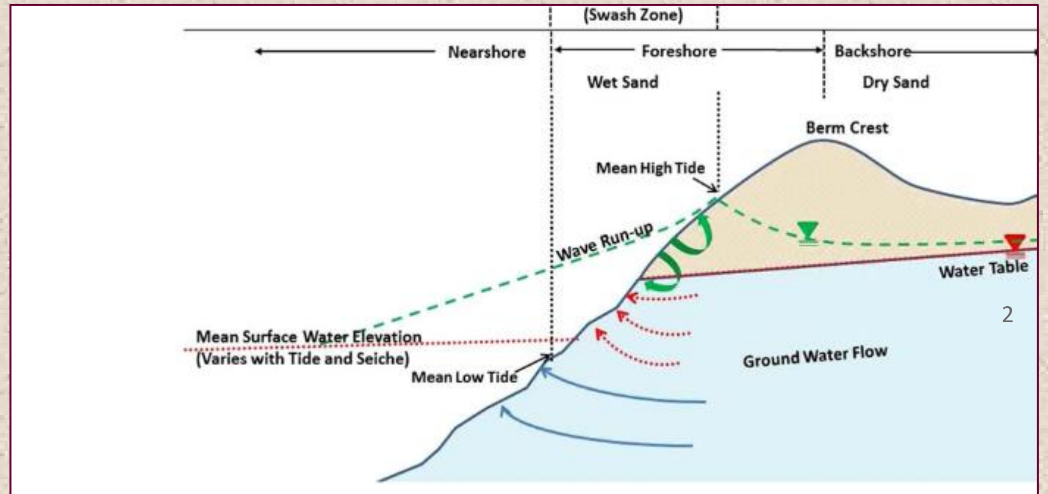


Fig. 1. Zones at the interface between beach sand and water. The terminology differs between tidal marine systems and non-tidal freshwater systems. M water elevations for marine systems tends to vary with tides. For freshwater systems, in particular within lakes, the mean surface water elevation tends t seiche. For river systems, mean surface water elevations vary with the seasonal elevation of the groundwater table and waves tend to run parallel to t opposed to the perpendicular direction observed in most marine and lake settings. (Image modified from Whitman *et al.*, 2014).

[1]Abreu *et al*. 2016 – doi: 10.1016/j.scitotenv.2016.08.160
[2]Solo-Gabriele *et al*. 2016 – doi: 10.1017/S0025315415000843;

Sand water interaction: Tidal wash-out, storm run-off, feet-dragging, animal skin shedding (including humans), Wastewater treatment plant outfall, ships, loitering

Weiskerger, C. J., *et al.* 2019. Impacts of a changing earth on microbial dynamics and human health risks in the continuum between beach water and sand. *Water research*, *162*, 456–470. https://doi.org/10.1016/j.watres.2019.07.006

Why does it matter?

1. Sand is a potential source for diffuse pollution in recreational water quality due to loitering, run-off, wild-life and feet-dragging,

2. Sand is where beach users spend most of their time at the beach,

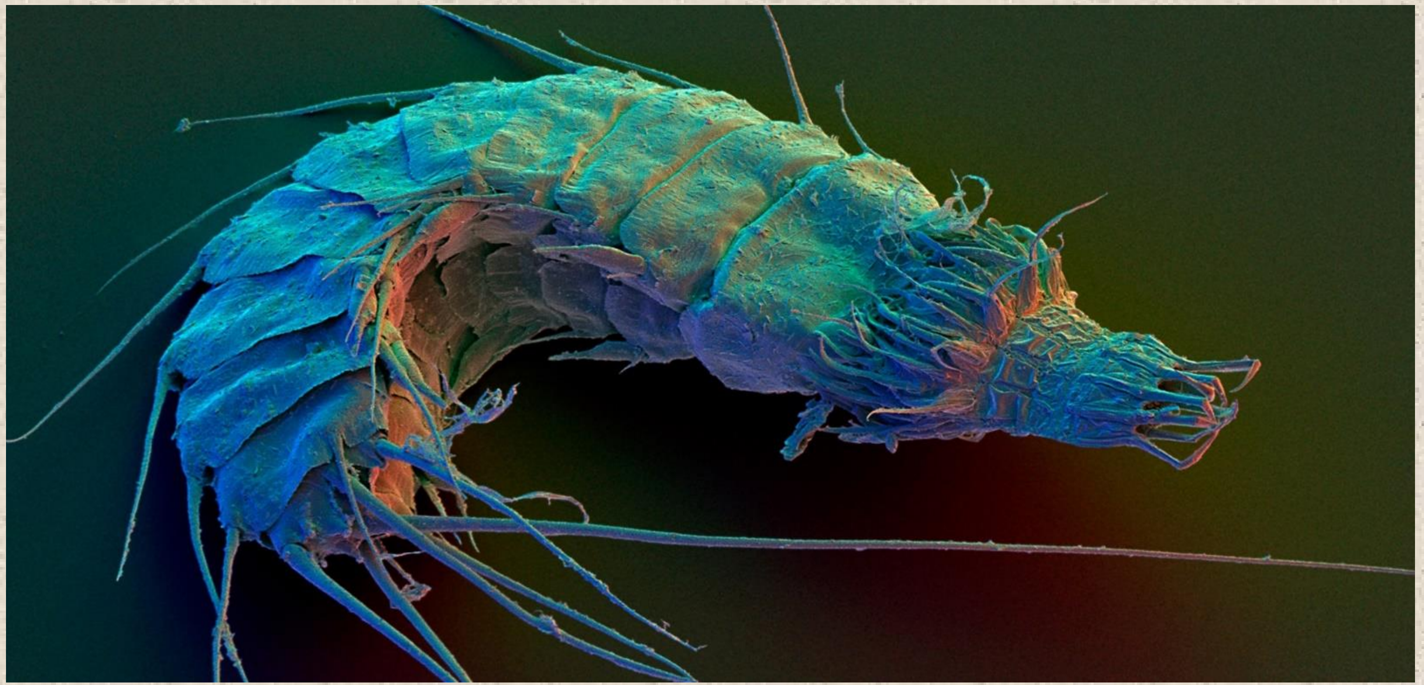
3. On a windy day at the beach, wind will lift sand particles, bringing along viable microbes which will be deposited all of your body, including nostrils, eyes and ears,

4. Allergies can potentially originate in highly contaminated beach sand hours before,

5. Beach is recommended for minimizing skin problems and to help patients recover from other illnesses, who are often more susceptible to opportunistic microorganisms than the regular beach user.

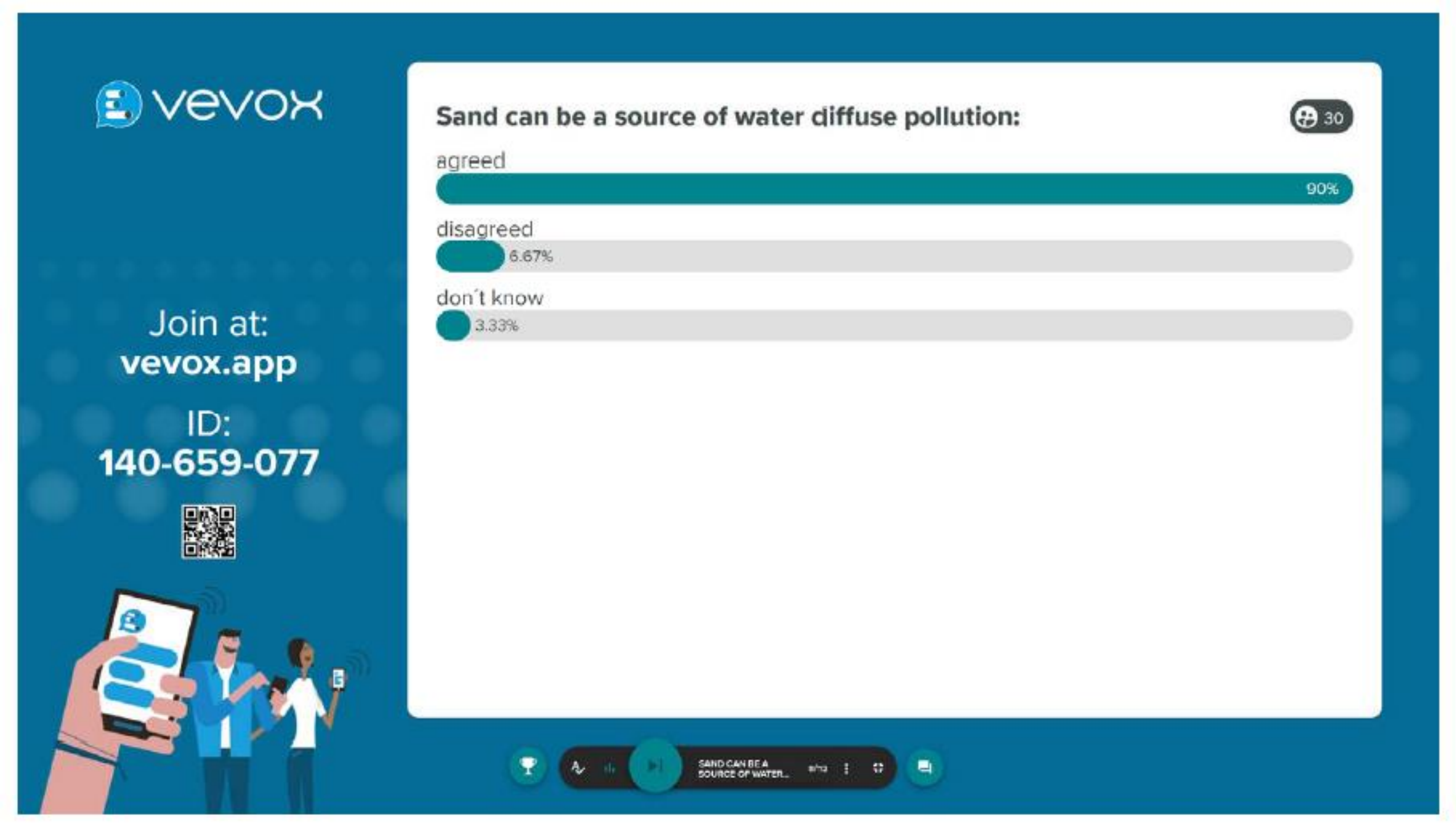
"The Micro Monsters Beneath Your Beach Blanket"

- There's a whole complex microbial community living in sand, with predation, decay, biofilms and even more complex organisms. Sand is a entire ecosystem!
- And we lie on it, and love to feel it under our bare feet during a long walk by the sea, etc.



A *Kinorhyncha in* Hakai Magazine, Coastal science and societies (text by Adrienne Mason, March 21, 2016) http://www.hakaimagazine.com/videos-visuals/micro-monsters-beneath-your-beach-blanket/

The international community agrees to the relevance of sand



How it all began

- For Bacteria: **1975** in Hanauma Bay, O'ahu, Hawai'i - Fujioka & Oshiro found that wild life and sand quality influenced the water quality on that site (an image will come next),
- For Fungi: **1960** in the Baltic Sea, Germany - Schönfeld, Rieth and Thianprasit found geophilic dermatophytes in supratidal sand,
- Also for Fungi: **1973** in the Portuguese, Adriatic and German Baltic coasts - Müller found *Epidermophyton floccosum* (anthropophilic dermatophyte) in supratidal sands.

Hanauma Bay, O’ahu, Hawai’i (photo by viator.com)

Where do we stand now

- 2017: Argentina included sand inspection for rubbish in its water quality standards,
- 2018: Lithuania added monitoring of helminths in sand to their National regulation,
- 2021: WHO launched its revised guidelines for recreational water quality and recommended sand monitoring,

- 2022: Blue flag in Portugal added sand quality to its awarding system, based on the enumeration per g of sand, of enterococci, *E. coli* and all Fungi.

BLUE FLAG

Current WHO recommendations:

- For FIB: 60 MPN/g for enterococci which was calculated through QMRA as the equivalent to 200 CFU/100 mL in water, which represents a risk of illness of less than 5% (H. Solo-Gabriele) - chapter 7 of the guidelines shows the calculations and supporting principles and literature.

- For Fungi: 90 CFU/g of all fungal species, following the Mycosands initiative results on a broad survey of beaches in Europe and Sydney, Australia – see next slides

Instituto_Nacional de Saúde

CESAM

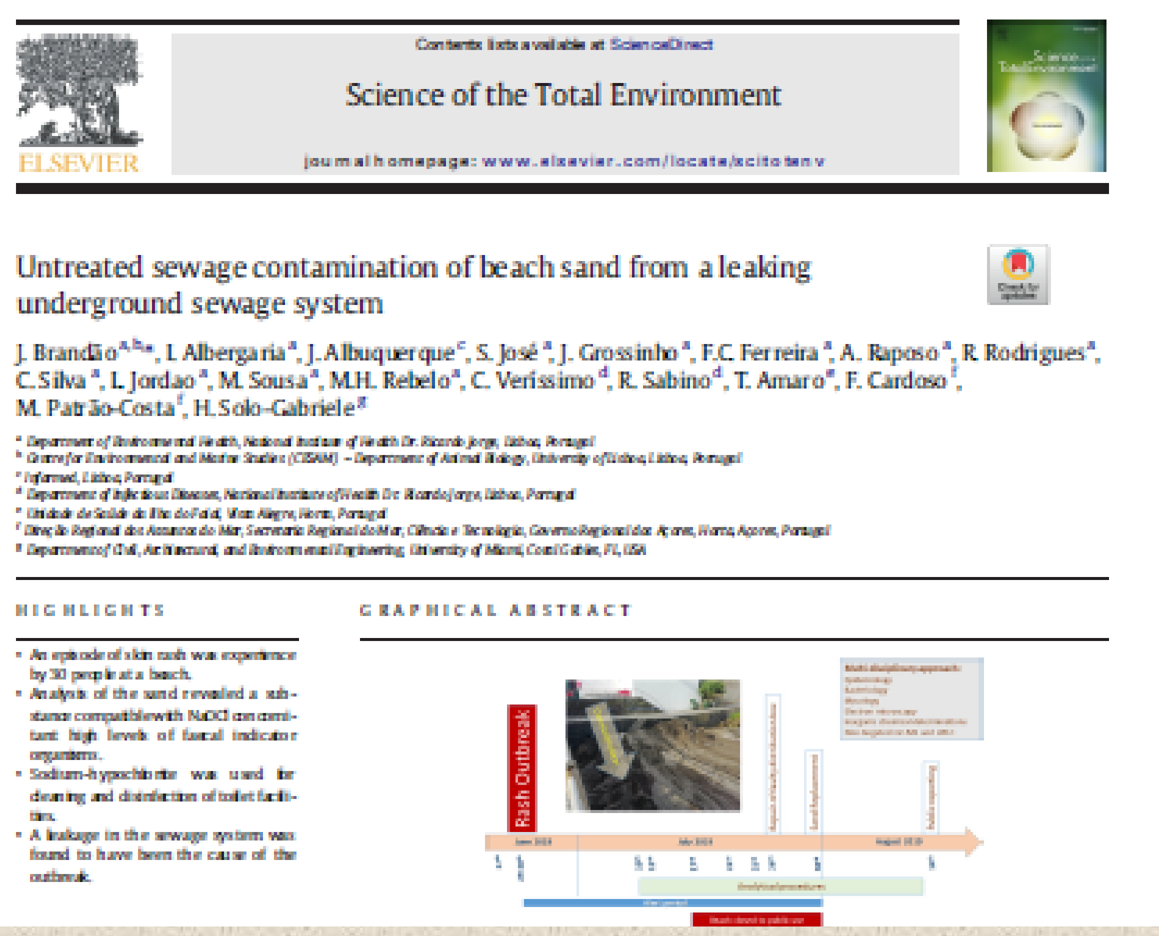
Ciências ULisboa

www.insa.pt

cE3c centre for ecology, evolution and environmental changes

An actual case:

- *"Untreated sewage contamination of beach sand from a leaking underground sewage system - An episode of skin rash was experienced by 29 people at a beach"*



Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Untreated sewage contamination of beach sand from a leaking underground sewage system

J. Brandão[a,b,*], I. Albergaria[a], J. Albuquerque[c], S. José[a], J. Grossinho[a], F.C. Ferreira[a], A. Raposo[a], R. Rodrigues[a], C. Silva[a], L. Jordao[a], M. Sousa[a], M.H. Rebelo[a], C. Veríssimo[d], R. Sabino[d], T. Amaro[e], F. Cardoso[f], M. Patrão-Costa[f], H. Solo-Gabriele[g]

[a] Department of Environmental Health, National Institute of Health Dr. Ricardo Jorge, Lisboa, Portugal
[b] Centre for Environmental and Marine Studies (CESAM) – Department of Animal Biology, University of Lisboa, Lisboa, Portugal
[c] Infarmed, Lisboa, Portugal
[d] Department of Infectious Diseases, National Institute of Health Dr. Ricardo Jorge, Lisboa, Portugal
[e] Unidade de Saúde da Ilha do Faial, Vila Alegre, Horta, Portugal
[f] Direção Regional dos Assuntos do Mar, Secretaria Regional do Mar, Ciência e Tecnologia, Governo Regional dos Açores, Horta, Açores, Portugal
[g] Department of Civil, Architectural, and Environmental Engineering, University of Miami, Coral Gables, FL, USA

HIGHLIGHTS

- An episode of skin rash was experienced by 30 people at a beach.
- Analysis of the sand revealed a substance compatible with NaOCl concomitant high levels of faecal indicator organisms.
- Sodium-hypochlorite was used for cleaning and disinfection of toilet facilities.
- A leakage in the sewage system was found to have been the cause of the outbreak.

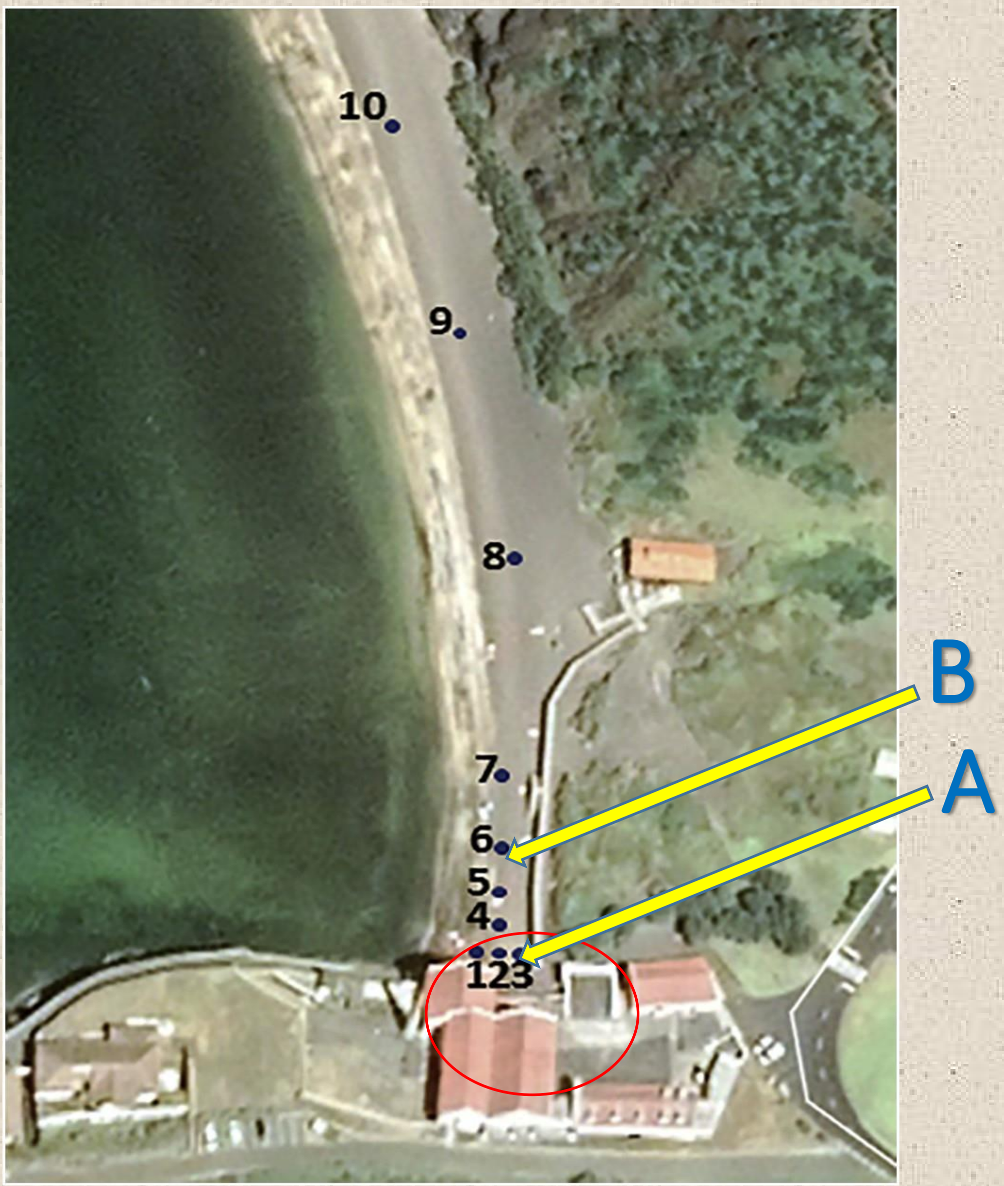
GRAPHICAL ABSTRACT

10.1016/j.scitotenv.2020.140237

What happened in this case?

- The chemical analysis of the sand revealed a substance compatible with Sodium-hypochlorite which was concomitant with high levels of viable faecal indicator organisms.
- This chemical was used for a major cleaning and disinfection operation of the toilet facilities, due to the start of the bathing season.
- A leakage in the sewage system was, in fact, the cause of the outbreak

Areal views of the beach Porto Pim



Analytical results (Microbiology)

	Coliforms (100)*	E. coli (20)*	Enterococci (20)*	Filamentous fungi (560)*	Yeast (60)*	Dermatophytes (15)*
1st campaign (10th July 2019)						
Sample A	**>201**	**>201**	**>201**	100 (50 Fusarium sp)	<1.0	<1.0
Sample B	29	<1.0	9	109	90 (88 *M. guilliermondii* + 2 *C. tropicalis*)	<1.0
2nd campaign (23rd July 2019)						
Sample 1	2	2	4	84	<1.0	<1.0
Sample 2	**>201**	<1.0	**>201**	385	<1.0	<1.0
Sample 3	**>201**	<1.0	6	85	65 (64 Rhodotorula sp.)	<1.0
Sample 4	33	<1.0	**145**	125	<1.0	<1.0
Sample 5	23	<1.0	<1.0	107	<1.0	<1.0
Sample 6	<1.0	<1.0	<1.0	190 (152 Fusarium sp.)	<1.0	<1.0
Sample 7	13	<1.0	1	183 (165 Aspergillus section Circundati)	2	<1.0
Sample 8	9	<1.0	<1.0	55	<1.0	<1.0
Sample 9	2	<1.0	13	5	2 (Rhodotorula sp.)	<1.0
Sample 10	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0

'MPN' = Maximum Probable Number, 'CFU' = Colony Forming Unit. *Maximum reference values per gram of sand.

Location of the degraded distribution box

A B C1 C2

(A) – Lid of the distribution box.

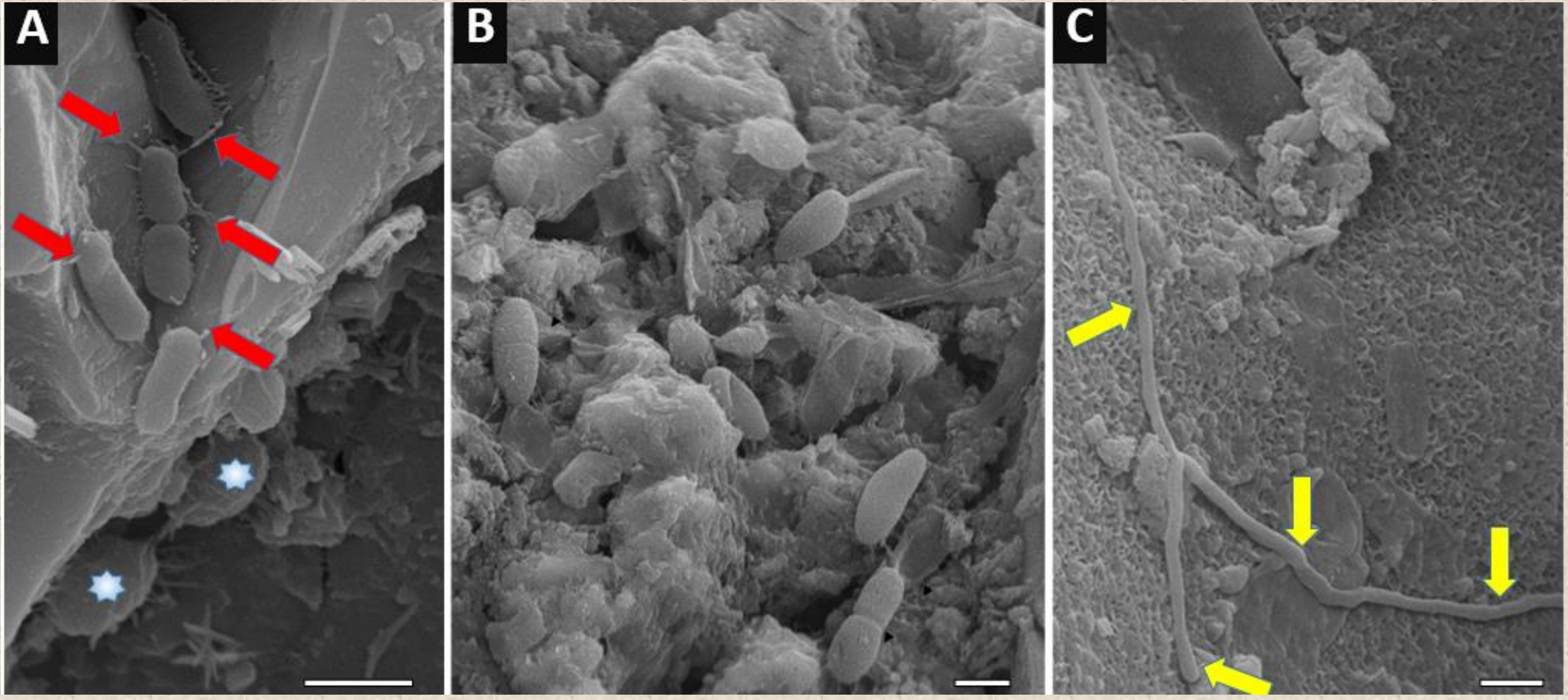
(B) – Inside of the distribution box after partial recovery (bottom) and before full sealing of the sidewalls.

(C1) – representation of the distribution box's position and beach access.

(C2) – Mechanic removal of all of the contaminated sand, as delineated by the analytical results on FIB until 50cm deep (80m3 in total). Point 3 had the highest levels of contamination (>201 MPN of Coliforms, of *E. coli*, and *Enterococci*)

Brandão *et al. 2020* 'Untreated sewage contamination of beach sand from a leaking underground sewage system' Science of The Total Environment 740:140237

‘Little monsters’ on the surface of grains of sand



Scanning electron microscopy of sand particles

Brandão *et al. 2020* ‘Untreated sewage contamination of beach sand from a leaking underground sewage system’ Science of The Total Environment 740:140237

Fungi can be informative as to types of contamination

Fungi found are typical plant pathogens and saprophytes(*) and common fecal pollution(**) presences

**Aspergillus* section *circundati*
**Fusarium* sp

***Meyerozyma guilliermondi*
***Rhodotorula* sp

Brandão *et al. 2020* ‘Untreated sewage contamination of beach sand from a leaking underground sewage system’ Science of The Total Environment 740:140237

How did it end?

- The island's health protection office interdicted the use of the beach until the pollution source was fully resolved and analytically proved.
- The beach was closed for more than a month.
- There were no reported follow-up cases of GI illness in the rash patients, despite the high levels of viable faecal indicator bacteria.
- A tropical storm destroyed the entire beach access shortly after the necessary corrections were made but soon became fully functional once again.

Can Microbial Source Tracking (MST) be used for sand?

- "supratidal sand samples were collected from several sites along the beach, followed by microbial source tracking (MST) analyses of Bacteroides marker genes for five animal species, including humans."

International Journal of *Environmental Research and Public Health*

MDPI

Article

Microbial Source Tracking as a Method of Determination of Beach Sand Contamination

Elisabete Valério [1,2,*,†], Maria Leonor Santos [1,†], Pedro Teixeira [1,2,3], Ricardo Matias [4], João Mendonça [5], Warish Ahmed [6] and João Brandão [1,2]

1 Departamento de Saúde Ambiental, Instituto Nacional de Saúde Doutor Ricardo Jorge, Avenida Padre Cruz, 1649-016 Lisboa, Portugal; leonorsantos.22.66@gmail.com (M.L.S.); pedro.teixeira@cm-lisboa.pt (P.T.); joao.brandao@insa.min-saude.pt (J.B.)
2 Centre for Environmental and Marine Studies (CESAM), Department of Animal Biology, University of Lisboa, 1349-017 Lisboa, Portugal
3 Câmara Municipal de Lisboa, Direção Municipal do Ambiente, Estrutura Verde, Clima e Energia, Laboratório de Bromatologia e Águas, Avenida Cidade do Porto S/N, 1700-111 Lisboa, Portugal
4 Unidade de Desporto e Promoção da Qualidade de Vida, 9700-042 Angra do Heroísmo, Portugal; rmatias@cmah.pt
5 Delegação de Saúde de Angra do Heroísmo, 9700-121 Angra do Heroísmo, Portugal; joaombmendonca@gmail.com
6 CSIRO Land and Water, Ecosciences Precinct, 41 Boggo Road, Dutton Park 4102, Australia; warish.ahmed@csiro.au
* Correspondence: elisabete.valerio@insa.min-saude.pt; Tel.: +351-217-519-200
† These authors contributed equally to this work.

Citation: Valério, E.; Santos, M.L.; Teixeira, P.; Matias, R.; Mendonça, J.; Ahmed, W.; Brandão, J. Microbial Source Tracking as a Method of Determination of Beach Sand Contamination. *Int. J. Environ. Res.*

Abstract: Beach sand may act as a reservoir for numerous microorganisms, including enteric pathogens. Several of these pathogens originate in human or animal feces, which may pose a public health risk. In August 2019, high levels of fecal indicator bacteria (FIB) were detected in the sand of the Azorean beach Prainha, Terceira Island, Portugal. Remediation measures were promptly implemented, including sand removal and the spraying of chlorine to restore the sand quality. To determine the source of the fecal contamination, during the first campaign, supratidal sand samples were collected from several sites along the beach, followed by microbial source tracking (MST)

doi.org/10.3390/ijerph19137934

What happened?

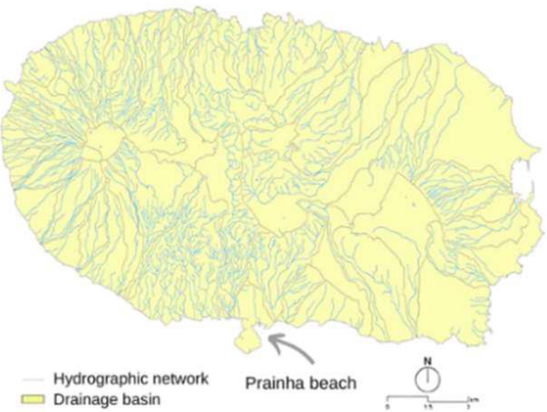
- In August 2019, high levels of fecal indicator bacteria (FIB) were detected in the sand of the Azorean beach Praínha, Terceira Island, Portugal
- Remediation measures were promptly implemented, including sand removal and the spraying of chlorine to restore the sand quality, followed by microbial source tracking (MST)
- Some of the sampling sites revealed the presence of marker genes from dogs, seagulls, and ruminants. The municipality enforced restrictive measures for dog-walking at the beach, which local inhabitants often did in the evenings

Praínha and the pollution

Satellite image

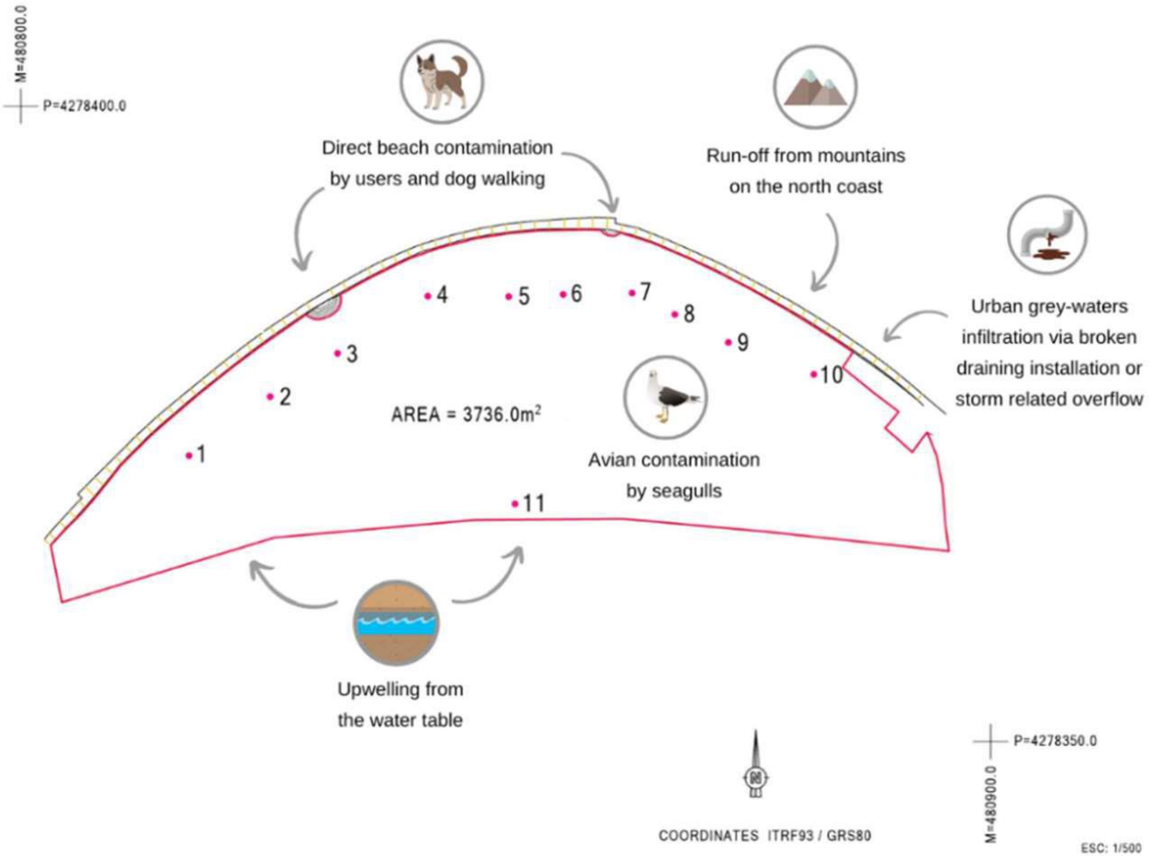
Google Earth, ©2019 CNES / Airbus [48]

Hydrographic map



Simbiente Açores - Engenharia e Gestão Ambiental [49]

Beach topography & Sampling points



Instituto Nacional de Saúde | CESAM | Ciências ULisboa | www.insa.pt | cE3c centre for ecology, evolution and environmental changes

The Mycosands working group

(Lead by Esther Segal, Jean Pierre Gangneux & João Brandão)

Aim: Fungal diversity and abundance in beach **sand and recreational waters** - relevance to human health

Bridging Medical Mycology and Recreational Water Quality

Keywords:
Beach Sand
Recreational water quality
Anti-Microbial Resistance
Core taxa
Ecology
Environmental Health
Inland and Coastal Beaches
Urban Beaches
Moulds
Yeasts

THE TEAM:

France	
Name	**Area**
Frédéric Roger	Atlantic coast
Hélène Guegan	Atlantic coast
Jean-Pierre Gangneux	Atlantic coast
Laurence Delhaes	Bordeaux
Patrice Le Pape	Mediterranean coast
Sébastien Bertout	Mediterranean coast
Stéphane Ranque	Mediterranean coast

Lithuania	
Name	**Area**
Eglė Jonikaitė	Baltic Sea
Marija Kataržytė	Baltic Sea

Sweden	
Name	**Area**
Lena Klingspor	Atlantic coast

Croatia	
Name	**Area**
Darija Vukić Lušić	Adriatic Sea
Slaven Josic	Adriatic Sea

Serbia	
Name	**Area**
Aleksandra Barac	Inland water Basin
Valentina Arsić Arsenijević	Inland water Basin

Romania	
Name	**Area**
Mihai Mares & Collaborators	Black Sea

Italy	
Name	**Area**
Anna Maria Tortorano	Inland water Basin
Anna Prigitano	Inland water Basin
Antonella De Donno	Adriatic Sea
Florent Morio	Mediterranean coast
Francesca Serio	Adriatic Sea
Laura Trovato	Mediterranean coast
Massimo Cogliati	Adriatic Sea
Salvatore C. Oliveri	Mediterranean coast
Salvatore Rubino	Mediterranean coast

Turkey	
Name	**Area**
Betil Ozhak	Mediterranean coast
Çağrı Ergin	Mediterranean coast
Dilara Ogunc	Mediterranean coast
Gule Cinar	Mediterranean coast
Mümtaz Güran	Mediterranean coast
Nilgün Çerikçioğlu	Mediterranean coast
Sevtap Arikan-Akdagli	Mediterranean coast

Ireland	
Name	**Area**
Wim Meijer & Collaborators	Irish Sea

Israel	
Name	**Area**
Esther Segal	Mediterranean coast
Michael Frenkel	Mediterranean coast

Greece	
Name	**Area**
Aristea Velegraki	Mediterranean coast
Emanuel Roilides	Mediterranean coast
Joseph Meletiadis	Mediterranean coast
Maria Efstratiou	Mediterranean coast

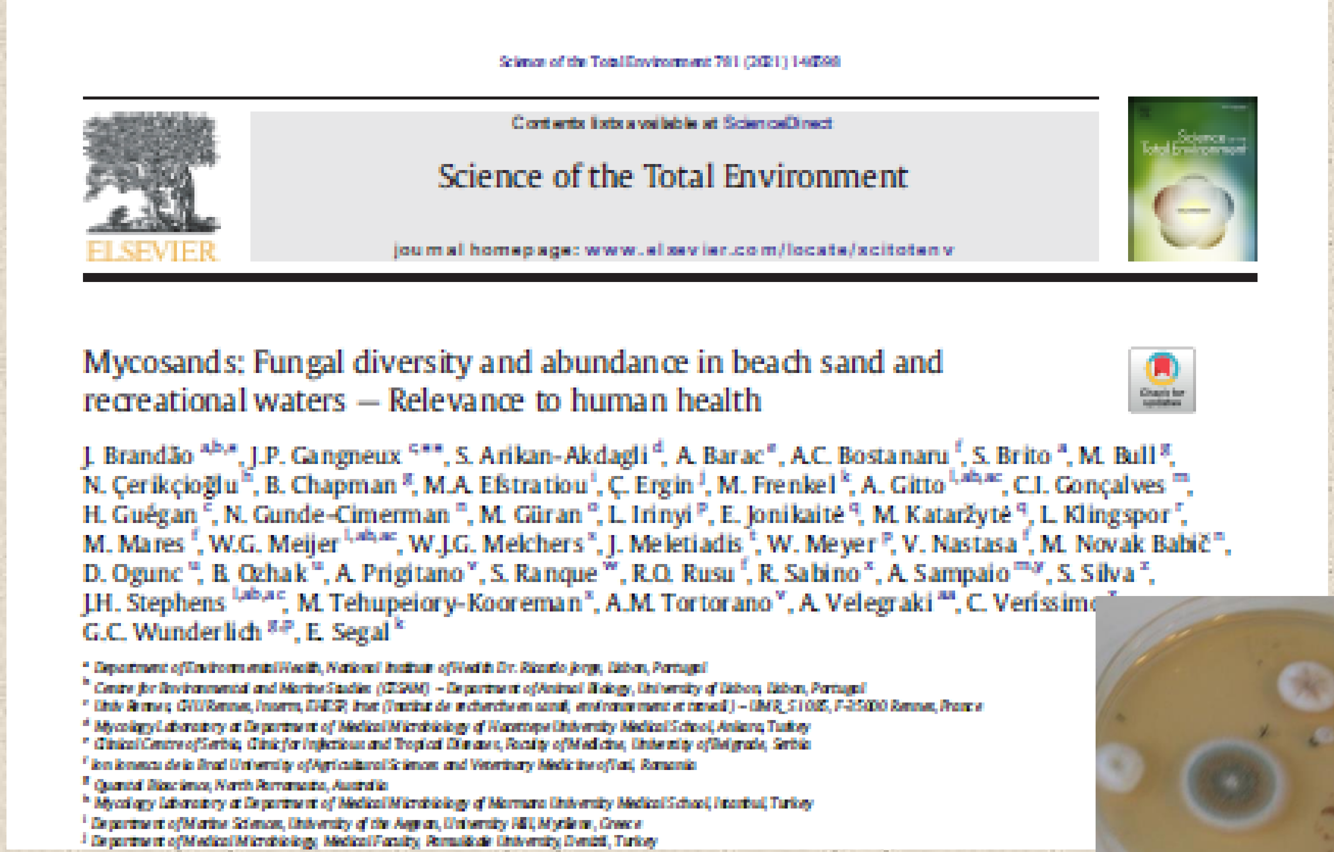
USA	
Name	**Area**
Alexis Danielle Guerra	Irvine, Ca, USA
Helena Solo-gabriele & Co	Miami, Fl, USA
Larissa Montas	Miami, Fl, USA
Sunny Jiang	Irvine, Ca, USA

Netherlands	
Name	**Area**
Wieland Meyer & Collaborators	Sidney
Marlou Tehupeiory-Kooreman	Inland water Basin
Paul Verweij	Inland water Basin
Willem Melchers	Atlantic coast

Portugal	
Name	**Area**
Ana Sampaio	Atlantic coast
Cristina Veríssimo	Atlantic coast
Joao Brandao	Atlantic coast
Raquel Sabino	Atlantic coast
Siyu Huang	Atlantic coast
Susana Pereira	Atlantic coast

Fungal diversity and abundance in beach sand and recreational waters - relevance to human health

- "91 bathing sites, 372 samples of sand, 13 countries"
- "315 water samples,11 countries"



Science of the Total Environment 781 (2021) 146598

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

ELSEVIER

Mycosands: Fungal diversity and abundance in beach sand and recreational waters — Relevance to human health

J. Brandão [a,b,*], J.P. Gangneux [c,**], S. Arikan-Akdagli [d], A. Barac [e], A.C. Bostanaru [f], S. Brito [a], M. Bull [g], N. Çerikçioğlu [h], B. Chapman [g], M.A. Efstratiou [i], Ç. Ergin [j], M. Frenkel [k], A. Gitto [l,ab,ac], C.I. Gonçalves [m], H. Guégan [c], N. Gunde-Cimerman [n], M. Güran [o], L. Irinyi [p], E. Jonikaitė [q], M. Kataržytė [q], L. Klingspor [r], M. Mares [f], W.G. Meijer [l,ab,ac], W.J.G. Melchers [s], J. Meletiadis [t], W. Meyer [p], V. Nastasa [f], M. Novak Babič [n], D. Ogunc [u], B. Ozhak [u], A. Prigitano [v], S. Ranque [w], R.O. Rusu [f], R. Sabino [x], A. Sampaio [m,y], S. Silva [x], J.H. Stephens [l,ab,ac], M. Tehupeiory-Kooreman [s], A.M. Tortorano [v], A. Velegraki [aa], C. Veríssimo [z], G.C. Wunderlich [g,p], E. Segal [k]

[a] Department of Environmental Health, National Institute of Health Dr. Ricardo Jorge, Lisbon, Portugal
[b] Centre for Environmental and Marine Studies (CESAM) – Department of Animal Biology, University of Lisbon, Lisbon, Portugal
[c] Univ Rennes, CHU Rennes, Inserm, EHESP, Irset (Institut de recherche en santé, environnement et travail) – UMR_S1085, F-35000 Rennes, France
[d] Mycology Laboratory at Department of Medical Microbiology of Hacettepe University Medical School, Ankara, Turkey
[e] Clinical Centre of Serbia, Clinic for Infectious and Tropical Diseases, Faculty of Medicine, University of Belgrade, Serbia
[f] Ion Ionescu de la Brad University of Agricultural Sciences and Veterinary Medicine of Iasi, Romania
[g] Quantal Bioscience, North Parramatta, Australia
[h] Mycology Laboratory at Department of Medical Microbiology of Marmara University Medical School, Istanbul, Turkey
[i] Department of Marine Sciences, University of the Aegean, University Hill, Mytilene, Greece
[j] Department of Medical Microbiology, Medical Faculty, Pamukkale University Denizli, Turkey

doi.org/10.1016/j.scitotenv.2021.146598

Mycosands Sampling sites

Geographical distribution of the sampling points using mapping with QGIS (Version 3.10.0-A Coruña). Circles correspond to urban beaches and diamonds to non-urban beaches. Dots within the shapes indicate water-sampling sites. Red=Northwest Europe, Green=Southwest Europe, Blue=Mediterranean, Brown=Black Sea and Purple=Sydney (Australia)

Mycosands conclusions 1/2

- Median number of all fungi in any beach sand (‘All Fungi’) is 89.2 CFU/g*
- Inland beaches have higher counts than coastal beaches (2017.0 vs 76.7 CFU/g)
- Species composition of mycoflora differs between coastal and inland beaches.
- Hotter climates favour the presence of fungi in sand.
- Fungi and Yeasts correlate negatively to the hours of sunshine

*Integrated (rounded to 90 CFU/g) in the WHO guidelines

Mycosands conclusions 2/2

- Fall/Winter present higher counts of fungi in sand than Spring/Summer.
- Urban and non-urban beaches have different mycoflora composition
- Both sand and water should be monitored for fungi
- *Candida albicans*, dermatophytes, endemic fungi and other fungi should be considered in the future
- Fungal analysis of water needs more data before reference values can be established

Mycosands II (To be concluded during 2024)

- Focus on fungi that can grow at 37ºC, the ones able to cause invasive fungal infections (IFI).
- Rerun looking for dermatophytes in both sand and water
- Look for *Candida auris*
- Test anti fungal resistances of all *Candida* spp and *A. fumigatus* sensu stricto strains isolated from sand and from water
- Generate more data on fungi in water (37ªC) to complement data from the first version of the Mycosands initiative, including resistance to antimicrobials

Mould and yeasts: what to expect (Spin-off of Mycosands)

- "The present study employed data collected during the Mycosands survey to investigate the environmental factors influencing yeasts and molds distribution along European shores applying a species distribution modelling approach."

Science of the Total Environment 859 (2023) 160132

Contents lists available at ScienceDirect

ELSEVIER

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Environmental and bioclimatic factors influencing yeasts and molds distribution along European shores

M. Cogliati [a,*], S. Arikan-Akdagli [b], A. Barac [c], A.C. Bostanaru [d], S. Brito [x], N. Çerikçioğlu [e], M.A. Efstratiou [f], Ç. Ergin [g], M.C. Esposto [a], M. Frenkel [h], J.P. Gangneux [i], A. Gitto [j], C.I. Gonçalves [k], H. Guegan [i], N. Gunde-Cimerman [l], M. Güran [m], E. Jonikaitė [n], M. Kataržytė [n], L. Klingspor [o], M. Mares [d], W.G. Meijer [j], W.J.G. Melchers [p], J. Meletiadis [q], V. Nastasa [d], M. Novak Babič [l], D. Ogunc [r], B. Ozhak [r], A. Prigitano [a], S. Ranque [s], L. Romanò [a], R.O. Rusu [d], R. Sabino [t,u], A. Sampaio [k,v], S. Silva [w], J.H. Stephens [j], M. Tehupeiory-Kooreman [p], A. Velegraki [x,aa], C. Veríssimo [t], E. Segal [h], J. Brandão [y,z]

[a] Department of Biomedical Sciences for Health, Università degli Studi di Milano, Milano, Italy
[b] Mycology Laboratory at Department of Medical Microbiology of Hacettepe University Medical School, Ankara, Turkey
[c] Clinical Centre of Serbia, Clinic for Infectious and Tropical Diseases, Faculty of Medicine, University of Belgrade, Serbia
[d] Ion Ionescu de la Brad University of Life Sciences, Iasi, Romania
[e] Mycology Laboratory at Department of Medical Microbiology of Marmara University Medical School, Istanbul, Turkey
[f] Department of Marine Sciences, University of the Aegean, University Hill, Mytilene, Greece
[g] Department of Medical Microbiology, Medical Faculty, Pamukkale University, Denizli, Turkey
[h] Department of Clinical Microbiology and Immunology, Sackler School of Medicine, Tel Aviv University, Tel Aviv, Israel
[i] Univ Rennes, CHU Rennes, Inserm, EHESP, Irset (Institut de recherche en santé, environnement et travail) – UMR_S 1085, F-35000 Rennes, France
[j] UCD School of Biomolecular and Biomedical Science, UCD Earth Institute, and UCD Conway Institute, University College Dublin, Ireland
[k] Department of Biology and Environment, University of Trás-os-Montes and Alto Douro (UTAD), Vila Real, Portugal
[l] Department of Biology, Biotechnical Faculty, University of Ljubljana, Slovenia
[m] Faculty of Medicine, Eastern Mediterranean University, Famagusta, Northern Cyprus, Mersin, Turkey
[n] Marine Research Institute, Klaipėda University, Klaipėda, Lithuania
[o] Division of Clinical Microbiology, Department of Laboratory Medicine, Karolinska Institutet, Stockholm, Sweden
[p] Medical Microbiology, Radboud University Medical Centre (Radboudumc), Nijmegen, the Netherlands
[q] Clinical Microbiology Laboratory, Attikon University Hospital, Medical School, National and Kapodistrian University of Athens, Athens, Greece
[r] Department of Medical Microbiology, Akdeniz University Medical School, Antalya, Turkey
[s] Aix Marseille Univ, IHU-Méditerranée Infection, AP-HM, IRD, SSA, VITROME, Marseille, France
[t] Reference Unit for Parasitic and Fungal Infections, Department of Infectious Diseases, National Institute of Health Doutor Ricardo Jorge, Lisbon, Portugal
[u] Instituto de Saúde Ambiental, Faculdade de Medicina, Universidade de Lisboa, 1649-028 Lisboa, Portugal

doi.org/10.1016/j.scitotenv.2022.160132

What was studied

- Data were compared to climatic datasets (temperature, precipitation, and solar radiation), soil datasets (chemical and physical properties), and water datasets (temperature, salinity, and chlorophyll-a concentration) downloaded from web databases (analyses were performed by MaxEnt software).

Table 1
Number of locations where filamentous fungi and yeast-like fungi were isolated from sand or water samples.

Filamentous fungi			Yeast-like fungi		
Fungal species/category	Sand	Water	Fungal species/category	Sand	Water
Aspergillus flavus	8	1	*Candida albicans*	5	2
Aspergillus fumigatus	20	8	*Candida dubliniensis*	3	2
Aspergillus niger	29	11	*Candida. glabrata*	3	3
Aspergillus spp.	45	27	*Candida parapsilosis s.l.*	4	1
Fusarium spp.	20	4	*Candida tropicalis*	4	2
Dematiaceous	27	11	*Candida* spp.	21	8
Dermatophytes	10	2	*Cryptococcus* spp.	7	0
Molds	51	31	*Rhodotorula* spp.	21	7
			Yeasts	32	14

Red numbers indicate that the number of occurrence points was not sufficient to perform MaxEnt analysis.

What was found

- Yeasts seem to tolerate low temperatures better during winter than molds and this reflects a higher suitability for the Northern European coasts. This difference is more evident considering suitability in waters.
- Both distributions of molds and yeasts are influenced by basic soil pH, probably because acidic soils are more favorable to bacterial growth.
- Soils with high nitrogen concentrations are not suitable for fungal growth, which, in contrast, are optimal for plant growth, favored by this environment.
- Finally,molds show affinity with soil rich in nickel and yeasts with soils rich in cadmium resulting in a distribution mainly at the mouths of European rivers or lagoons, where these metals accumulate in river sediments.

Finding *Candida* spp at the beach

- On the basis of physical properties of soil, the model did not identify neither a specific geographical area nor a specific type of soil associated to *Candida* spp.).

- On the contrary, most of soil textures seem to be suitable for *Candida* spp. survival.

- Furthermore, considering heavy metal concentrations in soil, the analysis of contributing variables showed a correlation with soils containing high cadmium concentrations which are spotted on the distribution map in some specific locations.

- Selvarajan *et al.* 2024 also studied metals and fungi for further reference (Beach sand mycobiome: The silent threat of pathogenic fungi and toxic metal contamination for beachgoers - https://doi.org/10.1016/j.marpolbul.2023.115895

M. Cogliati et al. — *Science of the Total Environment 859 (2023) 160132*

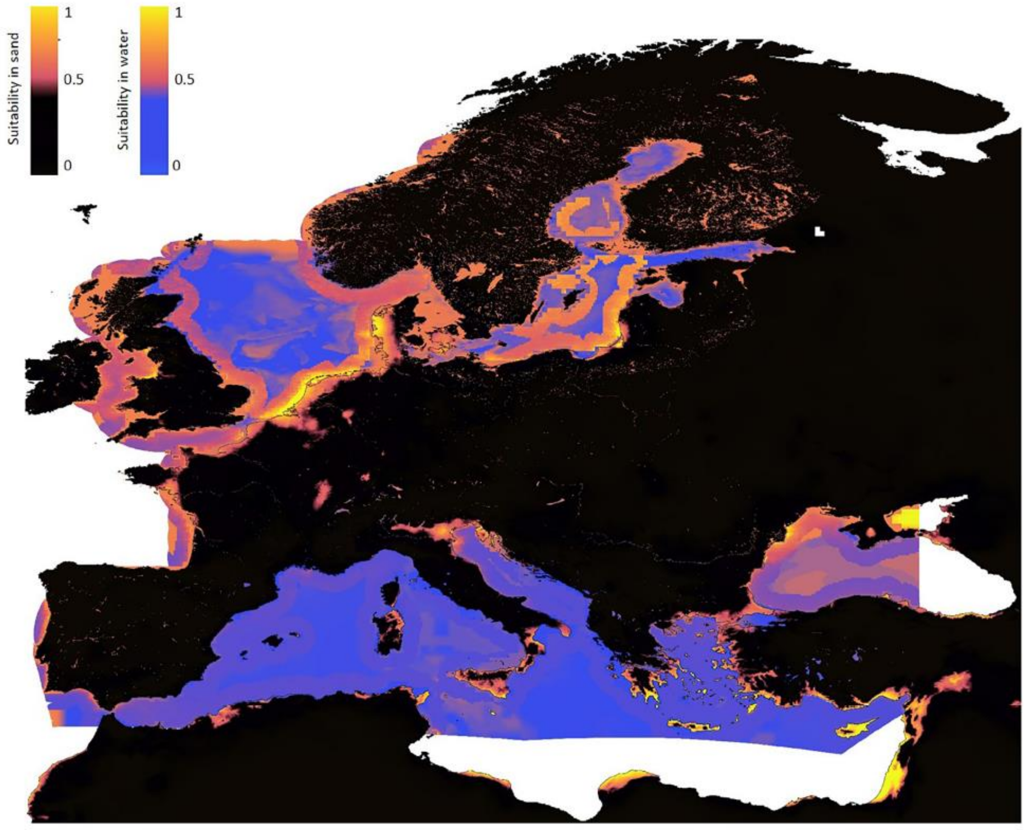
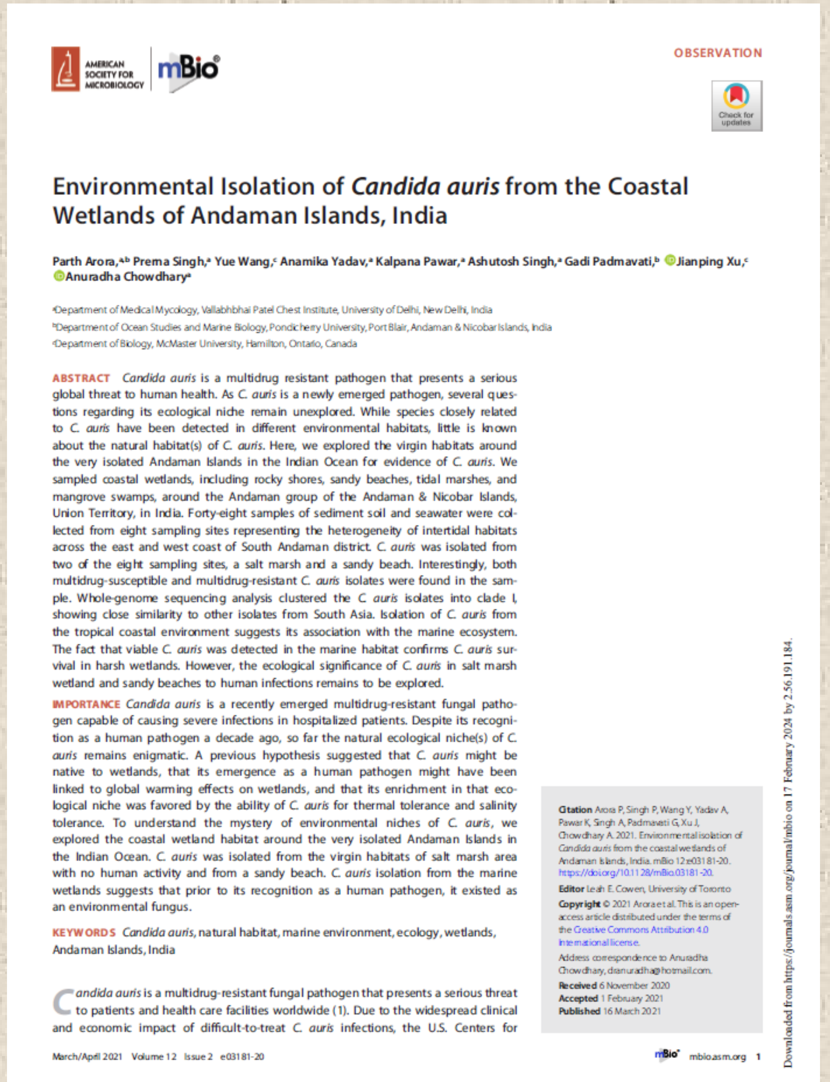


Fig. 6. Merging image showing shore and water distribution models for *Candida* spp.

What about *Candida auris*?

- “We sampled coastal wetlands, including rocky shores, sandy beaches, tidal marshes, and mangrove swamps, around the Andaman group of the Andaman & Nicobar Islands, Union Territory, in India.“
- “Forty-eight samples of sediment soil and seawater were collected from eight sampling sites representing the heterogeneity of intertidal habitats across the east and west coast of South Andaman district.”
- “C. auris was isolated from two of the eight sampling sites, a salt marsh and a sandy beach.”



AMERICAN SOCIETY FOR MICROBIOLOGY | mBio®

OBSERVATION

Check for updates

Environmental Isolation of *Candida auris* from the Coastal Wetlands of Andaman Islands, India

Parth Arora,[a,b] Prema Singh,[a] Yue Wang,[c] Anamika Yadav,[a] Kalpana Pawar,[a] Ashutosh Singh,[a] Gadi Padmavati,[b] Jianping Xu,[c] Anuradha Chowdhary[a]

[a]Department of Medical Mycology, Vallabhbhai Patel Chest Institute, University of Delhi, New Delhi, India
[b]Department of Ocean Studies and Marine Biology, Pondicherry University, Port Blair, Andaman & Nicobar Islands, India
[c]Department of Biology, McMaster University, Hamilton, Ontario, Canada

ABSTRACT *Candida auris* is a multidrug resistant pathogen that presents a serious global threat to human health. As *C. auris* is a newly emerged pathogen, several questions regarding its ecological niche remain unexplored. While species closely related to *C. auris* have been detected in different environmental habitats, little is known about the natural habitat(s) of *C. auris*. Here, we explored the virgin habitats around the very isolated Andaman Islands in the Indian Ocean for evidence of *C. auris*. We sampled coastal wetlands, including rocky shores, sandy beaches, tidal marshes, and mangrove swamps, around the Andaman group of the Andaman & Nicobar Islands, Union Territory, in India. Forty-eight samples of sediment soil and seawater were collected from eight sampling sites representing the heterogeneity of intertidal habitats across the east and west coast of South Andaman district. *C. auris* was isolated from two of the eight sampling sites, a salt marsh and a sandy beach. Interestingly, both multidrug-susceptible and multidrug-resistant *C. auris* isolates were found in the sample. Whole-genome sequencing analysis clustered the *C. auris* isolates into clade I, showing close similarity to other isolates from South Asia. Isolation of *C. auris* from the tropical coastal environment suggests its association with the marine ecosystem. The fact that viable *C. auris* was detected in the marine habitat confirms *C. auris* survival in harsh wetlands. However, the ecological significance of *C. auris* in salt marsh wetland and sandy beaches to human infections remains to be explored.

IMPORTANCE *Candida auris* is a recently emerged multidrug-resistant fungal pathogen capable of causing severe infections in hospitalized patients. Despite its recognition as a human pathogen a decade ago, so far the natural ecological niche(s) of *C. auris* remains enigmatic. A previous hypothesis suggested that *C. auris* might be native to wetlands, that its emergence as a human pathogen might have been linked to global warming effects on wetlands, and that its enrichment in that ecological niche was favored by the ability of *C. auris* for thermal tolerance and salinity tolerance. To understand the mystery of environmental niches of *C. auris*, we explored the coastal wetland habitat around the very isolated Andaman Islands in the Indian Ocean. *C. auris* was isolated from the virgin habitats of salt marsh area with no human activity and from a sandy beach. *C. auris* isolation from the marine wetlands suggests that prior to its recognition as a human pathogen, it existed as an environmental fungus.

KEYWORDS *Candida auris*, natural habitat, marine environment, ecology, wetlands, Andaman Islands, India

Candida auris is a multidrug-resistant fungal pathogen that presents a serious threat to patients and health care facilities worldwide (1). Due to the widespread clinical and economic impact of difficult-to-treat *C. auris* infections, the U.S. Centers for

Citation Arora P, Singh P, Wang Y, Yadav A, Pawar K, Singh A, Padmavati G, Xu J, Chowdhary A. 2021. Environmental isolation of *Candida auris* from the coastal wetlands of Andaman Islands, India. mBio 12:e03181-20. https://doi.org/10.1128/mBio.03181-20.

Editor Leah E. Cowen, University of Toronto

Address correspondence to Anuradha Chowdhary, dranuradha@hotmail.com.

Received 6 November 2020
Accepted 1 February 2021
Published 16 March 2021

doi.org/10.1128/mbio.03181-20)

Detection of enteric viruses in beach sand

- "In this study, the first objective was to evaluate the presence of seven viruses (Aichi virus, enterovirus, hepatitis A virus, human adenovirus, norovirus, rotavirus, and severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)) in sands collected at public beaches. The second objective was to assess the spatial distribution of enteric viruses in beach sand."

Science of the Total Environment 901 (2023) 165836

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

ELSEVIER

Detection of enteric viruses and SARS-CoV-2 in beach sand

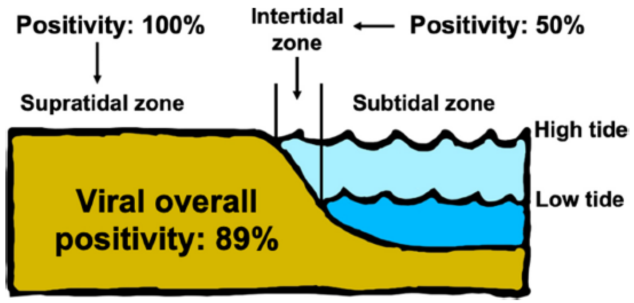
A. Robalo[a], J. Brandão[c], T. Shibata[d,e], H. Solo-Gabriele[f], R. Santos[a,b], S. Monteiro[a,b,*]

[a] Laboratorio Analises, Técnico Lisboa, Universidade Lisboa, Portugal
[b] Departamento de Engenharia e Ciências Nucleares, Técnico Lisboa, Universidade de Lisboa, Portugal
[c] Department of Environmental Health, National Institute of Health Dr. Ricardo Jorge, Lisboa, Portugal
[d] Institute for the Study of the Environment, Sustainability, and Energy, Northern Illinois University, DeKalb, IL, USA
[e] Center for Southeast Asian Studies, Northern Illinois University, DeKalb, IL, USA
[f] Department of Chemical, Environmental, and Materials Engineering, University of Miami, Coral Gables, FL, USA

HIGHLIGHTS

- Enteric viruses detected in high prevalence (89 %) in beach sand
- Aichi virus most frequently detected virus (74 %)
- Distinct viral distribution in intertidal and supratidal beach sand
- Higher viral diversity in the supratidal zone
- Beach events with high impact on sand quality

GRAPHICAL ABSTRACT



doi.org/10.1016/j.scitotenv.2022.160132

Findings

- • Enteric viruses detected in high prevalence (89 %) in beach sand
- • Aichi virus most frequently detected virus (74 %)
- • Distinct viral distribution in intertidal and supratidal beach sand
- • Higher viral diversity in the supratidal zone
- • Beach events with high impact on sand quality

A. Robalo et al. Science of the Total Environment 901 (2023) 165836

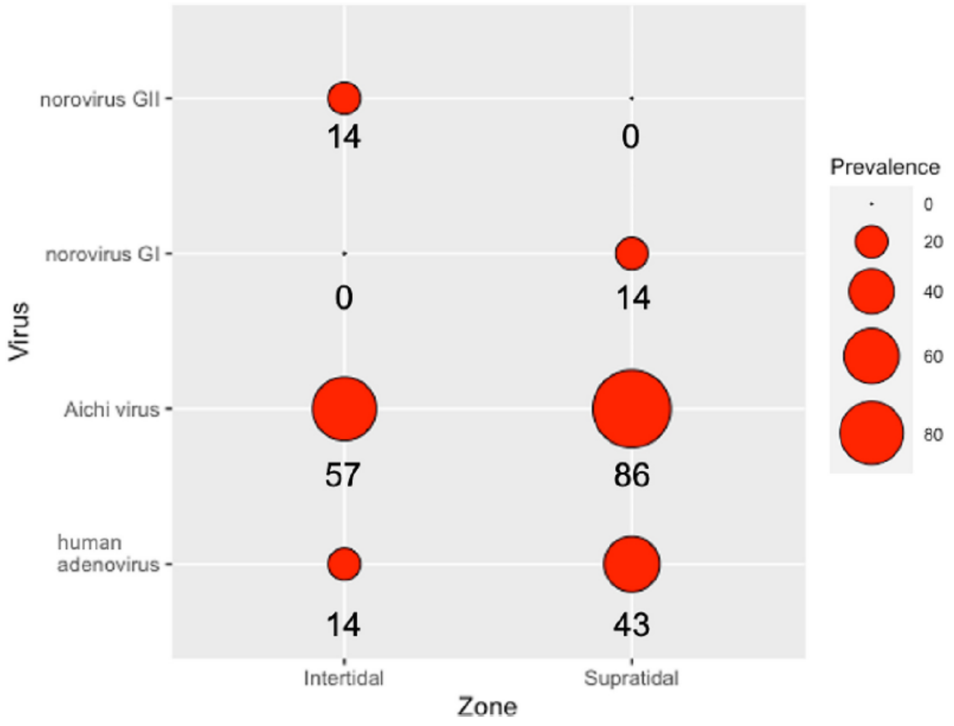


Fig. 2. Detection of viruses in beach samples from the supratidal and intertidal zones. The size of the circle is related to the relative percentage of detection of the viruses in each zone.

Way forward

- Beach classification based on sand monitoring, as currently happens with water, is a relevant issue requiring international strategies,
- Epidemiological studies should be run to confirm the validity of the new WHO 60 MPN/g limit recommendation for enterococci,
- Antimicrobial resistance and other microbes need to be investigated in sand and water, some of which on a risk-based approach, keeping in mind that climate change will have implications on what currently know,
- More fungal parameters need to be designed for endemic areas for sand and water, as recommended by the new WHO guidelines.

Acknowledgments

- The entire team of the Mycosands initiative for generating new data on fungal contaminants of beach sand,
- The European Confederation of Medical Mycology and The International Society of Human and Animal Mycology for financing Mycosands' meetings,
- All those involved in the episode in Azores, authors and otherwise,
- To Dr. Kirs and Dr Yan for organizing this presentation

Thank you! Questions?