**Sandy Beach Microbes: the Good, the Bad, and the Flesh-eating**

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It’s the middle of summer, which means sun, sand and surf for many people in the U.S. Whether you hit up a crowded public beach or a deserted island, you’re sharing your space with billions of microbes that colonize and thrive in near-marine environments all year round. In one study, direct microscopic counts found more bacteria per gram of sand than people in Manhattan! The shore contains as wide a variety of microbes as it does of people, with many of the same sorts of characters: from the helpful and unassuming, to the bad, to the terrifying. Don’t worry, most of these microbes fall into the first two categories.

**The Good: Diverse Microbial Communities are Caretakers of Aquatic Environments.**

From recyclers to caretakers, microbes play an important part in aquatic homeostasis. All beaches support populations of microbes, but a study from Rutgers University determined that [not all beaches are the same](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4836431/). Microbial ecology differs not only between regions­­—such as freshwater beaches on the Great Lakes, or Atlantic or Pacific ocean beaches—but also between locations on the same beach.

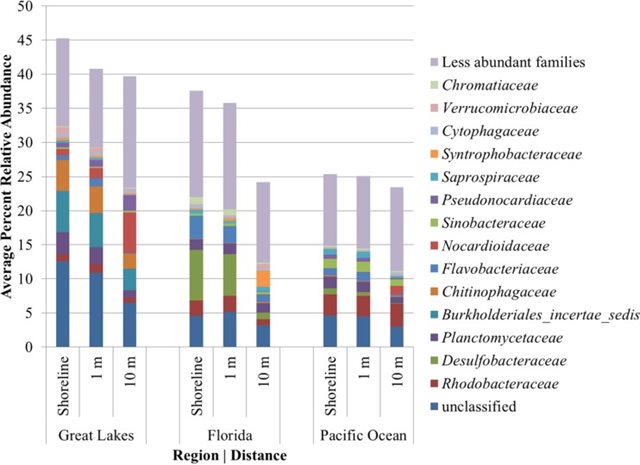
**Fresh vs. Salt Water Microbes**

Do you prefer the refreshing feel of freshwater beaches, or do you find yourself craving the salty air of the ocean? Freshwater and saltwater beaches have distinct microbial communities (more on microbial differences on the same beach later). In a 2016 study by Staley et al., when compared to saltwater beaches, freshwater beaches tend to have more *Actinobacteria*, gram-positive bacteria that perform several beneficial roles. These microbes keep beaches clean by decomposing organic matter in both aquatic and soil environments. Actinobacterial species are also extremely important in human medicine; many of the antibiotics we use today are compounds isolated from this phylum. Compared to marine beaches, freshwater beaches also contain higher levels of β-Proteobacteria, Gram-negative bacteria that use a vast array of organic compounds and/or sunlight to create energy, and of members of *Verrucomicrobia*, a phylum of bacteria that have been identified as beneficial symbionts of eukaryotic hosts, including ectosymbionts of [protists](http://journal.frontiersin.org/article/10.3389/fmicb.2016.00498/full) and [endosymbionts of nematodes](https://academic.oup.com/gbe/article/7/9/2727/592822/Comparative-Genomics-of-a-Plant-Parasitic-Nematode).

In contrast, marine beaches have more γ-Proteobacteria and δ-Proteobacteria. These are diverse phyla that are capable of complex metabolic processes like oxidizing methane and hydrogen sulfide or reducing sulfur-containing compounds. Many members of these phyla are also symbiotic with geothermal vent-dwelling animals. These heat-loving bacteria may seem irrelevant to human life, but some genera of β-Proteobacteria, such as *Nitrobacteriacea*, have been used in industrial sewage waste treatment because of their ability to oxidize ammonia into nitrite. This microbial sanitation process is called bioremediation, and reduces the levels of harsh chemicals to sanitize and degrade harmful waste products. Marine beaches also contain higher levels of *Firmicutes*, aerobic Gram-positive bacteria commonly found in the [human gut](https://en.wikipedia.org/wiki/Gut_flora), and *Planctomycetes*, a phylum of bacteria that may have beneficial relationships with [marine algae](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4042473/).

**Where to Spread your Towel: Microbial Diversity within the Same Beach**

Even on one beach, microbes differ in species composition and diversity between locations relative to the shoreline. The beach can be split up into 3 areas: the near-shore, which is an area permanently saturated with water, the intertidal zone, an area over which waves break and that experiences periodic wetting and drying; and the backshore, which consists mainly of land and does not experience tidal wetting. Certain microbes, such as those in the family *[Nocardioidaceae](https://link.springer.com/content/pdf/10.1007/978-3-642-30138-4_193.pdf" \t "_blank)*, can be found in increasing in abundance the further away from the water one samples, regardless of whether the beach was fresh water or ocean water. Other microbes such as those in the family *[Flavobacteriaceae](https://link.springer.com/referenceworkentry/10.1007%2F978-3-642-38954-2_130)* are more abundantly found in areas exposed to water than in areas further from the shoreline. Overall, the diversity of a complex landscape like a beach cannot be predicted simply by assessing fresh/salt water and location on the beach.

[](https://asm.org/Articles/2017/August/sandy-beach-microbes-the-good-the-bad-and-the-fles#image-modal-2b6b18f6-95ef-46ef-b4f1-2087f1378138)Figure 1. (click to enlarge) Not only do bacterial species differ from region to region, but they also differ based on where you sample relative to the shoreline. Here is a family-level classification of 3 different beaches and 3 locations within those beaches.

Source: <https://aem.asm.org/content/82/9/2751>

**Health and Microbial Diversity?**

Recreational waters have long been monitored for possible human pathogens by testing for the presence and relative abundance of human fecal microbes such as *Escherichia coli*, *Salmonella*, *Shigella*, and other *Enterobacteriaceae*. However, only recently have beach managers begun testing the quality of sand as well. Historically, human pathogens found at the beach have been attributed to fecal contamination of water/sand by other humans and animals, but a number of [studies](https://www.cambridge.org/core/journals/journal-of-the-marine-biological-association-of-the-united-kingdom/article/beach-sand-and-the-potential-for-infectious-disease-transmission-observations-and-recommendations/358E2327F6F8FEF0ADA18F1022957CDC) have identified that microbial pathogens in beach sands are [increasing](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3109870/) and that not all are necessarily of fecal origin. Therefore, understanding beach microbial ecology is important to understanding the effect of these diverse species on public health.

**The Bad and the Terrifying: Beach Pathogens**

It has been an often-repeated claim that human enteric bacteria cannot live outside the host for long periods of time. However, both commensal and pathogenic human-associated microbes have been found in samples of beach sand at any time of the year. These microbes include bacteria such as *Staphylococcus* species, *Escherichia coli* and *Enterobacteriacea*, in addition to fungi, viruses and parasites. One way people assess the safety of beaches is by counting the numbers of fecal coliforms per 100 mL of water. According to water testing labs, current coliform counts for beaches should [not exceed](http://www.eai-labs.com/services/recreational_water.html) 88 coliforms per 100 mL in any one sample, or exceed a three-sample average over a 60-day period of 47 coliforms per 100 mL. But the number of pathogens to total coliforms is not a set number, and fecal contamination is not the only supplier of pathogens to the beach. Here are a few pathogenic microbes that you may unfortunately encounter even on beaches that have “safe” coliform counts:

***Staphylococcus species*:** This gram-positive human commensal (Staph for short) is usually found on the skin and in nasal and oral cavities in healthy people. However, when introduced to an open cut (and even depending on the [local microbial ecology of the wound site)](https://www.ncbi.nlm.nih.gov/pubmed/27582729), such as a cut from stepping on a sharp shell, Staph can colonize the area and cause painful symptoms such as boils and even eye infections. If allowed to progress, Staph infections can become fatal when they reach the lungs or blood. *Staphylococcus* abundance is correlated tightly with the number of people frequenting the beach, peaking in mid-summer months. Surfers who routinely sustain injuries from the sport [frequently suffer from Staph](http://www.surfline.com/surf-news/is-the-72-hour-rule-still-the-foremost-guideline-for-avoiding-sickness-the-dangers-of-surfing-after-a-rain_145202/) infections due to frequent cuts and scrapes. Experts suggest staying out of the water for 72 hours after a storm to avoid human-contaminated runoff, including [fecal bacteria from sewer systems](http://msu-water.msu.edu/wp-content/uploads/2014/06/Storm-vs.pdf), entering the ocean.

***Fungal Dermatophytes:*** Dermatophytes are fungal skin pathogens that require keratin, a protein found in skin and nails, to grow. These fungi can easily be spread by direct contact from other people, animals, and soil (including sand), and cause a skin infection called dermatomycosis, or [Tinea](https://en.wikipedia.org/wiki/Tinea), a general term which encompasses more common fungal infections such as athlete’s foot, ringworm, and nail infections, as well as fungal infections on almost any part of the body. Common beach dermatophytes include the species *Trichophyton mentagrophytes*, the most common source of dermatomycosis in Europe, *Trichophyton rubrum*, the most common source of dermatomycosis in the world, and *Microsporum nanum*.

Staying away from moist sand won’t help you avoid these pathogens though. All three of these species have been successfully isolated from sandy, non-flooded areas of coastal beaches. Other opportunistic pathogenic fungi, such as *Aspergillus* species and *Candida* species, have been found in wet, flooded beaches exposed to high tides. Though infections by these organisms are more common in immunocompromised patients, anyone can pick up an unsuspecting [fungal skin infection.](http://www.asmscience.org/content/journal/microbiolspec/10.1128/microbiolspec.FUNK-0049-2016) But not to worry, these can usually be treated topically with antifungal medications.

***Enteroviruses:*** Characterized by infection via ingestion and transfer to the intestines, enteroviruses are a genus of single-stranded RNA viruses that encompass many human serotypes. [Enteroviruses](https://en.wikipedia.org/wiki/Enterovirus) were once classified into four broad categories: polioviruses, Coxsackie A viruses, Coxsackie B viruses, and echoviruses, though the four categories overlap significantly with one another. Enteroviruses are responsible for several diseases, including but not limited to polio, hand foot and mouth disease, encephalitis, and acute conjunctivitis, and in some cases have been thought to contribute to type I diabetes. The presence of enterovirus on beaches is highly correlated with the presence of beachgoers, and it is primarily spread from one person to another via sand or water. If you thought viruses can’t live outside the host, a study by [Pianetti et al.](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4219924/" \l "R180)may change your mind. This research group detected enteric viruses in 23% of submerged sand samples from marine beaches in Italy, the majority of those viruses being human pathogens like [reoviruses](http://emedicine.medscape.com/article/227348-overview) and enteroviruses. Though these are technically enteric microbes, viruses do not show up on fecal coliform tests because the test is not designed to identify or quantify viruses.

[](https://asm.org/ASM/media/Article-Images/2017/August/Toxocara-canis-parasites-8-3-17.JPG)Figure 2. Toxocara canis parasites. [Source](https://upload.wikimedia.org/wikipedia/commons/3/32/T.canis_adults.JPG)

***Parasites:*** If you go to beaches where dogs are allowed, be aware of the *Toxocara canis* parasite. Though this parasite primarily infects dogs, humans and other mammals can become infected by ingesting *Toxocara* eggs. These spiky, yellow worms can grow up to 18 cm long, and depending on where they are deposited in the body can cause severe complications such as an enlarged liver, vision problems, myocarditis or respiratory failure.

***Flesh-eating Bacteria:*** Flesh-eating disease is no myth, and there have been[more than a few](http://www.al.com/news/mobile/index.ssf/2017/07/fifth_vibrio_case_confirmed_in.html) cases of this terrifying infection in the news recently. The term flesh-eating bacteria is a little sensational, but the medical term for the infection is [necrotizing fasciitis](http://www.webmd.com/skin-problems-and-treatments/tc/necrotizing-fasciitis-flesh-eating-bacteria-topic-overview), an infection that kills the soft tissue. Many microbes are capable of becoming “flesh eating” under the right circumstances. Common microbes such as *Streptococcus*, *Klebsiella*, *Clostridium*, *Escherichia*, *Staphylococcus* and *Aeromonas* species can cause severe flesh infections in people who are immunocompromised, have diabetes,chronic malignancies, or suffer from alcoholism or drug abuse. Rarely *Vibrio vulnificus*, a marine microbe that often infects marine invertebrates, can also cause necrotizing fasciitis. All it takes is for one of these microbes to enter through a small cut, lesion, or [tattoo](http://www.cbsnews.com/news/man-dies-after-flesh-eating-bacteria-vibrio-infects-new-tattoo/). Once infected, the only way to remove the infection is surgically, often resulting in severe loss of tissue and even entire limbs. If you know you are in a high-risk group for acquiring infections, make sure you talk to your doctor about outings to the beach, and whether entering the water is a good idea.

Necrotizing Fasciitis of the leg.

Source: <https://upload.wikimedia.org/wikipedia/commons/thumb/6/6a/Necrotizing_fasciitis_left_leg.JPEG/800px-Necrotizing_fasciitis_left_leg.JPEG>

**Understanding Ecology is the Path to Public Health**

The beach is a great place to spend time during the summer, but understanding the ecology of the shore can be essential to having a good time. The distribution and diversity of microbes at the beach are affected not only by location, salt, and relative moisture, but also by how other humans and animals interact with the sand and water. Some pathogens come straight from other hosts, and some live in the sea all year long. Thus, efforts to document and understand how diversity of beach microbes evolves and changes can be crucial for public health. What we have gathered so far is that beaches can be affected by many sources, some not even close to the shore. We can all improve the healthiness of our beaches by reducing the amount of chemicals and waste dumped into storm drains and avoiding beach time if we are sick. For more information on safe swimming visit the [CDC website](https://www.cdc.gov/healthywater/swimming/index.html) or visit your [state’s](https://www.cdc.gov/healthywater/swimming/states.html) healthy swimming resources.