Samples were collected from two beaches in south Florida. Hollywood Beach is a popular bathing location. The sand was collected from Hollywood Beach, Florida (August 02 – May 03) using bacterial-sized polystyrene particles (0.5 µm diameter). The beach is located midway between the high and low tide mark. After collection, the sand was stored at 4°C for 24 h before processing. Results:

Recreational beaches are periodically closed when high counts of fecal indicator bacteria are detected in the water. It is assumed that these high indicator counts imply the presence of pathogens that could pose health risks to bathers. An ongoing study has measured the numbers of enterococci and E. coli in the water column, in wet sand, and in dry sand above the high tide level of three Florida beaches. Bacteria are diluted by monodispersed filters using sterile (autoclaved) and NOC (N204, E. coli) (The data show that sand concentrations indicate bacteria at 0.001–0.001 relative to water. There are two important questions arising from this result: Firstly, do these bacteria represent the presence of pathogens or are they high numbers indicating and due to the survival of “environmentally adapted” indicator? Secondly, does the sand act as a sink or a reservoir for the indicator organisms that could be flushed out on tidal cycles and then wash back into the water column? No, the data indicate that indicator organisms were detected during routine sampling by water management, could be misleading. The present study address both of these issues. The possible health hazard of high fecal indicator counts in the sand would be investigated. The high density of enterococci in the sand above the high tide line has been replicated (Table 1). In just one tidal cycle, 85% of the particles were removed from the sand, and 60% of the indicators in the water column were removed (Hartz, pers. comm.). It is likely, therefore, that the number of indicator bacteria in wet sand is influenced by the following equation:

\[ \text{Number of indicators in wet sand} = \text{Number of indicators in water} + \text{Washout of indicators} \]

The scale of this transport of bacteria into the water was examined in a laboratory experiment and via a field experiment using bacterial-sized polystyrene particles (0.5 µm diameter). This shows that the results of the laboratory experiment that 100% (fluorescently labeled E. coli) and a red fluorescent protein were inserted into the water column. Bacteria were added on sand by highway to other doors to enter into and were collected by various methods (e.g., centrifugation with and without chemicals) as well as by bacterial PCR using labeled (E. coli) and cell counts by fluorescent methods within 24 h (Harte, pers. comm.). Results of the three treatments (low, medium, high energy) showed that in all cases, E. coli were rapidly washed out from the sand. Data show that 60% of bacteria returned to the sand under high energy conditions and remained 50–60% for the low and medium energy conditions.

This dramatic removal of bacteria from the sand by wave action was also found in the case of the site where mammal experiment using bacterial-sized polystyrene particles (Fig. 4). In just one tidal cycle, more than 90% of the particles were removed from the sand, irrespective of depth.

Discussion:

It is clear that sand contains much higher levels of fecal indicator organisms than those observed by the data in Figure 1. As part of a two-year study which shows those higher density conditions a beach front, the behavior of indicator organisms in sand has been studied with mammal experiments. These studies have suggested that field organisms will play in the predicted coastal ecosystem. The sand beach is a good example of these interactions. Because the sand beach is a complex ecosystem, it is likely that the behavior of indicator bacteria in sand will be influenced by multiple factors. This is an important observation because indicator bacteria that are not present in the water column, but are present at high levels in the sand. The numbers of indicators in the sand can be influenced by the following equation:

\[ \text{Number of indicators in sand} = \text{Number of indicators in water} + \text{Washout of indicators} \]

Materials and Methods:

For counting, beads were added to sand in the swash zone, and by comparing the numbers of enterococci in near shore waters (within 10 m of the shoreline) with the concentrations of enterococci in sand at the same depths, we found significantly higher numbers of enterococci (the recommended indicator for fecal bacteria) in the sand. The low number of beads remaining would likely be explained by the high densities of indicators in the sand.

Aims:

• Determine the number of bacteria in the sand and water of a local beach.
• Determine the extent of numbers of bacteria from sand to the water.
• If this is significant, this will help implicate factors for water management who seriously put the quality of bathing water by sampling indicator bacteria in the water immediately adjacent to the swash zone.

Methods and Materials:

Experiments were conducted to determine whether these high numbers in the sand constitute a health risk to beach users. This involves measuring numbers of indicators as they are changing in both the sand and water column. Methods for recombinant bacteria have been developed and are being used to determine whether bacterial survival and reproduction in sand and the epidemiological study on incidences of illness after beach use are suggesting that present indicators are inappropriate and improved methods for recreational water quality testing are required.

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References:

Palmer, H. A., and Brink, H. N. 1999. The potential in situ inactivation of Enterococcus faecalis and enterococci in water column, sand, and dry sand above the high tide level of three Florida. Data show that 50% of bacteria returned to the sand under high energy conditions and remained 50–60% for the low and medium energy conditions.

This dramatic removal of bacteria from the sand by wave action was also found in the case of the site where mammal experiment using bacterial-sized polystyrene particles (Fig. 4). In just one tidal cycle, more than 90% of the particles were removed from the sand, irrespective of depth.