How does moisture affect sand resistance to erosion by wind and waves?

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Bishop Conaty Our Lady of Loretto

Abstract (Summary)

- Our Research Question was *How does moisture affect sand resistance to erosion by wind and waves?* We choose this question because of the erosion problem in California, specifically at the beach. We understood the concept of what erosion is but wanted to go deeper into how it affects us and our environment. In order to investigate this we went to Malibu Lagoon Beach to collect data samples, there we observed how varying degrees of water saturation influenced the stability of the shoreline's sediment. The data showed that moderate moisture content significantly increased sand cohesion, whereas completely dry sand was easily displaced by wind and overly saturated sand became unstable due to reduced friction. In conclusion we determined that moisture acts as a stabilizing "glue" up to a certain threshold, but beyond that point, it can actually facilitate erosion by allowing sand particles to shift and slump more freely.
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Background Information for Research

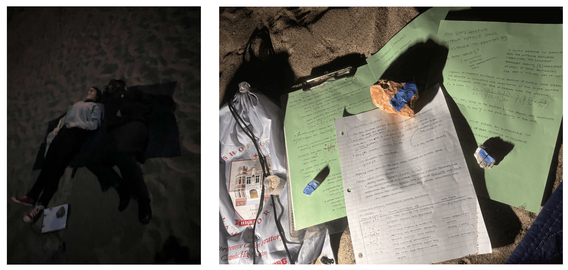
- We decided to research this topic because of the beach erosion issue that exists in California. Understanding how moisture affects sand is essential to understanding how our beaches are being affected by erosion. Before starting this research project we understood what erosion itself was, as well as an idea of how moisture and sand plays out. However we wanted to lean in deeper and understand how it works and how it affects not only our environment but the ecosystem as well.

Research Question & Hypothesis

The research question for this investigation is: How does the moisture content of sand affect its resistance to erosion caused by wind and waves? This study hypothesizes that as moisture in sand increases, the sand becomes more resistant to erosion because water creates cohesion between individual sand particles, helping them stick together and reducing their movement when exposed to wind or wave action. However, if the sand becomes overly saturated, its resistance to erosion may decrease as excess water lowers friction and allows particles to shift more easily. This research is important to environmental and global communities because understanding how moisture influences sand erosion can help address issues such as coastal erosion, desertification, and land loos driven by climate change, stronger storms, and rising sea levels, ultimately supporting better coastal management of protection of ecosystems and human settlements.

Planning and Carrying out the Investigation

- ❑ Our plan for this investigation was to collect data from NASA official website and from our own field observations at Malibu Lagoon Beach.
- ❑ We planned to collect/analyze soil moisture and erosion data from Malibu Beach, CA at least once a week , but it wasn't possible, so we only went once. We collect sand moisture and observed wind and wave conditions.
- ❑ Include a map showing where the data were collected.
  - The study location was Malibu Lagoon Beach

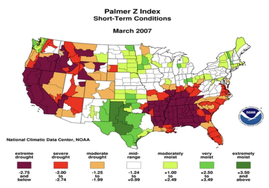


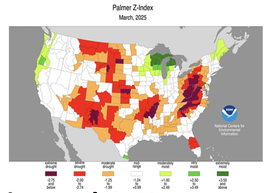
Field Photos ***(requires release forms)***

Figure 1: Map of the study site location on Malibu Beach, Lagoon (34°2' 0" N, 118°40' 45" W)

Data Analysis

Data Visualization





Data Relationships and Patterns

Based on both graphs, clear patterns in soil moisture can be seen across the United States. In March 2007, some regions, especially in the West and the Southeast, experienced severe drought, while parts of the central and southern U.S. were more moist. By March 2025, drought conditions appear more widespread across the central, southwestern, and eastern regions, with fewer areas showing high moisture levels. This trend suggests that dry conditions have become more common in many areas over time. Drier soil has less cohesion, making sand more valuable to erosion by wind and waves, while wetter regions show greater resistance to erosion due to increased moisture holding sand particles together.

Figure 2: Wind and Moisture Relationship.
As soil moisture decreases, sand becomes more susceptible to wind erosion because dry sand particles have less cohesion and are more easily lifted and transported by wind.
Wind speed of Malibu Beach, California

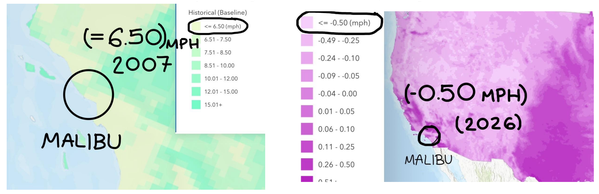
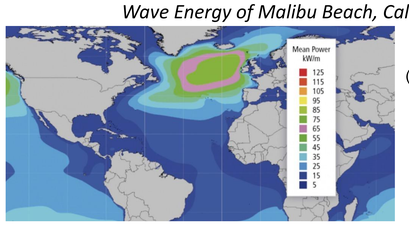
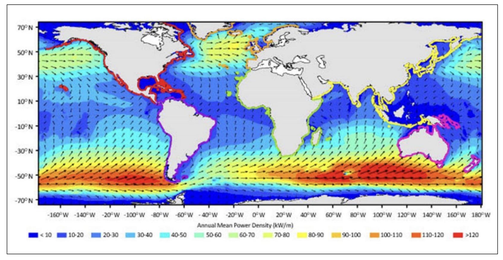


Figure 3: Wave Energy and Moisture Relationship
As moisture levels in sand decrease, wave action causes greater erosion because dry or loosely packed sand is less stable and more easily displaced by moving water.
Wave Energy of Malibu Beach, California



(2015)

(2025)



Data Interpretation

Relating Data to the Research Question

- The data does help answer the research question because it highlights different moisture levels in sand affect how easily wind and waves can erode it. Both images depict that lower moisture leads to higher erosion, which connects to the question we are investigating.
- The data can be used as evidence to support our claim by showing that sand with higher moisture is harder to erode. In both images, erosion increases when moisture decrease, which supports our hypothesis that moisture creates cohesion between sand and helps them stay in place.
- Uncertainties and limitations, including possible sources of error , in our investigation were the natural changes in wind speed, wave energy and different tide levels during our data collection. Not only that but moisture levels in sand can change due to the sunlight or by people in the beach.
- There might be a cause and effect relationship because the results show a pattern when moisture decreases, erosion increases. meaning that moisture influences how easily sand is moved by wind and waves.

Conclusion/Next Steps

We found that our thinking about the research question changed as we analyzed the data, because we initially believed that higher moisture always increased sand's resistance to erosion, but the results suggested the relationship is more complex. While moderate moisture increases cohesion between sand particles and reduce erosion, extremely wet or saturated conditions may still allow erosion due to reduced friction and increased wave or water movement. Another way to interpret the data is that erosion is influenced not only by moisture, but also by factors such as wind speed, wavy energy, and soil type, which can intensify erosion even when moisture levels vary. We could improve the investigation by using more localized soil moisture data, analyzing multiple ears and seasons, and combining moisture data with wind and wave measurements. For future research, we recommend studying different sand grain sizes, comparing coastal and desert environments, and examining how climate change may affect erosion patterns.

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