Evaluation of Alternative Water Quality Indicators for Water Contact Recreation at Beaches and Estuaries Alternative Indicators for Water Contact Recreation

SDSU and SWAMP investigated how well alternative indicators track with traditional indicator bacteria analysis

Overview: Water quality objectives in the San Diego Regional Water Quality Control Board's Basin Plan used to ensure waters are safe for contact recreation (e.g. swimming, surfing) rely on measurements of fecal associated bacteria ("indicator bacteria) to assess risk. Indicator bacteria have been used for over fifty years to assess risk for human health. However, indicator bacteria provide an indirect risk assessment because the measurement of specific bacteria, namely *E. Coli* and *Enterococcus*, is used as a proxy for the presence of fecal material that contains pathogens that can make humans sick (e.g. human waste, cattle waste). Recently scientists have focused on alternative indicators that can more directly assess risk and/or sources of fecal material. The purpose of this study was to conduct a side-by-side evaluation of newer alternative indicators, including those analyzing DNA using polymerase chain reaction (PCR), with traditional indicator bacteria.

What was analyzed?
The San Diego Water Board used Surface Water Ambient Monitoring Program (SWAMP) funds to contract with San Diego State University (SDSU) for the side-by-side analysis of the following parameters:
  1) E. Coli (current)
  2) Enterococcus (current)
  3) Somatic Coliphage
  4) Bacteroides Human Fecal Marker 183 (HF183) via qPCR
  5) Pepper Mild Mottle Virus (PMMoV) via qPCR
  6) Adenovirus via qPCR
  7) Norovirus via qPCR

Where and when was sampling conducted?
San Diego Water Board staff sampled ocean and estuarine water from 4 locations with high levels of ocean recreational use but with varied anthropogenic development.
  1) Doheny Beach/San Juan River Estuary
  2) Harbor Beach/San Luis Rey River Estuary
  3) Trestles Beach/San Mateo Creek Estuary
  4) Church Beach/San Onofre Creek Estuary

The San Juan and San Luis Rey rivers have high and moderate levels of upstream development, respectively, while the San Mateo and San Onofre Creek watersheds are largely open space with some development immediately upstream from and adjacent to their estuaries. Thus, both San Mateo and San Onofre were considered and evaluated as potential "reference" locations for the purposes of the study.

From November 01, 2021, to January 17, 2024, Water Board scientists and engineers collected a total of 371 samples in dry and wet weather conditions.

What were the results?

Fecal indicator concentrations were significantly greater at highly developed watershed sites than they were at reference sites, and the magnitude of these differences were affected by weather and season. *E. coli* and somatic coliphages were good indicators of fecal pollution in estuaries, but not in beaches, and enterococci was a good indicator in both estuaries and beaches. This is consistent with their current application as water quality objectives. However, none of the general fecal indicators reliably coincided with qPCR detection of human-associated biomarkers or pathogenic enteric viruses. Detection of viruses was low, likely due to methods, volumes sampled, and choice of pathogen variants. Despite low detectability of viruses, the ratio of HF183:PMMoV was an indicator of viral presence. The ratio of HF183:PMMoV also varied by season, with ratios generally indicating "fresher" contamination during wet weather and "older" contamination during dry weather.

What are the recommendations?

The results from the study found more research on alternative indicators, specifically viral pathogens, is warranted to determine their utility in warning the public about water contact risk at beaches and estuaries. For example, while pathogenic viruses were detected in the study, their detection ability was limited in part due to having to select viral variants for testing. As a result, absence of detection of a viral pathogenic group (e.g. norovirus) is not a true "proof of absence." In addition, the study relied upon qPCR rather than ddPCR, which is a more sensitive method. While this does not negate study results, use of ddPCR is recommended moving forward to improve detectability of actual pathogens that cause illness. For general assessment of risk associated with human waste, sampling both HF183 and PPMoV shows promise for source tracking and remediation purposes.

Finally, despite lower watershed-scale levels of development, both San Mateo and San Onofre Creeks and their respective beaches had multiple detections of fecal contamination, including from human sources. Because of their adjacent development (e.g. campgrounds, commercial development), both San Mateo and San Onofre estuaries and beaches may not be not suitable for use as traditional "reference" beaches. Should a reference-based approach be used for setting water quality criteria, different waterbodies should be evaluated for preferential use.

Where can I find the data?

All data from the study has been submitted to the State Water Board's public database [CEDEN](#).

The San Diego Water Board is a state agency responsible for implementing provisions of the federal Clean Water Act and the California Water Code to protect the quality of water in the ocean, streams, bays and underground aquifers. The Basin Plan designates beneficial uses for water bodies within the region and establishes water quality objectives and implementation plans to protect those beneficial uses.

Photo of San Onofre Creek Estuary with sand berm breached following heavy storms in Spring 2023

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