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# Bacteriological water quality along the Tijuana–Ensenada, Baja California, México shoreline

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**Abstract**

This survey was part of a Binational Program (Mexico-United States) in microbiological water quality, with a goal to assess the shoreline bacteriological water quality from Tijuana to Ensenada, Mexico. Samples were collected at 29 sites (19 beaches and 10 outfalls), from the United States border to Punta Banda, Baja California, during summer (1998) and winter (1999). Total coliforms, fecal coliforms and enterococci were used as bacterial indicators. Standard methods were used for total and fecal coliforms, while the Enterolert quick method (IDEXX) was used for the enterococci. Compared with outfalls, the beaches exceeded water quality standards by a small percent, 25.3% in summer and 17% in winter. For outfalls, the percentage of shoreline that exceeded bacterial indicator thresholds had a minor value in summer (32.7%) than in winter (50%). Sites near wastewater discharges had the lowest quality and did not meet the microbiological water quality criteria for recreational use.


*Keywords:* Fecal coliform; Enterococci; Water quality; Indicator bacteria; Shoreline; Tijuana–Ensenada

## 1. Introduction

The cities of Tijuana and Ensenada have had an accelerated urban and industrial growth that have generated organic and bacteriological pollution at Baja California's northwest shoreline, due to the discharge of untreated or poorly treated domestic and industrial wastewaters into the ocean. The combined volume of wastewater discharged to the shoreline is of 40 million gallons per/day, which have produced a deterioration of the seawater quality (Segovia-Zavala et al., 1995; Tanahara-Romero, 1996). The Mexican government has set up pollution thresholds for wastewaters (SEMARNAT, 1997) to avoid and reduce the shoreline's bacteriological pollution and has participated in the construction of new treatment facilities, such as the Mexico-US binational treatment facility at San Ysidro, CA and the El Naranjo treatment facility at Ensenada, Mexico. Although researchers from Secretaria de Marina and Baja California Autonomous University (UABC) have undertaken some surveys related to the pollution of Baja California shoreline to determine the seawater microbiological quality (Segovia-Zavala and Orozco-Borbón, 1986 Orozco-Borbón and Sañudo-Wilhelmy, 1988; Segovia-Zavala et al., 1995 Morales-Chávez, 2000), the integration of the data has been limited by a lack of coordination among the institutions, and by differences on sampling

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techniques and methodology. Contrasting with the aforementioned, this survey was carried out in conjunction with 21 US organizations as part of the Southern California Bight Regional Monitoring Project, under the coordination of the U.S. Southern California Coastal Water Research Project (SCCWRP). All the participating laboratories made a coordinated effort to collect and analyze samples to assess the bacteriological water quality along the shoreline of the Southern California Bight (SCB), from Point Concepcion, US, to Punta Banda, Baja California, during summer of 1998 and winter of 1999.

This study presents the results obtained at the Mexican shoreline, from the US border to Punta Banda, Baja California.

## 2. Materials and methods

### 2.1. Study site

The climate is like that of the Mediterranean, with most of the precipitation occurring during winter months. Annual mean precipitation ranges from 7.73 in. in Tijuana to 11.09 in. in Ensenada (SAHOP, 1994). The currents are variable, with flow inversions, but oriented mainly along the coast (Fig. 1) with a path from north to south for most of the year, with a mean speed of 0.19 m $s^{-1}$ (Álvarez-Sánchez et al., 1990; Argote-Espinoza et al., 1991; Figueroa-González, 2005; Durazo-Arvizu, unpublished results).

The shoreline was sampled at 29 sites (19 beaches, 5 sewage discharges and 5 freshwater outlets) from Playas de Tijuana to Punta Banda, Baja California (Fig. 1). This area has approximately 80 miles of shoreline. Samples were collected on a weekly basis, for a period of five consecutive weeks in summer of 1998, and in winter of 1999. Sampling sites were selected using a stratified random approach and its location was set by a GPS System. Samples were collected in sterile bottles, placed on ice and then transported to the laboratories for their immediate analysis. Total coliforms and fecal coliforms were measured by the Most Probable Number Methodology (MPN) with five test tube series (APHA, 1995). Enterococci were measured by the substrate technology test Enterolert (IDEXX Laboratories, Inc., Portland, ME). Enterococci were only analyzed during the winter. Total coliform-fecal coliform ratio was considered as a fourth bacterial indicator threshold. Bacterial data were compared with the daily and monthly bacterial indicators thresholds (Table 1), obtained from a combination of the Assembly Bill 411 (AB411) legislation and the California Ocean Plan (1990).

Shallow water salinity, temperature and pH were measured at each sampling site. Salinity (‰) was determined with a Beckman Inductive Salinometer, RS10 model; a Fisher Scientific digital calibrated thermometer was used for the temperature; and the pH was measured with a Fisher Scientific Potentiometer, Accumet model.

The assessment of shoreline conditions (outfalls and beaches) focused upon estimating the percent of shoreline-miles that exceeded a threshold of concern. The term "shoreline mile-days" was used when only daily thresholds were used to estimate the percent of shoreline-miles exceeded. The statistical design was done in accordance with Thompson (1992). Pearson correlation analysis was used for the comparison between bacterial indicators. Prior to the survey, all participating laboratories took part in a series of intercalibration and performance exercises designed to assess accuracy and comparability goals.

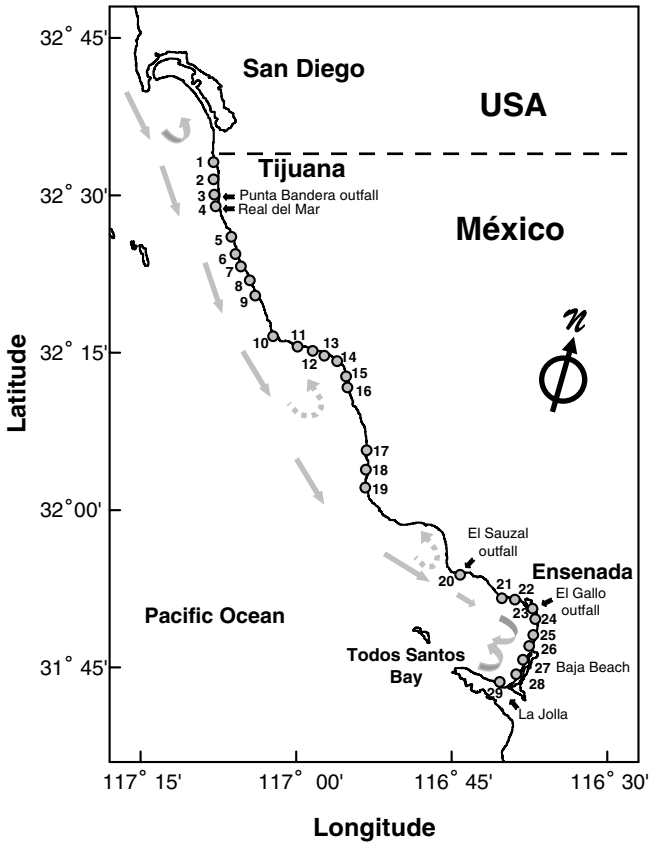


Fig. 1. Map of the sampling sites along the Tijuana–Ensenada shoreline. The arrows represent the current flows. Dot arrows represent unpublished result (see text for details).

Table 1
Indicator thresholds used in the shoreline microbiology study

| Indicator | Daily threshold (cfu or MPN per 100 $ml^{-1}$) | Monthly threshold (cfu or MPN per 100 $ml^{-1}$) |
|---|---|---|
| Total Coliforms | 10,000 | 20% of samples > 1000 |
| Fecal Coliforms | 400 | 200 (GM) |
| Enterococci | 104 | 35 (GM) |
| Total/fecal ratio | When TC > 1000 and TC/FC ⩽ 10 also, when TC > 1000 and TC/FC ⩽ 5 | |

GM = Geometric mean over 30 days period.