Public Mis-Notification of Coastal Water Quality: A Probabilistic Evaluation of Posting Errors at Huntington Beach, California

JOON HA KIM AND STANLEY B. GRANT*
Department of Chemical Engineering and Materials Science, The Henry Samueli School of Engineering, University of California, Irvine, California 92697

Whenever measurements of fecal pollution in coastal bathing waters reach levels that might pose a significant health risk, warning signs are posted on public beaches in California. Analysis of historical shoreline monitoring data from Huntington Beach, southern California, reveals that protocols used to decide whether to post a sign are prone to error. Errors in public notification (referred to here as posting errors) originate from the variable character of pollutant concentrations in the ocean, the relatively infrequent sampling schedule adopted by most monitoring programs (daily to weekly), and the intrinsic error associated with binary advisories in which the public is either warned or not. In this paper, we derive a probabilistic framework for estimating posting error rates, which at Huntington Beach range from 0 to 41%, and show that relatively high sample-to-sample correlations (>0.4) are required to significantly reduce binary advisory posting errors. Public mis-notification of coastal water quality can be reduced by utilizing probabilistic approaches for predicting current coastal water quality, and adopting analog, instead of binary, warning systems.

Introduction

Many government-sponsored environmental monitoring programs issue health advisories whenever pollutant concentrations reach levels that might pose a threat to human health. The utility of health advisory programs logically depends on their ability to disseminate timely and accurate information, in a format that is useful and easy to understand. This study examines the health advisory component of a large (statewide) shoreline water quality monitoring program in California. Health advisories take the form of warning signs that are posted at public beaches whenever shoreline water quality (as measured by fecal indicator bacteria) fails to meet one or more of seven different state standards. The California health advisory program is one of a growing number of such programs nationwide, sponsored in part by the Federal Beaches Environmental and Coastal Health Act passed by the U.S. Congress in October 2000 (*1*−*4*). A noteworthy aspect of the California program is its binary nature, in which information about coastal water quality is conveyed to the public by the presence or absence of warning signs on the beach during the high-use period from April 1 through October 31 of every year. This binary approach stands in contrast to other long-standing reporting programs, for example, weather forecasts, in which the information provided to the public is probabilistic in nature (*5*).

In this paper, we set out to answer several questions: (1) What is the magnitude of error associated with binary health advisories? (2) How are these error rates affected by the degree to which the concentrations of bacteria in consecutive samples are correlated? (3) Can the accuracy and effectiveness of health advisories be improved by changing the way data are collected and analyzed and/or by changing the way water quality information is conveyed to the public? To answer these questions, we develop a probabilistic framework for analyzing posting errors and compare the theory to observations of posting errors at Huntington Beach in southern California. Huntington Beach is an ideal natural laboratory to examine shoreline water quality issues because of the magnitude of the historical water quality problem, the wealth of available shoreline monitoring data, and the fact that a series of special studies have been conducted with a wide range of sampling frequencies (*6*−*8*).

Public Notification of Shoreline Water Quality in California

Beginning July 1, 1999, the State of California mandated fecal indicator bacteria monitoring at all public beaches with more than 50 000 annual visitors and established seven statewide concentration standards for fecal indicator bacteria in the surf zone. When the concentration of indicator bacteria at a monitoring site exceeds any of the California standards, the local health official must post a sign warning beach goers of potential health risks associated with entering the water (*surf zone posting*). If a sewage spill is suspected, the local health official may close the surf to public access (*surf zone closure*). Four of the seven standards are single-sample standards, for which a monitoring site is considered to be out of compliance if the concentration of indicator bacteria in a single sample exceeds specified concentrations for total coliform (TC), fecal coliform (FC), and *Enterococcus* species (ENT). The California single-sample standards for TC, FC, and ENT are respectively 10 000, 400, and 104 most probable number (MPN) or colony forming units (cfu)/100 mL; a fourth single-sample standard for TC of 1000 MPN or cfu/100 mL applies when the TC/FC ratio falls below 10. The remaining standards are 30-day geometric mean standards, for which a monitoring site is considered to be out of compliance if the geometric means of TC, FC, and ENT in all samples collected within a 30-day period exceed 1000, 200, and 35 MPN or cfu/100 mL, respectively. These standards correspond, at least theoretically, to a threshold rate of bather illness of 19 cases of highly credible gastrointestinal disease for every 1000 bathers. (*3*, *9*−*11*) There are many historical reasons for choosing this particular threshold, including the fact that it represents the background rate of gastrointestinal illness among the general population (*12*).

Observations of Posting Errors at Huntington Beach

The surf zone posting protocols described above were adopted with the goal of conveying to the public up-to-date information about surf zone water quality. However, a post de facto comparison of posting records and water quality test results indicates that the public is often mis-notified about current water quality conditions. This point is illustrated in Figure 1A where we compare measurements of

* Corresponding author e-mail: sbgrant@uci.edu; phone: (949)824-7320; fax: (949)824-2541.

10.1021/es034382v CCC: $27.50
Published on Web 03/24/2004