Visual Beach

Pathogen Modeling: Clean and Safe Water

What is the problem? The problem is pathogens (bacteria, viruses, and protozoa) in the waters at public beaches. These pathogens can cause illness in exposed humans, ranging in severity from rashes, swimmer's itch, and throat infections, to stomach cramps and nausea, and, in extreme cases, to cholera, salmonella, typhoid fever, or hepatitis A. According to the Surfrider public interest group, Beaches makeup 2.7% of land at California's 240 state parks; however, this relatively small area supports 70% of state park attendance. In the summer of 1999, a 4.5-mile stretch of Huntington Beach (south of Los Angeles) shoreline was closed for two months. The economic impact was considerable; about one million dollars was spent on inspecting the city's sewer system alone. This inspection showed a major sewage leak was not the source of the problem.

Obvious sources of pathogens are sewage outfalls; however, because these sources are frequently discharged well offshore and are frequently designed to achieve high dilutions of effluents, they are not necessarily the major sources of beach contamination. Studies show that urban runoff, rivers, and upstream sources frequently account for the majority of the observed concentration. Consequently, wet weather is associated with the highest observed concentrations and combined sewer overflows represent major sources.

Pathogens are difficult to detect and measure directly, and their presence frequently cannot be measured accurately. Consequently, indicator organisms are used to determine the likely presence of pathogens. Coliform bacteria are used as indicators because, like human pathogens, they are found in the digestive systems of warm-blooded animals. Total coliforms are found in feces, but also in decaying matter and soil. Increasingly, indicator criteria focus on fecal coliform and enterococcus, which comes from the feces of warm-blooded animals, including humans. Enterococcus is preferred as a seawater indicator because it decays more uniformly both in fresh and sea water. The origin in warm-blooded animals is the reason that high bacterial concentrations are associated with wet weather; concentrations of fecal material deposited during dry weather wash into water bodies during storm events.

What can be done? An obvious solution to the problem of beach contamination is to control the sources. Increasingly, that is done. Inland publically owned treatment plants (POTWs) are required to treat wastewater before discharging it. Some coastal POTWs are granted waivers from secondary treatment through the federal 301(h) program, but only when they discharge

through well-designed offshore outfalls and meet other requirements. However, as indicated above, many sources of pathogens have non-human origins and cannot be controlled practically.

Another approach is prediction. In many cases, beach closure based on monitoring is in many cases overly protective, one reason being that quantitative measurement of bacterial concentrations frequently take 24 to 48 hours to complete. Public health warnings based on measurement are reactive; conditions that lead to the closure of a beach are dated and may no longer be valid. Warnings are likely to be open-ended and span periods during which bacterial concentrations do not exceed water quality criteria. A predictive approach may help to identify safe periods, as well as critical times to target and intensify monitoring. Such an approach will hopefully lead to accurate public announcements on the status of beaches.

The Research Approach: At various times since 1979, EPA has developed and disseminated models that predict the physical properties and dilution of plumes, most recently one called Visual Plumes. Visual Plumes is able to use time-series file input to analyze long sequences of conditions to determine critical dilutions. Visual Plumes also has the ability to model the buildup of background pollution in one-dimensional tidal channels. Finally, Visual Plumes has a sophisticated bacterial decay model sensitive to input of salinity, temperature, solar radiation, and water depth (absorption of radiation).

Visual Plumes will be adapted to create a new model, Visual Beach. A main task will generalize Visual Beach to accommodate additional sources, representing combined sewer overflows and other main sources. The second main task is to generalize the far-field transport algorithm to carry the pollutant from source to the points (beaches) of concern. An initial approach will enable the use of real-time data, as from current meters, to update the predicted position of contaminated water parcels that were released at earlier times. Knowledge of water parcel location, environmental conditions (movement), and time would be used to estimate the present position and concentration of all of the contaminated water parcels. In the future, the model may be linked to numerical hydrodynamical modules to make the model fully predictive.

Collaborating in this work is Dr. Philip J.W. Roberts of the Civil Engineering Department at Georgia Tech University, Atlanta, GA.

National Exposure Research Laboratory

For More Information:
Dr. Walter E. Frick, Oceanographer, Regulatory Support Branch,
Ecosystems Research Division
706-355-8319
frick.walter@epa.gov

For more information on this and other NERL science projects, visit our Website
http://www.epa.gov/nerl/