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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Final Report:

Development of Models for Beach Pathogens

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Introduction

The objective of this study is to develop a mathematical model to predict the distribution of pathogens on bathing beaches. Pathogens pose a risk of infection to bathers, and this risk may be increasing as more and more people visit or move to coastal areas. The risk of exposure to waterborne microbial pathogens can result in beach closings, and predictive models can provide early warnings and guide "real-time" sampling strategies on the beaches. They can also assist in the difficult task of finding the sources of high, intermittent, beach coliform levels. The present lack of such models hinders the best choice for source discharge locations, and may lead to unnecessary or overly prolonged beach closings, with high economic and public relations losses. Conversely, failure to close beaches during high bacterial levels may lead to unnecessary health risks for those exposed. This work is being undertaken in conjunction with the U.S. EPA BEACH (Beaches Environmental Assessment, Closure and Health) program. This is a multi-year program for reducing risks of infection to recreational water users. It contains several elements including development of rapid analytical methods to detect pathogens, the development of models for advance indication of exposure, intensive monitoring of selected beach sites, the dynamics of the near shore environment, and epidemiological studies. It also includes investigation of the effects of Combined Sewer Overflows (CSO's), mixed discharges of storm water and domestic wastewater, that can result in significant health risks.

The predictive model has been developed with the working title "Visual Beach." It is a specially modified version of Visual Plumes that utilizes either estimates of water transport or real-time current-meter data to track the transport of contaminants from various sources and to simultaneously predict the concentration of pathogens or other pollutants at beaches and other sensitive sites. The transport part of the model is based on the established EPA's Visual Plumes algorithms, which have been modified to support two-dimensional transport predictions using inputs from either current meter time-series data or predicted advection based on a hydrodynamic circulation model. The transport model includes stressors, for example, temperature, salinity, solar insolation, depth (light absorption), etc. The pathogen decay model is a modified Mancini pathogen model, an earlier version of which was already implemented in Visual Plumes. This resulted in much more sophisticated models of bacterial decay. No bacteriological work or experiments was done for this project. The intended usage of the model is to help public health authorities issue reliable beach advisories by using a Windows interface adapted to address the specific concerns and needs of public health authorities and users.

Far field simulations of bacterial transport were done with a progressive-vector-diagram (pvd) approach to advective transport using long time series of measured oceanic currents. The far field model is coupled to the near field model, and uses as input the output from the near field model. This includes near field dilution, plume rise height, and other plume variables. Following initial dilution (in the near field), the plume drifts with the ocean current and diffuses due to oceanic turbulence. Bacterial concentration reduction due to diffusion is quite slow, however, and bacterial decay is the more important process for reducing bacterial concentrations in the far field. This is the reason for the emphasis on improving the bacterial decay model. The near field models have also been improved as a result of the incorporation of the latest experimental results on plume mixing that are described in Tian (2002).

Simulations with actual field data have been run to investigate the dependence of the results on the values of the various parameters.

Publications

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Tian, X. (2002). "3DLIF and Its Applications to Studies of the Near Field Mixing of Wastewater Discharges," PhD Thesis, School of Civil and Environmental Engineering, Georgia Institute of Technology, Atlanta, Ga.