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Distribution of Fecal Indicator Bacteria in Flood Control Channels of Huntington Beach, California

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Abstract

High levels of fecal indicator bacteria (FIB) consisting of total coliform (TC), *E. coli* (EC), and enterococci (ENT) bacteria indicate the presence of fecal contamination in the surf zone. Previous studies indicated possible tidal influence of flood control channels on the coastal water quality. As part of a class project, 14 undergraduate students, consisting of Chemical Engineering and Environmental Engineering majors, performed this study during rising (flood) and falling (ebb) tides, and showed the distribution of FIB in flood control channels. While the students were exposed to field work and laboratory procedures for the water quality, the results have important implications in the design of the diversion systems during dry weather.

Introduction

Once viewed as being a sub-set of civil or chemical engineering, the discipline of environmental engineering has established a status in its own right worldwide[1-3]. The industry requires that new graduates have both increased knowledge in the field and capability to respond to public health and environmental protection issues[4]. In order to improve teaching-learning process active and interactive participation of the students is preferred over traditional lecture-based teaching process. This type teaching style is found to be more appealing to students with diverse learning styles[5].

In dry weather periods urban runoff generated by street cleaning, car washing and landscape irrigation has shown to contain high levels of FIB. Previous studies[6, 7] indicated that urban runoff can be the source of elevated surf zone levels of FIB at Huntington State Beach and Huntington City Beach in California. Sanders et al.[8] modeled tidal transport of urban runoff in flood control channels using the finite-volume method to understand the transport of pollutants toward the coastline. The goal of this study was to characterize FIB levels at various locations during neap and spring tides by exposing students to both fieldwork and laboratory procedures.

Methods

In Spring 2001 quarter at the University of California, Irvine, 14 undergraduate students, consisting of Chemical Engineering and Environmental Engineering majors, sampled and analyzed water samples at various locations shown in Figure 1. Due to intense work involved they were divided into groups of two to three students. Each group was responsible for sampling and analysis of the samples at a given sampling time. The sampling device designed by the students consisted of two 500-mL polypropylene bottles attached to a rope by a sample holder. At each station, two 500-mL water samples were collected in sterile polypropylene bottles eight times a day during neap (May 15, 2001) and spring (May 23, 2001) tides. For each bottle, salinity, pH, and turbidity of the sample were measured by temperature correction to 20^{o}C. 20 mL of the sample was analyzed for fecal indicator bacteria (TC, EC, ENT) using IDEXX Colilert (TC, EC) and Enterolert (ENT) tests performed in a 97 well Quanti-tray format. The experimental data were plotted on a grid with size of circles proportional to the measurements.

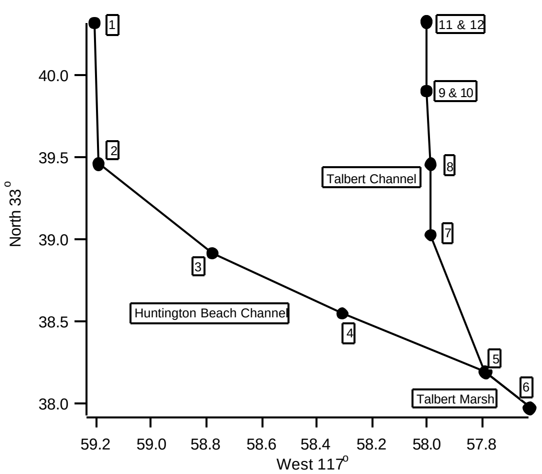

Figure 1. Sampling sites in Huntington Beach, California during neap (May 15, 2001) and spring (May 23, 2001) tides. Eight times a day, samples were collected consecutively by driving from sampling site 1 to site 12. The samples were analyzed for salinity, pH, turbidity, and fecal indicator bacteria (TC, EC, and ENT).

Huntington Beach Channel
1: Adams
2: Atlanta
3: Newland
4: Magnolia
Talbert Marsh
5: Brookhurst
6: Pacific Coast Highway

Talbert Channel
7: Hamilton
8: Atlanta
9: Indianapolis in front of the dam
10: Indianapolis behind the dam
11: Yorktown in front of the dam
12: Yorktown behind the dam

Results and Discussion

During the study Yorktown and Indianapolis stations were both diverted at the Talbert channel. The results are expressed as daily average concentrations. Salinity drop in Figure 2 reveals that the tides were reaching to the diversion system in Talbert channel. On the other hand, Adams station (farthest upstream) on the Huntington Beach channel was not affected by tides. Sea water exhibits higher pH than fresh water. Therefore, as shown in Figure 2, Talbert channel being more alkaline, indicates more tidal influence. Additionally, increasing turbidity upstream of both Talbert and Huntington Beach channels confirms urban runoff presence.

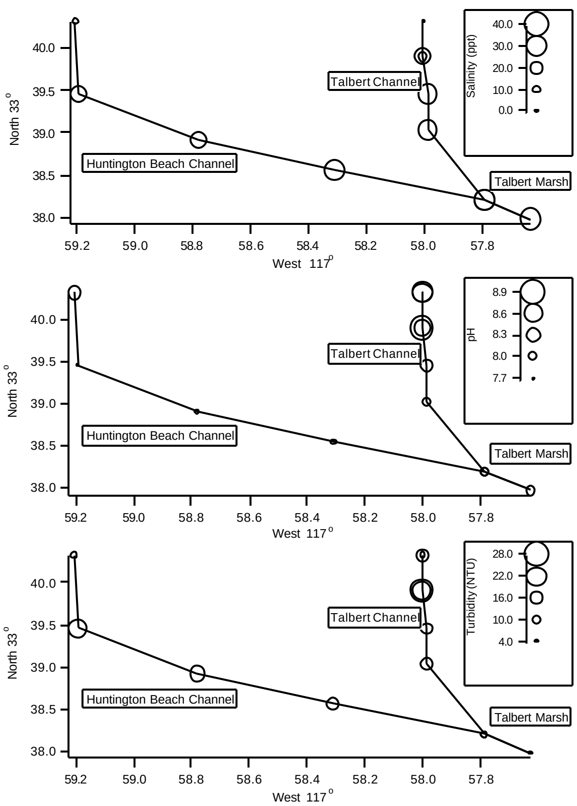

Figure 2. Mapping of salinity, pH and turbidity at Talbert and Huntington Beach flood control channels during neap tide on May 15, 2001. Each measurement represented by the size of the circle is arithmetic average of eight measurements taken within 24-hour period. The measurements are temperature corrected to 20°C.

As FIB follow a log-distribution[9], the microbial data are presented using geometric mean. Figure 3 depicts FIB concentrations plotted as daily geometric means of FIB. Along with increased turbidity, highest bacterial concentrations behind the diversions and upstream the channels (Figure 3) suggest that FIB are originated from urban runoff and diversion systems are effective in reducing microbial contamination. Both in Talbert and Huntington Beach channels, the residual TC and EC concentrations are highest at the end of the ebb tide indicating urban runoff as a source (data not shown). In addition, at the end of the ebb tide Talbert Marsh outlet had the highest ENT concentration confirming previous study[9] that identified Talbert Marsh and its bird population as a source. The results also confirmed the tidal modulation of indicator bacteria inside the channels.

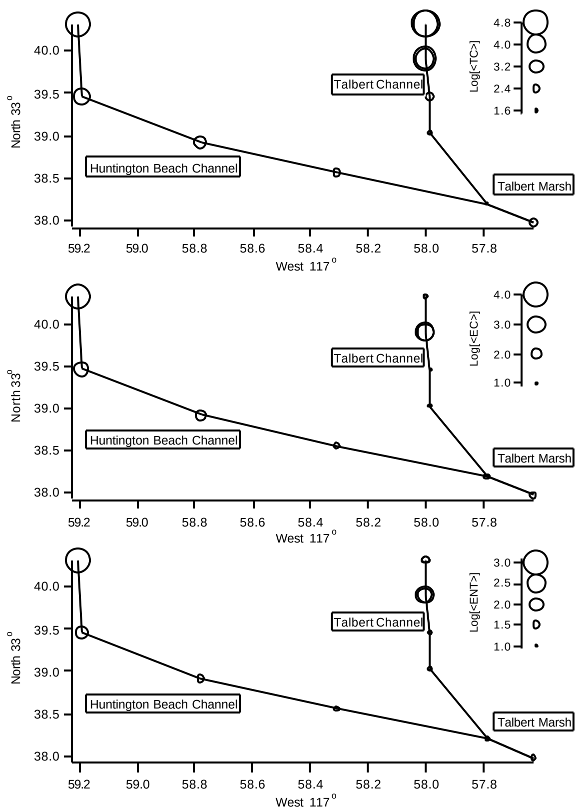

Figure 3. Mapping of the geometric mean of fecal indicator bacteria concentrations at Talbert and Huntington Beach flood control channels during neap tide on May 15, 2001. Each measurement represented by the size of the circle is geometric average of eight measurements taken within 24-hour period. The samples were analyzed for FIB (total coliform, *E. coli*, enterococci) using IDEXX Colilert (TC, EC) and Enterolert (ENT) tests performed in a 97 well Quanti-tray format.

The experiment was repeated during a spring tide on May 23, 2001 to observe any tidal influence due to higher tides. In accord with neap tide results, while the salinity decreased, both pH and turbidity measurements increased upstream the flood control channels (Figure 4). While tides were higher, the diversions in the Talbert channel and Adams station in the Huntington Beach channel were not affected by the tides. As depicted in Figure 5, FIB concentrations are highest behind the diversions and Adams station. The results indicate that FIB are originated from urban runoff and their distribution is comparable to the results shown in Figure 3 during neap tide. Similarly, the residual indicator bacteria concentrations are highest at the end of the ebb tide (data not shown). As before, the tidal modulation of ENT is stronger than TC and EC in all stations.

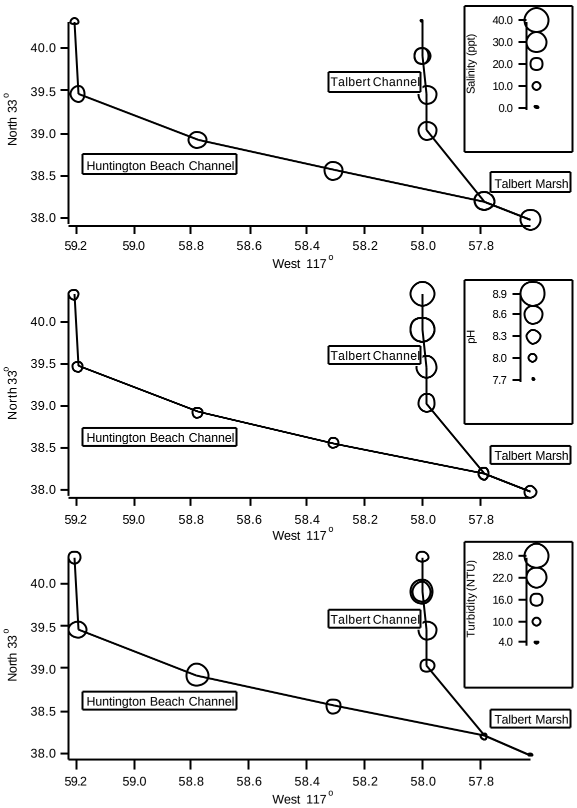

Figure 4. Mapping of salinity, pH and turbidity at Talbert and Huntington Beach flood control channels during spring tide on May 23, 2001. Each measurement represented by the size of the circle is arithmetic average of 8 measurements taken within 24-hour period. The measurements are temperature corrected to 20°C.

Student Evaluations

Upon successful completion of field experiments, students were asked to write the findings of the study in a scientific paper format. While most of the students found the fieldwork very valuable, some referred as being labor intensive. Since the study was conducted in the last three weeks of the course, the students were able to interpret the result effectively and satisfactory. In the context of instructional methods, first, the students worked in small groups (2-3 students) to collect and analyze the samples. Second, as a class, they compiled the results of two different sets of experiments. Third, each student wrote his/her interpretation of results in a term paper.

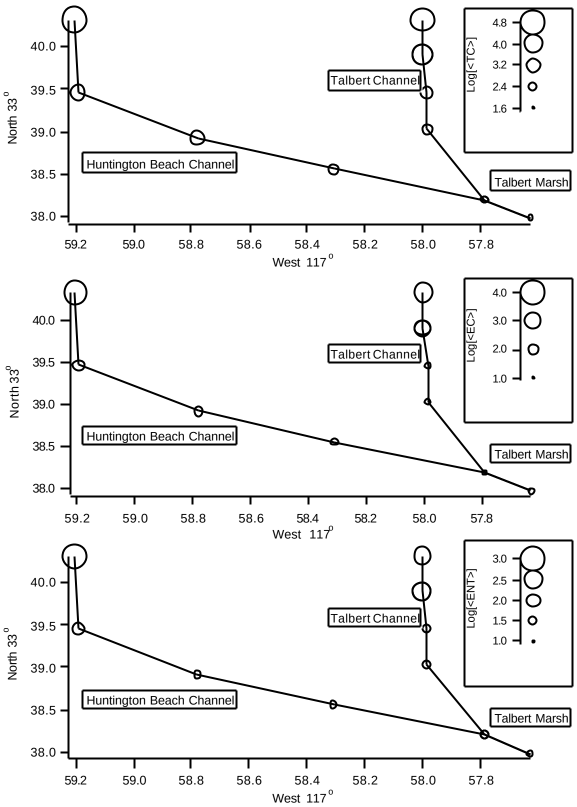

Figure 5. Mapping of the geometric mean of fecal indicator bacteria concentrations at Talbert and Huntington Beach flood control channels during spring tide on May 23, 2001. Each measurement represented by the size of the circle is geometric average of eight measurements taken within 24-hour period. The samples were analyzed for FIB (total coliform, *E. coli*, enterococci) using IDEXX Colilert (TC, EC) and Enterolert (ENT) tests performed in a 97 well Quanti-tray format.

Conclusions

The results of fieldwork that was conducted as part of a class project during neap and spring tides in May 2001 are summarized in this paper. While the field study served as a hands-on experience for the students, it also confirmed the results of the previous study[9] that identified urban runoff as a non-point source to coastal waters pollution in Huntington Beach, California. Considering the importance of tidal modulation of the channels in the design of diversion systems, the study indicated that the diversion system used is effective in reducing bacterial transport to the surf zone.

Acknowledgments

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