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# Recreational water quality response to a filtering barrier at a Great Lakes beach

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ABSTRACT

Recent research has sought to determine the off- or onshore origin of fecal indicator bacteria (FIB) in order to improve local recreational water quality. In an effort to reduce offshore contamination, a filtering barrier (FB) was installed at Calumet Beach, Lake Michigan, Chicago, IL. A horseshoe-shaped curtain (146 m long, 0.18 mm apparent opening size, 1.5–1.6 m deepest point) was designed to exclude FIB containing or promoting debris and thus reduce the number of swimming advisories during the examination period of July through September 2012. Mean water *Escherichia coli* concentrations were significantly lower at southern transects (S; outside FB) than at transects within the FB (WN) and at northern transects (N; outside FB) (1.45 log (MPN)/100 ml vs. 1.74 and 1.72, respectively, $p < 0.05$, $n = 234$). Turbidity was significantly higher at the WN transects ($p < 0.001$, $n = 233$), but it tended to increase throughout the sampling season within and outside the FB. *E. coli* in adjacent foreshore sand was significantly lower at the WN transects. A combination of factors might explain higher *E. coli* and turbidity within the FB including increased sediment resuspension, trapped algae, shallowing within the FB, and large lake hydrodynamic processes. This remediation approach may find better use in a different hydrodynamic setting, but the results of this experiment provide insight on sources of contamination and nearshore dynamics that may direct future beach management strategies.

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## 1. Introduction

Beach managers at freshwater and marine swimming beaches have explored different strategies to improve microbial water quality, decrease bacteria contamination, protect the health of beach users, and limit the frequency of beach closures. Best management practices have included storm water and urban runoff reduction techniques, wildlife control (i.e., bird exclusion, harassment, population reduction) (Converse et al., 2012), beach grooming or beach grade enhancements, and installation of in-place systems such as beach curtains or ultra-violet disinfection devices (Koski and Kinzelman, 2010).

Beach management practices require first an assessment of contributing bacteria sources, including both those originating at the beach itself (onshore) and those from distant locations (offshore). Strategies to minimize onshore contamination (e.g., contaminated sand, amassed algae, and resident birds) have included the use of beach grooming. Grooming not only can improve the aesthetics of the beach by removing litter, deposited vegetation, detritus, and animal fecal droppings, but it can also successfully reduce fecal indicator bacteria (FIB) in nearshore sand and subsequently in beach water (Kinzelman et al., 2004, 2003). Where resident gull and geese populations are a problem, bird deterrent strategies (e.g., canine harassment, wiring, distress calls) have also improved bacteria concentrations in the water (Converse et al., 2012).

To decrease the amount of bacteria coming from offshore sources (e.g., algal material, detritus, sewage contamination), an in-place filtration system, improved circulation, or point source diversion may be explored. Use of in-place filtration systems for controlling microbial contamination is very recent and has had only few applications, thus its effectiveness has not been established. Similar systems such as silt screens or turbidity curtains have been used to control sediment plumes caused by dredging, construction, restoration, demolition, and shoreline stabilization in marine and freshwater environments for the past 40 years worldwide (Johanson, 1978; Netzband and Adnitt, 2009; Pennekamp et al., 1996). Some of these systems are completely impermeable and create a confined settling area for suspended solids, or permeable with various opening sizes that allow for filtration of some of the

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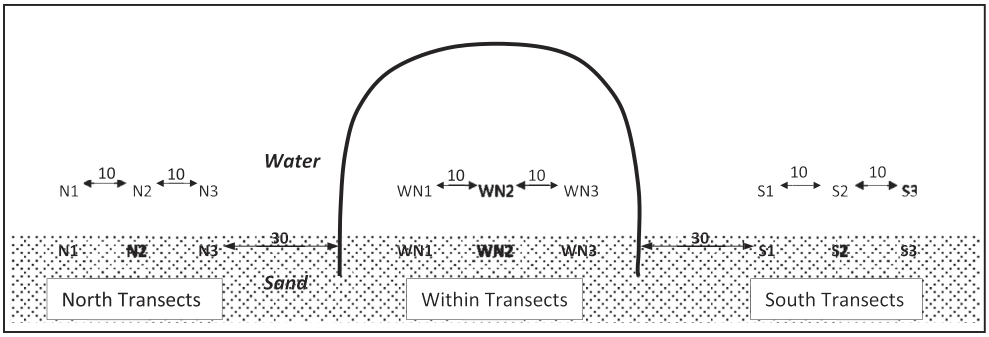


**Fig. 1.** Diagram of sampling strategy at the Filtering Barrier (FB) at Calumet Beach in Chicago. Numbers on top of the arrows represent distances, in meters. All water samples were collected in 45-cm deep water, and sand samples were collected 1–2 m shoreward from the lake.

solids (Francingues and Palermo, 2005; Oglivie et al., 2012; Palermo et al., 2008).

The current study was conducted at a Chicago swimming beach, where microbial water quality is affected by several impediments: two river outfalls, Grand Calumet River on the south and Calumet River on the north (Nevers et al., 2007); a large algal mat present at the north end of the beach for most of the summer season, attracting many waterfowl (Byappanahalli et al., 2003); frequent deposits of organic material or detritus (Whitman, unpublished data); and nearshore sand contamination. All of these have been identified as contributing high bacteria concentrations to nearshore water during favorable wind and lake current conditions (Edge and Hill, 2007), leading to swim advisories posted at Chicago's beaches.

In an effort to reduce offshore contamination and control turbidity-driven microbial loading, a filtering barrier (FB) was installed at Calumet Beach in Chicago. This barrier was intended to filter out algae, detritus, and other particle-associated bacteria (Hipsey et al., 2006) from the offshore and create an enclosure of low bacteria levels safe for use by the public during recreational season. The goal of the study was to evaluate the effect of the FB on turbidity and *Escherichia coli* concentrations in nearshore water and sand of the swimming area at Calumet Beach within and outside of the enclosure for an 8-week period.

## 2. Methods

### 2.1. Filtering barrier description

The FB installed at Calumet Beach in Chicago on July 26, 2012, was a 146-m long, horseshoe-shaped curtain, anchored to the lake floor. The greatest distance from the shore was 60 ± 5 m, enclosing an area of approximately 250 $m^2$. The 283-g non-woven geotextile curtain consisted of 2 fabrics: inner fabric with 0.43 mm Apparent Opening Size (AOS) and thickness of 0.7 mm, and outer fabric with 0.18 mm AOS and 2.3 mm thickness. The inner fabric was used primarily as a strength membrane but carried some filtering capabilities, and outer fabric was the primary filter (Mackworth Aquatic Environmental Systems, Scarborough, ME).

There were some changes in hydrology observed throughout the time the FB was in place at the beach, which likely affected the experimental outcome. For example, during the installation of the FB, water depth at the deepest point (portion parallel to shore) was 1.5–1.6 m, and during the removal, the same point was barely 1.1–1.3 m. There was a significant sand accumulation (at least 0.3–0.5 m) along the inner north portion of the FB, adjacent to the shoreline transition, which extended from the shore to approximately 12–15 m toward the center of the FB.

### 2.2. Sampling strategy and laboratory procedures

Lake water and nearshore sand samples were collected 3 times a week between June and September 2012 before the FB installation ($n = 15$, water; 7 sand samples), and with the FB in place ($n = 234$ water; 96 sand samples). Pre-FB installation samples were collected at one site – N3 (Fig. 1). Three replicated water and sand samples were collected from the following transects: within the FB (WN) and on both sides outside of the FB (N and S), as indicated on the sampling diagram.

All water samples were collected by submerging a sterile Nalgene bottle below the water surface in 45-cm deep water. Moist, subsurface sand samples (2–10 cm depth) were collected 1–2 m shoreward from the lake. Samples were transported to the laboratory in a cooler on ice and processed within 4 h of collection. All three replicated water samples were analyzed individually. For sand, equal amounts of 3 replicates were combined, and the resulting composite sand sample was analyzed for *E. coli*. On a few occasions, sand sample replicates were analyzed individually to evaluate variation among the replicates. In the laboratory, sand samples were well homogenized, combined if needed, then 100 g of sand was added to a sterile 500-ml bottle, followed by 200 ml of phosphate-buffered water (PBW, pH 6.8). The mixture was shaken for 2 min, and the supernatant was analyzed for *E. coli*. On four occasions, paired water samples from inside and outside the FB were collected adjacent to and along the entire curtain, spaced every 10 m (from 0 to 120 m), using sterile polyethylene bags.

Culturable *E. coli* concentrations were measured using Colilert-18 defined substrate technique (IDEXX, Inc., Westbrook, ME) and were expressed as most probable number (MPN)/100 ml water or (MPN)/1 g dry weight of sand. Turbidity measurements were performed on all water samples (NTU; 2100N Turbidimeter, Hach Company, Loveland, CO).

### 2.3. Hydrometeorological data

Hydrological measurements were obtained from a water quality buoy (NexSens Technology, Inc.) deployed at about 1.8 m deep water in the middle of Calumet Beach embayment area. The buoy collected continuous measurements (every 5 min) of wave height, wave period, turbidity, water temperature, and lake level. Continuous meteorological measurements (every 5 min) were collected from a weather station located at 63rd Street Beach, approximately 8 km NNW of the study beach, including solar radiation, barometric pressure, relative humidity, air temperature, and rainfall. All data were aggregated as mean values of the 4-h period prior to water collection time, rainfall was recorded as 24 h cumulative total.