Report as of FY2006 for 2003CA50G: Dynamics of Point and Non-Point Source Fecal Pollution from an Urban Watershed in Southern California

Publications

- Conference Proceedings:
  - Grant, Stanley; Jong Ho Ahn; Paul DiGiacomo; Nikolay Nezlin; Sunny Jiang ; Cristiane Surbeck, 2005, Impact of storm water runoff on Coastal Water Quality, in the National Meeting of The American Chemical Society, San Diego, CA.
  - Surbeck, Cristiane; Stanley Grant; Jong Ho Ahn; Sunny Jiang, 2006, Fecal pollution and suspended particle sin stormwater runoff from an urban coastal watershed, in ACS…
  - Surbeck, Cristiane; Stanley Grant; Jong Ho Ahn, 2005, Storm water runoff from an urban watershed in southern California: top-down approach for characterizing and modeling pollutant loading rates, in EWRI 2005: Impacts of Global Climate Change, ASCE Press, Reston, VA, NA.
  - Brooks, Daniel, Stanley Grant; Patricia A. Holden. 2005. Progression of riverine bacterial community composition and diversity during two large rainstorms. American Society for Microbiology, 105th General Meeting, June 5th - 9th, 2005. Atlanta, GA.
- Articles in Refereed Scientific Journals:
  - Ahn, Jong Ho; Stanley Grant; Cristiane Surbeck; Paul DiGiacomo; Nikolay Nezlin; Sunny Jiang, 2005, Coastal water quality impact of stormwater runoff from an urban watershed in southern California, Environmental Science and Technology, 39, 5940-5953.
  - Surbeck, Cristiane; Sunny Jian; Jong Ho Ahn; Stanley Grant, 2006, Flow fingerprinting fecal pollution and suspended solids in stormwater runoff from an urban coastal watershed, Environmental Science and Technology, in press.
- Dissertations:
  - Brooks, Dan. 2005. Fecal pollution and microbial community composition and diversity in an urban river during two large rainstorms in southern California. “MS Degree Report”. Department of Mechanical and Environmental Engineering. University of California, Santa Barbara, CA. 28 pp.

Report Follows

This research project is focused on the fate and transport of microorganisms and suspended particles in surface waters from an urban coastal watershed along an inland-to-ocean transect (creeks, rivers, estuaries, surf zone, offshore).

Problem. Recently, surface water runoff has emerged as the primary source of pollutant loading to the urban ocean due to changes in civil infrastructure, such as damming and development. Surface waters in southern California are negatively impacted by microorganisms and suspended particles, consequently failing many total maximum daily load (TMDL) requirements and potentially affecting the health of recreational swimmers. Therefore, the sources of pollutants in urban runoff must be quantified as part of assessing pollutant loads, and there is a need to understand the fate and transport of pollutants in a watershed system in order to reduce the impact through the development and deployment of best management practices (BMPs).

Research Objectives. The objective is to elucidate the origins and fluvial transport of fecal indicator bacteria, human pathogenic viruses, and suspended particles along an inland-to-ocean transect in the Santa Ana River watershed, southern California, during dry weather and episodic storm events, and to identify coastal water quality impact from a highly urbanized coastal watershed system. This research includes the following specific goals:

- To characterize the concentrations of fecal indicator bacteria and suspended sediment in storm water runoff from the Santa Ana River.
- To understand the origin and transport mechanism of suspended particles through the characteristics of particle size spectra eroded from an urban watershed.
- To assess coastal water quality impact of storm water runoff and the correlation between in-situ measurements and remote sensing.
- To assess the impact of urban runoff and treated wastewater in the growth and die-off mechanisms of fecal indicator bacteria.
- To assess microbial community changes in storm water runoff in the Santa Ana River as indicators of fecal pollution and runoff origins

Methodology.

- High frequency sampling of stormwater runoff at three sites in the Santa Ana River watershed over three storms. Measurements on runoff samples included: fecal indicator bacteria (total coliform, *E. coli*, and enterococci), fecal indicator virus (F^+ coliphage), human pathogenic virus (human adenovirus and human enterovirus by nested polymerase chain reaction, PCR), suspended particles (mass and size distribution), and microbial community composition by analysis of terminal restriction fragment length polymorphisms (TRFLPs) of particle-associated and free-living eubacteria.
- Merging of satellite sensing of runoff plumes with shipboard measurements of runoff plumes, and in situ sensor data. Measurements included: MODIS satellite data (true color images), NEOCO in situ sensor at Newport Pier (1/4 min^{-1}, salinity, temperature, chlorophyll), fecal indicator bacteria in surf zone (conducted by Orange County Sanitation District, OCSD), offshore (UCI and Bight 03), human pathogenic virus, suspended particles.
- Dry-weather transect sampling of stretch of Cucamonga Creek. Measurements include: fecal indicator bacteria, dissolved organic carbon, nitrate, ammonium, phosphorus, dissolved oxygen, pH, salinity and conductivity.
- Microcosm studies using different combinations of Cucamonga Creek baseflow, sterilized baseflow, treated wastewater discharge, sterilized treated wastewater discharge, and nutrient broth. Sampling of microcosms over time and measuring fecal indicator bacteria.

Principal Findings. Principal findings are the following:

a. Within-watershed stormwater studies:

- Concentrations of fecal indicator bacteria and fecal indicator viruses increase sharply during the rising limb of the storm hydrographs and do not fall with the falling limb of the storm hydrographs.
- Concentrations of suspended particles follow the shape of the storm hydrographs.
- Human adenovirus and human enterovirus results were negative (below detection limits using PCR and nested PCR), except for one positive result of adenovirus during the early part of a storm, downstream of the treated discharge of a tertiary wastewater treatment plant.
- Bacterial communities were both particle-associated and free-living in storm runoff. Whether the two fractions were similar depended on the site.
- Bacterial communities differed by site and were particularly distinct in the ocean. They also varied between storms within a site, but when one site was sampled during the course of a hydrograph no temporal variations in microbial communities were observed.

b. Coastal water quality impacts:
    - Storm water runoff impacts coastal ocean water quality, both in the surf zone and offshore, with water quality in the surf zone frequently exceeding marine bathing standards by >500%.
    - F^+ coliphage, human adenoviruses and enteroviruses detected just offshore of the Santa Ana River outlet.
    - Turbidity plumes generated by the Santa Ana River spread out over a very large area (exceeding 100 km^2).
    - Bacteria and viruses appear to be associated with particles smaller than 53 microns, or they are not particle associated. This results was confirmed both by culture-dependent and culture-independent microbiological methods.

Significance.

a. Within-watershed stormwater studies:

- Fecal indicator bacteria appear to be ubiquitous across the urban landscape and are washed off into receiving water bodies during storms.
- Traditional best management practices (BMPs) for treating stormwater pollutants may not be effective for treating bacterial pollutants.
- Flow fingerprints—or changes in the concentration of stormwater constituents with volumetric flow rate in the river—appear to be a useful analytical tool for determining sources of pollutants in stormwater runoff from urban watershseds.
- Community fingerprints appear to be site-specific which implies that microbes may be tracers for runoff water quality from various, integrated sources upstream.

b. Coastal ocean studies:

- Turbidity detected by MODIS satellite sensors does not necessarily correlate with water quality, as measured by fecal indicator bacteria, fecal indicator viruses, and human pathogenic viruses.
- Coastal impact of storm water runoff depends on prevailing ocean currents and waves, within-plume processing of particles and pathogens, and the timing, magnitude, and nature of runoff discharged from the river over the course of a storm.