Report for 2003VI9B: Fecal Coliform Bacteria Removal Efficiency for Stormwater BMPs in the Virgin Islands

- unclassified:
  - No publications have resulted to date from this research project.

Report Follows

Summary Report on

Fecal Coliform Bacteria Removal Efficiency for Stormwater Runoff BMPs in the Virgin Islands

Problem and Research Objectives

Fecal pollution from nonpoint sources has been recognized as a major source of water quality impairment in streams, estuaries, and near coastal ocean waters throughout the United States, including the Virgin Islands (DPNR 2003). Fecal pollution is typically indicated by the presence of indicator organisms, including fecal coliform bacteria. Fecal coliform bacteria can originate from human, domestic animal, or wildlife sources, and may present exaggerated problems in tropical areas due to warm temperatures and heavy rainfall (Toranzos 1999).

Best Management Practices (BMPs) used for reducing fecal coliform bacterial contamination of stormwater runoff in the Virgin Islands has included detention ponds, as well as vegetated swales, filter strips, and other engineered structures (DPNR, 2003). Unfortunately, the efficiency of fecal coliform bacteria removal by various BMPs is largely unknown, particularly on local or regional levels. Overall, testing of fecal coliform bacterial removal using BMPs has been limited, and has generally occurred in more temperate areas. Results have shown wide variations in BMP removal efficiency on a regional basis and results from one area may not be applicable to others (Scheuler 2000).

The research objective for this project was to evaluate the performance of detention ponds as BMPs for fecal coliform bacterial pollution reduction under conditions within the Virgin Islands. Performance was evaluated by measuring fecal coliform loading at the inlet to a detention pond and at the outlet during storm events. Loading was calculated by integrating stormwater flow with fecal coliform density. The difference in fecal coliform load in runoff water entering and exiting the pond allowed calculation of the removal efficiency.

Methodology

The detention pond studied in this effort is located just south of Weymouth Rhymer Highway, in the upper portion of the Turpentine Run watershed in St. Thomas, U. S. Virgin Islands (Figure 1.). The pond was chosen based on the regional use of detention ponds as BMPs and local advice identifying the Turpentine Run gut as an area of concern for pollutant loading into the Benner Bay and Mangrove Lagoon area receiving waters. Although the pond may or may not have been installed specifically to serve as a BMP for pollution reduction or stormwater retention, it serves to do so. Samples also were obtained at the USGS Gaging Station at Turpentine Run (Figure 1), which has no BMP installed. Effluent from a wastewater treatment facility located upstream potentially impacts this section of Turpentine Run.

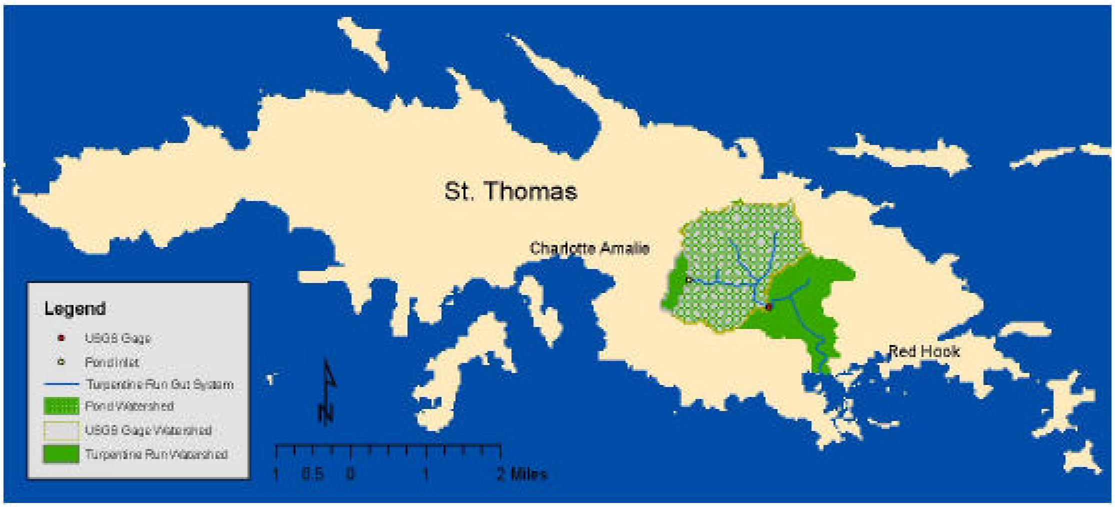

Figure 1. Location of Study Areas and Associated Watersheds

Sampling events occurred only during times of rainfall and generation of flow into the pond. Water samples were collected per APHA Methods 9060 A., and 9060 B., for collection of water and wastewater samples (APHA 1998). Bacterial enumeration was performed immediately following sampling, and was accomplished by APHA Method 9222 B, for membrane filtration enumeration of fecal coliform bacteria (APHA 1998). Stormwater velocity measurement occurred concurrently with collection of each water sample. Stormwater flow was measured with a Marsh-McBirney Flowmate Model 2000 Portable Flowmeter, following guidelines for width integrated flow measurement in streams and piped systems.

Principal Findings and Significance

Samples were obtained during rainfall events at the study area locations beginning on 2 November, and ending 13 November 2003. Data were obtained for fecal coliform concentration, water flow, pH, temperature, and salinity. Rain events that generated stormwater runoff and flow into the study area pond occurred on November 2, 3, 7, 8, 9, and 13 (Table 1). In summary, it appears that the pond performs well as a BMP for reducing fecal coliform loading, but the reductions seen are probably a result of the stormwater storage capacity of the pond. When the storage of the pond was exceeded, the pond did not appear to reduce fecal coliform density, and, in fact, it may have increased (Table 1). Although the increase observed is not statistically measurable with the single data point, it is possible that fecal coliform concentrations can increase due to sediment re-suspension (Davies et al. 1995, Desmarais et al. 2002).

Table 1. Fecal Coliform Data

Location	Date	Time	FCD (cfu/100ml)	Flow (m3/s)	Load (cfu/s)
Pond Inlet	11/2/2003	14:10	28	0.000396	111
Pond Inlet	11/2/2003	15:10	27	0.001825	493
Pond Inlet	11/3/2003	13:35	9	0.000531	48
Pond Inlet	11/7/2003	08:10	162	0.00088	1427
Pond Inlet	11/8/2003	12:30	9	0.001056	95
Pond Inlet	11/9/2003	09:45	81	0.003605	2923
Pond Inlet	11/9/2003	11:45	18	0	0
Pond Inlet	11/13/2003	10:45	27	0.01216	3286
Pond Outlet	11/2/2003	14:16	28	0	0
Pond Outlet	11/2/2003	15:25	210	0	0
Pond Outlet	11/3/2003	13:45	36	0	0
Pond Outlet	11/7/2003	08:32	36	0	0
Pond Outlet	11/8/2003	12:50	9	0	0
Pond Outlet	11/9/2003	10:00	72	0	0
Pond Outlet	11/9/2003	11:59	0	0	0
Pond Outlet	11/11/2003	09:50	63	Flash Flood Conditions	
Pond Outlet	11/13/2003	10:14	27	0.0182	4919
USGS Gaging Station	11/2/2003	16:40	1364	0.090614	1235642
USGS Gaging Station	11/3/2003	14:15	117	0.006796	7959
USGS Gaging Station	11/7/2003	08:54	1273	0.036812	468514
USGS Gaging Station	11/8/2003	13:12	54	0.017273	9337
USGS Gaging Station	11/9/2003	10:45	360	0.039644	142717
USGS Gaging Station	11/9/2003	12:15	270	0.028317	76455
USGS Gaging Station	11/11/2003	10:35	5000	8.877317	4.44E+08
USGS Gaging Station	11/12/2003	13:37	545	2.010493	10966324
USGS Gaging Station	11/12/2003	13:52	455	1.529107	6950487
USGS Gaging Station	11/12/2003	14:10	182	1.291246	2347720
USGS Gaging Station	11/13/2003	11:15	63	0.339802	214289

cfu = Colony Forming Units   m3 = Cubic Meter   s = Second

Between November 11 and 14, approximately 11.62 inches of rain were recorded at the University of the Virgin Islands weather station. This storm event created hazardous conditions at the study area pond site, and sampling there was not possible. The intensity of the rainfall was unfortunate, in that the pond first experienced outflow beginning in this event. Outflow from the pond was sampled only once, on November 13, when conditions had temporarily improved. During the project sampling duration, this was the only occasion that the pond storage capacity was exceeded, and only one data point is available to compare inlet and outlet fecal coliform concentrations during periods of outflow from the pond. Samples were obtained throughout this period at the USGS Turpentine Run gaging station (Table 1).

It is interesting to note that although over 11.5 inches of precipitation was recorded at the UVI weather station, less than 8 inches was recorded during the same time period at the USGS Turpentine Run gaging station (Table 2). Additionally, although flow was measured at the USGS Turpentine Run gaging station at each sampling event, visual inspection revealed that little or no flow was often observed at areas farther downstream. Because pollutant loading from Turpentine Run is of concern to Benner Bay and the

Mangrove Lagoon area receiving waters, it suggests that the relationships between rainfall and stormwater runoff at the Turpentine Run watershed outlet needs to be better understood. It is also apparent that the spatial variability of rainfall on St. Thomas needs to be evaluated.

Table 2. Rainfall Data

	Rainfall by Location (in)	
Date	UVI	Gaging Station
11/12/2003	2.09	1.78
11/13/2003	2.67	3.29
11/14/2003	4.08	2.71
11/15/2003	2.78	0.15
Total	11.62	7.93

Final project activities will include the installation of a water level indicator at the study area pond. A Global Water Instrumentation, Inc., Model WL-15 water level indicator has been purchased and will be installed during the week of July 12-16, 2004. The water level indicator will provide data for the evaluation of pond hydrodynamic properties, watershed response, and evaporation rates. Data collected will be useful in completing hydrologic analyses begun in October 2003, but which were interrupted by extreme flood conditions in the study area pond. Although the current project extension period ends as of August 31, 2004, analyses will continue beyond the project end date, and may be incorporated into further funded research efforts.

References

APHA. 1998. Standard Methods for the Examination of Water and Wastewater. 20th Edition. American Public Health Association. Water Pollution Control Federation. United Book Press, Baltimore Maryland.

Davies, C.M., J.A.H. Long, M. Donald, and N.J. Ashbolt. 1995. Survival of Fecal Microorganisms in Marine and Freshwater Sediments. *Applied and Environmental Microbiology 61(5)*: 1888-1896

Desmarais, T.R., H.M. Solo-Gabriele, and C.J. Palmer. 2002. Influence of Soil on Fecal Indicator Organisms in a Tidally Influenced Subtropical Environment. *Applied and Environmental Microbiology* 68(3): 1165-1172

Division of Planning and Natural Resources. 2003. *Coastal Water Quality Monitoring Manual.* Accessed March 19, 2003. Available: http://www.ocrm.nos.noaa.gov/PDF/USVI_Monitoring_Manual.pdf.

Schueler, T. 2000. *Why Stormwater Matters*. In: The practice of watershed protection. Pp365-376. Center for Watershed Protection, Ellicott City, MD.

Toranzos, G. 1999. *Tropical Microbiota and its Influence on Water Quality*. Abstract. Accessed March 19, 2003. Available: http://rps.uvi.edu/WRRI/seminars.htm - sem1