Water Resources Research Center

Annual Technical Report

FY 1998

Introduction

For Fiscal Year 1998, the New Hampshire Water Resources Research Center (WRRC) was funded by USGS for administration and two research projects. The administration of the program primarily included maintenance of the library, grant management, correspondence, and outreach. The two projects funded each addressed water quality, which was identified in previous years as an area of high concern for stakeholders. The two projects include "A Survey of 50 NH Lakes for Microcystins" and "Bacterial and Nutrient Dynamics in Stormwater Control Systems in New Hampshire." Microcystins are algal toxins that are naturally produced by blue-green algae; the algae proliferate in waters receiving excessive phosphorus inputs. Stormwater runoff is a persistent problem in coastal New Hampshire, where shellfish beds are threatened by fecal contamination from a variety of sources. The research project addresses the effectiveness of control measures taken to reduce pollution by stormwaters.

Research Program

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Bacterial and Nutrient Dynamics in Stormwater Control Systems in New Hampshire
Project Number	C-03
Start Date	09/01/1997
End Date	08/31/1999
Research Category	Water Quality
Focus Category #1	Non Point Pollution
Focus Category #2	Nutrients
Focus Category #3	Water Quality
Lead Institution	Unversity of New Hampshire

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Stephen H. Jones	Associate Professor	Unversity of New Hampshire	01

Problem and Research Objectives

Stormwater runoff is a widely recognized source of fecal-borne microbial and nutrient contaminants waters that poses public and environmental health threats and restricts the potential uses of surface waters throughout New Hampshire and the region. However, the public health significance of stormwater-associated bacterial contaminants and the fate of runoff-borne nutrients in stormwater control systems are not well understood. BMPs used to reduce contaminant loading from runoff have often been designed to be effective under somewhat limited environmental conditions. This becomes a significant issue in areas such as the northeastern U.S. where widely variable temperatures and environmental conditions can have effects on designed treatment processes, especially for contaminants that are subject to change from biological activities.

The main focus of the study will be on assessing microbial contamination, based on previous results and the current concerns for these contaminants. Not only are microbial contaminants the main concern of the new EPA National Estuaries Project in New Hampshire, but pathogens were of concern to all NEPs surveyed at a recent national meeting (Brown and Volk, 1997). More than half of the nation's estuaries consider pathogens a significant concern relative to other issues, and many point to stormwater as an important source of all contaminants. In many studies, bacterial indicator contamination during dry periods and in runoff where no human sources of contaminants can be identified has been attributed to animal sources. In numerous recent studies in New Hampshire, evidence for animal sources has not been apparent and elevated concentrations of indicator bacteria following storms at some locations appeared to be independent of any identifiable sources (Jones and Langan, 1993; 1994; 1996). The hypothesis for this proposed study is that small numbers of bacteria giving positive indicator tests can multiply in the environment under favorable conditions in wet stormwater control systems during dry periods and give misleading indications of fecal contamination in effluent water.

Two common runoff control systems in coastal New Hampshire are wet ponds and vegetated swales. Preliminary studies showed these systems were inconsistently effective at removing contaminants in New Hampshire (Jones and Langan, 1996). The goal of the ongoing project has been to conduct field studies to assess the effectiveness of these BMPs for minimizing downstream contamination under the varying environmental conditions of New Hampshire. Initially, two wet ponds and two vegetated swales served as study sites. However, the study has expanded overall since it started because of focused overlaps with other, simultaneous related studies. The specific objectives for this project remain as follows:

1. compare the effectiveness of two types of stormwater control systems for preventing downstream contamination from runoff during storm events;
2. determine the seasonal impact of dry weather incubation time on concentrations and forms of contaminants;
3. determine the public health significance of bacterial contamination in stormwater.

Methodology

The study sites include wet ponds, detention ponds and vegetated swales, some of which were the subject of a previous study (Jones and Langan, 1996). The wet ponds include cattail ponds with effluent discharged to level spreaders or ditches, and one that has staggered dikes. The vegetated swales are high flow systems that discharge either into level spreaders or to natural wetlands. The drainage areas for all systems are large shopping center parking lots in the seacoast area of New Hampshire. No leaky sewers or cross connections with sanitary sewers have been observed at these sites. Site characteristics such as drainage area, traffic, maintenance and cleaning activities, size and volume of control system, and downstream areas have been documented.

All sites will have been prepared for ease of sample collection, flow measurements and equipment accessibility. Debris has been removed, and V-notch weirs installed at the effluent ends of the swales and near the effluent ends of some of the wet ponds to aid flow measurements and sample collection. Flow measurements have been used to determine increases in flow from stormwater runoff to help timing of the first flush sampling and for gauging the intensity of runoff discharge from the different storms. Rain gauges have been used for measuring rainfall volume and rate. Relative dry weather conditions have been assessed by documenting the depth of water and flow at defined sites within the different systems.

Objective 1: compare the effectiveness of two types of stormwater control systems for preventing downstream contamination from runoff during storm events;

> Samples have been collected from essentially all sites before, during and after 10 storms of >0.5"/24 h that have occurred in all four seasons. Sampling during some warm month periods has been impossible during long-term drought conditions because wet ponds have been dry and infiltration exceeded runoff during storms. For some storms, continued sampling has occurred following the event during extended dry weather conditions to determine the effect of incubation within the system on bacterial numbers. Some sampling has involved paired sampling at the points of inflow to and outflow of the some systems. Samples have been collected as grab samples because of the need for rapid refrigeration to depress biological activities that can modify nutrients and change bacterial numbers.

> Sample bottles have been preconditioned by acid washing for nutrient analyses and autoclaved for microbial analyses. Water and ambient air temperatures, conductivity, dissolved oxygen, pH and flow have been measured in situ with appropriate meters at the time of sampling. Rainfall volume and intensity have been determined from rain gauge measurements and from data collected routinely by local weather stations. Water samples have been refrigerated on ice in coolers immediately after collection and transported to the lab for analysis within 6-20 hours. Samples have been analyzed for bacterial indicators used for classifying surface waters in NH (fecal coliforms, Escherichia coli and enterococci), and for dissolved nitrogen (nitrate/nitrite, ammonium, dissolved organic nitrogen). Most samples collected in the beginning of the project included analyses for dissolved organic carbon (DOC), total phosphorus and suspended solids. These analyses were discontinued after 12/97 as the project expended to include more sites.

> Pollutant treatment efficiencies are being calculated by comparing contaminant loads leaving the systems with loads entering the systems. Differences within system types (swales; ponds) are being analyzed to determine if other factors could be affecting contaminant removal.

Objective 2: determine the seasonal impact of dry weather incubation time on concentrations and forms

of contaminants;

In addition to storm event sampling, dry weather sampling has been conducted between storms during extended dry periods to provide base flow information on contaminants and conditions within the study areas and to document changes in concentrations as a result of incubation in wet systems. The frequency of sampling during dry periods after storm events has varied, but the general approach has been to sample the day before, the day after, two days after then at longer intervals until the next storm event. Water samples have been collected within excavated areas of the swales and diked pond, and at the points of water inflow and outflow in the other pond system. Samples of sediment from within the ponds and swales have also been collected to determine whether sediments are acting as reservoirs of contaminants as well as providing information for proper disposal and handling of sediments removed as part of maintenance procedures. Samples have been analyzed for the same bacterial indicators,, and dissolved nutrients as for water samples.

Objective 3: determine the public health significance of bacterial contamination in stormwater;

At sites that have elevated microbial indicator levels, samples collected during at least one event per season have been analyzed for common bacterial pathogens. These include Pseudomonas aeruginosa and Clostridium perfringens, in addition to Escherichia coli. These pathogens have been targeted in other stormwater studies (Jones et al., 1999; Jones, 1998; Ellis and Wu, 1995; Field and O'Shea, 1992). The sampling strategy has been similar for the pathogens as for the indicator bacteria. The main goal has been to determine the presence and the temporal dynamics of these organisms within the systems. We have also been interested in seeing what is coming into and what flows out of the systems.

Principal Findings and Significance

The weather during the project has provided a variety of conditions for study. There have been significant rainfall events and extended dry periods during the different seasons. Sampling has occurred as frequently as possible to gather enough information for the different conditions that occur to be able to make useful conclusions.

Objective 1

Extensive numbers of samples have been collected in different stormwater control systems during this study. The results have provided a variety of findings for the different types of systems. Depending on the type and conditions within the system, results have shown some to apparently remove contaminants while others have higher concentrations in effluent compared to influent. For any given system, the results can vary from storm to storm as well as between seasons. In addition, the different bacteria and nutrients have exhibited different responses. The closely related fecal coliforms and Escherichia coli often exhibit very similar responses, but differ from enterococci and the pathogens. As expected, ammonium and nitrate act quite different, often in inverse trends. The two major swale systems have had vastly different conditions. One has been dry for most of the warm season sample dates and the other has characteristically low dissolved oxygen, reflecting almost continuous, stagnant water and high oxygen demand within the cattail root zones. The wet ponds have also exhibited different overall conditions. The ongoing study has a continued focus on differences in contaminant loading coming into and leaving the systems.

Objective 2

Numerous dry weather periods have been the target of sampling to determine the seasonal impact of dry weather incubation time on concentrations and forms of contaminants. In some cases, data are now available for pre-storm, post storm, and next storm periods to help understand the dynamics of contaminants within the systems and the eventual effects on contaminant loading from the systems. As was the case for the comparison of the different types of systems, the results of this part of the study have varied over a wide range. Some systems under some conditions appear to have had enhanced survival and possibly growth of bacterial contaminants during storm events while others have shown bacteria to disappear during dry weather. The effects of all conditions, including temperature, water depth, dissolved oxygen and nutrients on the survival of the bacteria are being considered in the interpretation of the dry weather data. The study has also included intensive in situ sampling of bacterial contaminants during dry weather in an attempt to better characterize the dynamics of bacterial population changes. Laboratory incubations of bacterial isolates and untreated water samples from the systems have also been included to provide more detailed studies of the bacteria under controlled environmental conditions.

Objective 3

In general, the two bacterial pathogens have been detected only at low concentrations compared to the bacterial indicators. Where measurable concentrations have been recorded, it appears that P. aeruginosa does not persist within the wet systems and effluent concentrations are generally lower than influent concentrations during storm events. More data accumulated during the rest of the study will provide a better understanding of the significance of these bacterial pathogens in the stormwater control systems of this study.

In addition, an extensive literature search on the public health significance of stormwater microorganisms has been conducted. The review was initiated as part of the proposal preparation for this project, and has been extended as part of this and other projects. The review, with sections focusing on the issue in New Hampshire's Seacoast, has been published as a report to the New Hampshire Department of Environmental Services (Jones, 1999). Portions of the review will probably be published in the scientific literature in collaboration with NHDES scientists.

REFERENCES

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Descriptors

bacteria, nutrients, storm water management, contaminant transport, public health, water quality standards

Articles in Refereed Scientific Journals

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Water Resources Research Institute Reports

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Jones, S.H. 1999. Public health significance of stormwater-borne microorganisms. Final Report. NH Department of Environmental Services, Concord, NH. 41 pp.

Jones, S.H. 1998. Monitoring of dry weather bacteria levels in stormwater detention systems. Final report. NH Office of State Planning/Coastal Program, Concord, NH. 27 pp.

Basic Project Information

Basic Project Information	
Category	**Data**
Title	A Survey of 50 NH Lakes for Microcystins
Project Number	02
Start Date	09/01/1998

End Date	08/31/2000
Research Category	Water Quality
Focus Category #1	Toxic Substances
Focus Category #2	Water Quality
Focus Category #3	Ecology
Lead Institution	Unversity of New Hampshire

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
James F. Haney	Professor	Unversity of New Hampshire	01
Miyoshi Ikawa	Professor	Unversity of New Hampshire	02

Problem and Research Objectives

Cyanobacteria blooms pose a potential threat to the use of lakes for both recreation and drinking water supplies. There are increasing reports of health problems associated with toxic cyanobacteria such as Microcystis in many parts of the world. Preliminary investigations in New Hampshire lakes indicated the presence of the hepatotoxin microcystin in lakes of varying trophic status. The major objective of this study is to conduct a survey of New Hampshire's lakes to determine which lakes contain toxic cyanobacteria that produce microcystins and evaluate whether there is a direct relationship between the presence of the cyanobacteria toxins and the trophic condition of the lakes.

Methodology

50 study lakes were selected to represent a wide range of lake basin types, nutrient conditions and geographic regions within New Hampshire. During the summer, triplicate samples for toxin analysis were collected from the plankton and from filtered and unfiltered water from each study lake. Parallel samples were also taken for analysis of nutrient (phosphorus and nitrogen) as well as chlorophyll a and dissolved color. Plankton samples were also taken for identification and enumeration. Depth profiles were measured of the light using a underwater probe and data logger as well as temperature, specific conductance, dissolved oxygen, redox, pH, turbidity, and phytoplankton fluorescence using a multiparameter probe. Phytoplankton, zooplankton and lake water were analyzed for microcystins using the enzyme-ligand immunosorbant assay (ELISA) confirmed with high performance liquid chromatography (HPLC).

Principal Findings and Significance

During the summer, 1999, sampling trips were made to approximately 40 of the 50 selected study lakes. The remaining lakes will be sampled during the early summer of 2000. The lakes selected represented a great diversity of trophic conditions, from ultra-oligotrophic to hyper-eutrophic lakes as well as geographic regions including urban/suburban southern New Hampshire, Coastal Plain, White Mountains and the Northern Forest. Laboratory analyses total phosphorus, chlorophyll a and water color have been completed on approximately one half of the lake samples. Remaining chemical analyses, ELISA assays and plankton enumeration will be completed during this fall and winter. Graphic analysis has been

completed for most of the analyzed data and statistical analyses will be done as the data sets are completed.

Descriptors

biotoxins, microcystins, Microcystis, cyanobacteria, algae, eutrophication, lakes, water quality

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