Water Resources Research Institute

of The University of North Carolina

ANNUAL PROGRAM

CURRENT RESEARCH JULY 1, 1995 TO JUNE 30, 1996

The Water Resources Research Institute is a unit of The University of North Carolina system headquartered in Jordan Hall on the North Carolina State University campus.

It is one of 54 state water institutes authorized by the Water Resources Research Act of 1964 to administer and promote federal/state partnerships in research and information transfer on water-related issues.

The mission of WRRI is threefold: to identify the state's ever-changing research needs, to motivate and support research by qualified scientists, and to provide for technology transfer.

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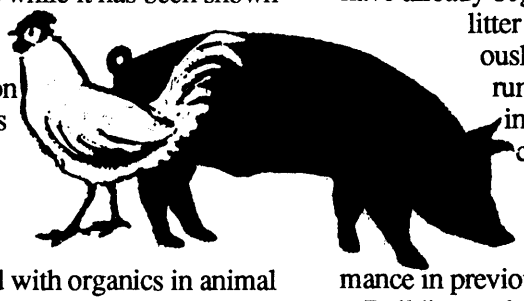
NEW RESEARCH

NCSU researchers study how well vegetated buffers reduce pollutants in runoff from fields where poultry litter has been applied

Wendell Gilliam has been studying the problem of nonpoint source water pollution in North Carolina for 26 years, recently focusing his research on the effectiveness of grass and riparian buffers in removing pollutants from agricultural runoff. While Gilliam knows buffers can be useful in protecting water quality, he sounds a note of caution about relying on current data to design buffers to protect streams near fields where animal waste is applied.

Gilliam says that while it has been shown that buffers can be effective, most previous research on buffer effectiveness has been on fields where inorganic fertilizers have been applied, and nutrients associated with organics in animal waste behave differently than inorganic nutrients. Phosphorous from animal waste moves through soils more easily than inorganic phosphorous, and nitrogen in animal waste must be mineralized to inorganic forms before it can be taken up by plants. It is possible, then, that nutrients in animal wastes may move off site more easily than inorganic nutrients. Furthermore, he says, a major concern associated with land application of animal wastes is bacterial contamination of waters, and virtually nothing is known about the ability of planted or natural buffers to remove bacteria from runoff.



Because he believes that land application of waste from concentrated animal operations poses the largest nonpoint source threat to water quality in the state, Gilliam says it is crucial to base recommendations for animal waste best management practices on better information than is now available. His current WRRI project is aimed at providing that information.

Using sites equipped and instrumented for previous research on buffer effectiveness, Gilliam and co-investigators Robert Mikkelsen and John Parsons will evaluate the effectiveness of grass and riparian buffers in removing nutrients and fecal coliform bacteria from runoff from a field where poultry litter has been applied. They have already begun incorporating poultry litter at two six-plot sites previously used for research on runoff from fields not receiving animal waste. They will compare the effectiveness of buffers in cleaning up runoff from waste-treated fields with their performance in previous research.

Building on hydrologic and chemical data produced by previous research and new data gathered in the current project, the investigators will also evaluate the latest version of the GLEAMS runoff model and will develop and test routines for simulating flow of water and chemicals through grass and riparian buffers.

The investigators intend to provide information to predict the effectiveness of buffers under a range of site conditions and to design requirements for buffers between streams and areas receiving animal waste.

Grass and Riparian Buffer Treatment of Runoff from Land Receiving Animal Waste (70146)
J.W. Gilliam, J.R. Parsons, & R.L. Mikkelsen, North Carolina State University
July 1, 1995 to June 30, 1996
Funded by WRRI

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INSTITUTE RESEARCH PRIORITIES

Priorities established by the WRRI Advisory Committee for the current research year reflect a growing awareness by policy makers, administrators, and the public of the need to focus on basinwide water quality management strategies and to identify and devote resources to the most pressing problems. Topics given highest priority by the Advisory Committee are:

- ❖ understanding basinwide processes and effects and developing effective basinwide management strategies;
- ❖ evaluating and further developing nonpoint source management approaches, with attention to the role of riparian buffers;
- ❖ assessing and responding to microbial and disinfection by-product threats to drinking water safety;
- ❖ building awareness of the need for water conservation and reuse and assessing reuse potential;
- ❖ improving methods for wetland creation and restoration and improving mitigation practices, including banking;
- ❖ addressing water quality threats from concentrated animal operations;
- ❖ assessing risk from groundwater contamination and balancing risk against cost of remediation.

NEW RESEARCH

UNC Chapel Hill research focuses on predicting disinfection by-products from knowledge of source water

It is well documented that when water containing significant amounts of natural organic matter (NOM) is disinfected with chlorine, a variety of disinfection by-products (DBPs) is produced. Some of these DBPs have been shown to be carcinogenic or mutagenic, and it is believed that more by-products are formed than have been identified so far. EPA is in the process of regulating harmful by-products of disinfection in drinking water, and water supply managers face difficult decisions about how to treat water to kill bacteria and other microbiological contaminants without creating unacceptable levels of chemical by-products.

Research has produced some general knowledge about DBP formation. It has been shown that higher total organic carbon in a source water and longer chlorine contact times lead to higher concentrations of trihalomethanes—one class of DBPs. However, the components of natural organic matter and, therefore, how it reacts when it comes into contact with chlorine varies from place to place and from season to season at any one place. There is currently no way for water managers and regulators to predict what kinds or what concentrations of by-products will be produced when water from any particular source is disinfected at any particular time. That means water managers ordered to reduce DBPs in drinking water have a moving target if they try to pretreat water to remove DBP "precursors" before chlorination. And, it means they do not know if they have been successful until finished drinking water emerges from the end of the treatment train.

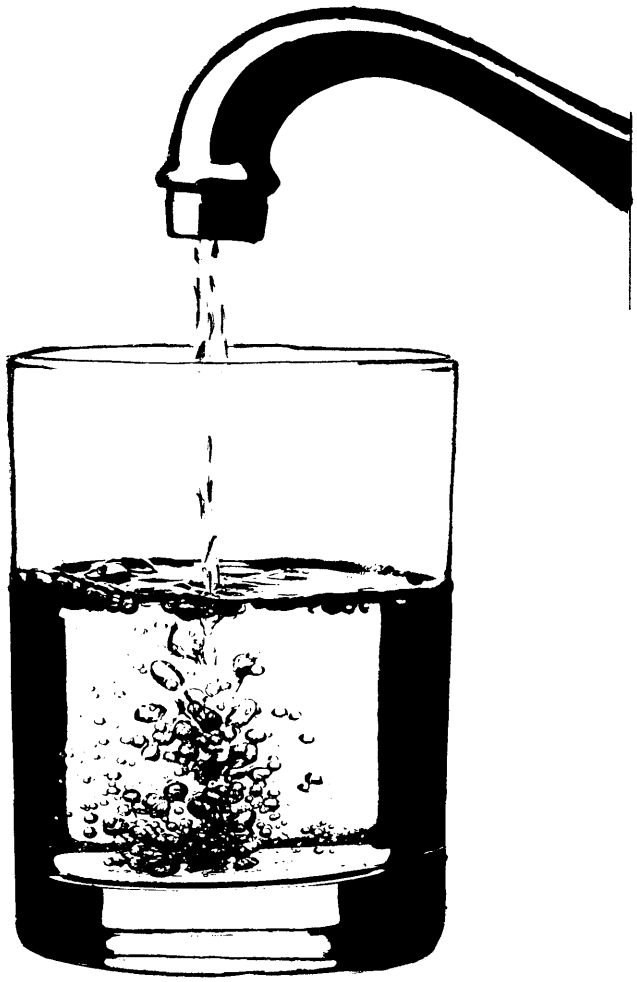
If source water could be sampled and the natural organic matter characterized as to its geochemical properties, and if certain properties could be tied to production and concentrations of specific disinfection by-products, then water managers could potentially adjust treatment processes to prevent the production of DBPs.

In this project, Russell F. Christman of the Department of Environmental Sciences and Engineering at UNC Chapel Hill will test a technique that he believes will permit prediction of levels of selected classes of by-products from a knowledge of the amount of total organic carbon in a water supply that is produced within the water body and the amount that is transported into the water supply from the watershed area.

The technique Christman will explore combines use of the emerging process of capillary electrophoresis to separate components of NOM based on their charge density and the use of substances known to react with specific possible components of NOM to increase detection of these components. To test his hypothesis that this process can characterize NOM according to its geochemical properties, Christman will process samples of water from six highly protected water supplies and six less protected water supplies. He expects that NOM from protected sources, which will have been generated within the source itself, will exhibit markedly different geochemical properties than NOM from less protected sources, which will have bound up nutrients, trace metals, minerals, and other anthropogenic contaminants from outside the water source. Chlorination of the water samples and analysis for by-products will allow correlation of by-products with geochemical characteristics of NOM.

If this research proves fruitful, subsequent research will focus on development of field models of the separation system for on-site measurements.

A New Method for Characterizing Aquatic Organic Matter (70142)
Russell F. Christman, University of North Carolina at Chapel Hill
May 1, 1995 to June 30, 1996
Funded by WRRI



NEW RESEARCH

Researcher at Institute of Marine Sciences will study what happens to nitrogen from ag runoff to South River

Past research focusing on freshwater streams has shown that the natural breakdown of nitrogenous compounds (denitrification) in bottom sediments and water and the consequent loss of nitrogen to the atmosphere helps to mitigate the harmful effects of nitrogen loading from agricultural fields to stream systems. There is evidence that the amount of nitrogen breakdown that takes place is determined by a number of physical and chemical parameters, including availability of oxygen in bottom sediments, inputs of nitrogen, and frequent changes in water inputs and outflows in a system (hydrology).

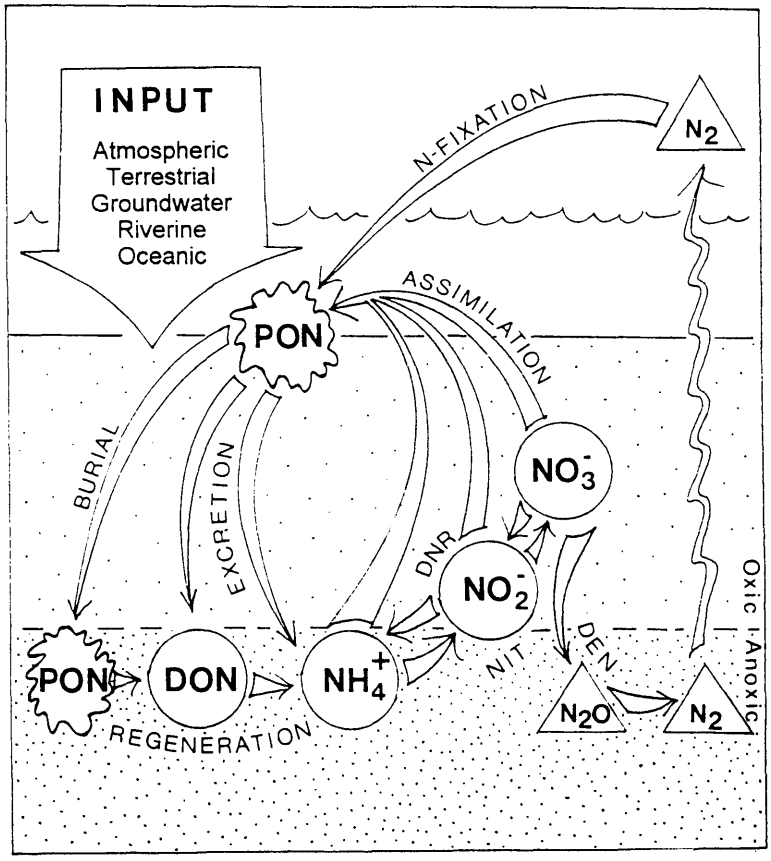
Hans Paerl of the UNC Institute of Marine Sciences thinks it is important to know how much, when, and where denitrification takes place in Coastal Plain headwater creeks of the South River, which flows into the nutrient-threatened Neuse River estuary. Headwaters of South River drain Open Grounds Farm, an extensive row crop and cattle operation. In these headwater creeks, seasonal loading of nitrogen from agricultural fields can be high, oxygen-depressing freshwater/saltwater stratification is common, and winds constantly affect the hydrology of the system. This combination of conditions means that what is known about denitrification in freshwater systems cannot be applied to this estuarine headwater system.

Paerl thinks it is crucial to measure directly the rate of denitrification in South River headwater creeks so that nitrogen loss through this pathway can be compared to rates of denitrification in water best management practices (BMPs)—such as drainage ditches controlled by flashboard risers, rock dams/filters, constructed wetlands, and vegetated buffer strips. He also believes it is necessary to know if BMPs affect denitrification rates in creeks by altering hydrology and oxygen supply. Knowing where denitrification is most efficient, he says, can be helpful in selecting BMPs to optimize nitrogen removal.

To find answers to his questions, Paerl, a technician, and several students are conducting a study on Culvert Creek, a small tributary of the South River in Carteret County. Through analysis of sediment and water samples taken monthly, they will determine seasonal denitrification rates at five sites along a transect running from a farm ditch, through Culvert Creek to the upper South River. They will determine how rain affects denitrification in the creek, with particular emphasis on rains following field application of fertilizer and with particular attention to wind speed and direction and indications of stratification. Using systems being installed as part of an EPA BMP-monitoring program, they will also measure denitrification in four drainage ditches controlled by flashboard risers, rock dams/filters, constructed wetlands, and vegetated buffer strips.

By comparing rates of denitrification in creeks and various water management practices, Paerl expects to provide useful information for selecting and operating agricultural BMPs to reduce the effects of nitrogen loading to South River and the Neuse River Estuary. In addition, improved estimates of the role denitirfication plays in riverine and estuarine nitrogen budgets will result.

Denitrification Dynamics of an Estuarine Headwater Creek Receiving Agricultural Runoff: The South River Estuary, NC (70139)
Hans W. Paerl, UNC-CH Institute of Marine Sciences
Jan 1, 1995 to Dec 31, 1995
Funded by WRRI



The availability of nitrogen for use by algae in estuaries is controlled by inputs of nitrogen as well as internal nitrogen cycling, including remineralization, coupled nitrification-denitrification and (in some cases) nitrogen-fixation.

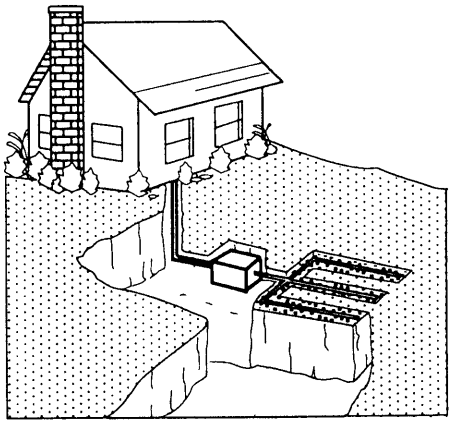
NEW RESEARCH

NCSU scientist will study whether inorganic constituents of wastewater can reduce capability of soils to transmit water through septic drainfields

Because it is often prohibitively expensive to extend public wastewater services to rural and suburban areas, North Carolinians rely heavily on septic systems for disposal of household wastewater. By the year 2000 there may be more than two million septic systems in use in the state. It is therefore crucial to understand factors that contribute to septic system failure and to develop strategies for preventing failure and restoring failing systems.

Design, siting, installation and operational inadequacies, including overloading and lack of maintenance, are known to account for many septic system problems. Drainfield clogging due to biomat formation is also known to prevent infiltration of wastewater and cause failure of systems that have been used for many years. However, while it is known that the ability of soil to transmit water depends on the properties of the liquid applied to soil as well as properties of the soil itself, little research has been done on the effect that inorganic constituents of wastewater may have on the saturated hydraulic conductivity (K_{sat}) of soils.

Building on his many years of research on on-site wastewater disposal on North Carolina soils, Aziz Amoozegar of the NCSU Department of Soil Science will study which inorganic constituents of wastewater can alter the physical and chemical properties of three different North Carolina soils so as to affect the rate of wastewater movement through them. Since it is known that sodium applied to soil can destroy soil structure and reduce the ability of soil to transmit water, Amoozegar will also explore the possibility of reversing drainfield damage caused by sodium through application of lime or other materials containing calcium.



In field studies, five different kinds of simulated wastewater, whose inorganic chemical composition has been determined, will be applied to two soils and one saprolite. Tap water will be used as a reference. Infiltration rate for each soil/solution combination will be evaluated and K_{sat} will be measured. K_{sat} of the various soils/solution combinations will also be measured in the laboratory. Data analyses will be performed to identify the inorganic constituents and other properties responsible for changes in infiltration rate or K_{sat}. At the end of the infiltration studies, undisturbed soil samples will be collected from the depth where K_{sat} was measured and extracted in the laboratory for determination of cations and anions in the wastewater. Following a resting period, lime or gypsum solution will be applied to the infiltration areas of the field sites and infiltration rates will be measured to determine if infiltration capacity can be restored (if it was lost due to chemicals).

These studies are expected to produce information for making recommendations to septic tank owners as to the potential for certain chemicals to damage drainfields and lead to system failure.

(In a related study, Amoozegar will also evaluate whether pretreatment of wastewater improves the performance of drip wastewater systems, currently being evaluated as an alternative system by the N.C. Division of Environmental Health.)

Impact of Wastewater Quality on the Long-term Acceptance Rate of Soils for On-site Wastewater Disposal Systems (70140)
Aziz Amoozegar, North Carolina State University
Mar 1, 1995 to June 30, 1996

NEW RESEARCH

NCSU researchers will study whether Nags Head septic tanks are degrading groundwater in Cape Hatteras National Seashore

Elevated soundside bacterial counts and dense algae blooms in ditches near park-adjacent residential development indicate that septic systems in the highly developed town of Nags Head may be degrading water quality in adjacent areas of the Cape Hatteras National Seashore. Shellfish beds have been closed in several soundside locations, and algae blooms in ditches that direct surface and groundwater to park marsh and stream habitat suggest that nutrient enriched waters are entering the Seashore.

The water table in the Nags Head area is less than 3 feet below the land surface, leaving a very limited space

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NEW RESEARCH

UNC investigator will study bioremediation of sites contaminated by manufactured gas tars

Across the United States, there are estimated to be between 1,500 and 3,000 former manufactured gas plant (MGP) sites contaminated with tars derived from coal and oil. More than 30 of these sites have been discovered in North Carolina. Pollutants of most concern include polycyclic aromatic hydrocarbons (PAH), some of which are known to be carcinogenic. All of the carcinogenic PAH are characterized by high molecular weight and very low solubility in water. Although these compounds readily form nonaqueous phases and bind tightly to soil constituents, water that comes into contact with them can become toxic. Tars associated with MGP sites have been discovered both in the subsurface and as sediment in surface waters. As a result, MGP sites pose a threat to both surface and groundwater quality.

While some PAH in contaminated soils can be degraded into harmless compounds by bacteria, high molecular weight PAH do not yield easily to bioremediation and are not entirely removed by the process. Therefore, what might be a low-cost cleanup method for MGP sites may not satisfy cleanup standards because of the carcinogenic PAH left behind.

In a new project building on his ongoing research, Michael Aitken of the UNC-Chapel Hill Department of Environmental Sciences and Engineering will evaluate methods to overcome the factors he believes limit the biodegradation of high molecular weight PAH. Specifically, he will study the ability of several different surfactants to pry PAH loose from soils and make them available for bacterial degradation, and will also study the addition of other chemicals to enhance the growth of PAH-degrading organisms.

Aitken's research will consist of bench-scale slurry-phase bioremediation of contaminated soil from a MGP site. He will operate a two-stage bioreactor system in which contaminated soil will first undergo conventional treatment and will then be treated with (1) a surfactant alone, (2) the surfactant in conjunction with a supplemental growth substrate, and (3) the supplemental growth substrate alone. Aitken's hypothesis is that neither surfactant nor supplemental substrate alone will achieve the desired level of bioremediation but that both will do the job.

If Aitken can demonstrate methods to degrade carcinogenic PAH to levels lower than now possible, then bioremediation could be considered for many of the MGP sites in North Carolina. That would mean contaminants could be permanently rendered harmless, which is not the case if a site must be capped and isolated or if the soil is excavated and landfilled. Bioremediation may also be more acceptable to the public or to regulatory officials than alternative methods of destroying the contaminants, such as incineration.

Slurry Phase Bioremediation of Contaminated Soil from a Former Manufactured Gas Plant Site (70144)
Michael D. Aitken
University of North Carolina at Chapel Hill
July 1, 1995 to June 30, 1996
Funded by WRRI

Cape Hatteras National Seashore research continued

between septic leach fields and groundwater. In addition, extremely sandy, porous soils greatly decrease effluent retention time. Once effluent reaches groundwater, natural flow processes transport nutrients and microorganisms directly to discharge zones on the ocean and sound.

The continued health of the unique vegetative communities and habitats found in the Seashore is linked to water quality; moreover, visitor health and safety may be threatened by groundwater from septic fields flowing into public recreation sites. There is an urgent need to determine if groundwater quality on Bodie Island within the Seashore is being degraded by septic effluent and identify the sources and pathways of degrading constituents. This project is aimed at providing that information.

David Evans of the NCSU Department of Marine, Earth and Atmospheric Sciences and Aziz Amoozegar of the NCSU Department of Soil Science will establish shallow groundwater monitoring transects to define the flow patterns of shallow groundwater in the park and the park-adjacent Nags Head area. They will sample and analyze groundwater to determine background conditions and to track substances indicative of septic effluent, particularly nitrate, phosphate, and fecal coliform bacteria. In addition, they will monitor rainfall (to measure recharge) and measure groundwater levels throughout the year to document the effect of disposal of waste from seasonal residents and visitors on water table elevations. They will also sample surface water on both the ocean and sound sides of the island several times to establish ambient surface water quality and provide a basis for comparison to conditions downgradient from septic fields. Finally they will prepare an interpretive report of their findings and recommend if additional study needs to be done.

Assessing the Impact of Septic Discharge on Water Quality on the Cape Hatteras National Seashore (70147)
David G. Evans and Aziz Amoozegar,
North Carolina State University
May 1, 1995 to April 30, 1997
Funded by WRRI and the National Park Service

NEW RESEARCH

UNC researcher will perform bench-scale assessments of activated carbon adsorption and membrane separation technologies for controlling precursors of disinfection by-products

EPA is expected soon to promulgate the Information Collection Rule (ICR) to support regulation of disinfection by-products (DBPs) under the Safe Drinking Water Act. The ICR will likely require water utilities that serve more than 100,000 customers and that use a surface water source with a DBP precursor concentration, as measured by total organic carbon (TOC), of more than 4 milligrams per liter to test technologies to remove this TOC. Based on size and recent TOC measurements, four N.C. utilities may be required to perform either or both bench-scale and pilot-scale tests of two technologies: activated carbon adsorption and membrane separation. Because water utility personnel do not have the expertise to perform these tests, consulting firms, which are geared more for pilot-scale than bench -scale testing, will probably have to be hired.

Although EPA may not require it, bench-scale testing prior to pilot-scale testing would be useful for several reasons. First, test procedures are not well established, and it would be helpful to evaluate test protocol on specific waters before spending large sums for pilot plant tests. Second, the ICR will require evaluation of seasonal influences on the production of DBPs, and bench-scale testing lends itself more to seasonal start-ups and shutdowns than larger pilot plant operations. Finally, smaller utilities in North Carolina will eventually be required to comply with the same DBP limits now facing large utilities, and information generated by bench-scale tests on waters with characteristics similar to their sources will be of benefit to them.

In this project, Dr. Francis A. DiGiano of the UNC-Chapel Hill Department of Environmental Sciences and Engineering in the School of Public Health will demonstrate the usefulness of bench-scale testing for assessing the effectiveness and cost of activated carbon adsorption and membrane separation for DBP precursor control and will develop valuable information for design and planning of pilot-scale testing. At the same time, he will evaluate which of these two technologies might produce the best results at the four N.C. water utilities subject to the ICR.

In the first year of the study, DiGiano will focus on the water utilities of Raleigh and Durham and the second year on the water utilities of Greensboro and Fayetteville. Seasonally, he will obtain samples of water that has been treated by conventional chemical coagulation-sedimentation and filtration (but not chlorination) from the water treatment plants and characterize the water as to its TOC, DBP formation and other related water quality parameters. He will also use samples for both the standard protocol for bench-scale testing of activated carbon adsorption (rapid, small-scale column test) and for modified versions of this protocol. Building on his knowledge base from previous research, DiGiano will also develop a protocol for bench-scale testing of membrane separations.

Bench-scale testing of these technologies is expected to indicate how well each removes TOC. In addition, estimates will be made of the capital costs (related to the size of the treatment units and the life of activated carbon or membranes) and operational costs (related to the frequency of regeneration of activated carbon or the frequency of membrane cleaning).

Compliance with EPA's Information Collection Rule for North Carolina Surface Water Supplies: Bench-scale Testing of the Efficacy of Carbon Adsorption and Membrane Separation (70145)
Francis A. DiGiano, University of North Carolina at Chapel Hill
July 1, 1995 to June 30, 1996
Funded by WRRI

NEW RESEARCH

Duke University scientist will develop method to assess reproductive damage to fish from chemical contaminants

Streams and other surface water in North Carolina are vulnerable to a variety of chemical contaminants from both point and nonpoint sources. Although many of these contaminants are not acutely toxic, recent research indicates chronic exposure to them may affect the reproductive health of fish. This possibility is of particular concern to managers of North Carolina's declining fishery resource. Assessing the reproductive hazard that chemical contaminants pose to Southeastern freshwater fish requires new techniques validated for use with these warmwater species.

To shed light on the effects of chemical contaminants on fish reproduction, Richard Di Giulio of Duke University's School of the Environment will build on previous research in which he identified biochemical and physiological responses of fish (biomarkers) to exposure to bleached kraft mill effluent (BKME). In this

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CONTINUING RESEARCH
NCSU engineers study natural remediation of petroleum contaminated groundwater and soil

In 1993, the N.C. Environmental Management Commission adopted new groundwater regulations that allow "natural remediation" of gasoline contaminated sites that pose no threat to human health or the environment. A clean-up plan using natural remediation would call for removing the source of contamination and heavily contaminated soil and allowing dissolved contaminants to be degraded by soil microorganisms. In order to decide when it is appropriate to use natural remediation, regulators need to know how fast the contaminant plume will spread and how quickly it might be degraded by soil microorganisms. Most research on biodegradation of gasoline constituents have been done in the laboratory. In earlier studies, NCSU engineers Robert C. Borden and Morton A. Barlaz found that biodegradation rates in laboratory experiments may be much greater than actual rates in the field. In ongoing research, they are attempting to discover what causes the difference in biodegradation rates and what factors control the rate of biodegradation of petroleum contaminants in soil and groundwater. Previously, the engineers conducted extensive field studies at a gasoline-contaminated site near Rocky Point where they found iron-reducing bacteria in the soil breaking down benzene, toluene, ethylbenzene and xylene isomers (BTEX), which are constituents of gasoline. In the current phase of the project, they are continuing monitoring of "microcosms" constructed with aquifer material from the Rocky Point site to determine the effects of varying amounts of iron-rich minerals on biodegradation and the effect of blending soil to distribute clay throughout the sand matrix. From their studies, the researchers intend to evaluate the importance of iron reduction on the natural attenuation of dissolved BTEX in the subsurface.

Influence of Iron Reduction on the Natural Bioremediation of Petroleum Spills (70132)
Robert C. Borden and Morton A. Barlaz, North Carolina State University
July 1, 1993 to Dec 31, 1995
Funded by WRRI

Method for assessing reproductive damage to fish continued

study he will use in vitro techniques developed in earlier research to evaluate reproductive impacts to fish in the Pigeon River resulting from exposure to BKME. In vitro methods use organs, tissues or cells from living organisms for testing. For this project gonadal tissue from fish will be used to evaluate steroid biosynthetic capacity, and livers will be used to screen for estrogenic effects and genotoxicity. Biomarkers previously identified will be used to track and quantify exposure to BKME for correlation with in vitro data.

Feral fish for the study will be collected above and at several locations below the outfall of a bleached kraft mill at Canton, NC, and from pristine reference rivers. In addition to field studies with feral fish, controlled studies will be conducted using fish exposed to constant dilutions of BKME for extended time periods in the artificial outdoor streams at the National Council for Air and Stream Improvement's experiment facility in New Bern.

The overall goal of the project is to develop an efficient methodology for screening and monitoring the reproductive impacts of aquatic pollutants on fish in North Carolina surface waters.

This study comes at a time when paper mills in North Carolina and elsewhere are planning process changes in response to proposed regulations mandating reduction of chlorinated organic compounds in effluents. The study will provide essential baseline data for future reference as mills implement changes.

However, while this study focuses on BKME, the approaches to be developed are potentially highly applicable to other sources of pollution, including nonpoint sources, as well.

In Vitro Methods for Screening and Evaluating Reproductive Impacts of Aquatic Pollutants on Fish (70141)
Richard T. Di Giulio, Duke University
June 1, 1995 to June 30, 1996
Funded by WRRI

CONTINUING RESEARCH
NCSU scientist investigates summer draw-down to control hydrilla in Lake Gaston

With the exotic *Hydrilla verticillata* spreading and the cost of herbicide treatment climbing in Lake Gaston, power companies that use the lake and the Corps of Engineers are assessing the feasibility of a summer draw-down to control the aquatic weed. Research has shown that a short-term summer draw-down can suppress vegetative growth and tuber production of hydrilla. However, the possible effect of a draw-down on desirable aquatic vegetation was not known. In research drawing to a close, Stratford Kay of the NCSU Department of Crop Science has evaluated how short-term exposure to summer drying conditions would influence the survival, growth

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CONTINUING RESEARCH

UNC-Wilmington scientists studying potential for algal blooms in Cape Fear and New rivers find unusual conditions

In a project that began in the spring of 1994, Michael Mallin and Lawrence Cahoon of UNC-Wilmington have been analyzing and experimenting with water samples from the Cape Fear River upstream and downstream of Wilmington and from the New River near Sneads Ferry. The purpose of their experiments was to determine which nutrient (phosphorous or nitrogen) and which seasonal conditions favor algal growth in the rivers.

They have found that upstream of Wilmington, where the Cape Fear is highly colored and turbid, there are high nutrient concentrations but low chlorophyll *a* concentrations, which are indicative of low algal growth. In this section of the Cape Fear, they have concluded, algal growth is held in check primarily by lack of light in the water column.

In estuarine conditions downstream from Wilmington, where waters are less highly colored and are well mixed by wind, tide, and river current, things are more complex. Analysis of samples from that location indicated that algal growth is higher. Experiments indicated that nitrogen is limiting in late summer and phosphorous, in spring. The investigators also suspect that weather and winds may play a role in controlling algal growth in the estuary area by periodically increasing turbidity and causing light limitation.

In the New River Estuary, which is heavily impacted by sewage effluent, the investigators found high phosphorous concentrations, as expected, and nitrogen limitation. However, they also found evidence of significant silica limitation. The investigators say this is the first reported incidence of silica limitation in a North Carolina estuary. They point out these conditions are representative of advanced eutrophication and that they lead to a change in the kind of algae that dominate the system.

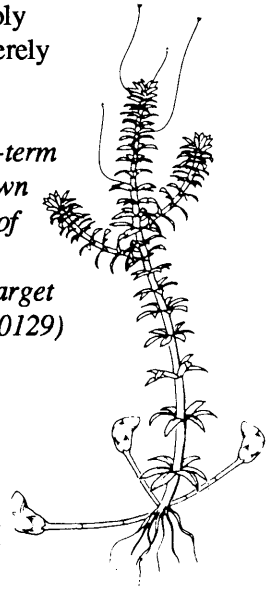
In the second year of this project, investigators are shifting their attention on the Cape Fear downstream, from the river to the estuary. They will focus on demonstrating that in the lower estuary, nitrogen is limiting in summer and phosphorous, in spring. Conclusive evidence of this limitation regime would have implications for management of wastewater inputs to the estuary.

On the New River, investigators will seek to confirm their hypothesis that algal growth is limited by nitrogen year-round and secondarily by silica. They will also examine the structure of the algae community to determine if a shift toward noxious and toxic species is taking place.

Nutrient Limitation and Eutrophication Potential of the Cape Fear and New River Estuaries (70136)
Michael A. Mallin and Lawrence B. Cahoon, University of North Carolina at Wilmington
May 15, 1994 to June 30, 1996
Funded by WRRI

Hydrilla research continued

and biomass production of two submersed plants (fanwort and Eurasian watermilfoil), one floating-leaf species (watershield), and two emergent species (waterwillow and soft rush). All these plants have been found in Lake Gaston. Results indicate that a drawdown very likely will have an adverse impact on submersed species but that emergent and floating-leaf vegetation probably would not be severely affected.



Effects of a Short-term Summer Drawdown for Management of Monoecious Hydrilla on Nontarget Aquatic Plants (70129)
Stratford H. Kay
North Carolina State University
April 1, 1993 to Sept 30, 1995
Funded by WRRI

Continuing Research

NCSU investigators develop hydrologic simulations to help identify wetlands

Much of the controversy over wetlands delineation involves determining whether wetland hydrology exists on sites that are flooded or saturated only part of the year. While soil and plant types can indicate the existence of wetland hydrology, using soil and plant indicators is not possible on sites that have been altered. On such sites, direct evaluation of hydrology through water table monitoring is necessary; however, variability of weather may make it necessary to monitor water tables for long periods to be sure results represent response to average weather conditions. Because monitoring for long periods is usually not an option, investigators in the Department of Biological and Agricultural Engineering at NCSU are working to develop reference wetland simulations which can be used to identify and delineate wetlands. R. Wayne Skaggs, G.M. Chescheir, and D.M. Amatya are developing and testing reference wetland simulations for a range of sites in nonriverine, poorly drained interstream flats using the shallow water-table model

continued next page

CONTINUING RESEARCH

UNC-Charlotte earth scientists examine performance of stormwater retention ponds for protecting water quality

Preliminary study of stormwater retention ponds led UNC-Charlotte earth scientists Randall D. Forsythe, Craig Allan and John Diemer to suspect that as these ponds age they could become sources rather than sinks of pollution. In 1993, they launched an effort to evaluate retention ponds built by the Soil Conservation Service in the Derita area of Charlotte in the 1950s. They determined that more than 30 percent of the Derita detention basins have elevated background turbidities, indicating high levels of suspended sediments and the potential for discharges from the ponds to become sources of surface water pollution. The most commonly used model for predicting pond pollutant removal efficiency does not account for the effects of sediment resuspension. This discovery together with projections for construction of hundreds, perhaps thousands, more ponds across the Piedmont suggested a critical need for better performance evaluation criteria and strategies to maintain detention ponds.

To produce the understanding of pond life and performance needed, the scientists studied sediment accumulation in 20 wet detention ponds representing a range of characteristics and found evidence that using background sediment deposit rates to predict pond life may not result in an accurate prediction. As the project comes to a close, the investigators are concluding studies on one failing detention pond in an effort to discover why sediment is resuspended in older detention ponds and how resuspended sediment and seepage from failing ponds may affect downstream water supplies and habitats.

In situ Investigation of Sediment Resuspension and Seepage Losses from a Stormwater Retention Basin in the Piedmont of North Carolina (70134)
Randall Forsythe, Craig Allan, John Diemer, University of North Carolina at Charlotte
June 1, 1993 to Dec 31, 1995
Funded by WRRI

Wetlands research continued

DRAINMOD and the water table response model WATERCOM.

Simulation studies and field tests conducted in the first phase of the project indicate proposed methods are feasible. In the second year of the project, investigators will complete analyses and testing with two years of field data. They will also ask the U.S. Corps of Engineers and the Natural Resources Conservation Service, who will be principal users of the methods being developed, to provide review and feedback.

Development of Methods for Evaluating Wetland Hydrology (70137)
R.W. Skaggs, G.M. Chescheir, and D.M. Amatya, North Carolina State University
May 15, 1994 to June 30, 1996
Funded by WRRI

In order to address research needs of specific groups, WRRI promotes partnership arrangements. One such partnership is the N.C. Urban Water Consortium.

WRRI in cooperation with several of North Carolina's larger cities established the Urban Water Consortium to provide a program of research and development and technology transfer on water problems that urban areas share. Through this partnership, WRRI and the State of North Carolina help individual facilities and regions solve problems related to local environmental or regulatory circumstances.

The Consortium program is administered by the Institute. Participating cities support and guide the program through annual dues and enhancement funds, which are matched by state funds, and representation on an advisory board. Membership in the Consortium is limited to cities or special districts in North Carolina.

The program initially received support from the N.C. Department of Environment, Health, and Natural Resources and appropriations from the N.C. General Assembly. Current Consortium members are the Orange Water and Sewer Authority, Raleigh, Durham, High Point, Burlington, Winston-Salem, Charlotte, and Greenville.

Urban water research needs cover a broad range of topics. Problems addressed with Consortium support are described on the following pages.

NEW RESEARCH

UNC-Chapel Hill investigator will create model to optimize operation of Durham's water supply reservoirs

The water supply system for the City of Durham is a complicated collection of two water reservoirs in different watersheds, several pumping stations and transmission mains, and two treatment plants, each with clearwells, finished water pumping stations, and transmission mains. This complexity presents challenges in operation. With so many pumping stations, most with a different electric cost, it is not obvious which pumping scheme will minimize energy costs. Both reservoirs use hydraulically driven pumps when reservoir inflows are high to avoid electric costs; however, these pumps consume substantial amounts of water forcing a tradeoff between conserving water and electricity. In addition, while the two reservoirs provide enough water to meet demand in normal and wet years, a problem may arise during drought years, particularly as demand increases. Finally, as reservoirs are drawn down close to working volume limits, water quality deteriorates, giving rise to higher treatment cost and risk of customer complaints. Therefore, the city must determine optimal operation not with full reservoir capacity but with restricted capacity. To assist the City of Durham in addressing these interrelated issues, Donald Lauria of the UNC-Chapel Hill Department of Environmental Sciences and Engineering will develop a mathematical optimization model with which the city will be able to determine optimal patterns of operation for given scenarios. While principles and advantages of such models have been described in the technical literature for years, advances in computer hardware and software have recently made complex optimization models feasible and practicable. This will be the largest and most comprehensive application of a zero-one (0,1) mixed integer programming (MIP) model ever made for the type system serving the City of Durham.

Optimization Model for Durham Reservoir System (50209)
Donald T. Lauria, University of North Carolina at Chapel Hill
July 1, 1995 to June 30, 1997
Funded by the City of Durham through the Urban Water Consortium

CONTINUING RESEARCH

NCSU scientists continue to evaluate agricultural use of lime-stabilized wastewater sludge

In a project that began in 1993, Bill Rogers and Fred Cox of the Department of Soil Science at North Carolina State University have conducted tests at Agricultural Research Station fields and NCSU greenhouses to determine if lime-stabilized wastewater biosolids (sludge) can be used as an agricultural liming agent. They have conducted several different experiments with the lime-stabilized sludge product Lime Plus and a commercial dolomitic agricultural lime to compare effects on soil properties and plant growth.

Results of greenhouse and field experiments to date indicate that lime-stabilized sludge seems to increase soil pH more quickly than agricultural lime and raises pH to a higher level. Plants grown with lime-stabilized sludge had higher calcium and lower magnesium concentrations than plants grown with agricultural lime. This indicates that continued use of lime-stabilized sludge could result in a calcium-magnesium imbalance and that overuse of the material could result in a magnesium deficiency if magnesium is low initially.

Rogers and Cox are now conducting studies to determine more accurately the residual effect of lime-stabilized sludge and its potential for maintaining a higher soil pH in comparison with agricultural lime.

Use of Lime-Stabilized Product as an Agricultural Liming Agent (50183)
F.R. Cox, North Carolina State University
Jan 1, 1993 to Dec 31, 1995
Funded by the Charlotte-Mecklenburg Uitilities Department through the Urban Water Consortium

Continuing Research

NCSU hydrogeologist studies nitrates in groundwater at wastewater sludge application site

In the first phase of this project, Charles W. Welby of the NCSU Department of Marine, Earth and Atmospheric Sciences has studied the routes of nitrate movement into groundwater and to surface water from sludge application fields at Raleigh's Neuse River wastewater treatment plant and from a dairy waste application site at NCSU's Randleigh Dairy Farm.

In phase two of the project, Welby is studying the rate at which nitrate from commercial fertilizer moves to shallow groundwater under normal cropping conditions at the Neuse River site. Data from these studies will allow the investigator to compare the amounts of nitrates and rates of movement of nitrates that reach groundwater from fields treated with artificial fertilizer, animal waste, and sewage sludge.

A Study of Nitrate Movement to Ground Water at the Neuse River Wastewater Treatment Plant Facility Phase II (50202)
Charles W. Welby, North Carolina State University
Sept 1, 1994 to Oct 31, 1995
Funded by the City of Raleigh through the N.C. Urban Water Consortium

NEW RESEARCH

UNC-Chapel Hill scientists will investigate apparent violation of trace element limits by several N. C. wastewater treatment plants

A number of municipal wastewater treatment plants in North Carolina appear to periodically violate their discharge limits for mercury, cadmium and cyanide. The apparent violations may stem from the fact that the permitted discharge levels for these contaminants tend to be close to their practical limits of quantitation using conventional analytical procedures.

In this project, Philip Singer and Howard Wienberg of the UNC-Chapel Hill Department of Environmental Sciences and Engineering will develop a protocol for analyzing these trace contaminants and, using the protocol, will determine whether or not the levels of trace contaminants in the effluents of a group of wastewater treatment facilities actually do violate their permitted levels. Utilities to be included in the study are the cities of Burlington, Durham, Greenville, High Point, Raleigh and Winston-Salem; the Charlotte Mecklenburg Utility District (CMUD); and the Orange Water and Sewer Authority (OWASA).

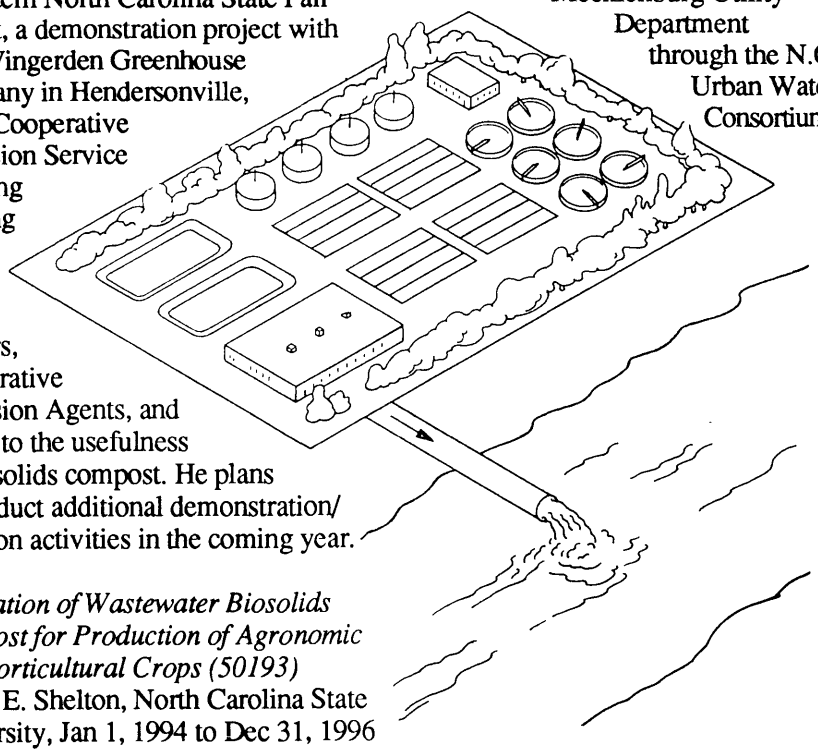
The investigators will meet with EPA scientists and staff of the N.C. Division of Environmental Management to determine appropriate sample handling, analytical techniques and expectations for measurement of these trace contaminants. They will then develop an analytical protocol to identify key issues and possible sources of error in measuring trace contaminants in wastewaters and propose an approach for resolving these issues. Once the protocol is adopted, the investigators will apply it to samples from each participating utility. The final phase of the project will involve analysis of influent and effluent samples and samples from elsewhere in the treatment plant in an effort to identify potential sources of mercury, cadmium and cyanide.

Assessment of Trace Element Concentrations in Municipal Wastewater Treatment Plant Discharges in North Carolina (50210)
Philip C. Singer and Howard S. Wienberg, University of North Carolina at Chapel Hill
Sept 1, 1995 to Feb 28, 1997
Funded by the N.C. Urban Water Consortium

CONTINUING RESEARCH

NCSU scientist continues evaluation of uses of "biosolids" compost

In a project begun in 1994, James E. Shelton of the NCSU Soil Science Department continues to evaluate the potential for use of compost made with wastewater "biosolids" for growing agronomic and horticultural crops. In previous research Shelton has evaluated the use of biosolids compost produced by the Charlotte-Mecklenburg Utility Department (CMUD) for sod production and for the production of dwarf nandina. Currently, Shelton is using CMUD compost to grow burley tobacco, a sensitive indicator species, to determine the bioavailability of heavy metals in the compost. He is also continuing to experiment with the use of biosolids compost to grow greenhouse and nursery crops, currently focusing on the production of potted tomatoes. The purpose of the greenhouse/nursery studies is to determine the concentration of wastewater biosolids compost that can be used in potting media. In the past year, the investigator organized a Western North Carolina State Fair exhibit, a demonstration project with Van Wingerden Greenhouse Company in Hendersonville, and a Cooperative Extension Service planning meeting to introduce farmers, Cooperative Extension Agents, and others to the usefulness of biosolids compost. He plans to conduct additional demonstration/eduction activities in the coming year.



Evaluation of Wastewater Biosolids Compost for Production of Agronomic and Horticultural Crops (50193)
James E. Shelton, North Carolina State University, Jan 1, 1994 to Dec 31, 1996
Funded by the Charlotte-Mecklenburg Utility Department through the N.C. Urban Water Consortium

CONTINUING RESEARCH

NCSU researchers compare stormwater cleansing ability of pond and pond-wetland system

In a project launched in January 1993, NCSU investigators are continuing to collect data to compare the pollutant removing effectiveness of a wet detention pond (on Davis Drive) and a combined pond-wetland system (on Piedmont Parkway) in High Point's City Lake watershed and to predict pollutant removal efficiencies of ponds and pond-wetland systems.

Since 1993, inflow and outflow from 15 storms have been analyzed at the Davis Pond, and sampling at this site have been terminated. Since 1994, inflow and outflow from 11 storms has been analyzed at the Piedmont pond-wetland system. Investigators are using contaminant concentrations and flow data to determine pollutant loads and removal efficiencies for each structure on an event basis, a monthly basis, a seasonal basis, and an annual basis. Tracer tests, sediment analyses, nutrient analyses, temperature/DO profiles, and pesticide analyses are providing information on the processes controlling pollutant removal in the structures.

Investigators have completed calibration of the MINLAKE (Minnesota Lake Water Quality Management Model) model for the Davis Pond and are performing sensitivity analysis. They will examine methods of optimizing pond performance by varying different parameters. Sampling at the Piedmont pond-wetland system continues, and grab sampling of Piedmont tributaries will be done to determine the variance between monitored and unmonitored inflow parameters. MINLAKE will be calibrated to estimate the pollutant removal efficiency of this system as well.

Evaluation of Ponds and Wetlands for Protection of Public Water Supplies (50184)
Sarah L. Liehr and Robert C. Borden, North Carolina State University
Jan 1, 1993 to Jan 31, 1996
Funded by WRRI, the Urban Water Consortium, and the City of High Point

NEW RESEARCH

NCSU engineers expand investigation of effectiveness of stormwater structures to different configurations, different land uses

For the last two years, Robert Borden and Sarah Liehr of the NCSU Department of Civil Engineering have been examining the pollutant removal efficiency of two stormwater detention ponds in the City of High Point's water supply watershed. One structure, a detention pond, drains 1,258 acres of farmland and woodland. The other structure, a pond-wetland system, drains 1,220 acres that includes a petroleum tank farm, industrial acreage and open space.

The investigators have found that the pollutant removal efficiencies of the ponds are quite different and believe the difference is related to concentration of pollutants in runoff and timing of runoff. The information they have collected and the pollutant removal models they are developing for these two ponds will be useful for evaluating the water quality benefits of stormwater ponds. However, it will be difficult to evaluate the effectiveness of stormwater ponds in areas where land use is substantially different from the areas currently being studied or of stormwater structures with different physical configurations.

In this project, the researchers will collect data from three new ponds the City of High Point is building: Regency, a shallow pond/wetland system receiving runoff from a 4,000 acre developing watershed; Mall A, a pond receiving runoff from a heavily developed 800 acre watershed; and Mall B, a medium size pond receiving runoff from a 150-acre shopping mall. They will monitor the mall ponds for 15 months and the pond/wetland for 18 months. They will use monitoring results to calculate the overall removal efficiency of each structure and evaluate the relative performance of the different control devices. They will also calibrate the lake water quality model, MINLAKE to each structure, perform continuous simulations for the monitoring period, and use simulation results to estimate seasonal and long-term treatment efficiencies for each structure.

Evaluation of Ponds and Wetlands for the Protection of Public Water Supplies Continuation (50211)
Robert C. Borden and Sarah K. Liehr
North Carolina State University
Jan 1, 1996 to Dec 31, 1997
Funded by the N.C. Urban Water Consortium and the City of High Point

CONTINUING RESEARCH

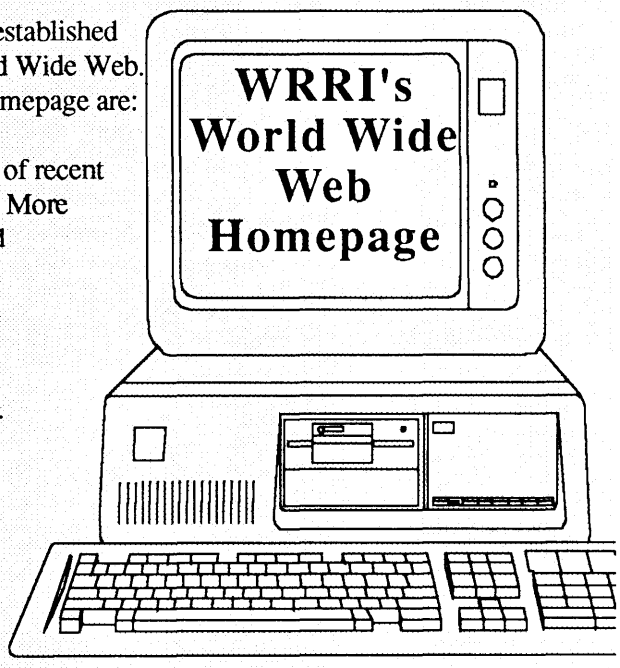
Project investigates potential for pesticides in water supplies

In this project, Robert E. Holman of WRRI is investigating the potential amount, type, and source of pesticides detected in water supply watersheds for Durham, Greenville and Orange Water and Sewer Authority. Agricultural cropland and the type and amount of crops grown in the watersheds have been determined from Department of Agriculture records. The type and amount of pesticide used on particular crops have been determined. Boundaries and hydrology for each watershed have been digitized for use in a Geographic Information System. Estimates of pesticide loading for each watershed have been determined. In the second phase of this study, sampling for 11 pesticides is being conducted for one year. The sampling sites have been expanded to include the water intakes of Burlington, Charlotte, High Point, Raleigh and Winston-Salem. This study phase is to determine the relationship between the estimated pesticide loading versus actual sampling results.

Evaluation of Pesticides in Three Water Supply Watersheds (50189)
Robert E. Holman, Water Resources Research Institute of The University of North Carolina
Nov 1, 1992 to June 30, 1996
Funded by the N.C. Urban Water Consortium

URL=http://www2.ncsu.edu/ncsu/CIL/WRRI

During 1994-95, WRRI established a homepage on the World Wide Web. Available through our homepage are:



- Summaries of a number of recent WRRI technical reports. More summaries will be added as time allows.
- The *WRRI NEWS*
- Some WRRI fact sheets. Other will be added.
- The 1995-96 WRRI Annual Program
- Links to homepages of other state water institutes, federal and state agencies dealing with water resources, and the Universities Water Information Network (UWIN).

In time, we hope to also make available our water resources expertise directory and our listing of water resources research projects being conducted throughout the University of North Carolina system.

Eventually, we expect all these documents will be searchable by keyword.

Student Intern Program

WRRI has undertaken four intern projects with state and federal agencies.

The first effort is sponsored by the N.C. Office of Waste Reduction. Three interns are supported through this project, and the students work by assisting the staff during on-site audits and preparing reports on the methods of pollution prevention employed by different industries. All graduating interns in this project have gained employment with government or industry in the pollution prevention sector.

The second effort is sponsored by the N.C. Division of Land Resources, Land Quality Section. One intern is supported through this project, and the student works directly with the staff education specialist and provides presentations to schools and the regulated community. The individual also helps to develop new materials to support the educational focus of the Land Quality section.

The third effort is sponsored by the National Oceanic and Atmospheric Administration. NOAA's Marine Fisheries Center in Beaufort, NC, is supporting three minority intern students during the summer. These interns work directly with the research staff on projects of mutual interest that involves the development of both field and laboratory experience.

The last effort is sponsored by the U.S. Geological Survey. The USGS District Office in Raleigh is supporting two intern students during the summer. These interns work with the research staff on stormwater and geochemistry projects in the Raleigh and Charlotte offices.

TECHNOLOGY TRANSFER

WRRI disseminates information and promotes adoption of new technology and practices through publication of newsletters and technical completion reports on its projects and through sponsorship and co-sponsorship of conferences, workshops and seminars. Technology transfer activities carried out during 1994-95 are reported on these pages.

WRRI TECHNICAL REPORTS

In 1994-95, WRRI published 15 peer-reviewed technical completion reports:

WRRI-281 *Treatability Assessment of Jordan Lake*
WRRI-282 *Assessment of Municipal Sludge Management Practices in North Carolina*
WRRI-283 *Prediction of Pollutant Movement from Poorly Drained Soils*
WRRI-284 *Effects of Urbanization and Land Use Changes on Low Streamflow*
WRRI-285 *Movement and Dissipation of Toxicants and Water in Natural Soil Environments*
WRRI-286 *Reduction in Sediment and Chemical Load from Agricultural Field Runoff by Vegetative Filter Strips*
WRRI-287 *Anaerobic iodegradation of Hazardous Organics in Groundwater Down Gradient of a Sanitary Landfill*
WRRI-288 *An Improved Viral Indicator of Fecal Contamination and Treatment Process Efficiency to Meet New EPA Drinking Water Regulations*
WRRI-289 *Wetland Restoration and Creation: Development of a Handbook Covering Six Coastal Wetland Types*
WRRI-290 *An Experimental Investigation of Hot Water and Cosolvent Flushing for Remediation of NAPL-Contaminated Aquifers*
WRRI-291 *Nitrogen Loading Sources and Eutrophication of the Neuse River Estuary, North Carolina: Direct and Indirect Roles of Atmospheric Deposition*
WRRI-292 *Feasibility of Wastewater Reuse at the National Spinning Company, Inc. in Washington, North Carolina*
WRRI-293 *Improvement of the Nanofiltration Membrane Process by Addition of Powdered Activated Carbon for Enhanced Removal of Precursors to Disinfection Byproducts in Small Water Utilities*
SRS-15 *Groundwater Geochemistry of the Castle Hayne Aquifer in the Region of Capacity Use Area No. 1, Northeastern North Carolina*
SRS-16 *Use of Lime-Treated Wastewater Sludge-Soil Mixtures for Daily Cover in Solid Waste Landfills*

WRRI reports are distributed to libraries, and synopses of reports are published in the WRRI newsletter and distributed to interested research faculty, other state water institutes, and relevant government agencies.

Single copies of WRRI reports are made available free to federal/state water resource agencies, state water resources research institutes, and other water research institutions with which exchange agreements have been made.

Single copies of publications are available to North Carolina residents at a cost of $4 per copy prepaid ($6 per copy if billed) and to nonresidents at a cost of $8 per copy prepaid ($10 per copy if billed). Send requests to WRRI, Box 7912, North Carolina State University, Raleigh, NC 27695-7912 or call (919) 515-2815.

An updated listing of all WRRI publications, including technical reports, is published annually and may be obtained by calling the Institute office.

NEWSLETTERS

WRRI publishes two newsletters. The *WRRI NEWS* is published every other month and sent to nearly 3200 federal and state agencies, university personnel, multi-county planning regions, city and local officials, environmental groups, consultants, businesses and individuals. The *NEWS* regularly covers a wide range of water-related topics from current federal and state legislation and regulatory activities to new research findings and listings of water-related publications.

The WRRI NEWS is available free of charge to residents of North Carolina. To be added to the mailing list, call or write WRRI.

Email subscriptions to the WRRI NEWS are also available to anyone with an Internet address. To subscribe, send an Email message to: listserv@ncsu.edu. In the message say: subscribe WRRI-NEWS your full name.

An electronic version of the newsletter is also accessible on WRRI's World Wide Web homepage: URL=http://www2.ncsu.edu/ncsu/CIL/WRRI

The *Urban Water Consortium News* is published annually and distributed to members of the Urban Water Consortium who use the newsletter to keep their constituencies (city councils, county commissions, etc.) informed about the activities of the consortium and about water-related issues affecting municipalities. The newsletter carries descriptions of research funded through the consortium as well as news about water-related projects undertaken independently by members, and state and federal programs and legislation.

The Institute also produces a newsletter, *Sediments*, for the N.C. Sedimentation Control Commission to provide information and assistance to the regulated community and to facilitate communication among personnel of state and local erosion and sediment control programs. This newsletter is free. To be added to the mailing list contact WRRI or Toby Vinson in the N.C. Land Quality Section at (919) 733-4574.

Workshops and Conferences

During 1994-95, WRRI sponsored, helped plan and executed two conferences, 2 workshops and 3 forums.

Environmental Impact Prediction Conference. In October, WRRI, the N.C. Supercomputing Center, Cray Research Inc., the U.S. Environmental Protection Agency and the National Institute for Environmental Health Sciences presented a two-day conference on utilizing computer models to help predict environmental impact. Approximately 175 people attended.

Water Reuse: The Next Step Forum. In November, WRRI and the N.C. Water Resources Association conducted a forum on water reuse. Forty-nine people attended.

Composting in the Carolinas Conference. In January, WRRI, the N.C. Department of Environment, Health, and Natural Resources, North Carolina State University, the S.C. Department of Health and Environmental Control, and Clemson University conducted a three-day conference on composting in North Carolina and South Carolina. The focus was on issues associated with composting of municipal solid waste, yard wastes, biosolids and other organic wastes. About 180 attended.

Erosion and Sediment Control Workshop for Local Programs. In January, WRRI, the N.C. Sedimentation Control Commission and the N.C. Land Quality Section presented a two-day workshop to allow local programs to get together and exchange ideas and practices utilized at the local level. Seventy-eight attended.

Water Quality Trends: NAWQA Perspective Forum. In February, WRRI and the N.C. Water Resources Association presented a forum on the U.S. Geological Survey's National Water Quality Assessment (NAWQA) program. Forty-two attended.

Stormwater Management Opportunities for Small Communities Workshop. In April, WRRI, Land-of-Sky Council of Governments, and the N.C. Division of Environmental management conducted a stormwater conference to provide up-to-date information on stormwater management in North Carolina and assist local government officials in developing comprehensive stormwater management programs. About 55 people attended.

N.C. Wetlands Task Force: Overview and Perspectives Forum. In May, WRRI and the N.C. Water Resources Association presented a forum on the results of a task force appointed by Secretary Jonathan Howes of the N.C. Department of Environment, Health, and Natural Resources to evaluate current regulations in North Carolina affecting wetlands. Sixty-two attended.

Water Resources Research Seminar Series

Each year a number of research faculty engaged in projects funded by WRRI present a seminar on their work. This year about 200 university faculty and students and personnel of federal, state, and local agencies attended nine seminars presented by the following investigators:

Mark D. Sobsey, Department of Environmental Sciences and Engineering, UNC-Chapel Hill, *Viral Indicators of Fecal Contamination in Surface Waters*

Aziz Amoozegar, Department of Soil Science, NCSU, *Aerobic Pretreatment for On-Site Wastewater Disposal*

Donald E. Francisco, Department of Environmental Sciences and Engineering, UNC-Chapel Hill, *Evaluation of Test Animals for Toxicity Testing*

R. Wayne Skaggs, Department of Biological and Agricultural Engineering, NCSU, *Assessing Wetland Hydrologic Status*

Richard T. Di Giulio, School of the Environment, Duke University, *Biomarkers for Pulp and Paper Mill Effluent Exposure*

Fred R. Cox, Department of Soil Science, NCSU, *Lime-Plus as an Agricultural Liming Agent*

Mike Mallin, Department of Biological Science, UNC-Wilmington, *Nutrient Limits in the Cape Fear Estuary*

Carlyle Franklin, Department of Forestry, NCSU, *Nitrogen Cycling in Forest Filter Zones*

Stratford Kay, Department of Crop Science, NCSU, *Short-term Summer Drawdown as a Possible Tool for Management of Monoecious Hydrilla*