

N.C. native will lead WRRI

by Jeri Gray

Susan N. White grew up in Orange County, NC, received a BS in biology from Duke University and did graduate work there, including a year as a research assistant in the Duke Wetlands Center and two years as a teaching assistant and education assessment consultant.

After receiving a PhD from the University of Georgia, she began building a career in ecosystem research management and leadership, never straying too far from home. Her first station was in Silver Spring, MD, as federal program officer for NOAA's Estuarine Research Division. She then moved to Charleston, SC—first as Deputy Director and later as Director and Supervisory Ecologist of NOAA's Hollings Marine Laboratory and Center of Excellence in Oceans and Human Health.

Now, White is returning to the Research Triangle area as Executive Director of North Carolina Sea Grant and the Water Resources Research Institute—both inter-institutional research and outreach programs of The University of North Carolina system headquartered at N.C. State University. She will begin her official duties when current director, Michael P. Voiland, retires at the end of 2012.

In announcing White's selection to lead Sea Grant and WRRI, Terri L. Lomax—NCSU Vice Chancellor for Research, Innovation and Economic Development—emphasized White's strong science background and leadership in working with a mix of partners and stakeholders.

"She will be a great leader for Sea Grant and WRRI programs here that have strong traditions of assisting and guiding communities, businesses, organizations

and the public," Lomax said. Sea Grant focuses on the ecosystems and economies of the coastal region, while WRRI supports research and technology transfer in areas related to freshwater ecosystems.

At the Hollings Lab, White worked in a unique partnership with the College of Charleston, Medical University of South Carolina, South Carolina Department of Natural Resources, and the National Institute of Standards and Technology to bring basic, applied, and medical researchers together to work collaboratively on factors that affect the health of coastal waters and humans who live in or visit the coastal zone. She provided leadership for a multi-disciplinary research program involving 85 PhD scientists and a total staff of 130, including students; administered a NOAA budget of \$4.5 million and extramural funds of \$1.5-2 million; worked with a science board and executive board for overarching science and policy direction; and sought research opportunities to support the mission of NOAA and its stakeholders.



Among White's science and policy interests is watershed approaches (mountain to sea) to environmental management issues and the integration of science into the development and practice of policy and management.

"I am excited to have this opportunity to work with the excellent teams associated with North Carolina Sea Grant and WRRI to continue to address the current and future critical coastal, ocean, and water resource issues in the state and within the region," she said.

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N.C. Division of Water Quality has “roadmap” for developing Nutrient Criteria Development Plan

At the November 8, 2012, meeting of the N.C. Environmental Management Commission, Dianne Reid of the Division of Water Quality (DWQ) presented an update on plans to develop nutrient criteria to satisfy EPA's insistence that the state adopt new nutrient standards.

DWQ and the EMC convened a nutrient forum in May to explore scientific and policy issues related to nutrient standards. As a next step, Reid said that DWQ will hold three meetings to get public input. The meetings are scheduled for Dec 4 in Raleigh; Dec 12 in Huntersville, and Dec 17 in Wilmington. [For additional information go to <http://portal.ncdenr.org/web/wq/ps/mtu/nutrientcriteria>]

Following the public meetings, DWQ staff will begin working on a Nutrient Criteria Development Plan, with the goal of having a draft by February 2013, presenting the draft to the Water Quality Committee in March, presenting it to the full EMC in May, then submitting the plan to EPA in June. Reid said that the aggressive timeline for proposing a plan to develop new nutrient criteria is being driven by EPA's grant process.

Reid told the commissioners that they should think of the Nutrient Criteria Development Plan as a series of prioritized projects that would address directives resulting from the Nutrient Forum. She said that DWQ staff have some ideas about nutrient criteria, but “nothing set in stone.”

Funding shortfall is focus of N.C. Water Resources Congress

“Things will just continue to get worse,” said Jim Medlock, Chief of the Programs Management Branch of the Corps of Engineers' Wilmington District.

“North Carolina is going to have to look after itself,” said Tom Reeder, Director of the N.C. Division of Water Resources.

Speaking at the annual meeting of the N.C. Water Resources Congress in November, both were referring to the disappearance of federal funding for beach nourishment and dwindling federal funding for inlet dredging and other local water resources projects.

Reeder said State budget makers were not generous with funding for water resources projects either.

“This was the first year that some

federally funded projects were not matched by state funds,” he said. The 2012 state budget appropriated \$3.5 million in carry forward funds to support shallow draft dredging under a Memorandum of Agreement with the Corps but appropriated funds for beach nourishment only for Carolina Beach.

Under directives from the General Assembly in S.L. 2012-190, the N.C. Wildlife Resources Commission and N.C. Division of Marine Fisheries conducted a study of funding options for inlet dredging and made recommendations in a recent report that focuses on funding dredging through inlet user fees. The report



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WRRI

NC State University, Box 7912,
Raleigh, NC 27695-7912
water_resources@ncsu.edu
<http://www.ncsu.edu/wrri/>

WRRI STAFF

Michael Voiland

Director
919-515-2455

David Genereux

Associate Director for Research
919-515-6017

Mary Beth Barrow

Business Officer
919-513-1152

Nicole Saladin Wilkinson

Coordinator for Research and Outreach
919-513-1216

Wendy Cox

Accounting Technician
919-513-7321

Anna Arnold

Communications and
Program Coordinator
919-513-1203

Nancy Simpson

Workshop Assistant
919-515-2815

Jeri Gray

Newsletter Editor
919-513-2772

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EMC accepts request for Declaratory Ruling on groundwater rules governing coal ash ponds

At its November 8 meeting, the N.C. Environmental Management Commission granted a request from several environmental groups to issue a ruling as to whether the N.C. Division of Water Quality is correctly applying rules governing clean up of contamination at coal ash ponds. Cape Fear River Watch, Sierra Club, Waterkeeper Alliance and Western North Carolina Alliance represented by the Southern Environmental Law Center, filed a Request for a Declaratory Ruling asking that the EMC clarify its groundwater rules by making the following rulings:

- Operators of coal ash lagoons with NPDES permits first issued before Dec 30, 1983, must take corrective action when their activity results in violation of groundwater quality standards, whether or not the standards have been exceeded at or beyond a compliance boundary.
- Operators of coal ash lagoons permitted before 1984 must take immediate action to eliminate sources of groundwater contamination in advance of implementation of a clean up plan.
- Operators of closed and inactive coal ash lagoons must implement corrective action as unpermitted activities when they cause groundwater contamination.

The petitioners argued that rule changes made by the EMC in 1992 categorizes pre-1984 coal ash lagoons as “deemed unpermitted” and that closed, inactive coal ash ponds are unpermitted because they have relinquished their NPDES permits. The petitioners interpret the groundwater rules as requiring unpermitted facilities to take immediate action to eliminate the source of contamination when it is found and then prepare a long-term cleanup plan.

The N.C. Department of Environment and Natural Resources and intervenors Duke Energy and Progress Energy Carolinas contend that the petitioners are “cherry picking” groundwater rule provisions to

support their interpretation and that DWQ has been correctly applying the rules. The N.C. League of Municipalities, N.C. Chamber of Commerce, City of Raleigh, Manufacturing and Chemical Industry Institute, N.C. Farm Bureau, and N.C. Pork Council submitted memos in support of the intervenors. All contended that the groundwater rules in question apply not just to coal ash lagoons but to many other facilities, including land application sites, and would require costly remedial action at many pre-1984 facilities.

At a call meeting on December 3, the EMC issued a ruling that staff of DENR has been correctly applying the groundwater rules by recognizing compliance boundaries at pre-1984 lagoons. Related documents are on the EMC website at <http://portal.ncdenr.org/web/emc/december-3-2012>.

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says that although it is practically impossible to determine inlet users from currently available information, users can be narrowed into a general population. It identifies several possible sources of revenue for inlet dredging and maintenance: removing the cap on sales and use tax on boats; removing the registration renewal exemption for commercial vessels; instituting a graduated boat registration fee based on vessel length; increasing fees for coastal recreational fishing licenses and for commercial licenses, permits and vessel registrations; and repealing the law allowing boaters to claim a refund for highway-use taxes. Revenue from these sources would be devoted to the Division of Water Resources Capital Fund and used to match local funds.

The report recommends creating navigation and nourishment districts to maintain navigation channels within their boundaries and suggests districts could use property assessments to assist in funding recurring maintenance.

Presumably, the General Assembly will consider recommendations in the report during the upcoming regular session of the 2013-2014 biennium, which convenes on January 30.

Beach nourishment, however, does not seem to have the attention of lawmakers, and local governments are considering a range of revenue sources for beach nourishment including higher occupancy taxes, property taxes and meals/sales taxes.

Funding for inland water resources projects is also sliding. David Williams, Deputy Director of the N.C. Division of Soil and Water Conservation said that federal funding for recovery from declared emergencies can no longer be used for removing debris from streams. That meant that when a massive log jam occurred on the French Broad River in Transylvania County, Williams had to turn to the Division of Water Resources for funding to help clear the obstruction, and that Transylvania County had to contribute to the effort.

Williams also said that there is no funding to address the significant numbers of old dams built under the federal small watershed program that are in extreme disrepair. He said that some of these are “high hazard” dams that present a threat to public safety. Many of the dams are actually owned by counties, cities, or local conservation districts, which, by and large, do not realize they are liable for them.

N.C. Supreme Court hears arguments in L&S Water Power *et al.* v. Piedmont Triad Regional Water Authority

On October 16, 2012, Attorney Scott Hale for L & S Water Power and other hydropower producers on the Deep River and Attorney Robert Brinson for the Piedmont Triad Regional Water Authority (PTRWA) presented oral arguments before the N.C. Supreme Court in a case that has broad implications for water law in North Carolina.

Background

PTRWA was organized by Randolph County and the municipalities of Greensboro, High Point, Jamestown, Archdale and Randleman to develop a public water supply for the six local governments. In 1992, the N.C. Environmental Management Commission (EMC) authorized PTRWA to use the power of eminent domain to condemn land to build the Randleman Dam and Reservoir and granted the Authority an Interbasin Transfer certificate to transfer up to 30.5 million gallons of water per day from the Deep River Basin to the Haw and Yadkin River Basins.

In 2008, as the reservoir was filling, a group of hydroelectric producers on the Deep River filed a complaint of inverse condemnation and asserted that PTRWA had taken their riparian rights by permanently decreasing flow in the river. The case was heard in Guilford County Superior Court, and in October 2009 the trial court handed down a decision agreeing with the hydroelectric producers.

In April 2011, the N.C. Court of Appeals upheld the Superior Court ruling that the PTRWA owes five downstream hydroelectric producers compensation for their loss of generating capacity because, by constructing the Randleman Dam, it perma-

nently reduced the flow of the Deep River. The Appeals Court decision was based on its interpretation of the riparian rights doctrine and application of the takings clause of the Fifth Amendment. PTRWA petitioned the N.C. Supreme Court for review, and in April of this year, the Court granted the petition.

Supreme Court review

Review by the Supreme Court is to determine if there are errors of law in the decision of the lower courts. Among the questions that the Justices of the Supreme Court are being asked to decide are:

- Did the trial court err in applying the common law of riparian rights unmodified by the EMC's IBT certificate and the "Impoundment Statute"?

Common law riparian rights includes a reasonable use principle that says that a riparian owner is entitled to the natural flow of a stream undiminished "except as may be caused by the reasonable use of water by other riparian owners." The "Impoundment Statute" (N. C. General Statutes § 143-215.44) provides that those who pay to construct a water impoundment have a right of withdrawal of excess volume of water attributable to the impoundment. The EMC certificate provided PTRWA with the right of eminent domain, which allowed it to condemn private property to build the Randleman Dam and impound the Deep River. PTRWA argues that the Impoundment Law modifies the common law of riparian rights by granting a superior interest in impounded water to a lawful impounder over other interests in the water.

The trial court ruled that riparian rights are vested property rights and that nothing in the impoundment statute or the EMC certificate relieves PTRWA of the obligation to pay just compensation for taking of the hydropower producers' riparian rights.

- Did the trial court err in finding no administrative remedies had to be exhausted?

PTRWA argues that the hydropower producers failed to pursue their objection to the minimum flow measure established by the EMC during the certificate proceedings or to challenge the permit and so failed to exhaust the administrative remedy provided by that proceeding.

The trial court said that the hydropower producers are not challenging the EMC certificate, but asking for just compensation for the taking of their riparian rights. In addition, the hydropower producers argue that the EMC's final environmental impact statement instructs that riparian rights are common law property rights, and if downstream owners think they have been damaged by the Randleman Dam project then they should resolve the conflict through negotiation or litigation with the PTRWA.

- Did the trial court err in finding that a reduction in the flow of a river is a "taking" of a compensable property right in a constitutional sense?

The Takings Clause of the Fifth Amendment to the U.S. Constitution provides that when a government uses its power to take private property for a public use, it must pay "just

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compensation” to the property owner. PTRWA argues that while the riparian owners have the right to use water, they do not own the water and, therefore, do not have private property rights in the flow of the water.

Friend of the Court briefs contemplate consequences

Friend of the Court briefs supporting the PTRWA were filed by the City of Salisbury, the N.C. League of Municipalities, Progress Energy Carolinas and the N.C. Electric Membership Corp., and the Water and Sewer Authority of Cabarrus County.

The brief by the City of Salisbury, written by V. Randall Tinsley, says the lower courts decided that the reasonable use rule does not apply in condemnation proceedings by erroneously applying drainage law [interference with surface water] to a water use dispute and adopted a new rule – “municipal liability for reduction of stream flow regardless of reasonableness.”

Says the brief, “There is no justification for disrupting the long-established system of riparian rights in this manner. Finally, there is no justification to disfavor municipal water supply and impose a new, unprecedented economic burden on North Carolinians who would pay higher water rates to provide undeserved payments to downstream riparian landowners.

“If allowed to stand the decision would change the law of water rights in North Carolina and, in the process, upset the settled expectations of local governments (and their citizens) regarding water allocation and water use in this State.”

The brief by Len S. Anthony for Progress Energy Carolinas and N.C. Electric Membership Corp. anticipates that if the Court of Appeals decision stands it will “result in great

uncertainty regarding the rights and responsibilities of PEC in operation of its lawful impoundments.

“This decision, if allowed to stand, would permit potential Plaintiffs to bide their time during EMC’s review of the project only to re-open issues decided in the hearing in subsequent litigation. The harm in such an outcome is in allowing potential Plaintiffs to attack these projects when they become operational, after a tremendous outlay of public and private funds.”

The League of Municipalities brief written by Kimberly S. Hibbard asserts, “The outcome of this case could have serious and direct fiscal impacts on municipalities. These anticipated impacts are made more acute by the forecast that North Carolina’s population will grow by as much as fifty percent by the year 2030, with much of the growth forecast for the piedmont where natural water supplies are stressed by the current demands . . . and the most viable means to provide the required water supplies is to expand the current number of reservoirs.”

After reviewing extensive North Carolina legislation modifying common law riparian rights, the brief concludes, “Collectively these statutes demonstrate that the General Assembly believed it was vested with substantial authority to control the flow of waters of the State as required by the public’s interest in those waters. It is respectfully submitted that had the General Assembly believed the riparian rights were as extensive as found . . . such laws would never have been passed.”

Questions from the Justices

During oral arguments on October 16, most of the questions from the Justices centered on the role of the EMC

in granting eminent domain.

Justice Martin asked if the EMC’s authority is more related to the environmental impact of a project than to the legal aspects. Mr. Brinson replied that the EMC’s role is both environmental and legal since the General Assembly delegated an area of authority to the EMC.

Justice Newby wanted to know if the EMC has the authority to order compensation. Mr. Brinson responded “Probably not, but there would first have to be a taking determination.”

Justice Jackson asked why the hydropower producers didn’t exhaust the administrative remedy. Mr. Hale replied that there is no administrative remedy in the EMC’s certificate process for compensation for a taking.

Justice Newby asked if other downstream riparian owners could have a complaint in the case. Mr. Hale replied that the time for raising complaints has expired so no other riparian owners can now come forward. Mr. Brinson commented that PTRWA is not now taking all the water it has been authorized to withdraw, presumably raising a question as to whether future increases in water withdrawal could restart the clock for complaints from downstream riparian owners.

It could be six months or more before the Supreme Court issues a decision. If the Supreme Court upholds the lower courts, a jury will be asked to decide the amount of compensation based on the reduction in generating capability. The hydropower producers have asked for \$5 million and could also receive up to \$1 million in attorney and expert witness fees.

Inside the EMC and SCC

Dr. David Moreau served as chairman of the N.C. Environmental Management for 16 years, longer than any other chairman. In July 2012, upon completion of his final term on the EMC, the commission and the Department of Environment and Natural Resources honored him with creation of the Dr. David H. Moreau Environmental Stewardship Award to be “conferred annually by the Secretary of the N.C. Department of Environment and Natural Resources to honor outstanding contributions and excellence in the protection and conservation of North Carolina’s water, air, and land resources in service to the people of North Carolina.” Dr. Moreau was the first recipient of the award. That same month he sat down with Bill Holman of Duke University and Richard Whisnant of the UNC Institute of Government to talk candidly about his most memorable experiences on the EMC. Here are some excerpts from that interview.

Bill: Your service on the commission was historic, and the commission got a lot of things done when you were chair. We want to capture some of that, but I got this tip on interviewing from Jack Betts—“Just get him to tell some stories.” So, do you have some stories about serving on the Environmental Management Commission?

Moreau: I have some choice memories of civil penalty remissions. One of the ones I remember best is about this woman from Ashe County we had fined \$10,000. She was 85 and probably weighed 85 pounds and her husband had been dead for ten years. We had fined her about \$10,000 for four underground storage tanks that were still in the ground that were supposed to have been removed.

Well, we’re sitting up there in all

our majesty around the big table peering down on this woman. She dissolved into tears 30 seconds into her presentation, and I’m sitting there thinking, “How the hell do we get out of this.”

About that time, this guy unfurled himself next to her. He was at least 6’ 5” and weighed at least 275 and he proceeds to say, “I am the sheriff of Ashe County, and I brought this good woman down here, and I want to make you a deal. Me and the boys will get those tanks out of the ground if you will reduce this woman’s fine.” We stood up and said, “Yes sir!”

That was one of the great moments of the civil penalties remission committee. We’ve streamlined this process now. We discovered that we didn’t have to listen to every case. And, so we developed this procedure to screen the cases to see which ones we wanted to hear oral presentations on. We had to act on every one of them but we did not have to hear oral presentations on all of them, and those things could go on for four hours. It was awful until you got one or two cases that you could tell stories about.

Another one I remember was about a \$20,000 fine we had put on some community in Moore County for wastewater spills during the big pre-Christmas freeze when there was snow and the power failed and the pump stations went out and the only thing the town could do [with sewage] was dump it. I was trying to be very sympathetic with these people. I thought there were pretty extreme conditions.

Well, one of the members of the EMC at that time was a dairy farmer from Denton. He spoke up and said, “I’ve got three hundred cows and they’ve all got sore teats, and if I don’t milk them they’re going to be hurting so I’ve got to do something even if I don’t have power. There’s no excuse

for this. They should have done something else.”

He swayed the committee and they upheld the fine. I thought it was a bit unjust, but if he was going down to the barns and hand milk his three hundred cows, the town could do something.

Bill: You reminded me recently that before you were appointed to the EMC, you spent 11 years on the Sedimentation Control Commission. Any stories about serving on that commission?

Moreau: There were some real characters on that commission. One of them was Joe Phillips, who served a long time as the appointee from the N.C. State soil science department. Joe could be outspoken. On one of our periodic fields trips, we went down to Fort Bragg during the first Gulf War to inspect a sediment problem on the jump zone. And it was a moonscape. They’d plow those drop fields eighteen inches deep and keep them plowed because if they dropped troops on those fields, they’d break their legs otherwise. And then when it rained that soil would just run right off there.

Well, we got through with that site visit and came back to debrief the general and Joe Phillips just flat chewed out the commanding general of Fort Bragg. I’m sitting there thinking, “Joe, Joe, they’re over there defending us!” It turned out that the commanding general Joe Phillips chewed out was none other than Hugh Shelton [Chairman of the Joint Chiefs of Staff from 1977 to 2001]. Maybe his N.C. State connection gave Joe license to do it, but the General was very cordial to Joe. He took it very well, and it worked. They got the problem fixed.

Are natural bacteria up to the job of remediating emerging contaminants of concern in the aquatic environment?

The entire ecosystem depends heavily on bacteria. They are the decomposers, transformers, and recyclers. As such, they are increasingly relied upon to remediate environmental pollution by hydrocarbons and other chemicals. However, new classes of contaminants, including many that are biochemically active, are being introduced into the water environment, and the ability of bacteria that inhabit aquatic ecosystems to break down and render harmless these pollutants is questionable.

Biochemically active contaminants

In 2011, 3.76 billion prescriptions for various drugs were filled in the United States—94.8 million in North Carolina alone. Because drugs are not 100 percent metabolized in the human body, some percentage of the compounds—including antibiotics, nonsteroidal anti-inflammatories, hormones, and a host of other pharmaceutically active compounds—is excreted and ends up going untreated or at best partially treated into the environment. In addition, some 70 percent of antibiotics sold in the United States is given to swine, cattle and poultry on farms where wastewater may be land applied and thereby reach groundwater and surface water.

A 2002 study by the USGS Toxic Substances Hydrology Program found human and veterinary drugs (including antibiotics and natural and synthetic hormones), plasticizers and other chemicals in 80 percent of the 139 streams sampled downstream from wastewater plants or livestock production areas in 30 states. About one-third of the streams sampled contained 10 or more of the pollutants.

Because neither wastewater

treatment systems nor conventional drinking water treatment systems are designed to remove these compounds, they can end up in drinking water in minute (parts per billion or trillion) amounts. A 2008 Associated Press study based on a review of scientific literature, government databases, interviews, and surveys of water systems in the nation's 50 largest cities and elsewhere, found that drinking water in at least 24 major metropolitan areas contained pharmaceutical residue.

While the body of research on the effects on human health of long-term exposure to minute pharmaceutical residues is sparse, some laboratory research has suggested effects at the cellular level, especially for endocrine disrupters. Perhaps the most serious potential threat to human health is the development of new antibiotic-resistant bacteria or "superbugs." There is increasing evidence that antibiotic resistance spreads from environmental sources and scientists think that higher antibiotic concentrations in aquatic environments may also increase the probability of bacteria developing resistance to drugs.

On the other hand, a growing body of research is decisively documenting the potential for ecosystem damage by biochemically active contaminants. Many studies have documented the feminizing effect of endocrine disrupting chemicals on fish. Other studies have found that non-steroidal anti-inflammatories can cause renal lesions and alteration of gills in fish. A study published in 2011 by scientists from the USGS and the University of Colorado found that low-concentration exposure to a sulfonamide antimicrobial—one of the most prevalent antimicrobial com-

pounds detected in a USGS nationwide groundwater survey—reduced the growth rate and nitrate reduction rate potential of denitrifying bacteria.

WRRR-sponsored research

Research has shown that neither conventional activated sludge nor biological nutrient removal processes followed by UV or chlorination disinfection completely removes most biochemically active contaminants. Removal efficiencies vary by treatment process and compound, in a range of around 24% to 90%.

Recently, advanced oxidation (chemical oxidation with hydroxyl radicals) has emerged as an effective method for removing or improving biodegradability of contaminants resistant to conventional wastewater treatment. The process does not transform 100 % of biochemically active contaminants to an inorganic state but produces photo-oxidation intermediates whose ecological effects and biodegradation potential are not known.

In a project funded by WRRR, Dr. Detlef R.U. Knappe and Carolina Baeza of the NCSU Department of Civil, Construction, and Environmental Engineering tested their hypothesis that treatment of biologically active contaminants by advanced oxidation produces intermediate compounds that can be mineralized faster by natural bacteria than their parent compounds can be.

To test their hypothesis, the scientists performed laboratory experiments using three biologically active contaminants (BACs): sulfadiazine—an antibiotic, bisphenol A—a plasticizer known to have endocrine disrupting effects, and diclofenac—a non-steroidal anti-inflammatory. All compounds are commonly found in wastewater treatment plant effluent.

The scientists worked with BACs labeled with carbon-14 to allow them to

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measure conversion by advanced oxidation and mineralization of photo-oxidation intermediates. They then spiked labeled BACs into ultra pure water and wastewater treatment plant effluent and treated them with a combination of ultraviolet light and hydrogen peroxide, one of several advanced oxidation processes. After advanced oxidation treatment, the researchers transferred samples to duplicate batch bioreactors. They inoculated the bioreactors with bacteria derived from Jordan Lake water and from Lake Wheeler sediment.

To provide a comparison that would allow them to measure the improvement in biodegradability due to advanced oxidation, they set up bioreactors with non-treated ¹⁴C-labeled parent compounds. For a negative control, they set up abiotic control reactors that were not inoculated and were spiked with sodium azide to inhibit biological activity. For a positive control and to assess the ability of the water and sediment bacteria to mineralize an easily biodegradable carbon source at trace levels, they set up bioreactor experiments with ¹⁴C-acetate.

All bioreactors were equipped with a NaOH trap that captured ¹⁴CO₂ produced from the mineralization of ¹⁴C-labeled photooxidation intermediates and parent compounds. ¹⁴CO₂ in NaOH traps was measured periodically for up to 65 days.

Results

The advanced oxidation step transformed 94% of the sulfadiazine, 88% of the bisphenol-A, and 99% of the diclofenac into intermediates and mineralized 27% of the diclofenac. Mineralization of the sulfadiazine and bisphenol-A was negligible.

In the bioreactors, lake water bacteria mineralized ¹⁴C-labeled oxidation intermediates extremely slowly (<1.1% for sulfadiazine, <0.8% for bisphenol-A and <0.8% for diclofenac after 30 days). Mineralization rates of the non-oxidized parent

compounds were even slower. Lake sediment bacteria biodegraded sulfadiazine and its intermediates more quickly than lake water bacteria, but mineralization rates were still slow (1.1% for the parent compound and 5.2% for the intermediates after 30 days).

The investigators say that their results show that although oxidation of antimicrobial compounds and endocrine disrupting compounds reduces the level of activity, biological mineralization of oxidation intermediates is extremely slow. This suggests that little mineralization can be accomplished by stream microorganisms between a wastewater treatment plant discharge and a downstream water treatment plant intake or an ecologically sensitive area.

For instance, they say, the travel time between the City of Raleigh wastewater treatment plant and the Neuse River estuary—a nursery for many species of fish—is 7-13 days. Assuming an average travel time of 10 days, sulfadiazine mineralization in aerobic sediments would be only about 0.5% for the parent compound and 3.5 % for oxidation intermediates. Mineralization of bisphenol-A and diclofenac or their oxidation intermediates by planktonic bacteria would be negligible.

Given their results, the scientists recommend that toxicological studies should be conducted to determine the possible effects of biologically active contaminant oxidation intermediates on aquatic life.

The report describing this study, NC-WRRRI 396: Protecting Receiving Waters: Removal of Biochemically Active Compounds from Wastewater by Sequential Photochemical and Biological Oxidation Processes by Detlef R. U. Knappe and Carolina Baeza can be downloaded at go.ncsu.edu/70234.

Scientists evaluate options for treating drinking water to remove biologically active contaminants

In the near future, public drinking water systems face the prospect of having to treat a new class of contaminants that are by-products of our lifestyle: pharmaceuticals and chemicals from personal care products that enter water sources primarily through wastewater treatment systems, including on-site septic systems. Many of these contaminants are biologically active, and although biologically active compounds (BACs) are typically present at trace levels (ng/L or parts-per-trillion range) in finished drinking water, the public is concerned about potential human health effects associated with chronic exposure.

In 2009, EPA finalized its third Contaminant Candidate List, which identifies priority contaminants for regulatory decision-making and information collection. Because of public concern and input—especially about endocrine disrupting compounds, which are designed to influence the human body in low concentrations, and antibiotics, EPA included on the final third Contaminant Candidate List ten pharmaceuticals—nine estrogenic hormones and one antibiotic. However, none of these pharmaceuticals is on the short list of contaminants being considered and evaluated for regulatory determinations, presumably because there is not sufficient information on their occurrence and health effects to allow the Agency to make a regulatory determination.

To help gather data on occurrence

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in finished drinking water and population exposure for endocrine disrupting contaminants, EPA's Third Unregulated Contaminant Monitoring rule, signed in April 2012, includes in its Screening Survey List seven hormones that all public water systems serving 100,000 or more people and representative samples of smaller systems will have to monitor for from January 2013 to December 2015.

While current public concern is highest about endocrine disrupting contaminants, other pharmaceuticals and BACs are sure to claim their place in the spotlight in the future. As EPA evaluates more and more BACs for regulatory action, it is critical for drinking water systems to evaluate their current treatment processes and explore new ones for removal of these contaminants.

WRRRI- N.C. Urban Water Consortium research

In a recently completed project Dr. Detlef R.U. Knappe of the NCSU Department of the Civil, Construction, and Environmental Engineering and Dr. Howard Weinberg of the UNC-Chapel Hill Department of Environmental Sciences and Engineering evaluated, at the bench scale, the effectiveness of drinking water treatment processes used by member utilities of the North Carolina Urban Water Consortium for removing biologically active contaminants (BACs).

The BACs they tested for treatability were bezafibrate (BZF), a lipid regulator; diclofenac, (DCF) a non-steroidal anti-inflammatory; ibuprofen (IBP), an analgesic; metoclopramide (MCP); an antiemetic; sulfamethoxazole (SMX), an antibiotic; and trimethoprim (TMP) an antibiotic.

After determining water quality characteristics of three test waters-

-two drinking water sources (OWASA's Cane Creek or Cane Creek/University Lake and raw Cape Fear River water) and effluent from the North Cary Water Reclamation Facility, they spiked solutions of the test compounds into one or more of these waters and evaluated the effectiveness of the following treatment processes for BAC removal: powdered activated carbon (PAC) adsorption, preozonation, preoxidation with potassium permanganate, and coagulation with ferric sulfate.

Tests using potassium permanganate as an oxidant quickly confirmed that potassium permanganate is not an effective broad-spectrum oxidant for the control of BACs. Tests using ferric sulfate as a coagulant showed measurable removal of only one BAC, tetracycline. Therefore, the study focused on PAC and preozonation.

PAC tests

The investigators conducted batch kinetic tests with PACs

- to compare the effectiveness of three commonly used PACs and one superfine PAC,
- to compare the adsorbability of the six test compounds,
- to determine the effect of pH on the adsorbability of pharmaceuticals, and
- to determine the effect of the background water matrix on pharmaceutical removal.

They used PAC prepared from three different base materials (wood, lignite coal, and bituminous coal) with diameters in the range of 17-25 μm (which the investigators called "as-received") and a superfine version of bituminous coal with diameter of about 0.3 μm . (To date, no information about the effectiveness of superfine PAC for BAC removal is available

in the published literature.)

PAC Results

Removal of SMX among the three "as-received" PACs was similar (~20% removal after a contact time of 60 minutes). In contrast to the results obtained with the as-received PACs, SMX removal with the superfine bituminous coal-PAC was approximately three times larger, ~60% after a contact time of 60 minutes. However, after a contact time of two weeks, the adsorption capacities of the "as received" and superfine PACs were similar. Therefore, grinding PAC into a superfine powder did not change the maximum uptake capacity for SMX, only the SMX uptake kinetics.

For TMP, there were distinct differences between the three as-received PAC types, with uptake in the order of wood PAC > bituminous coal PAC >> lignite coal PAC. As was the case with SMX, the superfine bituminous coal PAC produced greater TMP removals than any of the as-received PACs. As with SMX, the better performance of the superfine version of bituminous coal-PAC was primarily a result of improved adsorption kinetics. Thus, say the researchers, the use of superfine PAC may allow utilities to almost fully utilize the equilibrium uptake capacity of PAC, even when PAC contact times are short, as is often the case.

PAC tests with differing pH levels showed that pH affected the removal of TMP and SMX in opposite ways, with lower pH lowering the removal effectiveness for TMP but increasing the effectiveness for SMX.

To assess the effect of PAC dose on BAC removal, the investigators conducted jar tests with SMX and IBP, the two least adsorbable BACs tested in the study. SMX removal was most effectively accomplished with

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superfine bituminous coal PAC, with a dose of 20 mg/L producing 90% SMX removal. To obtain 90% SMX removal, the required dosage for “as received” PACs was 90-100 mg/L. Similar results were obtained for IBP removal. Therefore, say the investigators, 90% SMX and IBP removal is not achievable with as-received PACs at doses typically employed in drinking water treatment. In contrast, 90% SMX and IBP removal would be feasible with superfine PAC.

Tests also showed that the superfine versions of PACs enhanced adsorption rate and increased maximum adsorption capacity for natural organic matter but adversely affected turbidity removal, especially after short settling times. The results suggest that flocculant aids may be required to effectively incorporate superfine PAC into settleable floc. The timing of PAC additions relative to coagulants also affected turbidity, with removal being better when PAC was added before or together with coagulants. This suggests that to obtain the best settled-water quality in terms of BAC and turbidity removal, PAC should be added before the coagulant.

An additional jar test using 12 BACs [tetracycline, erythromycin-hydrate, carbamazepine, caffeine, DEET, atrazine, atenolol, acetaminophen, bezafibrate, sulfamethoxazole, trimethoprim and tris(2-chloroethyl)phosphate] at concentrations detected in surface waters (250 – 600 ng/L) showed that the wood-based PAC at 20 mg/L in the presence of alum removed all BACs, and removal percentages ranged from ~66% for sulfamethoxazole to >95% for trimethoprim.

Ozonation

The investigators conducted batch tests to determine if ozone is effective at oxidizing BZF, IBP, SMX, TMP, and DCF and if BAC removal can be predicted. They determined the oxidation of the five compounds experimentally at two ozone doses in each test water. At the higher ozone doses (0.6-0.9 mg O₃/mg TOC), all five compounds were completely oxidized in all waters. These results suggest that the ozonation of wastewater effluents, an important source of BACs, can effectively remove BAC parent compounds at doses (costs) that closely match those required during the preozonation of surface waters with moderate levels of TOC.

Using a model based on ozone decay rate and the ratio of hydroxyl radical to ozone concentration, the researchers predicted oxidation by ozone at various doses for 26 BACs in all three test waters. Experimental results obtained for BZF, IBP, DCF, TMP, and SMX confirmed model predictions for those five compounds. The model predicts that O₃ doses of ~1 mg O₃/mg TOC will be sufficient to achieve 99% parent compound removal for all 26 compounds except iopromide. The investigators say that ozone doses in this range are not uncommon during preozonation of North Carolina surface waters. As a result, say the investigators, utilities employing this treatment practice can expect to effectively oxidize 25 of the 26 BACs, for which they made parent compound removal predictions.

An additional experiment was conducted to assess the ability of ozone to oxidize the twelve micropollutants in OWASA source water. Ozone effectively oxidized 11 of the 12 compounds, with oxidation percentages for the 11 compounds ranging from ~79% for atrazine to >90% for the remaining 10 compounds. Ozonation was not effective for controlling the flame retardant TCEP, however.

The report for this research is available for download at go.ncsu.edu/50388.

Upcoming Events

The North Carolina Bar Association Foundation presents:

“Water A Key to Survival and Growth: Is There Enough for the Next 50 Years?”

Thursday, January 17, 2013

A live program will take place at the N.C. Bar Center in Cary. The program will be simulcast, and video replays are scheduled in March and April for Cary, Charlotte, Greensboro and Leland. The program provides 6 hours of CLE credit. A tuition discount is available for non-lawyer professionals. For additional program information and information on tuition and registration, go to: <http://www.ncbar.org/cle/programs/982ENR.aspx>

NCWRA

North Carolina
Water Resources Association

Upcoming luncheon forums:
**February 11, 2013, Clean Water
Management Trust Fund**

Download a brochure for
registration by mail at:
<http://ncsu.edu/wrri/code/events.htm>

Register online at
<http://www.ncwra.org/>

Don't miss the premier research conference focusing on North Carolina's Water Resource Issues, Solutions, and Opportunities

**The 15th WRRI
Annual Conference &
10th NCWRA Symposium**

**March 20-21, 2013
Jane S. McKimmon Center,
Raleigh, NC**

Details and Information at:
<http://go.ncsu.edu/wrriac>