Monitoring Drinking Water In North Carolina's Largest Watershed

BY CYNTHIA ADAMS

Lopez-Velandia completed her master's at North Carolina State University earlier this year. Her work caught the attention of fellow scientists and gifted students alike when she recently received third place at the Graduate Student Research Symposium for her research concerning 1,4-dioxane in the Cape Fear River watershed.

This honor was one among numerous awards Lopez-Velandia has won for research that has taken her across North Carolina's largest watershed. Her research has ascended in a field populated by talented scientists. She also won first place at the 3rd annual Latin American Student Association Research Symposium, took first place at the Environmental, Water Resources and Coastal Engineering Research Symposium and second place at the North Carolina American Water Works Association student poster contest.

The many awards affirm her seminal work with NC State professor Detlef Knappe, whose research focus will help safeguard North Carolina's drinking water. **Here's why you should know about this endeavor.**

JULIE WILLIAMS DIXON

When environmental engineer Catalina Lopez-Velandia turns on the water tap, her thoughts are on many things.

Although the water flowing from the tap may *look* just as water should, and may smell and taste as tap water normally does, it may not be as pure as it seems.

What is invisible to the eye most concerns Lopez-Velandia. However, she also knows it is nearly impossible to filter out the chemical she has been studying over the last two years—one that shouldn't be present.

Lopez-Velandia is specifically looking for an unregulated contaminant called 1,4-dioxane. The chemical is a by-product of some plastics and surfactant production processes, and it is also used as a solvent in a variety of manufacturing processes and products. It is found in waxes, paint strippers and varnishes. 1,4-Dioxane has been identified in the water supply of many North Carolina cities. It shouldn't be there.

It took a lot of tedious sample-taking before the research team understood the sheer scope of the problem.

The US Environmental Protection Agency (EPA) lists 1,4-dioxane as a likely human carcinogen. But it was largely overlooked by treatment facilities—treatment plants weren't aware of its concentration levels, primarily because they were not required to test for it. This year, the presence of the chemical was reported in the *Washington Post* a month after Lopez-Velandia defended her graduate thesis.

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For the past two years, Lopez-Velandia has been analyzing water supplies in the Cape Fear River basin for the presence of 1,4-dioxane. Her professor, Detlef Knappe, was initially tipped off by a colleague about the presence of 1,4-dioxane in North Carolina. Soon, the Knappe research group discovered that 1,4-dioxane concentrations in the drinking water of many residents in the Cape Fear Basin were higher than in most other locations in the United States. This was worrying, especially given that the basin is North Carolina's largest watershed, serving as a source of drinking water for about 1.5 million people.

Knappe wanted to know why such high 1,4-dioxane concentrations occurred. In order to do so, he had to get to the source of the contamination.

How was this solvent getting into our watershed?

"1,4-dioxane is widely used in many different applications," explains Lopez-Velandia.

JULIE WILLIAMS DIXON

"In the past, it was thought of as a ground water contaminant because it coexists with the solvent 1,1,1-trichloroethane, or TCA. TCA had ozone depletion potential so it was banned in 1995. As a result, 1,4-dioxane usage decreased."

Despite the ban of TCA, the levels of 1,4-dioxane found in the Cape Fear River Basin were high. The chemical 1,4-dioxane is a by-product in the production of plastics and surfactants, and it is also a solvent used in textile and specialty chemical production, among its many applications. It is also commonly found in detergents and personal care products, such as shampoos and cosmetics—all of which are discharged regularly into wastewater.

How long had this been a concern?

"It is hard to say," she replies by email. "But the first detection of 1,4-dioxane in water from NC was in a water sample that was collected in 1982 by Andrea Dietrich, then a student at UNC-Chapel Hill. Although 1,4-dioxane was detected, no concentration levels were reported at that time."

Contamination of the water supply by 1,4-dioxane is especially problematic because most drinking water treatment processes are not effective for 1,4-dioxane removal. Also, Lopez-Velandia showed that commercially available household filters were not effective for removing 1,4-dioxane from tap water.

Only a few years ago, Lopez-Velandia was still living in her native Colombia. Having earned two undergraduate degrees in environmental engineering and in chemical engineering from the Universidad de los Andes, she worked in a small Bogota, Colombia firm designing water treatment plants. The engineer, a small-framed woman with dark hair and warm, lively eyes, was then only 24 years of age.

She found the consulting work both useful and meaningful—two things that were important to her. Absorbed by the work, water treatment, Lopez-Velandia also grew more interested in extending her professional knowledge.

In 2013, she began investigating postgraduate studies abroad in the United States in earnest.

"While I was working, I was also searching for programs and professors with a strong water treatment emphasis. I found Dr. Knappe at NC State. I read his work and knew that was what I wanted to do."

She made contact with the professor. Knappe replied, and his response was positive. Lopez-Velandia felt confident that this was the mentor she wanted to study under; then, she began looking seriously at life in the Carolinas.

Lopez-Velandia quickly admits that she knew nothing about the culture of the

South, and nothing at all about Raleigh, North Carolina. An older sister lives in Miami with her family, yet Miami was a significant distance away from Raleigh. She began to research the Raleigh area to determine if this was an environment where she could enjoy living as well as studying. She relied largely upon what she could glean from the Internet. She noticed something specific that interested her about Raleigh. Nearby was a place named the Research Triangle Park. Lopez-Velandia dug further.

"After I researched the University, I was attracted by a small city having such a wide academic variety. I realized you had the Research Triangle Park, Durham and Chapel Hill. The Raleigh area has great academic institutions, but the advantage of a small city."

Raleigh was only small if you considered Lopez-Velandia's roots. By contrast, Bogota is a city of nine million. "It would take me two hours to drive from home to work," she adds, grimacing. As Lopez-Velandia studied the statistics of the Research Triangle area, she thought, "This sounds like a very nice place to live and work."

Her father, a lawyer, was adventurous by nature, and inspired her to be as well.

"At 16 years of age, my dad left his family to move from a small town to Bogota. He always told me, 'When you leave home, you grow. The experiences you get, those are experiences you will never forget.' He told me, 'You can do it. You will be a better person if you do.'"

She listened to her father's advice and her mind was made up—Lopez-Velandia enrolled at NC State.

A NEW FOCUS...

Meanwhile, Knappe had begun working on 1,4-dioxane, funded by National Science Foundation and North Carolina Urban Water Consortium grants. Lopez-Velandia joined Knappe's research group.

The widespread occurrence of 1,4-dioxane made it all the more challenging as a research effort. Lopez-Velandia explains that because 1,4-dioxane is commonly found in shampoos and cosmetics, it is nearly ubiquitous. In the concentrations that personal products contain, 1,4-dioxane levels in the resulting wastewater are quite low.

"But," she stresses, "What we are seeing [in the case of high levels found in NC] is a result of industrial contamination."

Lopez-Velandia explains how they approached the research of 1,4-dixoxane contamination within NC. "Our starting point was the data reported by the EPA in the Third Unregulated Contaminant Monitoring Rule. The EPA sampled different public water systems in the entire United States between 2013-15. The EPA collected 32,740 samples.

The results showed the Cape Fear Watershed as having the highest concentrations nationwide.

"We said, 'Wow.' What is making us special to have this level of contamination that is not found in surface water anywhere else? With the help of the North Carolina Department of Environmental Quality (DEQ), we located waste water treatment plant discharges and started mapping them within the Cape Fear River watershed. We sampled upstream and downstream of each wastewater discharge to identify 1,4-dioxane sources. We could quickly see a clear pattern. Some locations always showed a large increase in 1,4-dioxane concentrations and others did not."

The researchers noted variations in the point sources and streamflow. She explains there were two key factors affecting 1,4-dioxane concentrations: source variability and streamflow. Yet the concentrations of the contaminant were high—much too high.

The research work undertaken involved a full year of monthly sampling at 47 locations across the watershed, Lopez-Velandia explains. It required difficult, tedious, and methodical sampling. "There are so many variables—that is the biggest challenge," she admits. They pursued their data collection, returning to the field to take samples again and again. The repeated sampling attempted to capture different environmental conditions such as variability in stream flow.

The results were clear. Knappe's team documented identifiable hot spots associated with three municipal wastewater treatment plant discharges located in the headwaters of the Cape Fear River watershed.

Once the team identified the hotspots and the presence of 1,4-dioxane in the rivers, the team worked to identify what exactly was happening to the drinking water downstream.

The research team worked in three downstream towns, Pittsboro, Fayetteville, and Wilmington, in order to determine 1,4-dioxane levels and its fate during drinking water treatment.

"We collected daily composite samples over a period of eight weeks," she explains. Their findings showed high variability in the levels of 1,4 dioxane. "Sometimes we found 2 µg/L in Pittsboro and the next day we would see 35 µg/L." The EPA established that, if an individual were to drink 2 liters of water each day containing 1,4-dioxane at an average concentration of 0.35 µg/L over his or her entire lifetime, that person would have one-in-a-million increased chance of developing cancer as a direct result of drinking water containing this chemical.

Of the cities affected, each had unique issues. For example, Lopez-Velandia's research discovered that Pittsboro was the city most affected by 1,4-dioxane contamination. "Then, by the time you get to Wilmington the concentrations decrease, but they were never below 0.35 µg/L. 1,4-dioxane was not removed by the drinking water treatment processes in Pittsboro and Fayetteville, but, ozone treatment in Wilmington removed about two-thirds of the 1,4-dioxane levels present in the source water."

She adds, "1,4-dioxane loves water. There is no readily available treatment for it now. We have been working with the State, and DEQ is beginning to address the issue by modifying the discharge permits of the three waste water treatment plants we identified as key sources."

How safe is Cape Fear drinking water?

The Knappe research group discovered that 1,4-dioxane concentrations in the drinking water of many residents in the Cape Fear Basin were higher than in most other locations in the United States. The basin is North Carolina's largest watershed, serving as a source of drinking water for about 1.5 million people.

The EPA sampled different public water systems in the entire United States between 2013-15 for 1,4-dixoxane contamination (32,740 samples). The results showed the Cape Fear Watershed containing levels among the highest concentrations found nationwide.

JULIE WILLIAMS DIXON

Catalina Lopez-Velandia samples water from the Cape Fear Water Basin for analysis in the NC State lab overseen by Detlef Knappe. The presence of 1,4-dioxane in the drinking supply has been reported by NC media and the national press. However, tainted water related to Duke Energy's coal ash pits potentially eclipsed the issue of 1,4-dioxane.

Lopez-Velandia also studied home filtration devices to determine their effectiveness for 1,4-dioxane removal. None of the tested pitcher and refrigerator filters effectively removed 1,4-dioxane. Therefore, the NC State researchers devised a simple pitcher filter, using a tailored resin designed for 1,4-dioxane removal. The tailored home filtration device was built by opening a Brita cartridge, removing the sorbent materials and replacing them with an equal volume of carbonaceous resin designed for 1,4-dioxane removal.

She further explains.

"1,4-dioxane concentrations in drinking water derived from the CFR watershed can change rapidly. As a result, it is important to assess the performance of home filtration devices under variable 1,4-dioxane concentrations. Of particular interest is the possible release of 1,4-dioxane from the filter when a period of high 1,4-dioxane concentrations is followed by a period of low 1,4-dioxane concentrations. This assessment is less critical for drinking water derived from groundwater as groundwater concentrations of 1,4-dioxane are not expected to exhibit high temporal variability," Lopez-Velandia adds.

In short, Lopez-Velandia's research showed that the commercially available pitcher and refrigerator filters she tested "were not effective for 1,4-dioxane removal and prone to release 1,4-dioxane when influent concentrations were variable. In contrast, the custom filter exhibited an average removal of 72 percent, after treating 40 gallons of affected water, and that 1,4-dioxane release under variable influent concentrations was negligible." ■

For Further Information:

https://www.epa.gov/sites/production/files/2014-03/documents/ffrro_factsheet_contaminant_14-dioxane_january2014_final.pdf

https://www.nsf.gov/news/special_reports/science_nationcapefearwatershed.jsp

https://www.washingtonpost.com/national/health-science/in-us-drinking-water-many-chemicals-are-regulated—but-many-arent/2016/06/09/e48683bc-21b9-11e6-aa84-42391ba52c91_story.html

Catalina Lopez-Velandia: Short Take

How long is it suspected that 1,4-dioxane has been present in the NC water supply?

Lopez-Velandia: It is hard to say, but the first detection of 1,4-dioxane in water from NC was in 1982 by Andrea Dietrich, currently a professor at Virginia Tech. Although authors detected 1,4-D no concentrations were reported.

What is the end goal(s) of the research project with professor Detlef Knappe and your team?

Lopez-Velandia: His research is focused on developing and evaluating physical-chemical treatment processes for the control of emerging contaminants in drinking water and to overcome gaps between the Clean Water Act and the Safe Drinking Water Act by developing information about the effects of reactive and unregulated wastewater contaminants on drinking water quality and treatment.

FREEMAN FOTOGRAPHICS

The Cape Fear River Basin

Did you realize the **Cape Fear River Basin** is North Carolina's largest water resource serving a fourth of the state's population?

In addition to the Cape Fear, the Neuse River Basin and the Tar-Pamlico River Basins are of vital importance. According to the Clean Water Education Partnership, the Outer Banks of North Carolina is among few remaining natural coastal barrier island systems in the world.

1. The Cape Fear River Basin has 6,049 miles of streams and rivers and is North Carolina's largest river basin.

2. The Cape Fear River Basin covers 9,322 square miles, and it begins and ends in North Carolina. It contains 25 percent of North Carolina's total population.

3. The Cape Fear River is the only river in North Carolina that flows directly into the ocean.

4. The Cape Fear River Basin supports 95 different species of fish that support commercial and recreational fishing.

Source: Clean Water Education Partnership cleanwater@tjcog.org
NC Department of Environmental Quality (DEQ)
https://ncdenr.s3.amazonaws.com/s3fs-public/Water%20Resources/Planning_Section/Basin_Planning/Cape_Fear/Jordan_Lake/Model/cf-neuse.jpg