

William & Mary Environmental Law and Policy Review

Volume 40 (2015-2016)
Issue 2 Symposium Issue: *What's in Your
Water? A Discussion of Threats to Virginia's
Water Quality*

Article 5

February 2016

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Peter L. deFur, Laura E. Williams, and Sarah D. Sanford, *Emerging Contaminants in Virginia*, 40 Wm. & Mary Env'tl. L. & Pol'y Rev. 519 (2016), <https://scholarship.law.wm.edu/wmelpr/vol40/iss2/5>

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EMERGING CONTAMINANTS IN VIRGINIA

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ABSTRACT

This Article summarizes the rise of emerging contaminants in waterways in Virginia and nationwide, and how they affect ecological and human health. First, we review the scientific discovery of chemicals that alter hormone systems, reproductive and developmental processes and how these were discovered in waterways. We go on to explain the current state of emerging contaminant regulations, noting that few states have a clear understanding of what chemicals are discharged into surface waters. The Environmental Protection Agency (“EPA”) has no national effort in this area, despite congressional interest and action. Finally, we make recommendations for future emerging contaminant control and monitoring.

INTRODUCTION

Water quality in Virginia, not unlike the rest of the nation, is more important than ever due to an exponential increase in the demand for water. Intense population growth, aging infrastructure, and the lack of conservation strategies all contribute to the demand on water resources. During 2015, water supply problems gained extensive national attention as a result of the drought in California and flooding in Texas. Pollution has long been a serious concern, and our knowledge is expanding on the effects and behavior of nonconventional pollutants in the environment. While generally defined as any contaminant on which scientific knowledge is

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insufficient, emerging contaminants often fall into the following categories: pharmaceuticals, personal care products, endocrine disruptors, and industrial chemicals for which there may be no published health standards.¹ Emerging contaminants are found in everyday products including over-the-counter drugs, toys, food liners, and plastics, as well as in industrial-scale products like pesticides.² Emerging contaminants can enter the environment through many pathways. Over-the-counter drugs, personal care products, and other pharmaceuticals used by people are excreted in human waste, rinsed off during showering or bathing, or sometimes flushed down the toilet.³ Sewage is treated at water treatment plants, and the wastewater is discharged into streams and rivers. The problem is that many of these contaminants can survive the water treatment process and often make their way into surface waters, and sometimes even into drinking water supplies.⁴ Additionally, emerging contaminants involved in industrial processes and agriculture are often released directly into surface waters, via overflow on land or through leakage from storage structures.⁵

Some of the emerging contaminants, especially some organic chemicals, can alter reproduction, behavior, IQ, and other bodily functions.⁶ For both humans and wildlife, the most common identified health effect associated with exposure to emerging contaminants is disruption of the endocrine system.⁷ Exposure to emerging contaminants can interfere

¹ See MATTHEW C. JONES & BETH GRAVES, ENVTL. COUNCIL OF THE STATES, STATE EXPERIENCES WITH EMERGING CONTAMINANTS: RECOMMENDATIONS FOR FEDERAL ACTION 1–2 (2010).

² See Paul E. Stackelberg et al., *Persistence of Pharmaceutical Compounds and Other Organic Wastewater Contaminants in a Conventional Drinking-Water-Treatment Plant*, 329 SCI. TOTAL ENV'T 99, 99–100, 106–07 (2004).

³ See *id.* at 99–100, 102, 108.

⁴ See *id.*

⁵ See Dana W. Kolpin et al., *Pharmaceuticals, Hormones, and Other Organic Wastewater Contaminants in U.S. Streams, 1999–2000: A National Reconnaissance*, 36 ENVIRON. SCI. TECH. 1202–03, 1208 (2002).

⁶ See William P. Davis & Stephen A. Bortone, *Effects of Kraft Mill Effluent on the Sexuality of Fishes: An Environmental Early Warning?*, in CHEMICALLY-INDUCED ALTERATIONS IN SEXUAL AND FUNCTIONAL DEVELOPMENT: THE WILDLIFE/HUMAN CONNECTION 113, 123 (Theo Colborn & Coralie Clement eds., Princeton Scientific Publishing Co. 1992). See generally Rebecca Klaper & Lyman C. Welch, *Emerging Contaminant Threats and the Great Lakes: Existing Science, Estimating Relative Risk and Determining Policies*, ALLIANCE FOR THE GREAT LAKES (2011), <http://www.greatlakes.org/Document.Doc?id=1072> [<http://perma.cc/S2MJ-Q2B5>] (expanding on the suspected correlation between emerging contaminants and adverse impacts on fertility and cancer rates).

⁷ See *Emerging Contaminants in U.S. Waters: Hearing Before the Subcomm. On Water Resources and the Environment of the H. Comm. On Transportation and Infrastructure*, 110th Cong. 22 (2010) (statement of Herb Buxton, Program Coordinator, U.S. Geological

with the body's hormone signals and create physiological damage that, in some instances, can span generations.⁸

Emerging contaminants are found in surface waters throughout the world, although in Virginia, this class of contaminants lacks a statutory and regulatory definition. Emerging contaminants are instead termed "microconstituents" by the Virginia Department of Environmental Quality ("VA DEQ").⁹ The EPA is also under pressure from lawmakers to study the effects of emerging contaminants on human and ecological health and act to protect both from harmful effects.¹⁰

I. HISTORY OF EMERGING CONTAMINANTS

A. *Background/General History*

While emerging contaminants have been around for decades, they were not written about until the 1960s. The first mainstream work to touch on emerging contaminants was *Silent Spring* by Rachel Carson, published in 1962.¹¹ Carson described to the world the adverse effects of the now-banned chlorinated pesticide DDT on osprey and bald eagle populations, before the category of emerging contaminants even had a name.¹² Bald eagles and other predatory birds were exposed to DDT by consuming contaminated fish.¹³ DDT, like other emerging contaminants, interfered with the birds' reproductive processes, and birds laid eggs with eggshells that were too thin and often cracked during incubation.¹⁴ Populations declined steeply until the EPA banned the use of DDT in 1972.¹⁵

Survey) [hereinafter *Hearings*].

⁸ See Amanda Mascarelli, *BPA Is Still Everywhere, and Mounting Evidence Suggests Harmful Effects*, WASH. POST, Dec. 9, 2013, https://www.washingtonpost.com/national/health-science/bpa-is-still-everywhere-and-mounting-evidence-suggests-harmful-effects/2013/12/06/2ff4a462-5b5d-11e3-a49b-90a0e156254b_story.html [<https://perma.cc/N6D2-P46U>].

⁹ JONES & GRAVES, *supra* note 1, at 21.

¹⁰ See *Hearings*, *supra* note 7, at 48–53 (statement of Dr. Peter deFur, Research Assoc. Prof., Virginia Commonwealth Univ.).

¹¹ RACHEL CARSON, *SILENT SPRING* 5–37 (1962).

¹² *Id.* at 118–23.

¹³ *Id.*

¹⁴ *Id.*

¹⁵ See ANDREW HANSEN ET AL., *The Population Ecology of Bald Eagles Along the Pacific Northwest Coast*, in *BALD EAGLES IN ALASKA* 1, 119 (Bruce A. Wright & Phil Schempf eds., 2008), available at https://www.uas.alaska.edu/arts_sciences/docs/bald-eagles-ak12-07.pdf [<https://perma.cc/GZ8G-J4UD>] (last modified Mar. 16, 2015).

While *Silent Spring* highlighted the dangers of pesticide contamination in wildlife, there was still a long way to go until scientists understood the danger of emerging contaminants as a group.

Fish sex change, known as intersex, was first noticed in the United States in Florida during the 1970s.¹⁶ Davis and Bortone later confirmed the masculinization of female fish downstream from a pulp mill in western Florida.¹⁷ Chemicals from a processing plant that made paper pulp out of trees turned out to be estrogenic and stimulated biological responses in fish.¹⁸

It was in the late 1980s that the late Dr. Theo Colborn began putting together the pieces in investigations of wildlife populations in the Great Lakes, and the possible causes of declines.¹⁹ She assembled a group of biologists studying seemingly disparate topics related to reproduction and development in a range of vertebrate animals in order to discern the common features.²⁰ The 1992 publication of the workshop results garnered the attention of some scientists but few others.²¹

In the 1990s, the issue of fish sex change resurfaced as intersex fish were noticed in rivers throughout the U.K.²² In 1994–1995, Harries et al. conducted a study on effluents from five different sewage-treatment works (“STWs”) into rivers throughout England. The scientists placed previously unexposed male trout at various distances downstream of the effluent entry points.²³ In four cases, male trout placed close to the entry point of the effluents showed marked and rapid increases in vitellogenin concentrations.²⁴ Vitellogenin is a protein precursor to egg yolk and is hence naturally found only in female animals. The presence of vitellogenin in male fish has increasingly been used as an indicator of exposure to endocrine disrupting chemicals in the water.²⁵

¹⁶ See Stephen A. Bortone & William P. Davis, *Fish Intersexuality as Indicator of Environmental Stress*, 44 *BIOSCIENCE* 165, 165–72 (1994).

¹⁷ *Id.*

¹⁸ *Id.* at 165–68.

¹⁹ Elizabeth Grossman et al., *In Memoriam—Theo Colborn*, 123 *ENVTL. HEALTH PERSP.* 201, A54 (2015), available at <http://ehp.niehs.nih.gov/1509743/> [<http://perma.cc/LD3S-6R8B>].

²⁰ See Theo Colborn, Preface to *CHEMICALLY-INDUCED ALTERATIONS IN SEXUAL AND FUNCTIONAL DEVELOPMENT: THE WILDLIFE/HUMAN CONNECTION* at xii–xiv (Theo Colborn & Coralie Clement eds., Princeton Scientific Publishing Co. 1992).

²¹ See *id.*

²² Jule E. Harries ET AL., *A Survey of Estrogenic Activity in United Kingdom Inland Waters*, 15 *ENVTL. TOXICOLOGY CHEMISTRY* 1993, 1994 (1996).

²³ *Id.* at 1994–99.

²⁴ See *id.*

²⁵ *Id.* at 1993.

In 1996, a study by Leroy Folmar et al., was published regarding endocrine disruption of male fish in Minnesota rivers.²⁶ Serum was collected from male carp at five different riverine locations in Minnesota.²⁷ The study revealed that male fish from an effluent channel below the St. Paul metropolitan sewage treatment plant had significantly elevated concentrations of an egg yolk precursor protein and significantly decreased testosterone concentrations compared to male carp from the St. Croix River, a National Wild and Scenic River.²⁸ Male carp from the Minnesota River also exhibited depressed testosterone concentrations.²⁹ This study followed from the work in England and suggested, as reported in England, that North American rivers were receiving estrogenic chemicals able to alter biological functions in aquatic species.³⁰

The issue of sex change in aquatic vertebrates began coming up in scientific studies around the nation. In 1995, and again in 1999–2000, studies by the USGS on Lake Mead in Nevada and Arizona showed that male carp exhibited low blood levels of androgen and smaller testes compared to male fish from reference sites.³¹ A study from Florida showed that alligators living in pesticide-contaminated lakes exhibited reproductive and developmental defects.³²

By the mid-1990s, endocrine disruption science was being brought into the mainstream, thanks much in part to Theo Colborn's book *Our Stolen Future*, published in 1996.³³ In it, Dr. Colborn, with Pete Myers and Diane Dumanoski, pieced together evidence from wildlife studies, human data, and laboratory experiments to present the newly emerging case regarding the largely unknown threat of man-made chemicals.³⁴

²⁶ See Leroy C. Folmar et al., *Vitellogenin Induction and Reduced Serum Testosterone Concentrations in Feral Male Carp (Cyprinus carpio) Captured Near a Major Metropolitan Sewage Treatment Plant*, 104 ENVTL. HEALTH PERSP. 1096, 1096–1101 (1996).

²⁷ *Id.*

²⁸ See *id.* at 1096, 1098–99.

²⁹ *Id.*

³⁰ See *id.* at 1096–99.

³¹ See MICHAEL R. ROSEN ET AL., INVESTIGATIONS OF THE EFFECTS OF SYNTHETIC CHEMICALS ON THE ENDOCRINE SYSTEM OF COMMON CARP IN LAKE MEAD, NEVADA AND ARIZONA 1, 2–3 (2007) available at <http://pubs.usgs.gov/fs/2006/3131/pdf/fs20063131.pdf> [<http://perma.cc/9PEV-ADXA>].

³² See Louis J. Guillette, Jr. et al., *Alligators and Endocrine Disrupting Contaminants: A Current Perspective*, 40 AM. ZOOLOGIST 438, 438–52 (2000).

³³ See generally THEO COLBORN ET AL., *OUR STOLEN FUTURE: ARE WE THREATENING OUR FERTILITY, INTELLIGENCE, AND SURVIVAL?—A SCIENTIFIC DETECTIVE STORY* 11–28 (1st ed. 1996).

³⁴ See *id.* at 11–28, 143–87.

Building off of decades of research, the book links sexual abnormalities, birth defects, and reproductive failures in wildlife to endocrine disrupting chemicals.³⁵ Perhaps more alarming are the effects that these chemicals appear to have on humans. Colborn points to the dramatic increase in endometriosis and hormone-related cancers experienced by women, as well as drops in male sperm counts.³⁶

A landmark USGS study was published in 2002 on emerging contaminants in streams nationwide.³⁷ Kolpin et al. sampled 139 streams in 30 states and measured hundreds of chemicals.³⁸ The list of chemicals in the investigation included a wide range of chemicals that were known to be present or suspected to be found in wastewaters.³⁹ Most of the streams were downstream from urbanized areas and agriculture. The USGS scientists detected emerging contaminants in 80% of the streams sampled.⁴⁰ The most common contaminants were fecal steroids, plant and animal steroids, insect repellent, caffeine, disinfectants, fire retardants, and detergents.⁴¹ Below is a summary of the types of emerging contaminants detected in the study:

- 17 antibiotics
- 15 prescriptions drugs
- 7 non-prescription drugs
- 18 hormones, including several steroids
- 39 other chemicals⁴²

The fact that these contaminants were detected on a national scale shows that they are able to survive wastewater treatment and biodegradation.⁴³ The cumulative effects of these chemicals on people or aquatic animals are largely unknown with few exceptions where abnormalities in fish have been traced back to wastewater discharges.⁴⁴

Recent research has revealed more troublesome news on the behavior of emerging contaminants. Studies have shown that microbes used

³⁵ See *id.* at 83, 151–55, 158–63.

³⁶ See *id.* at 172–86.

³⁷ See Kolpin et al., *supra* note 5, at 1202–11.

³⁸ *Id.* at 1203–05.

³⁹ *Id.* at 1203.

⁴⁰ *Id.* at 1208.

⁴¹ See *id.* at 1204–05.

⁴² See *id.*

⁴³ See Kolpin et al., *supra* note 5, at 1210.

⁴⁴ See *id.* at 1208.

at wastewater treatment plants can actually increase the concentrations of some pharmaceuticals.⁴⁵ Researchers analyzing wastewater at a Milwaukee-area treatment plant found that two pharmaceuticals, the antibiotic ofloxacin and the anti-epileptic drug carbamazepine, were present in treated wastewater at higher concentrations than when they went into the treatment plant.⁴⁶ The scientists believe that microbes, which are used by wastewater treatment plants to decompose organic matter in sewage, may be piecing back together the drugs that human bodies have broken down and excreted.⁴⁷

Several states have taken the lead on identifying emerging contaminants in state waterways. So far, Delaware, California, Minnesota, and Oregon have all conducted surveys.⁴⁸ Because pharmaceuticals, along with antibiotics, personal care products, and flame retardants, were found in every other state, and pharmaceutical use does not differ much between states, there is strong reason to believe that these emerging contaminants are present in Virginia waterways as well.⁴⁹

B. Virginia

Little research has been done on the topic of emerging contaminants in Virginia waterways. A series of observable problems such as external lesions and intersex fish in the Shenandoah and James River basins prompted a 2007 study in the Shenandoah and James Rivers by the USGS.⁵⁰ Sampling of nine locations in the Shenandoah River Basin and two in the James River Basin detected polycyclic aromatic hydrocarbons, pesticides, polychlorinated biphenyls, atrazine, fragrance components, caffeine and nicotine metabolites, and natural and synthetic hormones.⁵¹

⁴⁵ See Benjamin Blair et al., *Evaluating the Degradation, Sorption, and Negative Mass Balances of Pharmaceuticals and Personal Care Products During Wastewater Treatment*, 134 CHEMOSPHERE 395, 395–401 (2015); see also Xiu-Sheng Miao, Jian-Jun Yang & Chris D. Metcalfe, *Carbamazepine and Its Metabolites in Wastewater and in Biosolids in a Municipal Wastewater Treatment Plant*, 39 ENVIRON. SCI. TECHNOL. 7469, 7469–75 (2005).

⁴⁶ See Blair et al., *supra* note 45, at 399.

⁴⁷ See *id.* at 400.

⁴⁸ See, e.g., *Chemicals of Concern*, ENVTL. STEWARDSHIP CONCEPTS, <http://www.estewards.com/chemicals-of-concern/> [<http://perma.cc/BY2K-ZM74>] (last visited Nov. 12, 2015).

⁴⁹ See EPA, *Pharmaceuticals and Personal Care Products in Water*, <http://water.epa.gov/scitech/swguidance/ppcp/index.cfm> [<http://perma.cc/7PWN-DVNL>] (last visited Nov. 12, 2015).

⁵⁰ See DAVID ALVAREZ ET AL., RECONNAISSANCE OF PERSISTENT AND EMERGING CONTAMINANTS IN THE SHENANDOAH AND JAMES RIVER BASINS, VIRGINIA, DURING SPRING OF 2007 1 (2008) available at <http://pubs.usgs.gov/of/2008/1231/pdf/OF2008-1231.pdf> [<http://perma.cc/N848-TCGE>].

⁵¹ See *id.* at 2, 8, 16–17.

Similar results have been observed on the Potomac River. A 2002 series of fish kills in the South Fork of the Potomac River led USGS scientists to investigate potential causes.⁵² The researchers found that the majority of the dead male fish had intersex characteristics.⁵³ Further research revealed that intersex was prevalent in male fish in over 80% of Potomac River tributaries.⁵⁴ A 2006 study by the USGS showed that male smallmouth bass from the most populated and farmed sites in the Upper Potomac River Basin had the highest chances of having immature eggs in their testes.⁵⁵

While these studies were very important for understanding the presence of emerging contaminants in Virginia, they were still highly focused and limited in scope. There is a pressing need to conduct more comprehensive studies in Virginia, for both the type of emerging contaminants in our waters and the prevalence of the contaminants in different waterways.

II. ECOLOGICAL AND HUMAN HEALTH EFFECTS

Even low-level exposure to select emerging contaminants, such as hormones, can cause detrimental effects in aquatic species.⁵⁶ Wollenberger et al. conducted a study in 2000 investigating the acute and chronic toxicity of nine antibiotics on freshwater crustacean *Daphnia magna*.⁵⁷ No reproductive toxicity was observed during acute exposure; however, antibiotics caused mortality in the parent generation during the long-term exposure.⁵⁸ Chronic low-level environmental exposure is a greater concern than acute exposure.⁵⁹ The problems occur at the level of the endocrine system.⁶⁰ The endocrine system is made up of glands that produce and release hormones.⁶¹ Hormones control activities such as reproduction,

⁵² See POTOMAC CONSERVANCY, STATE OF THE NATION'S RIVER 2009: EMERGING CONTAMINANTS IN THE POTOMAC RIVER 1 (2009) available at http://static1.squarespace.com/static/52260563e4b0e56a47d7efa6/t/527bc001e4b04a4b5511528f/1383841793424/pc_sonr_11+09+09+lr1.pdf [<http://perma.cc/6RWU-8GTM>].

⁵³ *Id.*

⁵⁴ *Id.*

⁵⁵ *See id.*

⁵⁶ See Kolpin et al., *supra* note 5, at 1208.

⁵⁷ See L. Wollenberger et al., *Acute and Chronic Toxicity of Veterinary Antibiotics to Daphnia Magna*, 40 CHEMOSPHERE 723 (2000).

⁵⁸ *Id.* at 729.

⁵⁹ See Kolpin et al., *supra* note 5, at 1208.

⁶⁰ *Id.* at 1210.

⁶¹ See MICHAEL R ROSEN ET AL., INVESTIGATIONS OF THE EFFECTS OF SYNTHETIC CHEMICALS ON THE ENDOCRINE SYSTEM OF COMMON CARP IN LAKE MEAD, NEVADA AND ARIZONA 2

development, and growth.⁶² For certain animals, hormones determine the sex of the organism during early development.⁶³ An endocrine disruptor can mimic, modify, or block the action of a hormone found in the body.⁶⁴

A. *Ecological Health*

For wildlife, exposure to emerging contaminants can occur through multiple pathways: air, water, soil, sediment, and food.⁶⁵ Once an emerging contaminant is introduced to an environment, it can move through an ecosystem through bioaccumulation, the accumulation of a contaminant in the tissues of a living organism, or biomagnification, the process by which the concentration of a contaminant increases as it moves up the food chain.⁶⁶ A study conducted in 2011 focused on persistent organic pollutants (“POPs”) in the Arctic. Through the use of a bioaccumulation model, concentrations of PCBs and DDTs were found to be 10–1000 times higher at the top than at the base of the food web.⁶⁷ This finding suggests the biomagnification of these pollutants in Arctic animals.⁶⁸

Multiple adverse effects have been observed as a result of exposure to emerging contaminants. Effects in wildlife range from deformities to early life stage mortality, although the majority of adverse effects have to do with reproduction.⁶⁹ Scientific studies cite the following reproductive problems as effect-based responses to endocrine disrupting chemicals: reproductive dysfunction, abnormal reproductive morphology, sex ratio skew, altered sex steroid levels, and reduced reproductive success.⁷⁰

One of the most vulnerable categories of wildlife is fish. Because fish spend their entire life in water, and because they are passing water through their bodies to extract oxygen, fish near urbanized areas come into contact with more emerging contaminants than most wild animals. One of the most notable responses to endocrine disrupting chemicals in

(2007), available at <http://pubs.usgs.gov/fs/2006/3131/pdf/fs20063131.pdf> [<http://perma.cc/N6DC-LS79>].

⁶² *Id.*

⁶³ *Id.*

⁶⁴ *See id.*

⁶⁵ *See* WORLD HEALTH ORG., GLOBAL ASSESSMENT OF THE STATE-OF-THE-SCIENCE OF ENDOCRINE DISRUPTORS 91–92 (Terri Damstra et al. eds., 1998) available at http://www.who.int/ipcs/publications/new_issues/endocrine_disruptors/en/ [<http://perma.cc/Q37Q-UUDE>].

⁶⁶ *Id.* at 34.

⁶⁷ *See id.* at 91.

⁶⁸ *See id.* at 108.

⁶⁹ *See id.* at 34–39.

⁷⁰ *See id.* at 34–49.

fish is the production of vitellogenin in juvenile and male fish.⁷¹ Vitellogenin is an egg yolk precursor protein, and is hence naturally found only in females.⁷² The presence of vitellogenin in male fish has increasingly been used as an indicator of waters contaminated with endocrine disrupting chemicals.⁷³ Reproductive abnormalities are also present in fish in the form of altered gonadal development.⁷⁴

B. *Human Health*

Humans are also exposed to emerging contaminants through a variety of pathways. Exposure may occur through taking medications, consuming contaminated fish, shellfish, or other wildlife, air contact, skin contact, water contact, and drinking water.⁷⁵ The National Institute of Environmental Health Sciences ("NIEHS") lists the following health effects of endocrine disruptors:

- Reductions in male fertility and declines in the number of males born.
- Abnormalities in male reproductive organs.
- Female reproductive health issues, including fertility problems, early puberty, and early reproductive senescence.
- Increases in mammary, ovarian, and prostate cancers.
- Increases in immune and autoimmune diseases, and some neurodegenerative diseases.⁷⁶

The estrogenic compound bisphenol A, better known as BPA, is used in manufacturing plastics and resins.⁷⁷ Although the dangers of using products made with BPAs were widely advertised around 2008, BPA is still present in many products.⁷⁸ Studies have shown that perinatal

⁷¹ See WORLD HEALTH ORG., PHARMACEUTICALS IN DRINKING-WATER, PUBLIC HEALTH AND ENVIRONMENT: WATER, SANITATION, HYGIENE AND HEALTH 42–43 (2011).

⁷² See *id.* at 16.

⁷³ *Id.* at 128.

⁷⁴ See *id.* at 43–44.

⁷⁵ See *Endocrine Disruptors*, NAT'L INST. OF ENVTL. HEALTH SCIS., at 2 (2010), available at http://www.niehs.nih.gov/health/materials/endocrine_disruptors_508.pdf [<http://perma.cc/2W9L-QCXU>].

⁷⁶ See *id.* at 1–4.

⁷⁷ See *Bisphenol A (BPA)*, NAT'L INST. OF ENVTL. HEALTH SCIENCES, at 1–2 (2010), http://www.niehs.nih.gov/health/assets/docs_a_e/bisphenol_a_bpa_508.pdf [<http://perma.cc/C5ST-8VM7>].

⁷⁸ See Mascarelli, *supra* note 8.

exposure to low doses of BPA affects body weight in babies and the estrous cycle in exposed females.⁷⁹ Exposure to BPA can also lead to resistance to chemotherapy in breast cancer patients.⁸⁰

C. EDCs in Drinking Water

It is known that combinations of compounds are often more dangerous than individual compounds.⁸¹ Yet, drinking water criteria are still based on the toxicity of individual compounds.⁸² In a study on contaminants in a conventional drinking water treatment plant, Stackelberg et al. detected between eleven and seventeen different organic wastewater contaminants in four separate samples of finished water.⁸³ The Stackelberg study was the first of its kind to show that many compounds survive water treatment processes and end up in drinking water supplies.⁸⁴ Most of the compounds found in the finished samples did not have currently established drinking water standards or health advisories.⁸⁵ This leads to unknown potential health consequences.

Endocrine disruptors may pose the greatest risk to human health during the prenatal and early postnatal development.⁸⁶ During this time, organs and neural systems are developing, and hormone disruptions can cause significant physiological effects.⁸⁷

III. CURRENT STATE OF REGULATIONS AND MONITORING

Since the enactment of the 1996 amendments to the Safe Drinking Water Act, EPA is required to determine at least five contaminants

⁷⁹ See Beverly S. Rubin et al., *Perinatal exposure to low doses of bisphenol A affects body weight, patterns of estrous cyclicity, and plasma LH levels*, 109 ENVIRON. HEALTH PERSP. 675, 675–80 (2001).

⁸⁰ See Elizabeth W. LaPensee et al., *Bisphenol A at Low Nanomolar Doses Confers Chemoresistance in Estrogen Receptor- α -Positive and -Negative Breast Cancer Cells*, 117 ENVIRON. HEALTH PERSP. 175, 175–80 (2009).

⁸¹ See, e.g., Sasha Harris-Lovett, *Combinations of “Safe” Chemicals May Increase Cancer Risk, Study Suggests*, L.A. TIMES, July 1, 2015.

⁸² See Paul E. Stackelberg et al., *Persistence of pharmaceutical compounds and other organic wastewater contaminants in a conventional drinking-water-treatment plant*, 329 SCI. TOTAL ENVIRON. 99, 99–113 (2004).

⁸³ See *id.* at 99, 108.

⁸⁴ *Id.* at 99, 111.

⁸⁵ *Id.* at 99, 100.

⁸⁶ See NAT'L INST. OF ENVTL. HEALTH SCIENCES, *supra* note 75, at 1–4.

⁸⁷ *Id.*

presenting the greatest public health concern every five years.⁸⁸ In the past, EPA has selected contaminants for regulatory determinations based on data availability, not public health concerns.⁸⁹

In 2003 and 2008, the EPA issued final regulatory determinations on 20 contaminants.⁹⁰ In both cases, EPA decided not to implement a drinking water regulation.⁹¹ In the September of 2008, Congress weighed in on the issue of emerging contaminants at the Water Resources Subcommittee Hearing on Emerging Contaminants in U.S. Waters.⁹² Of the 8,000 cancer-causing chemicals in use, less than 300 had permit limits.⁹³

Between 1996 and 2011, EPA failed to recommend any new contaminants for regulation.⁹⁴ A lack of coordinated occurrence and health effects data is the primary cause of EPA's inability to make regulatory determinations.⁹⁵

EPA, several state agencies, and federal natural resource agencies such as USGS have been studying new variations of contaminants in surface and groundwater for more than 10 years.⁹⁶ It was over a decade ago that the USGS surveyed US waters to determine the extent to which emerging contaminants were present.⁹⁷ Since then, little has been done to understand the nature and extent of this problem that has the potential to exert far-reaching consequences for human health and the environment.

National policy, set in the Clean Water Act, envisions "fishable, swimmable waters," but the implementation of this policy was created in a context of toxic chemicals quite different from the long list measured

⁸⁸ 42 U.S.C. § 300g-1(b)(1)(B)(i) (1996).

⁸⁹ See U.S. GOV'T ACCOUNTABILITY OFFICE, GAO-11-254 SAFE DRINKING WATER ACT: EPA SHOULD IMPROVE IMPLEMENTATION OF REQUIREMENTS ON WHETHER TO REGULATE ADDITIONAL CONTAMINANTS 1-146 (2011).

⁹⁰ See *id.*

⁹¹ See *id.*

⁹² See *Emerging Contaminants in U.S. Waters: Hearing Before the Subcommittee on Water Resources and Env't of the Comm. on Transp. and Infrac.*, 110th Cong. 48-53 (2008).

⁹³ See *id.* at 48-53 (statement of Dr. Peter deFur, Research Assoc. Prof., Virginia Commonwealth Univ.).

⁹⁴ See, e.g., Edwin Mora, *EPA is Failing to Identify Drinking Water Contaminants Posing the Greatest Health Risk*, CNS NEWS (July 18, 2011), <http://www.cnsnews.com/news/article/epa-failing-identify-drinking-water-contaminants-posing-greatest-health-risk> [http://perma.cc/2Y9L-BNVE].

⁹⁵ See U.S. GOV'T ACCOUNTABILITY OFFICE, *supra* note 89, at 17.

⁹⁶ See U.S. GEOLOGICAL SURVEY, U.S. DEP'T OF THE INTERIOR, FS-027002, *Pharmaceuticals, Hormones, and Organic Wastewater Contaminants in U.S. Streams*, at 1-2 (2002).

⁹⁷ See, e.g., Tom Meersman, *Down the Drain, They Remain—These Everyday Items Show up in Our Waters Long After You Forget About Them*, STAR TRIBUNE (Minneapolis), Nov. 14, 2004, at 1A.

by USGS.⁹⁸ Water quality programs at the federal and state level have not caught up with the new reality of achieving and maintaining water quality.⁹⁹ EPA is now putting some effort into this area to understand the scientific and technical aspects of surface waters contaminated with nonconventional contaminants. While national policy for water quality comes from the federal Clean Water Act, it is implemented at the state level.¹⁰⁰ State agencies do not have a history of leading the way in terms of updating water quality criteria.¹⁰¹ Nor do state agencies insist on a comprehensive evaluation of all chemical constituents in the effluent of discharge permit holders.¹⁰²

Most countries do not have programs implemented to test for pharmaceuticals in drinking water.¹⁰³

CONCLUSIONS AND RECOMMENDATIONS

- More research and data collection on emerging contaminants
- Increase education on proper disposal of pharmaceuticals and personal care products
- Regulations on chemicals as groups rather than individual, chemical by chemical, regulation
- Proactive rather than reactive monitoring

While the Kolpin et al. USGS study was biased to sample waterways that would likely contain detectable levels of emerging contaminants, their findings may help Virginia hypothesize as to what contaminates our rivers, since consumer product use is similar throughout the country.¹⁰⁴ The rivers and streams of Virginia, with watersheds dominated by agriculture,

⁹⁸ See, e.g., *Kan. Natural Res. Council, Inc. v. Whitman*, 255 F. Supp. 2d 1208 (D. Kan. 2003). See generally Kolpin et al., *supra* note 5.

⁹⁹ See Charles Duhigg, *Clean Water Laws Are Neglected, at a Cost in Suffering*, N.Y. TIMES, Sept. 12, 2009, http://www.nytimes.com/2009/09/13/us/13water.html?_r=0 [<http://perma.cc/4W5M-9YBG>].

¹⁰⁰ See 33 U.S.C. § 1313 (2012).

¹⁰¹ See, e.g., Emma Bryce, *E.P.A. Updates Decades-Old Water Quality Standard*, N.Y. TIMES, Dec. 3, 2012, <http://green.blogs.nytimes.com/2012/12/03/e-p-a-updates-a-decades-old-water-quality-standard/> [<http://perma.cc/9LBU-QR8V>].

¹⁰² See 33 U.S.C. § 1317 (2012) (describing what pollutants are covered by the Clean Water Act).

¹⁰³ See WORLD HEALTH ORG., *supra* note 71, at 1–49.

¹⁰⁴ See Kolpin et al., *supra* note 5, at 1202–11.

urbanization and industrialization provide the state with much of its drinking water. Without actual data, however, Virginia cannot be proactive in protecting its citizens' health by improving wastewater treatment and regulating the use and disposal of pharmaceuticals, personal care products and other emerging contaminants. Other states and regions (such as Minnesota, California, Delaware and the Delaware River Basin Commission) are addressing this problem, starting with investigations to identify the nature and extent of the occurrence of emerging contaminants.¹⁰⁵

To be on the cutting edge scientifically, politically and environmentally, Virginia can begin sampling now and collecting long-term data so that we can better understand the nature of the problem. As our nation's birthplace, Virginia has long received national attention for its successes and failures in the environmental realm, and research would contribute to the national body of knowledge on emerging contaminants as well as demonstrate the Commonwealth's dedication to protecting our drinking water supplies and aquatic habitats. The current lack of knowledge on the toxicological effects of emerging contaminants makes it imperative to first identify what is present in Virginia's waters so we can then prioritize creating toxicological profiles and regulations for those contaminants. With 30 USGS water flow monitoring stations in the basins of Potomac, York, James, Roanoke and Tennessee Rivers, sampling opportunities are easily accessible.¹⁰⁶ It would also be necessary to identify the locations of wastewater treatment plants, with effluents likely to contain antibiotics, prescriptions, over-the-counter drugs, steroids, hormones, personal care products, oil combustion products and other commonly used chemicals.¹⁰⁷ Sampling downstream and upstream of the wastewater treatment plants would help identify which chemicals enter Virginia's waters through treatment plant effluent and which chemicals enter through other pathways, such as urban and agricultural runoff.

In order to better characterize the nature of the problem in Virginia, a coordinated effort among federal, state, and private dischargers

¹⁰⁵ See, e.g., MINN. DEP'T OF HEALTH, *Contaminants of Emerging Concern: Protecting Minnesota's Water Resources*, <http://www.health.state.mn.us/cec> [<http://perma.cc/H32P-WQZB>]; STATE WATER RES. CONTROL BD., *Emerging contaminants*, http://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/EmergingContaminants.shtml [<http://perma.cc/F4LN-EEUX>]; DEL. RIVER BASIN COMM'N, *Contaminants of Emerging Concern*, <http://www.nj.gov/drbc/quality/reports/emerging/> [<http://perma.cc/V7FK-J28Q>].

¹⁰⁶ See, e.g., U.S. GEOLOGICAL SURVEY, U.S. DEP'T OF THE INTERIOR, *USGS Water Data for the Nation*, <http://waterdata.usgs.gov/nwis> [<http://perma.cc/96DL-WKVG>].

¹⁰⁷ See Kolpin et al., *supra* note 5, at 1202–11.

should be implemented to gather the data on current status and trends. The state of Virginia should require complete characterization of all constituents, targeting the emerging contaminants. At the very least, the state could require permit holders to measure those emerging contaminants that have been reported in the effluent of similar dischargers in the United States, or reported by USGS. Controlling some types of emerging contaminants and inputs is not an insurmountable task and there are efficiencies that will allow controls on multiple contaminants at once: erosion and sediment control will also capture many contaminants that adhere to soil particles. Both in Virginia and at the national level, there is a need to expand research efforts and gather more data on emerging contaminants.

A. *New Technologies*

New methods are under development to allow POTWs to make operational and structural changes to reduce or eliminate discharges via digestion or capture.¹⁰⁸ Because the original research on this issue in England revealed that POTWs were a source of natural and pharmaceutical estrogen, engineers have been investigating ways to modify current operations to digest estrogenic steroids.¹⁰⁹

¹⁰⁸ See, e.g., UNIV. OF MINN., *Improve Wastewater Loading Quality in POTWs*, <http://mntap.umn.edu/POTW/wastewater.html> [<http://perma.cc/LKE8-BJHZ>].

¹⁰⁹ See, e.g., N. Paterakis et al., *The effectiveness of anaerobic digestion in removing estrogens and nonylphenol ethoxylates*, 1200 J. HAZARDOUS MATERIALS 88, 88–95 (2012).

