Evaluation of Heavy Metal Concentrations in Fish from the Dan River in 2014 and 2015

DAN RIVER

DANVILLE, VIRGINIA

Letter Health Consultation

March 9, 2017

Virginia Department of Health
Division of Environmental Epidemiology
109 Governor Street
Richmond, Virginia 23219

COMMONWEALTH of VIRGINIA

Department of Health – Office of Epidemiology

MARISSA J. LEVINE, MD, MPH
INTERIM STATE HEALTH COMMISSIONER

PO BOX 2448
RICHMOND, VA 23218

TTY 7-1-1 OR
1-800-828-1120

March 9, 2017

Gabriel Darkwah
Lab Data Coordinator
Virginia Department of Environmental Quality
629 E. Main Street
Richmond, VA 23219

Dear Gabriel Darkwah,

Thank you for providing the analysis results of metal contaminants in fish tissue from fish collected along the Dan River, VA in 2014 and 2015. The Virginia Department of Health (VDH) has finished reviewing the results for public health implications, as requested. VDH concludes that current fish consumption advisories remain in effect for the Dan River and its tributaries, and that no additional fish consumption advisories are needed.

BACKGROUND

In 2014 and 2015, the Virginia Department of Environmental Quality (DEQ) collected fish along the length of the Dan River, from the Virginia/North Carolina border to the Clarksville Marina. A map of this area showing the fish sampling locations can be found in the attachment (**Figure 1**). This was done to evaluate whether the coal ash release at Duke Energy in NC has resulted in changes in heavy metal concentrations in fish tissue from the Dan River upstream of Danville. Fish collection, laboratory analysis, and how screening values (SVs) were derived are not discussed in this health consultation.

DISCUSSION

In both 2014 and 2015, 160 fish samples were collected from nine different sites along the Dan River and were analyzed for 17 different metal analytes including: aluminum (Al), antimony (Sb), arsenic (As), barium (Ba), beryllium (Be), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), manganese (Mn), nickel (Ni), selenium (Se), silver (Ag), thallium (Tl), vanadium (V), zinc (Zn), and mercury (Hg). In all of the samples tested (2014 and 2015), less than 1% contained measurable concentrations of the following: Be, Cd, Ni, Pb, Sb, Tl, and V. For those samples in which the analytes were detected at measurable levels, all except for Hg were below

the VDH SVs, and are therefore of no concern.[1,2] The fish tissues that contained arsenic and mercury will be discussed separately. A summary of all heavy metal data can be found in the attachment (**Table 3**).

Arsenic

Arsenic is a naturally-occurring heavy metal that exists in inorganic and organic forms. It can be found in soil, water, and food. Inorganic arsenic can cause irritation to the digestive system and loss of red and white blood cells. It is also classified as a known human carcinogen, and due to that, has screening values for both carcinogenic and non-carcinogenic effects. While inorganic arsenic is a concern in drinking water and in some food products, the organic forms of arsenic in fish tissues are not thought to be toxic in humans.[3] The sampling method used for this study was for total arsenic, which does not distinguish among forms of arsenic. Some research shows that in both marine and freshwater fish, organic forms of arsenic account for the majority of arsenic in fish muscle tissues (>70%).[4]

Arsenic was detected in 49 out of 160 (30.6%) fish collected in 2014 and 36 out of 160 (22.5%) fish collected in 2015. VDH assumed that 20% of the total arsenic reported was inorganic (total arsenic concentration x 0.2 = inorganic arsenic concentration) and then compared the inorganic arsenic concentration to VDH's arsenic SVs. In 2014 one fish sample exceeded the SV for cancer (0.09 mg/kg) at 0.19 mg/kg wet weight. None of the samples collected in 2015 met or exceeded the SVs.

Mercury

Mercury is a naturally-occurring heavy metal that exists in three forms: elemental, inorganic, and organic. Elemental mercury enters the environment through both anthropogenic and natural sources, and methylmercury (meHg) is formed by microorganisms in aquatic environments, where it then enters the food chain. This is the form most commonly found in biological tissues, and is the greatest threat to human health due to its ability to bioaccumulate and biomagnify in aquatic and terrestrial environments. Methylmercury can cause mild to severe neurological symptoms, and is especially of concern to pregnant women and women of child-bearing age due to its ability to cross the placenta barriers, which can result in damage to the developing fetus, especially in the brain and kidneys. Studies have found associations between mothers who consumed fish with meHg while pregnant and children with developmental delays. Similarly, children are at greater risk of meHg exposure because their brains are still developing and the ability of meHg to cross the blood-brain barrier. Chronic exposure to meHg can result in

[1] http://www.townhall.virginia.gov/

[2] Dwight D. Flammia, Rebecca LePrell, Matthew F. Skiljo, Egbe Egiebor. Metal Concentration in Fish Tissue: Implications for Public Health Following Coal Ash Release to Dan River. Presented at the 2014 National Fish Forum on Contaminants in Fish. Alexandria, VA. September2014.

[3] Toxicological Profile for Arsenic. U.S. Department of Health and Human Services, Agency for Toxic Substances and Disease Registry. August 2007.

[4] "Arsenic and Fish Consumption." U.S. Environmental Protection Agency, Health and Ecological Criteria Division, Office of Science and Technology. December 1997.

impaired vision, speech, walking, and hearing, a lack of coordination and "pins and needles" sensations. There is evidence that exposure to meHg can have adverse effects on the cardiovascular, immune, and reproductive systems as well.[5]

Top predators of food chains (including predatory fish) contain the highest concentrations of meHg. Concentrations of meHg in fish tissues increase with age, mass, and trophic level of the fish, and therefore fish consumption advisories often include guidelines specific to size and species of fish.[5] Health organizations recommend eating fish that are lower on the food chain, and are smaller in size because they are expected to have lower mercury concentrations in their tissues.

The current fish consumption guidelines in Virginia for mercury are as follows:

- When mercury levels in fish range from 0.5 to less than 1.0 milligrams per kilogram (mg/kg), VDH recommends limiting consumption of contaminated fish species to two 8-oz meals per month.
- When mercury levels in fish range from 1.0 to less than 2.0 milligrams/kilogram (mg/kg), VDH recommends limiting consumption of contaminated fish species to one 8-oz meal per month.
- When levels equal or exceed 2.0 mg/kg in fish, VDH recommends avoiding consumption of contaminated fish species.

Mercury (Hg) was detected in all fish samples collected along the Dan River (see **Table 2** for full summary of Hg data), however most were below the VDH screening values. Concentrations of mercury exceeded the VDH SV of 0.5 mg/kg wet weight (ppm) in fish collected in 6 of the sampling sites in 2014 and in 2 of the sampling sites in 2015, with tissue concentrations ranging from 0.51 – 1.25 ppm. The species with the highest Hg concentrations included largemouth bass, smallmouth bass, white bass, walleye, flathead catfish, and blue catfish. **Table 1** (below) contains a summary of the fish species, concentration of mercury, and collection sites.

Table 1: Summary of fish tissue samples that exceeded mercury screening value.*

Collection Site	Fish Species	Year	Hg Conc. (ppm)	Mass of Fish (g)
1	Largemouth Bass	2014	0.53	760
2	Largemouth Bass	2014	0.54	946
4	Walleye	2014	0.65	1,366.5
5	Flathead Catfish	2014	1.23	17,000
5	Flathead Catfish	2014	0.96	14,400
5	Flathead Catfish	2014	0.82	14,200
5	Flathead Catfish	2014	0.65	11,200

[5] Toxicological Profile for Mercury. U.S. Department of Health and Human Services, Agency for Toxic Substances and Disease Registry. March 1999.

Collection Site	Fish Species	Year	Hg Conc. (ppm)	Mass of Fish (g)
5	Flathead Catfish	2014	0.63	5,700
5	Blue Catfish	2015	0.56	-
7	Flathead Catfish	2014	0.83	14,200
8	Flathead Catfish	2014	0.56	6,500
8	Smallmouth Bass	2014	0.71	1,581
8	Spotted Bass	2015	0.70	-
8	White Bass	2014	1.25	428
8	Walleye	2014	0.51	1,434

*Sites 1 and 2 are upstream of Danville. ppm = parts per million. g = grams

CONCLUSION

VDH concludes that the existing fish consumption advisory for the Dan River is protective of health.

RECOMMENDATIONS

VDH recommends that current fish consumption advisories remain in effect for the Dan River and that there is continued monitoring of fish in the Dan River.

VDH also recommends that pregnant women, nursing mothers, and young children should not consume fish contaminated with methylmercury at concentrations equal or exceed 0.5 ppm.

Rachel Ellick, M.S.
Health Assessor
Virginia Department of Health
Richmond, VA 23219

Dwight Flammia, Ph.D.
State Public Health Toxicologist
Virginia Department of Health
Richmond, VA 23219

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Table 2 (part 1): 2014 and 2015 summary of mercury concentrations (mg/kg wet weight), divided by sampling location (site) and fish species.

Site	Fish Species	2014		2015	
		Number of Fish Collected	Mercury Concentration average (range)	Number of Fish Collected	Mercury Concentration average (range)
1	Golden Redhorse	7	0.22 (0.16-0.3)	2	0.21 (0.13-0.3)
	Largemouth Bass	**2**	**0.40 (0.27-0.53)**	-	-
	Redbreast Sunfish	10	0.08 (0.06-0.11)	5	0.09
	Smallmouth Bass	-	-	5	0.29 (0.26-0.32)
2	Bluegill Sunfish	15	0.063 (0.05-0.08)	9	0.07 (0.06-0.07)
	Carp	2	0.06	5	0.14 (0.08-0.18)
	Channel Catfish	5	0.10	6	0.23 (0.10-0.37)
	Golden Redhorse	7	0.28 (0.22-0.42)	10	0.31 (0.29-0.35)
	Largemouth Bass	**6**	**0.35 (0.15-0.54)**	5	0.31 (0.20-0.49)
	Quillback	3	0.29	2	0.31
	Redbreast Sunfish	8	0.16 (0.13-0.18)	10	0.08 (0.07-0.08)
	Redear Sunfish	6	0.20 (0.16-0.22)	-	-
3	Carp	2	0.08	4	0.12 (0.10-0.13)
	Golden Redhorse	10	0.26 (0.13-0.41)	10	0.22 (0.12-0.27)
	Largemouth Bass	6	0.30 (0.17-0.44)	3	0.32 (0.23-0.36)
	Quillback	-	-	4	0.25 (0.23-0.27)
	Redbreast Sunfish	25	0.09 (0.08-0.10)	22	0.08 (0.06-0.13)
	Smallmouth Bass	4	0.17	3	0.20 (0.16-0.25)
	White Sucker	5	0.12	-	-
4	Bluegill Sunfish	3	0.09	-	-
	Blue Catfish	7	0.23 (0.13-0.44)	-	-
	Carp	4	0.21 (0.17-0.25)	4	0.23 (0.19-0.28)
	Channel Catfish	8	0.13 (0.10-0.16)	10	0.10 (0.06-0.19)
	Flathead Catfish	-	-	1	0.34
	Golden Redhorse	-	-	8	0.19 (0.16-0.23)
	Gizzard Shad	-	-	5	0.30
	Quillback	6	0.18 (0.14-0.21)	-	-
	Redbreast Sunfish	3	0.05	-	-
	Redear Sunfish	2	0.06	1	0.06
	Smallmouth Bass	2	0.22	1	0.16
	Shorthead Redhorse	9	0.18 (0.11-0.28)	3	0.16
	White Bass	2	0.29	2	0.11
	Redhorse Sucker	10	0.11 (0.09-0.15)	-	-
	Walleye	**4**	**0.52 (0.39-0.65)**	-	-
5	Bluegill Sunfish	4	0.07	5	0.09
	Blue Catfish	14	0.29 (0.13-0.45)	**13**	**0.28 (0.18-0.56)**
	Carp	5	0.17 (0.15-0.19)	6	0.24 (0.17-0.29)
	Channel Catfish	6	0.11 (0.08-0.14)	7	0.08 (0.07-0.09)
	Flathead Catfish	**6**	**0.86 (0.63-1.23)**	3	0.35
	Golden Redhorse	1	0.09	8	0.19 (0.14-0.25)
	Largemouth Bass	-	-	2	0.15 (0.15-0.15)
	Redear Sunfish	2	0.12	9	0.07 (0.07-0.08)
	Spotted Bass	2	0.28	3	0.26 (0.13-0.49)
	Shorthead Redhorse	3	0.22	-	-
	White Bass	1	0.22	-	-

Fish that exceeded VDH screening values are in bold and underlined.

Table 2 (part 2): 2014 and 2015 summary of mercury concentrations (mg/kg wet weight), divided by sampling location (site) and fish species.

Site	Fish Species	2014		2015	
		Total Number of Fish Collected	Mercury Concentration average (range)	Total Number of Fish Collected	Mercury Concentration average (range)
6	Bluegill Sunfish	20	0.11 (0.10-0.12)	12	0.11 (0.10-0.12)
	Blue Catfish	-	-	4	0.30 (0.22-0.38)
	Carp	5	0.20 (0.18-0.21)	2	0.16 (0.12-0.19)
	Channel Catfish	9	0.12 (0.11-0.13)	2	0.22 (0.19-0.24)
	Golden Redhorse	3	0.20	10	0.19 (0.14-0.23)
	Largemouth Bass	7	0.31 (0.20-0.39)	7	0.18 (0.13-0.24)
	Redear Sunfish	5	0.07	8	0.11 (0.09-0.13)
	Shorthead Redhorse	10	0.17 (0.11-0.22)	-	-
7	Bluegill Sunfish	15	0.08 (0.08-0.09)	10	0.08 (0.07-0.08)
	Channel Catfish	3	0.22	4	0.08 (0.07-0.08)
	Flathead Catfish	**1**	**0.83**	-	-
	Golden Redhorse	9	0.17 (0.16-0.19)	8	0.16 (0.09-0.24)
	Largemouth Bass	11	0.32 (0.23-0.37)	8	0.23 (0.11-0.46)
	Redear Sunfish	15	0.10 (0.06-0.15)	5	0.10 (0.04-0.13)
	Shorthead Redhorse	6	0.13 (0.12-0.14)	-	-
8	Bluegill Sunfish	-	-	4	0.09
	Blue Catfish	17	0.26 (0.17-0.43)	2	0.16 (0.14-0.18)
	Carp	5	0.24 (0.19-0.29)	2	0.23 (0.20-0.25)
	Channel Catfish	4	0.08	14	0.13 (0.07-0.30)
	Flathead Catfish	**1**	**0.56**	1	0.29
	Golden Redhorse	5	0.13 (0.08-0.18)	10	0.17 (0.07-0.28)
	Largemouth Bass	1	0.19	-	-
	Redbreast Sunfish	3	0.05	-	-
	Redear Sunfish	2	0.06	-	-
	Smallmouth Bass	**1**	**0.71**	-	-
	Spotted Bass	1	0.29	**5**	**0.34 (0.16-0.70)**
	Shorthead Redhorse	-	-	6	0.11 (0.08-0.14)
	White Bass	**1**	**1.25**	5	0.15 (0.14-0.16)
	Walleye	**2**	**0.51**	-	-
9	Channel Catfish	2	0.09	-	-
	Smallmouth Bass	2	0.1	-	-
	Redhorse Sucker	5	0.12 (0.11-0.13)	-	-

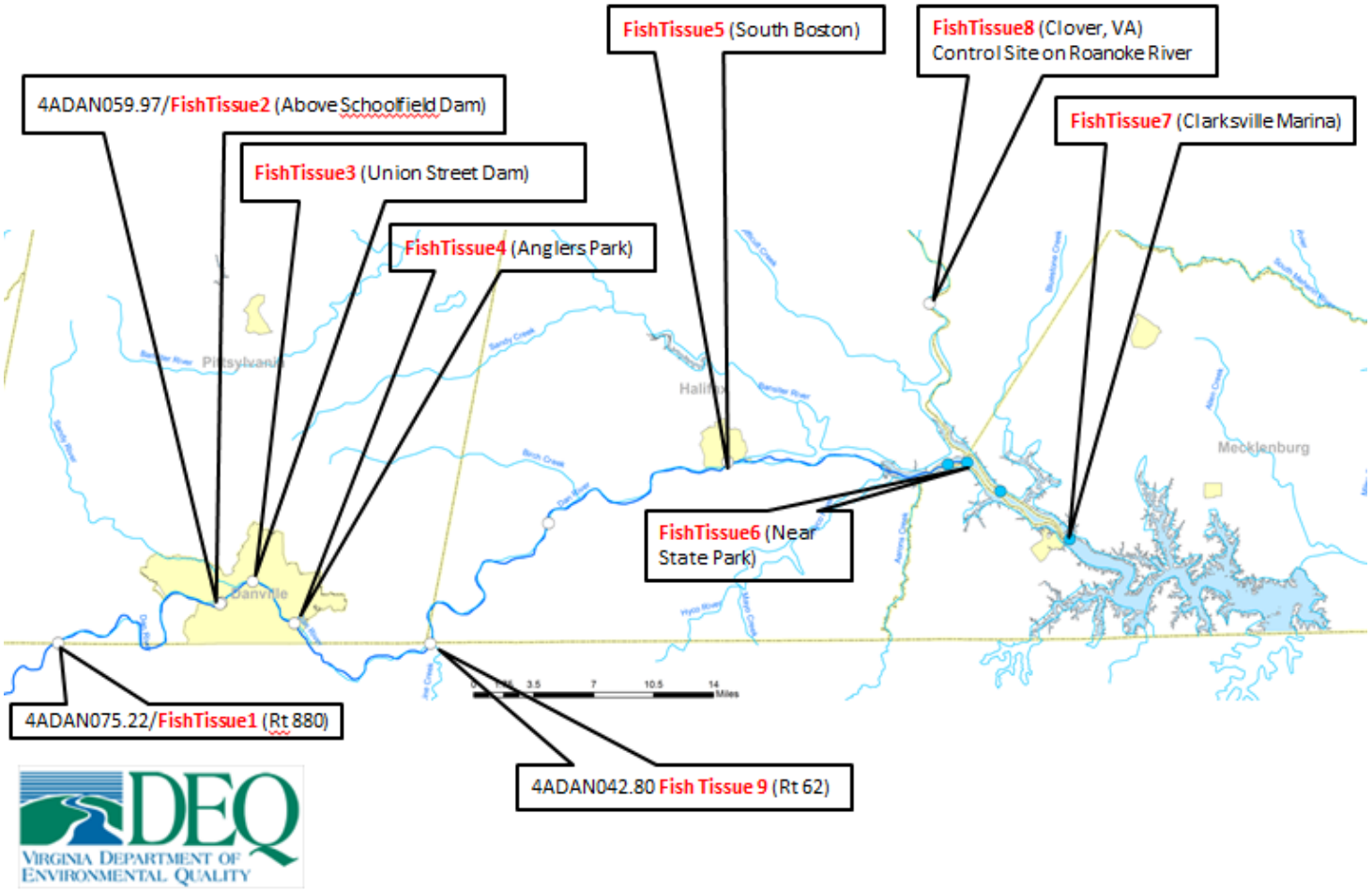
Fish that exceeded VDH screening values are in bold and underlined

Table 3: Summary of heavy metal concentrations in all fish samples from 2014 and 2015, including the number and percent of samples* in which analytes were detected, and the number and percent of samples that exceeded screening values. Metal concentrations are reported as mg/kg wet weight in edible fish tissue.

	Al	Sb	As**	Ba	Be	Cd	Cr	Cu	Pb	Hg	Mn	Ni	Se	Ag	Tl	V	Zn
MDL (mg/kg)	**0.20**	**0.02**	**0.03**	**0.20**	**0.02**	**0.02**	**0.01**	**0.08**	**0.02**	**0.01**	**0.10**	**0.09**	**0.20**	**0.02**	**0.03**	**0.02**	**0.50**
Screening Value (mg/kg)	**5286**	**-**	**1.59 (non-cancer) 0.09 (cancer)**	**-**	**-**	**0.53**	**4.76**	**52**	**-**	**0.50**	**53**	**-**	**26**	**-**	**-**	**-**	**1585**
2014 # samples above MDL	24	0	49	20	0	1	15	156	1	160	110	1	155	40	0	1	160
2014 % samples above MDL	15%	-	30.6%	12.5%	-	0.6%	9.4%	97.5%	0.6%	100%	68.8%	0.6%	96.9%	25%	-	0.6%	100%
2014 min concentration	<0.20	-	<0.03	<0.20	-	<0.02	<0.01	<0.08	<0.02	0.05	<0.10	<0.09	<0.20	<0.02	-	<0.02	2.64
2014 max concentration	0.89	-	0.19	0.43	-	0.04	0.09	1.36	0.03	1.25	2.03	0.10	3.72	0.10	-	0.04	41.70
2014 # samples above SV	-	-	1	-	-	-	-	-	-	13	-	-	-	-	-	-	-
2014 % samples above SV	-	-	0.6%	-	-	-	-	-	-	8.1%	-	-	-	-	-	-	-
2015 # samples above MDL	14	0	36	17	0	0	4	154	0	160	117	0	156	56	0	0	160
2015 % samples above MDL	8.8%	-	22.5%	10.6%	-	-	2.5%	96.3%	-	100%	73.1%	-	97.5%	35%	-	-	100%
2015 min concentration	0.21	-	<0.03	<0.20	-	-	<0.01	<0.08	-	0.03	<0.10	-	<0.20	<0.02	-	<0.02	2.75
2015 max concentration	1.51	-	0.036	0.58	-	-	0.04	1.08	-	0.70	4.02	-	1.51	0.13	-	0.10	17.40
2015 # samples above SV	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-
2015 % samples above SV	-	-	-	-	-	-	-	-	-	1.25%	-	-	-	-	-	-	-

*Some fish collected were analyzed as composite samples. Numbers reflect the number of samples analyzed, not total number of fish.
**The value for arsenic in the table is 20% of the total reported.
*** (-) indicates not applicable
MDL = method detection limit

Figure 1. Map of fish sampling locations.[6]



[6] Provided by DEQ. Personal Communication. January 27, 2017

Figure 2. Current fish consumption advisories for the Dan River.

WATERBODY AND AFFECTED BOUNDARIES	AFFECTED LOCALITIES	CONTAMINANT	SPECIES	ADVISORIES/RESTRICTIONS
Dan River (within the state of Virginia from the Brantley Steam Plant Dam in Danville downstream to the confluence with Roanoke River on John. H. Kerr Reservoir, including its tributaries Hyco River up to Rt. 738 bridge and Banister River up to the Banister Dam. These river segments comprise ~67 miles).	Danville City, Pittsylvania Co., Halifax Co., Mecklenburg Co.	PCBs, Mercury	Flathead Catfish ≥ 32 inches 	**DO NOT EAT**
		PCBs, Mercury	Flathead Catfish < 32 inches 	No more than two meals/ month
		PCBs	Carp 	
		PCBs	Redhorse Sucker 	
		PCBs	Channel Catfish 	
		PCBs, Mercury	Striped Bass 	
		PCBs, Mercury	White Bass 	
		PCBs	White Perch 	
		PCBs, Mercury	Blue Catfish 	
		PCBs	Walleye 	
		PCBs, Mercury	Longnose Gar 	
		Mercury	Largemouth Bass