Surface Water Samples Reviewed for Public Health Implications

Dutch Gap Conservation
CHESTERFIELD, VIRGINIA

Letter Health Consultation

June 15, 2023

Virginia Department of Health
Office of Environmental Health Services
109 Governor Street
Richmond, Virginia 23219

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COMMONWEALTH of VIRGINIA

Department of Health

Karen Shelton, MD
State Health Commissioner

P O BOX 2448
RICHMOND, VA 23218

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

June 15, 2023

Alexander Samuel, M.D.
Chesterfield Health District
9501 Lucy Corr Circle
Chesterfield, VA 23832

BACKGROUND

This letter is in response to questions received by the Chesterfield County Health Department from Chesterfield Department of Conservation and Recreation (DCR) regarding Dutch Gap Conservation. DCR is specifically concerned about people kayaking and swimming in the Dutch Gap Conservation area which contains navigable waters of the James River and is open to the general boating public.

The Virginia Department of Health (VDH) has reviewed information provided in emails from DCR and the Department of Environmental Quality (DEQ). A summary of that information is provided here for you. The Dutch Gap consists of 810 acres of woodlands, wildlife and waterways along the James River. The tidal lagoon of the Dutch Gap Conservation Area is owned by Chesterfield County and is a former gravel pit adjacent to the Dominion Energy Chesterfield Power Station, which is being decommissioned from coal burning operations. There are two large coal fly ash storage ponds immediately adjacent to Dutch Gap Conservation Area that are being removed and remediated as part of this decommissioning. The DEQ, which has issued a Virginia Pollutant Discharge Elimination System permit to Dominion Energy, provided VDH the surface water heavy metals monitoring results circa 2016 and 2017. The highest concentration for each metal is included in Table 1. Children and adults have been observed swimming and kayaking for several hours near old barges in the lagoon.

DISCUSSION

Exposure to heavy metals in the surface water was evaluated using the Agency for Toxic Substances and Disease Registry's (ATSDR) comparison values (CVs). The CV is a concentration based upon toxicological studies of humans and animals that is intended to be well below what might cause health effects and is used as a screening level. Concentrations of chemicals that exceed the CV are evaluated further to determine the potential health risk. CVs used to evaluate contaminants in surface water:

- Reference media evaluation guides (RMEGs) are ATSDR-derived CVs based on non-cancer health effects for chronic exposure duration only. RMEGs represent the concentration in a specific medium (e.g., water or soil) at which daily human exposure is unlikely to result in adverse non-carcinogenic effects.
- Cancer risk evaluation guides (CREGs) are ATSDR-specific CVs that are used to identify concentrations of cancer-causing substances that are unlikely to result in a significant increase of cancer rates in an exposed population. ATSDR develops CREGs using the U.S. Environmental Protection Agency (EPA's) cancer slope factor or inhalation unit risk, a target risk level (10^{-6}), and default exposure assumptions. The target risk level of 10^{-6} represents an estimated risk of 1 excess cancer case in an exposed population of 1 million.
- Environmental media evaluation guides (EMEGs) are ATSDR-specific CVs that are based on ATSDR's MRLs for non-cancer health effects. They represent estimated contaminant concentrations below which humans exposed during a specific timeframe (acute, intermediate, or chronic) are not expected to experience noncarcinogenic health effects.
- Maximum Contaminant Level (MCL) are the highest level of a contaminant that is allowed in drinking water. MCLs are set by the EPA as close to maximum contaminant level goals (MCLGs) as feasible using the best available treatment technology and taking cost into consideration. MCLs are enforceable standards. MCLGs are concentration of contaminants in drinking water below which there is no known or expected risk to health. MCLGs are non-enforceable public health goals.

CV comparisons for most elements analyzed are given in Table 1 below. Only arsenic and cadmium exceeded their CV. ATSDR's public health assessment site tool (PHAST) was used to further evaluate any arsenic and cadmium. PHAST allows VDH to evaluate potential health impacts by calculating site-specific exposure doses.

Table 1. Maximum metals concentrations (circa 2016 and 2017) in surface water compared to CVs.

Contaminant Name	Maximum Site Concentration (ppb)	CV (ppb)	CV Type
Aluminum	451	7,000	Chronic EMEG Child / Intermediate EMEG Child
Antimony	0.32	2.8	RMEG Child
Arsenic	**2.73**	0.016	CREG
Barium	39.6	1,400	Chronic EMEG Child / Intermediate EMEG Child / RMEG Child
Beryllium	1	14	Chronic EMEG Child / RMEG Child
Cadmium	**1**	0.70	Chronic EMEG Child
Chromium	1.44	100	MCL
Copper	1.9	140	Intermediate EMEG Child
Lead	1	15	MCL
Nickel	1.52	140	RMEG Child
Selenium	2.09	35	Chronic EMEG Child / RMEG Child
Silver	0.1	35	RMEG Child
Strontium	109	4,200	RMEG Child
Thallium	0.1	2	MCL
Zinc	4.06	2,100	Chronic EMEG Child / Intermediate EMEG Child / RMEG Child

DEQ (source of concentrations); **Bold face** are concentrations that exceeded one or more CVs; ppb: parts per billion.

There are no ATSDR health-based CVs for six elements: calcium, iron, manganese, magnesium, potassium, and sodium (see Table 2). Iron and manganese exceeded the secondary drinking water standard, which is not a health-based standard but based upon unpleasant flavor or cosmetic effects such as water discoloration. These elements were additionally compared to their Tolerable Upper Limit (UL).[1] The UL for children under 14 years was used for iron, while only an UL for adults was available for calcium and manganese. For all three elements someone consuming a liter of river water would be consuming only a tiny fraction of the UL. There are no ULs set for magnesium, sodium, and potassium for any age group. It is highly unlikely that

[1] From https://ods.od.nih.gov/HealthInformation/nutrientrecommendations.aspx last accessed June 2023.

anyone would incidentally ingest enough surface water at Dutch Gap Conservation area for magnesium, sodium, and potassium to be a health concern.

Table 1. Maximum metals concentrations (circa 2016 and 2017) in surface water compared to alternative standards where no CV is available.

Contaminant Name	Maximum Site Concentration	Alternative Standard	Standard Type
Calcium	26.9 mg/L	2500 mg/d	UL (adults)
Iron	622 µg/L	300 µg/L	Secondary drinking water standard
		40,000 µg/d	UL (children <14 yrs)
Magnesium	4.78 mg/L	N/A	N/A
Manganese	62.7 µg/L	50 µg/L	Secondary drinking water standard
		11,000 µg/d	UL (adults)
Potassium	2.7 mg/L	N/A	N/A
Sodium	15.4 mg/L	N/A	N/A

DEQ (source of concentrations), UL: Tolerable Upper Intake Level; mg/L: milligrams per liter; µg/L: micrograms per liter.

Site-specific exposure doses

Arsenic and cadmium exceeded their CV. This does not mean that there is a health hazard, but that people's exposure to the water needs to be evaluated further to determine if people are ingesting a large enough volume of water over a long enough time to experience health effects. These were evaluated further for exposure of all ages to water during recreation, since the area is used for kayaking and swimming.

Exposure risks were calculated for children aged 1 year to adults. Results for both typical water ingestion rates and reasonable maximum ingestion rates were determined. For cadmium an intermediate duration exposure scenario involving 2 hours of water recreation five days a week for 12 weeks in a year was evaluated. For arsenic, no intermediate health-based reference dose has been set, so an acute 2-hour exposure scenario was evaluated. See Appendix A for more information.

For both arsenic (Table 3) and cadmium (Table 4) the hazard quotient determined was less than 1 for all age groups and for both the typical exposure level and reasonable maximum exposure. A hazard quotient greater than 1 means the recommended maximum dose has been exceeded and a person might experience health risks. A hazard quotient less than one means that no adverse health effects are expected.

Table 3. Swimming: Site-specific combined ingestion and dermal exposure doses for acute exposure to arsenic in surface water at 0.00273 mg/L along with non-cancer hazard quotients*

Exposure Group	CTE Dose (mg/kg/day)	CTE Non-cancer Hazard Quotient	RME Dose (mg/kg/day)	RME Non-cancer Hazard Quotient
1 to < 2 years	2.6E-05	0.0052	6.0E-05	0.012
2 to < 6 years	1.8E-05	0.0035	4.0E-05	0.0080
6 to < 11 years	1.0E-05	0.0021	2.2E-05	0.0045
11 to < 16 years	6.2E-06	0.0012	1.3E-05	0.0026
16 to <21 years	5.1E-06	0.0010	1.1E-05	0.0021
Adult	2.8E-06	0.00055	6.2E-06	0.0012

Abbreviations: CTE = central tendency exposure (typical); mg/kg/day = milligram chemical per kilogram body weight per day; mg/L = milligram chemical per liter water; RME = reasonable maximum exposure (higher) *The calculations in this table were generated using ATSDR's PHAST v2.2.1.0. The non-cancer hazard quotients were calculated using the EPC: 0.0027 mg/L and acute (less than two weeks) minimal risk level of 0.005 mg/kg/day.

Table 4. Swimming: Site-specific combined ingestion and dermal exposure doses for intermediate exposure to cadmium in surface water at 0.001 mg/L along with non-cancer hazard quotients*

Exposure Group	CTE Dose (mg/kg/day)	CTE Non-cancer Hazard Quotient	RME Dose (mg/kg/day)	RME Non-cancer Hazard Quotient
1 to < 2 years	1.9E-05	0.039	2.8E-05	0.057
2 to < 6 years	1.6E-05	0.032	2.2E-05	0.043
6 to < 11 years	1.2E-05	0.024	1.5E-05	0.030
11 to < 16 years	9.2E-06	0.018	1.1E-05	0.022
16 to < 21 years	8.3E-06	0.017	9.7E-06	0.019
Adult	7.4E-06	0.015	8.3E-06	0.017

Abbreviations: CTE = central tendency exposure (typical); mg/kg/day = milligram chemical per kilogram body weight per day; mg/L = milligram chemical per liter water; RME = reasonable maximum exposure (higher) *The calculations in this table were generated using ATSDR's PHAST v2.2.1.0. The non-cancer hazard quotients were calculated using the intermediate (two weeks to less than 1 year) minimal risk level of 0.0005 mg/kg/day.

CONCLUSION

The highest concentrations of metals in surface water collected circa 2016 and 2017 at Dutch Gap Conservation area evaluated by the Virginia Department of Health are not a health concern for swimmers or kayakers ages 1 year old to adult.

RECOMMENDATION

The Virginia Department of Health does not have any recommendations at this time.

Please let me know if you have any questions or concerns with this environmental health assessment or additional information or data to evaluate.

Dwight Flammia, Ph.D.
State Public Health Toxicologist
109 Governor Street Room 616
Richmond, VA 23219
dwight.flammia@vdh.virginia.gov

Amy Hayes, Ph.D.
Health Assessor
109 Governor Street Room 615
Richmond, VA 23219
amy.hayes@vdh.virginia.gov

Appendix A.

PUBLIC HEALTH ASSESSMENT SITE TOOL

Site-specific Parameters Table
PHAST Report, v2.2.1.0, June 2, 2023

Equations

Surface Water Ingestion Exposure Dose Equation

$$D_{noncancer} = (C \times IR \times t_{event} \times EV \times EF_{noncancer}) \div BW \quad \textbf{Equation 1}$$

$D_{noncancer}$ = dose (mg/kg/day), C = contaminant concentration (mg/L), IR = intake rate (L/hr), t_{event} = event duration (hr/event), EV = event frequency (events/day), $EF_{noncancer}$ = exposure factor (unitless), BW = body weight (kg)

Administered Dermal Dose Equation

$$ADD_{noncancer} = (DA_{event} \times SA \times EV \times EF_{noncancer}) \div (BW \times ABS_{GI}) \quad \textbf{Equation 2}$$

$ADD_{noncancer}$ = administered dermal dose (mg/kg/day), DA_{event} = absorbed dose per event (mg/cm^2/event), SA = skin surface area available for contact (cm^2), EV = event frequency (events/day), $EF_{noncancer}$ = exposure factor (unitless), BW = body weight (kg), ABS_{GI} = gastrointestinal absorption factor (unitless)

Hazard Quotient

$$HQ = D_{noncancer} \div HG \quad \textbf{Equation 3}$$

HQ = hazard quotient, $D_{noncancer}$ = dose (mg/kg/day), HG = health guideline (e.g., oral MRL, RfD)

Cancer Risk Equations

$$CR = D_{noncancer} \times CSF \times (ED \div LY) \quad \text{Equation 4}$$

$$\text{ADAF-adjusted } CR = (D_{noncancer} \times CSF) \times (ED \div LY) \times ADAF \quad \text{Equation 5}$$

$$\text{Total } CR = \text{Sum of the CR for all exposure groups} \quad \text{Equation 6}$$

CR = cancer risk (unitless), $D_{noncancer}$ = dose, CSF = oral cancer slope factor [$(mg/kg/day)^{-1}$], EF (cancer) = exposure factor (cancer) calculated as follows: EF (non-cancer; unitless) x exposure group specific exposure duration (years) ÷ lifetime of 78 years, ADAF = age-dependent adjustment factor (unitless), ED = exposure duration (years), LY = lifetime years (78 years)

Site-specific Exposure Factors

Duration Category	Event Duration (hours/event)	Event Frequency (events/day)	Days per Week	Weeks per Year	Years	Exposure Group Specific $EF_{noncancer}$	Exposure Group Specific* EF_{cancer}
Acute	2	1	-	-	-	1	-
Intermediate	2	1	5	12	-	0.71	-
Chronic	NA	NA	NA	NA	NA	NA	= $EF_{noncancer}$ x Exposure Duration for $Cancer_{Exposure\ Group}$ (years) ÷ 78 years

Abbreviations: EF = exposure factor; NC = not calculated

* Cancer risk is averaged over a lifetime of exposure (78 years).

Site-specific Exposure Parameters

Exposure Group	Body Weight (kg)	Exposure Duration (years)	CTE Intake Rate (L/hr)	RME Intake Rate (L/hr)	Custom Intake Rate (L/hr)	Combined Skin Surface Area (cm^2)	Notes
1 to < 2 years	11.4	-	0.0490	0.120	-	5,300	-
2 to < 6 years	17.4	-	0.0490	0.120	-	7,225	-
6 to < 11 years	31.8	-	0.0490	0.120	-	10,800	-
11 to < 16 years	56.8	-	0.0490	0.120	-	15,900	-
16 to < 21 years	71.6	-	0.0490	0.120	-	18,400	-
Total Child (all age groups)	-	0	-	-	-	-	-
Adult	80	-	0.0210	0.0710	-	19,652	-

Abbreviations: cm^2 = centimeters square skin; CTE = central tendency exposure (typical); kg = kilograms; L/hr = liters per hour; RME = reasonable maximum exposure (higher)

Contaminant Information

Contaminant Name	Entered Concentration	EPC Type	Converted Concentration*	ABS_{GI}	DA_{event}
Arsenic	2.73 µg/L	Maximum	0.00273 mg/L	1	5.46E-09 mg/cm²/event
Cadmium	1 µg/L	Maximum	0.001 mg/L	0.05	2E-09 mg/cm²/event

Abbreviations: µg/L = micrograms per liter; ABS_{GI} = gastrointestinal absorption factor; DA_{event} = absorbed dose per event; EPC = exposure point concentration; mg/cm²/event = milligrams per centimeter squared per event; mg/L = milligram chemical per liter water

* Contaminant concentration converted to standard unit for calculating exposure.