Bermuda Institute of Ocean Sciences
17 Biological Station, St. George's GE 01, Bermuda
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Water Tank Sampling, June 2021

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12 August, 2021

- The chemical water quality in rainwater-harvested water tanks was assessed at five residential properties in Bermuda in June 2021 in accordance with the requirements of Belco's Operating License.
- Sample locations were determined by input from Belco and DENR in response to concerns from residents over the potential for drinking water contamination resulting from atmospheric deposition of exhaust emissions on roof surfaces.
- Water samples were analysed for total dissolved solids (TDS) and total suspended solids (TSS), a suite of 31 metals, 21 polycyclic aromatic hydrocarbons (PAHs), and 17 specific congeners of polychlorinated dibenzo dioxins/furans (PCDD/Fs).
- The results were compared with Primary and Secondary Drinking Water Standards in effect in Bermuda and the USA.
- The Secondary Drinking Water Standard for iron (Fe) was exceeded at one of the locations tested.
- No other Drinking Water Standards were exceeded.

1 - Sampling

Sampling was conducted independently by BIOS personnel on 21 June 2021, witnessed by representatives from BELCO and DENR. All water samples were collected from a spigot or faucet located as close to the foot valve as possible, prior to any filtration system. Samples can thus be considered to be representative of tank water supplied to the residence without any effects from plumbing and any subsequent water treatment processes.

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Water was sampled from tanks at the following residences:

Site 1) Bluff Lane

Site 2) St. John's Lane

Site 3) St. John's Road

Site 4) Astwood Close

Site 5) Euclid Avenue

Water was collected in pre-cleaned bottles supplied by the analytical laboratory. Bottles were handled while wearing new nitrile gloves to avoid sample contamination. Sample containers with preservative were filled by manually decanting water from a corresponding clean container.

After filling, sample containers were immediately labelled and double-bagged in PE "zip-lock" bags and stored in coolers with frozen freezer blocks. Samples were transported to the BIOS laboratory and stored in refrigerators at 4°C prior to shipping, for which sample containers were packed in insulated cooler boxes with bubble wrap and freezer blocks that had been frozen at -80°C. Chain of custody forms were completed by BIOS personnel to record all sample information and these were dispatched with the samples. The containers were shipped using FedEx Priority Alert service to ensure that they would be kept refrigerated in the event of any delay during shipping.

All chemical analyses were performed by Bureau Veritas Laboratories, Bedford, Nova Scotia, Canada. BV Labs are accredited by the Standards Council of Canada and conform with the requirements of ISO/IEC 17025:2005. All analytical results from BV Labs were sent in duplicate to BIOS and BELCO.

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Water samples were analysed for total dissolved solids (TDS) and total suspended solids (TSS), a suite of 31 metals, 21 polycyclic aromatic hydrocarbons (PAHs), and 17 specific congeners of polychlorinated dibenzo dioxins/furans (PCDD/Fs).

Results

Analytical results for water from the 5 residences are shown in Table 1 (metals) and Table 2 (PAHs and PCDD/Fs) below. Note that PAHs were present below the detection limits in all samples.

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TDS/TSS and Metals							
	UNITS	SITE 1	SITE 2	SITE 3	SITE 4	SITE 5	RDL
Total Dissolved Solids	mg/L	37	70	31	280	66	1.0
Total Suspended Solids	mg/L	ND	1.4	1.8	ND	ND	1.0
Total Mercury (Hg)	µg/L	ND	ND	ND	ND	ND	0.013
Total Aluminum (Al)	µg/L	17	130	26	6.7	250	5.0
Total Antimony (Sb)	µg/L	ND	1.6	1.3	1.0	ND	1.0
Total Arsenic (As)	µg/L	ND	ND	ND	ND	ND	1.0
Total Barium (Ba)	µg/L	28	4.3	5.8	4.1	8.4	1.0
Total Beryllium (Be)	µg/L	ND	ND	ND	ND	ND	1.0
Total Bismuth (Bi)	µg/L	ND	ND	ND	ND	ND	2.0
Total Boron (B)	µg/L	ND	ND	ND	54	ND	50
Total Cadmium (Cd)	µg/L	ND	0.011	0.066	0.023	ND	0.01
Total Calcium (Ca)	µg/L	8500	17000	21000	80000	13000	100
Total Chromium (Cr)	µg/L	ND	1.1	1.1	1.1	1.5	1.0
Total Cobalt (Co)	µg/L	ND	ND	ND	ND	ND	0.4
Total Copper (Cu)	µg/L	18	90	18	17	8.7	0.5
Total Iron (Fe)	µg/L	100	ND	330	ND	ND	50
Total Lead (Pb)	µg/L	1.0	3.8	4.2	0.64	0.81	0.5
Total Magnesium (Mg)	µg/L	930	1600	1300	3500	1100	100
Total Manganese (Mn)	µg/L	ND	ND	46	ND	ND	2.0
Total Molybdenum (Mo)	µg/L	ND	ND	ND	ND	ND	2.0
Total Nickel (Ni)	µg/L	ND	ND	4.2	ND	ND	2.0
Total Phosphorus (P)	µg/L	ND	ND	ND	ND	ND	100
Total Potassium (K)	µg/L	660	930	820	2500	2500	100
Total Selenium (Se)	µg/L	ND	ND	ND	0.61	ND	0.5
Total Silver (Ag)	µg/L	ND	ND	ND	ND	ND	0.1
Total Sodium (Na)	µg/L	9900	12000	8400	25000	9300	100
Total Strontium (Sr)	µg/L	100	110	320	1500	110	2.0
Total Thallium (Tl)	µg/L	ND	ND	ND	ND	ND	0.1
Total Tin (Sn)	µg/L	ND	ND	ND	ND	ND	2.0
Total Titanium (Ti)	µg/L	ND	ND	ND	ND	ND	2.0
Total Uranium (U)	µg/L	ND	ND	ND	0.67	ND	0.1
Total Vanadium (V)	µg/L	2.9	5.9	4.5	ND	8.3	2.0
Total Zinc (Zn)	µg/L	50	42	610	17	11	5.0

Table 1: Total Dissolved Solids, Total Suspended Solids, and Metals in tank water at five residences in Bermuda. ND = not detected; RDL = Reportable Detection Limit.

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Polycyclic Aromatic Hydrocarbons (PAHs)							
	UNITS	**SITE 1**	**SITE 2**	**SITE 3**	**SITE 4**	**SITE 5**	**RDL/MDL**
1-Methylnaphthalene	µg/L	ND	ND	ND	ND	ND	0.05
2-Methylnaphthalene	µg/L	ND	ND	ND	ND	ND	0.05
Acenaphthene	µg/L	ND	ND	ND	ND	ND	0.01
Acenaphthylene	µg/L	ND	ND	ND	ND	ND	0.01
Anthracene	µg/L	ND	ND	ND	ND	ND	0.01
Benzo(a)anthracene	µg/L	ND	ND	ND	ND	ND	0.01
Benzo(a)pyrene	µg/L	ND	ND	ND	ND	ND	0.01
Benzo(b)fluoranthene	µg/L	ND	ND	ND	ND	ND	0.01
Benzo(b/j)fluoranthene	µg/L	ND	ND	ND	ND	ND	0.02
Benzo(g,h,i)perylene	µg/L	ND	ND	ND	ND	ND	0.01
Benzo(j)fluoranthene	µg/L	ND	ND	ND	ND	ND	0.01
Benzo(k)fluoranthene	µg/L	ND	ND	ND	ND	ND	0.01
Chrysene	µg/L	ND	ND	ND	ND	ND	0.01
Dibenzo(a,h)anthracene	µg/L	ND	ND	ND	ND	ND	0.01
Fluoranthene	µg/L	ND	ND	ND	ND	ND	0.01
Fluorene	µg/L	ND	ND	ND	ND	ND	0.01
Indeno(1,2,3-cd)pyrene	µg/L	ND	ND	ND	ND	ND	0.01
Naphthalene	µg/L	ND	ND	ND	ND	ND	0.2
Perylene	µg/L	ND	ND	ND	ND	ND	0.01
Phenanthrene	µg/L	ND	ND	ND	ND	ND	0.01
Pyrene	µg/L	ND	ND	ND	ND	ND	0.01
Polychlorinated Dibenzo Dioxins/Furans (PCDD/Fs)							
2,3,7,8-Tetra CDD	pg/L	ND	ND	ND	ND	ND	4.00
1,2,3,7,8-Penta CDD	pg/L	ND	ND	ND	ND	ND	4.00
1,2,3,4,7,8-Hexa CDD	pg/L	ND	ND	ND	ND	ND	4.00
1,2,3,6,7,8-Hexa CDD	pg/L	ND	ND	ND	ND	ND	4.00
1,2,3,7,8,9-Hexa CDD	pg/L	ND	ND	ND	ND	ND	4.00
1,2,3,4,6,7,8-Hepta CDD	pg/L	ND	ND	ND	4.44	ND	4.00
Octa CDD	pg/L	ND	ND	1.72	17.6	2.43	8.00
Total Tetra CDD	pg/L	ND	ND	ND	ND	ND	4.00
Total Penta CDD	pg/L	ND	ND	ND	ND	ND	4.00
Total Hexa CDD	pg/L	ND	ND	ND	ND	ND	4.00
Total Hepta CDD	pg/L	ND	ND	ND	4.44	ND	4.00
2,3,7,8-Tetra CDF	pg/L	ND	ND	ND	ND	ND	4.00
1,2,3,7,8-Penta CDF	pg/L	ND	ND	ND	ND	ND	4.00
2,3,4,7,8-Penta CDF	pg/L	ND	ND	ND	ND	ND	4.00
1,2,3,4,7,8-Hexa CDF	pg/L	ND	ND	ND	ND	ND	4.00
1,2,3,6,7,8-Hexa CDF	pg/L	ND	ND	ND	ND	ND	4.00
2,3,4,6,7,8-Hexa CDF	pg/L	ND	ND	ND	ND	ND	4.00
1,2,3,7,8,9-Hexa CDF	pg/L	ND	ND	ND	ND	ND	4.00
1,2,3,4,6,7,8-Hepta CDF	pg/L	ND	ND	ND	3.48	ND	4.00
1,2,3,4,7,8,9-Hepta CDF	pg/L	ND	ND	ND	ND	ND	4.00
Octa CDF	pg/L	ND	ND	ND	9.07	ND	8.00
Total Tetra CDF	pg/L	ND	ND	ND	ND	ND	4.00
Total Penta CDF	pg/L	ND	ND	ND	ND	ND	4.00
Total Hexa CDF	pg/L	ND	ND	ND	ND	ND	4.00
Total Hepta CDF	pg/L	ND	ND	ND	9.14	ND	4.00

Table 2: PAHs and PCDD/Fs in tank water at five residences in Bermuda. ND = not detected; RDL = Reportable Detection Limit (for PAHs); MDL = Methods Detection Limit (for PCDD/Fs).

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These results were compared with the drinking water standards in effect in Bermuda, as legislated by the Department of Health, and also with the US Federal drinking water regulations established by the US Environmental Protection Agency (EPA). Both sets of standards are shown in Table 3 below.

		BERMUDA		USA	
	Units	**Primary Std**	**Secondary Std**	**Primary Std**	**Secondary Std**
Total Dissolved Solids	mg/L		500		500
Total Mercury (Hg)	µg/L	2.0		2.0	
Total Aluminum (Al)	µg/L		200		200
Total Antimony (Sb)	µg/L			6.0	
Total Arsenic (As)	µg/L	10		10	
Total Barium (Ba)	µg/L			2000	
Total Beryllium (Be)	µg/L			4.0	
Total Cadmium (Cd)	µg/L	5.0		5.0	
Total Chromium (Cr)	µg/L	100		100	
Total Copper (Cu)	µg/L		1000	1300*	1000
Total Iron (Fe)	µg/L		300		300
Total Lead (Pb)	µg/L			15*	
Total Manganese (Mn)	µg/L		50		50
Total Selenium (Se)	µg/L	50		50	
Total Silver (Ag)	µg/L		100		100
Total Thallium (Tl)	µg/L			2.0	
Total Uranium (U)	µg/L			30	
Total Zinc (Zn)	µg/L		5000		5000
Benzo(a)pyrene	µg/L			0.2	
2,3,7,8-Tetra CDD	pg/L			30	

Table 3: Drinking water standards in effect in Bermuda and USA. * denotes action level limit - see text for explanation.

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Primary Drinking Water Standards are established to be protective of human health. Exceedance of these values indicates a potential risk from consumption. Under US Federal law, levels of lead (Pb) and copper (Cu) in water are regulated by a Treatment Technique that requires water suppliers to control the corrosiveness of their water. If more than 10 percent of tap water samples exceed the action level, water suppliers must take additional corrective steps.

Secondary Drinking Water Standards are established for protection on aesthetic or taste grounds. Exceedance of these values may cause negative visual and/or taste and odour responses.

Comparison of the data in Tables 1 and 2 with the standards in Table 3 indicate that two Drinking Water Standard was exceeded, each at two different locations location: the Secondary Drinking Water Standard for iron (Fe) of 300 μg/L was exceeded at Site 3 (93 St. John's Road), achieving a level of 330 μg/L; and the Secondary Drinking Water Standard for aluminium (Al) of 200 μg/L was exceeded at Site 5 (3 Euclid Avenue), achieving a level of 250 μg/L.

High concentrations of iron (Fe) in tank water may be indicative of: i) dissolution of rust particles; ii) corrosion of plumbing, pipes, etc. or other fixtures; iii) input from soil (local soil has a high Fe content). Exceedance of the secondary DWS for Fe may result in the tank water developing a metallic taste when consumed and the presence of reddish-brown staining on water fixtures and laundry.

High concentrations of aluminium (Al) may arise from leaching from soil present in the water tank: Al is present at high concentrations in local soil. Consumption of water that exceeds the secondary DWS for Al may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water.