Bermuda Institute of Ocean Sciences
17 Biological Station, St. George's GE 01, Bermuda
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Water Tank Sampling, October 2023

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- The chemical water quality in rainwater-harvested water tanks was assessed at 8 residential properties and two schools in Bermuda in October 2023 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), total suspended solids (TSS), pH, a suite of 31 metals, and a suite of 21 polycyclic aromatic hydrocarbons (PAHs – also called polyaromatic hydrocarbons).
- The results were compared with Primary and Secondary Drinking Water Standards in effect in Bermuda and the USA.
- The Secondary Drinking Water Standard for aluminium (Al) was exceeded at one private residence and the Secondary Drinking Water Standard for iron (Fe) was exceeded at one of the schools. Exceedance of Secondary Drinking Water Standards generally results in aesthetic and cosmetic effects (i.e. appearance, odour, and taste of water) and does not indicate an immediate health risk.
- No other Primary or Secondary Drinking Water Standards were exceeded.

Bermuda Institute of Ocean Sciences
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1 - Sampling

Water sampling was conducted by BIOS personnel on 19 October 2023, 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 and prior to any domestic water treatment processes.

Samples were collected in pre-cleaned bottles supplied by the analytical laboratory. At each location, bottles were handled while wearing new nitrile gloves to avoid sample contamination.

Water was sampled from tanks at the following locations:

Site 1) 7 Euclid Ave

Site 2) Uppington Cres Condominiums

Site 3) Trelawney Ct Condominiums

Site 4) Saltus School

Site 5) Mount Langton Residences

Site 6) 8 Woodlands Rd

Site 7) 99 St. John's Rd

Site 8) 2 St. John's Rd

Site 9) 87 St. John's Rd

Site 10) Berkley School

After filling, sample containers were immediately labelled and double-bagged in polyethylene "zip-lock" bags and kept in coolers with freezer blocks which were frozen at -60°C for 24 hours immediately prior to use. After sampling all sites, the samples were transported immediately to the local courier facility (FedEx) for express shipping to the analytical laboratory. Chain of custody forms were completed by BIOS personnel to record all sample information and these

Bermuda Institute of Ocean Sciences
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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.

Water samples were analysed for total dissolved solids (TDS) and total suspended solids (TSS), water pH, a suite of 31 metals, and a suite of 21 polycyclic aromatic hydrocarbons (PAHs).

Results

Analytical results for water from the 10 locations are shown in Table 2 (inorganics and metals) and Table 3 (PAHs).

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 1, below.

Bermuda Institute of Ocean Sciences
17 Biological Station, St. George's GE 01, Bermuda
T 441 297 1880 F 441 297 8143

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

Bermuda Institute of Ocean Sciences
17 Biological Station, St. George's GE 01, Bermuda
T 441 297 1880 F 441 297 8143

		1	2	3	4	5	6	7	8	9	10	RDL
Inorganics												
Total Dissolved Solids	mg/L	25	35	140	25	45	385	60	95	45	25	10
pH	pH	7.28	8.11	8.13	7.35	7.69	7.65	7.93	9.45	7.91	7.65	n/a
Total Suspended Solids	mg/L	ND	ND	ND	6.2	ND	ND	ND	ND	ND	ND	1.0
Metals												
Total Mercury (Hg)	µg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.013
Total Aluminum (Al)	µg/L	36	21	13	140	140	7	160	210	120	13	5.0
Total Antimony (Sb)	µg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.0
Total Arsenic (As)	µg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.0
Total Barium (Ba)	µg/L	2.6	4.8	1.9	2.1	6	4.9	3.0	3.7	2.1	10.0	1.0
Total Beryllium (Be)	µg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.10
Total Bismuth (Bi)	µg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.0
Total Boron (B)	µg/L	ND	ND	330	ND	ND	64	ND	140	ND	ND	50
Total Cadmium (Cd)	µg/L	0.019	0.012	ND	0.02	ND	0.044	0.03	0.018	0.092	0.011	0.010
Total Calcium (Ca)	µg/L	5100	5400	4100	4700	7800	93000	10000	13000	9100	5400	100
Total Chromium (Cr)	µg/L	ND	ND	ND	ND	ND	1.3	2.5	1.1	ND	ND	1.0
Total Cobalt (Co)	µg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.40
Total Copper (Cu)	µg/L	6	18	ND	7	23	55	25.0	250	6	56	0.50
Total Iron (Fe)	µg/L	ND	71	52	440	82	ND	ND	ND	ND	ND	50
Total Lead (Pb)	µg/L	1.8	1.8	ND	0.9	2.20	2.5	1.6	9.7	0.51	0.92	0.50
Total Magnesium (Mg)	µg/L	550	500	610	580	790	3700	610	600	690	600	100
Total Manganese (Mn)	µg/L	ND	ND	ND	7.8	ND	ND	ND	ND	ND	ND	2.0
Total Molybdenum (Mo)	µg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.0
Total Nickel (Ni)	µg/L	ND	ND	ND	2.1	ND	ND	ND	ND	ND	ND	2.0
Total Phosphorus (P)	µg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	100
Total Potassium (K)	µg/L	290	420	2000	240	580	5300	2200	990	300	1100	100
Total Selenium (Se)	µg/L	ND	ND	ND	ND	ND	1.7	ND	ND	ND	ND	0.50
Total Silver (Ag)	µg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.10
Total Sodium (Na)	µg/L	4700	5500	44000	5200	8700	22000	6300	15000	4700	6300	100
Total Strontium (Sr)	µg/L	25	79	32	36	140	1700	48	88	28	68	2.0
Total Thallium (Tl)	µg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.10
Total Tin (Sn)	µg/L	ND	ND	ND	ND	ND	ND	ND	3	ND	ND	2.0
Total Titanium (Ti)	µg/L	ND	ND	2.3	4	ND	ND	ND	ND	ND	ND	2.0
Total Uranium (U)	µg/L	ND	ND	ND	ND	ND	0.65	ND	ND	ND	ND	0.10
Total Vanadium (V)	µg/L	2.6	ND	ND	3	ND	2.9	13	11	7.8	ND	2.0
Total Zinc (Zn)	µg/L	29	66	110	550	43	52	31	94	110	250.0	5.0

Table 2: Total Dissolved Solids, Total Suspended Solids, pH and Total Metals in tank water at 10 locations in Bermuda, Oct 2023. ND = not detected; RDL = Reportable Detection Limit.

Bermuda Institute of Ocean Sciences
17 Biological Station, St. George's GE 01, Bermuda
T 441 297 1880 F 441 297 8143

		1	2	3	4	5	6	7	8	9	10	RDL
Polyaromatic Hydrocarbons												
1-Methylnaphthalene	µg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.052
2-Methylnaphthalene	µg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.052
Acenaphthene	µg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.010
Acenaphthylene	µg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.010
Anthracene	µg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.010
Benzo(a)anthracene	µg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.010
Benzo(a)pyrene	µg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.010
Benzo(b)fluoranthene	µg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.010
Benzo(b/j)fluoranthene	µg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.021
Benzo(g,h,i)perylene	µg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.010
Benzo(j)fluoranthene	µg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.010
Benzo(k)fluoranthene	µg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.010
Chrysene	µg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.010
Dibenzo(a,h)anthracene	µg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.010
Fluoranthene	µg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.010
Fluorene	µg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.010
Indeno(1,2,3-cd)pyrene	µg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.010
Naphthalene	µg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.208
Perylene	µg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.010
Phenanthrene	µg/L	0.011	0.01	ND	0.011	0.011	ND	ND	0.011	0.013	ND	0.010
Pyrene	µg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.010

Table 3: PAHs in tank water at 10 locations in Bermuda, Oct 2023. ND = not detected; RDL = Reportable Detection Limit (for PAHs).

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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 2 and 3 with the standards in Table 1 indicate two incidences of a Secondary Drinking Water Standard being exceeded:

1) Tank water at one private residence (location 8) exceeded the standard for aluminium (sample concentration 210 μg/L versus a secondary standard of 200 μg/L). High concentrations of aluminium (Al) may arise from soil present in the water tank (Al is naturally present at high concentrations in local soil), or from the corrosion of aluminium fittings located in or close to the roof-tank system.

2) Water from one of the school sites (location 4) exceeded the standard for iron (sample concentration 440 μg/L versus a secondary standard of 300 μg/L). This sample was also observed to be slightly cloudy and recorded the only reported value of suspended solids, suggesting that the tank water is turbid and the observed iron is a result of suspended sediment particles in the water. High concentrations of iron (Fe) in water may be indicative of:
i) dissolution of wind-blown rust particles; ii) corrosion of plumbing, roof fixtures, etc.; iii) input

Bermuda Institute of Ocean Sciences
17 Biological Station, St. George's GE 01, Bermuda
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from soil (local soil naturally 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.