ISS Potable Water Sampling and Chemical Analysis Results for 2016

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This paper continues the annual tradition, at this conference, of summarizing the results of chemical analyses performed on archival potable water samples returned from the International Space Station (ISS). 2016 represented a banner year for life aboard the ISS, including the successful conclusion for 2 crewmembers of a record 1-year mission. Water reclaimed from urine and/or humidity condensate remained the primary source of potable water for the crewmembers of ISS Expeditions 46-50. The year was also marked by the end of a long-standing tradition of U.S. sampling and monitoring of Russian Segment potable water sources. Two water samples, taken during Expedition 46 and returned on Soyuz 44 in March 2016, represented the final Russian Segment samples to be collected and analyzed by the U.S. side. Although anticipated for 2016, a rise in the total organic carbon (TOC) concentration of the product water from the U.S. water processor assembly due to breakthrough of organic contaminants from the system did not materialize, as evidenced by the onboard TOC analyzer and archival sample results.

Nomenclature

DAI	Direct Aqueous Injection
DMSD	Dimethylsilanediol
EPA	Environmental Protection Agency
GC/MS	Gas Chromatography/Mass Spectrometry
HX	Heat Exchanger
IC	Ion Chromatography
ICP/MS	Inductively Coupled Plasma/Mass Spectrometry
ISS	International Space Station
JSC	Johnson Space Center
LC	Liquid Chromatography
LCV	Leuco Crystal Violet

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MCL	Maximum Contaminant Level
MMST	Monomethylsilanediol
MORD	Medical Operations Requirements Document
N/A	Not Applicable
NA	Not Analyzed
NASA	National Aeronautics and Space Administration
NTU	Nephelometric Turbidity Unit
PWD	Potable-Water Dispenser
RL	Reporting Limit
RI	Refractive Index
SRV-K	System for Regeneration of Condensate Water
SVO-ZV	System for Water Storage and Dispensing
SWEG	Spacecraft Water Exposure Guideline
TEC	Toxicology and Environmental Chemistry
THM	Trihalomethanes
TOCA	Total Organic Carbon Analyzer
U.S.	United States
UV-VIS	Ultraviolet-Visible
WPA	Water Processor Assembly

I. Introduction

This paper continues the annual and long-standing tradition, at this conference, of summarizing the results of chemical analyses performed on archival potable water samples returned from the International Space Station (ISS). Analytical results for samples collected in 2016 during Expeditions 46-49 (see Table 1) are presented and discussed herein. Analytical data for samples returned during Expeditions 1-45 have been reported previously[1-14].

The archival-water samples that returned on Soyuz 44-47 vehicles during 2016 were destowed at the landing site in Kazakhstan then turned over to a NASA representative for transportation on a NASA aircraft along with the returning U.S. crews. A representative of the NASA Johnson Space Center (JSC) Toxicology and Environmental Chemistry (TEC) laboratory received all returned samples upon their arrival at Ellington Field in Houston, Texas and delivered them to the JSC laboratory directly for allocation and analysis.

Sample allocation was performed in the laboratory based upon returned sample volume. Samples with sufficient volume received full chemical characterization using the standard and custom analytical methods identified in Table 2, while those with insufficient volume required reductions in sensitivity and/or elimination of some analyses.

Analytical results for the Russian Segment and U.S. Segment water samples were evaluated for compliance with the potable-water quality requirements found in the *ISS Medical Operations Requirement Document* (MORD)[15] and the *System Specification for the ISS* document[16], respectively.

Table 1. Archival Potable Water Samples Returned during Expeditions 46 through 49

Expedition	Flight No.	Samples Received	Sample Type	Sample Collection Date	Sample Receipt Date
46	**Soyuz 44**	1	PWD Ambient	1/25/2016	3/3/2016
		1	PWD Hot	2/2/2016	
		1	SRV-K Hot	2/2/2016	
		1	SVO-ZV	2/2/2016	
	Total:	**4**			
47	**Soyuz 45**	1	PWD Ambient	4/4/2016	6/19/2016
		1	PWD Hot	5/25/2016	
	Total:	**2**			
48	**Soyuz 46**	1	PWD Hot	8/2/2016	9/7/2016
		1	PWD Ambient	8/23/2016	
	Total:	**2**			
49	**Soyuz 47**	1	PWD Hot	9/19/2016	10/31/2016
		1	PWD Ambient	10/18/2016	
	Total:	**2**			

Table 2. Methods for Water Analysis in TEC Laboratory

Method	Parameter
Potentiometric	pH and conductivity
Gravimetric	Total Solids
Nephelometric	Turbidity
Leuco crystal violet (LCV)	Iodine and iodide
Inductively coupled plasma/mass spectrometry (ICP/MS)	Metals/Minerals
Ion chromatography (IC)	Inorganic anions & cations, organic acids and amines
Ultraviolet or heated persulfate oxidation	Total organic carbon (TOC)
Direct injection gas chromatography/mass spectrometry (GC/MS)	Alcohols and glycols
GC/MS with a purge and trap concentrator	Volatile organics
GC/MS after liquid/liquid extraction	Semi-volatile organics
Liquid chromatography (LC) with UV diode array detector	Urea/Caprolactam
GC/MS after derivatization and extraction	Formaldehyde
LC with refractive index detector	Silanols (dimethylsilanediol and monomethylsilanetriol)

II. Background

During 2016 the ISS Expeditions 46-49 crews, including two long-duration crewmembers, relied on recycled water as their primary potable water source. Available onboard water supplies included U.S. Segment potable water recovered from urine distillate and humidity condensate, Russian Segment potable water regenerated from humidity condensate, and Russian ground-supplied potable water.

U.S. Potable Water System

The U.S. Segment water processor assembly (WPA) produces potable water recovered from a combined wastewater feed consisting of humidity condensate and urine distillate. As shown in Figure 1[1], inorganic and organic contaminants are removed using a variety of treatment processes. Although iodine residual biocide is added to the WPA product water prior to storage, it is later removed at the U.S. Potable Water Dispenser (PWD) point-of-use prior to crew consumption. The onboard total organic carbon analyzer (TOCA) monitors total organic carbon (TOC) concentrations in WPA product water directly via hose on a weekly basis and indirectly via bag filled from the PWD on a monthly basis. The WPA, TOCA and PWD have been previously described in detail.[1-14]

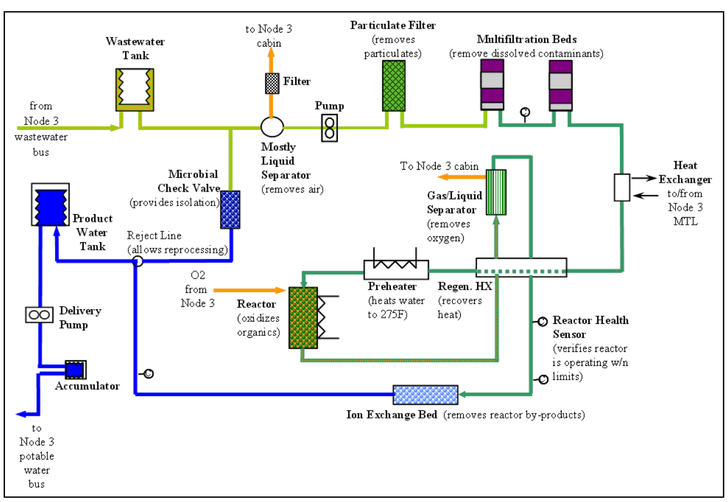

Figure 1 - U.S. Segment Water Processor Assembly (WPA)[1].

Russian Segment Water Systems

The Russian Segment of the ISS provides two separate systems for stored and regenerated potable water. The SRV-K regenerated potable water system removes contaminants from humidity condensate using several treatment processes, and adds silver biocide and minerals to the product water prior to storage. Product water is pasteurized for microbial control and available for crew use from either the hot or warm ports of the SRV-K galley. The SVO-ZV stored water system provides the crews with access to ground-supplied potable water delivered on Russian Progress vehicles at ambient temperature. Both the SRV-K and SVO-ZV water systems have been previously described in detail.[1-14]

III. Discussion of Analytical Results

Tabulations of analytical data for ISS return-water samples collected during Expeditions 46 through 49 from the SRV-K (regenerated), SVO-ZV (stored), and WPA water supplies are presented in Appendices 1, 2, and 3, respectively. Each appendix contains the results of chemical analyses performed by the TEC laboratory at JSC along with the corresponding ISS potability limits for comparison. A discussion of these results chronologically by ISS expedition follows.

Expedition 46

The Expedition 46 crew collected 4 archival potable-water samples from the PWD ambient, PWD hot, SRV-K hot, and SVO-ZV ports during 2016, as detailed in Table 1. These samples were returned on Soyuz 44 and received in the TEC laboratory at JSC on March 3, 2016 for chemical analysis. Due to limited sample volumes, total solids were not measured on any of the samples and turbidity was not measured on the SVO-ZV sample. The long-standing tradition of U.S. sampling and monitoring of Russian Segment potable water sources came to an end during 2016, as the two water samples taken during Expedition 46 represented the final Russian Segment samples to be collected and returned by the U.S. side for analysis.

ISS U.S. Segment

PWD Potable-Water Samples

For the PWD ambient and hot water samples collected on January 25 and February 2, 2016, all chemical parameters measured therein met the U.S. Segment water quality requirements in the *System Specification for the International Space Station,* SSP 41000[16]. Total iodine was not detected (<0.05 mg/L) in either PWD sample, thereby meeting the ISS potability limit at the point of consumption of <0.2 mg/L. The long-term historical trend for total iodine in water produced by the WPA is shown in Figure 2. The measured TOC concentrations were below the method reporting limit (<0.1 mg/L) in PWD ambient and 0.16 mg/L in PWD hot, and well below the ISS potability limit of 3.0 mg/L. As shown in Table 3, the TOC results for Expedition 46 archive samples were consistent with TOC concentrations measured in flight using the Total Organic Carbon Analyzer (TOCA). The long-term historical TOC trend in water produced by the WPA is shown in Figure 3. Full organic characterization was performed per Table 2 but methyl sulfone was the only individual organic target compound detected in the samples (PWD ambient = 89 μg/L, PWD hot = 127 μg/L). Methyl sulfone is considered to be toxicologically insignificant at the levels found.

Table 3. Comparison of In-flight TOCA to Expedition 46 Archive Samples

In-flight TOCA Results			E46 Archive Sample Results		
Date	**Location**	**TOC (mg/L)**	**Date**	**Location**	**TOC (mg/L)**
1/25/16	PWD ambient	<0.285	1/25/16	PWD ambient	<0.10
2/2/16	PWD hot	<0.285	2/2/16	PWD hot	0.16

ISS Russian Segment

SRV-K Potable-Water Sample

For the SRV-K hot water sample collected on February 2, 2016, all chemical parameters measured therein met the Russian Segment water quality requirements in the *ISS Medical Operations Requirements Document* (MORD)[15]. The total silver concentration (36 μg/L) was below the minimum effective biocidal level of 100 μg/L, which may increase the risk of microbial growth in the system. The TOC level measured in the SRV-K sample was 0.25 mg/L, and well below the MORD limit of 20 mg/L. The long-term historical TOC trend in water samples collected from the SRV-K water system is shown in Figure 4. No individual organic target compounds were detected in the SRV-K sample.

SVO-ZV Potable-Water Sample

For the SVO-ZV water sample collected on February 2, 2016, all chemical parameters measured therein met the quality requirements in the ISS MORD[15]. The long-term historical trend for manganese in samples collected from the SVO-ZV water system is shown in Figure 5. The manganese level of 43 µg/L was below the MORD limit of 50 µg/L. The total silver concentration (90 µg/L) was below the minimum effective biocidal level of 100 µg/L, which may increase the risk of microbial growth in the system. The TOC level measured in the sample was 1.14 mg/L, and well below the MORD limit. No individual organic target compounds were detected in the SVO-ZV sample.

Expedition 47

The Expedition 47 crew collected 2 archival potable-water samples from the PWD ambient and hot ports during 2016 (see Table 1). Both samples were returned on Soyuz 45 and received at JSC on June 19, 2016 for chemical analysis. Each sample underwent full chemical characterization per Table 2, except total solids were not measured due to limited volume.

ISS U.S. Segment

PWD Potable-Water Samples

For the PWD ambient and hot water samples collected on April 4 and May 25, 2016, all chemical parameters measured therein met the U.S. Segment water quality requirements in SSP 41000[16]. Total iodine was not detected (<0.05 mg/L) in either sample, thereby meeting the ISS potability limit at the point of consumption (Figure 2). The measured TOC concentrations were 0.11 mg/L in PWD ambient and 0.13 mg/L in PWD hot, and well below the ISS potability limit (Figure 3). As shown in Table 4, the TOC results for Expedition 47 archive samples were consistent with TOC concentrations measured in flight with TOCA. Full organic characterization was performed per Table 2 but methyl sulfone was the only individual organic target compound detected in the samples (PWD ambient = 92 µg/L, PWD hot = 101 µg/L). Methyl sulfone is considered to be toxicologically insignificant at the levels found.

Table 4. Comparison of In-flight TOCA to Expedition 47 Archive Samples

In-flight TOCA Results			E47 Archive Sample Results		
Date	**Location**	**TOC (mg/L)**	**Date**	**Location**	**TOC (mg/L)**
4/4/16	PWD ambient	<0.285	4/4/16	PWD ambient	0.11
5/25/16	PWD hot	<0.285	5/25/16	PWD hot	0.13

Expedition 48

The Expedition 48 crew collected 2 archival potable-water samples from the PWD hot and ambient ports during 2016 (Table 1). Both samples were returned on Soyuz 46 and received at JSC on September 7, 2016 for chemical analysis. Each sample underwent full chemical characterization per Table 2, except total solids were not measured due to limited volume.

ISS U.S. Segment

PWD Potable-Water Samples

For the PWD hot and ambient water samples collected on August 2 and August 23, 2016, all chemical parameters measured therein met the ISS potability limits in SSP 41000[16]. Total iodine was not detected in either sample and thereby met the ISS potability limit at the point of consumption (Figure 2). The measured TOC concentrations were 0.41 mg/L (PWD hot) and 0.31 mg/L (PWD ambient), and well below the ISS potability limit (Figure 3). Although the TOC results for Expedition 48 were higher than those for Expeditions 46 and 47, they were still comparable to TOC concentrations measured in flight with TOCA as shown in Table 5. Methyl sulfone was the only individual organic target compound detected in the samples (PWD hot = 88 µg/L, PWD ambient = 108 µg/L) based upon full organic characterization per Table 2.

Table 5. Comparison of In-flight TOCA to Expedition 48 Archive Samples

In-flight TOCA Results			E48 Archive Sample Results		
Date	**Location**	**TOC (mg/L)**	**Date**	**Location**	**TOC (mg/L)**
8/2/16	PWD hot	<0.285	8/2/16	PWD hot	0.41
8/23/16	PWD ambient	<0.285	8/23/16	PWD ambient	0.31

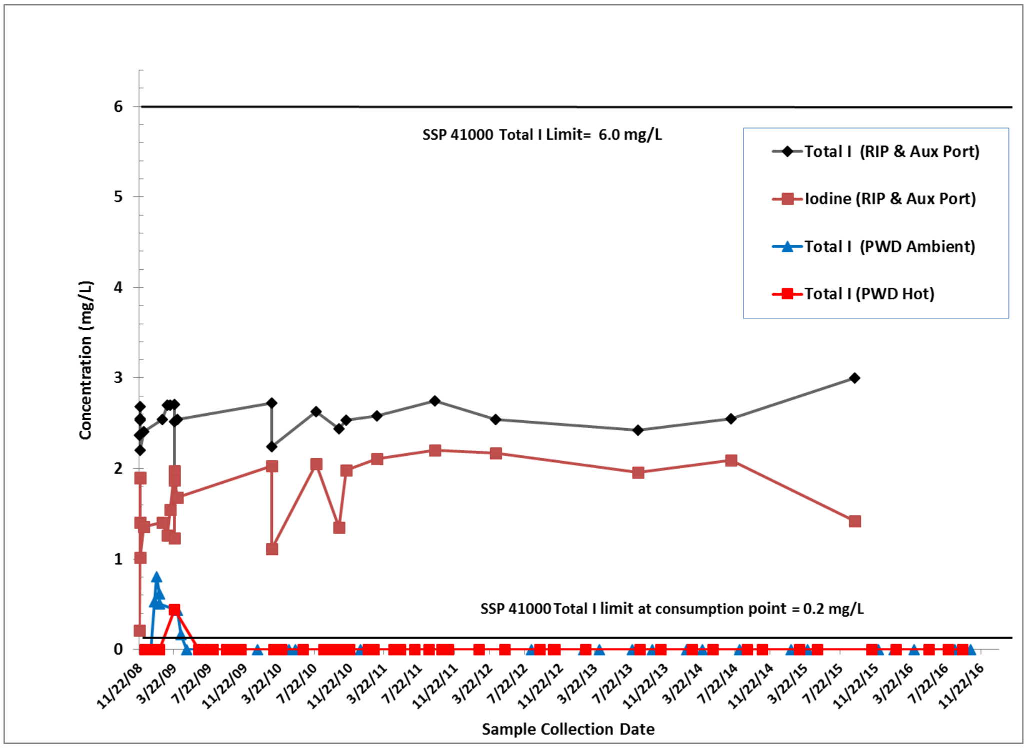

Figure 2 - Total I & iodine levels in WPA archival-water samples from ISS ULF2 to Soyuz 47 [1-14].
2016 data are from Expeditions 46-49

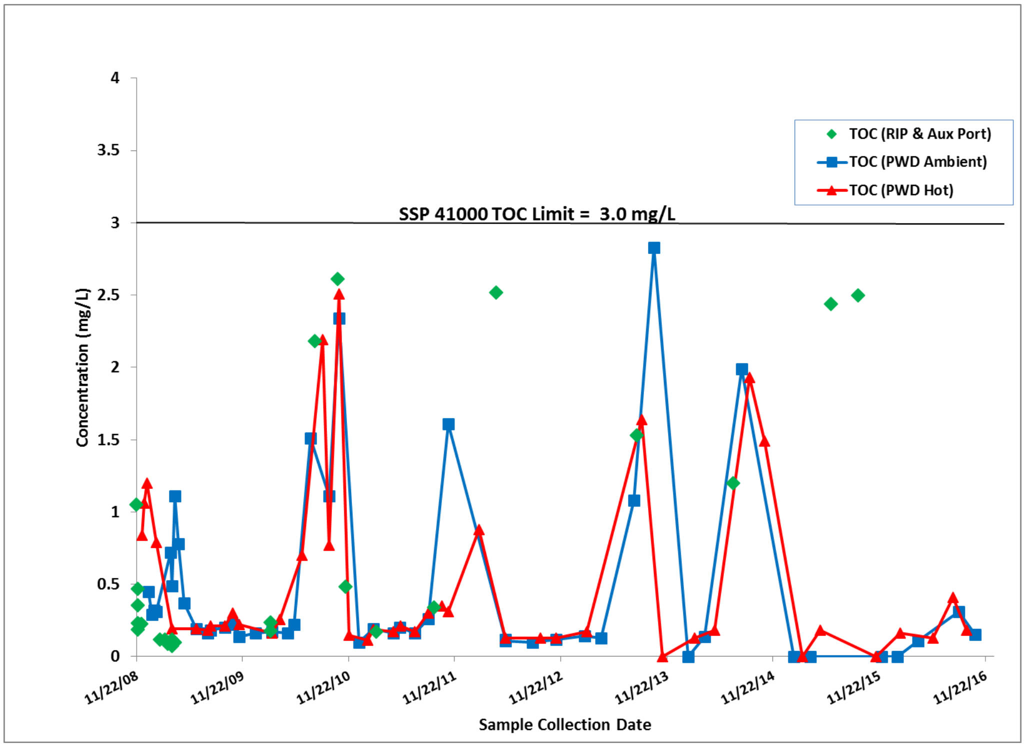

Figure 3 - TOC levels in WPA archival-water samples from ISS ULF2 to Soyuz 47 [1-14].
2016 data are from Expeditions 46-49

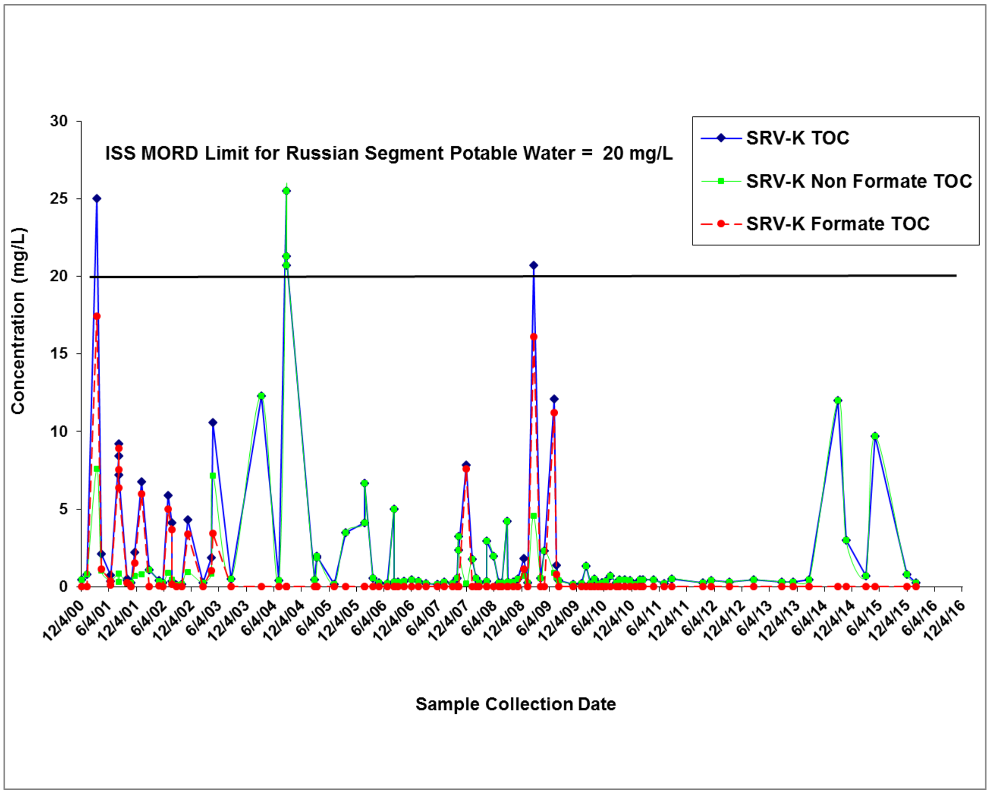

Figure 4 - Total, formate, and nonformate organic carbon levels in SRV-K water samples from ISS Flights 4A to Soyuz 44 [1-14].
2016 data are from Expedition 46

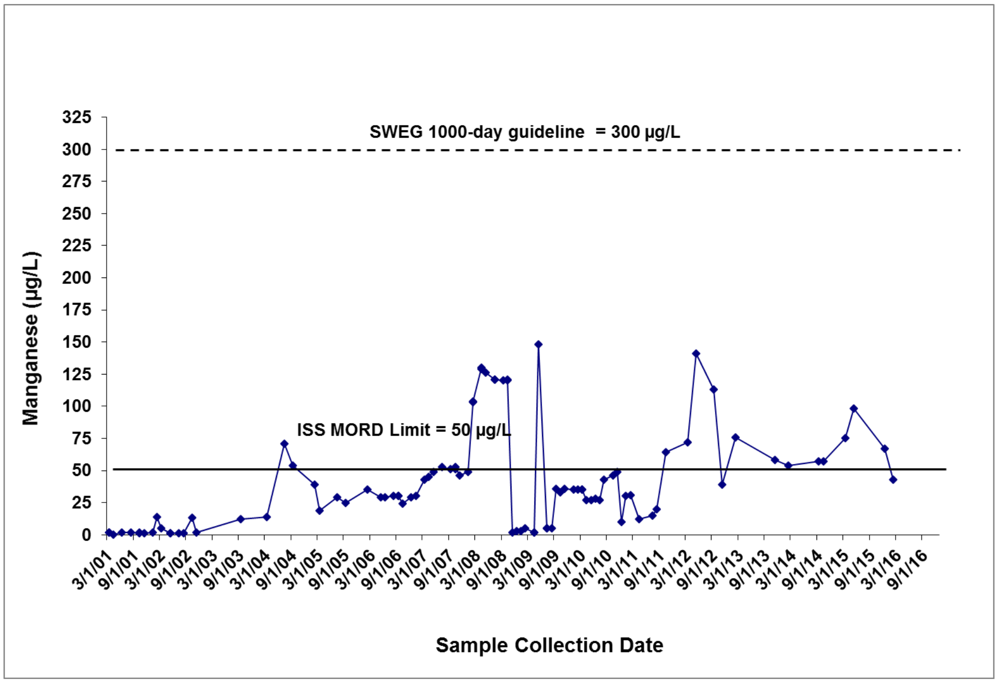

Figure 5 - Manganese levels in SVO-ZV water samples from ISS Flights 5A to Soyuz 44 [1-14].
2016 data are from Expedition 46

Expedition 49

The Expedition 49 crew collected 2 archival potable-water samples from the PWD hot and ambient ports during 2016 as detailed in Table 1. Both samples were returned on Soyuz 47 and received at JSC on October 31, 2016 for chemical analysis. Each sample underwent full chemical characterization per Table 2.

ISS U.S. Segment

PWD Potable-Water Samples

For the PWD hot and ambient water samples collected on September 19 and October 18, 2016, all chemical parameters measured therein met the ISS potability limits in SSP 41000[16]. Total iodine was not detected in either sample and thereby met the ISS potability limit at the point of consumption (Figure 2). The measured TOC concentrations were 0.18 mg/L (PWD hot) and 0.15 mg/L (PWD ambient), and well below the ISS potability limit (Figure 3). The TOC results for Expedition 48 archive samples were comparable to TOC concentrations measured in flight with TOCA as shown in Table 6. Methyl sulfone was again detected in both of the samples (PWD hot = 105 μg/L, PWD ambient = 111 μg/L) based upon full organic characterization per Table 2.

Table 6. Comparison of In-flight TOCA to Expedition 49 Archive Samples

In-flight TOCA Results			E49 Archive Sample Results		
Date	**Location**	**TOC (mg/L)**	**Date**	**Location**	**TOC (mg/L)**
9/19/16	PWD hot	<0.285	9/19/16	PWD hot	0.18
10/18/16	PWD ambient	<0.285	10/18/16	PWD ambient	0.15

IV. Conclusions and Recommendations

Chemical analyses results for PWD samples collected in 2016 and returned on Soyuz flights 44-47 demonstrated that the WPA product water was chemically acceptable for consumption by the ISS Expeditions 46-49 crews. All chemical parameters measured in these archive-water samples met the ISS potability limits. The TOC results for the 2016 archive samples were comparable to those of the in-flight TOCA as shown in Tables 3 through 6, reconfirming the value and necessity of TOCA as a real-time monitor for tracking TOC rises and for planning and scheduling change out of water system consumables. Although anticipated, a rise in the total organic carbon (TOC) concentration of the product water from the WPA due to breakthrough of organic contaminants did not occur in 2016, as evidenced by the onboard TOC analyzer and archival sample results. Continued monitoring of the WPA product water via archive sample return and in-flight TOCA is recommended and essential, as TOCA data from 2017 subsequently demonstrated the onset of the expected TOC rise and the need for scheduling WPA maintenance.

The long-standing tradition of U.S. sampling and monitoring of Russian Segment potable water sources came to an end during 2016. The two samples taken during Expedition 46 represented the final Russian Segment samples to be collected and returned by the U.S. side for analysis. The chemical analyses results for those samples confirmed that the Russian Segment potable water was chemically acceptable for crew consumption. All chemical parameters measured in the samples met the ISS potability limits. Silver biocide levels in both the SRV-K and SVO-ZV samples were below the minimum acceptable biocide level of 100 μg/L, which can increase the risk of microbial growth in those systems. The results also suggested that heating of the water by the pasteurization unit served as the primary means of microbial control in the SRV-K galley.

Appendices

Appendix 1 and Appendix 2 provide the chemical analysis results for archival potable-water samples returned during Expeditions 46-49 of 2016 from the Russian Segment SRV-K (regenerated water) and SVO-ZV (stored water) systems, respectively. Two water samples taken during Expedition 46 represented the final Russian Segment samples to be collected and returned by the U.S. side for analysis. Appendix 3 contains the results for U.S. Segment archival-water samples that were collected and returned in 2016 from the PWD hot and ambient ports.

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Appendix 1. ISS SRV-K Potable Water (Regenerated) Summary of Analytes Detected in Samples Returned from Expedition 46

Mission				**Soyuz 44/Exp. 46**
Sample Location		**Potable Water**		SRV-K Hot
Sample Description		**Maximum Contaminant**	**Maximum Contaminant**	Potable Water
Sample Date		**Level**	**Level**	2/2/2016
Analysis/Sample ID	**Units**	**(MCL)**	**Source**	**20160303004**
Physical Characteristics				
pH	pH units	5.5-9.0	MORD	6.96
Conductivity	µS/cm			41
Turbidity	NTU	1.5*	MORD	<0.4
Total Iodine (LCV) - 0 of 1 target analyte above Reporting Limit (RL)				
Anions/Cations (IC) - 5 of 11 target analytes above RL				
Chloride	mg/L	250	MORD	0.8
Sulfate	mg/L	250	MORD	1.5
Calcium	mg/L	100	MORD	4.23
Magnesium	mg/L	50	MORD	1.71
Sodium	mg/L			0.50
Metals (ICP/MS) - 12 of 23 target analytes above RL				
Calcium	mg/L	100	MORD	4.16
Magnesium	mg/L	50	MORD	1.63
Potassium	mg/L			0.12
Sodium	mg/L			0.48
Aluminum	µg/L			12
Barium	µg/L	1,000/10,000	MORD/SWEG	5
Copper	µg/L	1,000/1,300	MORD/EPA	7
Manganese	µg/L	50/300	MORD/SWEG	19
Nickel	µg/L	100/300	MORD/SWEG	4
Silver	µg/L	500/400	MORD/SWEG	36
Silver, Dissolved	µg/L			25
Zinc	µg/L	5,000/2,000	MORD/SWEG	43
Silicon (ICP/MS)				
Silicon (ICP/MS)	µg/L			106
Total Organic Carbon (Heated persulfate oxidation)				
Inorganic Carbon	mg/L			4.41
Organic Carbon	mg/L	20**	MORD	0.25
Volatile Organics (GC/MS) - 0 of 84 target analytes above RL				
Volatile Organics -Special Interest Compounds (Semi-quantitative) - 0 of 2 target analytes above RL				
Semi-volatiles (GC/MS) - Target List - 0 of 9 target analytes above RL				
Acid Extractables (GC/MS) -EPA 625 List - 0 of 15 target analytes above RL				
Base/Neutral Extractables (GC/MS)- EPA 625 List - 0 of 45 target analytes above RL				
Semi-volatiles- Special Interest Compounds (Semi-quantitative - 2 pt curve) - 0 of 47 target analytes above RL				
Alcohols (DAI/GC/MS) - 0 of 14 target analytes above RL				
Glycols (DAI/GC/MS) - 0 of 2 target analytes above RL				
Silanols (LC/RI) (R & D Method -NIST traceable standard not available) - 0 of 2 target analytes above RL				
Carboxylates (IC) - 0 of 11 target analytes above RL				
Amines (IC) - 0 of 4 target analytes above RL				
Aldehydes (GC/MS) - 0 of 1 target analyte above RL				
Non-volatiles (LC/UV-VIS) - 0 of 2 target analytes above RL				
Organic Carbon Recovery	percent			0.00
Unaccounted Organic Carbon	mg/L			0.25
*MORD limit 1.5 mg/L (Russian method)				
**limit does not include contribution from formate				
SWEG - 1000 days (5-2006)				

Appendix 2. ISS SVO-ZV Potable Water (Stored) Summary of Analytes Detected in Samples Returned from Expedition 46

Mission				Soyuz 44/Exp. 46
Sample Location		Potable Water		SVO-ZV
Sample Description		Maximum Contaminant	Maximum Contaminant	Potable Water
Sample Date		Level	Level	2/2/2016
Analysis/Sample ID	Units	(MCL)	Source	20160303003
Physical Characteristics				
pH	pH units	5.5-9.0	MORD	7.72
Conductivity	µS/cm			310
Turbidity	NTU	1.5*	MORD	NA
Total Iodine (LCV) - 0 of 1 target analyte above Reporting Limit (RL)				
Anions/Cations (IC) - 7 of 11 target analytes above RL				
Chloride	mg/L	250	MORD	10.8
Fluoride	mg/L	1.5/4	MORD/EPA	0.2
Sulfate	mg/L	250	MORD	29.8
Calcium	mg/L	100	MORD	35.1
Magnesium	mg/L	50	MORD	10.8
Potassium	mg/L			3.10
Sodium	mg/L			11.5
Metals (ICP/MS) - 15 of 23 target analytes above RL				
Calcium	mg/L	100	MORD	34.9
Magnesium	mg/L	50	MORD	10.5
Potassium	mg/L			2.92
Sodium	mg/L			11.0
Aluminum	µg/L			183
Arsenic	µg/L	10	MORD/EPA	1
Barium	µg/L	1,000/10,000	MORD/SWEG	25
Copper	µg/L	1,000/1,300	MORD/EPA	1
Iron	µg/L	300	MORD	18
Manganese	µg/L	50/300	MORD/SWEG	43
Molybdenum	µg/L			2
Nickel	µg/L	100/300	MORD/SWEG	9
Silver	µg/L	500/400	MORD/SWEG	90
Silver, Dissolved	µg/L			2
Zinc	µg/L	5,000/2,000	MORD/SWEG	62
Silicon (ICP/MS)				
Silicon (ICP/MS)	µg/L			1,850
Total Organic Carbon (OI)				
Inorganic Carbon	mg/L			27.8
Organic Carbon	mg/L	20**	MORD	1.14
Volatile Organics (GC/MS) - 0 of 84 target analytes above RL				
Volatile Organics -Special Interest Compounds (Semi-quantitative) - 0 of 2 target analytes above RL				
Semi-volatiles (GC/MS) - Target List - 0 of 9 target analytes above RL				
Acid Extractables (GC/MS) -EPA 625 List - 0 of 15 target analytes above RL				
Base/Neutral Extractables (GC/MS)- EPA 625 List - 0 of 45 target analytes above RL				
Semi-volatiles- Special Interest Compounds (Semi-quantitative - 2 pt curve) - 0 of 47 target analytes above RL				
Alcohols (DAI/GC/MS) - 0 of 14 target analytes above RL				
Glycols (DAI/GC/MS) - 0 of 2 target analytes above RL				
Silanols (LC/RI) (R & D Method -NIST traceable standard not available) - 0 of 2 target analytes above RL				
Carboxylates (IC) - 0 of 11 target analytes above RL				
Amines (IC) - 0 of 4 target analytes above RL				
Aldehydes (GC/MS) - 0 of 1 target analyte above RL				
Non-volatiles (LC/UV-VIS) - 0 of 2 target analytes above RL				
Organic Carbon Recovery	percent			0.00
Unaccounted Organic Carbon	mg/L			1.14
NA = not analyzed				
*MORD limit 1.5 mg/L (Russian method)				
**limit does not include contribution from formate				
SWEG - 1000 days (5-2006)				

Appendix 3. ISS WPA - PWD Ambient and Hot Summary of Analytes Detected in Samples Returned from Expeditions 46 through 49

Mission				Soyuz 44/Exp. 46		Soyuz 45/Exp. 47		Soyuz 46/Expedition 48		Soyuz 47/Expedition 49	
Sample Location		Potable Water		WPA PWD Ambient	WPA PWD Hot	WPA PWD Ambient	WPA PWD Hot	WPA PWD Hot	WPA PWD Ambient	WPA PWD Hot	WPA PWD Ambient
Sample Description		Maximum Contaminant	Maximum Contaminant	Potable Water	Potable Water	Potable Water	Potable Water	Potable Water	Potable Water	Potable Water	Potable Water
Sample Date		Level	Level	1/25/2016	2/2/2016	4/4/2016	5/25/2016	8/2/2016	8/23/2016	9/19/2016	10/18/2016
Analysis/Sample ID	Units	(MCL)	Source	20160303001	20160303002	20160620001	20160620002	20160908001	20160908002	20161031001	20161031002
Physical Characteristics											
pH	pH units	4.5-8.5	41000	5.20	5.10	5.86	5.36	5.54	5.34	5.57	5.32
Conductivity	µS/cm			2	2	2	2	2	2	2	2
Turbidity	NTU	1	41000	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Iodine (LCV)											
Total I	mg/L	6/0.2	41000 (tl I max/tl I at pt of consumption)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iodine	mg/L			<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iodide	mg/L			<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Anions/Cations (IC) - 0 of 11 target analytes above Reporting Limit (RL)											
Metals (ICP/MS) - 9 of 22 target analytes above RL											
Calcium	mg/L	30	41000	0.07	<0.01	0.02	0.02	<0.01	<0.01	0.01	0.02
Potassium	mg/L	340	41000	0.02	0.04	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium	mg/L			0.02	0.02	0.02	0.05	<0.01	<0.01	<0.01	<0.01
Aluminum	µg/L			1	<1	2	2	<1	<1	2	2
Barium	µg/L	10,000	SWEG&41000	<1	<1	<1	<1	6	<1	<1	<1
Cadmium	µg/L	22	SWEG&41000	1	<1	<1	<1	<1	<1	<1	<1
Copper	µg/L	1,000	41000	<1	<1	<1	<1	<1	<1	2	<1
Nickel	µg/L	300	SWEG&41000	3	5	3	3	5	<1	4	3
Zinc	µg/L	2,000	SWEG&41000	42	5	2	3	2	2	3	4
Silicon (ICP/MS)											
Silicon (ICP/MS)	µg/L			104	125	78	46	28	25	63	119
Total Organic Carbon (Sievers)											
Inorganic Carbon	mg/L			1.04	1.13	1.03	1.02	1.01	0.99	0.97	0.97
Organic Carbon	mg/L	3	41000	<0.10	0.16	0.11	0.13	0.41	0.31	0.18	0.15
Volatile Organics (GC/MS) - 0 of 84 target analytes above RL											
Volatile Organics -Special Interest Compounds (Semi-quantitative) - 0 of 2 target analytes above RL											
Semi-volatiles (GC/MS) - Target List - 1 of 9 target analytes above RL											
Methyl sulfone	µg/L			89	127	92	101	88	108	105	111
Acid Extractables (GC/MS) -EPA 625 List - 0 of 15 target analytes above RL											
Base/Neutral Extractables (GC/MS)- EPA 625 List - 1 of 45 target analytes above RL											
Diethylphthalate	µg/L			<20	<20	<20	<20	<20	<20	21	<20
Volatile Organics -Special Interest Compounds (Semi-quantitative) - 0 of 2 target analytes above RL											
Alcohols (DAI/GC/MS) - 0 of 14 target analytes above RL											
Glycols (DAI/GC/MS) - 0 of 2 target analytes above RL											
Silanols (LC/RI) (R & D Method -NIST traceable standard not available) - 0 of 2 target analytes above RL											
Carboxylates (IC) - 0 of 11 target analytes above RL											
Amines (IC) - 0 of 4 target analytes above RL											
Aldehydes (GC/MS) - 0 of 1 target analyte above RL											
Non-volatiles (LC/UV-VIS) - 0 of 2 target analytes above RL											
Organic Carbon Recovery	percent			N/A	20.78	20.73	19.24	5.42	8.89	23.21	18.76
Unaccounted Organic Carbon	mg/L			N/A	0.12	0.09	0.11	0.39	0.28	0.13	0.12

SWEG - Spacecraft Water Exposure Guideline
N/A - Not analyzed