Acronym: SWAB

Title: Surface, Water and Air Biocharacterization - A Comprehensive Characterization of Microorganisms and Allergens in Spacecraft Environment

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Increment(s) Assigned: 13, 14, 15, 19, 20

Brief Research Summary (PAO): A Comprehensive Characterization of Microorganisms and Allergens in Spacecraft (SWAB) will use advanced molecular techniques to comprehensively evaluate microbes on board the space station, including pathogens (organisms that may cause disease). It also will track changes in the microbial community as spacecraft visit the station and new station modules are added. This study will allow an assessment of the risk of microbes to the crew and the spacecraft.

Research Summary:

- Previous microbial analysis of spacecraft only identify microorganisms that will grow in culture, omitting greater than 90% of all microorganisms including pathogens such as *Legionella* (the bacterium which causes Legionnaires' disease) and *Cryptosporidium* (a parasite common in contaminated water).

- The incidence of potent allergens, such as dust mites, has never been systematically studied in spacecraft environments and microbial toxins have not been previously monitored.

- This study will use modern molecular techniques to identify microorganisms and allergens. Direct sampling of the ISS allows identification of the microbial communities present, and determination of whether these change or mutate over time.

- SWAB complements the nominal ISS environmental monitoring by providing a comparison of analyses from current media-based and advanced molecular-based technologies.

Detailed Research Description: During long-duration spaceflight, spacecraft build up a diverse array of microorganisms that directly interacts with the crew of the vehicle. Most microorganisms are harmless or even beneficial to the crew; however, the presence of medically significant organisms appearing in this environment could adversely affect crew health and performance during long duration missions. The primary goal of this experiment is to use advanced technologies to better understand the types of organisms that the crew could encounter, their sources, and assess the potential risks.

This study of microorganisms, allergens, and microbial toxins in the spacecraft environment was initiated to ensure the health, safety, and performance of crewmembers during flight. All previous methods evaluating spacecraft ecology have utilized culture-based methodology, thus many organisms have been omitted from isolation, including medically significant organisms, such as the pathogen *Legionella* (the bacteria that causes Legionnaire's disease). Likewise, culturable bacteria and fungi have been the only potential allergens studied; the more potent allergens, such as dust mites, have never been analyzed in spacecraft environments. This study utilizes modern molecular biology, advanced microscopy, and immunochemical techniques to examine air, surface, and water samples for bacteria and fungi, pathogenic protozoa, allergens, and microbial toxins.

To accomplish this goal, new collection techniques have been developed to improve the quality of the sample being returned from ISS for analysis. Air samples are being collected through a novel gelatin filter to improve collection efficiency. These filters can retain particles as small as viruses. Water and surface samples have been designed to improve DNA recovery using a DNA preservative that is composed of a mixture of SDS and EDTA in Tris buffer.

Analysis of the in-flight samples will focus around molecular techniques. These include bacterial fingerprinting, bacterial and fungal ribosomal identification, and quantitative PCR to identify and enumerate specific genes in environmental samples. The identification of specific genes is critical in the assessment of microorganisms for particular characteristics, including the production of microbial toxins. The samples returned from flight will also be evaluated using denaturing gradient gel electrophoresis (DGGE), a technique that allows identification of the bacteria without any amplification of the organisms with growth on media. This technique holds the potential to increase the number of different identified species by 100 fold.

Project Type: Payload

Images and Captions:

NASA Image: ISS010E11563 - An example of contamination that has developed on one of the interior panels aboard ISS. This image shows how contamination can form on interior ISS surfaces. Crews have weekly sessions to clean ISS surfaces. SWAB will help us understand the microbes involved in contamination and how to deal with them.

The air sampling device used for the SWAB experiment, which collects air through a gelatin filter and can retain particles as small as viruses. Image courtesy of NASA.

Dust mites collected on a previous human spaceflight.

NASA Images ISS011E09993 and ISS006E27228 - Crew routinely sample air, water, and surfaces on ISS for bacteria and molds to monitor the effectiveness of cleaning and disinfection activities. Many key organisms that could cause infection cannot be cultured using these methods. The SWAB investigation will take a variety of samples before and after visiting flights to ISS.

NASA Image: ISS013E80083 - Expedition 13 European Astronaut Thomas Reiter collects surface samples for the SWAB experiment prior to the arrival of STS-115.

NASA Image: ISS013E80070 - Expedition 13 ESA Astronaut Thomas Reiter prepares the air sampler to take samples for the SWAB experiment prior to the arrival of STS-115.

NASA Image: ISS015E07583 - Expeditions 14 and 15 Astronaut and Flight Engineer (FE-2), Sunita

Williams, during setup for the Surface, Water and Air Biocharacterization (SWAB) experiment in the U.S. Laboratory/Destiny.

NASA Image: ISS0515E07586 - Astronaut Sunita L. Williams, Expeditions 14 and 15 flight engineer, conducts a Surface, Water and Air Biocharacterization (SWAB) air sampling in the Destiny laboratory of the International Space Station.

Operations Location: ISS Inflight

Brief Research Operations:

- Each new ISS module and visiting vehicle is sampled prior to launch to develop a baseline of contamination. A set of collections is done each time a new vehicle docks, for a total of eight dockings. Each set of collections consists of four air samples, twelve surface samples and two water samples.

- Once returned to Earth, modern molecular biology, advanced microscopy, and immunochemical techniques will be applied to these samples to identify bacteria and fungi (total composition and specific pathogens), pathogenic protozoa, specific allergens, and microbial toxins.

Operational Requirements: The SWAB flight hardware requires no station power. Only the air sampler will require battery power. The new collection techniques are designed to require approximately the same amount of time as the current environmental monitoring, approximately 240 minutes. Data is recorded on the archival bags and no biohazardous trash is created.

Operational Protocols: Preflight surface, water, and air samples will be collected from all launch vehicles and ISS modules traveling to ISS and will be obtained by PI team. Air and surface samples are collected from a diverse range of locations in the vehicle or module at L-15 or 15-20 days prior to hatch closure. A mixture of new locations and previously sampled locations will be selected on a case-by-case basis determined by the PI team. Preflight water samples from the water delivery vehicle are to be collected at approximately L-15. Collection of in-flight air and surface samples from ISS will occur prior to every vehicle docking to ISS during the life of the SWAB Experiment. Four air samples and 12 surface samples will be collected during each collection session. Any surface condensate will be collected, if available. The SWAB Return Kit containing in-flight samples will return on each subsequent Shuttle flight.The time, humidity, and temperature of the ISS shall be monitored during the in-flight operations. Two water-samples (one hot and one ambient) will be obtained every 4 weeks from the Potable Water Dispenser (PWD) scheduled to be added to ISS in September of 2008.

Category: Human Research and Countermeasure Development for Exploration

Subcategory: Microbiology in the Space Environment

Space Applications: Knowing the microorganisms that the crew will encounter is crucial in assessing the risk to the health of the crew and performance of the spacecraft systems. By studying the types of organisms and the change in this ecosystem over time, preventative and disinfection regiments can be developed to mitigate the accumulation of medically significant organisms or microorganisms that could foul filters or degrade components of the spacecraft.

Earth Applications: The results of this study will provide insight into changes that occur in the microbial ecology of semi-closed systems. The development of specific primers for bacterial enumeration and fungal identification during this study will also advance the ability of ground-based investigators to diagnose the potential sources of microbial contamination and give insight into the causes of health related microbial contamination issues such as "sick building syndrome."

Manifest Status: Completed

Supporting Organization: Exploration Systems Mission Directorate (ESMD)

Previous Missions: SWAB has been previously performed on ISS Expedition 13.

Results: The focus of the research, thus far, has been on ground-based studies to prepare for sample collection, processing, and analysis. Due to limitations on time and refrigeration during flight, the goal of the sampling research was to determine methods to minimize bacterial growth and protein activity after sample collection in order to retain the DNA of all constituents of the sample. A mixture of SDS and EDTA in Tris buffer was developed that had protective capabilities for the microbial DNA that will be transported from ISS for at least 6 months. Because of the potential of limited DNA in a given sample, ground studies have also focused on DNA extraction techniques that would be acceptable and efficient for bacterial, fungal, and viral analysis.

The ground-based research also focused on optimizing the flight hardware for preflight and ISS sample collection. The hardware has passed Critical Design Review with only minimal backup testing required. The engineering expertise of the JSC support team has reconfigured the ASD air sampler for flight use with minimal changes. An association with Charm Sciences, Inc. has led to the development of a custom surface sampling swab that contains the SDS - EDTA solution for DNA preservation. In addition, specialized water collection bags that are modification of the current ISS water collection bags, have been developed to release the SDS-EDTA solution into the bag without risking contact with the crew. Previous relationships with Russian colleagues at Energia and the Institute of Biomedical Problems helped to incorporate the International Partners and their ISS components into this study.

Related Publications:
Castro VA, Thrasher AN, Healy M, Ott CM, Pierson DL. Microbial characterization during the early habitation of the International Space Station. Microbial Ecology. 2004 ;47:119-126.

Song B, Leff LG. Identification and Characterization of Bacterial Isolates form the Mir Space Station. Microbiological Research. 2005 ;160:111-117.

Ott CM, Bruce RJ, Pierson DL. Microbial Characterization of Free Floating Condensate Aboard the Mir Space Station. Microbial Ecology. 2004 ;47:133-136.

Web Sites:
Science@NASA - Preventing "Sick" Spaceships

Related Payload(s): ANITA, DAFT