How clean is the International Space Station?

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The International Space Station with the Space Shuttle Atlantis docked on the right and a Russian Soyuz on the far left in 2011.

State-of-the-art molecular analysis of dust samples from the International Space Station (ISS) has been employed to reveal new information about some of the potential bacterial agents present in the astronauts' space environment. The research, published in the open access journal *Microbiome*, reported presence of the opportunistic bacterial pathogens that are mostly innocuous on Earth but can lead to infections that result in inflammations or skin irritations. The findings of this study help NASA establish a baseline for monitoring the cleanliness of the ISS, which will in turn help manage astronaut health in the future. However, since the study is based on genetic analysis, it could not conclude whether these bacteria are harmful to astronaut health.

The ISS is a unique built environment, experiencing microgravity, space radiation and elevated carbon dioxide, and constant presence of humans. Understanding the nature of the communities of microbes—the microbiome—in the ISS is key to managing astronaut health and maintenance of ISS equipment.

Traditional microbiology techniques, which culture bacteria and fungi in the lab, have previously been used to assess the composition of this community. Now scientists from NASA's Jet Propulsion Laboratory have used the latest DNA sequencing technologies to rapidly and precisely identify the microorganisms present on the ISS, filling in the gaps left by traditional methods, and highlighting pathogens that may pose a threat to astronauts.

The team collected air filter samples and vacuum bag dust from the ISS. They then compared these samples with dust from NASA 'cleanrooms', environmentally controlled and closed built spaces on Earth. Key differences between the cleanrooms and the ISS are the cleanrooms circulate fresh air while the ISS filters and recirculates air, and the ISS is inhabited continuously with only six people while 50 people may be in a cleanrooms in a day but not inhabit it continuously. Whilst these Earth cleanrooms are not air-tight, they have several layers of rooms that would prevent free exchange of air particulates.

The researchers analyzed the samples for microorganisms, and then stained their cells with a dye to determine whether they were living or dead. This enabled them to measure the size and diversity of viable bacterial and fungal populations, and determine how closely the conditions in the Earth cleanrooms compare with the ISS environment.

Their results show that Actinobacteria, a type of bacteria associated with human skin, made up a larger proportion of the microbial community in the ISS than in the cleanrooms, which the authors conclude could be due to the more stringent cleaning regimes possible on Earth.

Two groups of opportunistic pathogens that can lead to infections were also found in the ISS dust samples, but the research did not address the virulence of these pathogens in closed environments or the risk of infection to astronauts.

Lead author of the study, Kasthuri Venkateswaran, said: "By using both traditional and state-of-the-art molecular analysis techniques we can build a clearer picture of the International Space Station's microbial community, helping to spot bacterial agents that may damage equipment or threaten astronaut health, and identify areas in need of more stringent cleaning."

The authors also highlight how these newer DNA sequencing technologies can be used to study the impact of microgravity on the stability of the ISS's microbial community, which will be important for long-duration missions, such as NASA's journey to Mars.

More information: Aleksandra Checinska et al. Microbiomes of the dust particles collected from the International Space Station and Spacecraft Assembly Facilities, *Microbiome* (2015). DOI: 10.1186/s40168-015-0116-3

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