Microbial Ecology of NASA Curation Clean Rooms

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Clean room standards like ISO 14644 [1] used for facilities that construct spacecraft and store returned samples do not explicitly account for microbial contamination. While there are associated ISO standards for monitoring and controlling bio-contamination in clean rooms [2][2] it is not always standard practice to do so. The NASA Astromaterials Acquisition and Curation Office maintains seven separate clean labs for storing extraterrestrial samples from the Moon, meteorites, cosmic dust, asteroids, comets, solar wind particles, and microparticle impact samples. These labs are routinely monitored for particulate and trace metal contamination. However, the sample collections are either non-sterile at the time of collection (e.g., meteorites) or are no longer being used to address scientific questions that could be affected by non-sterile conditions (e.g., Lunar samples). Outside of isolated studies[3] there has not been a systematic, longitudinal characterization of the microbial ecology of NASA curation clean rooms. In accordance with the advanced curation initiative[4], and to prepare for future sample return missions, we have initiated a routine microbiological monitoring program in the Antarctic Meteorite Lab. This monitoring program will be used to determine what microbes are capable of surviving in these oligotrophic environments and whether or not they are capable of altering the sample collections in any significant manner. Repeat sampling will allow us to understand how routine use of these labs affects the microbial ecology over time.

We chose to begin our investigation in the Meteorite Lab because it has a lower ISO cleanliness standard (ISO 7) than most of the curation labs (ISO 6 – ISO 5) and therefore is likely to contain a higher bio-burden that we can sample without decreasing the cleanliness level of the lab. Additionally, most of the meteorites were collected from Antarctica and have been exposed to the terrestrial environment for thousands of years. Thus, it is possible that some of the organisms in this lab are transplants from the Antarctic environment. As we establish a routine sampling protocol that does not affect sample integrity we will extend our sampling efforts to the ISO 4-6 labs with a special focus on the Lunar Lab.

Preliminary results from the Meteorite Lab indicate that fungi may play a larger role in clean room ecology than previously recognized. Although overall counts were comparable to other cleanroom assessments, fungal colonies comprised 83-97% of the isolates from Meteorite Lab samples. This result is especially interesting since many fungal species are capable of producing amino acids like Aib (α-aminoisobutryic acid) and Iva (isovaline) that are often considered to be extra-terrestrial when identified in meteorites[5,6]. Curation facilities for the upcoming OSIRIS-REx and Hayabusa2 missions will be carefully monitored for fungal contamination to avoid inadvertent alteration of pristine carbonaceous asteroid samples.

We will present culture-based and culture-independent time-series data from several NASA curation clean rooms that demonstrate how routine usage affects the microbial ecology. The results of this work will inform astrobiology and Planetary Protection efforts for upcoming missions.

References

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