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Marvels of Fungi 4

Fungi as Astronauts

Microorganisms are natural constituents of the environment and exist in air, water, soil and various biotic systems. Microbes readily adapt to changes in environmental variables such as nutrient levels, temperatures, O_2 concentrations, atmospheric pressure and light intensity and exhibit a variety of physiological and morphological changes. Recently space biologists have become interested about the effects of zero- gravity (µg) o n microbial growth, physiology, molecular biology and pathogenicity behaviors of microbes in International Space station (ISS).

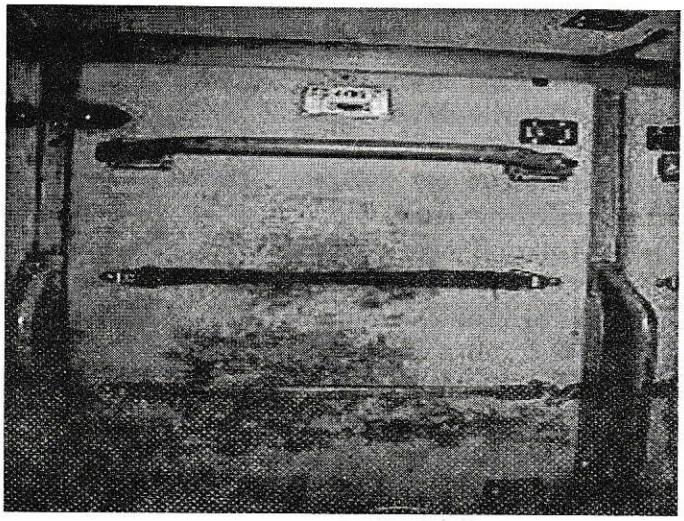
Microorganisms are introduced into the spacecraft through several avenues. Crew members are primary source of microbes in confined space habitats as the apparently healthy human body can host approximately 50 species of fungi and bacteria. Biological payloads, resupply vehicles, hardware components of the vehicle and supply loads from earth provide additional sources of microbiota. The US and Russian space programs have performed many studies of the effects of space flights on crew members and microorganisms both residential of the spacecraft and selected experimental species of fungi and bacteria.

Because all earth organisms including the microbes have evolved in a 1g environment, the microgravity conditions of space flights may result in alterations of cell structures and metabolic processes. Studies of effects of space flights on microbial physiology, human-physiology and microbial ecology especially the nature of the host-microbe interactions in this unique habitat have generated voluminous data. The effects of space flight on microbial growth rate have shown a general tendency towards increased cell growth, biomass production and increased of growth kinetics. Several studies have suggested space flight induced in microbial physiology such as decreased antibiotic susceptibility. Thus, *Neisseria meningitides* showed a 21% increase in resistance to the antibiotic Sulfadiazine in an experiment conducted in *Mir* program of Russia. Other studies showed changes in circadian rhythms, changes in metabolic processes and even genetic alteration. Several bacteria have shown phage induction during space flight suggesting increased activity of dormant viruses. In a recent study it has been found that astronaught's immune systems especially the leucocytes decrease during long-duration missions. Immunity changes during space flights make astronauts more vulnerable to infections. NASA research in 2004 showed that the pattern of gene activity in some microbes differs in µg conditions. It has been found that the common food borne pathogen Salmonella becomes more virulent and more resistant to drugs when grown in weightlessness conditions. This quite alarming for the astronauts whose immune systems both cellular and immunochemical are functioning below normal capacity. To keep astronauts healthy and to better understand microbial infection in general, scientists want to know exactly which genes are affected by microgravity and why these genes are changed?
Several fungi have been used as test organisms to find out whether their ability to produce antibiotics, anticancer, anti-cholesterol and immunosuppressant drugs, fermentation of alcohol and many other useful products in micro-gravity condition of ISS remains unaltered or altered as compared with that of the gravity condition of earth (1g). The main fungal species studied were *Ulocladium chartarum, Alternaria chartarum,* which causes bio-deterioration of organic and inorganic materials of the spacecraft and suspected to be a possible contaminant in spacecraft. Other species studied were *Aspergillus niger* which is of industrial importance because 99 percent of global commercial citric acid fermentation; *Cladosporium herbarum* which is the predominant mold spore in air and also grows on dead herbaceous and woody plants, textiles, rubber, paper, and foodstuffs of all kinds; and *Basipetospora halophila,* that is an extremophile for salt.

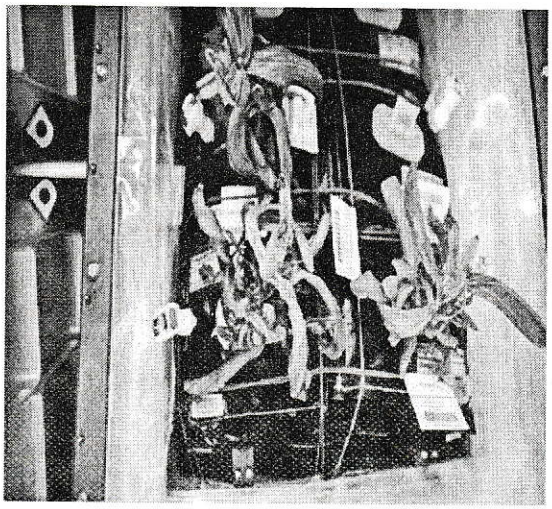
Ulocladium chartarum and other fungal species can grow invasively unnoticed in the depth of surfaces containing very small amount of substrate posing a risk factor for biodegradation of structural components by production of acid and probably is a contaminant from earth. It is also a direct threat for crew health. *Candida albicans* is found in 80% of human's skin, the oral cavity, gastro-intestinal and uro-genital tracts of both men and women. In ISS, this weak pathogen showed increase in pathogenicity and resistance against the antifungal drugs. Moreover, the astronauts showed substantial decrease in immunity to diseases after prolonged stay in ISS.

Growth, sporulation, and metabolic activities of the selected filamentous fungi during space flight in ISS were investigated with appropriate controls in earth. It has been found that in ISS, aerial mycelium was less and majority of mycelia were submerged and sporulation was mostly on submerged hyphae. The mushroom fungus *Coprinus cinereous* fruit body production was normal like earth, but stalk of mushroom was more elongated than earth controls. The mushroom fungus *Pleurotus* (many species) has the capacity of quick production of large amount of food and capable of decomposition of the lignocellulosic wastes in the space and has potency of cultivation in long space flights.

In 2016, NASA scientists proclaimed that two extremophile fungi *Cryomyces antarcticus* and *Cryomyces minteri* of Antarctica soil (McMurdo Dry Valleys — one of the most Mars-like environments on Earth) can survive in simulated Mars conditions in ISS for more than 18 months. More interesting is the finding that some fungi (yet to be properly identified) can grow on the surface body of space station and can tolerate high dosage of cosmic radiation. A new machine has been installed in ISS for DNA sequencing of the Space microbes *in situ* in space (especially the new ones growing on outer surface) so that they can be properly identified *in situ.*



Mold growing on a panel of the ISS where exercise clothes were hung to dry. Credit : NASA



Moldy lettuce grown aboard the ISS as part of The Veggie plant growth facility. Credit: NASA

(All data collected from NASA Space biology especially Space Mycology reports and is gratefully acknowledged. India is now a prominent participant in conducting space flights. The space biology is a new area of study and the Space Mycology would be of great interest to our students of Mycology in India)

Collected by
Prof. K.R.Samaddar
Kalyani University
Kalyani 741235, West Bengal
(krs_kly@yahoo.com)