Closed environments and microbiology: Research challenges and application potential on Earth

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Microbiology in closed environments

Space missions have become longer and more complex:
- **ISS**
- lunar habitat
- manned mission to NEO
- manned mission to Mars

The closed environment of a spacecraft on a long-term manned mission or a planetary habitat is a very special environment for microorganisms with a direct or indirect impact on the health, safety or performance of astronauts.
Microbiology in closed environments

Microorganisms can assist

- waste management
- air recycling
- water recycling
- food production
- medicine production
- manufacture of products.

Microorganisms are a hazard

- damaging food supplies
- damaging the spacecraft structure
- damaging the spacecraft systems
- causing sickness among the crew.
The Mars 500 experiment MICHA: Microbial ecology of confined habitats

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Aim of the MICHA project

- Study of the microbial bioburden and biodiversity in different biotopes in confined environments
- Characterization of the evolution of microbial communities in confined environments in view of long-term manned space flight
- Testing of new microbial and nutraceutical products to support the human intestinal microflora (UNITUS)
- Testing of new eco-compatible microbial products to prevent biocontamination of space materials (UNITUS)
- Testing the resistance of selected spore-forming and/or heat-tolerant microbes in confined environment with respect to planetary protection requirements
Sampling program and sample collection

- Sampling of crew, surfaces and air

- Samples are taken by the crew members and stored for analysis by the scientific teams (outside the habitat).

- The first batch of frozen samples was delivered to DLR and UNITUS in January 2011.
Sampling once per month

Examples of sampling locations
Air sampling and analysis - cultivation

According to ECSS-Q-ST-70-55C

G.1 Air sampling assay

- Sampling of 300 l air with 30 l/min on a gelatine filter exposed horizontally once per month at 9 locations inside the Mars 500 facility
- Storage and transport of gelatine filters at -80°C
- Placement of filters on R2A plates
- Incubation at 32°C for 72h and colony counting
First results from air samples

The highest number of cfu in location 4 and 5 in July, September and October 2010
Swabs dry
12 samples every month

DNA extraction

PCR
Cloning
Phylogeny

qPCR
Inventory estimation
Characterisation of selected microbial isolates

- Mesophilic aerobic bacteria isolated after heat shock
- Analysis of the physiological potential of spore-forming and/or heat tolerant microorganisms by resistance tests
  - ionizing radiation and mars-like UV radiation
  - oxidative agents
  - desiccation
  - freeze-thaw cycles, investigating diurnal and seasonal Mars surface temperature variations
  - antibiotics

Planetary protection concerns:
- Could these isolates survive the long travel to Mars as hitchhikers?
- Could these isolates survive on Mars?

Medical concerns:
- Does the resistance of these isolates against antibiotics change during a long-term mission?
Outcome of MICHA

These investigations will support the development of adequate protocols and equipment to prevent, detect and counteract hazardous microbial contaminations / growth during long-term isolation in space and on Earth.
Thank you for your attention!
Examples of sampling locations

Sampling once per month
Spaceflight-associated risk for diseases

from HRP-47060, June 2009, NASA, JSC, TX, USA