

Comparison of simulation results with measurements in case of a bio-contamination in a closed habitat

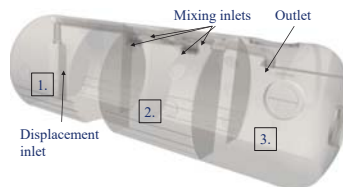
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INTRODUCTION

- In manned spaceflight, crew health is threatened by microorganisms and their enhanced pathogenicity due to microgravity
- Human immune response is weakened in microgravity
- It is mandatory to better understand the mechanisms of bio-contamination in confined habitats
- Microbial aerosols can be used as model particles when the dispersion and deposition of particles and reliability of the simulation methods are studied
- Computational fluid dynamics (CFD) can be used for evaluation of indoor microbial contamination and possible spread of harmful microbes in hermetic environments
- Aim of this study was to compare the deposition results of the CFD simulation with the measured particle deposition

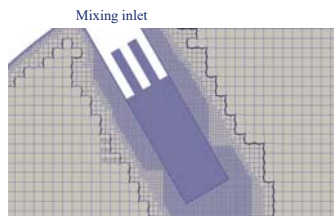
CASE

- Experimental chamber similar size with Columbus Laboratory (ISS module)
- Three zones:
 - Displacement ventilation zone
 - Mixing ventilation zone
 - Outlet (exhaust) zone



METHODS

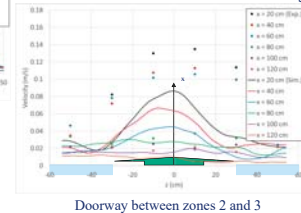
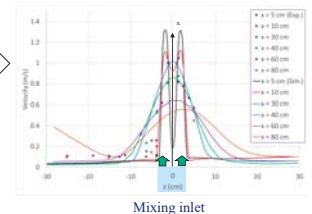
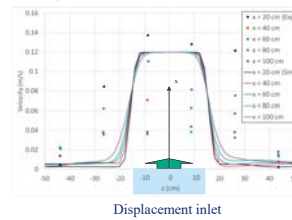
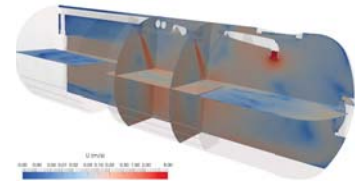
- Open source software:
 - Salome for pre-processing (www.salome-platform.org)
 - cfMesh for grid generation (cfmesh.com)
 - OpenFOAM for solution (www.openfoam.org)
 - Paraview for post-processing (www.paraview.org)
- Air field:
 - WALE turbulence model (LES, large eddy simulation)
 - Simulated 300 s to obtain statistically steady field
 - After that, simulated 300 s and time-averaged
 - Grid: 81.1 million cells
 - Simulation time: Ten weeks with 400 CPU cores
- Particle simulation:
 - Lagrangian method using time-averaged air flow field
 - Simulated first removing all particles hitting wall from the simulation (1800 s, 10000 particles per second, measured size distribution)
 - After that, all particles hitting the wall is considered stuck on the wall and simulation is continued 1200 s
 - Simulation time: Couple of days using one to tens of CPU cores



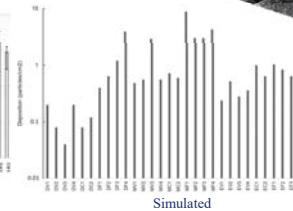
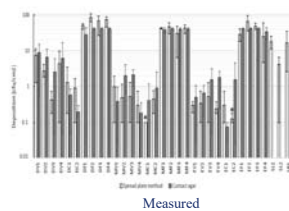
RESULTS

- Comparison of simulated time-averaged velocity with measured velocity in:

- Close to displacement inlet
- Close to mixing inlet
- Outlet chamber



- Comparison of simulated deposition with the measured deposition



d = displacement zone
m = mixing zone
e = exhaust zone
v = vertical surface
c = ceiling
f = floor

Conclusions

- Particles mainly deposit on the floor surfaces but also to the supply air diffusers
- Both the CFD simulation and particle deposition in experiments with *Bacillus* particles resulted similar deposition sites
- Open source software tools are very capable simulation tools because of the three main factors:
 - Efficient and open implementation of the models
 - Heavy parallelization possible because absence of license fees
 - Possible customization because of open source code

ACKNOWLEDGEMENTS

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