TAMPERE UNIVERSITY OF TECHNOLOGY

Removal of odours in dry toilets by biofiltration

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Objective

- To prevent odours in dry toilets and their surroundings
- Method biofiltration
- Are odours deriving from urine or fecal matter?
- Which odours need to be removed?

Biofiltration

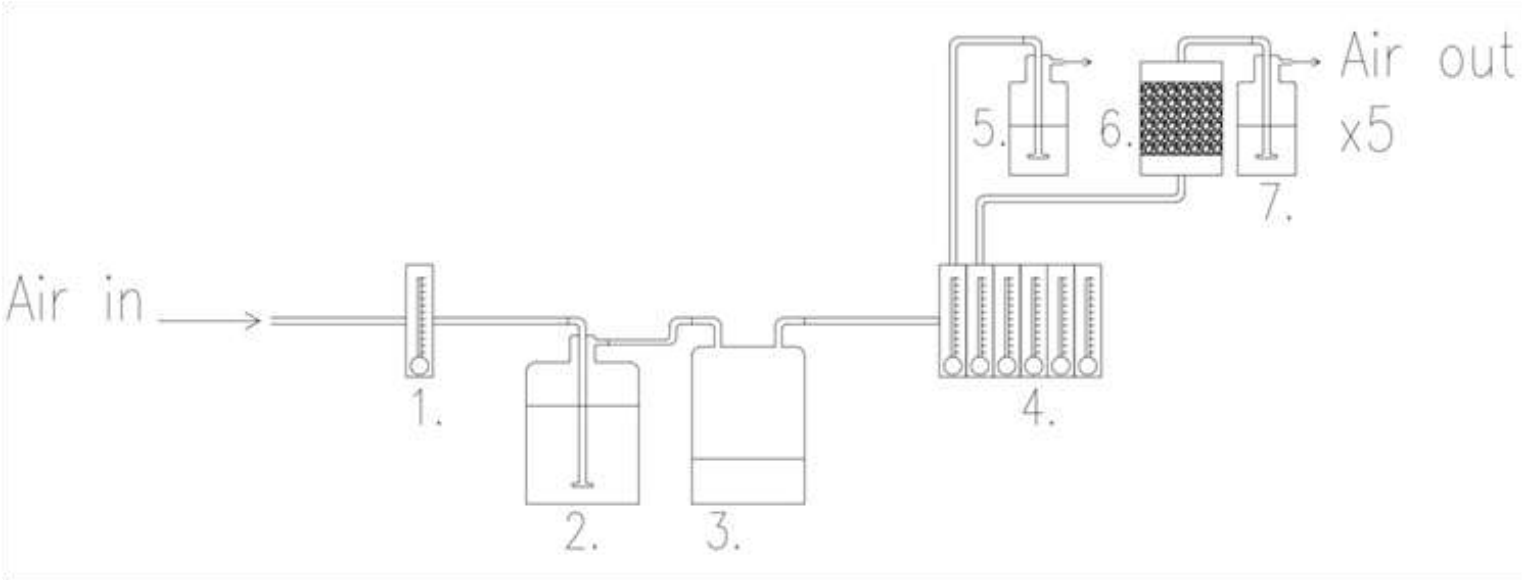
- Removal of odours or contaminants by filtration through material containing micro-organisms that can degrade targeted compounds
- Transfer to water phase is essential

Purpose of laboratory study

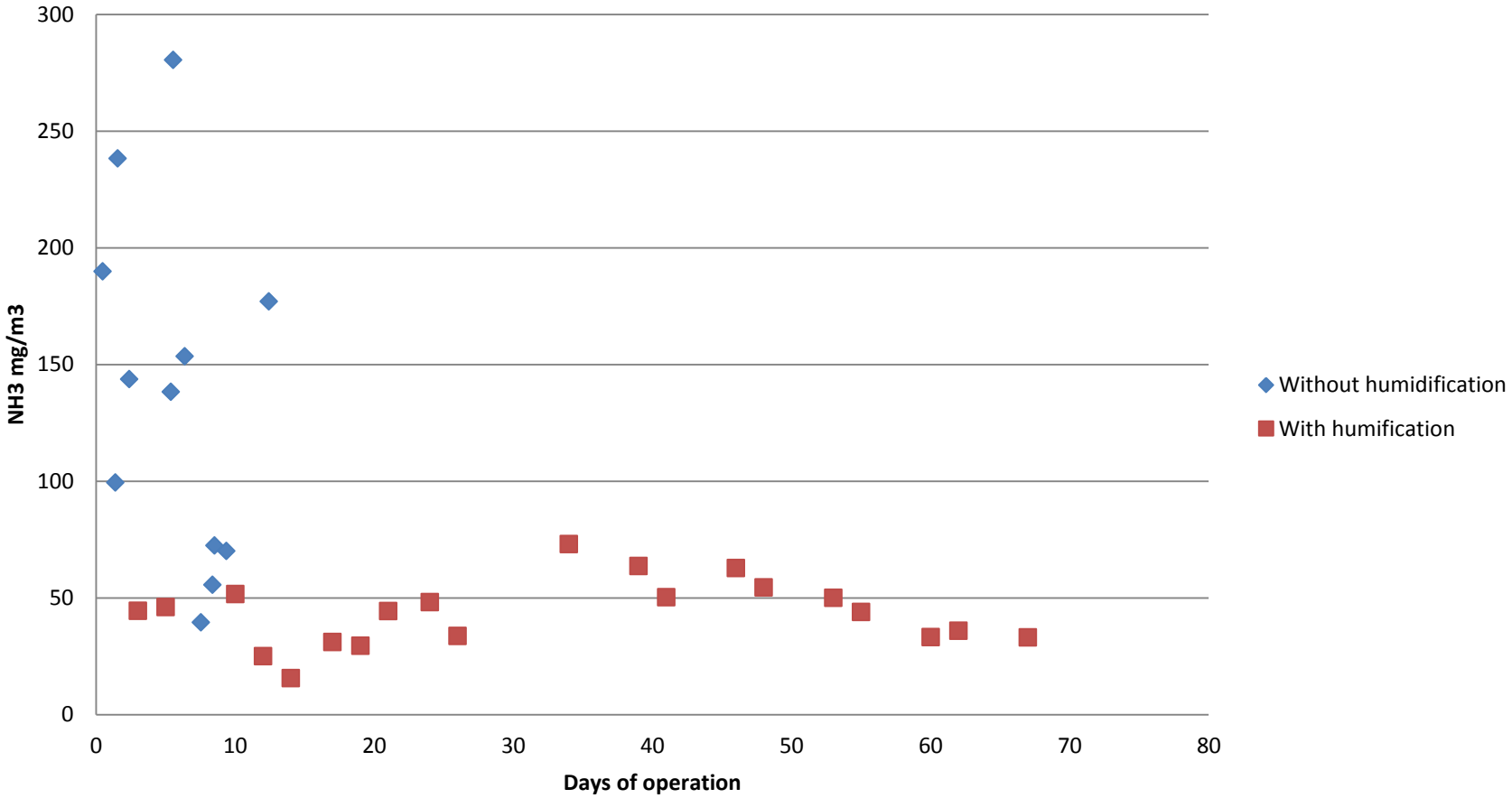
- To develop biofiltration system for dry toilet system to remove odours deriving from stored urine
- To determine quantities of ammonia (NH_3) and volatile organic compounds (VOCs) released from stored urine
- To find out if biofiltration is suitable process to remove ammonia and volatile organic compounds produced during urine storage
- To study impact of humidification

Laboratory experiments

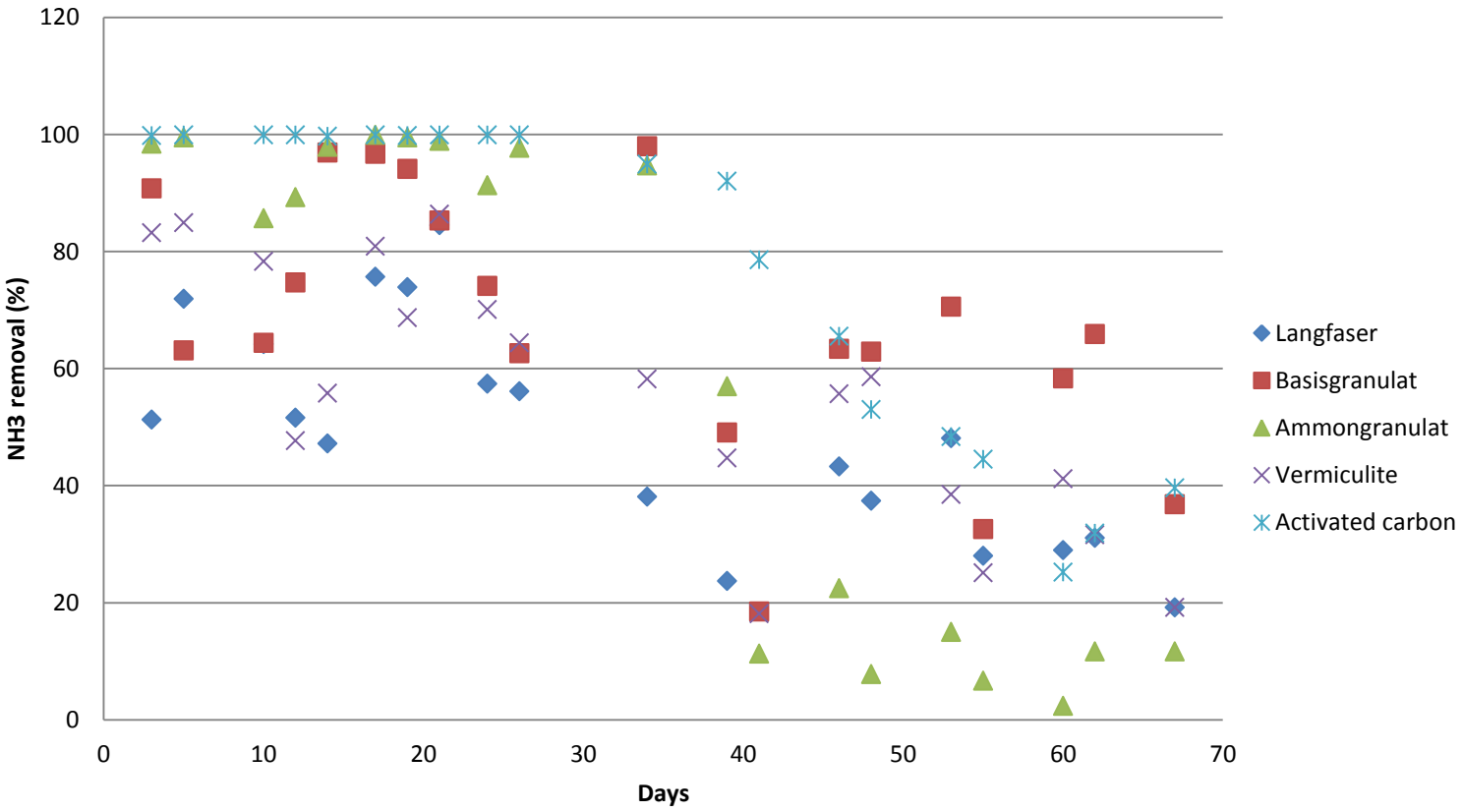
- Small-scale biofilters with five different materials, including UgnCleanPellets© from UGN Umwelttechnik



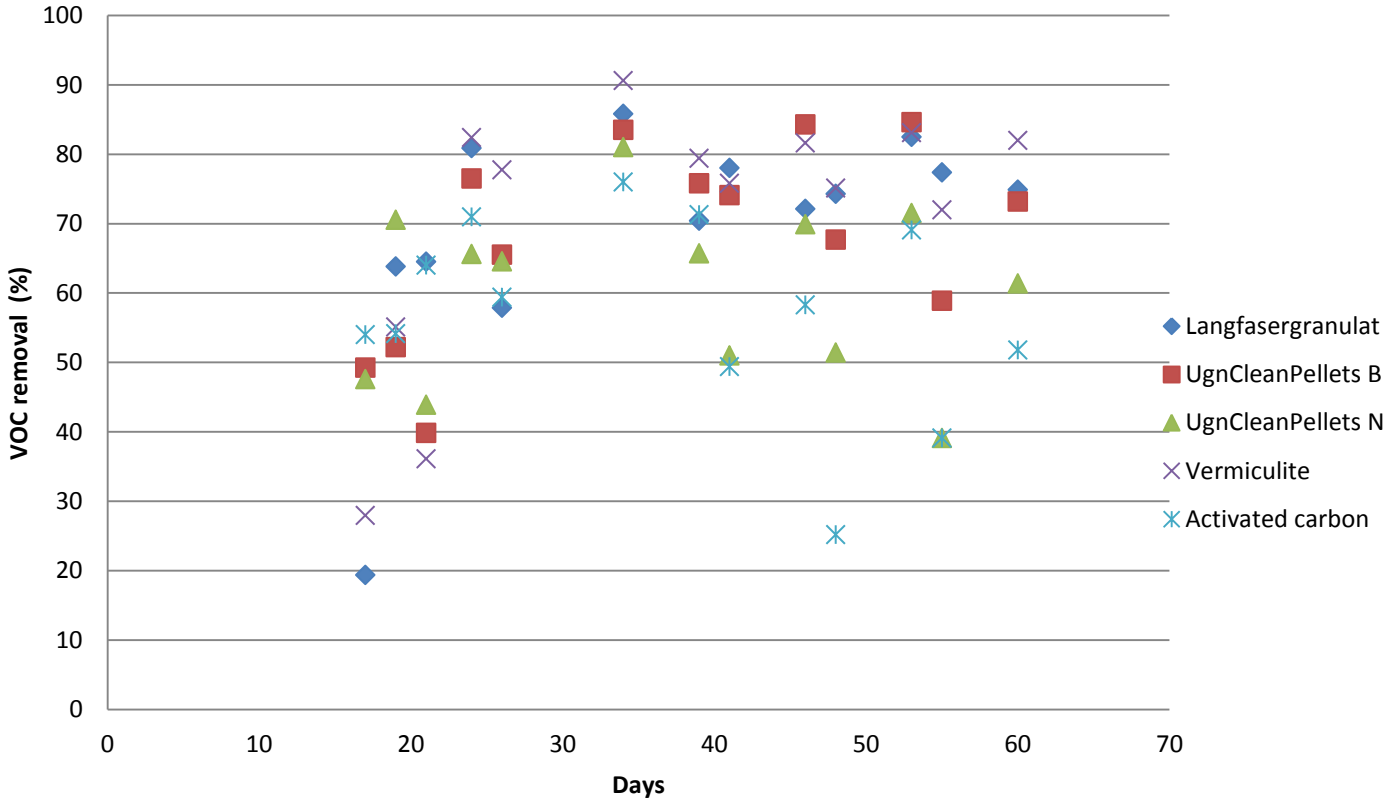
Release of ammonia into air



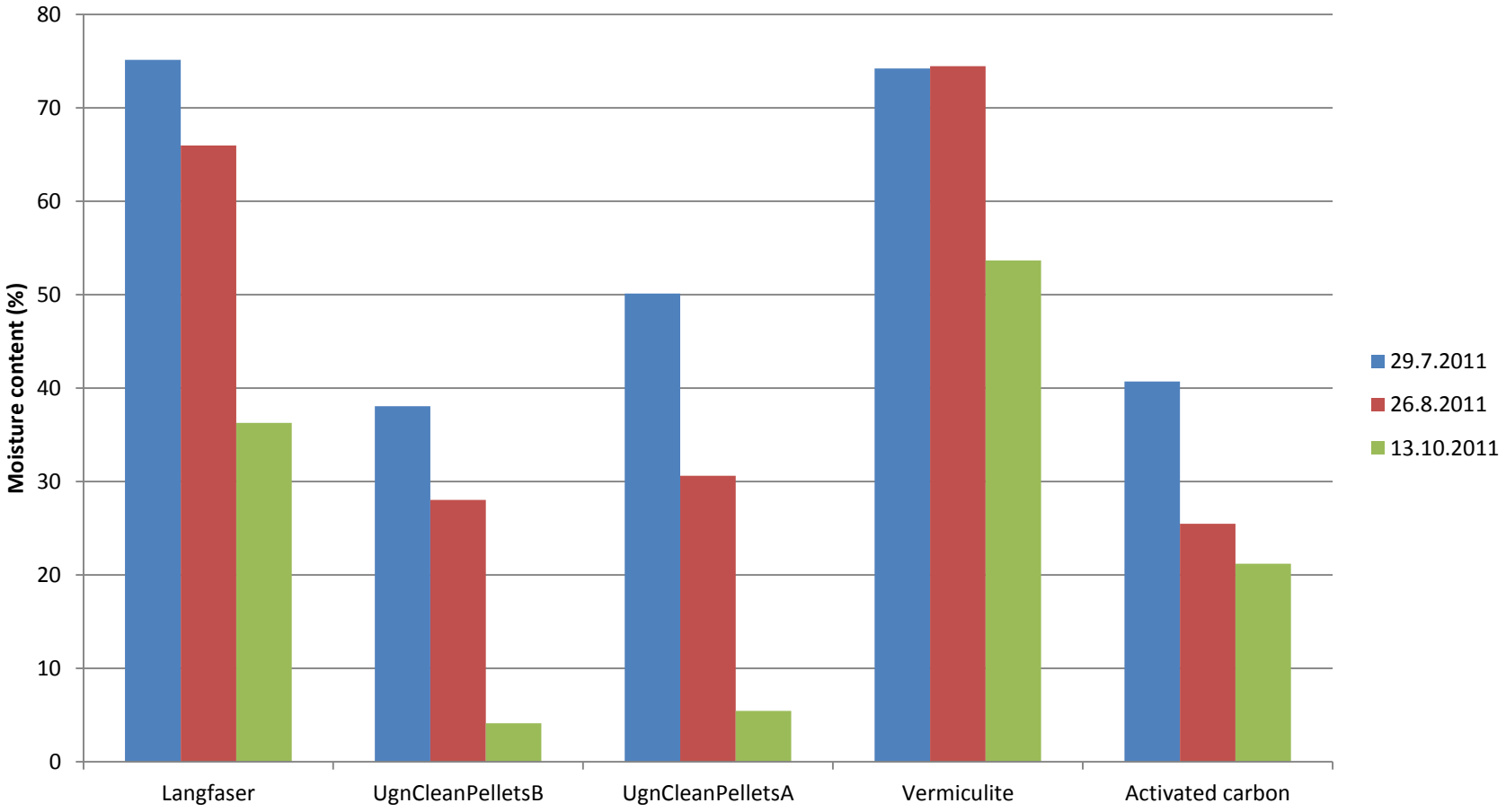
Results: Ammonia



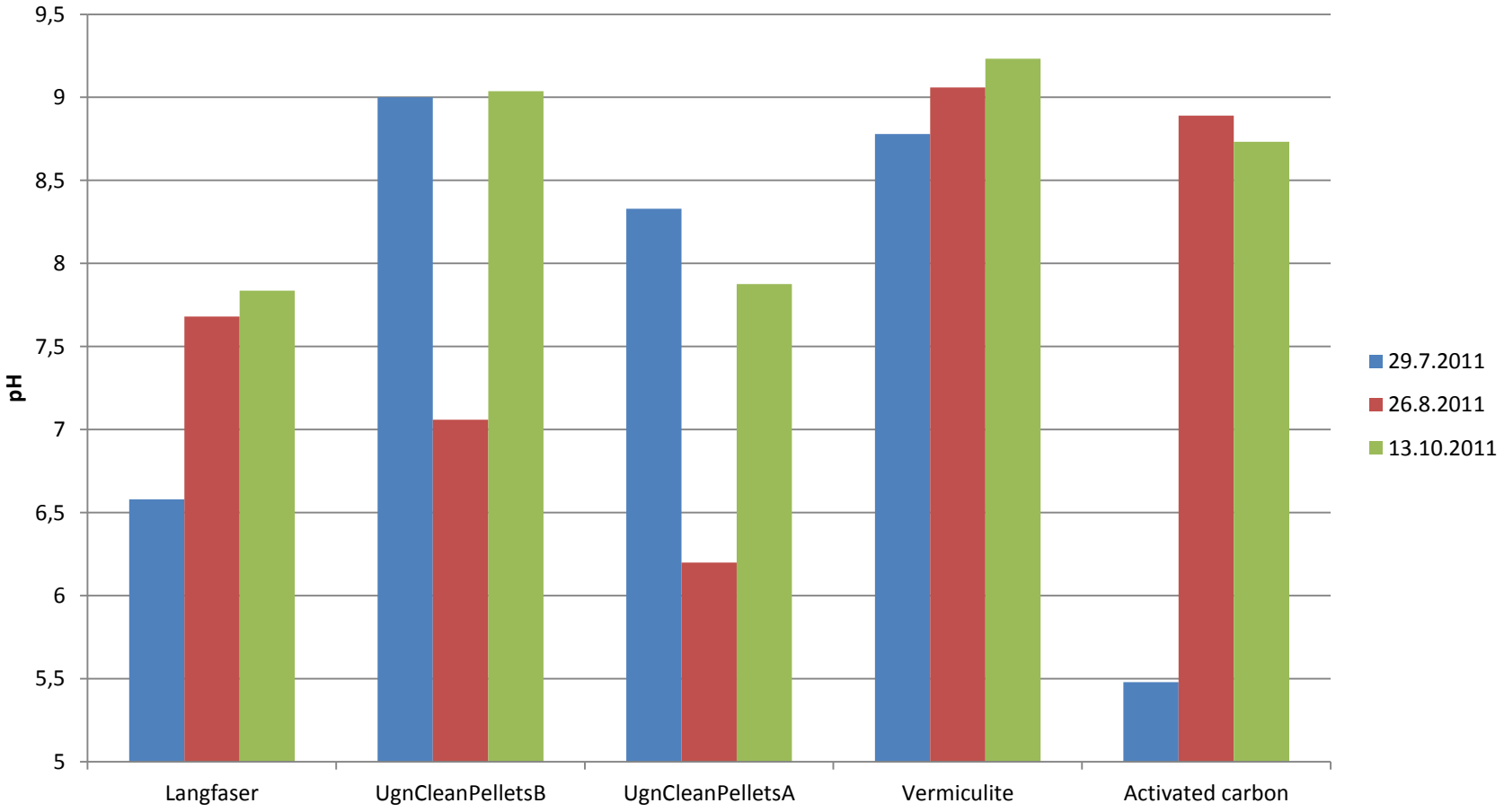
Results: VOC


100
90
80
70
60
50
40
30
20
10
0
VOC removal (%)
0
10
20
30
40
50
60
70
Days
Langfasergranulat
UgnCleanPellets B
UgnCleanPellets N
Vermiculite
Activated carbon

Material properties

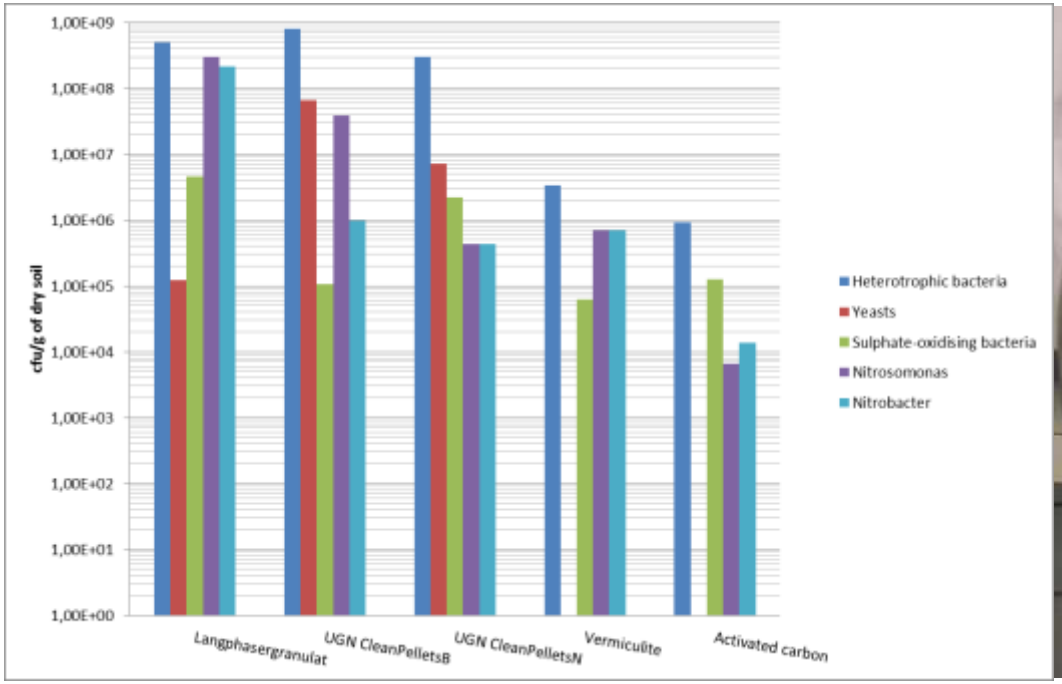


Material properties



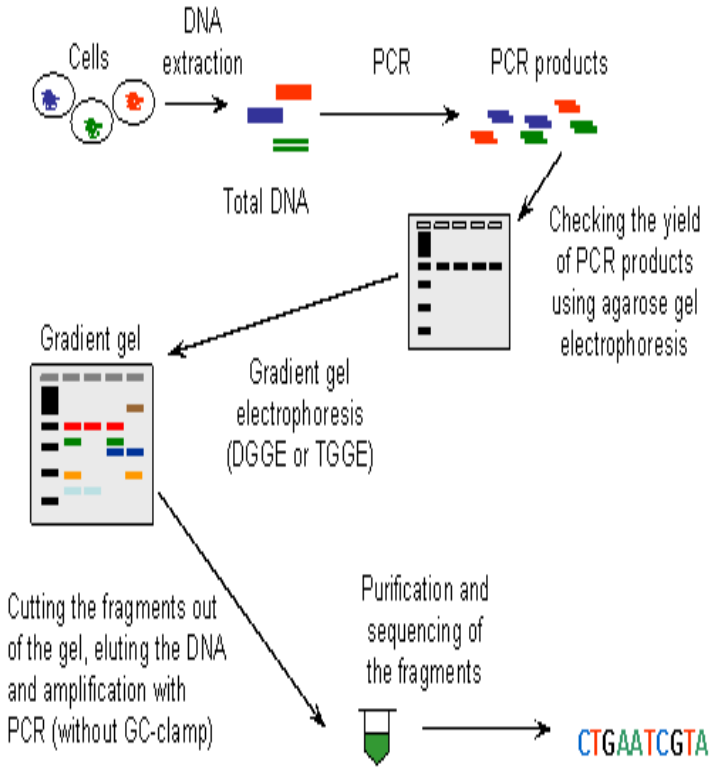
Viable counts of micro-organisms

- Bacteria in all materials, fungi in most of the materials



Microbial diversity in the biofilter

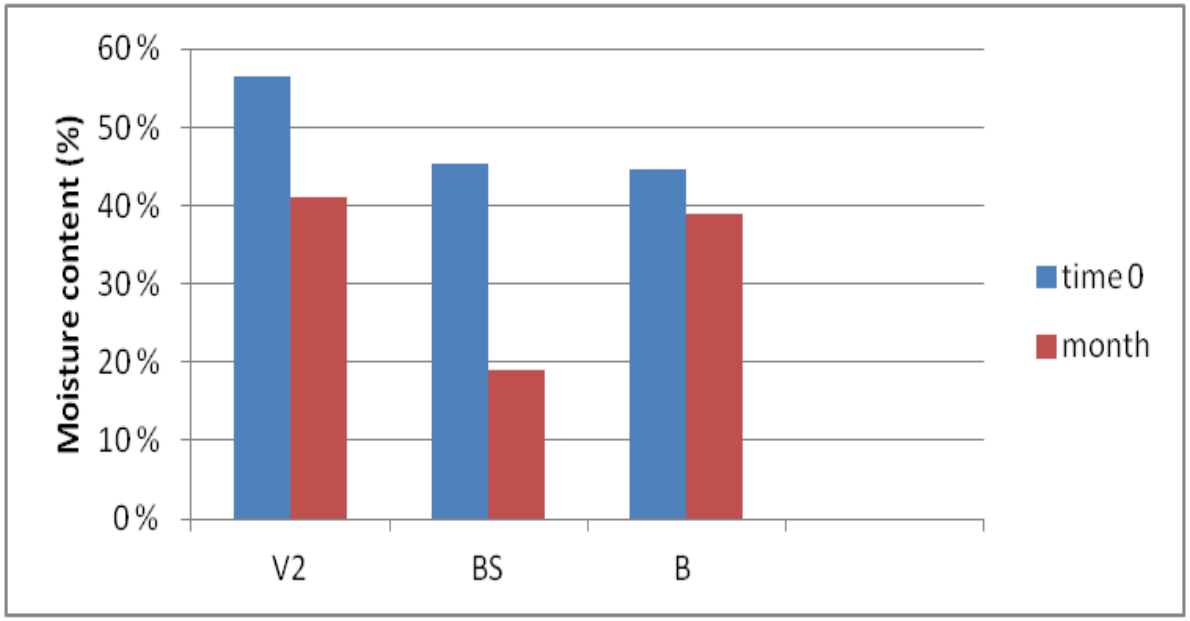
DGGE (denaturing gradient gel electrophoresis)



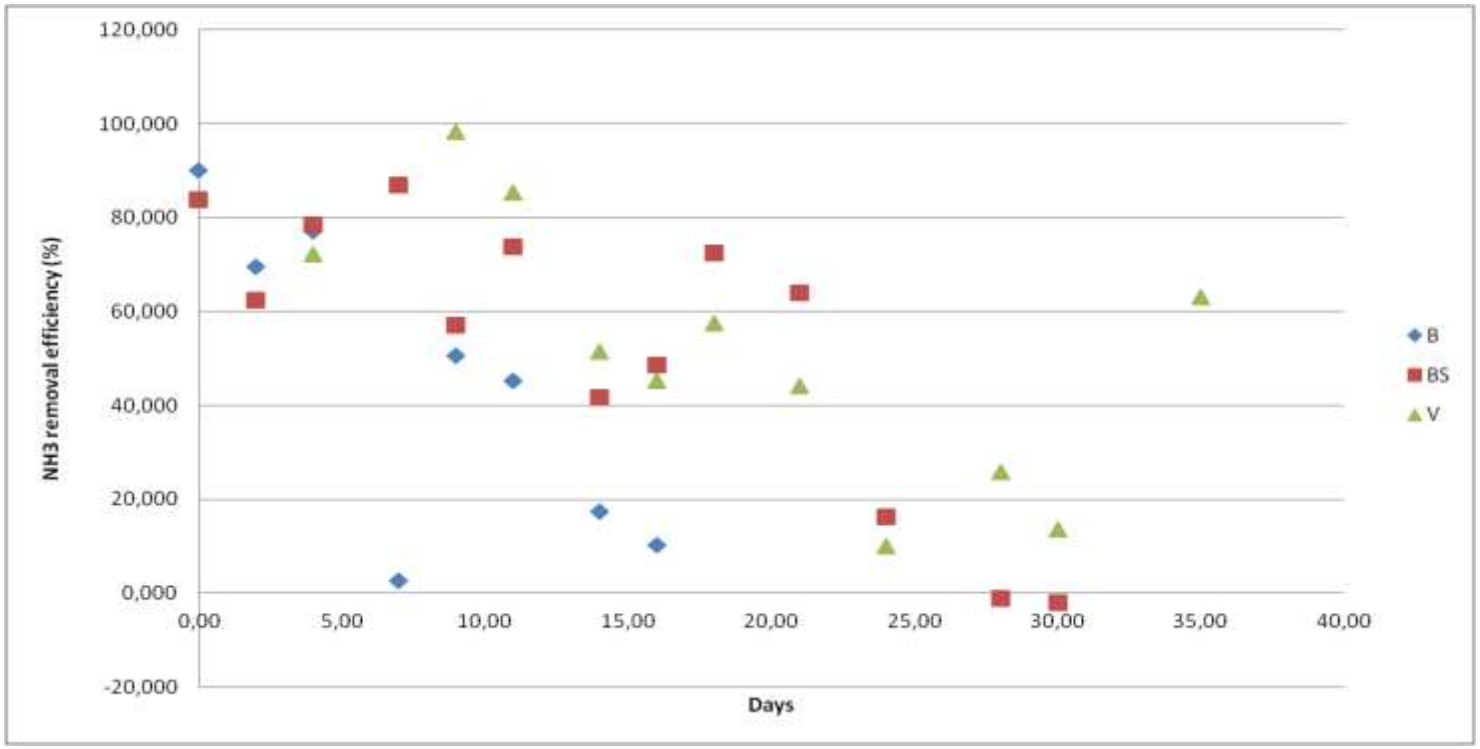
- Different bacteria were found with high similarity to genus of:
  - ***Sphingomonas* strains:**
    - ***Sphingobacterium daejeonense***
    - ***Sphingobacterium mizutaii***
  - **Genus *Flavobacterium***
  - **Several uncultured unidentifiable bacteria.**

Development of new material

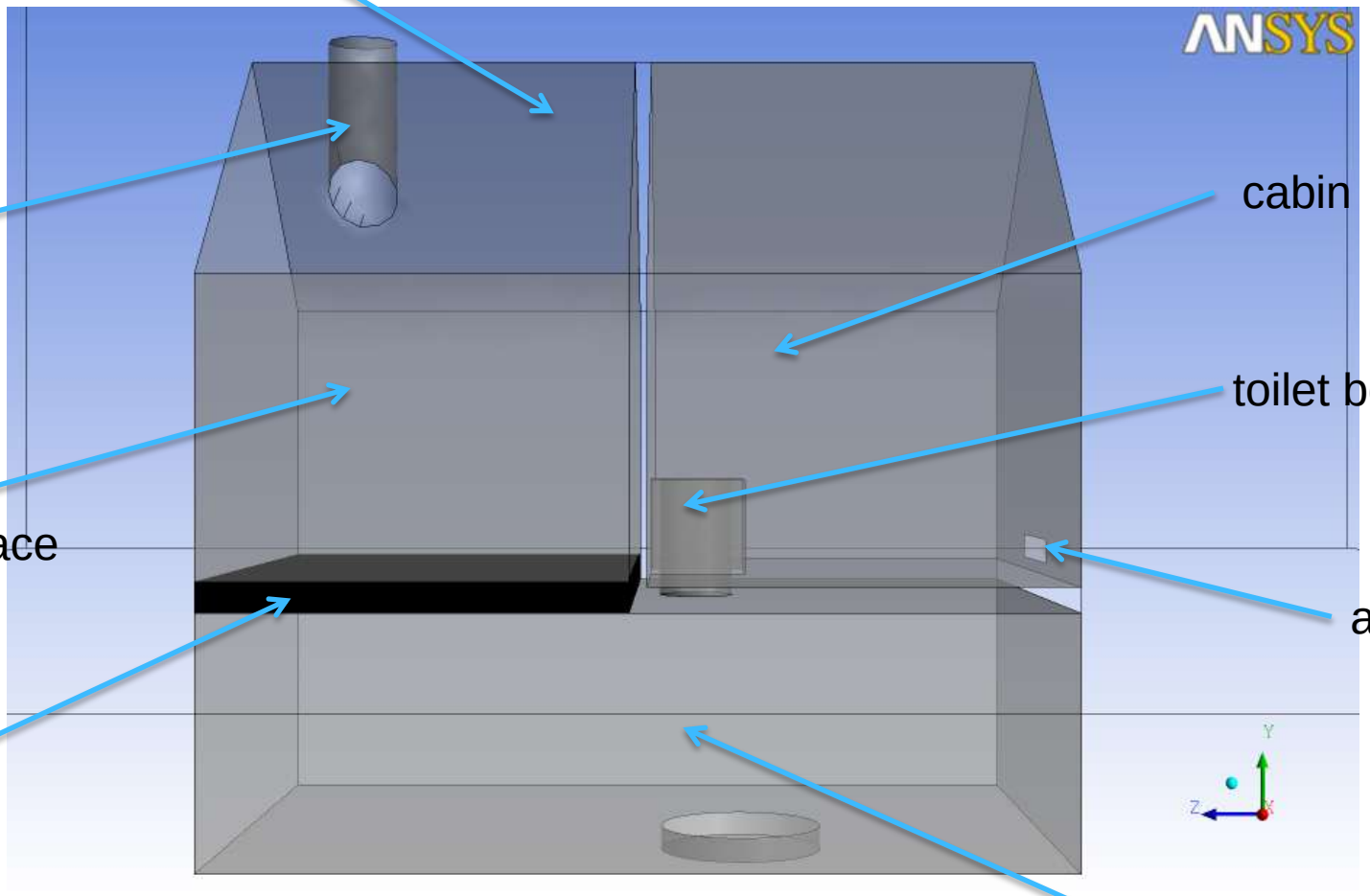
- The new material does not dry out as fast as pellets tested in first experiment, but irrigation is still needed



NH3 removal with new material



Toilet CFD model geometry

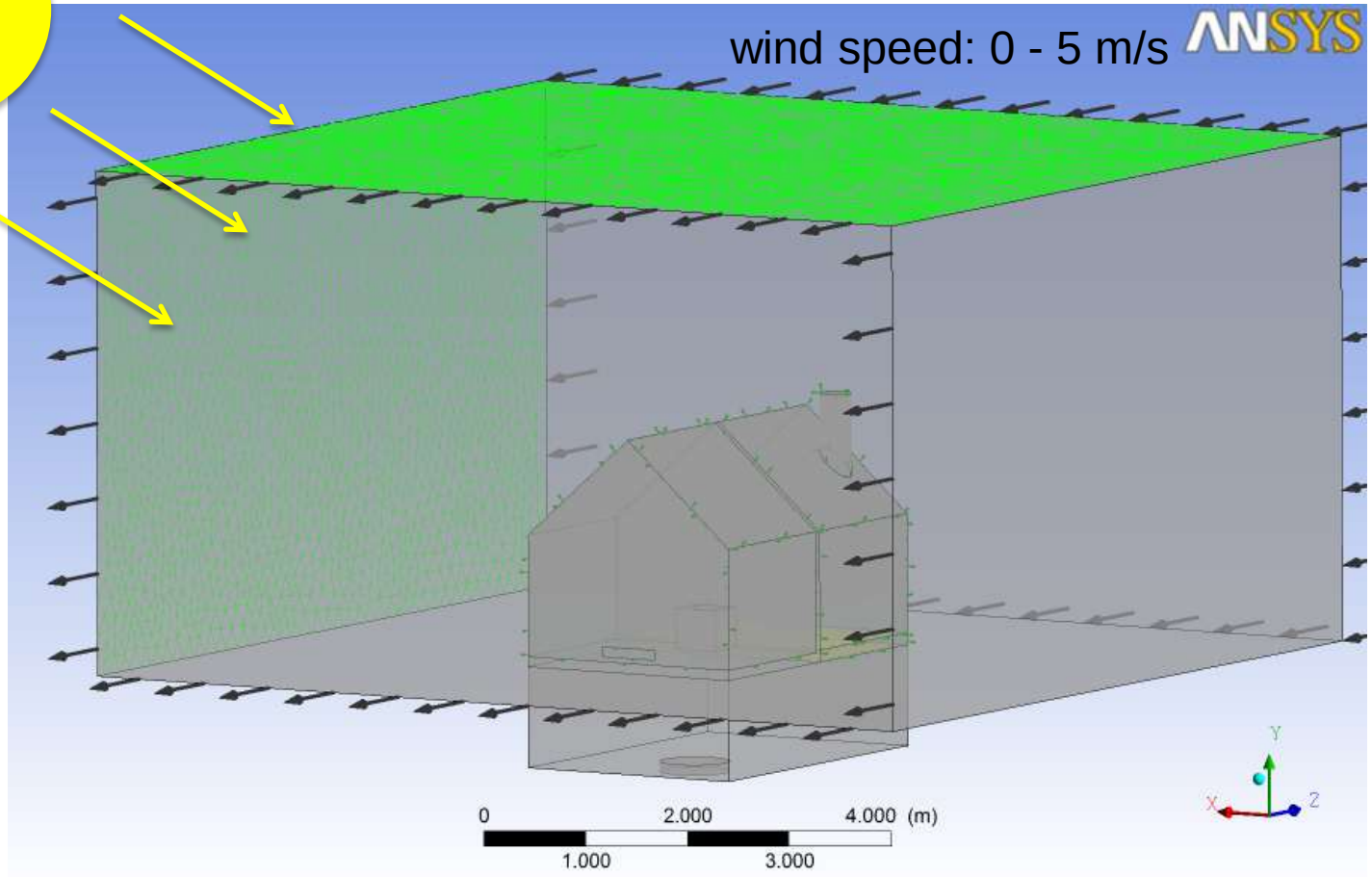


CFD modelling of flow in a dry toilet with a biofilter

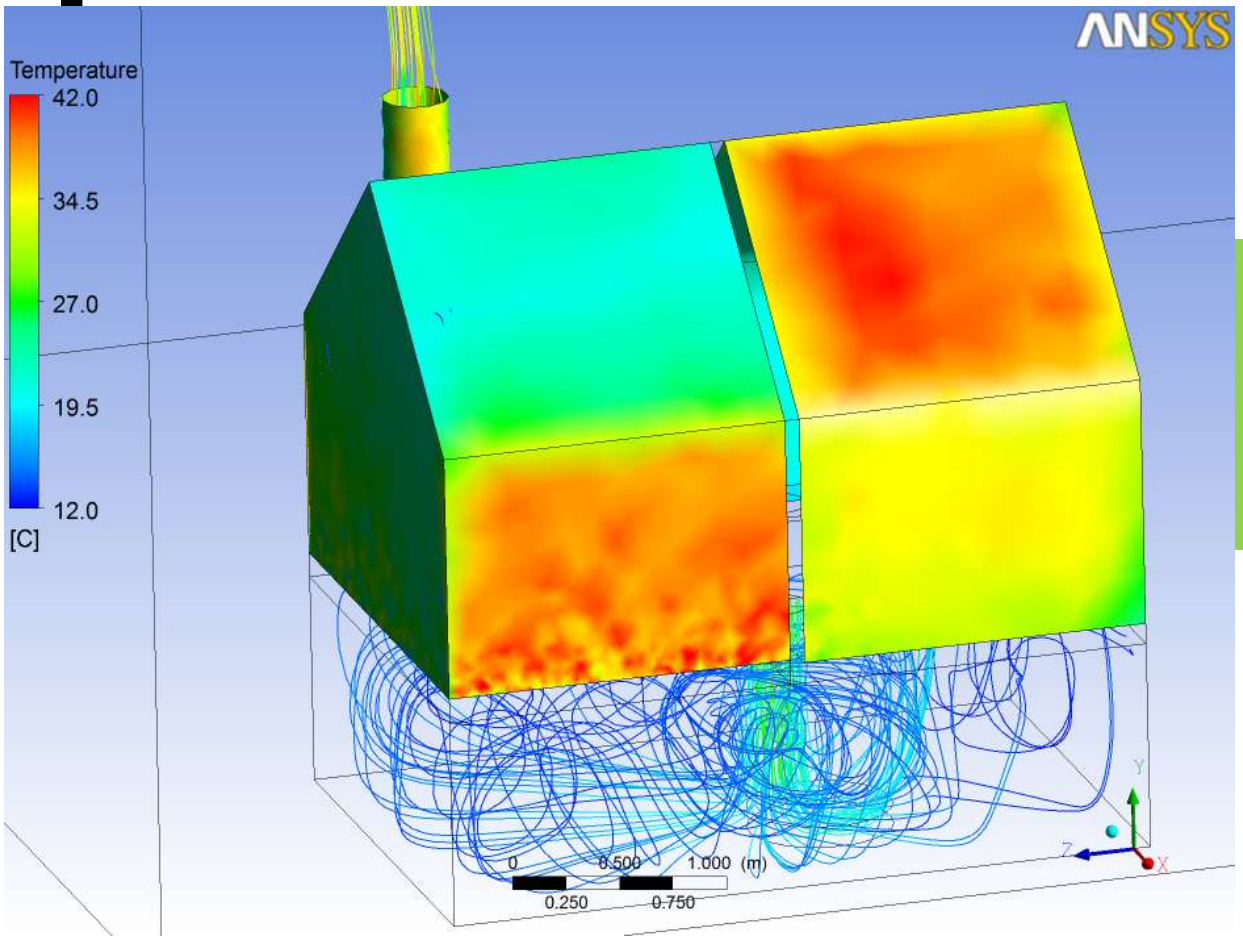
- Computational Fluid Dynamics (CFD) used to model both natural and forced ventilation in the dry toilet.
- Natural ventilated flow driven by solar heating of air in the technical space of dry toilet.
  - warm air rises - exits through chimney - drawing cold air from surroundings
- Can natural ventilation drive air flow through resistance of biofilter?

CFD model domain

solar radiation: 0 – 400 W/m^2



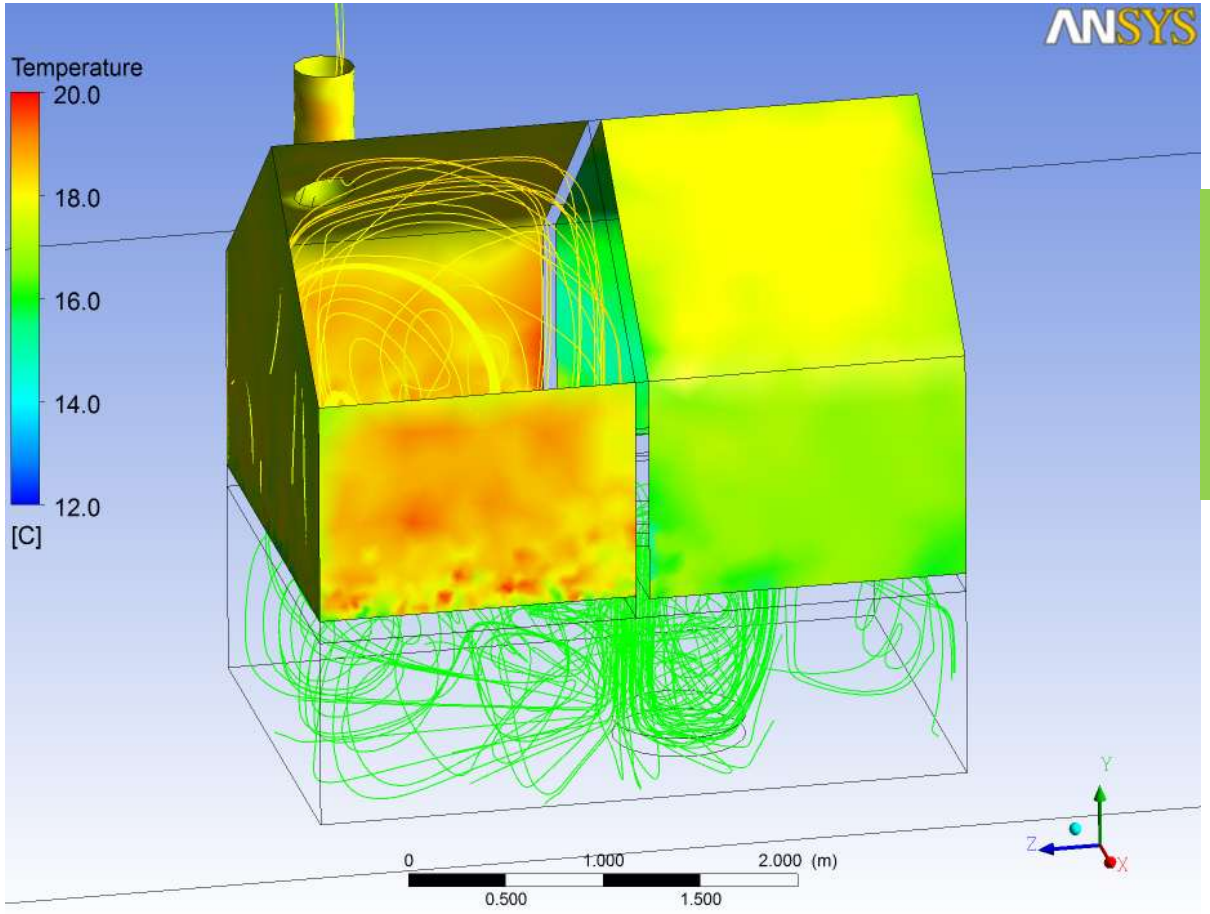
Streamlines and wall temperatures



Solar heat flux = 400 W/m^2

Wall emissivity = 0.5

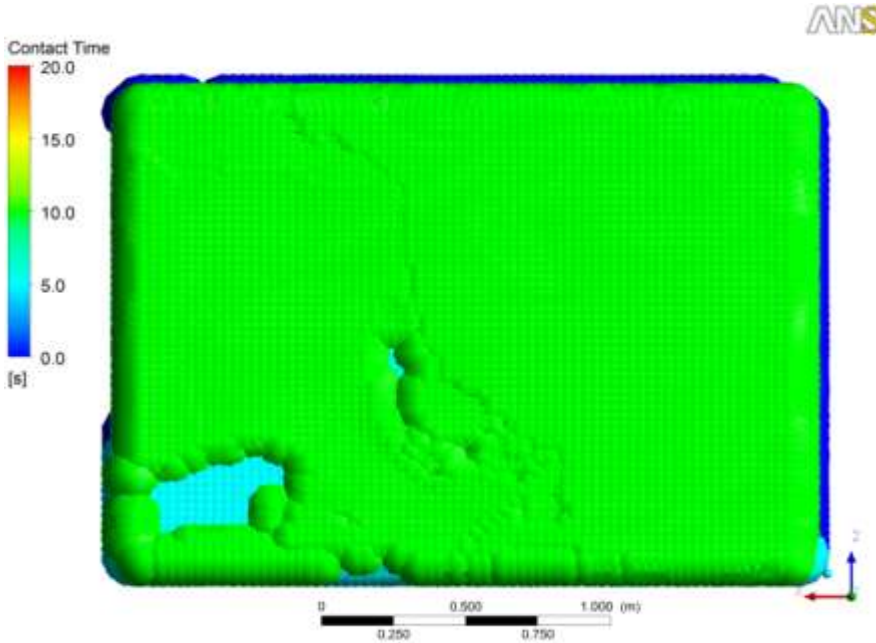
Streamlines and wall temperatures

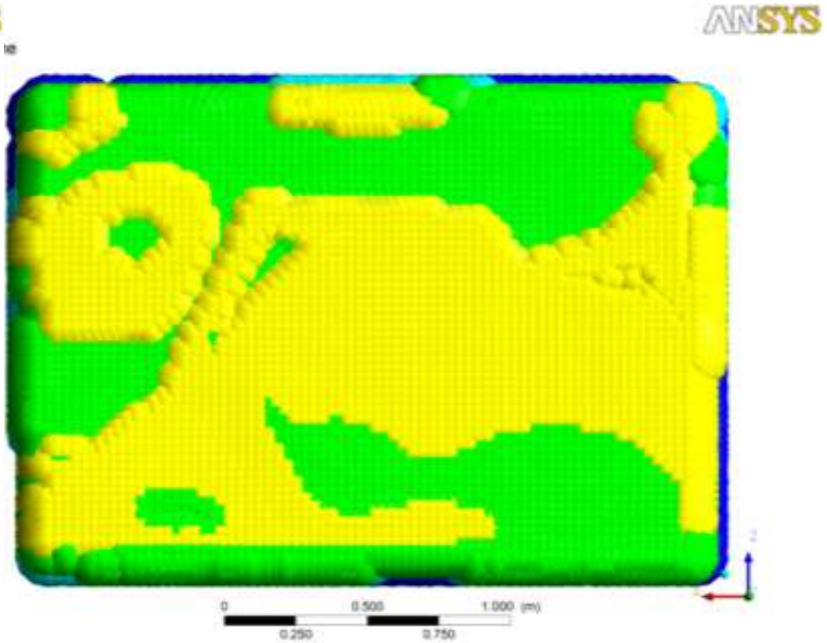


Solar heat flux = 100 W/m^2

Wall emissivity = 0.05

Air contact time with filter





- Filter Media A
- Solar Heat Flux
  = 400 W/m^2
- Wall Emissivity = 0.5

- Filter Media A
- Solar Heat Flux
  = 400 W/m^2
- Wall Emissivity = 0.05

Conclusions

- Biofilters can remove odourous compounds from stored urine, but
- Combined removal of both ammonia and VOCs was not efficient.
- Development of new materials is recommended to achieve combined removal of ammonia and VOCs
- Moisture balance of filter bed needs to be ensured

Conclusions

- Solar heating can drive natural ventilated air flow in toilet with biofilter
- Ventilation flow rate in toilet is dependent on a number of factors: radiation intensity, wall emissivity, filter media permeability, area of air inlet and outlet
- Ventilation flow rate determines the contact time of air with the filter

Work continues

- Tests of forced and natural ventilation are underway at Ecosphere in Saint Ferreol Trente Pas using artificially created conditions
- Irrigation with rainwater is applied to ensure sufficient moisture in biofilter bed

Acknowledgements

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