Abstract

Basing on separation of grey- and blackwater wastewater from toilets can be collected and drained advantageously by the use of low pressure drainage system in urban areas. Due to high concentrations caused by low flushing volumes, a recovery of nutrients and energy as well as a reduction of total costs can be achieved. From operational experience of these low pressure sewer systems in residential areas clogging of the piping system is known caused by formation of solids on the inner pipe surface. However, systematic studies on the origin of these solids and the relevant influencing parameters are still missing.

The aim of the present work is to identify these processes and to develop suitable concepts to increase operational safety of low pressure sewer systems for blackwater. Therefore, investigations were carried out on existing low pressure sewer systems and the formation process of deposits (encrustation) was reproduced using synthetic blackwater.

Analysis of samples from various low pressure sewer systems revealed that incrustations consist of organic as well as inorganic components. The organic fraction could be attributed to depositions of the suspended cellulose and faeces components in the black water as a result of thin film evaporation on the inner pipe surface. As major constituents of the inorganic fraction the minerals hydroxyapatite, struvite and calcite have been identified. By implementation of the chemical and physical processes in a thermodynamic model, the formation of these minerals could be traced on precipitation processes, which are the result of the hydrolysis of urea from black water. While the majority of these precipitations remained suspended in the black water, only a small fraction crystallized as a result of microbial metabolic activity on the pipe surface which leads to formation of mineral incrustations.

By establishing a model of the blackwater system, the multi-phase formation process which leads to the formation of incrustations could be reconstructed under laboratory and pilot scale conditions; thereby, the structural and organizational parameters influencing the formation process could be identified. Contrary to the results of previous investigations, the influence of flushing water hardness, temperature, and the reduced pressure are regarded as insignificant on the formation of incrustations. However, surface roughness, shear stresses and the air/water-ratio were found to play a significant role in the formation of the incrustations. In addition, the highly turbulent 2-phase mixture in the low pressure sewer system was simulated using a CFD Model. Results indicate that
fluviatile effects can significantly decrease persistence of incrustations. While the application of chemicals for controlling incrustations gave poor results, a high cleaning performance could be achieved by mechanical-abrasive methods. As part of the KREIS project, a large-scale implementation of presented prevention concepts will take place in the Jenfelder Au, Germany.

Keywords: Blackwater, incrustation, deposits, low pressure toilets, vacuum toilets, precipitation, urea hydrolysis, CFD flow simulation