Verification of the efficiency of chemical disinfection and sanitation measures in in-builiding distribution systems

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1. Introduction

Most microorganisms are organized in biofilms. Biofilms grow on almost any water contact surface such as, for example, found in water-systems used in private homes or in public buildings including health care facilities. Furthermore biofilm-associated pathogens become significantly more important due to their ability to induce nosocomial infections.

In the Institute for Hygiene and Public Health at Bonn University biofilms are generated in a silicone tube model. In silicone tubes, biofilm formation and growth can be observed. Previously investigations have shown that the CFU can reach 10⁷ per cm² (Otte, 2006). In the same tubes the total cell count of microorganisms can increase by 10⁸ cells/cm².

2. Methods

The current study focuses on the situation in in-building distribution systems. Different chemical disinfectants were tested with respect to their efficacy on biofilms in silicone tubes: free chlorine (electrochemically activated), chlorine dioxide, hydrogen peroxide (H_2O_2) , silver, and fruit acids.

According to the widely differing manufacturers' instructions for the usage of the disinfectants we developed three different variations of the silicone tube model to simulate practical use conditions:

- 1. Continuous treatment of biofilms over a long period of time (one to three months): the disinfectant is added to a fresh water reservoir with a dosing system at a defined concentration according to the German Drinking Water Ordinance from 2001.
- 2. Intermittent treatment: In a closed circulation system, the disinfectant is transmitted added to a biofilm-contaminated silicone tube at the concentration recommended by the manufacturer for a defined period of time and at a constant flow rate (400 ml/min).

Additionally the efficacy of the external disinfection treatment and the monitoring of the potential for biofilm formation with the Hygiene-Monitor® should be supervised. The growth of biofilm was analyzed before and after the treatment with a combination of conventional microbiological and molecular methods. These methods include cultivation on R2A-agar to determine the number of heterotrophic microorganisms, DAPI staining to determine the total microbial cell count (TCC) and scanning electron microscopic (SEM) photographs to visualize the tube surface after treatment.

3. Results

The continuous treatment with 0.3 ppm free chlorine (limit value German Drinking Water Ordinance) leads to a reduction of the CFU/cm² down to the detection limit after 70 days. The total cell count was still on a level of > 10¹ per cm². SEM pictures still showed biofilm residues on the surface, which are potential attachment points for new microorganisms. A concentration of 0.2 ppm was required for chlorine dioxide to reduce the CFU/cm² up to the detection limit within the same time frame. SEM pictures also showed biofilm residues, determination of the TCC has not been completed, yet.

Shock treatments also showed good results. H_2O_2 in combination with silver at a concentration of 10.000 ppm reduce the CFU/cm² down to the detection limit within six hours. H_2O_2 with fruit acids at the same concentration requires only four hours achieving the same result. In both cases, the TCC showed a level of > 10^1 per cm².

Investigations with the Hygiene-Monitor® were done under practical conditions with ozone. A model biofilm was integrated in an ozonisation system. After periodic treatments with an investigation period of 14 days, the CFU/cm² were reduced down to the detection limit. During the same time period the TCC/cm² was also minimized down to the detection level and SEM pictures showed no biofilm residues.

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Follow-up research should yield information about possible recontamination after a successful disinfection. First results showed that in silicone tubes 14 days after ending of the treatment the number of colony forming units reached nearly the same level as before. Determination of the TCC is in progress.

Literature

Otte, A. (2006) Wirksamkeitsprüfung verschiedener Desinfektionsverfahren und antimikrobieller Oberflächen zur Vermeidung bzw. Reduktion von Biofilmen in trinkwasserführenden Silikonschlauchmodells Verwendung des Hausinstallationssystemen unter molekularbiologischer Bestimmung der Biofilm-Population. Dissertation der Mathematisch-Naturwissenschaftlichen Fakultät der Rheinischen Friedrich-Wilhelms-Universität Bonn

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