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Testing of UV Bottom Valve

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1 Project and background description

The aim of this project was to test a UV bottom valve developed by Drain Clean System ApS regarding the UV bottom valve's ability to reduce the number of bacteria in a drain pipe from a sink at employee toilet facilities at Danish Technological Institute.

For the test, Drain Clean System installed the developed UV bottom valve in a sink in the toilet used daily by the employees at Danish Technological Institute (hereafter referred to as "test sink"). A corresponding sink without an installed UV bottom valve, located at a close proximity, functioned as a control sink (hereafter referred to as "control sink").

The test included:

- Quantitative analysis of bacteria in biofilm (depth: 6 cm from drain) in test sink and control sink before and after installation of a new UV bottom valve (test sink), i.e. disinfection (control sink). The number of bacteria was quantified as the total viable count at 22 °C.

- Quantitative analysis of bacteria in biofilm (depth: 6 cm from drain) in test and control sink after 11 and 42 days of identical use of both sinks. The number of bacteria was quantified as the total viable count at 22 °C.

- Measurement of external temperature of the UV bottom valve.

1.1 *Background*

The developed technology has an aim to reduce the spreading of microorganisms from sinks. It is assumed that microorganisms spread partly due to the biofilm in the drain pipe of sink and partly to the development of bio-aerosols that arise during usage of the sink from remaining water in water trap. The test carried out with the developed UV bottom valve focuses on the effect of UV bottom valve on the biofilm formation in the drain pipe.

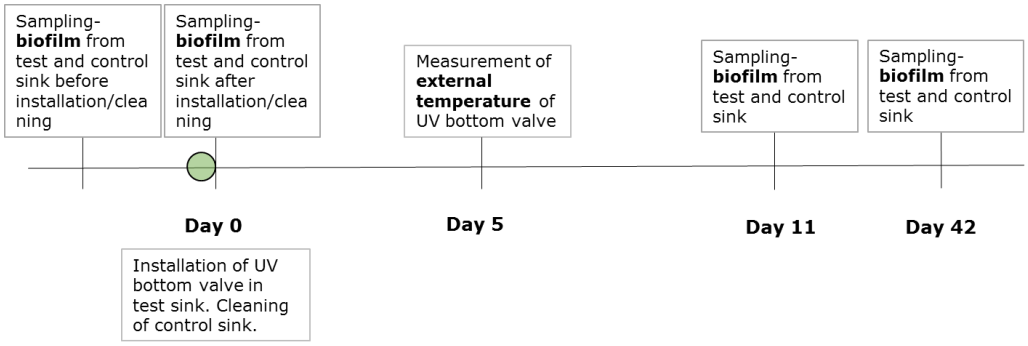
According to Environmental Project No.1901 (Miljøprojekt nr. 1901), the spreading of bacteria is a serious source of infection at hospitals. The spreading of waterborne *Pseudomonas aeruginosa* is of special concern and are considered to be the reason behind the spread of infection resulting in deadly outcomes at many hospitals (Miljøprojekt 1901, 2016, ISBN: 978-87-93529-06-9).

2 Methods

2.1 *Experimental design*

On 5 April 2018, a new and clean UV bottom valve from Drain Clean System ApS was installed in the sink in the toilet at Danish Technological Institute. The UV bottom valve was not turned off at any time during the experiment. This sink is hereafter referred to as *test sink*. The down pipe of the test sink was not cleaned before the experiment. At the same time, the sink in a corresponding toilet next door was cleaned very thoroughly (cleaning of water seal, drain pipe, rubber rings, etc. and disinfection with sodium hydroxide) to work as the negative control in the experiment as it was not possible to install a new corresponding valve without UV light. The cleaned sink is hereafter referred to as *control sink*.

Biofilm sampling was carried out from both sink drain pipes. The timeline below illustrates the progress of the completed tests which will be described in detail in next chapter.



2.2 *Sampling and analysis*

Sampling of biofilm from control and test sink was carried out on day 0 before and directly after the installation of UV bottom valve in the test sink and a thorough cleaning of the control sink. After a 11-day and 42-day period of identical daily usage of both sinks, final samples of biofilm were taken from both control and test sink.

Sampling of biofilm was carried out with sterile cotton swabs (Steriswab™, Medical Wire & Equipment). At each sampling, 3 samples were taken from drain pipes at areas of 0.5 cm^2 at 6 cm depth directly over the light source in test sink. Sampling on day 0, day 11 and day 42 were taken at the same depth and on the same surface material, but at different places.

Bacteria on the cotton swab were transferred to 2 ml salt water solution (0.9 %) through 3 cycles per 30 second shake on vortex-mixer, 30 second sonication and final 30 second vortexing. A sterile, unused cotton swab was transferred to salt water solution as a negative control sample.

Hereafter, 1 ml of diluted solutions (10^0-10^{-8}) were plated out on chromogenic, dehydrated media (Compact Dry TC, Hardy Diagnostics) and incubated at 22 °C. After 72 hours, the colonies (colony forming units, CFU) on plates were counted.

3 Results

3.1 *Biofilm formation*

Samples that were taken before installation of UV bottom valve (test sink) and cleaning (control sink) represents normal sink conditions after a long-term use. The analysis confirms that the sink drain pipe is covered with biofilm with numerous (>10^{10} CFU/0.5 cm^2) bacteria (Fig. 1).

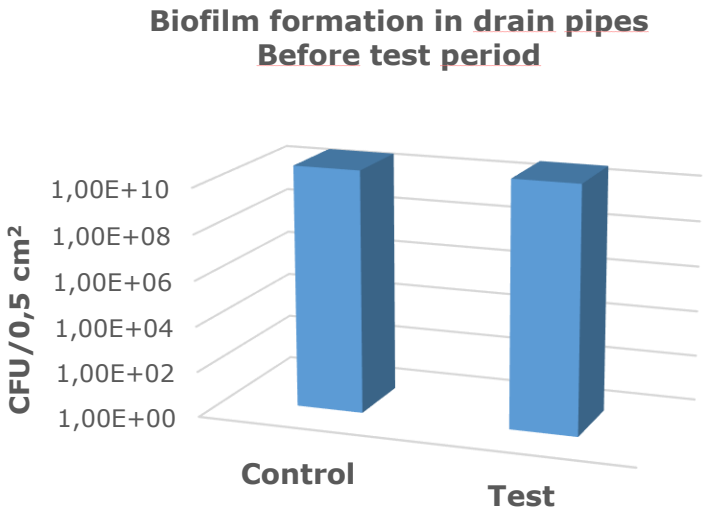


Figure 1 Number of CFU in the drain pipe of both sinks before installing a UV bottom valve in the test sink and cleaning of control sink (0.5 cm^2, depth: 6 cm).

Samples from day 0, taken directly after installation of UV bottom valve in the test sink and disinfection of the control sink, exhibited a comparable number of bacteria (approx. 100 CFU/0.5 cm^2) in these two drain pipes (Figure 2).

After 11 days of normal use of both sinks, on average 3200 CFU/0.5 cm^2 were detected in the control sink, while it was not possible to observe any growth on the sampling plates from the test sink.

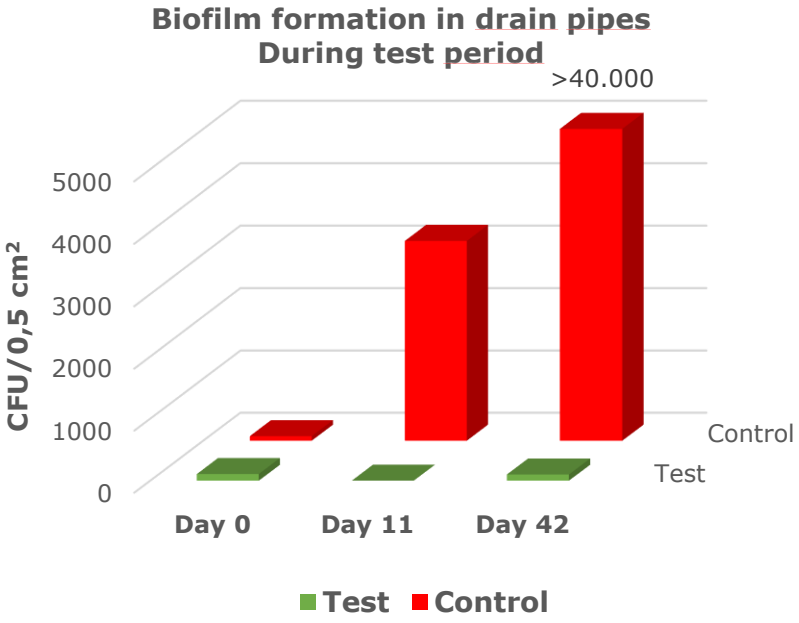


Figure 2 Number of CFU in both test and control sink drain pipes on day 0, day 11 and day 42 respectively during test period.

After 42-day normal use of both sinks, on average >40,000 CFU/0.5 cm^2 were detected in the control sink, while <100 CFU/0.5 cm^2 were detected in test sink drain.
Plating of negative control sample did not indicate growth on plates, which confirms the sterility of the cotton swab and salt water solution.

3.2 *External sink temperature*

The external temperature of the UV bottom valve was measured on day 5 during the test period and was 38.1 °C.

4 Discussion

The performed tests on UV bottom valve from Drain Clean System ApS show that the UV bottom valve effectively limits the formation of biofilm in the drain pipe of a sink.

A limitation in the performed test was that the drain in the control sink was not unused on day 0 (as test sink). This was solved by thorough cleaning and disinfection, and this way the comparable results for both sinks on day 0 were ensured. The surface of the drain in control sink may be better suited to biofilm formation due to e.g. calcareous deposits, wear of sink surface coating etc. However, it is not likely that this alone explains the high number of bacteria in control sink compared to test sink.

The effectiveness of UV bottom valve has been assessed based on 42-day usage of the sink. It is expected that the observed effectiveness can be maintained over a longer period of time.

5 Conclusion

On the basis of this test and according to the presented data, it is concluded that the UV bottom valve effectively reduced the number of bacteria present in the sink drain pipe during a 42-day test period.

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