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Research Brief

Efficacy of automated disinfection with ozonated water in reducing sink drainage system colonization with *Pseudomonas* species and *Candida auris*

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Sinks in healthcare facilities are a potential reservoir for the dissemination of gram-negative bacilli and *Candida* spp.[1–4] Addressing sink contamination is challenging because sink drainage systems provide a favorable environment for pathogen colonization and biofilm formation, but they are not amenable to cleaning and disinfection. Disinfection of sinks with agents such as bleach, acetic acid, and hydrogen peroxide have been effective in some studies.[1,2] However, such approaches may be difficult to implement long-term due to the time and effort required and the caustic nature of agents such as bleach.

Ozonated water has been reported to be effective in killing many pathogens.[5,6] However, information on the efficacy of ozonated water for sink disinfection is limited. Here, we examined the efficacy of a sink providing automated disinfection with ozonated water against established sink drainage system colonization with *Pseudomonas aeruginosa* and *Candida auris*.

The SmartFLO3 sink (Franke Kindred, Canada) includes features designed to limit dispersal (eg, a 23-cm-deep bowl) and an enclosed electrode that causes ozonation (0.1–0.35 ppm) and formation of reactive oxygen species in dispensed water. The sink also provides an automated, programmable flush with increased concentration of ozonated water (0.9–2.5 ppm), typically every 4 hours. The sink used in these experiments had access ports in the P-trap and in the drainage pipe distal to the P-trap. According to the manufacturer, the concentrations of ozone produced by the sink are safe for human drinking or bathing and are noncaustic to drain pipes.

We tested the efficacy of ozonated water (0.9–0.12 ppm ozone) produced by the sink against a strain of *Pseudomonas aeruginosa* isolated from a sink at the Cleveland VA Medical Center and 3 strains of *Candida auris* (MRL#31102, MRL#31103, and AR-BANK#0381).[7] For *P. aeruginosa*, we used the American Society for Testing and Materials (ASTM) Standard quantitative carrier disk method (ASTM E2197-11).[8] For *C. auris*, we used the method recommended by the Environmental Protection Agency.[9] Five percent fetal calf serum (Remel, Lenexa, KS) was used as the organic load. After a 10-minute exposure, carriers were neutralized with Dey-Engley neutralizer (Remel). The experiments were repeated in triplicate. The concentration of ozone was measured using an ozone test kit, model OZ-2x (Hach Company, Loveland, CA).

We examined the efficacy of automated disinfection with ozonated water in reducing established sink colonization with *P. aeruginosa* and *C. auris*. To establish colonization, the ozone generator was turned off and 10^6 colony-forming units (CFU) of both organisms were inoculated into the P-trap; the water was run for 30 seconds every 4 hours, and 25 mL of tryptic soy broth was poured down the drain once daily. Cotton-tipped swabs were used to sample the P-trap, the port distal to the P-trap, and the proximal sink drain to a depth of 2.5 cm below the strainer every 24 hours. Colonization with both organisms was established throughout the system and was maintained for at least 1 week before the ozone generator was turned on with continued exposure to water and tryptic soy broth. Sampling continued every 24 hours for 14 days; cultures were collected 4 hours after ozone flush disinfection. The swabs were vortexed in 1 mL of Dey-Engley neutralizer, serially diluted, and plated onto MacConkey agar and Sabouraud dextrose agar (Becton-Dickinson, Sparks, MD) to quantify *P. aeruginosa* and *C. auris*, respectively. The experiment was repeated twice.

On steel discs, each of the pathogens was reduced by ≥3.1 $\log_{10}$CFU with 10 minutes of exposure. During the sink colonization process, both pathogens were detected distal to the P-trap within 5 days and at the strainer within 13 days after inoculation. Once established, the concentrations of the pathogens at each sampling site remained stable during the week prior to turning on the ozone generator.

Figure 1 shows the concentrations of the pathogens in the strainer, the P-trap, and the pipes distal to the P-trap at baseline and during the 14-day period of exposure to ozonated water for one of the experiments. The results for both sets of experiments were similar. At baseline, the concentration of *P. aeruginosa* at each sample site was ~5–6 $\log_{10}$CFU per swab, whereas *C. auris*

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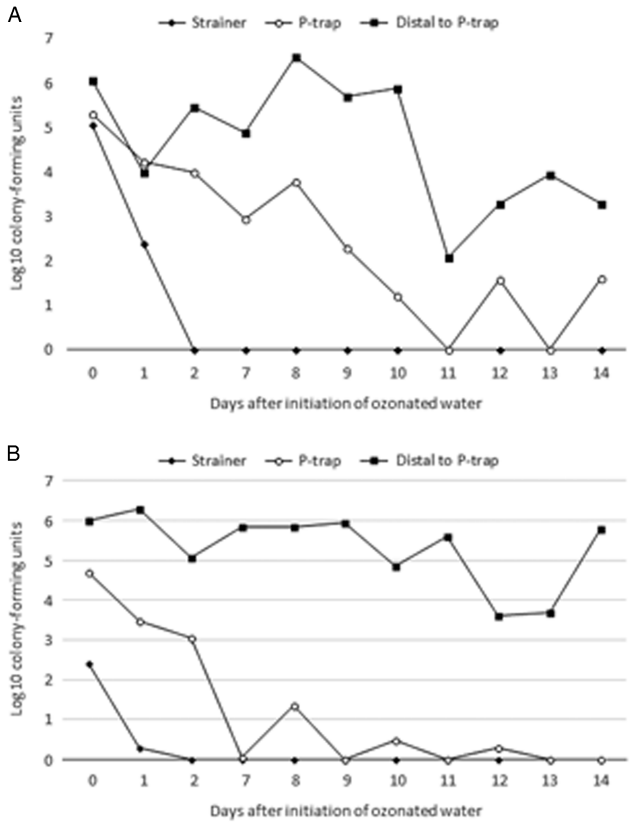

Fig. 1. Efficacy of intermittent flushes with ozonated water on the concentration of *Pseudomonas aeruginosa* (A) and *Candida auris* (B) in the strainer, the P-trap, and distal to the P-trap of a colonized sink.

was present at a lower concentration in the strainer than at the other sites. After beginning ozonated water disinfection, both pathogens were reduced to undetectable levels in the strainer within 2 days. In the P-trap, the concentration of both pathogens decreased gradually, and both were undetectable or were present at low concentrations after 10 days. In contrast, both pathogens continued to be detected in relatively high concentrations distal to the P-trap.

Our findings demonstrate that repeated exposure to ozonated water is effective in reducing *P. aeruginosa* and *C. auris* in colonized sinks. The pathogens were reduced to an undetectable level in the strainer, suggesting that ozonated water could be useful to reduce the risk for transmission from colonized sinks. The ability to provide an automated, programmable flush with a disinfecting solution is an important feature of the sink if the goal is long-term maintenance of sink disinfection.

Our study has some limitations. We examined the impact of ozonated water in a single sink design for a 2-week period with 2 pathogens. We assessed the impact of relatively low ozone concentrations. Higher ozone concentrations might be more effective in reducing pathogens within and distal to the P-trap. Finally, it is not clear how well daily instillation of tryptic soy broth mimics real-world exposure of sinks to nutrients. In a recent study, nutrient-rich solutions (eg, intravenous fluids) were frequently poured down sink drains.[10]

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