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Peracetic acid disinfection: An effective way to reduce antibiotics resistant bacteria from raw hospital wastewater

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Abstract Risk of infection from antibiotic resistant bacteria from wastewater to the workers in the plant can be reduced by disinfecting wastewater. Peracetic acid (PAA) was used to disinfect the raw wastewater from hospital in pilot scale experiment. Batch experiment was conducted in parallel to confirm the dose of PAA used in the pilot experiment. Degradation of PAA was fast that resulted to no residual effect to the process of wastewater treatment plant. Numbers of ciprofloxacin resistant bacteria was reduced from $5 \cdot 10^4$ cfu/ml to $<1 \cdot 10^1$ cfu/ml using 75 mg/L PAA with 10 min contact time. Similarity on removal of ciprofloxacin resistant bacteria from pilot experiment and batch experiments were observed. Removal of ciprofloxacin resistant bacteria increased by increasing contact time and PAA concentration. The method appears an ideal technology to minimize the risk of antibiotic resistant bacteria to the sewage workers when new centralized super hospital are constructed in Denmark utilizing the unbranched direct connection of wastewater from hospital to the WWTP.

Keywords: Antibiotic resistant bacteria; Hospital wastewater; Peracetic acid; Disinfection

1. Introduction

The excessive use of antibiotics in human, animal and plant caused the increase in spread of Antibiotics resistant bacteria in the environment (Sharma et al., 2016; Turolla et al., 2018). Wastewater has been reported to be an important vehicle to spread antibiotic resistant bacteria among many environmental compartments (Baquero et al., 2008). There is a plan to build few centralized super hospitals replacing the many hospitals in each city in Denmark. The wastewater from these large hospitals will be connected directly to the wastewater treatment plant using a separate pipe. The centralization means antibiotic resistant bacteria found in hospital wastewater can pose increased risk to the workers in the few receiving wastewater treatment plant.

Chemical disinfection is one way to reduce the antibiotic resistant bacteria by disinfecting hospital wastewater at the hospital utilizing the wastewater pipe from hospital to the WWTP as a retention tank. Ciprofloxacin is commonly used as a broad-spectrum antibiotic and ciprofloxacin resistant bacteria present predominantly in the domestic and hospital wastewater. Therefore, disinfection effectiveness was studied on ciprofloxacin resistant bacteria. Peracetic acid (PAA) is a strong disinfectant with a wide spectrum of antimicrobial activity (Chhetri et al., 2014; Luukkonen et al., 2015). Commercial PAA is available as an acidic quaternary equilibrium mixture of PAA, hydrogen peroxide, acetic acid, and water. The residues after PAA use are acetic acid, hydrogen peroxide, and water. Acetic acid is further biodegraded to carbon dioxide whilst hydrogen peroxide degrades to oxygen and water; neither are considered toxic to aquatic life.

The aim of this study was to reduce the number of antibiotic resistant bacteria by chemical disinfection of hospital wastewater using PAA before it reach the wastewater treatment plant. This will enable to minimize the risk from the infection of antibiotic resistant bacteria to the workers in the WWTP.

2. Materials and methods

Raw wastewater was collected from Hillerød hospital located at northern part of Copenhagen, Denmark. PAA (CAS no: 79-21-0) solution containing 15% (w/w) of technical grade disinfectant was supplied by Novadan Aps (Kolding, Denmark). Concentration profiles of PAA together with hydrogen peroxide over time was measured until 40 min using the colorimetric method described by Chhetri et al., (2020). In parallel, samples for microbiological analysis was collected after 1-20 min of contact time, residual PAA and hydrogen peroxide from samples was neutralized by adding 100 mg/L sodium thiosulfate, followed by 50 mg/L catalase. Ciprofloxacin resistant bacteria were enumerated in CompactDry plate using spread plate technique by mixing diluent water

consisting 4 mg/L ciprofloxacin. Pilot scale experiment was conducted in the container developed by Norlex A/S consisting of pipe reactor to reflect the retention time of wastewater from hospital to the inlet of wastewater treatment plant. In the container, different sampling point was constructed in the pipe reactor so that sample can be collected at different retention time. A batch experiment was performed in parallel to the pilot experiment on raw hospital wastewater to confirm the PAA dose delivered in the pilot experiment. After corresponding contact time that was used in pilot experiment, a fraction of each sample was processed for ciprofloxacin resistant bacteria enumeration and in parallel concentration profiles of PAA was measured until 40 min in the remaining sample. Untreated wastewater was collected at the inlet of pilot container before starting and end of experiment to enumerate the initial number of ciprofloxacin resistant bacteria, pH and COD.

3. Results and discussion

pH and COD of untreated hospital wastewater was 7.8 and 445 mg/L, respectively. Three concentration of PAA (50, 75 and 100 mg/L) were used for pilot and batch experiment. Concentration of PAA and hydrogen peroxide in the hospital wastewater was measured after 1, 5, 10, 20 min. Fast degradation of PAA was observed, and concentration of PAA was less than 0.5 mg/L after 10 min. However, around 40% of initial hydrogen peroxide was left when it was measured after 40 min contact time (Figure 1, Top). Batch experiment was carried out in parallel with pilot experiment to avoid the changes in wastewater over prolonged storage time. Similarity on degradation of PAA and hydrogen peroxide was observed when concentration of PAA and hydrogen peroxide was measured in batch experiment. (Figure 1, bottom).

When 50 mg/L PAA with 1 min contact time was used 0.8 log of ciprofloxacin resistant bacteria was removed and removal was increased to 2.4 log when 50 mg/L of PAA was used with 20 min contact time. When concentration of PAA was increased, removal of ciprofloxacin resistant bacteria was also increased. Number of ciprofloxacin resistant bacteria was less than 10 cfu/ml (under detection limit) and log removal was more than 3.7 log when 75 mg/L PAA was used for disinfection with 10 min contact time. (Figure 2). Number of ciprofloxacin resistant bacteria was reduced from $5 \cdot 10^4$ cfu/ml to $<1 \cdot 10^1$ cfu/ml by applying 75 mg/L PAA at 10 min contact time. Similar and better removal of ciprofloxacin resistant bacteria was observed in batch experiment. The better removal of ciprofloxacin resistant bacteria in the batch experiment could be due to better mixing of wastewater and PAA in batch experiment compare to only initial mixing in pilot experiment.

4. Conclusion

This study suggests that PAA can be used to treat hospital wastewater at source enabling a retention time through structures that transport the wastewater from hospital to the inlet of WWTP. PAA degradation was fast so there will be no risk from the residual disinfectant to the process of wastewater treatment plant. Similarity on removal of ciprofloxacin resistant bacteria from pilot experiment and batch experiment were observed when different concentration of PAA was used with different contact time. Disinfection of hospital wastewater at the source (hospital) using PAA seems to be feasible for reducing antibiotic resistant bacteria. This will minimize the risk of infection from antibiotic resistant bacteria to the plant workers when the new centralized super hospital are constructed in Denmark and direct connection of wastewater from hospital to the WWTP is established.

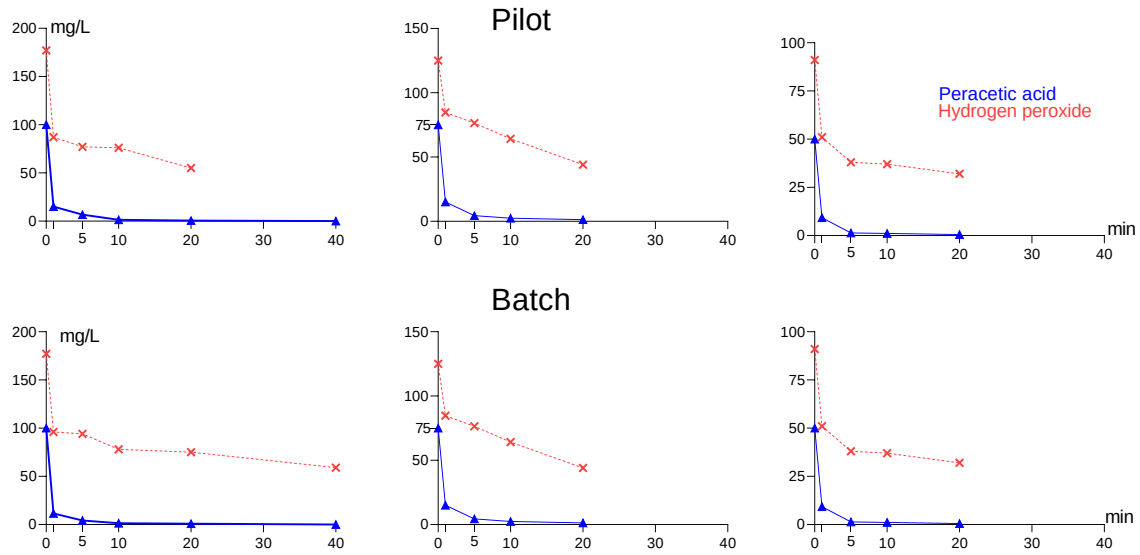

Figure 1: Concentration profile of PAA in the pilot experiment (top) and batch experiment (bottom). Dotted line in the graph represent the concentration of hydrogen peroxide present in the commercial PAA solution.

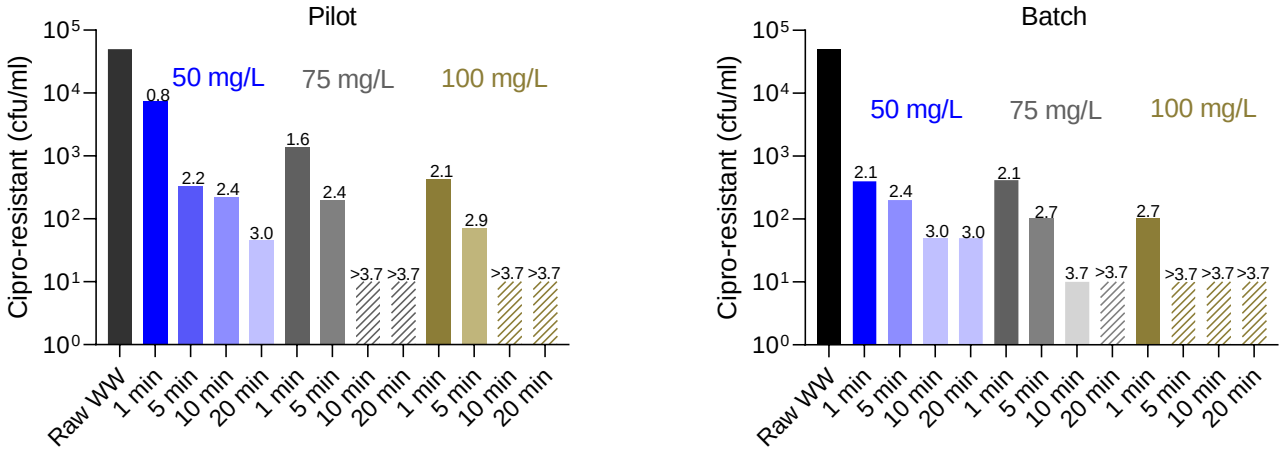

Figure 2. Removal of ciprofloxacin resistant bacteria from pilot scale experiment (left) batch scale experiment (right) treated with different concentration of PAA and contact time. Both experiment were conducted on same time. Number above the bar in the graph represent the log removal. Detection limit was 10 cfu/mL.

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