Miele

Bacterial Log Reduction in Service Textiles

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Laundry Disinfection of Microfiber Mops and Microfiber Clothes by the Miele PW 6101 LL Washing Machine and the PT 7251 NI EL Dryer*

***Please note the models in this study have been updated to PWM 912 EL and PDR 914 EL.**

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Transmission of bacterial, virial and fungal infections by laundry have been documented (Frisby 1957; McNeil 1964; Standaert et al., 1994; Gibson et al., 1999; Borg and Portelli 1999; Duffy et al., 2014). Thus, proper handling and laundering is essential for control of pathogenic microorganisms via laundry. Removal of pathogenic microorganisms during laundering is achieved by a combination of physical and chemical factors as well as temperature. Physical factors include mechanical action by the action of the washing machine. Chemical action includes effects of the detergent and disinfectants (chlorine, activated oxygen bleach i.e. Perborate or TAED (Tetraacetylethylenediamine/ percarbonate compounds). Wash water temperatures above 40°C (104°F) have a detrimental impact on microorganisms and can play a significant role in the removal (killing; inaction) of microorganisms (Bockmuhl 2017).

Proper laundering of institutional (healthcare, nursing homes, hotel) service textiles and mops is important in preventing transmission of infectious microorganisms. This is especially true in the healthcare industry where transmission of antibiotic resistant bacteria has become a major problem. These bacteria include methicillin-resistant Staphylococcus aureus (MRSA), vancomycin-resistant enterococcus, and carbapenem-resistant Enterobacteriaceae. These bacteria have been identified on hospital fabrics and clothing of healthcare workers (Perry et al. 2001). They have been found to survive for weeks on hospital fabrics (Koca et al. 2011). Under conditions of storage (hamper, closet) before or after laundering bacterial numbers can increase (Hamer et al. 2011).

It has been suggested that fungi present in clothing may also play a role in transmission of dermatitis and onchomycossis (infection of the nails) (Ossowski and Duchmann, 1997). Fungal pathogens have been isolated from patients suffering from tinea pedis (Amichael et al. 2013). Clothing has been linked to transmission of Microsporium canis (Bloomfield et al. 2011). M. canis belongs to the group of dermatophyte fungi, which are closely related microorganisms that have the ability to invade the stratum corneum of the epidermis and keratinized tissues derived from it, such as skin, nails, and hair of humans and animals. These fungi produce an infection called dermatophytosis, commonly referred to as ringworm or tinea. Of 70 household washing machines sampled in one study, 79% were positive for fungi (Babic et al., 2015). Among the species detected, the opportunistic fungi Candida and Fusarium were detected. Fungi can also cause life threating infections among the immunocompromised. Murcormycosis, an infection of the order Mucorales, can cause mortality rates which can exceed 50% (Reden et al. 2005). Outbreaks have been associated with linens in healthcare (Sundermann et al. 2019). It was found that 33% to 73% of the recently laundered linens were contaminated with Aspergillus (Sundermann et al. 2019).

A wide range of enteric and respiratory viruses have been detected in textiles including rota, hepatitis A, B, herpes simplex, SARS-CoV-2, influenza, and adeno (Bergson et al. 1990; Keefe 2004; Bloomfield et al. 2011; De Silva et al. 2014; Phan et al. 2019; Jiang et al. 2020).

The blood-borne pathogen hepatitis B virus has been shown to be transmitted by sharing bathroom towels. Hepatitis A and vaccinia (smallpox virus) viruses have also been shown to be transmitted by textiles (Bloomfield et al. 2011). Most respiratory viruses, including SARS CoV-2 do not survive more than a day or two in clothing (Boone and Gerba 2007; Harbout et al. 2020). The survival of influenza virus in clothing was found to be related to the rate of water loss during drying (Ikeda et al. 2015). Thickness of the cloth and its color was related to survival with faster inactivation in black cloth. However, some enteric viruses, such as rotavirus and hepatitis A virus may survive for weeks (Boone and Gerba, 2007; Yeargin et al. 2016).

Pathogenic bacteria and molds, such as Salmonella and MRSA, may survive for weeks in clothing (Bloomfield et al. 2011). Naturally occurring Pseudomonas aeruginosa and Acinetobacter can grow in clothing after laundering with clothing from wastewater treatment workers (Maal-Bared, 2019). Apparently the naturally occurring bacteria have adapted to the laundering conditions, and enough organic matter remains for their regrowth during storage after laundering.

Microfiber mops and cleaning clothes have been shown to have better removal capabilities in removing dirt and bacteria from contaminated surfaces (Wren et al. 2008). Thus, they were selected to demonstrate the ability of the Miele PW 6101 washing machine and PT 7251 NI EL dryer to decontaminate several types of bacteria responsible for hospital acquired infections in reusable microfiber mops. Bacteria included in the study were:

- Methicillin resistant Staphylococcus aureus (MRSA) (ATCC 33592)
- Enterococcus fecalis VRE (ATCC 700221)
- Escherichia coli CRE (ATCC BA2469)

This study involved testing the reduction of the bacteria in microfiber mop heads and clothes. The mops were 45 cm (17.7 in) wide and 13.5 cm (5.31 in) in length, before beginning the project. They were washed in the Miele PW 6101 using program cycle 100 to eliminate any naturally occurring bacteria on the mop heads and cleaning clothes.

Cultures of the test organisms were grown overnight and inoculated onto 9 mop sections or microfiber cleaning clothes as described in Appendix 1. Because of the large size of the mop heads, to which the bacteria were added, they were cut into four sections to reduce the size of the mop that had to be processed to recover the bacteria.

The dimensions of the mop head sections used for bacteria testing were 6 cm (2.36 in) by 13.5 cm (5.31 in) in size. In addition to the bacterial inoculated mops, 25 intact mop heads were included in the wash load for a total weight of 2.4 kg (11.6 pounds). To simulate a dirt load, 2 +/-0.02 grams of vacuum cleaner dust was added to each mop head. The wash cycle was then set and the items were washed according to the programming of the cycle. Three inoculated mop head sections inoculated with bacteria were removed for testing and the mop heads placed into the Miele PT 7251 dryer and the remaining inoculated mop head sections processed for bacterial testing.

The microfiber cleaning clothes were composed of 80% polyester and 20% polyamide and measured 30 X 28 cm (11.81 X 11.02 in) after washing. A dirt load was stimulated by addition of 1 mL of a 1% solution of fetal calf serum in distilled water to each cloth. Bacteria were recovered as described for the mop heads.

The bacteria were recovered from the mop head sections as described in Appendix 2. Three types of programed washing conditions were tested:

- 100: Chemical disinfection, with thermal disinfection and souring agent;
- 101: Thermal disinfection and souring agent (no chemical disinfection);
- 102: Thermal disinfection only (no chemical disinfection or souring agent).

The programing allows a control of the washing temperature as addition of detergent, souring agent and activated oxygen activated bleach at various stages of the laundering process.

Thermal disinfection was accomplished by water temperature of 162°F (72.2°C) for 25 minutes.

A detergent, Derval Solo was used at a dose of 80 ml = 8ml/Kg (Chemische Fabrik Kreussler and Co., Wiesbaden, Germany). The chemical disinfectant was Ottalin Peracet (Chemische) added at a dose of 20 ml = 2ml/Kg for a contact time of 25 min. It was obtained from Kreussler, Tampa, FL. The souring agent, Otalin Citro (Chemische), was added at a concentration of 20 ml = 2ml/Kg for a contact time of 4 min.

Results

The results of bacterial reductions by the different washing programs are shown in Table 1. The maximum log reduction varies between the different bacteria, because they grow to different concentrations, and not always to the same concentration could be added to the bacteria each time. All of the bacteria were reduced in concentration by more than 7 Logs. Most of the bacteria were reduced below the detection limit of the assay method, drying usually eliminated the remaining bacteria. A 5 to 6 Log reduction is usually considered disinfected.

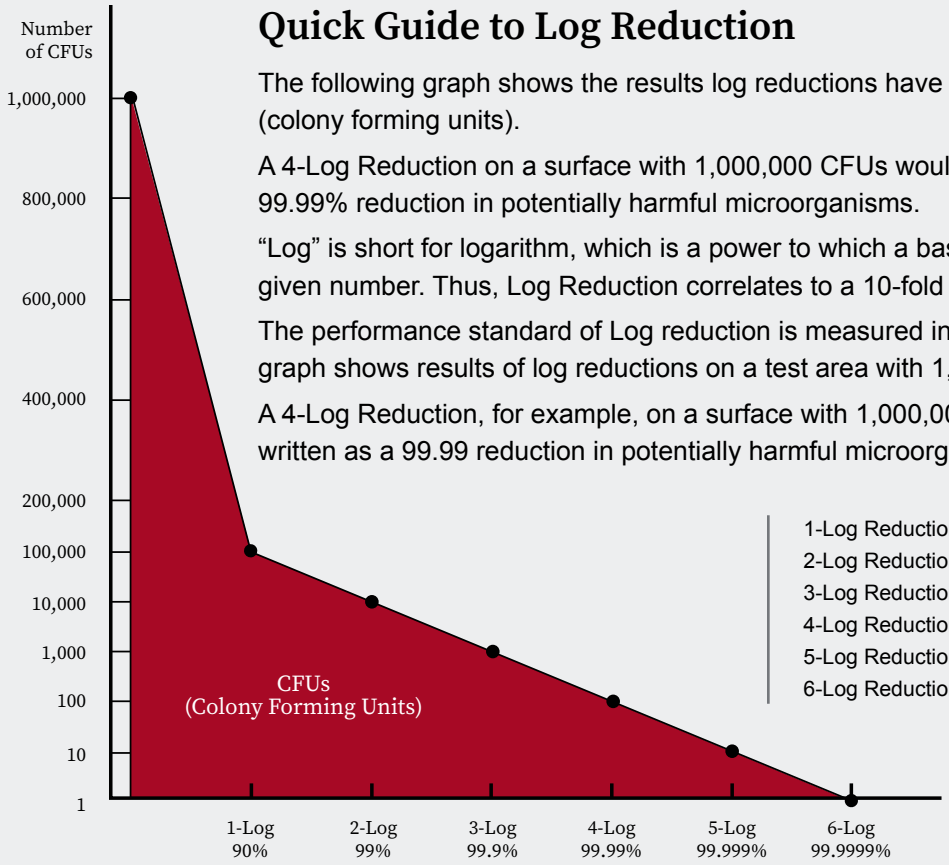
Table 1. Reduction of MRSA in mops (Average of triplicates for each wash condition)

Program	MRSA		CRE		VRE	
	Mop	Cloth	Mop	Cloth	Mop	Cloth
100: Chemical disinfection, with thermal disinfection and souring agent	>8.30	>7.22	8.40	>8.35	>7.42	7.61
101: Thermal disinfection and souring agent	>8.24	7.84	7.51	>8.52	7.36	>8.01
102: Thermal disinfection only	>8.24	7.75	7.92	>8.32	>7.42	>8.11

*Colony forming units in the cloth

Discussion

All of the washing cycles used in this study demonstrated that the Miele PW 6101 LL Washing Machine was effective in disinfecting all of the antibiotic resistant bacteria. The temperature of the wash water was effective alone in achieving disinfection of the mop heads and clothes even in the presence of a dirt load.



Quick Guide to Log Reduction

The following graph shows the results log reductions have on a test area with 1,000,000 CFUs (colony forming units).

A 4-Log Reduction on a surface with 1,000,000 CFUs would leave 100 CFUs, which is written as a 99.99% reduction in potentially harmful microorganisms.

"Log" is short for logarithm, which is a power to which a base, such as 10, can be raised to produce a given number. Thus, Log Reduction correlates to a 10-fold reduction i.e. 1 log = 90% reduction.

The performance standard of Log reduction is measured in terms of colony forming units (CFUs). The graph shows results of log reductions on a test area with 1,000,000 CFUs remaining.

A 4-Log Reduction, for example, on a surface with 1,000,000 CFUs would leave 100 CFUs, which is written as a 99.99 reduction in potentially harmful microorganisms.

1-Log Reduction (Log1): Number of CFUs is 10 times smaller
2-Log Reduction (Log2): Number of CFUs is 100 times smaller
3-Log Reduction (Log3): Number of CFUs is 1,000 times smaller
4-Log Reduction (Log4): Number of CFUs is 10,000 times smaller
5-Log Reduction (Log5): Number of CFUs is 100,000 times smaller
6-Log Reduction (Log6): Number of CFUs is 1,000,000 times smaller

Exceptional results on mops— Heavily soiled and wet mops require special attention. In a customized program, mops are spun at the very beginning of the cycle to minimize the carryover of soil into the wash cycle as such. This process ensures best possible cleaning performance combined with gentle fabric care.

Impregnation of mops and cleaning cloths— Mops and cleaning cloths are impregnated after washing with the requisite detergents and disinfectants to facilitate immediate re-use. This process ensures a rapid turnaround, improves surface cleaning performance and, compared to manual reprocessing, results in significant time saving.

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Appendix 1

Test Protocol for Mop and Microfiber Washing and Drying (Version 1)

1. Prepare an overnight culture of the test bacterium. (Grow in trypticase soy broth overnight in an Erlenmeyer flask in the shaking water bath at 37°C).
2. To each mop to which the bacteria will be added add 2 grams of vacuum cleaner dust by placing it on a flat surface and moving the mop over the surface. In the case of the microfiber clothes a dirt load was stimulated by addition of one mL 1% fetal calf serum in distilled water.
3. Add 5 mL as 0.1 mL drops across the surface of the mop surface for a total of 45 mL to 9 mops (be sure to mark the contaminated mops). In the case of the cleaning clothes 0.1 mL amount were added for a total of one mL to each clot.
4. Let the drops dry at room temperature for 45 minutes.
5. Process 3 of the mops/clothes as pre-wash controls.
6. Place the bacterial contaminated mops/clothes in the washing machine along with 25 non-contaminated mops.
7. Run on the 100/101/102 pre-programmed wash cycle.
8. Remove 3 of the contaminated mops/clothes for bacterial testing.
9. Place the remaining mops/clothes in the drier set at the programmed 100 dry cycle.
10. Remove the 3 remaining mops/cloths and process for bacterial testing.

Appendix 2

Protocol for Bacterial Testing (Version 1)

1. Place the contaminated mop/cloth in a plastic bag containing 30 mL of 1% peptone broth.
2. Close the bag and manually knead the bag for 3-5 minutes until the broth is totally adsorbed by the microfiber mop/cloth.
3. Place in the stomacher for 3 minutes and then squeeze as much broth from the mop. If need press between steel plates.
4. Record the number of mL recovered from each mop/cloth.
5. Remove 0.1 mL of liquid for dilution for assay in phosphate buffered saline and pass a 10 mL aliquot through a Millipore 0.45 µm pore size membrane (this will allow us to determine a greater log reduction of the organisms.
6. Spread plate the dilution on trypticase soy agar (TSA) media. The filter is placed on the same agar media.
7. Incubate overnight at 37°C and count the bacterial colonies.
8. Calculate the number of colonies recovered from each mop considering the volumes of peptone broth recovered.

Miele Benchmark Performance Plus Washers and Dryers

Are your facility's mops free of infectious bacteria?

Thermal disinfection is powerful and kills potentially harmful microorganisms in service textiles.

The toughest laundry requires rugged machines designed to disinfect, provide superb cleaning and expert fabric care. The PW 800 series washers and companion dryers offer the ideal solution for any facility seeking to reduce infection potential, increase visitor/resident trust and satisfaction and minimize costs associated with water, energy or outsourced services.

Compared with competitive products, Miele Professional's Benchmark Machines line of industrial washer extractors clean more effectively, are more user friendly, are easier to install and represent a benchmark in the industry for energy and water efficiency.

The widely different needs of target laundry-care markets require tailored solutions to achieve perfect washing and disinfection results. To achieve this, Miele Professional relies on customized process technology, i.e. wash programs tailored to the specific needs of specific users.

Miele's programs are controlled by the Profitronic M Controller, which is an innovation originating from Miele's own electronics plant. These sophisticated, high-end controls are not purchased 'off the shelf' but are meticulously designed to meet the most stringent demands. The Profitronic M Controller allows short cycles even in disinfection programs and ensures disinfection temperatures are maintained to achieve thermal and chemo-thermal disinfection. One particular benefit of freely programmable controls is the ability to accommodate and enable customization.

Even special laundry-care requirements can be met with ease, as it is also possible to modify existing programs on Miele machines.

The stainless-steel Performance Plus washers offer enhanced programmability and incorporate the innovative EcoSpeed wash rhythm for world class results. By precisely controlling the drum rotational speeds, the Performance Plus washers clean extremely effectively in an even shorter cycle time, maximizing water and energy efficiency.

All washers feature a purpose-designed suds container, which reduces water levels for the wash and rinse cycles. The enhanced patented honeycomb drum 2.0 features ribs with a new array of perforations, allowing for faster and more thorough washing. The washers also offer improved ergonomics with an easy-to-use automatic door that closes at the touch of a finger. The slim machine width allows the units to be put on a pallet jack for easy delivery and install.

- Freely programmable controls
- 199 program slots
- Pre-defined programs standard
- Special programs: wet cleaning (WetCare), thermal and chemo-thermal disinfection, mops, cloths, door mats, pads, sensitive outerwear, bedding, curtains, reproofing
- Eco program
- Short program duration
- 11 languages
- Low energy consumption
- Low water consumption
- Honeycomb drum
- Large drum volumes
- Connection for up to 12 dispenser pumps
- On-board high-performance heater elements
- Proven process security thanks to integrated data recording system

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