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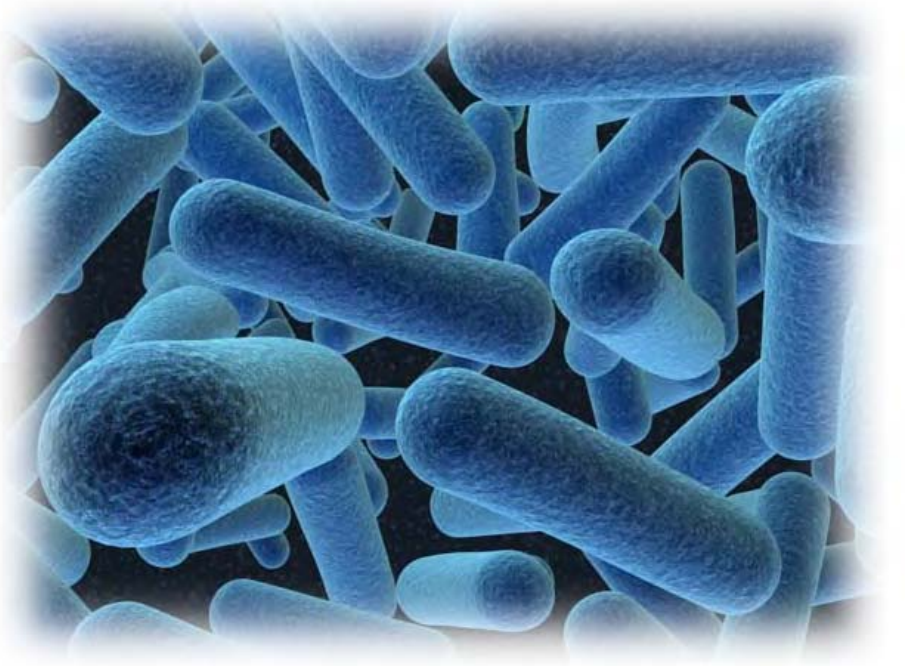

Study on Bacterial Reduction as Influenced by Drying

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Dec15, 2011
Revised Jan 24, 2012
Revised April 17. 2012

Williams® Direct Dryers™
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The benefits of drying personal protective equipment and apparel has been the purview of subjective assessment based on observation/experience and common sense/conjecture. In the past, It has been difficult to quantify these benefits other than observing that dried gear tends to be less "smelly" and the wearing of dry gear logically must be healthier than wearing wet. This report takes the next step and begins the qualitative and quantitative assessment of drying.

Special thanks must be given to Ms Jayme Wiggins RN, BSN, NR-EMT-B of the Children's Hospital Medical Center of Akron without which this report would not be possible.

Overview

In the early 1990's the concept of drying personal gear was in its infancy. Commonly held belief stated that if "it" wouldn't go in a rotary dryer than drying just wasn't possible and not necessary.

Williams® pioneered the concept of drying ski boots on a mass scale in numerous rental operations. Operators were pleased with the decreased turnaround time between re-use but also commented on the sudden abatement of locker room odor.

Direct Drying™

Williams® Direct Dryers™ specializes in the design, development and manufacture of drying equipment required to dry Personal Protective Equipment (PPE) and many other types of personal wear.

Direct drying is defined as the application (or directing of) warmed (sometimes ambient) air to the farthest and hardest part of the garment to dry. As opposed to alternative drying solutions which depend on a global approach (usually rotary style dryers), direct drying uses a localized regime of drying points. This is especially useful when applied to the drying of items such as: boots, gloves, helmets, face pieces, and purpose built protective gear.

Williams® Subjective Case Study

Case Study

An internationally know ski resort approached *Williams*® with a very specific problem related to the development of a proposed employee services building. The facility was intended to provide locker storage for 750 employees. The catch being, these were outside workers who after the end of each shift must deposit their issued coat, pants plus ski boots in a locker over night. Next morning the employee would have to don this gear.

The obvious problems were: wet gear and the impact on employee comfort; plus the resulting potential for extreme locker room odor.

Williams® developed a prototype dryer designed to dry and store boots plus create a convection current within the locker. The client did a full scale mock up to test four units.

The evaluation consisted of running the coat and pants through a washing machine to spin cycle; filling the boots with water then dumping out. The wet gear was placed in each of the four test lockers and left for 24hours with the prototype dryer on. It should be noted that these dryers used only 14W of energy.

Upon completion, the client contacted *Williams*® and stated that: as she was presently standing on one of the dryers and the test was a complete success would we please proceed with the order.

Not withstanding the initial test success, after over 15 years of operation the facilities are still noted for their complete absence of locker room odor.

Study Observations

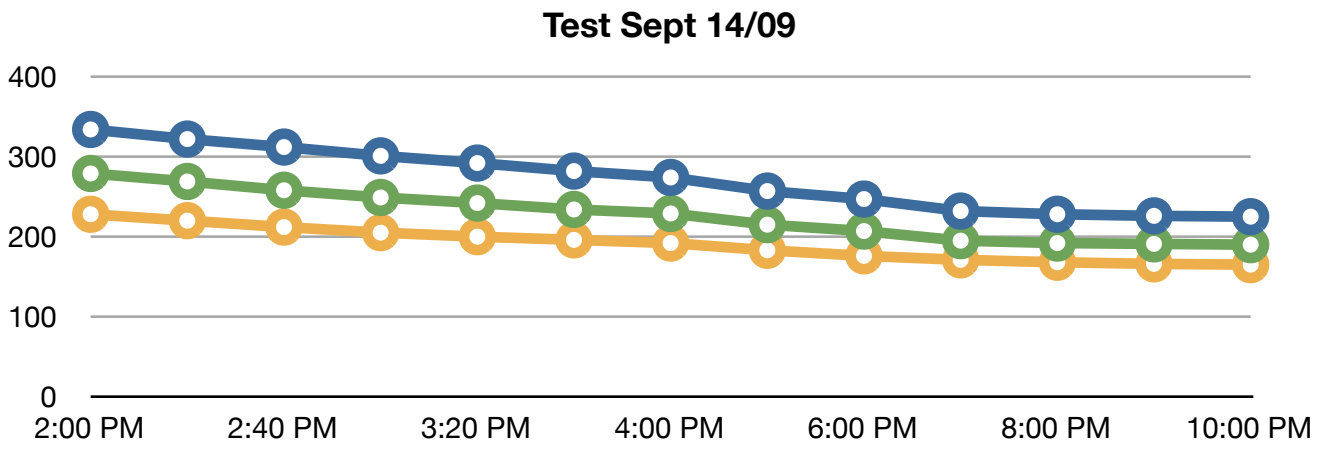
There are three general conditions which support the growth of microbes: warmth, moisture, and darkness, each of which is found without exclusion in all personal protective equipment. Control of bacterial load can be enhanced by the simple application of this knowledge. Moreover, the elimination of moisture seems to provide a singularly effective means of limiting bacterial growth.

However, the removal of moisture from fabrics is, in itself, not a simple matter. *Williams*® has conducted numerous drying tests on various types of gear, each with individually unique fabric signatures. From these tests, we were able to conclude while under similar drying conditions:

1. All fabrics saturate at different moisture levels and dry at different rates (not surprising).
2. All fabrics have a point at which they "feel dry" to the touch are, in fact, still moist to the order of 5% of initial saturation levels.

When a fabric feels dry there is still sufficient liquid available to nurture bacterial growth. In order to explain this phenomenon, we hypothesized that at a microscopic level water adheres to fabric fibers, similar to "hydrotropism", driven by inter-molecular attractive forces between the liquid and solid surfaces. Thus liquid cohesion combined with adhesion to a solid creates a strong bond which must be broken to complete drying.

Practically speaking this takes additional energy to break the attractive forces between liquid and solid. That is why a Direct Dryer™ is designed to deliver warmed air at 10˚-15˚F/6˚-8˚C above room temperature. This design balances the need for warmth without the prospect of overheating the fabric (reference NFPA 1851 "Care & Maintenance of Protective Ensembles" which limits heat applied to fabrics to 104˚F/32˚C).



The above graph demonstrates a normal drying curve. The asymptotical finish is typical of the additional energy required to overcome "hydrotropism".

This drying test was conducted on Fire Fighter gloves for Underwriters Laboratories Inc.

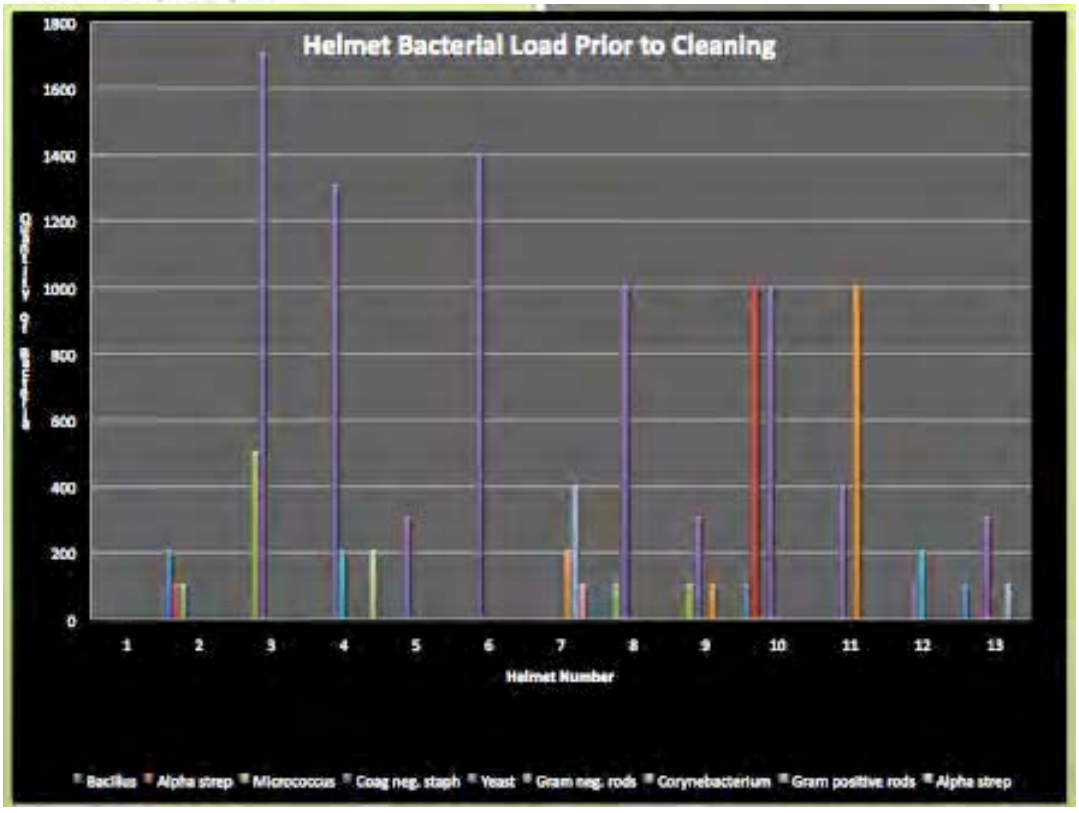
Akron Children's Hospital Qualitative/Quantitative Case Study[1]

Qualitative and Quantitative study of the reduction of bacterial load in flight helmets

- 13 month study evaluating the type and quantity of bacteria that grows within our flight helmets.
- Initiation of practices to reduce bacterial growth such as cleaning regimen and use of specifically designed helmet dryer.
- Evaluation of data and implementation of evidence based change of practice

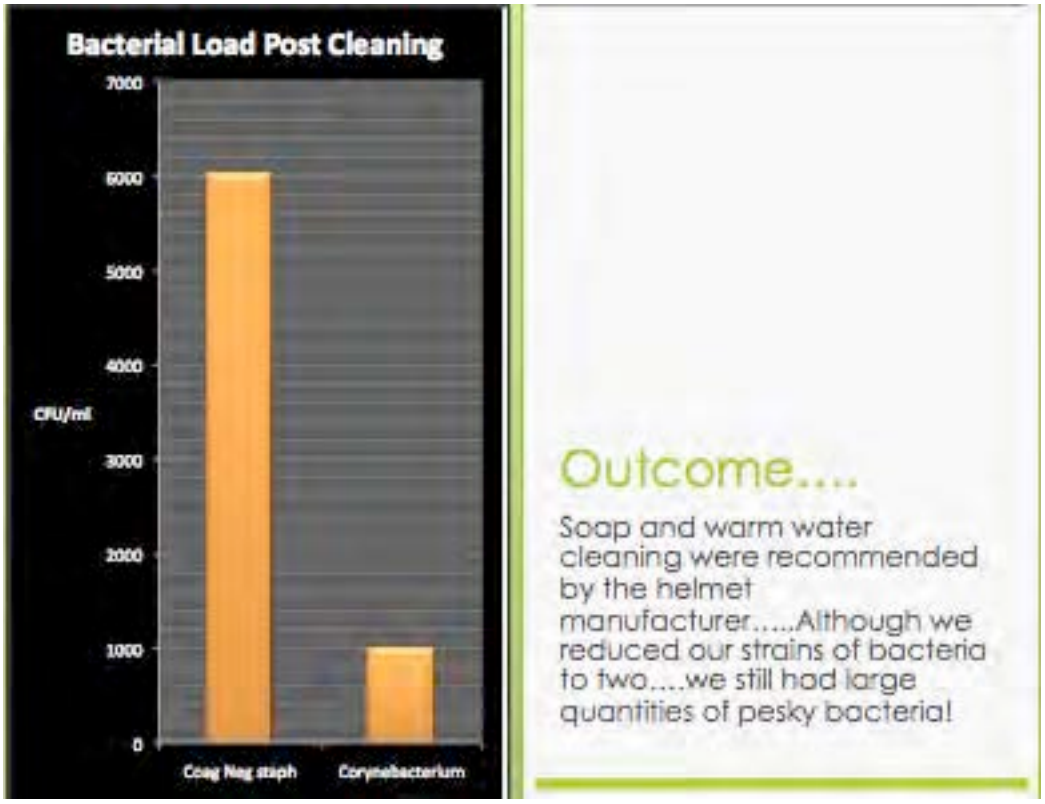
We studied our helmets to answer the question.....

1 Excerpts from Power Point Presentation P16-28 inclusive prepared by Jayme Wiggins RN, BSN, NREMT-B



See Appendix A for a description of the different microbes found in the flight helmets.


Yuck...
How can we fix this?


Bacterial Load Post Cleaning
7000
6000
5000
4000
CFU/ml
3000
2000
1000
0
Coag Neg staph
Corynebacterium
Outcome....
Soap and warm water cleaning were recommended by the helmet manufacturer.....Although we reduced our strains of bacteria to two....we still had large quantities of pesky bacteria!

Networking & Research....putting great ideas together!

Meeting new people across the world.....

Williams Direct Dryer showed great interest in our effort to reduce the bacterial load found in our flight helmets.

Proven bacterial load reduction in firefighter gear....

Model H12

Williams® Direct Dryers™

With a little ingenuity.....

Our helmet dryer was created...but not without cost!

The initial proposal of the cost of the dryer was approx. $3600.00. After working with Williams for purposes of research, they agreed to let us use the dryer for our pilot study.

We were able to reduce our bacteria significantly using cleaning and the dryer....


But the really impressive results came from consistent use of the dryer...even between cleanings!
BACTERIAL LOAD 30 DAYS AFTER CLEANING USING ONLY HELMET DRYER


And after the impressive data was shared with Williams Direct Dryer.....
The custom designed helmet dryer that was designed for purposes of our study was donated to Akron Children's Hospital without cost by Williams!

Results

Microbe Quantities (cfu/ml)

	Prior to Cleaning	Wash Per Manufacturers'	Continuous Drying per *Williams®*
All Helmets	38000	7000	19
Per Helmet	2923	538	1
% Reduction		81.6%	99.95%

Microbe Varieties Remaining after Each Cleaning Technique

	Prior to Cleaning	Wash Per Manufacturers'	Continuous Drying per *Williams®*
All Helmets	9	2	0
% Reduction		77%	100%

Conclusions

- A large number and variety of microbes can populate a flight helmet.
- The type of microbes found in flight helmets can cause a significant variety of human diseases.
- Washing and drying flight helmets per manufacturer's recommendation reduces the microbe load by 77% however 22% of the varieties are still present.
- Direct Drying™ on a continuous basis effectively eliminates microbe load and variety by 100%.

Appendix A Definitions

Bacillus

Bacillus is a member of the division Firmicutes. Common in nature, Bacillus includes both free-living and pathogenic species. Two special Bacillus species are: B. anthracis and B. cereus. These are associated medically with anthrax (former) and food poisoning (latter).

Alpha-hemolytic streptococci

The Streptococcus family is responsible for many medical conditions including: meningitis, endocarditis, erysipelas, and necrotizing fasciitis. The alpha version breaks down red blood cells by oxidizing the iron in the hemoglobin. S. pneumococcus is the leading cause of bacterial pneumonia.

Micrococcus

Micrococcus is a genus of bacteria that can be found in a wide host of readily found environmental conditions. M. luteus is well know for its role in transforming human sweat into an unpleasant odor well know in locker room conditions.

Coagulase-negative staphylococcus

Staphylococcus is another genus of bacteria which includes numerous species. A wide variety of diseases in both humans and animals are associated with staphylococcal toxins such as food poisoning and sialadenitis, the inflammation of a salivary gland.

Yeast

Yeasts are found in the Fungi kingdom with thousands of known species and probably 100 times more not yet described. Yeast microbes have provided for the well being of humanity through the development of fermentation in all its glorious forms. Never-the-less, there are a group of pathogenic yeasts which can significantly affect immunocompromised individuals plus others which cause the ubiquitous “yeast” infections to which we are all familiar.

Gram-positive rods

Gram staining of these bacteria create a dark blue or violet color. Rods refer to the shape of the bacilli which is rod shaped as opposed to Streptococcus and Staphylococcus which are spherically shaped. Most pathogens in humans are Gram-positive organisms.

Gram-negative rods

Gram-negative rods cannot retain the crystal violet stain which leave them showing as a red or pink color. The result (staining & cell shape) is another grouping of species within the Bacteria Domain. Medically significant conditions associated with these forms include organisms that cause: gonorrhoeae, meningitis and a hole host of respiratory, urinary and gastrointestinal problems.

Corynebacterium

Corynebacterium is a Gram-positive rod bacterium which is mostly benign and common in nature. However, in its pathogenic incarnation the result can be the acute and infectious contagion, diphtheria.

Streptococcus viridans

Viridans *Streptococcus* is a catch all group of streptococcal bacteria that are most abundant in the mouth which can result in tooth decay and gingival infections. They have the potential to cause heart related issues if they enter the blood stream.