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TITLE: Removal of aerosolized contaminants from working canines via a field wipe-down procedure.

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HIGHLIGHTS

- Common veterinary antiseptic cleansers can be used in wipe-down decontamination of working canines.
- Contaminant reduction was unaffected by coat type when Labrador retrievers were compared to German shepherds.
- Wipes saturated with dilute 7.5% povidone-iodine scrub were more effective than wipes saturated with dilute 2% chlorhexidine gluconate scrub or water in reducing the burden of a simulated aerosolized contaminant on working canine exterior coats.

ABSTRACT

Evidence-based canine decontamination protocols are underrepresented in the veterinary literature. Aerosolized microbiological and chemical contaminants can pose a risk in deployment environments highlighting the need for improved canine field decontamination strategies. Prior work has established the efficacy of traditional, water-intensive methods on contaminant removal from the coat of the working canine; however, it is not known if similar reductions can be achieved with simple field expedient methods when resources are limited. The objective of this study was to measure the reduction of aerosolized contamination via a practical "wipe-down" procedure performed on working canine coats contaminated with a fluorescent, non-toxic, water-based aerosol. Disposable, lint-free towels were saturated with one of three treatments: water, 2% chlorhexidine gluconate scrub (CHX), or 7.5% povidone-iodine scrub (PVD). Both CHX and PVD were diluted at a 1:4 ratio. Treatments were randomly assigned to one of three quadrants established across the shoulders and back of commonly utilized working dog breeds

(Labrador retrievers, n = 16; German shepherds, n = 16). The fourth quadrant remained unwiped, serving as a control. Reduction in fluorescent marker contamination was measured and compared across all quadrants. PVD demonstrated greater marker reduction compared to CHX or water in both breeds ($P < 0.0001$). Reduction was similar between CHX or water in Labradors ($P = 0.86$) and shepherds ($P = 0.06$). Effective wipe-down strategies using common veterinary cleansers should be further investigated and incorporated into decontamination practices to safeguard working canine health and prevent cross-contamination of human personnel working with these animals.

INTRODUCTION

Working canines frequently operate in contaminated environments. Contact with aerosolized contaminants is possible when operations occur near contaminated waters (*e.g.*, floodwater, sewage). Such aerosols may harbor pathogenic microorganisms (1) and/or hazardous chemicals that can contaminate the exterior coat of the working canine, posing direct health risks to the canine through inhalation, ingestion and skin contact as well as to human personnel through fomite transmission. While any canine may be at risk, breeds at greatest risk for exposure include those utilized for working disciplines including Labrador retrievers and German shepherds. Evidence-based decontamination strategies are needed to mitigate the potential health risk posed by aerosolized contaminants present on the coat of the working canine.

Decontamination of working canines deployed to contaminated environments has been recommended previously and should be incorporated into training protocols and best practices

(2–4). Current canine decontamination procedures utilize significant amounts of water, which may not be available in resource-limited settings. In this study, a simple field expedient decontamination method using disposable towels saturated with 2% chlorhexidine gluconate scrub (CHX), or 7.5% povidone-iodine scrub (PVD) diluted at a 1:4 ratio, was evaluated for efficacy in reducing the burden of a simulated aerosol contaminant on the exterior coat of the working canine. In addition to ease of use, this water-restrictive method also reduces the likelihood of wash-in effect by removing surface contamination directly, and minimizes disruption of the canine's epidermal barrier which may occur with full-body bathing and traditional water-intensive decontamination. We hypothesize that our method effectively removes a simulated water-based aerosol contaminant from the coat of working canines in resource-limited settings and may preserve dermal health.

MATERIALS & METHODS

Animal enrollment

Institutional Animal Care & Use approval (# 19-031) was obtained from Southern Illinois University prior to the initiation of this study. Working canines (Labrador retrievers, n = 16; and German shepherds, n = 17) from two facilities were utilized in this study. Black Labradors (upland sporting dogs) from a single kennel, housed in similar conditions and maintained on a single commercially available balanced diet (chicken and rice) were included. German shepherds (military/law enforcement dogs) from a single facility, housed in similar conditions and maintained on a single commercially available, balanced diet (chicken and rice) were included. All canines were assessed for health by a licensed veterinarian prior to inclusion in the study. One dog was removed from the study due to the presence of a skin lesion at the

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anatomical site where the decontamination methods were to be evaluated. Results are presented for the remaining 32 canines.

Application of contaminant and wipe-down procedure

The dorsal aspect of each canine was divided into quadrants (**Figure 1**) and dermal pH was measured at the base of the tail in triplicate using a hand-held dermal pH meter (HI 99181 Portable Waterproof Skin pH Meter, Hanna Instruments, Woonsocket, Rhode Island) to document pre-existing dermal conditions prior to application of the simulated aerosol contaminant.

A simulated, non-toxic fluorescent contaminant (GloGerm®, Moab, UT) was combined with water to create a 1:8 ratio solution. A commercially available sprayer (Master Blaster, Bottle Crew Farmington Hills, MI) was used to aerosolize and apply the simulated contaminant. The sprayer was held at a distance of 60 cm (±5) from the canine's hips and directed parallel from the rear to the front of the canine to create an aerosolized contamination of 49 (±11) droplets/cm^2. An Elizabethan collar was used to protect the canine's head from exposure.

Following application of the contaminant, disposable, lint-free towels (Davelen©; Derwood, Maryland) were saturated and utilized for wipe-down decontamination with one of the following three treatments: water (H_2O), 2% chlorhexidine gluconate scrub (CHX), or 7.5% povidone-iodine scrub (PVD). The two cleansers were diluted with water at a ratio of 1:4. Wipe-down with one of the three treated towels was randomly assigned to a quadrant on the dorsal aspect of the canine. The last remaining quadrant was left unwiped to serve as a control for comparison of contaminant reduction. Following cleanser wipe-down, a second wipe was performed using a water saturated towel to remove any antiseptic cleanser residue.

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Fluorescence, indicative of simulated aerosol contamination, was documented in each of the quadrants on the dorsal aspect of the canine following wipe-down and compared with the control quadrant via digital imaging using a Canon T5i DSLR (Canon Inc., Tokyo, Japan) camera positioned 45 cm (± 5) from the canine. Categorical scoring of fluorescence reduction was utilized according to a method previously published (5–7). The scoring method was applied utilizing two blinded and independent reviewers with 82% agreement. Scores were defined as follows: 0 = <25% contamination reduction; 1 = 25% – 50% contamination reduction; 2 = 51% – 75% contamination reduction; 3 = >75% contamination reduction. No score discrepancies > 1 were observed between reviewers. A score of 3 (±75% reduction) was considered successful decontamination. Contaminant reduction scores for each treatment are reported as a percentage of total frequency (192 total scores).

Statistical Analysis

Data entry was performed using Microsoft Excel (Microsoft Corporation, Redmond WA) and data were analyzed using SAS, version 9.4 (SAS Institute Inc, Cary, NC). Dermal pH data were analyzed using PROC GLM and categorical data for fluorescence reduction were analyzed using PROC FREQ. Significance for all variables of interest was established at $P < 0.05$.

RESULTS

Dermal pH

Dermal pH of study participants was unaffected by breed when shepherds were compared to retrievers ($P = 0.3393$). Mean dermal pH was 8.32 and 8.60 for German shepherds and Labrador retrievers, respectively. Additionally, no differences in dermal pH were observed

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between intact males (8.38), intact females (8.73), or spayed females (8.35) (P = 8.30). No effect was evident for breed*sex (P = 0.8175).

Contaminant reduction

Contaminant reduction was similar between Labrador retrievers and German shepherds (P = 0.6417; **Figure 2)**. Amongst Labrador retrievers, the greatest frequency of successful decontamination scores was observed with PVD (success = 26) compared to CHX (success = 8) or water (success = 7) wipes (P < 0.0001). Similarly, amongst German shepherds, the highest frequency of successful decontamination was also seen with PVD scores (success = 21) as compared to CHX (success = 3) or water (success = 6) (P < 0.0001, **Table 1**).

Frequency of scores for each cleanser indicating successful contaminant removal are shown in **Figure 3.** Overall, cleanser treatment significantly impacted contaminant reduction for study participants (P < 0.0001) with a greater rate of successful reduction (68.75%) associated with PVD treatment. Furthermore, when CHX (20% successful scores) was compared to water (23% successful scores), no significant difference in success scores was observed (P = 0.4568).

DISCUSSION

Evidence-based field decontamination strategies are needed to address the wide range of environmental hazards working canines are likely to encounter during disaster, search and rescue, law enforcement, and national security responses. While inhalation of hazardous aerosols remains difficult to prevent in working canines, aerosol contamination of the exterior coat with water-based aerosols can be mitigated. In this study, a simple wipe-down procedure using disposable towels saturated with diluted 7.5% povidone-iodine scrub, a common veterinary

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antiseptic cleanser, was found to have greater efficacy in reducing the burden of a simulated water-based aerosol contaminant from the coats of working canines compared to towels saturated with water or dilute 2% chlorhexidine gluconate scrub.

Working canines can be tasked to environments rich in pathogenic microbiota. Following hurricanes (8,9) and floods (10) , high levels of coliforms owing to raw sewage and wastewater system failures have frequently been detected in floodwater. Aerosolization of floodwater can occur both naturally and during boat operations. Additionally, urban environments are frequently contaminated with pathogenic microorganisms (11). Air quality in urban centers is closely linked to local water quality; while diverse in microbiota, urban aerosols frequently carry pathogenic bacteria and viruses associated with sewage and wastewater treatment (12). Working canines contaminated with aerosolized contaminants may accidentally ingest pathogenic microorganisms through self-grooming behaviors leading to gastrointestinal disease. Cross-contamination of human personnel with pathogenic microorganisms from a working canine's exterior coat (fomite transmission) may place these individuals at risk for infection as well. Working canine decontamination is therefore essential to protecting both canine and human health.

Decontamination is essential to prevent or limit direct and secondary exposure to toxins and pathogens encountered during field operations and is often performed multiple times a day (13). Serial decontamination, while necessary, can disrupt the working canine's epidermal barrier and diminish the protective effects of healthy skin and coat (13) increasing the likelihood of absorption of hazardous materials through the skin. Human studies demonstrate that repeated use of soap damages protein and lipids in the skin's stratum corneum, leading to detectable dryness, redness, and irritation and increased skin permeability (14,15). Prior canine studies (16,

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17) identified impacts of washing on skin by measuring dermal pH and barrier function of the epidermis as measured by trans epidermal water loss (TEWL; Discepolo) and the Canine Atopic Dermatitis Extent and Severity Index (CASESI; Zoran). Discepolo et al. demonstrated that cleanser selection can have a significant impact on the skin barrier with a single use, with Dawn® dish soap causing more significant dermal effects than Nolvasan® or Betadine®. Zoran demonstrated that repeated washing resulted in mild to moderate skin irritation in dogs in as little as 4.9 days using Dawn®, which contains sodium lauryl sulfate (SLS), a high-anionic surfactant known to cause skin disruption in humans (18). Interestingly, we found that use of wipe-down procedures employing disposable towels saturated with water, 2% CHX, or 7.5% povidone-iodine solution had no adverse impact on dermal pH. Decontamination using such field-expedient procedures can balance the need for frequent decontamination with preservation of canine skin integrity, with more traditional detergent-based decontamination reserved for the end of a work cycle.

The working canine's coat provides a natural barrier to contamination, reducing direct skin exposure to some contaminants. Decontamination procedures that utilize large amounts of water have the potential to cause a "wash-in" effect whereby the decontamination procedure itself or the cleaner/biocidal enhances the penetration of contamination through the hair or into the skin (19,20). An effective wipe-down procedure reduces the burden of aerosolized contaminants on the working canine's exterior cut, limits the amount of clean water needed for field decontamination when resources are limited, and may even minimize the "wash-in" effect when performed frequently prior to traditional, water-intensive decontamination methods at the end of a work cycle.

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While previous work has shown that working canines are readily exposed to and contaminated with oil-based agents through direct contact (5,6), we are only just starting to understand the risk of contamination with water-based aerosols present in the environment. A simple field-expedient wipe-down procedure utilizing disposable towels saturated with 7.5% povidone-iodine solution may effectively reduce the burden of water-based aerosol contaminant on the coats of working canines without adversely affecting dermal pH. Further work is needed to define appropriate exposure thresholds for performing wipe-down vs. traditional decontamination during working canine field operations.

ETHICS STATEMENT

Procedures for this work were approved in advance by the Institutional Animal Care & Use Committee at Southern Illinois University (protocol #19-031)

AUTHOR CONTRIBUTIONS

EP supervised study design, study execution, data collection, data analysis, manuscript writing, and review. EKJ contributed to study design, study execution, data collection, manuscript writing and review. DRD contributed to study design, study execution, data collection, data analysis, manuscript writing and review. SYL contributed to study design, data analysis, manuscript writing and review.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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Figure 1: Canine dorsal area divided into quadrants for testing of a wipe-down procedure by removal of a simulated aerosolized contaminant. A = score 0 (unwiped control); B = Score 2; C = Score 1; D = Score 3.

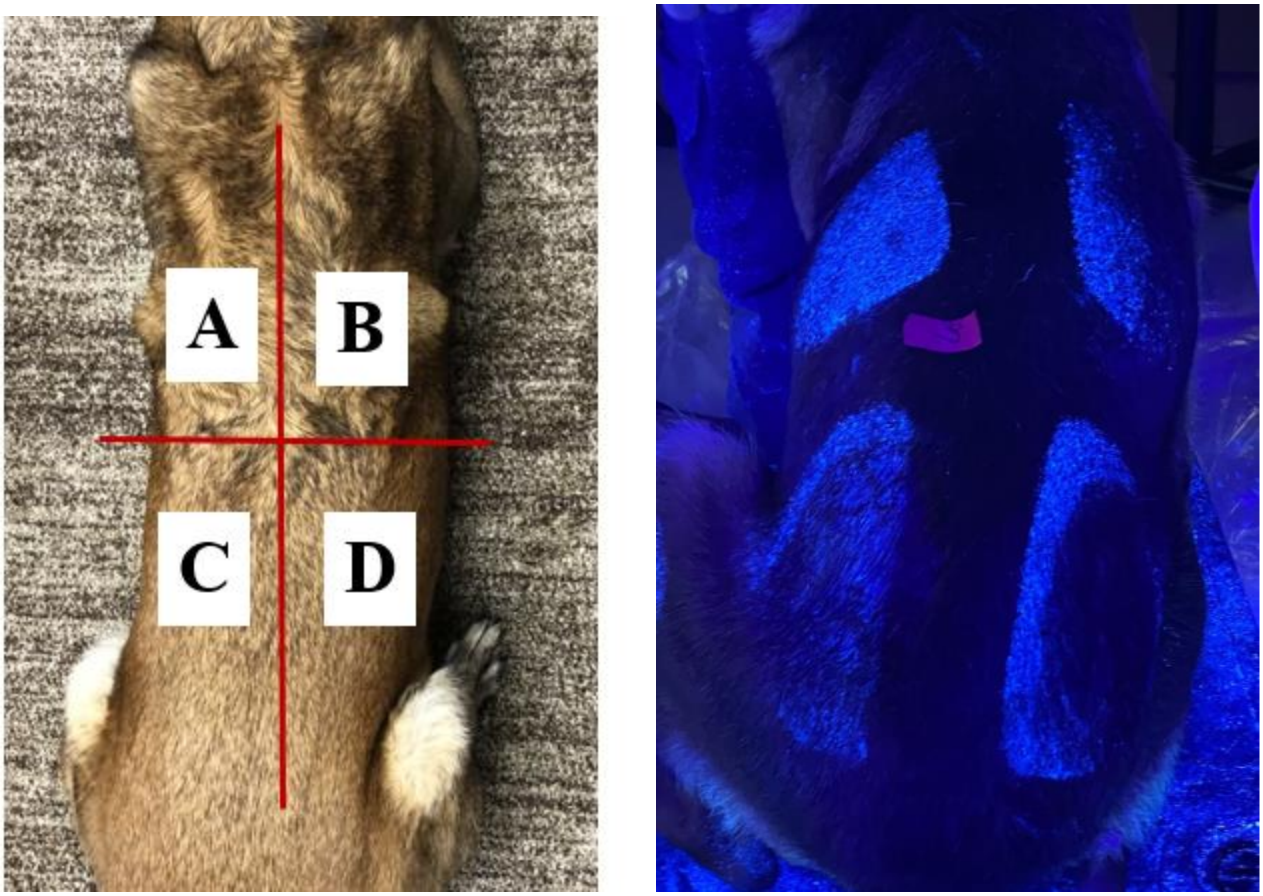

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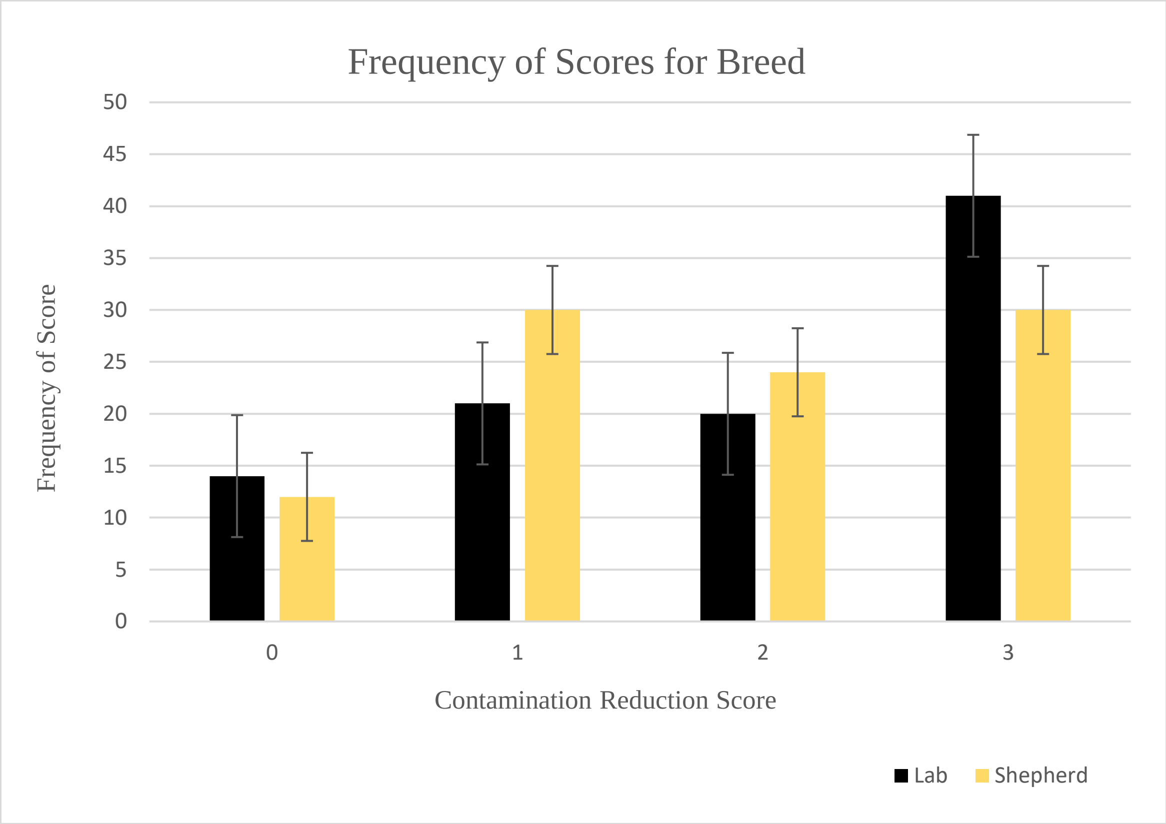
Figure 2: Reduction scores[1] using a simulated aerosolized contaminant were unaffected by breed (P = 0.6417).



[1]Contamination reduction scores assigned as follows: 0 = <25% contamination reduction; 1 = 25% – 50% contamination reduction; 2 = 51% – 75% contamination reduction; 3 = >75% contamination reduction.

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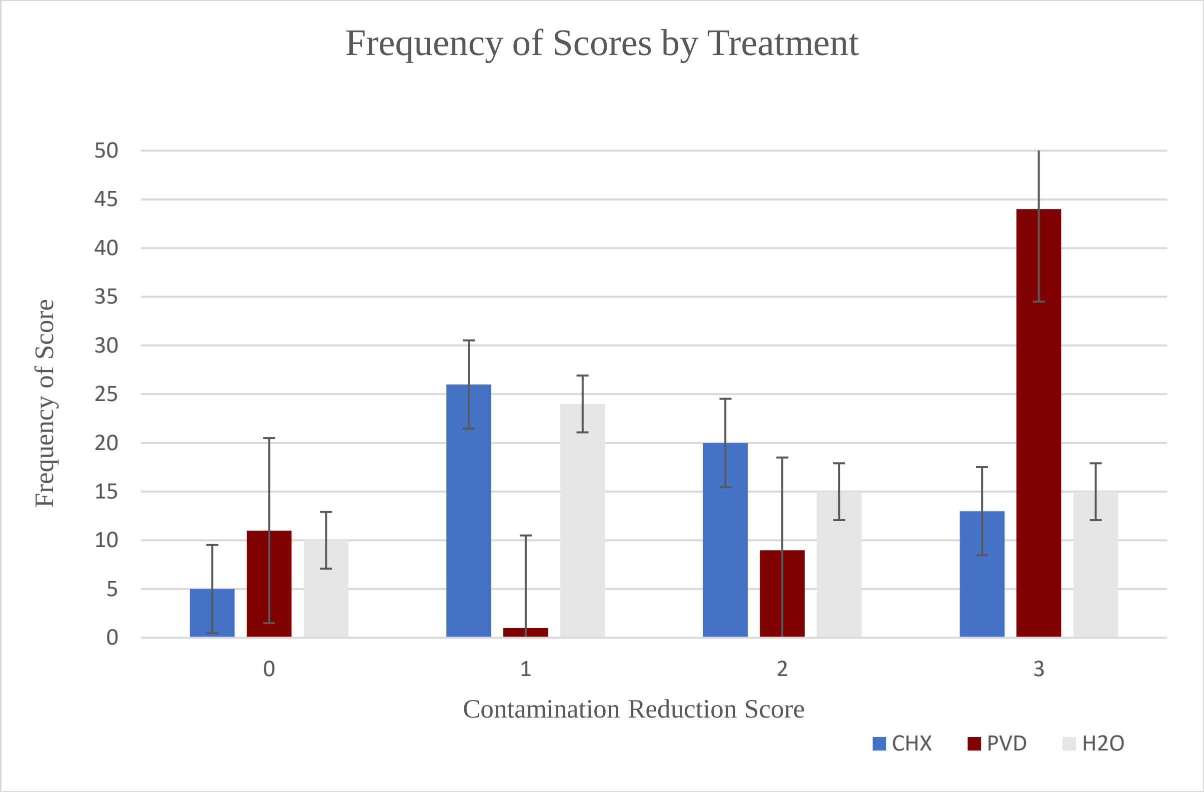
Figure 3: Cleanser selection impacts reduction scores[1] using a simulated aerosolized contaminant ($P < 0.0001$).



[1]Contamination reduction scores assigned as follows: 0 = <25% contamination reduction; 1 = 25% – 50% contamination reduction; 2 = 51% – 75% contamination reduction; 3 = >75% contamination reduction.

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Table 1. Frequency of successful[1] wipe down utilizing common working breeds and veterinary antiseptic cleansers.

	Water	Povidone-Iodine	Chlorhexidine Gluconate	P value
Labrador retrievers	7[a]	26[b]	8[a]	P < 0.001
German shepherds	6[a]	21[b]	3[a]	P < 0.001

[1]Success = contaminant reduction score of 3

[a,b]Unlike superscripts indicate statistical significance.