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The Effect of Disinfectants, Cleaning, and Drying Practices on Oriental Rugs Flooded with Contaminated River Water: Public Health and Policy Implications

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The Effect of Disinfectants, Cleaning, and Drying Practices on Oriental Rugs Flooded with Contaminated River Water: Public Health and Policy Implications

by

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DISSERTATION COMMITTEE PAGE

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The Effect of Disinfectants, Cleaning, and Drying Practices on Oriental Rugs Flooded with Contaminated River Water: Public Health and Policy Implications

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Dedication

This dissertation study is dedicated to the many individuals who have stood by my side during this long process. Most importantly, I thank my lovely wife Janice for her unwavering support and encouragement throughout this journey. You have sacrificed the most and I will always be indebted to you. Your encouragement and kind words assisted me more than you will ever know.

To my beautiful daughter Jean who has shown me the true meaning of life and taught me what it means to be a father. I am humbled by her strength and perseverance.

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And lastly to my loving wife Janice, whose encouragement, inspiration, and devotion never faltered throughout my journey. I am deeply indebted to her for her willingness to read page after page and comment on revision after revision. She contributed so much as my grammarian and editor. Her patience contributed more than I can say to the completion of this doctorate.

Abstract

The Effect of Disinfectants, Cleaning, and Drying Practices on Oriental Rugs Flooded with Contaminated River Water: Public Health and Policy Implications

Oriental rugs contaminated with Category 3 floodwater potentially harbor environmental bacteria known to be human pathogens. River water inoculated with three species of gram positive and gram negative environmental bacteria (*Escherichia coli*, *Enterococcus faecalis*, *Pseudomonas aeruginosa*) were used to assess the effectiveness of disinfectant type, cleaning methodology and drying practices by examining the survival rates of bacteria. Rug sections were immersed for one hour in contaminated water, saturated in one of three EPA registered disinfectant products (Phenol, Quaternary chloride, and Thyme oil) or tap water as a control, followed by cleaning and drying. The results showed that all disinfectants reduced the overall microbial load better than tap water. Two applications of disinfectants were slightly more effective than one application, which, in combination with drying in 24 hours or less, produced an effect that notably reduced microbial counts. These results provide in-plant rug cleaners the ability to assess the benefits of different products and drying procedures, and demonstrate significant reductions of potentially pathogenic bacteria in Oriental rugs contaminated with Category 3 water.

Keywords bacteria, *Escherichia coli*, *Enterococcus faecalis*, and *Pseudomonas aeruginosa*, Category 3 water, efficacy of cleaning and decontamination, contents remediation, microbial contamination, sewage, Oriental Rugs.

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Chapter 1

Introduction

It is widely recognized that as worldwide flooding increases, the presence of high levels of fecal bacteria (Centers for Disease Control, 1993) and microbial pathogens generate concern surrounding the long-term impact of floodwaters carrying microorganisms into our dwellings (Sinigalliano et al., 2007). When a dwelling is contaminated with sewage or organic matter, as is the case with river flooding, a serious threat to human life exists (Berry et al., 1994). All organic material must be removed and complex fibrous surfaces found in flooring textiles must be disinfected, cleaned and dried before returning them to the home (Berry et al., 1994). Disinfection can be defined as a significant reduction of disease-causing bacteria; cleaning is the identification and physical removal of unwanted matter; and drying as the facilitated evaporation of water from a wet material or surface. Together these three processes reduce potential damage to human health or valuable material. Research has shown that levels of culturable bacteria from gypsum board were over 100 times greater in water damaged areas than in samples from non-water-damaged areas (Andersson et al., 1997).

The research questions I address are: 1) to determine if textile restoration practices effectively reduce microbial burden and health risk versus perceived cleanliness; and 2) can the adoption of a uniform, emerging flood policy for cleaning and restoration of flooded dwellings and their contents, benefit the public and influence policy? It is my hope that this inquiry into flooding phenomena will help shape human responses and lower health risks to one of our planet's most costly natural disasters.

The Red Cross estimates that between 1970 and 1995 floods affected more than 1.5 billion people worldwide (Pielke & Downton, 2002). Floods were the number one natural disaster in the United States in terms of lives lost and the extremity of damage to property throughout the 20th Century (Perry, 2000; Morrow, 1999). In the United States, with numbers adjusted for inflation, the economic losses have increased from approximately $1 billion in the 1940s to approximately $5 billion in the 1990s (Figure 1.1). Evidence suggests a link to anthropogenically driven climate change (Steffen et al., 2005). As recently as 2007, The National Institute of Environmental Health Sciences (NIEHS) challenged scientists to focus on those environmental factors most likely to contribute to human disease following a major flood. Contaminated Oriental rugs may constitute such an environmental and public-health challenge.

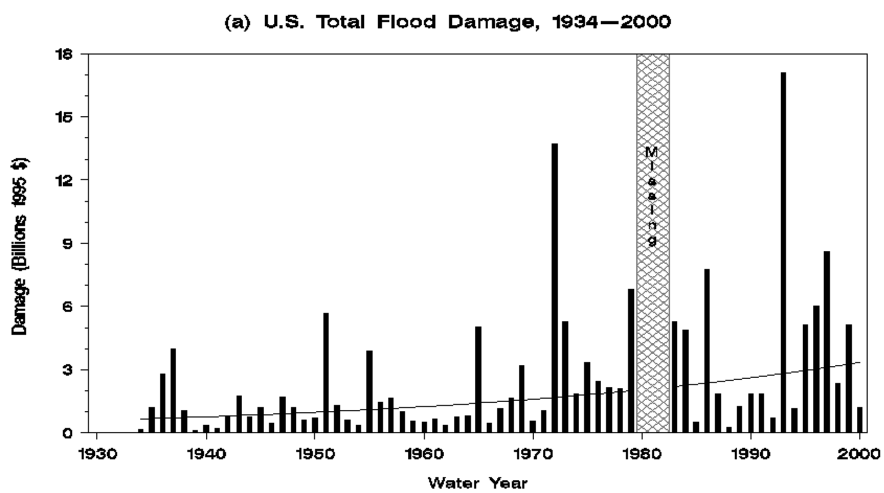

Figure 1.1 Flood damage cost in the United States, 1926–2000, adjusted for inflation (Pielke & Downton, 2002).

Floods often occur as bodies of water rise to overflow land that is not normally submerged due to prolonged rainfall, snowmelt and dam-breaks (Ward, 1990; Handmer, Penning-Roswell & Tapell, 1999). Heavy rainfall is the most common cause (Smith, 1996). Hurricane Katrina made landfall flooding the New Orleans area on August 29, 2005, resulting in massive flooding in both urbanized and industrial areas and creating concerns that a public health crisis could result from the microbiologically contaminated flood-waters (Centers for Disease Control, 2005; Centers for Disease Control, 2006). Floodwaters in New Orleans from hurricanes Katrina and Rita were found to contain high levels of fecal indicator bacteria and a variety of microbial pathogens (Sinigalliano et al., 2007). Once floodwater receded, preliminary investigations documented mean total coliform and total *Escherichia coli* (*E. coli*) levels as high as 8 X 10^8 CFU per 100 ml (Presley et al., 2006). The Environmental Protection Agency (EPA) published a news release that "*E. coli* was detected in 11 of the sample sites, indicating the presence of fecal bacteria (Figure 1.2). Pathogenic organisms may be transmitted by fecally-polluted water to the bodies of water that humans come in contact with through flooding. The primary sources of fecal bacteria in the United States waterways are from livestock manure applications and urban sewer overflows (Hutchinson, Walters, Avery, Synge & Moore, 2004; Gerba & Smith, 2005). Flood damaged Oriental rugs may contain many kinds of pathogenic organisms that present serious health risks when human beings are exposed to these textiles (Berry et al., 1994). There is also a recognized exposure risk from inadequate and/or delayed remediation of flooring textiles contaminated in these situations.

Recent research has demonstrated significant bacterial amplification in flooded carpets occurs when remediation is delayed beyond 24 hours (Holland et al., 2012). Therefore, it is essential that remediation processes occur promptly following flooding, and that they have both a cleaning effect and an antimicrobial effect. Cleaning and disinfection of Oriental rugs are typically employed following flooding in an attempt to remove microorganisms known to be human pathogens while returning these textiles to a clean and sanitary condition without damaging them.

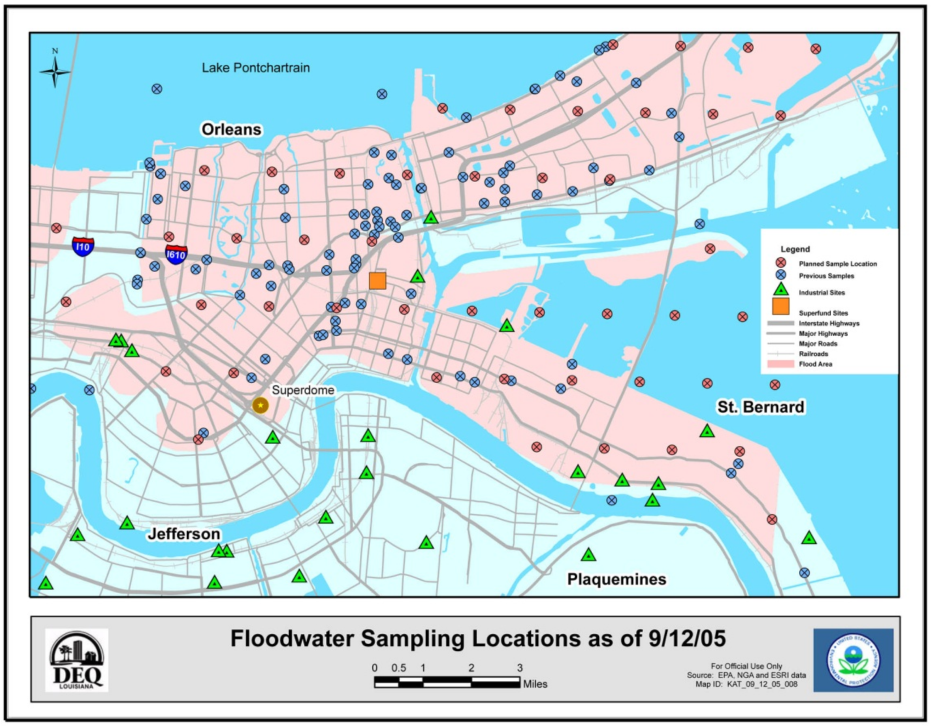

Figure 1.2 Bacteria sample sites from New Orleans flood area (EPA, 2005)

Once floodwaters subside, proper cleaning and disinfecting of affected materials are warranted because microorganisms will normally grow in water and on surfaces in contact with water as biofilms (Bartram, Cotruvo, Exner, Fricker, & Glasmacher, 2003; Centers for Disease Control, 2006). Cleaning is a process to reduce, by physical removal, overall levels of deposited soils, including disinfectant residues and associated human pathogens, protecting people and valuable materials (Berry, 1993). The process of disinfection allows for sanitization and can provide significant hygienic benefits. The nature of soils is diverse

(Asbury, 2011). Sediment deposited by floodwaters is likely to be composed of both organic and inorganic particles (e.g., plant matter and animal dander, dusts, skin particles, ash, fibers, plant pollen), microbials (e.g., bacteria and mold spores or hyphal fragments) and trace elements (e.g., pesticides, aromatic hydrocarbons and heavy metals) (Luedtke, 2004). Porous materials are known to harbor and support a variety of these microorganisms that can be released, potentially representing an inhalation risk if proper remediation techniques are not followed.

Numerous factors influence the efficacy of cleaning and disinfecting contaminated flood damaged and potentially salvable items. Factors that influence the success rate of cleaning include the types of detergents and chemical disinfectants used, temperature, evaporation, and time. In the case of textiles, the harshness or corrosiveness of cleaning agents and/or disinfectants determines whether or not a strong concentration should be used (Spaulding & Emmons, 1958). Ideally, the concentration should be adequate to kill aggregates of the target organisms without causing damage to the material. Additionally, disinfectants must be in contact with microorganisms for an adequate dwell time in order to penetrate cell walls and cell membranes and inactivate them. Therefore, the nature of the disinfectant and the types of microbial contaminants must be given consideration when determining the overall effectiveness and use of the disinfectant as a killing agent. This is critical when a porous surface is involved.

Building occupants and professional cleaners who restore dwellings and contents affected by contaminated flood-waters are potentially at significant risk for infectious disease and adverse health effects from exposure to sewage contaminated materials. Attempts to salvage materials can liberate endotoxins, mycotoxins, allergens, infectious agents, and pose a substantial risk for susceptible populations such as the elderly, infants and those with suppressed immune systems (Cole, 2006). In the recent past, the widespread incidence of flooding (Pielke & Downton, 2002) has demonstrated that microbial contamination of textiles is inevitable in dwellings. Restoration of Oriental rugs and other valuable (e.g., historical, sentimental, monetary) textiles have been encouraged by means of specialized cleaning or laundering (ANSI/IICRC, 2006; ANSI/IICRC, 2008; Rapp, 2011). Nonetheless, no generally accepted consensus of what constitutes a “clean” and “sanitary” textile has been established, although, a sanitary condition can be defined as one with a low health risk.

There have been many studies indicating that bacteria-laden runoff entering rivers and streams (e.g., wildlife, livestock, human) is a common phenomenon (Edwards et al., 1997; Bicudo & Goyal, 2003). In the case of river flooding of dwellings, a heavy load of organic matter can penetrate the built environment causing extensive contamination of porous materials, especially textiles such as Oriental rugs, given their location on the floor. Foreign substances adhere to textile fibers and become entangled in the yarns and backing (Berry, 1993). In this study, two of the most common and basic construction knots used in Oriental rug weaving (Mallett, 1998), asymmetrical (wraps around two warp yarns, with only one warp yarn partially encircled) and symmetrical knots (yarn ends wrapped in opposite directions around two warp yarns) were selected because of the complexity encountered when attempting to remove contaminants entangled within and between yarns. No direct comparison of the influence of disinfectants, cleaning, and drying practices were made between the different knots. Although, recent studies suggest entanglement of microorganisms in textiles may be a protective and thus contributing factor to infection in hospital settings when inappropriate cleaning procedures are employed (Fijan, Koren, Cencic, & Sostar-Turk, 2007).

Human beings often have belongings that invoke strong memories and sentimental value; they may even be one-of-a-kind works of art. Such strong attachments often create a desire to salvage as many of these items as possible. Of primary importance is the fact that a flood victim may consider any item not completely destroyed as salvageable without regard to its being contaminated with microorganisms. This raises the question of safety and health concerns regarding the sanitary conditions of the items. My concern is that the role of cleaning, disinfecting and drying these textiles is poorly understood in the cleaning industry, which represents an under-emphasized and potentially widespread public health risk of increasing importance.

In the early 1990s, experts from the Centers for Disease Control (CDC) stated that microorganisms were present in less than 3% of flooding cases where wet indoor environments were involved (Centers for Disease Control, 1993). Those numbers increased sharply in the last few years, now applying to an estimated 70-80% of all flood cases. Often found in flooded dwellings, floor-covering textiles are highly susceptible to sewage-contaminated floodwater (Baily, 2005). Currently, the subject of textile cleaning following pollution with fecal-material causes concern among those employed in the fields of carpet and rug cleaning, water damage remediation, and mold remediation. In addressing this concern, preliminary studies have shown that even after thorough cleaning, microorganisms can be detected throughout textile fibers (Bernazzani, unpublished). In the course of volunteering to help test sewage-contaminated Oriental rugs in 2008, I discovered that hidden microbes remained when they were presumed to have been removed or inactivated during the cleaning process. This raised a critical question: if we could detect organisms imbedded in textiles after careful and professional cleaning, what is the condition of rugs cleaned by flood victims themselves? This question has recently taken on public health importance within the U.S. Environmental Protection Agency (USEPA).

The efficacy of cleaning textiles that have been saturated in Category 3 water (e.g., contaminated water, sewage, rising water from rivers and streams) is highly variable (Bernazzani 2008) and has not been fully elucidated. The IICRC standard and reference guide (ANSI/IICRC, 2006) states, in part:

> Area rugs and tapestries should be cleaned at an in-plant facility by a specialized expert. Spreading contaminants during cleaning can be a potential problem. Submersion cleaning of area rugs under water in a controlled wash pit with water covering contaminated textiles is less likely to aerosolize contaminants. If a high-value area rug or tapestry is saturated with Category 3 water and there is a decision to attempt salvage, it should be cleaned with submersion pre-cleaning, followed by saturation with appropriate antimicrobial and a secondary submersion cleaning. (p. 81)

Since 1994, The Institute of Inspection, Cleaning and Restoration Certification (IICRC) has published Standard and Reference Guides for Professional Water Damage Restoration (IICRC S500, 1994, 2000, 2006). These procedural standard and reference guides imply that in flooding situations the efficacy of cleaning and successful decontamination should be carefully evaluated to assure items affected by floodwater are returned to an acceptable sanitary or hygienic state. However, cleaning of oriental rugs to determine cleanliness has not been supported by any quantitative testing method. In fact, during the past few years, pilot studies have demonstrated variability of cleaning efficacy (Bernazzani, unpublished).

My dissertation describes cleaning practices and the effectiveness of varying classes of disinfectants (Thyme oil, Quaternary ammonium chloride, and Phenol) commonly used in the cleaning industry along with the influence of drying, in an effort to provide minimum recommendations for those who clean flood-contaminated Oriental rugs. Furthermore, the microbial colonization of floor coverings is well known (Kemper, Ayers, Jacobson, Smith, & White, 2005). I selected Oriental rugs because of the complexity of the knots that make up the woven textiles which trap and entangle microorganisms within the yarns and because they are often high value (e.g. sentimental, antique, monetary) and not always replaceable.

I also consider the implications of flood policy and regulations. The empirical results of my research suggest beneficial ways to clean, sanitize, and dry Oriental rugs. The results may also have a positive impact on other flood-contaminated personal belongings that are not as difficult to clean and sanitize (e.g. hard surfaces, non-porous material, valuable items).

While the impacts of floods on our environment have long been a concern for human beings, communicating the results of this study may have an influence on environmental policy and play a role in the social equity of environmental policy.

Chapter 2

The Effect of Disinfectants, Cleaning, and Drying on Flood-contaminated Oriental Rugs

Introduction

Oriental rugs contaminated with flood-water may contain many kinds of pathogenic microorganisms (ANSI/IICRC, 2006). Therefore, it is essential that the cleaning process has not only a cleaning effect but also an antimicrobial effect (Fijan et al., 2007). Because human beings who own these works of art may be susceptible to infection from contact with them after contamination (e.g. young children, the elderly, those whose systems are immunocompromised), it is recommended that the best practices available be used in disinfecting flood damaged Oriental rugs. For almost 150 years, chemical disinfectants have been used to kill microorganisms that cause human disease (Macher, Ammann, & American Conference of Governmental Industrial Hygienists, 1999). However, complications with disinfection have occurred since the mid-1800s when Joseph Lister began developing techniques used in medical procedures (Tortora, Funke, & Case, 2004). Inappropriately disinfected textiles are a possible reservoir for potentially pathogenic organisms and their components (fragments and toxins) that may become aerosolized and thus present an inhalation exposure risk (ANSI/IICRC, 2006).

Since 1994, the Institute of Inspection, Cleaning and Restoration Certification (IICRC) Standard and Reference Guide for Professional Water Damage Restoration S500 has included qualitative and quite descriptive disinfection definitions and procedural guidelines on their use. In the past few years, my novel and insightful line of research has called into question the assumed but untested efficacy of accepted disinfection techniques.

This study was initiated to further define whether disinfectant products, cleaning, and drying achieve together substantial reductions in bacterial activity and to provide minimum recommendations for professional restorers and flood victims who may attempt to clean flood-contaminated Oriental rugs.

Materials and Methods

In order to determine the potential for disinfecting contaminated textiles, the following experiment was performed with two used Oriental rugs of indeterminate age in visually good condition, knotted with 100% wool face yarns. Prior to the test, each rug was cleaned by submersion method using a neutral detergent and dried at Bon Ton Rug Cleansers, Watertown, Massachusetts. Two hundred (200) sections (~8.75 cm in diameter) 22.8 g (±1.5g) were cut from each rug using a stainless steel template and razor blade. Each sample was numbered for identification and placed in sterile bags.

Three randomly selected rug samples, x, y, and z (n=3) were used as controls and analyzed to determine levels of indicator organisms present prior to immersion in Category 3 water. IICRC defines Category 3 water as water that is grossly contaminated and can contain pathogenic, toxigenic or other harmful agents. Bacterial suspensions for use on selected test samples were prepared: bacterial stock cultures grown for 24 hours on Tryptic Soy Agar plates (TSA; Hardy Diagnostics, Santa Maria, CA) in an incubator at 37^0 C. After 24 hours the plates were removed from the incubator and resultant growth was quantified. Before immersion in contaminated river water, the mean bacterial colony-forming units (CFU) for three control samples was quantified at 307 CFU/ml (x = 190 CFU/ml, y = 370 CFU/ml, and z = 360 CFU/ml).

Sixteen samples were randomly selected from rug number 1, an Indo Hariz tied with symmetrical knots oftentimes referred to as Ghiordes or Turkish knots (Figure 2.1). This type of knot is commonly used for attaching face yarns because it is the most secure for pile rugs (Collingwood 1968). Sixteen additional samples were randomly selected from rug number 2, an Indian Design tied with asymmetrical knots (Figure 2.2) also referred to as a Persian or Sehna knot used by Eastern weavers (Collingwood, 1968). These knots provide an even distribution of pile over the surface of the rug. Asymmetrical and symmetrical knots can be densely packed and are among the most common knots found in hand knotted woven Oriental rugs (Mallett, 1998).

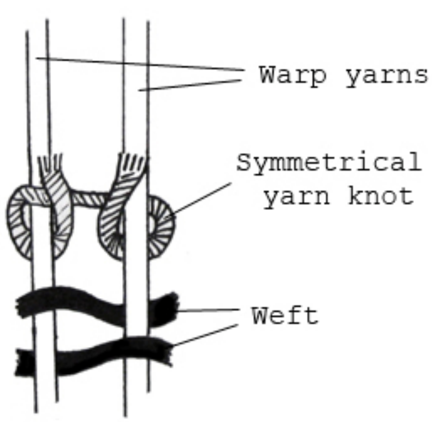

Figure 2.1 Symmetrical knot, ©Adam Costa (A. Costa, personal communication, 2012)

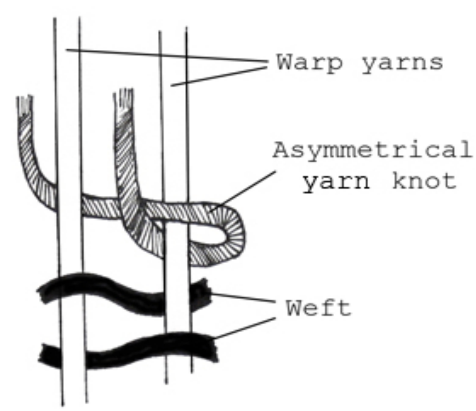

Figure 2.2 Asymmetrical knot, ©Adam Costa (A. Costa, personal communication, 2012)

To determine the efficacy of the selected disinfectant products and procedures, the following gram positive and gram negative bacteria originating from environmental sources such as soil and sewage were carefully chosen and used as representative potential pathogen species for the research project: NLML 1B70 *Escherichia coli* (gram negative), NLML 2B41 *Enterococcus faecalis* (gram positive), NLML 2B33 *Pseudomonas aeruginosa* (gram negative). All strains were maintained by Natural Link Mold Lab, Inc., Reno, Nevada.

Category 3 floodwater (e.g. contaminated water, sewage, rising water from rivers and streams) was collected from four points along the Connecticut River following three days of torrential rain, and kept under refrigeration. These collection sites included farm land in New Hampshire and Vermont and residential and commercial areas in Massachusetts and Connecticut. The water was characterized prior to introducing representative species as shown in Table 2.1. The collected river water was analyzed by Hub Testing Laboratory, Waltham, Massachusetts for Total Coliform Bacteria, *Pseudomonas aeruginosa*, pH, Total Dissolved Solids, Total Suspended Solids and Turbidity.

Table 2.1 Characterization of Connecticut River water

Parameter	Results
Total Coliform Bacteria	4 CFU/ml
Pseudomonas aeruginosa	0 CFU/ml
pH	7.5 pH units
Total Suspended Solids	7 ppm
Total Dissolved Solids	66 ppm
Turbidity	0.8 NTU

Bacterial stock cultures were grown for 24 hours on Tryptic Soy Agar plates (TSA; Hardy Diagnostics, Santa Maria, CA). These were then used to prepare the primary suspensions in 7.0 mL sterile H_2O for the organisms used as challenges. The suspensions were prepared to a minimum of 2 MacFarland cell density and were inoculated into the collected Category 3 water. Precisely 200 µL of primary suspension was used to inoculate each of the Oriental rug samples.

Disinfectants: Three Environmental Protection Agency (EPA) registered disinfectants commonly used in the water damage restoration industry were purchased for this study, with tap water used as a control. Tap water was collected and cultured for bacterial growth for 24 hours on Tryptic Soy Agar plates (TSA; Hardy Diagnostics, Santa Maria, CA). All plates showed the tap water contained less than 10 bacterial CFU per milliliter. Dilution instructions according to label claims were followed for each disinfectant product used. The control and disinfectants were identified as: A; tap water as a control, B; a ready to use botanical disinfectant containing thyme oil, 0.23% active product, C; a phenol based product with active ingredients 0-Phenylphenol 0.22% and Disobutylphenoxyethoxy ethyl dimethyl benzyl ammonium chloride monohydrate 0.70% mixed 2 oz per gallon with water, and D; a quaternary chloride based product with active ingredients Octyl decyl dimethyl ammonium chloride 1.65%, Dioctyl dimethyl ammonium chloride 0.66%, Didecyl dimethyl ammonium chloride 0.99%, Alkyl dimethyl benzyl ammonium chloride 2.20% mixed 2 oz per gallon with water . All disinfectant products were used within their specified use-life and maintained at ~21.1^0 C. Controls for growth, media, and neutralization were also employed as described before.

Neutralization of disinfectants: In order to neutralize and halt the action of disinfectants following each exposure period (i.e., 20 minutes 1 time and 20 minutes 2 times), neutralization by dilution with ~21.1^0 C tap water was conducted. Neutralization by dilution has been shown to be effective (Cole, Rutala, Nessen, Wannamaker, Weber, 1990). Temperatures were monitored with a thermometer with calibration traceable to a National Bureau of Standards Thermometer.

Contamination of Rug Samples

To examine the efficacy of disinfectant products and application rates (one time versus twice), a standardized cleaning protocol (CP) based on ANSI/IICRC S100 Standard and Reference Guide for Professional Carpet Cleaning, 2011 was employed. One half of the samples were randomly selected for one time disinfectant application for each of the disinfectants or the tap water control (A - tap water, B - thyme oil, C- phenolic, and D - quaternary chloride) and cleaning (n=16); while the remainder of samples (n=16) had the disinfectant process repeated a second time. The Oriental rug samples were contaminated by immersing each rug disk (~8.75 mm dia) in an inert plastic tray containing ~1.0 liter of contaminated river water (8.5 x10^7 bacterial CFU/ml) at ~21.1^0 C for one hour of contact and saturation.

Following one hour saturation in the contaminated river water, one half of contaminated rug samples (n=16) randomly selected for a single application of disinfectant were individually removed from the contaminated river water using stainless steel hooks attached to the top of each sample and placed into one of four inert plastic trays containing either ~1.0 liter of 3 disinfectant products: phenolic, quaternary chloride, thyme oil, or tap water as a control, at ~ 21.1^{0}C for twenty minutes. After twenty minutes dwell time, each individual rug sample was removed from the tray, rinsed by holding with a stainless steel hook under a faucet with ~3.0 liters of tap water at ~21.1^{0}C for 30 seconds, vacuum-extracted using a portable carpet extractor, followed by the application of ~40 ml of a neutral detergent (pH 7), and finally followed by a light tamping action with a nylon brush to provide uniform distribution of the neutral (pH 7) cleaning agent. Following detergent application and twenty minutes of dwell time, each sample (n=16) was removed and again rinsed with tap water for 30 seconds, then vacuum- extracted as previously described and hung to dry using the stainless steel clip.

The second half of the contaminated rug samples (n=16) randomly selected for a second application of disinfectant products were individually removed from the contaminated river water following one hour of saturation using stainless steel hooks attached to the top of each sample and placed into one of four inert plastic trays containing either tap water or one of the 3 disinfectant products as described previously. After twenty minutes dwell time, each individual rug sample was removed from its tray, and rinsed, vacuum- extracted, and neutralized as described before, and followed by a light tamping action with a nylon brush to provide uniform distribution of the neutral (pH 7) cleaning agent. Following the detergent application and twenty minutes of dwell time, each sample (n=16) was removed from the disposable cleaning tray and rinsed, vacuum-extracted reinserted into the same tray it was removed from for a second exposure to one of the disinfectants or tap water control as described before. After twenty minutes dwell time, each individual rug sample was removed from the disinfectant or tap water control, rinsed again, vacuum- extracted and hung to dry using the stainless steel clips.

To examine the effect of drying time, one half of rug sections selected for one time processing (n=16) were evaluated by placing two unique sets in two different drying conditions. One half of rug samples (n=16) were allowed to dry at ~22.1^0 C ambient air and ~29.9% relative humidity for 24 hours. The rug samples reaching their initial dry state temperature (22.1^0 C), as indicated with a Thermo Imaging Camera (Flir I7). The remaining samples (n=16) were selected for a process that involved drying in warm, wet conditions (31^{0}C ± 0.2 ^{0} and > 90% relative humidity) remaining wet at 24 hours. Samples placed in warm wet conditions did not dry in 24 hours and supported the growth of the test organisms.

At 24 hours of drying each rug sample (n=16 not dry and n=16 dry) was placed in an individual sterile bag containing ~40 ml of sterile water, aggressively shaken for ten seconds followed by collection of rinse water and plating of the collected water. A series of tenfold dilutions of the water samples were made to 10^{-6} and used for enumeration of bacterial contents using Tryptic Soy Agar plates (TSA; Hardy Diagnostics, Santa Maria, CA). After 24 hours, the plates were removed from the incubator and growth was quantified.

As a control, three randomly selected rug samples, x, y, and z (n=3) were analyzed to determine levels of indicator organisms present prior to immersion in Category 3 water. Preparation of bacterial suspensions for use on selected test samples: Bacterial stock cultures were grown for 24 hours on Tryptic Soy Agar plates (TSA; Hardy Diagnostics, Santa Maria, CA) in an incubator at 37^0 C. After 24 hours the plates were removed from the incubator and growth was quantified.

Results and Discussion

While specific health risks from bacteria in Oriental rugs have not been defined, there are some generally accepted threshold levels of bacteria for drinking water, swimming pools and edible ice. In order to evaluate acceptable levels of bacteria, Brandys (2011) researched acceptable standards that categorize bacterial water quality standards from various sources including the United States Environmental Protection Agency (EPA), World Health Organization (WHO), and others.

The EPA has test methods and performance standards for articles where public health issues may exist, including "Non-treated articles" which refers to articles, surfaces, or other inanimate objects which are not impregnated with, or have antimicrobial pesticides incorporated into them during, or after manufacture" (EPA, 1997). Oriental rugs may fit well into this category as carpets are specifically included in the agency's Scientific Advisory Panel discussions held in Arlington, Virginia on June 3, 1997 (EPA, 1997). During that meeting, the participants concluded: "antimicrobial efficiency is demonstrated when the number of test organisms on the test surface is reduced by 99.9% over that of parallel control surfaces." They also noted that the test microorganisms employed in the study must be pathogens that are likely to be encountered in the environment in which the product is to be used.

Effectiveness of the Cleaning, Disinfectant and Drying Processes

The results of this study have shown the successful development of a new methodological approach to the quantitative assessment of disinfection, cleaning, and drying of flooring textiles contaminated with Category 3 river water. It is important to note that while this study was grounded in the use of Category 3 water, the results are not meant to imply that sewage-saturated textiles would exhibit the same or similar results using the restorative approach described here. A definitive assessment of such an approach with sewage-saturated textiles, or the necessary modification of that approach to show effectiveness in terms of sanitary and hygienic acceptability, would necessitate an additional study using raw sewage in conjunction with the methodology developed in this study.

Under the conditions previously described, the disinfection process led to a significantly lower microbial burden than when cleaned with water alone, and when combined with a drying time of 24 hours or less, substantial decreases in microbial burden were observed. Rug samples dry in 24 hours decreased microbial contamination levels from 8.5×10^7 CFU/ml to as low as 3.2×10^2 CFU/ml. These data confirm that rapid drying (24 hours or less) efficiently reduces growth of microorganisms or resuscitation of sub-lethally damaged microbes. Overall, the microbial burden was reduced by 99.4% with water alone and 99.9% or greater using disinfectant products (Table 2.2).

Table 2.2 Reduction after immersion in disinfectant

Disinfectant Two Applications				
	CFU per ml Start	CFU per ml After dry	Log Reduction	Percent Reduction
Water	8.5×10^7	5.5×10^5	2 log	.994
Thyme oil	8.5×10^7	1.8×10^4	3 log	.999
Phenol	8.5×10^7	3.2×10^2	5 log	.9999
Quaternary	8.5×10^7	1.7×10^3	4 log	.9999

The cleaning, disinfection and drying processes were assessed microbiologically at 24 hours of drying. Each rug sample (n=16 not dry and n=16 dry) was removed from the drying racks and placed in individual sterile bags containing ~40 ml of sterile water, aggressively shaken for ten seconds followed by collection of rinse water and plating of the collected water using Tryptic Soy Agar plates (TSA; Hardy Diagnostics, Santa Maria, CA) and placed in an incubator at 37^0C for 24 hours. After 24 hours, the plates were removed from the incubator and examined for growth.

The effect of two applications of disinfectants combined with cleaning and drying in 24 hours or less provided acceptable results for sanitizing flood-contaminated Oriental rugs (Table 2.2). I observed that microbiocidal activity is improved when disinfectants are used on previously cleaned and disinfected surfaces. These data support the practice and recommendations of the IICRC that two applications of disinfectant products are the minimum needed to reliably kill flood related bacteria. In comparing one application with two applications of disinfectant products, two applications reduced test organisms better than a one-time application, resulting in a reduction from 8.5×10^7 CFU/ ml to as low as 3.2×10^2 CFU ml (Table 2.3).

In comparison with water treatment alone as the control disinfectant (Samples A 1-8), a substantially higher number of test organisms were found when compared with disinfectant application (Samples B 1-8, C 1-8, D 1-8 (Table 2.2).

In comparison with the rug samples that dried in 24 hours, the microbial burden in samples that were not dry in 24 hours increased from 8.5×10^7 CFU ml to as high as 3.4×10^8 ml. In terms of reduction of test organisms, all rugs samples dry in 24 hours led to significant reductions of microbial growth. These drying differences had a dramatic effect on results, as evidenced by the significant decrease of test organisms in the samples that were dry in 24 hours.

The results of this research support a recently published study on bacterial amplification in flooded flooring textiles and the need for rapid remediation (Holland et al., 2012), and demonstrate that one of the most important factors in the success of disinfecting contaminated water-damaged textiles is a drying time of 24 hours or less to significantly improve sanitation efficacy. However, the selection of appropriate disinfecting agents, as well as the number of applications, should be taken into consideration because it is a combination of all of these factors that successfully kill microorganisms. These findings also confirm that a botanical disinfectant can have considerable disinfection effect on textiles without fiber degradation.

Table 2.3 Average plate counts after immersion in category 3 H_2O at 8.5 x 10^7 CFU ml for 1 hour

	Disinfectant One Application		Disinfectant Two Applications	
	CFU per ml	CFU per ml	CFU per ml	CFU per ml
At 24 hrs	1 X Not Dry	1 X Dry	2 X Not Dry	2 X Dry
Water	3.4 x 10^8	1.5 x 10^6	1.3 x 10^8	5.5 x 10^5
Thyme oil	2.3 x 10^8	1.2 x 10^5	6.5 x 10^7	1.8 x 10^4
Phenol	2.3 x 10^8	4.6 x 10^3	1.8 x 10^8	3.2 x 10^2
Quaternary	1.8 x 10^8	3.1 x 10^2	1.7 x 10^8	1.7 x 10^3

Tactile and Visual Cleanliness

After drying, 24 individual Oriental rug samples used in the study were assessed by eight expert rug cleaning professionals. The expert participants were not informed about which samples were used as controls or which samples were immersed in the various disinfectant solutions. Additionally, no information was provided to the experts regarding drying times. The following subjective score was used to describe the degree of change in texture and color: #1 indicates no detectable change from the control; #2 indicates little change; #3 indicates moderate detectable change; #4 indicates substantial change; and #5 indicates highest detectable change (Figure 2.3). These tests were conducted blind without participants being aware of which samples received which treatment.

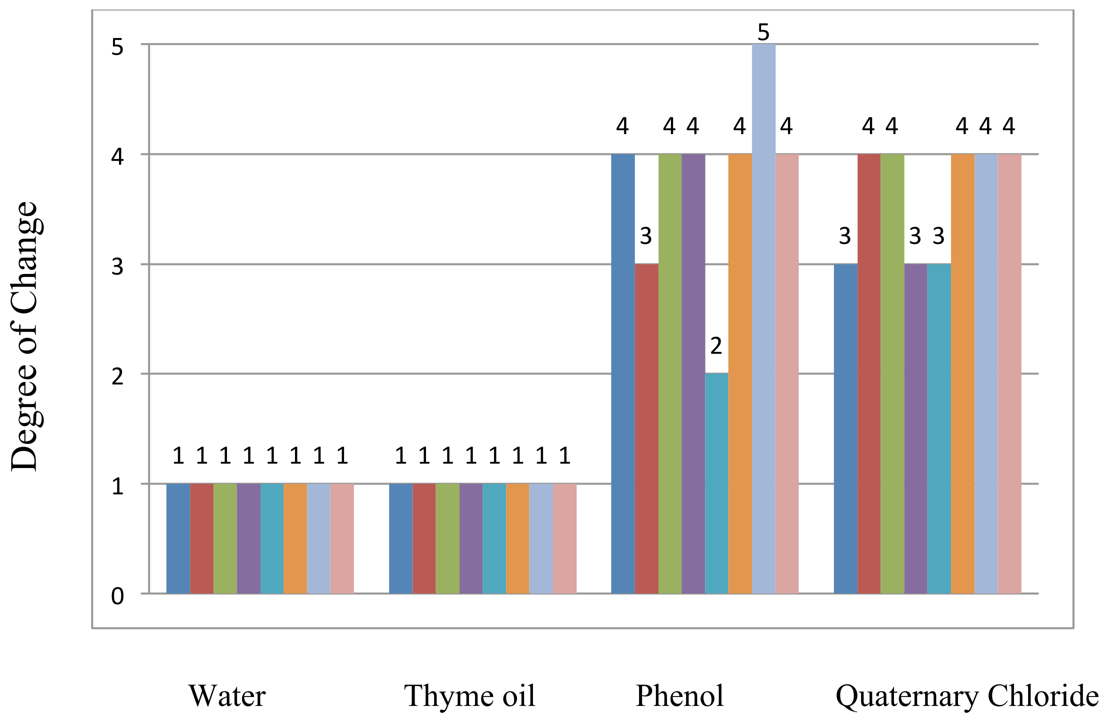

Figure 2.3 Tactile change observed by Oriental rug experts

As a final assessment of visual changes in fibers following drying, micrographs were obtained on a scanning electron microscope (SEM) located at Northeastern University Electron Microscopy Center, Boston, Massachusetts. Samples were randomly selected for examination by Northeastern microscopy technician William H. Fowle. The fiber samples were selected at random from those used in the two disinfectant immersions. Each fiber was prepared by sputter coating (Cressington Sputter Coater 108 Auto) and examined with a Hitachi S 4800 scanning electron microscope (SEM) (Figures 2.4 - 2.8).

Under the chosen test conditions, fibers examined with SEM indicate that fiber degradation (e.g. color, texture, hand) occurred in both the phenol-based (Figure 2.7) and quaternary ammonium chloride-based treatments (Figure 2.8), while the thyme oil (Figure 2.6) clearly showed no degradation, which was equivalent to the control fiber not used in the test (Figure 2.4) and the fiber using water as a control for the disinfectant (Figure 2.5). This was especially important because the results of the tactile tests findings observed by the rug experts, along with the SEM images, allows me to state my conclusions much more strongly. The tactile tests and SEM images interpretations provide a strong correlation of damage to textile fibers given the specific disinfecting treatment.

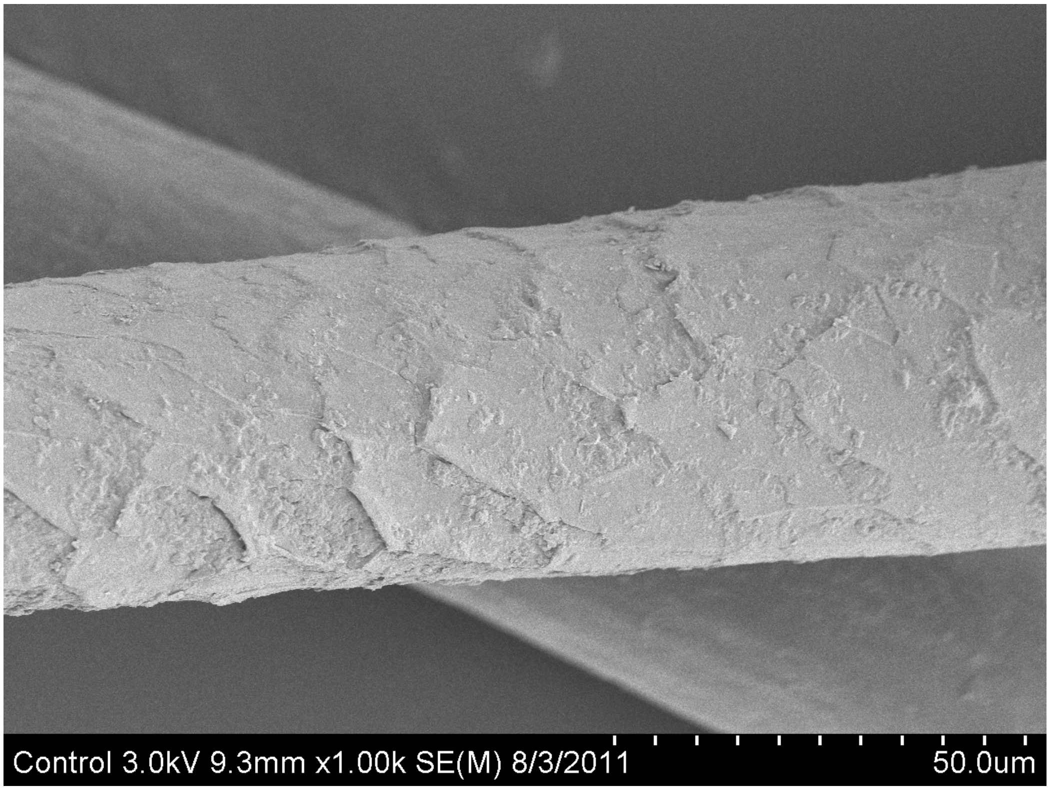

Figure 2.4 Control fiber not used in test

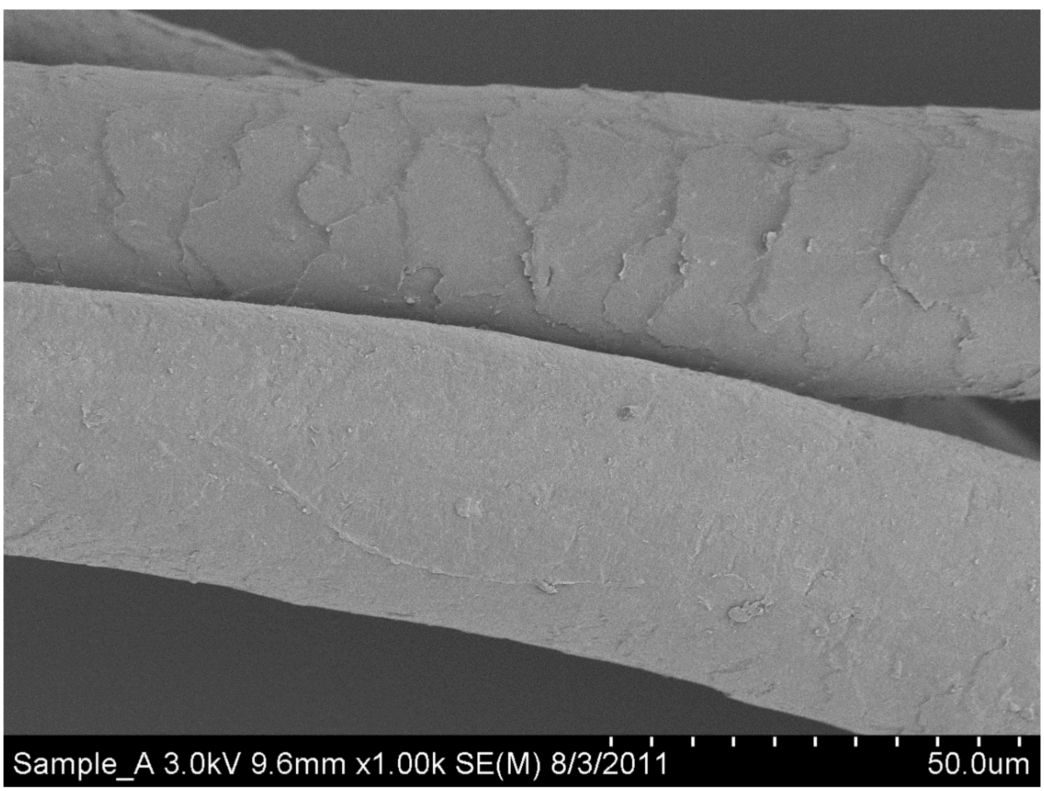

Figure 2.5 Fiber selected for immersion in water as control for disinfectant

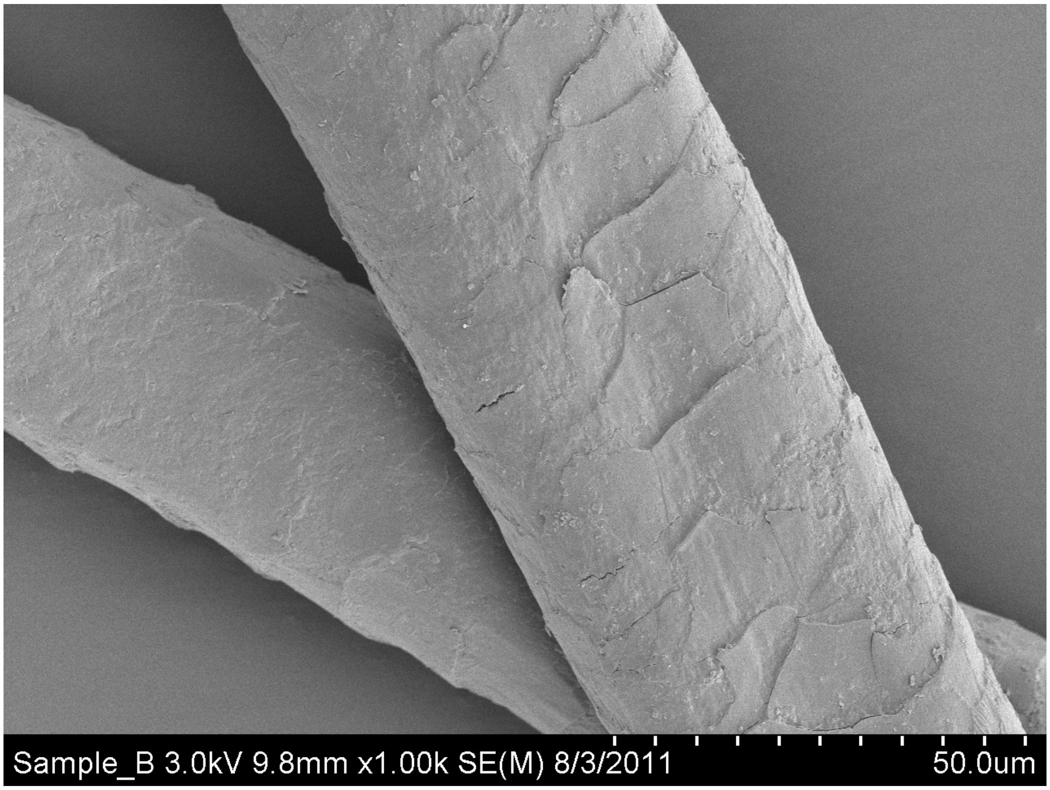

Figure 2.6 Fiber selected for immersion in thyme oil

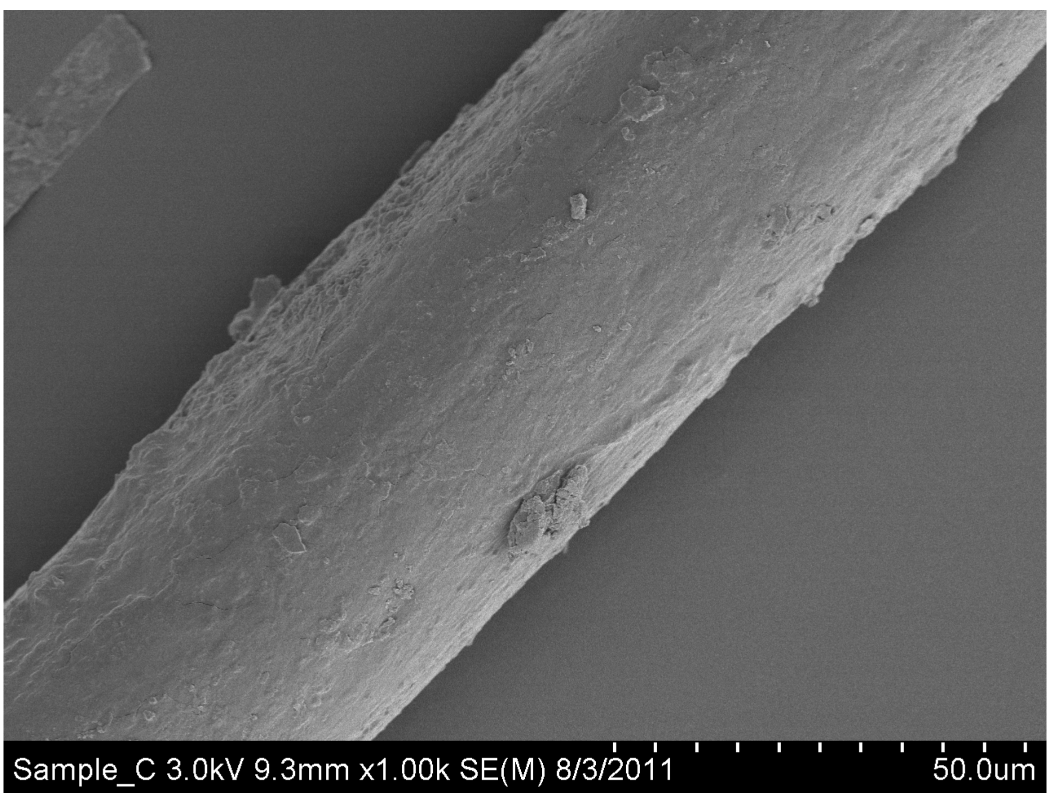

Figure 2.7 Fiber selected for immersion in phenol

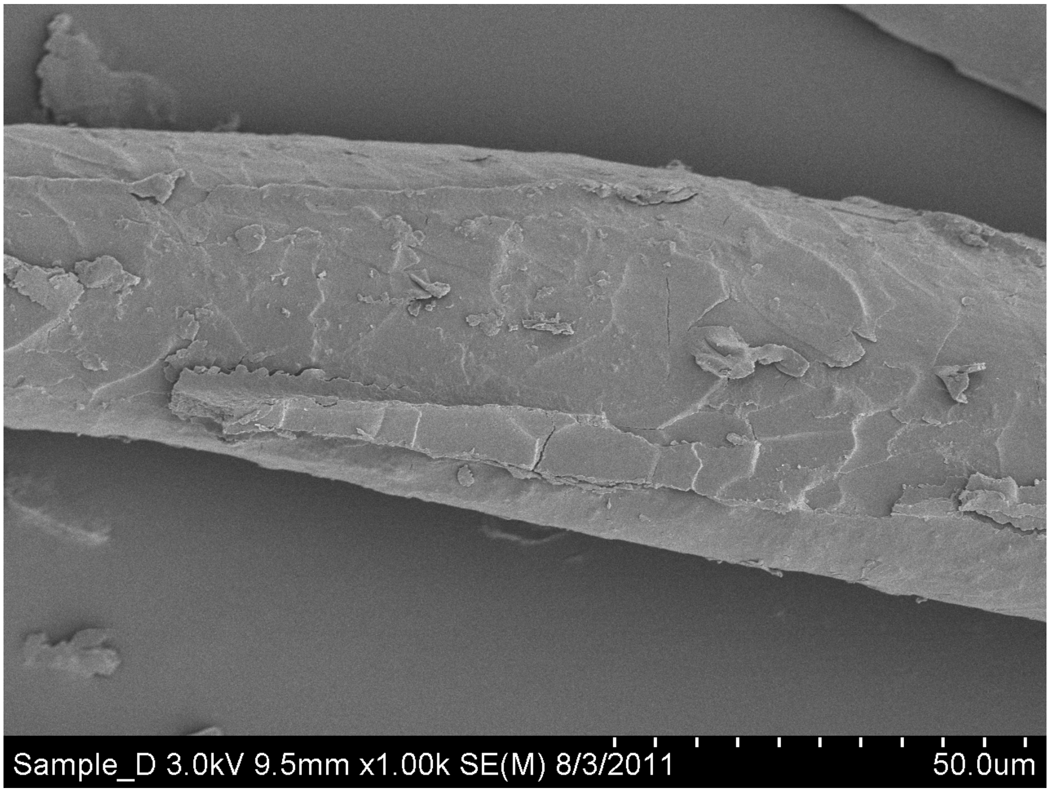

Figure 2.8 Fiber selected for immersion in quaternary ammonium chloride

Discussion

Much attention is devoted to cleaning flood-contaminated textiles for appearance; I developed this study grounded in cleaning for health. Currently, the subject of textile cleaning following pollution with flood-borne fecal material causes concern among those employed in the fields of carpet and rug cleaning, water damage, and mold remediation. Since 2008, in the course of volunteering to help test sewage-contaminated Oriental rugs, I discovered that hidden and viable microbes remained when they were presumed to have been removed during the cleaning process. This raised a critical question: If we could detect organisms imbedded in textiles after careful and professional cleaning, what organisms remain when Oriental rugs are cleaned by flood victims themselves? My research focused on studying the efficacy of killing and removing microbes from textiles after exposure to floodwaters containing fecal matter. My interest has motivated me to conduct this research specifically on works of art, solely Oriental rugs, because of the complexity of their construction, as well as their intrinsic value. However, the results of this study may influence the cleaning methods of other textiles. I have developed minimum recommendations that provide safe effective methods for cleaning, disinfecting and drying Oriental rugs that effectively remove microorganisms from textiles. This research will help to evolve and advance our understanding of cleaning contaminated Oriental rugs and disinfection efficacy by considering the effects of two independent factors; applying disinfectants and prompt drying.

I am committed to the continued development of safe techniques for cleaning textiles of historic or artistic value. My objective encompasses the advancement of "green" cleaning and recognizes the contribution that cleaning makes to good health. Cleaning procedures must be designed for the physical preservation of yarns and their structure, with the aim of minimizing damage to materials and most importantly, contributing to a healthy indoor environment. Special care must be taken to avoid the use of hazardous substances by cleaners and to minimize aerosolization of cleaning chemicals, microorganisms, or their byproducts. More importantly, the act of cleaning contaminated rugs is complicated by the difficulty of removing microorganisms trapped between complex yarn structures without degrading the textile or diminishing its historic, artistic, or monetary value.

The world's attention is focused on climate disruption and its attendant potential for environmental damage; more frequent flooding in many regions will increase the vulnerability of human populations. Recent observations demonstrate clearly that flooding events are increasing (Steffen et al., 2005). A wide range of substances, whose origin may be natural or anthropogenic, are deposited in our homes during flooding (e.g. mold, fecal matter, biological agents, bacteria and chemical-based products) that can have profound effects on the health of human beings. Accurate and reliable scientific research into the phenomenon of flooding and cleaning is important because it plays a role in public policy decisions, including insurance compensation, the allocation of finite public resources for flood victims, and flood prevention strategies.

As our nation struggles with large and increasing impacts on society, discussion of the science of restoring flooded dwellings and public policy regarding floods needs to take place today. In my professional career, I have always been an advocate for flood victims. This research has taken a complex subject to a new level because we are talking about health, which is one of the key issues in the world today.

Visual cleanliness alone cannot be an adequate determinant of microbiological contamination. Visual cleanliness acts as a necessary first stage so that essential disinfection is not impaired by residual contaminants. Beyond the visual surface of Oriental rugs lies an invisible layer of contaminants whose detection is less obvious. Addressing this level of contamination is the challenge embraced by this study.

Recommendations

In order to protect human health I recommend that all flood-contaminated Oriental rugs should be removed from homes and cleaned by the immersion method to protect the health of workers and flood victims. Every contaminated rug should be rinsed, immersed in a disinfectant with at least twenty minutes of dwell time, cleaned and have the process repeated a second time, followed by rapid drying in 24 hours or less. The drying of wet Oriental rugs following cleaning and disinfection requires a dry air stream to evaporate the water vapor from the surface. Increasing temperature at low humidity will accelerate drying. Efficacy testing should be performed following drying with involvement of an IEP for post-restoration testing to ensure complete decontamination (ANSI/IICRC S500, 2006).

The aim of this study was to determine the actual reduction of microbial burden from Category 3 flood-water via cleaning, applying disinfectants and rapid drying. This study did not include an investigation of possible influences from sea water, dwell time of Category 3 water for longer periods of time or temperature of the flood-water. My focus centered on results of Oriental rugs dry in 24 hours, however, research is needed on desiccation of microorganisms as time progresses after drying to determine what effect time will make in the final analysis.

Chapter 3

Implications for Flood Policy and Regulations

Introduction

Few concepts are more important to understanding the public-policy making process than the roles and power each stakeholder uses to influence the outcome of a policy. Legislators who have interest in a subject write a bill. If it passes into law, it is submitted to a regulatory agency that develops a policy through which it can be regulated. The new regulations, once implemented, force changes within industry and governmental agencies. In today's world bureaucratic structures and stakeholders with varying agendas make it difficult for researchers to find legislators who believe their issue is important enough for consideration. If researchers do find interested public officials they must demonstrate how a new policy will ultimately have a positive effect on both individuals and society while being revenue neutral or offset by fees or taxes. Today's policy process is based, in part, on interactions between interested stakeholders, special interest groups, organizations and political actors. In fact, political relationships between stakeholders play a major role in deciding a specific framework for a policy initiative (Coffman, 2007). Moreover, in the case of flood policies, changes that have a positive effect for individual flood victims may negatively impact other stakeholders (Table 3.1). For example, a new policy might be developed by a public health agency creating stricter safety practices for water remediation technicians. In order to comply with the stricter provision, an added financial burden is placed on the remediation technician's employer. The employer passes the added costs on to the flood victims who pass the costs on to their insurance carrier or pay more themselves due to stricter regulations. Therefore, the added regulations, which may improve safety for workers, has positive safety benefits while adversely affecting costs funded by others. A viable policy framework recognizes all of the materially interested stakeholders and attempts to place limits on political influence (Cobb & Ross, 1997). The decisions made by public officials in one area may affect options made by other public officials in other areas or at some point in the future (Ostrom, 2011). As a result, it is challenging to develop and implement substantial policy changes that affect both individuals and organizations.

Table 3.1 Implications of flood policies for various stakeholders

Sector	Sub-Sector	Segment	Concerns
Government	Local Regional State National	Building department Safety Regulatory FEMA	What branch will be responsible for implementing rules and regulations and will funding be allocated?
Public Health Officials	Government Insurance companies Self-insured businesses	Medical sector Personnel department	Budget/funding, Profit margin, How will it be funded?
Insurance Companies	Property Casualty Medical	Underwriting, property, casualty and claims departments	How will the added costs associated with paying for flood claims be addressed and how will profits be affected?
Individuals	Worldwide	Collective: Public Social	Who will pay premiums? Will coverage be mandatory?
Disaster restoration industry	Worldwide	Business	Who will be qualified to perform services and how will profit be affected?

Empirical Studies and Policy

My research is an effort, in part, to embrace this challenge and heighten the level of awareness about cleaning after floods. The findings will help the disaster restoration industry, public officials, and the insurance industry to better understand the benefits of properly cleaning, disinfecting and drying personal belongings contaminated by flood water. The importance of valid empirical evidence regarding cleaning, sanitizing and drying textiles should help foster a high degree of consensus between the cleaning professionals, public policy makers and the insurance industry without being contentious. Communicating this issue through the interdisciplinary lens of a scientist, scholar, indoor environmental professional, and someone interested in environmental policy will enable others to better understand these complicated issues. However, added financial burdens and subsidizing, or funding for additional expenses is a problem that will need to be addressed. My research considers different stakeholders, including populations where disadvantaged socio-economic status has limited influence regarding public policy decision making. Historically, disadvantaged socio-economic status has been defined by patterns of discrimination or exclusion, cultural distancing or a lack of political representation (Phillips & Morrow, 2007). My intent is to inform stakeholders who have interaction with the disaster restoration industry and public policy makers by conveying research that is critical to these groups at the local, state, and national level about the necessity of properly cleaning flood-damaged textiles.

While total flood damage varies from year to year, a statistically increasing trend has averaged 2.92% per year between 1932 and 1997 (Pielke & Downton, 2000). This trend underscores the need for policy makers to review the impact and efficacy of flood regulations. The participation of government officials is necessary in order to insure protection for the general population from loss and suffering following flooding events and the framework within which they operate must recognize that the world's most vulnerable populations are its poorest and least represented communities (Seaton, 2009; Few, 2003).

One of the key adverse effects of climate change is the widespread increased risk of flooding which is expected to fall disproportionately on the poor (Intergovernmental Panel on Climate Change, 2001).

Flood policy needs to be developed at all levels of government, most importantly at the federal level because no national health-based standards (e.g., OSHA or EPA standards) or exposure limits (e.g., NIOSH recommended exposure limits) for indoor biologic agents exist (Centers for Disease Control, 2006). The responsiveness of federal level public policy makers depends on the National Environmental Policy Act of 1969 (NEPA), which requires federal agencies only consider projects that have significant positive impact on the environment.

I feel my greatest contribution is my ability to communicate the science behind removing microorganisms from flooded environments in a way that people of all backgrounds and educational levels can understand. I have immersed myself in collaborative discussions with officials from the:

- Institute of Inspection Cleaning and Restoration Certification (IICRC);
- Federal Emergency Management Agency (FEMA);
- American College of Occupational and Environmental Medicine (ACOEM), and
- The insurance industry

My expertise lies in communicating procedures on how to safely clean, sanitize, and dry microbially flooded materials. My value lies in communicating the science and procedural standards of cleaning, disinfecting, and drying to key stakeholders and training trainers to train flood victims and volunteers who oftentimes are faced with the task of cleaning flooded homes.

In some states environmental laws are a part of everyday business life for cleaning professionals; in other states such laws are non-existent (Table 3.2). For example, Florida, Kentucky and Texas have laws requiring licensing for mold remediation professionals that are based in part on experience, certification, and accreditation. In these states regulations that follow these laws have the best intentions and while none are perfect they raise the bar of professionalism to protect consumers and workers. However, Connecticut has a law requiring school departments to provide an inspection and evaluation of the indoor air quality within each occupied school building without establishing any levels of what constitutes a "safe level" and does not specify what type of tests are required.

Table 3.2 Flood water and mold remediation legislation by state, January 2012

Alabama	**Description of Action**	**Type**	**Description of Content**	**Bill #**	**Action**
Alaska	None				none
Arizona	None				none
Arkansas	Mold investigation and remediation	Mold	Mold Investigation Advisory Board	SB 531 - ARS 803 ACT 1467	enacted
California	Toxic Mold Act Assembly Bill	Mold Mold	Established Task Force Toxic Mold Act Establish limits	SB 732 HB 284	enacted enacted
Colorado	Insurance Consumer Freedom of Choice Bill	Water Restoration	Prevents insurance companies from dictating which restoration company must be used in a covered loss.	HB1104	passed
Connecticut	An act concerning the inspection and evaluation of air quality in state buildings	Mold Remediation	Every five years department shall provide an inspection and evaluation of the indoor air quality within each occupied building under the custody and control of such department.	SB1051	passed
Delaware	None				none
Florida	Relating to Regulation of mold remediation	Mold Remediation	Regulates and licenses providers of mold remediation services.	SB2234	passed
Georgia	None				none
Hawaii	None				none
Idaho	None				none
Illinois	Mold Remediation Registration Act	Mold Remediation	Requires the Department of Public Health to submit a report to committees regarding (1) scientific evidence concerning health effects associated with fungi, bacteria, and their byproducts in indoor environment; and (2) standards for training, certification, and licensing of parties providing mold remediation services	SB1257	passed

Indiana	None				none
Iowa	None				none
Kansas	None				none
Kentucky	Licensing for those involved in mold remediation	Mold Remediation	At Attorney General	HB44	passed
Louisiana	Legislation to Propose Licensing for those involved in mold remediation	Mold Remediation and Water Restoration	To direct the State Licensing Board to develop proposed legislation creating a homeowner's bill of rights to protect homeowners when there is microbial contamination	HCR11	passed
Maine	An Act To Implement regulations for Mold in Buildings	Mold Remediation	This bill implements recommendations of the working group created pursuant to chapter 174 to study mold in buildings.	LD1903	passed
Maryland	AN ACT concerningResidential Real Property-Mold Standards	Mold Remediation - on hold funding	For the purpose of establishing the Task Force on the Development of Mold Assessment Standards in Residential Real Property;	HB1183	passed
Massachusetts	None				none
Michigan	A bill to amend 1937 PA 94, entitled "Use tax act"	Water Restoration	An act to provide for the levy, assessment, and collection of a specific excise tax on carpet cleaning	HB5198	passed
Minnesota	An act relating to pesticides application for water damage remediators	Remediation Pesticides	Pesticides application information access expanded	HF2459	passed
Mississippi	None				none
Missouri	None				none
Montana	None				none
Nebraska	None				none
Nevada	None				none
New Hampshire	None	Mold Remediation	Committee to assist on mold following flooding		none

New Jersey	An Act Concerning Mold Hazards in the Environment	Mold Remediation	Concerns mold hazards in indoor environments - several bills introduced 0/3/2011 NJ 2632 - Benson-Riley	NJS 2632 NJ S 1418 NJS 1959	pending
New Mexico	None				none
New York	Creation of Toxic Mold Task Force	Mold Remediation	An act to amend the public housing law, and health law in relation to mold remediation	A7414	active
North Carolina	None				none
North Dakota	None				none
Ohio	None				none
Oklahoma	None				none
Oregon	None				none
Pennsylvania	Pennsylvania Consolidated Amended	Mold Remediation	Provides for limitation of liability for mold and mold damage.	S457	referred to Judiciary
Rhode Island	RI S 108	Water Restoration	Creates mold advisory board		pending
South Carolina	None				none
South Dakota	Chapter 250 Disclosure of Lake contamination	Mold /water Restoration	An Act to require the disclosure of known contamination	SB127	passed
Tennessee	None				none
Texas	Mold Remediation Registration Act	Mold Licensing	Requires Licensing		passed
Utah	None				none
Vermont	Mold Contaminatio n Coverage	Insurance	Proposes insurance coverage		In Senate finance
Virginia	A BILL to license mold remediators	Mold Remediation	Provides training requirements	HB1789	passed
Washington	None				none
West Virginia	None				none
Wisconsin	Statute 254.1825	Mold Remediation	Bill establishes requirements for licensure of mold remediators	AB312	referred to Committee
Wyoming	None				none

A good state or federal model should include adoption of ANSI/IICRC procedural standards for remediation along with certification and licensing of remediation technicians. This ideal approach would require each technician providing remediation services to flood victims to acquire the core skills necessary to provide adequate remediation services (e.g., training, experience, and certification).

One of the most significant, but difficult to quantify, effects of flooding is its impact on health (Kolsky, 1999). The environmental impacts associated with flooding vary from state to state. Because the nature of flooding can be either predicable (e.g. monsoonal floods, prolonged seasonal rainfall, accumulation of rainwater in low lying areas, or snowmelt) or unpredictable (e.g. dam breaks, tidal surges, broken water lines), floods range from barely noticeable to catastrophes of diluvian proportions.

The lack of empirical research within the disaster restoration industry documents creates real and substantial challenges for remediation professionals, flood victims, insurance providers, and policy makers. The information contained in industry guidelines and standards is salient and following these consensus documents helps protect people's health and safety. However, disaster restoration technicians do not always follow recommended safety procedures (Berry, 1993). Part of the problem lies within the cleaning and restoration industry itself, which is both fragmented and strongly influenced by the insurance industry. By collaborating with each of the stakeholders, incremental improvements can be made in how environmental scholars and researchers can make sense of procedures where multiple, potentially incongruent documents appear to have validity but lack credible research.

The aggregation of research data will inform the outcome of public policy. Policy makers are more likely be motivated to create laws addressing flood mitigation if flood mitigation techniques are proven to have a positive outcome that protects the safety and health of workers and flood victims. Insurance companies would be more inclined to fund remediation activities if research indicates a benefit to health and safety. Ostrom's (2011) approach to get political actors involved with stakeholders in a situation provides insights regarding how to use information to link actions to positive outcomes (Figure 3.1). The cleaning and restoration industry will gain credibility if we conclude that the benefits of cleaning for health can be effective when done properly. Moreover, if all the stakeholders view cleaning the built environment and its contents following flooding as a way to provide maximum protection for health and safety, the cleaning and restoration industry, with whom the decision makers must interact, will gain credibility. Credibility for cleaning and restoration professionals is an important factor when it comes to working collaboratively with public policy makers (Fischer, 1995). When public officials understand information obtained from scientific research it can have a positive effect on outcome of regulations. When regulators understand that properly cleaning and drying a flooded home reduces health and safety risks for those conducting the work and those who will subsequently occupy the dwelling they can support regulations that achieve that outcome.

External Variables

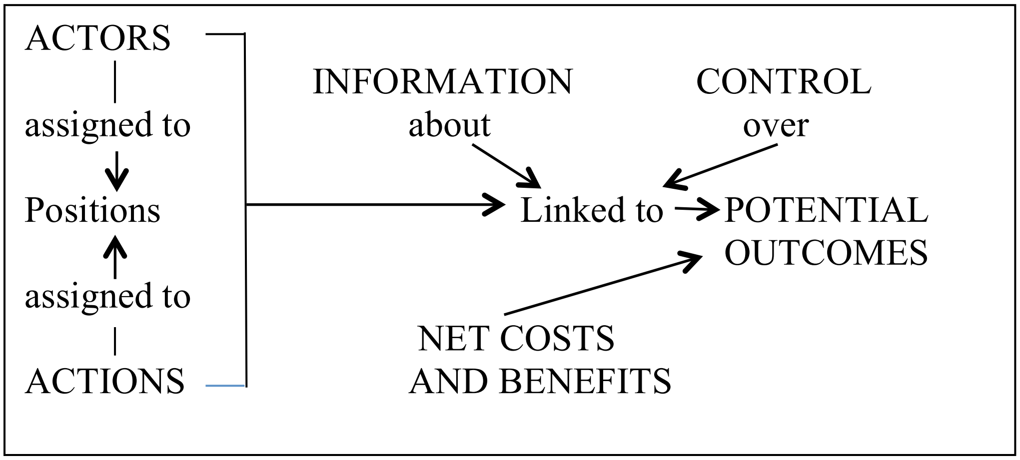

Figure 3.1 The Internal Structure of an Action Situation. (Ostrom, 2011, p. 10)

The adverse environmental impacts of a shifting climate and its attendant potential for flood damage should be alarmingly apparent, providing an opportunity for change today (Few, 2003). Assuming changes in flood patterns will occur, it can be anticipated that the burdens brought by flooding will intensify in some geographical regions and will likely affect areas not affected in the past. The majority of these impacts can be expected to fall primarily in low-income flood-prone areas, as was the case with Hurricane Katrina. Since Hurricane Katrina struck New Orleans in 2005, discussions of both the social and ecological consequences of flooding have taken place. Scientists agree that more frequent flooding will increase the exposure of human populations to a wide range of substances (e.g. mold, fecal matter, biological agents, bacteria and chemical-based products) both natural and anthropogenic in origin (Centers for Disease Control, 2010). The potential for these substances to be deposited in homes during flooding is great. It has motivated some states (e.g., Florida, Kentucky, Texas) to write regulations protecting workers and flood victims. State recognition and regulation is a good starting point and is, in part, attributable to living in the proximity, or perceived proximity, of flood prone areas. If we assess these regulations from a state level, we are likely to conclude that many regulators opt for policy alternatives that, at best, protect human beings when a flood event occurs in their own state. However, everyone is at risk because people live in, or near, flood zones and floods occur in all 50 states (National Flood Insurance Program, 2012).

Working on behalf of flood victims, public officials typically invite comments from individuals who can articulate their thoughts or concerns about a situation so they can better understand all sides of flood issues. However, flood victims may not be able to constructively engage in a dialogue because of lack of opportunity, venue, or the immediate challenges of subsistence and cleaning and drying of their damaged homes. Therefore, flood victims have little input in the decision making process and are typically ignored. The Kentucky Office of Consumer, Protection Office of the Attorney General, received a letter from Steven Rice, an indoor environmental professional and a participant in the Kentucky public hearings regarding a bill to regulate disaster remediation professionals (HB 44). Rice wrote: “There were no citizen stakeholders allowed in the process to advocate for consumer rights. Why did we choose not to learn from their experiences?” (S. E. Rice, personal communication, July 19, 2011). He believes that flood victims have developed a practical wisdom from their experience and should be heard. They know firsthand the consequences of flooding and through dialogue and constructive engagement can inform others about the needs of victims. In Kentucky regulators listened to each individual stakeholder’s comments which they recorded on large sheets of paper and asked if they had captured the salient points. Perhaps the most difficult perspective to understand is the point of view of a flood victim with no resources. To date, no regulations have been written in Kentucky. Regulators are still meeting and attempting to build consensus on regulations that offer guidance and assurance to their residents.

Florida, a state often affected by hurricanes and tropical storms, passed regulations requiring remediation contractors and inspectors to be licensed (SB 2234) by the Florida Department of Business and Professional Regulation (DBPR) before performing activities in mold contaminated flood damaged dwellings. The department required that individual technicians be licensed rather than developing rules regulating activities or procedures for remediation technicians to follow.

Florida statute 468.8413 states: “At a minimum, an individual with a GED and 4 years of verifiable experience who passes the licensure exam can be licensed.” Yet they have no authority to require a candidate for licensure attend a class or be certified. Technicians face significant challenges when remediating a flooded structure and should have formal training, experience, and certifications necessary to perform the required tasks of water damage remediation and provide appropriate documentation prior to licensing. State’s offering licensure without effective training lack adequate assurance of technical knowledge. Florida regulations lack specific triggers for what constitutes a contaminated indoor environment.

In 1994 Texas became the first state to regulate activities surrounding flooding, water damage, and mold remediation activities by licensing individual remediation technicians. The

Texas Mold Remediation Registration Act (MRRA) applies to anyone performing remediation activities that affect indoor air quality. Each technician must have experience, training, and be certified before applying for a license to clean, sanitize, demolish, or apply any treatment, including preventive activities, regarding mold or mold-contaminated matter that was not purposely grown at a location. Another distinguishing characteristic of the Texas regulations is that state governmental entities are not automatically exempt from the regulations.

While every flood situation is unique, we must ensure that flood victims, restoration professionals, or groups without political power have access to policy regulators. Every stakeholder should have a voice so that regulators can make informed decisions with all the facts. Regulators have an enhanced responsibility where flood-victims are concerned. They should understand the analytic role they play and must recognize there is no simplistic answer or universal solution. In the absence of scientific studies, regulators cannot adequately grasp the significance of the role cleaning for health. This study provides evidence that professional guidance must be followed in order to protect the safety and health for all those involved in flood remediation.

Environmental Justice and Policy

If we consider environmental justice, regulators may favor policy solutions that address their own interests whether intentionally or subconsciously. Regulatory inequities exist, in part, because those with sufficient wealth locate in neighborhoods where flooding is less likely to occur. In New Orleans, one of the poorest and most written about neighborhoods that flooded was the Lower Ninth Ward (Connolly, 2005; Muhammad, 2006). Low socioeconomic status individuals were disproportionately displaced in that area following Hurricane Katrina, an area that already faced major social oppression, race and class struggles (Falk, Hunt & Hunt, 2006). It is also well documented that many poor were disproportionately unable to obtain necessary health care following Hurricane Katrina (Zoraster, 2010). As the nation struggles with the increasing impacts of natural disasters on society, discussion of the science of restoring flooded homes and belongings must not be characterized by inaction. Some would argue that: "Where there is no action (or no action of consequence), there is no politics" (Barber, 2003). I disagree. These complex public awareness situations are philosophically rooted in arguments regarding participation and discourse articulated by Habermas (1970). In reality, inaction may simply reinforce existing power differences between socio-economic groups and provide easier means for powerful groups (e.g. lobbyists, property managers, insurance companies) to overwhelm the discussion for their own parochial interests.

To cope with the barrier of inaction I explored this and other problems through creating a dialogue at different levels of interaction: the flood victim's level, the cleaning and restoration industry's level, the insurance industry's level and the public policy level. In the past, policy makers and regulators have relied on untested assumptions and imprecise language rather than consideration and implementation of scientific studies. Today, the potential to effectively clean and disinfect dwellings and personal belongings exists. As proven in this study, modern techniques permit many items to be cleaned and disinfected to a pre-flood condition. Regardless of what direction policies or regulations take, a fundamental shift is needed to place more responsibility on cleaners and restorers whose obligation is to restore flooded homes to a clean and sanitary condition. Moreover, public policy needs to include funding mechanisms to cover emergency disaster restoration service to protect the health and welfare of citizens. Local and state governments must find ways to exercise authority to ensure cleaners perform work safely. Proper cleaning and disinfection of contents contaminated by flood water should be undertaken only by properly trained and certified technicians. Unfortunately flood victims are often burdened financially and undertake remediation on their own.

Human beings are vitally dependent upon clean and dry living spaces. During the last several decades the cleaning and restoration industry has evolved as information regarding water damage has become available, as scientific developments occur, and as advancements are made in restoration technology and practice. The emergence of new industry standards dealing with flood damage has significantly altered the way dwellings and contents are cleaned and sanitized following flood occurrences. Although the development of scientific standards is not itself political, today's water damage industry standards have opened the door to create a dialogue with government leaders.

Discussion

Thus far, promising strides have been made in state regulations and have been marked by small successes. In the summer of 2010 I testified in the Kentucky House of Representatives for passage of the state's first consumer protection law protecting the health and welfare of the citizens of Kentucky during mold remediation activities. The law was passed (HB 44) and is currently in the state Attorneys General' office undergoing review. Kentucky's law could be a catalyst for other states to follow, but one of the bill's weaknesses is it has too few benefits for flood victims and is subject to being diluted even more by lobbyists. The most powerful aspect of the law is that it publicizes health and safety risks that flood victims and volunteers face when attempting to remediate dwellings and contents contaminated by flood-water without properly trained professional help. It is crucial that individual flood victims, and the volunteers who want to help them, understand that dangers (e.g. bacteria, viruses, sewage, mold) do not recede with flood water. Oftentimes a slight musty odor, or what appears to be minor contamination, suggests that a more serious health threat may be lurking inside wall cavities or in and under rugs, carpets, and padding.

I have opened a dialogue with policy makers, including Congressional leaders in Florida, Louisiana, Massachusetts, Maine, New Hampshire, New Jersey, New York, Texas and Virginia. They have the best intentions, yet safety and health issues are not always their priority. Some states have adopted laws that protect worker's health during remediation and others are considering doing the same. Ultimately, all states should promulgate, and enforce, regulations that afford protection for both volunteers and professionals from potentially life threatening health implications following flooding. Recently I was invited to address members of the Property Loss Research Bureau's technical conference, the trade association for insurance carriers, regarding my research and discussed the potential health benefits for flood victims and disaster restoration technicians. I have been invited as guest lecturer at the Institute of Inspection Cleaning and Restoration's Certification Council to discuss the results of this research and its implication for the cleaning and disaster repair industry and have been an invited guest lecturer at Purdue University in Indiana to discuss flooding and microbial contamination for their disaster repair cohort. This research is useful because it provides guidance regarding safety procedures for professionals to follow. Various principles of proper flood remediation provide valuable direction for government agencies to follow, however, they remain very much the tool of states rather than providing guidance at the federal level. The cautionary lesson here is each state sets its own regulations and sometimes will confuse the issue for those professionals who perform water damage restoration as demonstrated by the variability of state laws. For me, the appeal of state regulations is that new rules create awareness that may evolve into more regulations on the national regulations.

Recently the emphasis on engineering safe cleaning processes to prevent health problems, combined with the mounting costs for remediating flood damage, has led to discussions with the Federal Emergency Management Agency (FEMA) to encourage the adoption of procedural standards for those who work in the disaster repair industry. It is FEMA that will play a crucial role in understanding the health and safety risks that face volunteers. FEMA has the backing of the federal government with funding to meet community needs regardless of whether other funding sources exist. FEMA has been concerned primarily with providing funding for flood victims without placing an emphasis on guidance to protect the health and safety risks faced by those providing volunteer service. An example that demonstrates the lack of proper guidance is the recommendation for using bleach (sodium hypochlorite) as a disinfectant. Even common household bleach can be hazardous to volunteer's health if inhaled causing damage to mucus membranes, contacted with skin, or mixed with ammonia creating dangers from explosion, or toxic fumes.

It is crucial that contaminated material in flooded dwellings be properly remediated. The best professional restorers have acquired skills through training and certification classes that instruct them on a core set of skills which include how to safely remediate contaminated materials. However, homeowners, often without insurance coverage, face the daunting task of restoring contaminated materials on their own or with the assistance of volunteers, many of whom are ill prepared and often unaware of potential health consequences they face. For example, in a meeting several years ago following a flood in New England, I asked a leader of one of the volunteer groups what safety precautions were employed when removing contaminated drywall from a flooded home. She told me they turn the worst side of the contaminated material away from their face as they carry it out of the flooded home, along with using bleach to scrub bacteria and mold they could see. State safety officials present told me they don't enforce laws enacted to protect individuals cleaning up after floods because of the nature of emergencies. Sadly, this situation has existed for too many years. Because state and national policy makers, including FEMA, are woefully short of resources to fund flood restoration efforts, untrained volunteers have filled the gap, leaving volunteers and homeowners at risk.

When funding is not available, as is the case with many flooding events, homeowners are left with few options for conducting remediation tasks other than accepting the assistance of untrained volunteers. This option of last resort will continue unless efforts are undertaken to provide guidance as needed without cost to flood victims who oftentimes do not have adequate financial resources. Today, a multitude of ecologically conscious volunteer groups and nongovernmental organizations (NGOs) are providing volunteers to assist flood victims in finding solutions to complex flood issues. These nonprofit organizations lower the cost to government. This transfer of responsibility has arisen in part because of the declining role of government funding. This shift among government, private sectors, and society has brought a new set of issues, challenges and opportunities for a new NGO to provide guidance needed for volunteers and flood victims. The lack of action by public officials demonstrates an increasing need for private sector initiatives to develop NGOs for the purpose of bringing stakeholders together, negotiating outcomes that benefit flood victims, and implementing solutions that help volunteers work safely together. The emergence of such institutions would confer legitimacy on the science of cleaning for health and assist volunteers for the common good of mankind. Therefore, the role of an NGO in training and equipping flood victims, and the volunteers who help them, with personal protection equipment is very important.

NGOs already play an important role in assisting disaster victims. Habitat for Humanity, the Red Cross, AmeriCorps, and similar groups are dedicated to helping flood victims, yet they are limited by volunteers and donations and remain focused on their primary goals. In 2010, Habitat for Humanity, together with AmeriCorps volunteers, helped rebuild 20 homes impacted by floodwaters in Cedar Rapids, Iowa (Habitat for Humanity, 2010). However, 4000 homes were damaged by the previous year's devastating floods. With the federal government's attention focused on the economy, it is unlikely any measures that add to the fiscal burden will be enacted to help flood victims. An NGO that can work together with other disaster assistance organizations to provide relevant training to prepare volunteers to safely clean, dry, and sanitize flooded dwellings could play a significant role in addressing the needs of flood victims.

The National Voluntary Organizations Active in Disaster (NVOAD) is one group dedicated to bringing together various organizations and strengthening relationships while advocating four guiding principles: cooperation, communication, coordination, and collaboration. The range of work provided by volunteers assisting in flooded areas is as broad as their interests. Volunteer groups are organized to perform various tasks, mobilizing public support, providing legal work, removing mud and debris, and function as agents of change. There is ample evidence to indicate that volunteers make a difference, however their safety must be a primary concern. Their remediation efforts in flooded homes needs to be performed correctly. They should be cautioned against potential dangers such as mixing chemicals and performing work in wet, contaminated spaces which pose health risks to themselves and others without training and guidance. A crisis no one is talking about is the lack of training for volunteers who risk their health to help others. The development of a non-profit disaster restoration organization established legally as 501(C) (3) corporation to assist flood victims and volunteers by providing training, guidance documents, and personal protection equipment (PPE) would be an ideal solution.

A successful grass roots organization requires participants with a broad range of skill sets. First, a team of stakeholders, including flood victims, need to assemble in order to reach consensus detailing needs and type of structure to be developed along with a charter to move from an idea to reality. Second, the development of an organization whose members are committed to serve the needs of flood victims must be formed. My research provides guidance documents which can be used by other volunteer disaster groups and result in working together with existing volunteer organizations, subject matter experts, and advocacy groups for the benefit of flood victims.

During the past two decades I have played a significant role in the disaster restoration industry. I have helped design and operate non-profit entities whose activities were determined by the collective will of its members. The launch of a nonprofit NGO providing a practical approach to cleanup of flood damaged dwellings is a paradigm shift that will help ensure that safety issues are not ignored. The primary aim is to provide training and resources for volunteers and flood victims who undertake the formidable task of safely cleaning, sanitizing, and drying dwellings impacted by floodwaters.

In general, there are many organizations that offer assistance to flood victims, however, the goal of this new organization will be to collaboratively work to provide recommendations based on empirical evidence and best practices when undertaking remediation activities. We are all living in a global village where helping flood victims is less restrained than ever before thanks to today's information revolution. Internet communication allows people to organize, communicate and train in ever growing numbers. Moreover, this communication phenomenon provides a solution that did not exist only a few years ago. This opportunity, based on sound science, excites me because it is built on existing relationships that began with my volunteering for committees including New Hampshire's Flood and Mold Task Force, ANSI/IICRC S500 Standard for Professional Water Damage Restoration, ANSI/IICRC S520 Standard and Reference Guide for Professional Mold Remediation, speaking with Congressional leaders, and volunteering to train volunteers from faith-based groups and regional outreach centers.

Conclusions

This research was conducted to determine the effect of disinfectants, cleaning and drying practices on flooring textiles contaminated with river water. My study demonstrates effective ways to safely clean and return flood contaminated flooring textiles to flood victims. I need to share this information with the message that engages government officials if flood policies are to be designed based on empirical research and the benefits of cleaning for health. All aspects ranging from the future of flood cleanup and how it's paid for, to insurance costs, could benefit from a wider appreciation of cleaning science. One beneficial insight of this dissertation is the discussion of increased risk from flooding faced by those who are impoverished and have little or no voice in public policy affairs. My recommendations are based on proven techniques and methods for cleaning and drying that help protect the health of workers and flood victims. Regulators cannot form intelligent opinions on these subjects, nor can they be intelligent policymakers, unless they understand the technological questions that underlie them. Only when policymakers understand enough science to see the underlying issues can they confront the problems productively. It is my sincere hope, and primary objective, that with this research, I can become a bridge between flood victims, cleaners, disaster restoration professionals, insurance companies, scientists, and government officials and advance the importance of effective cleaning following flooding by creating a nonprofit disaster restoration organization.

The following are important questions that need to be addressed by stakeholders:

- Will policymakers address flooding issues?
- Will regulators create an effective policy that assists flood victims?
- Will the professional disaster restoration industry collaborate with policymakers?

I look forward to continuing my efforts to bring attention to this critical subject by identifying and examining common interests and directions that ultimately will result in the greatest gains for public health within the cleaning industry and for flood victims.

Literature Cited

Andersson, M. A., Nkulin, M., Köljalg, U., Andersson, M. C., Rainey, F., Reijula, K., Hinikka, E., & Salkinoja-Salonen, M. (1997). Bacteria, molds, and toxins in water-damaged building materials. *Applied Environmental Microbiology, 63*(2), 387-393.

ANSI/IICRC. (2006). *Standard and reference guide for professional water damage restoration (ANSI/IICRC S500)* (3rd ed.). Vancouver, WA: Institute of Inspection, Cleaning and Restoration Certification.

ANSI/IICRC. (2008). *Standard and reference guide for professional mold restoration (IICRC S520)* (2nd ed.). Vancouver, WA: Institute of Inspection, Cleaning and Restoration Certification.

Asbury, G. H. (2011). X-ray fluorescence spectroscopy method development for quantitative evaluation of carpet cleaning technology. *AATCC Review, 11*(2), 58-64.

Baily, H. S. (2005). *Fungal contamination: A manual for investigation, remediation and control*. Jupiter, FL: BECi.

Barber, B. R. (2003). *Strong democracy: Participatory politics for a new age*. Berkeley, CA: University of California Press.

Bartram, J., Cotruvo, J., Exner, M., Fricker, C., & Glasmacher, A. (2003). *Heterotrophic plate counts and drinking-water safety: The significance of HPCs for water quality and human health*. Geneva: World Health Organization.

Bernazzani, D. (2008). *Hand woven rug cleaning: Assessment of cleaning efficiency of cleaning one of a kind, hand knotted Oriental rugs following contamination in Category 3 water*. Unpublished manuscript.

Berry, M. A., Bishop, J., Blackburn, C., Cole, E. C., Ewald, W. G., Smith, T., Suazo, N., & Swan, S. (1994). Suggested guidelines for remediation of damage from sewage backflow into buildings. *Journal of Environmental Health, 57*, 9-15.

Berry, M. A. (1993). *Protecting the built environment: Cleaning for health*. Chapel Hill, NC: Tricomm 21st Press.

Bicudo, J. R. & S. M. Goyal. (2003). Pathogens and manure management systems: A review. *Environmental Technology, 24*, 111-130.

Brandys, R. (2007, February). Quantifying bacteria levels in water categories 1-3. *Indoor Environment Connections*. Retrieved from http://www.ieconnections.com/archive/feb_07/feb_07.htm#article9

Brandys, R. (2011). *Worldwide exposure standards for mold and bacteria with assessment guidelines for air, water, dust, ductwork, carpet, insulation and bulk materials* (9th ed.). Hinsdale, IL: OEHCS, Inc., Publication Division.

Centers for Disease Control. (1993). Public health consequences of a flood disaster—Iowa, 1993. *MMWR: Morbidity and Mortality Weekly Report, 42*(34), 653-656. Retrieved from http://www.cdc.gov/mmwr/PDF/wk/mm4234.pdf

Centers for Disease Control. (2005). Hurricanes. *MMWR.* Retrieved from http://www.cdc.gov/mmwr/mguide_nd.html

Centers for Disease Control. (2006). Mold prevention strategies and possible health effects in the aftermath of hurricanes and major floods. *MMWR Recommendations and Reports, 55*(RR08), 1-27. Retrieved from http://www.cdc.gov/mmwr/preview/mmwrhtml/rr5508a1.htm

Centers for Disease Control. (2010). *Water related emergencies & outbreaks: Buildings and facilities damaged by flood water.* Retrieved from http://www.cdc.gov/healthywater/emergency/flood/buildings.html

Cobb, R., & Ross, M. (1997). *Cultural strategies of agenda denial: Avoidance, attack and redefinition*. Lawrence, KS: University of Kansas Press.

Coffman, J. (2007). What's different about evaluating advocacy and policy change? *The Evaluation Exchange, 13*(1), 2-4.

Cole, E. C. (2006). *Public & occupational health risks from exposure to sewage contamination*. Deptartment of Health Science, Brigham Young University.

Cole, E. C., Rutala W., Nessen L., Wannamaker N., Weber D. (1990). Effect of methodology, dilution, and exposure time on the tuberculocidal activity of glutaraldehyde-based disinfectants. *Applied Environmental Microbiology, 56*, 1813-1817.

Collingwood, P. (1968). *The techniques of rug weaving*. London: Faber.

Connolly, C. (2005, October 3). 9th Ward: History, yes, but a future? Race and class frame debate on rebuilding New Orleans district. *Washington Post*, p. A1.

Edwards, D. R., Coyne, M. S., Vendrell, P. F., Daniel, T. C., Moore, P. A., & Murdoch, J. F. (1997). Fecal coliform and streptococcus concentrations in runoff from grazed pastures in the Northwest Arkansas. *Journal of the American Water Resources Association, 33*, 413-422.

EPA. (2005). *Response to 2005 hurricanes: Find sampling locations and results.* Retrieved from http://www.epa.gov/enviro/katrina/emkatrina.html#othersampling

EPA. (1997, June 3-4). Federal Insecticide, Fungicide, and Rodenticide Act, Scientific Advisory Panel Meeting. Retrieved from http://www.epa.gov/scipoly/sap/meetings/1997/june/report.pdf

Falk, W. W., Hunt, M. O., Hunt, L. L. (2006). Hurricane Katrina and New Orleanians' sense of place: Return and reconstitution or "Gone with the Wind"? *Du Bois Review, 3*, 115-128.

Few, R. (2003). Flooding, vulnerability and coping strategies: Local responses to a global threat. Progress in development studies. *Progress in Development Studies, 3*(1), 43-58.

Fijan, S., Koren, S.,Cencic, A., Sostar-Turk, S. (2007). Antimicrobial disinfection effect of a laundering procedure for hospital textiles against various indicator bacteria and fungi using different substrates for simulating human excrements. *Diagnostic Microbiology and Infectious Disease, 57*, 251-257.

Fischer, F. (1995). *Evaluating public policy.* Chicago: Nelson-Hall Publishers.

Gerba C. P. & Smith, J. E. (2005). Sources of pathogenic microorganisms and fate during land application of wastes. *Journal of Quality, 34*(1), 114-120.

Habermas, J. (1970). *Toward a rational society*. Boston: Beacon Press.

Habitat for Humanity. (2010). Retrieved from http://www.habitat.org/support/report/2010

Handmer, J., Penning-Roswell, E., & Tapell, S. (1999). Flooding in a warmer world: The view from Europe. In T. E. Downing, A. A. Olsthoorn, & R. S. J. Tol (Eds.), *Climate, Change and Risk* (pp. 125-161). London: Routledge.

Holland, J., Banta, J., Passmore, B., Ayers, M., Abbott, S., & Cole, E. (2012). Bacterial amplification and in-place carpet drying: Implications for Category 1 water intrusion restoration. *Journal of Environmental Health*, *74*(9), 8-14.

Hutchinson M. L., Walters D., Avery S. M., Synge B. A., & Moore A. (2004). Levels of zoonotic agents in British livestock manures. *Applied Microbiology, 39*(2), 207-214.

Intergovernmental Panel on Climate Change (2001). *Climate change 2001: Impacts, adaptation, and vulnerability, summary for policymakers*. A report of Working Group II of the IPCC. Geneva: IPCC.

Kemper R. A., Ayers L., Jacobson C., Smith C., & White W. C. (2005). *Improved control of microbial exposure hazards in hospitals: A 30-month field study*. Retrieved from http://www.aegisasia.com/pdfnew/improved_control_of_microbial_exposure_a_30_month_field.pdf

Kolsky, P. (1999). *Performance-based evaluation of surface-water drainage for low income communities: A case study in Indore, Madhya Pradish* (Doctoral thesis). University of London.

Luedtke, A. E., (2004). Floor covering, dust, and airborne contaminants. *International E-journal of flooring sciences.* Retrieved from http://www.flooringsciences.org/e-journal/0407/0407_Luedtke_Dust-Airborne-Contaminants.pdf

Macher, J., Ammann, H. M., & American Conference of Governmental Industrial Hygienists. (1999). *Bioaerosols: Assessment and control*. Cincinnati, Ohio: ACGIH.

Mallett, M. (1998). *Woven structures: A guide to Oriental rug and textile analysis*. Atlanta, GA: Christopher Publications.

Morrow, B. H. (1999). Identifying and mapping community vulnerability. *Disasters, 23*(1), 1-18.

Muhammad, S. (2006). Hurricane Katrina: The Black nation's 9/11! A strategic perspective for self-determination. *Socialism and Democracy, 20*(2), 3-17, 219-220.

National Flood Insurance Program. (2012). *Resources: Flood facts.* Retrieved from http://www.floodsmart.gov/floodsmart/pages/flood_facts.jsp

Ostrom, E. (2011). Background on the institutional analysis and development framework. *Policy Studies Journal, 39*(1), 7-27.

Perry, C. (2000). *Significant floods in the United States during the 20th century.* Reston, VA: U.S. Dept. of the Interior, U.S. Geological Survey.

Pielke, R. A., & Downton, M. W. (2000). Precipitation and Damaging Floods: Trends in the United States 1932-97. *Journal of Climate, 13,* 3625- 3636.

Phillips, B., & Morrow, B. (2007). Social science research needs: Focus on vulnerable populations, forecasting, and warnings. *National Hazards Review, 8*(3), 61-68.

Presley, S. M., Rainwater, T., Austin, G., Zak, J., Cobb, G., Marsland, E., Tian, K., Zhang., B., & Anderson T. (2006). Assessment of pathogens and toxicants in New Orleans, LA following Hurricane Katrina. *Environmental Science & Technology, 40,* 468- 474.

Rapp, R. R. (2011). *Disaster recovery project management: Bringing order from chaos*. West Lafayette, Ind: Purdue University Press.

Seaton, J. (2009). *Flood control and poverty: Phillips County, AR and Guyana*. Retrieved from http://www.wlu.edu/documents/shepherd/academics/cap_2009_Seaton.pdf

Sinigalliano, C. D., Gidley, M., Shibata ,T., Whitman, D., Dixon, T., Laws, E., Hou, A., Bachoon, D., Brand, L., Amaral-Zettler, L., Gast, R., Stewart, G., Nigro, O., Fujioka, R., Betancourt, W., Vithanage, G., Mathews, J., Flemming, L., & Solo-Gabriele, H. (2007). Impacts of Hurricanes Katrina and Rita on the microbial landscape of the New Orleans area. *PNAS : Proceedings of the National Academy of Sciences,104,* 9029-9034.

Smith, K. (1996). *Environmental hazards: Assessing risk and reducing disaster*. London: Routledge.

Spaulding, E. H. and Emmons, E. K. (1958). Chemical disinfection. *American Journal of Nursing, 58,* 1238-1242.

Steffen, W., Anderson, A., Tyson, P., Jager, J., Matson, P., Moore, B., Oldfield, F., Richardson, K., Schellnhuber, H., Turner, B., & Wasson, R. (2005). *Global change and the earth system: A planet under pressure*. New York: Springer.

Tortora, G., Funke, B., & Case, C. (2004). *Microbiology: An introduction* (8th ed.). San Francisco, CA: Pearson.

Ward, R. C. (1990). *Principles of Hydrology*. London: McGraw-Hill Publishing Co.

Zoraster, R. M. (2010). Vulnerable populations: Hurricane Katrina as a case study. *Prehospital and Disaster Medicine, 25*(1), 74-78.

Appendices

Observation Form Oriental Rug Experts

Questions to help guide rug experts document change(s) in Oriental rug samples. Note: There was no “E” used in testing- it was an additional control.

Compared to the original sample - what changes if any do you detect?

Note: Change from 1 – 5 1 = no change 5 = highest change

Comments:

Table 1. Viable E. Coli Bacteria Levels for Common Animals Feces (Brandys, 2007)

Human	5,000,000 cfu/gram
Cat	40,000,000 cfu/gram
Dog	32,000,000 cfu/gram
Goose	310,000 cfu/gram

Table 2. Applicable Standards for Potable Water Interpretation (aka Category 1) (Brandys, 2007)

Standard Setting Body/Law	Maximum Level
USEPA Safety Drinking Water Act *	<50,000 CFU/100 ml
Brazil - potable drinking water	<50,000 CFU/100 ml
Honk Kong - Food and Hygiene Department	<50,000 CFU/100 ml
Pharmaceutical Industry - acceptable potable water	<50,000 CFU/100 ml
American Water Works Association - ANSI Standard C651.92	<50,000 CFU/100 ml

* This is not a legal US standard per se but the EPA recognizes that properly-chlorinated and maintained potable waters systems will have < 500 CFU/ml. The EPA website : (www.epa.gov/nerl/research/1999/html/g2-3.html) also states "An informal standard of 500 CFU/ml of potable water has been used as an indicator of the integrity of distribution systems."

Table 3. Heterotrophic Plate Count Standards for Swimming Pools (in CFU/100 ml) (Brandys, 2007)

Agency	Maximum Level*
US. Army, MA, AZ	< 20,000
Australia	< 10,000

*Note the standard for HPC in drinking water is actually higher than for swimming pools.

Table 4. Thermotolerant Coliform Plate Count Standards for Swimming Pools (in CFU/100 ml) (Brandys, 2007)

Agency	Maximum Level
UNEP/WHO (1985) Interim Criteria for Recreational Waters:	
<100 (50% average)	<1,000 max. (1 in 10 samples)
MA, AZ	<2

Table 5. *E. coli* Standards for Swimming Pools (in Counts/100 ml) (Brandys, 2007)

Agency	Maximum Level
New Hampshire	≤ 88

Table 6. Fecal Coliform Standards for Type I Reclaimed Water (Brandys, 2007)

Texas Natural Resource Conservation Commission (in CFU/100 ml)

Type 1 Reclaimed Water	Maximum Level
Fecal Coliform (average)	<20
Fecal Coliform (not to exceed)	<75

Table 7. Fecal Coliform and Total Coliform Standards for Type II Reclaimed Water (Brandys, 2007)

(in CFU/100 ml)

Type II Reclaimed Water	*Maximum Level*
Fecal Coliform (average)	<200 *
Fecal Coliform (not to exceed)	<800 *
Total Coliform	<2,000 **

*Texas Natural Resource Conservation Commission

**Valentina Lazarova Akiçca Bahri; "Water Reuse for Irrigation, Agriculture,Landscapes, and Turf Grass," CRC Press.

Table 8. Heterotrophic Plate Counts for Edible Ice (in CFU/100 ml) (Brandys, 2007)

Standard Setting Body/Law	Maximum Level Heterotrophic Plate Count (Total Plate Count)
WHO standard for edible ice*	<5,000,000
WHO standard for edible ice for infants and elderly with suppressed immune systems **	<300,000

*Geldreich, E. E. et al. 1975

**Richardson, 1998

Table 9. Coliform and Fecal Coliform in Typical Sewage (in CFU/100 ml) (Brandys, 2007)

Sewer Source	Total Coliforms	Fecal Coliforms
Esparto, CA	23,500,000	6,200,000
Shastina, CA	9,600,000	2,300,000
Los Banos, CA	62,000,000	23,000,000
Anaka, MN	47,400,000	10,200,000
Newport, MN	13,600,000	3,580,000
Red Wing, MN	17,700,000	4,050,000
Mankato, MN	5,525,000	2,630,000
Oakwood Beach, NJ	13,250,000	4,240,000
Middlesex, NJ	12,900,000	1,070,000
Keyport, NJ	2,210,000	641,000
Omaha, NE	45,800,000	5,360,000
Anderson, OH	17,200,000	4,600,000
Cincinnati, OH	34,800,000	4,900,000
Fargo, ND	1,300,000	290,000
Lawrence, MA	17,900,000	4,500,000
Median Value	15,400,000	4,240,000

Adapted by R. Brandys from: “Microbial Quality of Water Distribution Systems,“ Geldreich, 1992.

Table 10. Summary of Suggested Category 1, 2 and 3 Bacterial Ranges in Water (Brandys, 2007)

(in CFU/100 ml)

Water Category	Total Plate Count	Total Coliform Bacteria	Fecal Coliform
Category 1	<50,000	<100	≤75 *
Category 2	≥50,000 to <50,000,000	≥ 100 to <1,600,000	≥75 * to < 340,000
Category 3	≥50,000,000 to TNTC*	≥1,600,000	≥340,000

*uncontaminated recycled water used in toilets and urinals

TNTC = Too numerous to count. This varies depending upon the serial dilutions employed by the lab, but typically is 50,000,000 CFU/100 ml.