APPENDIX E

Suggested Guidelines for Remediation of Damage from Sewage Backflow into Buildings

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Introduction

Water is the single most long-term destructive substance in the indoor environment. It dissolves or weakens many materials and supports the growth of microorganisms on others. Because it flows, water has the capability to carry with it a wide variety of pathogens and allergens harmful to humans (1). In the best of worlds, buildings would be designed so that flooding would never occur; however, in the real world, water sometimes gets out of control in every building. When a water emergency occurs, quick reaction to seepage, spillage, flooding, or backups has many benefits. Quick reaction often saves valuable property from direct water damage as well as destruction from microbial growth. The longer any kind of water damage goes untreated, the greater the damage. Immediate response to a water emergency saves time and money, and protects property and health.

The primary objectives of controlling water damage are well known to professional restorers and public health professionals. These objectives are to protect public health, immediately remove harmful substances that enter into the environment with flowing water, restore the environment to a dry state, and salvage valuable property. The objectives are even more critical when flood waters contain animal or human body fluids or wastes (e.g., raw sewage) or other organic contaminants.

Sewage poses a very significant threat to human health. However, the severity of the health threat depends on the content of the sewage and the degree and extent of penetration into the building environment. The degree of penetration is dependent on the porosity of contaminated materials, the quantity of sewage, and the amount of time the sewage remains in contact with materials. Consider three examples of sewage spilling into an indoor environment; the restoration response may be different in each situation.

Situation 1. A very limited quantity of waste that originates in the built environment is deposited or flows slightly beyond the confines of the sewage system. In this situation, the waste is found in one specific location, is contained, and does not penetrate the building structure. A limited amount of contact time has occurred. An example of this situation might be waste that overflows in a bathroom and is deposited on and confined to a tile floor. In this situation, there is a limited quantity of waste, which is contained and does not contact absorbent materials. Decontamination, which includes water extraction, cleaning, and disinfection, can be effective in reducing this particular potential health risk.

Situation 2. Waste that originates in the built environment is deposited or flows beyond the confines of the building's disposal system. In this case, there is limited or confined flooding, but water and waste penetrate the structure and furnishings of the building. For example, flooding occurs in a men's room of an office building, water flows under a wall, and into the carpet of an adjacent hallway. In this case, there is a limited amount of waste that is confined to a relatively small area of the building, but it penetrates regions of the environment that have complex surfaces and are difficult to restore. Effective restoration involves decontamination (as in Situation 1) as above and drying all surfaces that have been in contact with the sewage. In the case of stretch-in carpet, lifting and cleaning the contaminated carpet, disposing of the cushion, and treating both sides of the carpet thoroughly with a disinfectant are all necessary. Affected porous wall materials need to be treated with a disinfectant and evaluated for replacement. Because of the confinement of the sewage spill, aggressive, comprehensive treatment can be effective.

Situation 3. Waste that originates in the built environment, along with other wastes from the main line of the sewage system, is backed up into the immediate environment, where the waste is widely dispersed and penetrates both the structure and its furnishings. In this situation, there is extensive risk because humans can be exposed to pathogenic raw wastes that have penetrated and become contained by the building and its furnishings. If flooding is from this kind of primary outside sewage system, occupants should be evacuated, and restoration should begin immediately. In this situation, cleaning and restoration professionals should be protected by using respirators with high-efficiency particulate air (HEPA) cartridges, rubber boots, gloves, splash goggles, and protective garments. Extreme care should be taken to avoid puncture wounds during the restoration process. Restoration staff who have cuts or open sores should not be allowed to work on this kind of restoration project. The principles of restoration of this situation are outlined in the last section of this paper, which contains specific recommendations for techniques.

The main discussion of this paper focuses on the potential health risks posed by a sewage backup similar to Situation 3.

Description of the Primary Problem

When a building is contaminated with sewage backing up from the septic lines, or flooding of a building occurs that involves sewage or a heavy load of organic matter, as in the case of river flooding, a serious threat to human health exists. Without appropriate action, extensive damage to materials will occur immediately or in time. Several days may elapse before the cause of the backup is determined, the problem is corrected, and flooding subsides. This allows extensive permeation and contamination of absorbent (hygroscopic) materials such as wood, gypsum, paper, and concrete to occur. This penetration with water and organic matter leads to the growth of potentially disease-causing (or opportunistic) microorganisms. These organisms may pose a serious health risk to occupants of the building. Organic matter and water-saturated materials can be used as substrate for the growth of microorganisms (such as gram-negative bacteria and toxigenic fungi) that can produce substances toxic to humans and damaging to materials. A large amount of water inside a building will cause high humidity, which can also contribute to microbial growth on structural materials and contents (2).

Questions To Be Raised After Sewage Contamination

Some of the questions to be answered in this situation include the following: What are the effects of the initial contamination on the building, its contents, and the health and welfare of its occupants? What is needed to thoroughly clean up the contamination and repair the damage? Should the entire building or a portion of the building be evacuated and, if so, for how long? Can semiporous materials be decontaminated, or should they be replaced? What are the consequences of using inadequate measures to remediate the damage? What are the indicators that help determine when the building is safe or not safe for occupancy? What methods should be used to test for these indicators? What is the effect of the sewage damage on other systems, especially the air changing system (ACS) and the heating, ventilating, and air conditioning (HVAC) systems in the built environment?

Issues of Concern Associated with the Problem

There are several factors bearing on the remediation of the problem. Among these are the nature of the contamination, the types of water-damaged materials (organic or synthetic; porous, semiporous, or nonporous), the sewage microflora (pathogens and allergens), organic matter load, water volume, and impact of ambient outdoor temperature and humidity on the indoor environment. Of major concern are the survival of sewage-borne microflora (viral, bacterial, fungal, parasitic) and their potential transmission to humans. The potential exists for some fungal and bacterial contaminants to establish an ecological niche and present a health risk from chronic exposure for some time after the event.

Scope of These Guidelines

The discussions within this paper will address the immediate and longer term effects of sewage-flooding contamination on the building's structural materials and contents; the potential effects on occupants; and the steps to remove contamination to include flushing with clean water and detergent solutions, vacuuming, dehumidification, and disinfection. The potential health threats presented at each stage of remediation will be discussed. These include the production of bioaerosols during removal of gross contamination, the long-term effects of residual moisture and organic matter on the building and occupants, and the colonization and growth of non-sewage-borne species of microorganisms such as molds and other fungi.

Assessment of Damage and Danger to Health

The factors that determine the extent of contamination within the building include the volume and the solids content of the sewage backflow, whether flooding is isolated to the basement or involves other levels as well, and how long the contamination has been in place.

The assumption must be that potential pathogens are present in the contamination. Such microbial contamination includes bacteria, fungi, viruses, and parasites. Table 1 lists the microflora that may be found in raw, untreated sewage and the diseases that these organisms have the potential to cause (3). Also, hypersensitivity lung disease has been shown to be caused by repeated flooding of homes with sewer water (4).

The routes of exposure of the building occupants to these pathogens are contact, ingestion, and inhalation. An incomplete or inadequate job of cleaning and disinfection may leave residue that can be a substrate for disease-causing microorganisms. Occupants may be infected by contacting contaminated surfaces, with inadvertent transmission from hands to mouth, or aerosolization of contamination may result in the inhalation of microorganisms or their products (e.g., endotoxins). Residue and microbial contaminants also can be tracked by occupants' feet to other parts of the building.

Another aspect of health impact is that the conditions caused by sewage backflow or flooding are conducive to the growth of nonsewage microorganisms. These conditions include wetness, humidity, and organic matter. Microorganisms, which exist in various life stages in both indoor and outdoor environments, would then have the opportunity for exponential population growth. These species (see Table 2) can produce bioaerosols, which are potential sources for disease. For example, mold allergy is a common source of indoor air symptoms and complaints (5).

In regard to the susceptibility of building occupants, those individuals whose immune systems are in some way compromised (i.e., immunocompromised), or who are otherwise susceptible due to age, medication, or underlying illness, are considered to be at greater risk of contracting potentially fatal infections than those individuals who are healthy.

Fundamental Considerations for Remediation

The factors to be considered in remediation include the types of materials affected, assessment of the degree of damage, the extent of contaminated absorbent material, the total contact time, the humidity, and the amount of ventilation available. The primary goal of remediation must be the complete removal and disposal of water and contamination using the sanitary sewer system if possible. Wet extraction systems should be used to completely remove sewage and water used for cleaning. As part of this phase of the operation, removal of affected contents and structural materials may be necessary. These items could include carpet, wallcovering porous wallboard, and insulation, and other substrates with the potential for mold growth. Disposal of nonrestorable contaminated materials requires that the materials be confined in plastic bags and transported to appropriate disposal facilities. In all cases, workers must be provided with appropriate personal protective equipment such as respirators, boots, gloves, splash goggles, and coveralls, and with equipment with which to remove contamination (6).

In order to speed the drying process, both mechanical and natural dehumidification should be employed as the gross contamination is removed and during restoration. An indoor humidity target of 40% relative humidity (RH) or less should be attained as quickly as possible (7). If possible, depending on the design of the contaminated space and the outdoor weather conditions, there should be ventilation with fans and evaporation of indoor water by introducing outside air. The use of dehumidifiers for removal of moisture from inside building surfaces and air is recommended. The ACS and HVAC systems may be considered as dehumidifiers, depending on the systems' mechanical capacity versus the extent of moisture load over time. Rapid drying that stresses proper management of temperature, airflow, and dehumidification is essential for success.

Dessicant dehumidifiers, using silica-gel or lithium chloride, could be employed as an adjunct to disinfection to reduce RH to as low a level as possible (8). Moisture content measurements of reclaimed materials is an important criterion of the success of adequate drying and the remediation process.

Chemical Disinfection

The processes of decontamination and disinfection will be important to ensure the elimination of pathogens and organisms that were contained in the sewage or that grew during the period of contamination. Even concrete can be colonized and broken down by microorganisms if it is allowed to remain wet and contaminated by organic matter. Chemicals categorized as disinfectants are appropriate in this application. A disinfectant may be defined as an agent that reduces significant numbers of pathogens on inanimate objects to a level below that expected to cause disease. Disinfectants may not kill spores, however, and, because some bacterial and fungal spores will always be present in the environment, it would not be feasible to attempt to kill all of the spores in an affected area. Emphasis instead should be placed on removal of the substrates, water, and organic matter needed for the growth of spores.

Choice of disinfectants depends on the degree of microbial killing required, the nature of surfaces to be treated, application safety, and the cost and ease of use of available agents. It is recommended that disinfectants be used in accordance with the manufacturer's instructions for use and dilution.

Classes of disinfectants and their common-use dilutions include alcohols (60 to 90% in water), quaternary ammonium compounds (0.4 to 1.6%), phenolics (0.5 to 5%), iodophors (75 ppm), glutaraldehydes (2%), household bleach (sodium hypochlorite, diluted 10%), and hydrogen peroxide (3 to 6%). The advantages and disadvantages of each of these disinfectants are given in Table 3. For example, the use of iodophores or low-concentration chlorine compounds would require that little organic matter be present on surfaces, a condition that may be difficult to achieve. Caution should be used in mixing some disinfectants. For example, mixing chlorine-containing solutions with ammonia or amine solutions will produce extremely toxic vapors, and could have lethal effects on workers or building occupants. Of critical importance is "contact time". Contact time is the length of time that the disinfectant is permitted to work on the contaminated surface. The contact time must be at least 15 min before additional cleaning and removal of the disinfectant is undertaken. Some disinfectants, such as the phenolics and glutaraldehydes, leave a residue that continues to suppress microbial growth for some time after treatment.

Health-Based Recommendations for Restoration

The following specific guidelines are presented with a goal of restoring the contaminated area such that the health of occupants is protected from any risk of pathogen-caused disease.

- Remediation should begin as soon as possible. The longer the contamination is allowed to persist, the greater the potential for microbial growth and resultant damage.

- Unprotected occupants and workers should be evacuated from the affected areas during the initial stages of decontamination, cleaning, and disinfection (e.g., until sewage has been removed and disinfectants applied).

- Technicians in the vicinity of the sewage during the initial stages of decontamination, cleaning, and disinfection should be equipped with an organic vapor HEPA respirator, rubber gloves, splash goggles, and boots. In the case of overhead contamination, technicians should also be equipped with goggles, hard hats, and protective suits. Technicians should report any wounds that occur during restoration and take care to avoid "cross-contamination" from affected to unaffected areas by foot traffic or material handling.

- After water removal, all affected materials should be decontaminated by spraying with a disinfectant solution. It is not the intent of this prespray to effect full disinfection because the presence of organics precludes this. The objective is to initiate the reduction and containment of microorganisms as quickly as possible.

- All affected materials should be evaluated for porosity (permeance). From this inspection, materials should be rated as highly porous (saturated), semiporous, and nonporous. Some materials may exhibit varying degrees of porosity, depending on the exposed surfaces. For example, the surface of painted drywall has very low porosity, yet the base of the wall may be unpainted or have exposed gypsum paper that is highly porous.

- Highly porous (permeance factor >10) materials that have been exposed to sewage backflow and have a value that exceeds the cost of restoration such as high-value rugs and carpet, upholstery, and other textiles should be removed and restored off site. Highly porous materials with low cost or replacement value, such as carpet cushion, carpet, cardboard, tackless strip, wicker, and straw, should be removed and discarded as soon as possible. Other materials, such as saturated mattresses and cloth upholstery, regardless of value, cannot be restored and should be discarded. If disposal is necessary, these materials should be bagged in plastic for removal to a proper disposal site.

- Semiporous (permeance factor of >1 to 10) materials, including items such as linoleum, vinyl wall covering and upholstery, and hardboard furniture, along with construction materials such as wood, painted drywall, and plaster, should be cleaned, disinfected, or replaced as part of the initial restoration process. If these materials are not removed or properly disinfected, they can become reservoirs for growth of microorganisms.

- Nonporous materials (permeance factor ≤1) such as Formica™, linoleum, vinyl, and tile finishing materials can be inspected for subsurface contamination with a nonpenetration moisture meter. Although these materials may be rated as nonporous, they must be evaluated carefully because contamination can migrate from the perimeter and become trapped below the surface. If migration of contamination below the surface has not occurred, these materials may be fully restored.

- Heavy organic matter, especially raw sewage and silt, must be physically removed by any safe means available. This may include the use of shovels, squeegees, septic pump trucks, wet vacuums, and moisture-extraction machines. Water must also be extracted from floor-covering fabrics such as carpets and rugs. All tools and machines, especially recovery tanks, wands, and hoses, must be cleaned and disinfected after use.

- Residual organic matter in cracks and crevices can be removed by pressure washing with a disinfectant solution. The solution then must be recovered with an extraction unit, immediately after application, to prevent further migration or saturation of contaminants into other porous materials.

- After removing heavy organics, affected materials must be cleaned before a second application of disinfectant takes place. Use of many cleaning agents, such as soaps and detergents, will solubilize most organic matter.

- After thoroughly cleaning all contaminated materials, a second application of disinfectant may be applied.

- Chemicals classified as disinfectants are appropriate for use in areas exposed to sewage backflow. These chemicals are defined as being capable of inactivating potential pathogenic microorganisms on inert substrates.

- Fully evaluate all factors that affect the success of decontamination. These include the organic matter present, extent of prior cleaning, type and level of microbial contamination, concentration and time of exposure to the disinfectant, and the nature of the material to be decontaminated.

- Sources such as Block (9) provide information about the classes of disinfectants.
  - *Glutaraldehydes*: These agents display a broad spectrum of activity and rapid rate of kill against the majority of microorganisms. Glutaraldehydes are capable of destroying all forms of microbial life including bacterial and fungal spores, tubercle bacilli, and viruses. They are excellent sporicides and will not corrode most materials. Disadvantages include increased peroral, percutaneous, and inhalation toxicity, along with elevated eye and skin irritation.
  - *Iodine and Iodine Compounds (Iodophors)*: These agents are highly effective, have broad-spectrum antimicrobial capabilities and exhibit some residual properties. Disadvantages include inactivation by organic matter, and vapors may pose a hazard to respiratory organs. Some formulations may stain porous materials an orange-yellow color.
  - *Phenolic Compounds*: These agents are stable (less inactivated by organic matter), broad spectrum (generally include antiviral properties), and readily available, and leave a residue. Disadvantages include substantially increased peroral, percutaneous, and inhalation toxicity, along with eye and skin irritation.
  - *Quaternary Ammonium Chloride Compounds (Quats)*: These agents have a limited spectrum of activity but are capable of killing gram-positive bacteria and fungi, and of inactivating gram-negative bacteria and some viruses. Quats have a naturally pleasant odor, counteract offensive odors, and are excellent cleaners. Ammonium chloride compounds are safer to use than most other disinfectants, because they are less toxic and cause less irritation to the mucus membranes. Quats, when diluted for use, are low in toxicity and irritation. Disadvantages of this class of agents include the facts that they are neither sporicidal nor tuberculocidal and that many formulations exhibit poor results against gram-negative bacteria and some viruses. Also, these compounds are incompatible with anionic cleaners (i.e., mutual neutralization of disinfectant and cleaner) and with the dye blockers in stain-resistant carpet.

- Procedures should be implemented to increase the rate of drying. Dampness and humidity must be reduced as much as possible by using the existing ACS or HVAC system, auxiliary fans, carpet dryers, and dehumidifiers. The indoor humidity in affected areas should be reduced to 40% RH as quickly as possible. Where flooding has been extensive, the drying process may require several days or longer to be effective. Adequate drying should be evaluated with a moisture meter. The humidity should be monitored with a hygrometer or a psychrometer.

- Because the use of disinfectants such as glutaraldehydes, iodophors, and phenolics for disinfection produce irritating vapors, appropriate personal protective equipment to preclude chemical exposure is required. The type of safety equipment used will depend on the disinfectant used, the concentration, and the method of application. The material safety data sheet (MSDS) and label instructions on the chosen disinfectant will provide more detailed information and must be reviewed before use.

- Environmental monitoring should consist of moisture measurements, rather than surface or air sampling for the presence of viable microorganisms. After the restoration process, surveillance of occupants for sickness, allergy, and sensitivity may also provide a measure of the adequacy of the clean-up operation.

- Area rugs and wall-to-wall carpet that have been extensively saturated with sewage backup are unlikely to be cost-effectively restored on site. Such rugs and carpet, along with the cushion, or underlayment, should be removed. Small rugs may be restored effectively through commercial laundering. If an effort is made to restore the carpet, extensive cleaning and saturation disinfection of the carpet should take place. All organic material must be removed, and the complex fibrous surfaces throughout the carpet must be disinfected. Following treatment, the carpet must be inspected thoroughly for cleanliness and dryness before being reinstalled in the restored environment. Carpet cushion must be removed, disposed of, and replaced with new material, without exception. Subflooring should be cleaned, disinfected, dried, and sealed if necessary before carpet and rugs are returned to the environment. Under no circumstances should efforts be made to restore carpet and rugs on site that have been extensively damaged by a Situation 3 sewage backup.

- In any case where it is deemed cost justifiable to restore carpet contaminated by sewage, an extraction cleaning method must be employed on all surfaces. Other carpet cleaning methods, such as absorbent compound, absorbent pad (bonnet), dry foam, or shampoo cleaning, are not adequate in that they may merely redistribute the contamination (10).

Disclaimer

The paper represents a technical discussion based on a review of scientific literature and the best professional judgment of the authors. It does not necessarily represent the official policy of EPA or any other government health agency. The paper is intended to serve as a vehicle for discussion on the subject of sewage backflow restoration and be the basis for future research and training activities.

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TABLE 1. DISEASE-CAUSING ORGANISMS IN SEWAGE (3)

Organisms	Disease
ENTERIC VIRUSES:	
Enteroviruses (67 types)	Gastroenteritis, heart anomalies, meningitis, others
Rotaviruses	Gastroenteritis
Parvovirus-like agents (at least 2 types)	Gastroenteritis
Hepatitus A virus	Infectious hepatitis
Adenoviruses (31 types)	Respiratory disease, conjunctivitus, others
BACTERIA:	
Escherichia coli (enteropathic types)	Gastroenteritis
	Typhoid fever
Salmonella (approx. 1,700 types)	Salmonellosis
Shigella (4 spp.)	Shigellosis (bacillary dysentery)
	Gastroenteritis
PROTOZOA:	
Balantidium coli	Balantidiasis
Entamoeba histolytica	Amoebiasis
Giardia lamblia	Giardiasis
HELMINTHS:	
Nematodes (roundworms)	
Ascaris lumbricoides	Ascariasis
Ancylostoma duodenale	Ancylostomiasis
Necator americanus	Necatoriasis
Ancylostoma braziliense (cat hookworm)	Cutaneous larva migrans
Ancylostoma caninum (dog hookworm)	Cutaneous larva migrans
Enterobius vermicularis (pinworm)	Enterobiasis
Strongyloides stercoralis (threadworm)	Strongyloidiasis
Toxocara cati (cat roundworm)	Visceral larva migrans
Toxocara canis (dog roundworm)	Visceral larva migrans
Trichuris trichiura (whip worm)	Trichuriasis
Cestodes (tapeworms)	
Taenia saginata (beef tapeworm)	Taeniasis
Tanenia solium (pork tapeworm)	Taeniasis
Hymenolepis nana (dwarf tapeworm)	Taeniasis
Echinococcus granulosus (dog tapeworm)	Unilocular echinococcosis
Echinococcus multilocularis	Alveolar hytid disease

TABLE 2. DISEASES RELATED TO BIOAEROSOLS (11,12)

CONTAGIOUS DISEASES: MANY VIRAL AND BACTERIAL DISEASES				
Infection	*Transmission Mode*	*Agents*	*Risk Factors*	*Evaluation*
Organisms must be viable.	Human to human. *Route of Infection* Through air or by contact.	Viruses: cannot reproduce without hosts, may survive on surfaces including ventilation or filtration. Bacteria (e.g., tuberculosis): generally not found in building substrates.	Genetic factors, lack of immunity, dose, virulence of agents, environmental factors. Immune deficiency; medications, substance abuse, etc.	Diagnosis, epidemiology; air/source sampling is ineffective. *Control* Avoid contact.
INFECTIONS FROM ENVIRONMENTAL SOURCES: MANY BACTERIAL AND FUNGAL DISEASES				
Infection	*Transmission Mode*	*Agents*	*Risk Factors*	*Evaluation*
Organisms must be viable; may also cause allergic/toxic response.	Environmental reservoirs; some such as chlamydia and rickettsia are associated with vector carriers such as rodents or other mammals. *Route of Infection* Through air or by contact.	Bacteria: *Legionella* (Legionnaire's disease and Pontiac Fever); flavobacteria, etc. Fungi: histoplasma, blastomyces, coccidioidomyces, *Cryptococcus*, *Aspergillus*, etc.	Genetic factors, lack of immunity, dose, virulence of agents, environmental factors. Immune deficiency; medications, substance abuse, etc.	Diagnosis, epidemiology, site observation, source sampling; air sampling may be useful for *Aspergillus* and *Pseudomonas*, but difficult for *Legionella*. *Control* Remove sources.
HYPERSENSITIVITY: ASTHMA AND HAY FEVER				
Immune Response	*Transmission Model*	*Agents*	*Risk Factors*	*Evaluation*
Diseases; agents of exposure need not be alive.	Environmental reservoirs. *Route of Contact* Inhalation.	Fungi (mostly spores), pollens, arthropods (mites, roaches), mammals (cat and dog danders), etc.	Genetic factors, sensitization, antigenicity.	Diagnosis, site observation, source sampling of reservoirs, air sampling. *Control* Remove sources, avoid allergens.
HYPERSENSITIVITY: HYPERSENSITIVITY PNEUMONITIS				
Immune Response	*Transmission Mode*	*Agents*	*Risk Factors*	*Evaluation*
Diseases; agents of exposure need not be alive.	Environmental reservoirs. *Route of Contact* Inhalation.	Bacteria, actinomyces, fungi (mostly spores), protozoa, proteins, biological organic dust.	Host risk unknown, prolonged and high levels of exposure, adjuvents, antigenicity.	Diagnosis, source sampling of reservoirs, air sampling. *Control* Remove sources, avoid allergens.

TABLE 2 (cont'd). DISEASES RELATED TO BIOAEROSOLS (11,12)

TOXICOSES: ACUTE TOXICITY, IMMUNE SUPPRESSION, CANCER, AND HUMIDIFIER FEVER				
Direct Cellular Effect	*Transmission Mode*	*Agents*	*Risk Factors*	*Evaluation*
Toxins or carcinogens of biological origin; exposure units need not be alive, and may linger, depending on chemical stability; cancer is rare.	From environmental reservoirs either associated with organisms or discharged by organisms.	Bacteria toxins: endotoxins and exotoxins. Fungal toxins: mycotoxins, such as alfatoxins.	Human response is constant; toxicity, dose, immune suppressors.	Diagnosis, site observation, source sampling of organisms, air sampling to verify exposure. *Control* Remove sources.

TABLE 3. PROPERTIES OF CLASSES OF ENVIRONMENTAL DISINFECTANTS (13,14,15)

Disinfectant/Class	Use Dilution Concentration	Action	Advantages	Disadvantages
Alcohols (ethanol, isopropanol)	60 to 90%	B, V, F	Nonstaining, nonirritating	Inactivated by organic matter, highly flammable
Quarternary ammonium compounds	0.4 to 1.6%	B*, V*, F	Inexpensive	Inactivated by organic matter, limited efficacy
Phenolics	0.4 to 0.5%	B, F, V, (T)	Inexpensive, residual	Toxic, irritant, corrosive
Iodophors	75 ppm	B, V, F, S**, T**	Stable, residual action	Inactivated by organic matter, expensive
Glutaraldehydes	2%	B, V, F, S**, T	Unaffected by organics, noncorrosive	Irritating vapors, expensive
Hypochlorites	≥5,000 ppm free chlorine (1:10)	B, V, F, S**, T	Inexpensive	Bleaching agent, toxic, corrosive, inactivated by organic matter; removes color from many interior decor fabrics; dissolves protein fibers (e.g., wool, silk)
Hydrogen peroxide	>3%	B, V, F, S**, T	Relatively stable	Corrosive, expensive; degrades in heat or ultraviolet light

Abbreviations:
B = Bactericidal
V = Virucidal
F = Fungicidal
* = Limited effectiveness
( ) = Not all formulations
T = Tuberculocidal
S = Sporicidal
** = Requires prolonged contact time

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Abstract

Sewage backflows are serious health threats to humans indoors. The purpose of this paper is to summarize what is known about health effects associated with sewage backflow into indoor environments and to make technical recommendations for safe, effective restoration. Risks to health from specific pathogens are considered, and the classes of disinfectants and their properties are discussed. The recommendations for remediation are based largely on the characteristics of the contaminated material and the length of time of the contamination.