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SUMMARY: When water infiltration has occurred in a building, either due to heavy rains, plumbing failures, or sewer backups, important steps must be taken to ensure the health and safety of individuals involved. Flood waters and residues may contain a broad range of potential hazards depending on the circumstances and location. Disease-causing organisms may be present, and chemical, biological or radioactive materials may become involved if the flood impacted on laboratory space. This information as well as the source of the water is critical knowledge when making decisions involving personal safety of cleanup personnel and determining what materials may be salvaged and those that must be discarded.

SCOPE: This guideline provides guidance to all UM departments on water damage restoration procedures. OSEH strongly recommends hiring professional carpet cleaners and water damage restoration companies for large floods or heavy sewage.

REFERENCE REGULATIONS: Code of the City of Ann Arbor, Chapter 28 of Title II, Sewer Use Ordinance

DEFINITIONS: *Building Occupants* - people who spend extended time periods in the building. Clients and visitors are also considered occupants.

Mildew/Mold - microscopic fungi that live and multiply on plant or animal matter.

RESPONSIBILITY: Deans, Directors and Department Heads

Actively support this Guideline within individual units.

Responsible for coordinating the implementation of any remedial action recommended.

Supervisors/Principal Investigators

Assign resources to support the implementation of this Guideline.

Follow Work~Connections procedures for any accidents, injuries, or exposures. http://www.workconnections.umich.edu/forms.html.

Employees

Comply with this Guideline and any further safety recommendations initialized by the supervisor/principal investigator.

Conduct their assigned tasks in a safe manner, wear appropriate personal protective equipment (PPE), and only use equipment for which they have been formally trained.

Report any job-related injuries or illnesses, questions on health and safety, or any unsafe or unhealthy working conditions to the supervisor/principal investigator. Contact OSEH to evaluate health and safety conditions.

OSEH

Review and revise the Guideline.

Respond to health concerns by investigating buildings and recommending remedial action.

Provide guidance on PPE selection for remedial procedures.

If necessary conduct comprehensive environmental monitoring for specific identified contaminants.

Plant Operations

Responsible for maintaining building infrastructure in a safe and healthy condition.

Assign resources to support the implementation of this Guideline.

Building Services/Environmental Services (UMHHC)

Coordinate with the affected Departments to implement the Guideline.

Contact OSEH to request technical assistance.

Risk Management

Evaluate water damage claims for potential insurance coverage. Coordinate cleanup efforts with affected Departments and implement this Guideline.

Contact OSEH to request technical assistance.

PROCEDURES: AFFECTED AREA SAFETY AND SANITATION

When planning a cleanup from a flood it is important to consider the source of water and the potential hazards. Water can be classified into the following categories.

Category 1 - "Clean": water originating from a source that does not pose substantial harm to humans. Examples of Category 1 water include broken water supply lines, tub and sink overflows, melting ice or snow, rainwater, and broken toilet tanks or toilet bowls that do not contain contaminants. Category 1 water may deteriorate to Category 2 or 3 over time or by coming into contact with other contaminants.

Category 2 – "Gray": water containing a significant degree of chemical, biological and/or physical contamination and having the potential to cause discomfort or sickness if consumed by or exposed to humans. Examples of Category 2 water include discharges from dishwashers or washing machines, overflows from toilet

bowls with some urine (no feces), sump pump water, chilled and condensate water and fire protection water. Category 2 water may deteriorate to Category 3 over time or by coming into contact with other contaminants.

Category 3 – "Black": grossly unsanitary water, containing pathogenic agents, arising from sewage or other contaminated water sources and having the likelihood of causing discomfort or sickness if consumed by or exposed to humans. Examples of Category 3 water include sewage, toilet backflows from beyond the trap and ground and surface waters that may contain organic matter, pesticides, heavy metals or other toxic substances.

When performing cleanup, it is also important to consider the following:

1. Water damages building components and equipment which can create physical or electrical safety hazards;
2. Water, mud, or sewage may contain biological or chemical contaminants that could create a health hazard. **Food preparation/service areas where flooding has occurred must be properly sanitized and inspected by OSEH before foods are prepared or served**. Any food that is impacted must be disposed of.
3. If a research laboratory was flooded the waters may become contaminated with hazardous research laboratory materials; **Call OSEH at 7-1143 if flood waters may have contacted research materials.**
4. Moisture will promote the growth of molds, fungus, and other microorganisms.

Sewage floods are particularly dangerous depending on the solids content and volume. Precautions should be taken to prevent contact with the materials and to isolate the area to prevent contaminants from being tracked to other parts of the building. Occupants not involved in the clean-up must be evacuated from these areas when sewage is present.

PERSONAL PROTECTIVE EQUIPMENT (PPE)

Only individuals conducting the clean-up should be in affected areas. Persons that are immunocompromised or susceptible due to age, medications, or respiratory health problems (e.g., asthma, emphysema, cystic fibrosis) should NOT undertake clean-up activities. Children, pets, and laboratory animals should not be allowed in these areas.

Boots and rubber gloves should be worn at all times. Splash goggles should also be worn when splashing of contaminated water may occur. Protective clothing and organic vapor/HEPA respirators should be worn by employees involved in the initial stages of heavy sewage decontamination (C*ontact OSEH (7-1142) for more information regarding the use of respiratory protection).* Provide good ventilation when using bleach or other potentially toxic disinfectants. Call OSEH to evaluate the disinfectants and/or safety measures utilized.

Cuts, open sores, or rashes should never be left exposed during clean-up procedures.

Do not smoke, eat, drink or apply cosmetics during clean up.

GENERAL SAFETY

Be aware of the potential for electrical shock! Wear rubber boots in wet areas until it is certain no electrical hazard exists. Plant Operations or the appropriate maintenance group should be called to turn off all main electrical switches in the area. Electric equipment used for clean-up in flooded areas must be protected with Ground Fault Circuit Interrupters (GFCI).

After the main power has been disconnected by an electrician, unplug electrical appliances in wet areas and do not turn on any appliances which have become wet until they have been thoroughly dried and checked for proper operation.

If the water may have come in contact with chemical, radiological, or biological hazards, contact OSEH at 7-1143 to evaluate the situation.

Do not use any open flame until the area has been ventilated for the potential presence of natural gas. The gas supply to all appliances in flooded areas should be shut off until the appliance has been checked. Plant Operations or the appropriate maintenance group should be called to turn off gas lines in the affected area. **Plant Operations can be reached 24 hours a day at 7-2059**.

Some building materials may contain hazardous substances such as asbestos or lead based paint. Prior to impacting or removing water damaged building materials, contact OSEH to have the affected area evaluated.

Persons suffering an injury, illness or exposure should report to the UM Occupational Health Services Clinic located in Room C380 of the Med Inn Building, if between the hours of 7:30am to 4:30pm, or otherwise to the UMHS Emergency Department located at 1500 East Medical Center Drive.

REMEDIATION PROCEDURES

Time is an essential consideration of remediation. All remediation projects should strive to complete initial cleaning within 24 hours. Organisms will not become airborne as long as they remain wet. As long as surfaces remain wet, the only way organisms can enter the body and cause disease is by splashing into the mouth, eyes, open cuts, etc. Once dried, organisms can be spread on dust particles by air movement. Therefore, it is important to disinfect contaminated surfaces as soon as possible after rinsing off heavy soil. In order to prevent decomposition and rotting of wet items, immediate drying after disinfection is necessary. Some materials that do not dry well must be removed and disposed. See **Appendix C** for a listing of building components and recommended treatment.

Bacteria, viruses, mold, fungi, etc. must be killed in the cleanup process. The most widely-accepted, safe, and effective sanitizing agent is hypochlorite in the form of household bleach. The bleach solution referred to is one cup of bleach to one gallon of water (the bleach solution needs 15 minutes contact time to kill organisms). For a

soapier cleaning solution that cuts dirt, add a half cup of mild detergent. **Warning! Mixing bleach with other cleaning chemicals may result in the generation of heat and/or poisonous gasses.** Other commercial disinfectants are also acceptable depending on the degree of contamination, nature of surfaces, application, safety or cost and ease of use. Only use EPA registered disinfectants according to the manufacturer's instructions.

Classes of acceptable disinfectants, concentrations, advantages and disadvantages can be found in Table 3 in Appendix E. Call OSEH at 7-1143 to address safety concerns of specific disinfectants and application techniques.

Use the following steps in all clean-up procedures:

1. Determine the water source and ensure the problem has been corrected by Plant Operations (7-2059) or the appropriate maintenance group.

2. Assure that the personal protection and general safety steps previously described have been taken.

3. Remove all water and gross contamination or soil as soon as possible. Using various methods, dry all surfaces as much as possible. The wettest areas can be pumped, squeegeed or mopped to a floor drain. A wet/dry vacuum can be used on flat surfaces to further remove remaining water. **See Appendix C for removal of water from specific building components.**

4. Determine what items will have to be discarded and remove them for disposal. Generally, if the disinfectant can be made to come in contact with all surfaces, an item may be salvageable. Non-porous materials can be easily cleaned with surface disinfectants. Porous materials are much more difficult to clean and require complicated cleaning procedures or disposal. Stuffed furniture, pillows, and mattresses will have to be discarded. Indoor/outdoor carpeting and rugs may be salvageable. Thick wall to wall carpets and padding will have to be discarded or professionally treated **(See Appendix B and Appendix C for carpet recommendations)**. Flood soaked drywall usually must be removed above the flood line **(See Appendix C)**. Anything that cannot be cleaned (like wet ceiling tiles), is too damaged, or is disposable (like cardboard boxes) should be discarded and replaced. Immediately discard food and other perishable items.

5. Start cleaning from the top floor or upper limit of flooding and work downward. Thoroughly rinse all visible soil from all items to be salvaged. Rinse the walls from several inches above the highest level the water reached to the floor. Carefully remove and rinse behind any base coving to remove all soil. Rinse down the entire floor. A mop can be used on both the walls and floors for this purpose.

6. Remove salvageable furnishings. Next remove moisture that has been absorbed by wood, plaster and other materials. Using fans and/or a dehumidifier, thoroughly ventilate the rooms to dry all surfaces. The indoor

humidity should be reduced to 40% relative humidity (RH) or less as soon as possible.

Quick drying is essential to prevent mold growth, reduce water damage, and speed the resumption of work or research. The following are ways to lower the humidity to prevent mold growth:

1. If the humidity outside is lower than indoors, open all adjacent doors and windows to exchange the moist indoor air for drier outdoor air. This option may not be appropriate for some buildings that need to remain secured. Also, many new buildings will not have windows that open.

2. Open all doors, closets, cabinets and access panels in wet areas. The more air is allowed to circulate, the faster the drying time will be.

3. Fans can be used to increase circulation and dry out the area. The central Heating Ventilating and Air Conditioning (HVAC) system in the building should not be used if the ducts were under water. Plant Operations AC Shop or the appropriate maintenance group will need to be called to ensure all water and contaminants are removed from the duct work.

4. Dehumidifiers can be used to increase the drying rate. Everything will dry quicker if the humidity can be reduced. If possible, utilize commercial dehumidifiers, which remove three to four times more water than home models. When using dehumidifiers, shut windows and doors. If there is severe flooding consider hiring a contractor for water removal.

5. Desiccants (materials that absorb moisture) can be useful in drying enclosed areas with poor ventilation. Commercial desiccants should be purchased for this purpose. Oil dry or cat litter made of clay and silica gel are also useful.

6. Commercial flood and carpet restoration companies that specialize in drying out flooded buildings should be used. Commercial vacuum trucks, fans, and dehumidifiers will dry an area very quickly. **See Appendix D for contractors** certified by the Institute of Inspection, Cleaning and Restoration Certification (IICRC).

7. Thoroughly wash and disinfect walls, ceilings and exposed wall cavities several inches up from the highest level reached by the flood waters and over the entire floor. Contact time of the disinfectant on contaminated surfaces is extremely important. All disinfectants should be permitted at least 15 minutes of initial contact time.

   An effective method is to use a mop or sponge to splash the disinfectant on the walls and over the floor. Make sure all affected surfaces have been contacted with the disinfectant. Smaller items may be immersed in the solution, while larger items will need to be hand scrubbed. Professional contractors may use commercial sprayers for large projects.

If walls have already dried, work from the floor to the ceiling to prevent streaking. (Dirty water splashed on dry walls may be absorbed and become almost impossible to remove.) Overlap sections, cleaning the ceiling last. Rinse well with clean water and thoroughly dry the surface. If painting is necessary after drying, use paint containing an anti-mildew agent.

Wall materials that have absorbed too much moisture may need to be removed. OSEH can determine this with the use of a moisture meter. Call OSEH to provide assistance in determining if walls have absorbed too much moisture.

8. Replace disposable HVAC filters to remove potentially trapped mold spores.

9. All flood waters, sewage, and cleaning solutions must be disposed of in sanitary sewers in accordance with the City of Ann Arbor Sewer Use Ordinance, Chapter 28 of Title II, Code of the City of Ann Arbor. Under no circumstances should waste water be disposed of in storm drains outside of buildings. Contact Plant Operations Plumbing Shop for a proper drainage location. Any questions should be directed to OSEH Environmental Protection and Permitting at 7-1143.

RELATED DOCUMENTS:

- UM Accident, Illness or Injury Report Form. http://www.umich.edu/~connect/forms.htm
- Centers for Disease Control and Prevention NCEH Fact sheet Molds in the Environment (http://www.cdc.gov/mold/links.htm) - See attached Appendix A
- IICRC S500-06 Std. Ref. Guide for Prof. Water Damage Restoration
- UM OSEH Guideline "Storm Water Management"
- Cleaning Flood-Damaged Carpets and Rugs & Flood Damaged Walls, Ceilings and Floors, University of Wisconsin Extension Publications (http://www.uwex.edu/ces/cty/kenosha/cnred/documents/Cleaning_carpets_rugs.pdf) - See attached Appendix B
- Repairing your Flooded Home, American Red Cross Disaster Services copyright 1998 (http://www2.redcross.org/static/file_cont333_lang0_150.pdf) - See modified step 4 in Appendix C
- Suggested Guidelines for Remediation of Damage from Sewage Backflow into Buildings, EPA/Research Triangle Institute/IICRC - See attached Appendix E

TECHNICAL SUPPORT:

Professional flood damage restoration and carpet cleaners are available in the area. Only companies certified by the Institute of Inspection, Cleaning and Restoration Certification (IICRC) should be used. See Appendix D for local IICRC Certified Professional Cleaners or contact the IICRC Referral system at 1-800-835-4624 or by visiting www.iicrc.org.

All referenced guidelines, regulations, and other documents are available through OSEH (7-1143).

ATTACHMENTS: Appendix A - Basics of Indoor Mold Contamination

APPENDIX A

Basics of Indoor Mold Contamination

What are Molds?

Molds are microscopic fungi that live on plant or animal matter. No one knows how many species of fungi exist but estimates range from tens of thousands to perhaps three hundred thousand or more. Most are filamentous organisms and the production of spores is characteristic of fungi in general. These spores can be air-, water-, or insect-borne. Some common indoor molds include: Cladosporium, Penicillium, Alternaria, Aspergillus, and Mucor. Many species of mold (Aspergillus, Penicillium, Fusarium, Trichoderma, and Stachybotrys) can produce mycotoxins. Mycotoxins are by-products of mold growth that can be injurious to humans through inhalation, skin contact, or ingestion.

How do molds affect people?

There are three possible health effects of molds in indoor air: Allergic reactions (hay fever, asthma, hypersensitivity pneumonitis); Infectious disease (growth of fungus on or in the body); and Toxic: (a disruption of cellular function and interaction with DNA). However, the exposure level at which the mold becomes a threat to health is unknown and there are no established air exposure standards for molds or mycotoxins.

Many people are sensitive to molds and an exposure can cause symptoms such as nasal stuffiness, eye irritation, or wheezing. It is not known how many spores are required to induce an allergic reaction because of individual susceptibility to amount, type and size of mold spores. Some people may have more severe reactions to molds including fever and shortness of breath. People with chronic illnesses, such as obstructive lung disease, may be at increased risk of developing mold infections in their lungs.

Where are molds found?

Molds are found in virtually every environment and can be detected, indoors and outdoors, year round. Mold growth is encouraged by warm and humid conditions. Outdoors they can be found in shady, damp areas or places where leaves or other vegetation is decomposing. Indoors they can be found where humidity levels are high or water damage has taken place.

What corrective action can be taken?

Mold growth indoors can occur when building components are chronically moist or are damaged by water. There is general agreement that active mold growth in indoor environments is unsanitary and must be corrected, regardless of the species of mold present. Sensitive individuals should avoid areas that are likely to have mold. Evacuation and immediate cleanup may be necessary if contamination in indoor environments results in extremely high airborne mold levels.

Repair of the defects that led to the water accumulation or elevated humidity, should be conducted in conjunction with, or prior to, mold remediation. Mold growth can be slowed or halted by keeping humidity levels below 40%. Specific methods of assessing and remediating fungal contamination should be based on the extent of visible contamination and underlying damage. Materials that are structurally sound and non-porous can be cleaned, disinfected and thoroughly dried for re-use. Porous materials should be removed and replaced. All remediation activities should be conducted in a manner that prevents the emission of mold and dust from leaving the work area and entering other areas of the building, while protecting the health of the workers performing the remediation.

APPENDIX B

Cleaning Flood-Damaged Carpets and Rugs
When to Discard, Clean or Call a Professional

When faced with flood-damaged carpeting and rugs, your options will depend on the source of flooding. If floodwater consisted of clean basement seepage or lawn runoff into a sub-basement, drying and cleaning is an easy decision. If sewage-contaminated floodwater has covered your carpeting, you probably will need to discard it for health safety reasons. You can assume the water and the carpet contain infectious organisms. Throw rugs can usually be saved.

GENERAL RULES

Wall-to-wall carpeting, most large area rugs and any rug with foam backing should be discarded if flooded with contaminated water. Except for valuable rugs, the time and expense of professional cleaning generally is not worth the effort or the health risk. If you are determined to salvage carpeting soaked with contaminated water, consult a professional cleaning company that services carpets at its own cleaning and drying facilities. A steam cleaning (hot-water extraction) method is preferable. A wall-to-wall carpet soaked by clean rainwater can be salvaged. Have it professionally cleaned or clean it using the directions below. Throw rugs usually can be cleaned adequately in a washing machine.

CLEANING RAIN-SOAKED CARPETS

Cleaning basement carpeting indoors is not a good idea in summer because you are adding even more moisture to an already wet area. If the carpeting is installed with tack strips you may be able to remove it, have it cleaned and reinstalled. Padding is nearly impossible to clean so it should be replaced.

If you can't remove the carpeting, dry it as quickly as possible to minimize growth of mildew/molds and fungi. If possible, use a wet/dry vacuum system. A dehumidifier can help remove moisture from the air. Keep windows closed when using a dehumidifier.

When the carpet is thoroughly dry, vacuum the area. Shampoo and repeat the drying process. Keep in mind that most modern carpeting is made of nylon and should not be treated with bleach. Vacuum again.

You can reduce a musty smell with the following process:

a) Sprinkle baking soda over the carpet, working it in with a broom or sponge mop.
b) Leave the baking soda treatment on overnight.
c) Vacuum the baking soda out. Vacuum twice, moving back and forth in a different direction the second time.

Information from : University of Wisconsin Cooperative Extension, Iowa State University Extension, American Red Cross/Federal Emergency Management Agency

APPENDIX C

Removing Water from Specific Building Components

Ceilings

Check for sagging ceilings and drain them carefully. If the floodwaters went above the ceiling, replace it if it is made of wallboard. A plaster ceiling will dry eventually, but if it has too many cracks or sags, it will have to be torn down and replaced. Remove any wet insulation in the ceiling to allow the joists to dry.

Walls

Flood soaked wallboard is usually removed and thrown away. Plaster and paneling can often be saved, but you still need to get air circulating in the wall cavities to dry the studs and sills. This often proves very difficult or impossible without special equipment.

Remove water trapped within the walls. To check for water, take off the baseboard. Stick an awl or knife into the wall about 2 inches above the floor. If water drips out, cut or drill a hole large enough to allow water to drain freely. (Use a hand or cordless drill or saw to avoid shock.) If you are going to replace the wallboard anyway, you don't have to be neat: use a hammer to knock out a hole. If your walls are plaster, a knife won't penetrate them. Drill a hole above the sill plate to drain the water. (Use a hand or cordless drill to avoid shock.) Do not use a hammer or chisel on plaster because the plaster could shatter.

You may have metal sill plates. A metal sill acts as a trough at the bottom of the wall cavity. Drill a hole at floor level to drain the water using a hand or cordless drill.

Repeat the process to drain all the wall cavities. Depending on the spacing between studs in your walls, make a hole every 16" or every 24". Watch out for the wiring which is usually at the same height as your electrical outlets. If there is wet insulation, you will have to remove the wallboard in order to take out all the insulation.

Wallboard/Drywall

Remove wallboard, plaster and paneling to at least the flood level. Wallboard acts like a sponge, drawing water up above the flood level when wet. It becomes very fragile if it stays wet for long and will fall apart when bumped. If soaked by contaminated floodwater, it can be a permanent health hazard and should be removed. If most of the wallboard was soaked by clean rainwater, consider cutting a 4- to 12-inch-high section from the bottom and top of walls. This creates a "chimney effect" of air movement for faster drying. If floodwaters soaked the wallboard at least four feet above the floor, you should take down all the wallboard and replace it. If the water level was less than four feet deep, remove the lower four feet of wallboard. You can fill the gap with 4' x 8' sheets installed sideways.

If the plaster or wallboard is clean and in good shape, you can drill or cut ventilating holes in each wall cavity. Place holes low enough so they will be covered by the baseboard after the wall dries out. Open up the wall on both sides of interior walls. For exterior walls, drill or cut holes on the inside of the building. However, if there is wet insulation, you will have to remove the plaster or wallboard in order to take out all the insulation.

Plaster
Plaster will survive a flood better than wallboard. It should not have to be replaced but it will take a very long time to dry. Sometimes the plaster will separate from the wood laths as it dries, and the wall will have to be removed and replaced.

Insulation
There are 3 main types of insulation and each reacts differently to floodwaters. Styrofoam survives best; it may only need to be hosed off. Fiberglass batts should be discarded if they are muddy. If soaked by clean rainwater, remove them so the rest of the wall can dry. Only replace the batts after they, and the wall, are completely dried. Cellulose (loose or blown-in treated paper) insulation will hold water for a long time. It can also lose its antifungal and fire retardant abilities. Therefore, flooded cellulose insulation should be replaced.

Wood
If allowed to dry naturally, wood will generally regain its original shape. Different layers of laminated wood, such as plywood, may dry at different rates, causing the layers to separate.

Some contaminants will stay in the wood pores after it dries, but not as much as stays in flooded wallboard. Wood studs and sills will be covered by new wallboard and painted, so they are removed from human contact. Therefore, wet wood studs and sills do not need to be replaced if they are allowed to dry properly.

Concrete block
The cavities in a concrete block wall will drain on their own. The water will not damage the concrete like it will wood or wallboard.

Wallcovering
Vinyl wallcovering seals the wall and prevents drying. Wallpaper paste is a favorite home for mold and mildew. For these reasons, you should remove all wallcovering that got wet and discard. (If vinyl wallcovering is loose on the bottom, you may be able to save it by pulling it off the wall up to the flood level. Clean and reapply it after everything dries.)

Paneling
Pry the bottom of each panel away from the wall. Use something to hold the bottom away from the sill so the cavities can drain and dry out. However, if there is wet insulation, you will have to remove the paneling in order to take out all the insulation.

Base Coving
Vinyl or wood base board covings hold the moisture in and allow molds to grow. Remove the coving to allow the walls to dry. The base boards can be cleaned and saved for reuse.

Floors
Carpeting soaked by contaminated floodwater or repeatedly soaked by clean water should be removed and discarded unless it can be sanitized at a commercial facility or by a commercial cleaner for a cost substantially less than replacement. Underlayment or padding should always be discarded since it cannot be effectively cleaned. Carpeting soaked by clean water with no previous water damage can be effectively cleaned if done within 24 hours. Area rugs and wall to

wall carpet saturated with sewage should be discarded. **(See Appendix B for additional carpet recommendations)**.

Indoor/outdoor carpeting and rugs need a very thorough treatment if they are to be safely salvaged. Remove them to a flat area such as a driveway. Hose down both sides of the carpet several times to thoroughly remove all soil. Follow this with several buckets of the bleach solution on each side, scrubbing with a broom; rinse both sides with clear water. Remove as much water as possible with a wet/dry vacuum and allow to thoroughly dry.

Vinyl flooring and floor tile may need to be removed to allow drying of subfloor.

Wooden floors should be dried gradually. Sudden drying could cause cracking or splitting. Some restoration companies can accelerate drying time by forcing air through the fluted underside of hardwood floorboards.

Air needs to circulate around flooded floors so they can dry out. This means removing the floor covering. Because floodwaters contain mud and dirt, most soaked floor coverings should be thrown away.

Air needs to circulate below the floor to dry it out. If a crawl space is flooded, pump it out. Remove any plastic sheets, vapor barriers or insulation from underneath the floor. (Be sure to replace them when the floor and foundation are completely dry.)

Assess whether your floors can be repaired, replaced or recovered. Consider your time and budget as you make any decisions. If hardwood floors are damaged beyond repair, you may want to forego the cost of replacement and instead cover them with carpeting, vinyl or linoleum. Or you might lay a new floor over the old, rather than replace it.

Plywood subfloors may have delaminated (separated) from excessive moisture, causing buckling. Sections may have to be replaced or have new plywood nailed over them. Badly warped hardwood floors usually can't be repaired. Warped, wide pine board flooring, however, will often flatten out after it has thoroughly dried.

To remove surface mildew on floors and woodwork, use a phosphate cleaning solution such as powdered automatic dishwashing detergent or trisodium phosphate (4 to 6 tablespoons to a gallon of water), available in hardware stores. Rinse with water and dry.

If a basement was flooded over the first floor, remove finished basement ceilings, or cut or drill holes between all the joists to allow circulation. Don't cut or drill near electric lines or pipes.

Information From: American Red Cross/Federal Emergency Management Agency - Disaster Services - Repairing Your Flooded Home- Step 4 & University of Wisconsin Extension Publications - Flood Damaged Walls, Ceilings and Floors

APPENDIX D

Local IICRC Certified Professional Cleaners

Belfor Property Restoration	261-7764 / www.belfor.com
J.G. Restoration	429-1900 / www.jgrestoration.com
Maize & Blue Carpet & Furniture Cleaning	483-7600 / www.mblue.com
Michigan Building Cleaning & Maintenance	971-7825
Michigan Professional Restoration	926-0100
Paul Davis Restoration	930-0303 / http://www.pauldaviscompanies.com/
Wolverine Carpet & Upholstery Cleaners	973-2222 / www.arearugcleaningcompany.com

For additional referrals call The Institute of Inspection, Cleaning and Restoration Certification (IICRC) at 1-800-835-4624 or visit www.iicrc.org.

APPENDIX E

Suggested Guidelines for Remediation of Damage from Sewage Backflow into Buildings

Michael A. Berry, Ph.D.; Jeff Bishop; Claude Blackburn; Eugene C. Cole, Dr. P.H.;
William G. Ewald; Terry Smith; Nathan Suazo; and Steve Swan

Mr. William G. Ewald
Health Scientist
Environmental Criteria and Assessment Office
U.S. Environmental Protection Agency (MD-52)
Research Triangle Park, NC 27711

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)

Infection	*Transmission Mode*	*Agents*	*Risk Factors*	*Evaluation*
CONTAGIOUS DISEASES: MANY VIRAL AND BACTERIAL DISEASES				
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				
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.
Immune Response	*Transmission Model*	*Agents*	*Risk Factors*	*Evaluation*
HYPERSENSITIVITY: ASTHMA AND HAY FEVER				
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.
Immune Response	*Transmission Mode*	*Agents*	*Risk Factors*	*Evaluation*
HYPERSENSITIVITY: HYPERSENSITIVITY PNEUMONITIS				
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

Biographical Sketches of Authors

Michael Berry is the Deputy Director and William Ewald is a Health Scientist at the U.S. Environmental Protection Agency's Environmental Criteria and Assessment Office at Research Triangle Park, NC.

Eugene Cole is a Research Scientist at Research Triangle Institute, Research Triangle Park, NC.

Jeff Bishop, Claude Blackburn, Terry Smith, Nathan Suazo, and Steve Swan are members of the International Institute of Cleaning and Restoration Certification.

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.