

Environmental and Health Issues Related to Flooding on the Mississippi River

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ABSTRACT

The floods on the Mississippi River in 1993 and 2008 had great consequences for the environment and health of individuals living near the river. This paper reviews the effects of the flooding and provides an overview of the associated environmental issues. In addition, the occupational safety and health concerns, disease prevention issues, injury prevention activities, and appropriate house cleanup actions after a flood are discussed.

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Introduction

The Mississippi River is the longest river in North America, flowing 3,781km from its source at Lake Itasca in Minnesota, through central USA and finally discharging 100 trillion gallons per year into the Gulf of Mexico. As Figure 1 (Center for Global Environmental Education, 2001) shows, the discharge increases steadily downstream as more tributaries add water to the river. For example, the large increase near St. Louis is caused by the addition of the flow of the Missouri and Illinois Rivers.

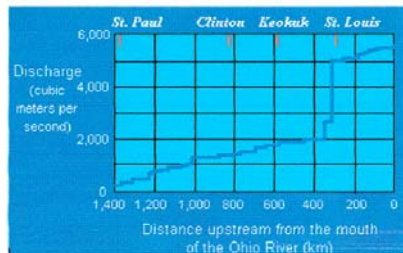


Figure 1. Mississippi Discharges as it flows from north to south. Source: Center for Global Environmental Education (2001). Hamline University Graduate School of Education, 1536 Hewitt Avenue, St. Paul, MN 55104-1284. Retrieved January 14, 2009 from: http://cgee.hamline.edu/rivers/Resources/river_days/info.html.

“Mississippi” is an Indian word meaning great river or gathering of waters -an appropriate name because the river basin measures 4.76 million km², covering about 40% of the USA and about one-eighth of North America (Figure 2). Of the world’s rivers, the Mississippi ranks third in length,

second in watershed area, and fifth in average discharge.

The Mississippi River is one of the most heavily engineered natural features in the U.S. The character of the floodplain has changed to accommodate agriculture and urbanization. Approximately 80% of the original wetlands along the river were drained since the 1940s. Wetlands act as natural storage reservoirs for floodwaters (Center for Global Environmental Education, 2001).



Figure 2. The Mississippi River Drainage Basin. Source: Wikipedia. (n.d.) Retrieved October 5, 2009 from: <http://www.nowater-nolife.org/watersheds/mississippi/map.html>.

The Mississippi River is one of the most heavily engineered natural features in the U.S. The character of the floodplain has changed to accommodate agriculture and urbanization. Approximately 80% of the original wetlands along the river were drained since the 1940’s. Wetlands act as natural storage reservoirs for floodwaters (Center for Global Environmental Education, 2001). A flood can be defined as the temporary overflow

of a river onto adjacent lands not normally covered by water.

The river channel itself has been artificially constrained by levees and floodwalls. These structures serve to increase the volume of water that can be held in the channel and thus increase the size of the flooded area if the levee breaks.

Levees are low ridges or earthen embankments made of dirt, sand or clay, built along the edges of a stream or river channel to prevent flooding of the adjacent land.

Levees can be either naturally occurring or man-made. Man-made levees consist of an earthen material such as dirt, with grass or some mat like vegetation planted on top of the levee’s bank to minimize erosion.

Dimensions of a levee are typically eight feet across the top, the height one foot above the level of a predicted flood having a 1 in 50 year frequency. The 1993 flood event was a 1-in-500-year event.

A common problem is overtopping. This occurs when the water level surpasses that of the levee height and the water overflows. The fast moving water can quickly erode the surface material of the levee and break through it onto the surrounding land.

The Mississippi Floods of 1993

The Midwest USA region received higher than normal precipitation during the first half of 1993. In many districts at least 600mm of rain fell between the beginning of June and late July. For example, in Cedar Rapids, Iowa, 850mm fell

between April and July, an amount equal to the average annual total. This made 1993 the wettest summer on record up to that point in time.

The ground was saturated because of cooler than normal conditions during the previous year (less evaporation). So, as water tables were already high, quick flow runoff delivered water rapidly to the river channels, causing unusually steep rising arms to the storm hydrographs along the Mississippi. Thunderstorms throughout June caused rapid surface runoff and flash floods.

The abnormal rainfall was attributed to a weather system formed when warm, moist air from the Gulf of Mexico collided with cold, dry air from Canada over the Midwest.

When the warm Gulf air cooled it lost the moisture it carried as rain. Normally this rain would have been distributed throughout the Northeastern states but a stalled high pressure system over the Southeast blocked the flow of the jet stream bringing a constant stream of storms over the Midwest.

St. Louis was protected by a massive floodwall. The wall developed a leak but held up over the length of the flood, in part because a levee break south of the city allowed the river level to drop around St. Louis and reduced pressure on levee at St. Louis.

Until 2008, the Great Flood of 1993 was the most costly and devastating flood in modern history to ravage the United States. Levee breaches resulted in the destruction of farmland, towns, and transportation routes. More than 20 million acres of land in nine states were inundated. At least 75 towns were completely flooded, some of which have still not been rebuilt. Approximately 54,000 people were evacuated, nearly 50,000 homes were destroyed or damaged and at least 47 people died.

The Midwest Floods of 2008: Wisconsin, Iowa, Indiana, and Illinois

On April 23, 2008 heavy rains began and three counties in Iowa were designated disaster areas by the Governor's proclamation. As a

result of the flooding, Cedar Rapids, Iowa had a mandatory evacuation of 24,000 people, at least 52 roads were closed, and bridges collapsed.

By early June 2008, heavy rain in the Midwest knocked out electricity, submerged roads, and destroyed homes and businesses in Indiana and Iowa. More than 2,500 National Guard members were deployed, and volunteers and soldiers filled 4.8 million sandbags to bolster levees against flooding. Runoff from Iowa, Illinois, and Wisconsin entered the Mississippi River and threatened to exceed the record levels set in 1993. In Hannibal, Missouri, for example, the river rose from its normal high of 28 feet to 31.5 feet on 19 June. The record river crest in Hannibal was 31.8 feet set in 1993.

Flooding and Health Risks

Health risks from flooding on the Mississippi River would be very similar to flooding on any major USA river. The remainder of this paper will expose issues relating to flooding from any river source. Health risks from flooding are not limited by the immediate danger of being swept away by flood waters. Other health concerns include contaminated flood waters, structural instability, septic system failure, electrical shock, and fire and explosion where natural or bottled gas is present.

Floodwaters often contain elevated levels of waterborne bacteria such as *E. coli* and *Enterococci* as well as contaminants such as industrial chemicals, motor oil, and diesel fuel. As a result, individuals should avoid any immediate contact with floodwaters and should never—in any circumstance—drink floodwater. Waterborne hazards remain even after the water recedes. The residue or “toxic sludge” often contains massive amounts of waterborne bacteria, toxic mold growth, and chemical contamination (Adjusters International, n.d.).

Structural instability can occur both during and after the flood. An initial building survey is needed to assure that a building is safe to enter. When standing water is pumped out of basements too

quickly (i.e., more than 1/3 per day), structural damage and wall collapse may occur due to pressure from surrounding water-saturated soil.

Environmental Health Safety Focus

When one looks at flooding, the public health professional is very interested in environmental health issues which include an initial safety focus (U.S. Public Health Service, 2003):

- Water Removal
- Power
- Natural gas
- Vector Control
- Underground Storage Tanks
- Food Safety

The public health professional also will focus on:

- Drinking water
- Wastewater
- Road conditions
- Solid waste/debris
- Sediments/soil contamination
- Housing

Occupational Safety and Health Issues for Workers in Flood Areas

“If water has been present anywhere near electrical circuits and electrical equipment, turn off the power at the main breaker or fuse on the service panel. Do not turn the power back on until electrical equipment has been inspected by a qualified electrician. Never enter flooded areas or touch electrical equipment if the ground is wet, unless you are certain that the power is off. Never handle a downed power line” (National Institute for Occupational Safety and Health [NIOSH], 1994).

“Flood cleanup activities may involve the use of gasoline - or diesel-powered pumps, generators, and pressure washers. Because these devices release carbon monoxide, a deadly, colorless, odorless gas, operate all gasoline-powered devices outdoors and *never* bring them indoors. It is virtually impossible to assess adequate ventilation. NIOSH has investigated several carbon monoxide poisoning deaths in the past caused by the use of gasoline-powered engines

indoors or in confined spaces” (NIOSH, 1994).

“Cleanup workers are at risk for developing serious musculoskeletal injuries to the hands, back, knees, and shoulders. Special attention is needed to avoid back injuries associated with manual lifting and handling of debris and building materials. To help prevent injury, use teams of two or more to move bulky objects, avoid lifting any material that weighs more than 50 pounds (per person), and use proper automated-assist lifting devices” (NIOSH, 1994).

“Flood waters can rearrange and damage natural walkways, as well as sidewalks, parking lots, roads, buildings, and open fields. Never assume that water-damaged structures or ground are stable. Buildings that have been submerged or have withstood rushing flood waters may have suffered structural damage and could be dangerous. Do not work in or around any flood-damaged building until it has been examined and certified as safe for work by a registered professional engineer or architect. Assume all stairs, floors, and roofs are unsafe until they are inspected. Leave immediately if shifting or unusual noises signal a possible collapse” (NIOSH, 1994).

“Flood waters can dislodge tanks, drums, pipes, and equipment, which may contain hazardous materials such as pesticides or propane. Do not attempt to move unidentified dislodged containers without first contacting the local fire department or hazardous materials team. If working in potentially contaminated areas, avoid skin contact or inhalation of vapors by wearing appropriate protective clothing and respirators. Contact NIOSH for more information on the proper safety equipment. Frequently and thoroughly wash skin areas that may have been exposed to pesticides and other hazardous chemicals” (NIOSH, 1994).

“Fire can pose a major threat to an already badly damaged flood area for several reasons: inoperative fire protection systems, hampered fire department response, inoperable firefighting water supplies, and flood-damaged fire protection

systems. Workers and employers must therefore take extra precautions. At least two fire extinguishers, each with a UL rating of at least 10A, should be provided at every cleanup job” (NIOSH, 1994).

“Workers and volunteers involved with flood cleanup should avoid direct skin contact with flood waters if possible and through the use of appropriate Personal Protective Equipment (PPE) and clothing. In most instances, the selection of PPE will be dependent on site specific conditions, hazards, and tasks; the list below provides interim guidance on PPE and clothing for flood response workers:

- Electrically insulated, watertight boots with steel shank, toe, and insole. Tennis shoes or sneakers should *not* be worn because they will transfer contamination and will not prevent punctures, bites, or crush injuries. Hip waders may be appropriate to help prevent contact with flood waters;
- Heavy, waterproof, cut-resistant work gloves. Other types of protective gloves may be required if handling identified material hazards;
- Goggles, safety glasses with side shields or full face shields. Sun/glare-protective lenses may be needed in some work settings;
- Soft hat or other protective head cover. Wear an American National Standards Institute (ANSI) rated hardhat if there is any danger of falling debris or electrical hazards;
- Hearing protection (when working in an environment with any noise that you must shout over to be heard);
- Comfortable, form fitting, light weight clothing including long pants and a long sleeved shirt or coveralls; and,
- Under some work conditions, NIOSH approved respirators may be necessary (e.g., for exposures to mold-contaminated materials/environments, or other recognized chemical, physical, or biological hazards)” (NIOSH, 2008).

Preventing Disease and Injury in a Flood

During and following a widespread flooding disaster, many questions arise from citizens within the communities affected, and from the many volunteers and organizations which are working in the devastated area. Personal health and safety is a priority for everyone. The following information is aimed at preventing both disease and injury by answering many common concerns and providing valuable preventive health tips.

Which immunizations will one need if one is exposed to flood water? No special immunizations are necessary. Experience and studies from previous serious national floods demonstrate that increased risk or incidence of tetanus, typhoid fever or hepatitis A had not occurred. Recommendations for these immunizations are the same as during non-flood conditions:

- Tetanus - A booster for tetanus should be given to anyone sustaining an injury (particularly lacerations and puncture wounds) that has not received a vaccination within the last 10 years, 5 years for particularly major or unclean wounds.
- Hepatitis A - Immune globulin is given only to those persons known to be in direct contact with a confirmed case of hepatitis A. Hepatitis A vaccines are not required.
- Typhoid - Prophylactic Typhoid vaccination is not recommended.

Which disease-causing agents may be present in floodwaters? Because local water systems may become contaminated and power outages are widespread following severe flooding, increased food borne and waterborne diarrheal illnesses may occur. A variety of sources, including animal and human waste, can contribute to water pollution.

- Diarrheal Illness (State of Delaware, 2004). Most diarrheal illnesses have incubation periods between one and seven days. Bloody diarrhea may occur with

certain infections. Testing for illness should be performed prior to treatment with medication because of the large number of causative agents that may require different antibiotics. Stool cultures submitted by your physician can be tested at the State Laboratory for Public Health. Local health departments should be notified of the results so cases can be investigated and appropriate follow up provided.

- Hepatitis A (State of Delaware, 2004). If hepatitis A is suspected, the doctor should draw blood and test for IgM antibodies for hepatitis A. It is especially important for the local health department to know if a person with this illness is a food handler or participates in a day care setting.
- Parasites (State of Delaware, 2004). Some waterborne parasites (e.g., giardia, cyclospora, and cryptosporidium) may also cause chronic diarrhea; testing by a physician can identify these diseases. Such diseases can be severe in immune compromised persons.
- Leptospirosis (State of Delaware, 2004). During widespread flooding of an area there may be a potential, but small, risk for a disease called leptospirosis, which is caused by exposure to animal urine. It is a bacterial disease that affects both humans and animals. Symptoms may range from none to high fever, headache, chills, muscle aches, vomiting, jaundice (yellow eyes and skin), abdominal pain, diarrhea or rash. If the disease is not treated, kidney damage or liver failure may develop as well as respiratory failure or meningitis. Death occurs rarely.

What problems can one encounter with flooded buildings? Residents working on or living in buildings damaged by water during flooding should be aware of the potential for biological contamination to their

homes and drinking water. If homes become flooded or wells are covered with water as a result of the flood, then certain measures should be taken in order to protect your health and safety. The following describes the public health problems associated with flooding, the misconceptions associated with flooding, and the measures to take to protect your health and safety after a flood.

Mildew, Mold, and Fungi. Mold (fungi) will grow in flooded buildings that do not dry out quickly. People living or working in buildings with wet carpet, walls, mattresses and/or furniture can have health problems such as allergies, asthma, (a form of troubled breathing), and sneezing. Mold and fungi can grow in these materials to numbers that can present a health risk after being wet for only 48 hours. Persons at highest risk are asthmatics, people with allergies, infants and children, elderly, pregnant women, people with existing respiratory diseases, and people with compromised immune systems. Spraying with a household disinfectant for fungi and mold will not remove the organisms and can exacerbate breathing problems.

Cleaning a House after Flooding

Cleaning

The four major steps to cleaning many items after the flood are (North Dakota State University Extension Service, n.d.):

- "Remove contaminated mud. Shovel out as much mud as possible; then, use a garden sprayer or hose to wash away mud from hard surfaces. Start cleaning walls at the bottom or where damage is worst. Remember to hose out heating ducts, disconnecting the furnace first."
- "Clean and scrub surfaces with hot water and a heavy-duty cleaner. Scrub off all contaminants with a brush. Rinse off soap."
- "Disinfect areas as bacteria can only be destroyed by disinfecting or sanitizing. This can be done by wiping or spraying surfaces with a solution of ¼ cup chlorine

bleach per gallon of water or a product that is labeled with an EPA registration number as a disinfectant. After wiping or spraying with a disinfectant, put the item out in the sun, if possible, for additional natural disinfecting plus drying. See Table 1 for specific recommendations."

- "Dry rooms by ventilating with an entrance and exhaust opening for air to promote cross-ventilation. Place a fan in a window or door with the fan to the outdoors. Seal the rest of the opening with cardboard, plywood or blankets so the fan can create a vacuum. Wood should have a moisture content of less than 15 percent before drywall, paneling, or other coverings are placed over it."

Mildew

If mildew has developed because the molds were not killed and the source is still damp, a strong product is required to remove it, and the required strength may ruin some household items (North Dakota State University Extension Service, n.d.). Mildew may be removed from walls and similar hard surfaces with this solution (Flood Smart, 1999):

- 1 gallon water
- ¾ cup liquid chlorine bleach
- 1 cup trisodium phosphate (available in hardware and discount stores as TSP)

Follow all safety precautions when using this strong solution. Wash a small area at a time. Rinse quickly, and dry with a soft cloth.

Clothing

To remove mildew from clothing or textiles that are colorfast, soak in a solution of 2 tablespoons liquid chlorine bleach and 1 quart water 5-15 minutes, then rinse. To remove mildew from non-bleachable items, mix 1 tablespoon fresh lemon juice and 1 tablespoon salt. Moisten the stain. If possible, spread in the sun to bleach. Rinse thoroughly. Another option is to soak the stain in 3% hydrogen peroxide for 15 minutes" (North Dakota State University Extension Service, n.d.).

Contaminated Drinking Water

Unhealthy bacteria may be present in residents' water if the public

water supply has lost power or if a private well has been flooded. The water in the home may be unsafe for drinking, cooking, or washing.

Many water lines run parallel to roads. If floodwater recedes too quickly, it can erode the ground under the roads, causing the roads to collapse and in turn break the water lines. This may contaminate public drinking water supplies and disrupt service.

If residents' public water supply has lost power or if a resident's private well has been flooded, the water for drinking, cooking, making ice, brushing teeth, and bathing should be boiled for approximately 3 to 5 minutes. Because boiling water can increase nitrate levels seen after flooding, young infants and pregnant women should not drink boiled water. Bottled water should be used by pregnant women and be used for preparing infant formula. If you cannot boil the water, add plain household bleach (which is 4% to 6% chlorine) using 1/4 teaspoon per gallon, shake, and let stand for 30 minutes. Water should have a slight bleach odor. Residents should continue with these procedures until tests show no bacteria in water. Customers of public water systems do not need to test their water. The operator of the public water system will conduct these tests. Private well users should contact their county health department for information on testing well water (Eastern Idaho Public Health District, n.d.).

People do not need to have their water tested if they are on a public water supply. The operator will conduct proper testing once floodwaters recede and power is restored. The state or local health departments will not take samples from homes served by a public water supply (Eastern Idaho Public Health District, n.d.).

Asbestos Building Materials

Homes may have building materials containing asbestos, which has been associated with respiratory diseases. Building materials that may contain asbestos include flooring, siding, roofing, pipe insulation, fireproofing, or decorative ceiling treatments.

If asbestos is suspected to be present in building materials, the materials should be carefully wetted to minimize dust production whenever they are being disturbed or moved from place to place.

Sewage

Flooding may cause wastewater to back up into homes that receive wastewater service from either private or community septic systems. Once the water recedes, a high water table may still prevent these systems from functioning for some time.

Wear rubber boots and waterproof gloves during cleanup if sewage backed up into your home. Remove and discard contaminated household goods such as wall coverings, rugs, cloth and drywall that cannot be disinfected.

Should one have concerns about wild animals and insects?

Mosquitoes. Flooding can result in excessive breeding of mosquitoes, resulting in the possibility of diseases being carried by the insects. Swarms of mosquitoes may be seen in the affected regions several weeks after the storm. Mosquito eggs can lie dormant for years without water. Those eggs will now hatch increasing the potential for mosquito-borne disease until the first frost. State pest management officials will address this problem (North Carolina Department of Health and Human Services, n.d.).

Residents should remove excess water from birdbaths, flower pots, tires, buckets and other containers to minimize the breeding of

mosquitoes. It may be necessary to have aerial spraying for mosquitoes. Please contact your local county health department for aerial spraying schedules. Although there is minimal risk to residents, it is advisable to stay indoors during aerial spraying.

Wild Animals. Wild animals displaced from their natural habitats may seek shelter in places where they may be exposed to people. Such animals may be infected with rabies (North Carolina Department of Health and Human Services, n.d.).

Dead Animals. Dead animals may be found around your home after a flood. The presence of these animals may result in excessive odor and increase in the number of flies. Widespread contamination from animal waste and untreated sewage may occur. The presence of carcasses can serve as reservoirs for those known organisms, such as coliforms, and will attract vectors such as flies that can contaminate food (North Carolina Department of Health and Human Services, n.d.).

How can one be sure that food is safe to eat? Refrigerated food is generally safe if the power has not been off for more than 2 to 3 hours. Most freezers will keep food safe without power for 36 to 48 hours if left closed. Any foods exposed to flood waters should be discarded. Contaminated food should be buried or sealed in plastic bags and placed in a landfill when possible (Seattle and King County Public Health 2009).

Final Thought

The floods of 1993 and 2008 were very destructive and caused many public health and environmental health concerns. We hope that the citizens have learned from these disasters and will make appropriate changes in the future to minimize health and environmental problems.

Table 1. Cleaners and Disinfectants

Type of Cleaner	Uses	Precautions	Additional Suggestions
Liquid household cleaner (Top Job, Ajax, Janitor in a Drum, Lysol, Mr. Clean)	Wash hard surfaces such as painted walls, floors, woodwork, and porcelain.	Dilute with water as directed on container for specific uses.	
Powdered household cleaner (Spic 'n Span, Ajax)	Removes mud, silt, greasy deposits.	Dissolve in water to make a solution.	
All-purpose laundry soaps	General household cleaning. Hand-washing and laundry. Moderately and heavily soiled and washable colorfast textiles.	Do not use on wool, silk or fabric blends containing these fibers.	Rinse well to remove suds.
All-purpose laundry detergents (Tide, Wisk Oxydol, Cheer)	Moderately or heavily soiled washable, colorfast textiles. Outside of appliances. Painted walls and woodwork. Floors.	Do not use on wool, silk or fabric blends containing these fibers.	Rinse well to remove suds.
Light-duty dishwashing soaps (Ivory Snow, Dreft) or detergents (Lux, Joy)	Lightly soiled washable fabrics and household textiles. Rugs and carpets. Appliances and furniture. Washable wall paper.	Safe for wool and silk fibers and fabric blends containing these fibers. Safe for most dyes.	Rinse well to remove suds.
Household ammonia	Hard surfaces: windows, walls, woodwork, floors, tile, porcelain.	Dilute in water. Do not get in eyes. May irritate skin.	
Trisodium phosphate (TSP 90)	Walls, woodwork, floors.	Powder. Dilute in water. Do not get in eyes. May irritate skin.	6 tablespoons per gallon of water.
Quaternary ammonium disinfectants	Laundry-safe for all fibers.	May cause some color change.	Add at beginning of rinse cycle.
Pine oil disinfectants (Pine-Sol)	Laundry-safe for washable clothing.	Do not use on wool or silk. Pine odor will linger on these fabrics.	Add before putting clothes in washer or dilute in 1 quart water.
Liquid chlorine bleach disinfectants (Clorox, Purex, Hilex)	Laundry.	Do not use on wool, silk or water-repellent fabrics.	Add bleach before putting clothes in washer or dilute in 1 quart water.
Phenolic disinfectants (Lestoil, Lysol)	Laundry-safe for washables.	Do not use on wool or silk.	Add in wash or rinse cycle.

Adapted from:

<http://www.debbiesimmonds.com/assets/pdfs/buyers/checklist%20for%20after%20a%20flood.pdf>

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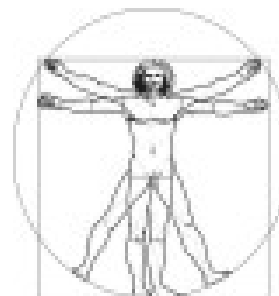
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