Disposing of Liquid Waste from Autopsies in Tsunami-Affected Areas: Interim Guidance from the Centers for Disease Control and Prevention

Requested by: CDC, Director's Emergency Operations Center, Occupational and Environmental Health Team

Requested from: National Center for Environmental Health, Environmental Health Services Branch

Collaborators from other Agencies and Centers:

Jim Smith, U.S. Environmental Protection Agency
Nancy Burton, National Institute for Occupational Safety and Health
Richard Nickle, Agency for Toxic Substances and Disease Registry
Larry Cseh, Agency for Toxic Substances and Disease Registry
Matthew Arduino, National Center for Infectious Diseases

Background

In tsunami-affected areas, liquid waste from human autopsies is being generated, collected, and stored. Each autopsy generates between 1 and 10 liters of liquid waste consisting of body fluids and rinse water used to clean and disinfect work surfaces. Current reports indicate that liquid waste is collected and stored in underground storage tanks, but other containers and methods of storage are likely being used. Because of the lack of storage facilities and onsite wastewater treatment operations, the CDC Field Team was asked to provide guidance on the final disposal of this waste.

Characterization of Waste Stream

Blood and body fluids generated during autopsy are collected and placed in storage tanks along with solutions used to clean and disinfect autopsy work surfaces. Common mortuary chemicals such as formaldehyde, formalin, or phenol are not being used during these autopsy procedures. The liquid waste mixture collected during autopsy is not disinfected or treated before being transferred to a stainless steel holding tank.

Potential Risks

Liquid waste generated during autopsy procedures may present environmental and public health hazards similar to those associated with medical waste and wastes generated at mortuaries and funeral homes. Although pathogens may be present in cadavers and in discharged blood and body fluids, little evidence exists that disease agents are transmitted to the public from these sources (U.S. Army 2001a; Harvey et al. 2002; Morgan 2004). Pathogens in the autopsy waste stream would be similar to those found in community-generated sewage. As with sewage, if properly managed, this autopsy waste presents minimal health and environmental risks.

Agents of endemic disease may be present in both autopsy waste streams and community-generated sewage. Diseases prevalent in Indonesia include cholera, dengue fever, hepatitis A, hepatitis B, Japanese encephalitis, leptospirosis, malaria, plague, schistosomiasis, typhoid, and yellow fever (U.S. Department of State 2005). Autopsy liquids may also contain hepatitis B virus (HBV), hepatitis C virus (HCV), hepatitis

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D virus (HDV), hepatitis E virus (HEV), human immunodeficiency virus (HIV), tuberculosis bacillus, group A streptococcal bacteria, and organisms that cause gastrointestinal illness.

The development of disease from exposure to pathogens is dependent on pathogen virulence, dose size, route of exposure, and individual susceptibility. In bloodborne infections, transmission requires a percutaneous exposure (needle stick or sharp penetrating object); direct contact with mucous membranes such as eyes, nose, or mouth; or direct contact with skin that is abraded, chapped, or afflicted with dermatitis (WHO 1983; CDC 1983; Reinhardt and Gordon 1991). Such direct contact or percutaneous exposure places pathologists and waste handlers at risk. Disease risk from any particular pathogen for persons working at autopsy facilities varies by the type of activity each person performs. A critical need exists to apply universal precautions and implement a postexposure plan of action to follow in the event of exposure. Persons who may come in contact with blood or body fluids should follow universal precautions, including the use of protective gloves, eyewear, mask, gown/apron, and shoe covers while working (CDC 1988; U.S. Army 2001b).

If autopsy waste is properly managed, the public will not come in contact with untreated or treated autopsy waste and is therefore not at risk for exposure to pathogens. The likelihood that pathogens will be present in this waste stream is reduced, because infectious disease agents survive for only a short time outside the human host. The World Health Organization (WHO) reports that most disease-causing agents do not survive long in the human body after death. HIV survives in dead people for up to 6 days (WHO 2004). HBV can survive outside the body for at least 7 days and still be infectious (CDC 2004). Organisms that may present an environmental exposure risk include HAV, HEV, *Vibrio cholerae, Leptospira interrogans*, and *Salmonella species*.

Environmental Surface Disinfection Procedure To Be Used

When handling liquid waste and the chemicals used for disinfection, personnel should follow universal precautions as described in this section. Disinfecting agents should be applied with care to minimize overuse and unnecessary exposure to chemicals. Surfaces that have come in contact with blood or body fluids should be cleaned with detergent and clean water. After surfaces have been cleaned, personnel should then disinfect the surfaces by wetting them with a solution of chlorine bleach (sodium hypochlorite) mixed with clean water to reach a concentration of 525 to 600 mg/L of available chlorine (CDC 2003). Other disinfectants labeled for use on environmental surfaces in hospital or health care settings can be used in place of chlorine.

To form the solution to be used to disinfect contaminated environmental surfaces, add common household or laundry bleach (unscented) containing 5.25 to 6% available chlorine (52,500 to 60,000 mg/L) to clean water to develop a 1 to 100 dilution (1% solution = 525 to 600 mg/L). This solution will be effective on most pathogens but may not eliminate bacterial spores and parasites.

A 1% chlorine solution for routine disinfection of surfaces can be prepared by adding

- 10 milliliters of 5.25 to 6% bleach to 1 liter of clean water,
- 50 milliliters of 5.25 to 6% bleach to 5 liters of clean water,
- 100 milliliters of 5.25 to 6% bleach to 10 liters of clean water,
- 200 milliliters of 5.25 to 6% bleach to 20 liters of clean water, or
- 1 liter of 5.25 to 6% bleach to 100 liters of clean water.

The effectiveness of the disinfection processes is influenced by the following:

- type of chemical used

- amount of chemical used
- contact time between disinfectant and liquid waste
- organic load of the waste
- temperature, humidity, and pH

Additional guidance on the use of disinfectants can be found in Attachment 1 of this document.

Worker Safety and Health Issues

The risk for developing disease from infectious agents in autopsy fluids is low. Proper handling and disposal of these wastes is needed to control exposure and to ensure an aesthetically and culturally acceptable method of waste management. Autopsy waste handlers have potential exposures to blood and body fluids; human waste pathogens; and environmental microbial contaminants from the decaying process (which have been associated with opportunistic infections) during generation, cleanup, transportation, storage, treatment, and disposal processes. Critical guidance is outlined in subsequent sections of this document. Additional guidance may be found in the documents referenced at the end of this document and at the Web sites listed under "Additional References" at the end of this section.

Recommendations for Personal Protective Equipment, Including Universal Precautions and Personal Hygiene

- Handwashing with soap or alcohol-based hand sanitizer is probably the most important step, because several of the microbial agents can be transmitted by a fecal-oral route.
- No one should eat, drink, or smoke in work areas where autopsy waste is handled.
- Universal precautions should be used to protect against bloodborne diseases. These precautions include the use of latex or nitrile gloves, safety goggles or face shields, impervious clothing or aprons, and masks.
- Aerosolization of pathogens while handling this waste is possible. The generation of aerosols (for example, by the use of high-pressure hoses for cleaning) in these work areas should be minimized. Avoiding procedures that create aerosols and using the appropriate work practices described previously should make respiratory protection unnecessary. In situations where workers may be exposed to aerosolized microorganisms, disposable NIOSH-approved N-95 respirators can be used for respiratory protection. **Note:** A respirator will work only if it is used correctly. Key elements for respiratory protection are fit-testing and training of each worker in the use, maintenance, and care of the respirator. Disposable facemasks and N-95 cartridges become ineffective when exposed to liquid splash directly on the filter materials. They should be replaced when splashed and when obviously soiled or contaminated with water or other potentially pathogenic material.
- Vaccinations for all employees handling human autopsy waste should include tetanus and diphtheria (Td), hepatitis A, typhoid, hepatitis B, and polio.
- HIV prophylaxis should be available in case a person's mucous membranes are accidentally exposed to autopsy waste. Administration of HIV prophylaxis in case of accidental exposure should be based on the type of exposure. Exposed workers should immediately report any blood or body fluid exposure to a qualified medical authority for appropriate assessment and treatment.
- Chemicals used to treat the autopsy waste stream may include chlorine (sodium hypochlorite), lime (calcium oxide), and soda ash (sodium carbonate). The occupational hazards associated with these three chemicals indicate that safe handling practices should be used for these chemicals. Chemical-resistant protective gloves and safety goggles would protect workers from accidental splashes during the treatment or disposal process.

Additional References

www.who.int/mediacentre/factsheets/fs253/en/

www.who.int/water_sanitation_health/medicalwaste/en/microbhazards.pdf
www.bt.cdc.gov/disasters/tsunamis/handleremains.asp
www.who.int/hac/techguidance/pht/en/11818.pdf
www.paho.org/English/DD/PIN/pr040923.htm
www.who.int/hac/techguidance/ems/flood_cds/en/
www.cdc.gov/niosh/npg/npg.html

Liquid Waste Management and Disposal Options

Seven options are proposed for consideration in disposal of wastes generated during the autopsy process. Authorities with an understanding of local conditions will need to assess the suitability of the options presented here and select the best practice for each waste-generation location.

1. Waste Reduction

If practical, blood and body fluids generated during autopsy should be absorbed on suitable material and placed in the body cavity. The body can than be moved to the location of final disposition (Dunsmore 1986).

2. Public Wastewater Treatment and Disposal System

A properly designed and functioning public wastewater disposal system has the capacity to adequately treat liquid wastes from many sources and dispose of these wastes in a manner that will not create an environmental or public health hazard. Disposal of wastes from the processing of corpses creates a waste stream that should be easily treatable by properly functioning public wastewater treatment and disposal systems. Communities where such wastewater disposal systems are available and properly operating should consider using this method of disposal for wastes generated from the autopsy processes. If this disposal option is selected, it is of critical importance that blood and body fluid waste be added slowly to the treatment system. This slow addition of liquid waste over a period of time will prevent overloading of the wastewater treatment system.

3. Septic Tank and Drain Field

On-site disposal of liquid wastes through the use of a septic tank and soil-absorption drain-field system has been an accepted method of human waste disposal for most of the past century, as long as the septic tank and drain field are properly designed, functioning, and maintained. However, many variables must be considered before using a septic tank system to dispose of autopsy waste. Assessing the system's performance history would be necessary. Adequate separation should exist between the bottom of the absorption field trench and the seasonally high water table or any impervious horizon such as bedrock or restrictive clays. The septic tank should be inspected to ensure water tightness. (Water tightness is ensured by removing the manhole cover and determining the depth of the liquid. If the tank is not filled to a level just below the inlet, tank leakage is likely occurring.) The system should also be of adequate size to accommodate the increase in the waste load. Shock loading of the septic tank system with an additional flow of wastewater could cause surface failure, such as the seeping of liquid waste to the ground surface. Any discharge of these wastes to a septic tank system should be done over a period of time without exceeding the design capacity of the system (NFDA 2004).

Preservative chemicals such as formaldehyde, formalin, and methanol present in the waste may impair the operation of subsurface disposal systems. Alternative disposal methods should be considered if chemicals are present in the waste stream.

4. Hospital/Commercial Incineration

Disposal by incineration using a hospital incinerator designed to destroy infectious waste or a using a commercial incinerator such as a rotary kiln or a fluidized bed are very effective methods of disposal for these types of wastes. However, such disposal may be costly, and care would need to be taken to ensure the proper injection rate of the material into the incineration unit. Transporting the liquid waste to an incineration site may also be an issue.

5. Disposal at Sea

The rapid logarithmic dilution of autopsy liquid waste by deep-sea disposal is an effective alternative under the current disaster circumstances. The waste would need to be transported to a boat or ship with the capacity to haul the liquid at least 5 miles beyond the shoreline for deep-sea disposal. To ensure maximum dilution, the waste needs to be slowly released while the ship is moving parallel to or away from the shore. If this option is considered, local authorities would need to determine and ensure compliance with national and international laws and regulations governing sea disposal.

6. Land Application

Applying liquid wastes to the land surface can be an effective method of waste disposal. However, as with septic tank systems, many variables must be considered to protect health and the environment. Siting of the disposal area is critical to proper land application of liquid wastes. Factors that must be carefully considered are location (including minimum distances from wells, surface waters, and residences), topography, drainage, soil depth, groundwater depth, security and access, and properly designed loading and application rates (U.S. EPA 1995a).

Because land application has the greatest exposure potential for human contact, it is very important to include a chemical stabilizer such as slaked lime [$Ca(OH)_2$] or quicklime (CaO) to the waste before applying it to the land surface. Slaked or hydrated lime is readily available in most parts of the world and is easy to handle and safe to work with. Lime added to the liquid waste in sufficient quantities to raise the pH above 12 for 2 hours or more after contact can reduce bacterial and viral pathogens by 99% or more. Lime stabilization reduces parasites including helminthic parasites by one or more logs (U.S. EPA 1995b). Lime can be mixed with liquid waste in a mixing tank. Mixing must be sufficient to ensure that the entire content comes into contact with the lime and undergoes the increase in pH. The pH of the liquid lime mixture should be measured at several locations to ensure that the pH is raised throughout the material (Spinosa and Vesilind 2001).

After uniform distribution over the land surface by use of a mechanical spreader or similar device, the waste should be mixed thoroughly in the upper soil horizons by using a tractor-pulled plow or farming disk. Lime stabilization effectively reduces potential exposures and minimizes health risks associated with land application of liquid waste (Spinosa and Vesilind 2001).

Land Application—Vector Attraction Reduction and Odor Control: Adult filth flies may be attracted to and feed on land-applied blood or body fluids. Mechanical transfer of pathogens by flies to humans and food is possible. Proper lime stabilization will reduce the attraction of vectors to the site and greatly decrease the risk for pathogen transfer by vectors.

Vector attraction reduction is best accomplished by holding the waste at a pH of 12 or higher for at least 2 hours, and then at a pH of 11.5 or more for an additional 22 hours.

Lime stabilization does not reduce volatile solids. Field experience has shown that the application of lime-stabilized material after the pH has dropped below 10.5 may create odor problems. Therefore, it is recommended that land application of biosolids take place as soon as possible after vector attraction reduction is completed and while pH remains elevated (U.S. EPA 1995c).

7. Trenching

Disposing of waste by pouring it into trenches is an appealing option because of the low-cost limited work required. However, trenching may present the greatest threat to groundwater contamination, because no mechanism exists for primary treatment (such as a septic tank), and uniform distribution of the waste could be difficult. Methods for trenching should follow the same guidance as those for installation of the drain-field portion of a conventional septic tank system. This guidance includes installing level trenches at depths that ensure a minimum of 1.5 meters of separation between the bottom of the trench and groundwater, bedrock, or any other restrictive horizon, and a minimum amount of soil cover to ensure that contact with humans is not possible. Other factors that must be carefully considered in addition to soil depth are location (including minimum distances from wells, surface waters, and residences), topography, soil permeability, and properly designed loading and application rates.

If chemicals such as formaldehyde or formalin are present in the waste stream in more than trace quantities, subsurface disposal by the trench disposal method should not be considered.

Environmental Considerations for the Selection of Land Disposal Sites: Assessment of Potential Sites for Land Application or Trench Burial of Liquid Waste from Cadaver Processing

This section and the following survey instrument describe considerations for assessing the suitability of a site for land application or trench burial of liquid waste from cadaver processing during the emergency situation following the tsunamis in Southeast Asia. This section describes general assessment considerations. Attachment 2 of this document provides a checklist for environmental health professionals to use in rapidly assessing a proposed liquid waste disposal site.

Note: This section does not address the availability of suitable equipment for land application (such as tractors, disk plows, tank trucks, or trailers with spreading apparatus), or cultural considerations related to land application of liquid waste from cadavers. These are inherently local issues that will need to be addressed onsite.

Location and Geography

The site should be located away from populated areas, surface water (e.g., streams, lakes), and water supply sources (including wells) as much as possible. WHO recommends that burials be sited at least 30 meters from surface water or springs and at least 250 meters from drinking water sources (including wells). However, these recommendations apply to bodies and not to liquid waste, and they are not universally applicable standards. For land application of biosolids, the interim best management practices of the city of Ottawa, Canada, recommend a minimum of 90 meters of separation distance from wells and 450 meters from residential areas and schools. (However, these practices are stricter than are the Ontario provincial guidelines.) Other local factors related to soils, hydrogeology, and cultural considerations may require larger separation distances. A technical site evaluation by an environmental health specialist, if one is available, would aid in appropriate site selection.

Topography

The site should not be in an area that experiences flooding or ponding during the rainy season. The site should also be as level as possible to minimize storm runoff, especially during the current rainy season. If significant runoff from the site is unavoidable, trenches should be dug around the site to collect and store runoff onsite.

Soils

Note: To make this document as useful as possible during this emergency situation, the authors have not included technical soils descriptions. A site and soils assessment by an environmental health specialist, if available, would be very useful.

The site should be in an area with soils of relatively fine-grained, mixed texture. Sandy soils, which would allow very rapid drainage, should be avoided. If the soil is thoroughly wetted and does not remain in a ball when squeezed, the soil is probably too sandy. The soil should have a depth of at least 1.5 meters over bedrock or any subsurface soil layer that is impermeable.

Depth to Groundwater

If waste is applied to the surface, a minimum distance of 1.5 meters should exist between the surface and the seasonal high groundwater table. If waste is buried in trenches, the **bottom** of the trench should be at least 1.5 meters above the seasonal high groundwater table. Because the rainy season is currently underway in the tsunami-affected areas, the seasonal high water table is likely to be approximately the current level of groundwater.

Access

Access to the autopsy waste disposal site should be controlled as much as possible, both during and after disposal. The site should be fenced and should not be used for agriculture, grazing, housing, or other uses during or after waste application. Because this document has been written without the benefit of specific information about the waste being disposed of or about the local environment, it is difficult to recommend a specific time frame for limiting access after disposal is completed. Guidelines for access to biosolid disposal sites vary depending on the content of the material. U.S. EPA biosolids guidance ranges from limiting all access for 3 years to allowing activities such as grazing after as little as 30 days. The interim best management practices for the city of Ottawa, Canada, state that farmers should wait at least 1 year after biosolids application before growing nonroot vegetable crops, 5 years before growing root-vegetable crops, and 5 years before using the land as pasture. The Ontario provincial guidelines are weaker, allowing for use as pastureland after only 2 to 6 months. All of these guidelines, however, generally require some level of monitoring, with modification of time frames if indicated on the basis of that monitoring. Limiting access for a minimum of 3 months after the last application of waste should ensure that potential pathogens have been attenuated; however, without the authors' having further information on the characteristics of the waste or the environment, this should not be taken as firm guidance.

Application Rates

Application rates for biosolids are often determined on the basis of nutrient requirements. This method is not applicable here. Also, using this method requires both the soil and the disposed-of material to be analyzed, which will likely not be possible. For land application, in the absence of better guidance, the liquid waste should be applied at a rate that the soil can readily absorb so that no surface runoff occurs. For trench burial, the liquid waste should be applied in narrow trenches so that it covers the bottom of the trench uniformly to a shallow depth (e.g., < 10 centimeters), and then covered immediately with soil so that no liquid is visible.

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Attachment 1

Calculation of Concentrations for Surface Decontamination Solutions

Making liquid solutions from dry materials

After mixing chlorine powders or high-strength granular products with water, allow the insoluble material to settle and pour off the clear liquid. Wear respirator to prevent inhalation of caustic dust.

General formula:

$$\text{Weight of dry material} = \frac{\text{desired concentration (\%) X desired volume X weight conversion}}{\text{\% active disinfectant in dry material}}$$

Weight conversions = 1000 for g and liters
8.33 for lb and US gal
10 for lb and UK gal

Example 1: 1 liter of a 2% chlorine solution is to be prepared for high-strength calcium hypochlorite (70% available chlorine):

$$\text{Weight} = \frac{2 \text{ x } 1 \text{ x } 1000}{70} = 28.6 \text{ g}$$

Thus, 28.6 g should be mixed in 1 liter of water.

Example 2: 1 gal (US) of a 2% chlorine solution is to be prepared for high-strength calcium hypochlorite (70% available chlorine):

$$\text{Weight} = \frac{2 \text{ x } 1 \text{ x } 8.33}{70} = 0.24 \text{ lb}$$

Thus, 0.24 lb should be mixed in 1 gal (US) of water.

Diluting concentrated solutions of bleach

To calculate the amount of water per unit volume of disinfectant concentrate:

General formula:

$$\text{Parts of water to be added to 1 part of disinfectant} = \frac{\text{concentration of concentrate (\%)}}{\text{final concentration of solution (\%)}}$$

Example: To make a 0.4% chlorin–e solution from household bleach containing a chlorine concentration of 5.25%:

$$\text{Parts of water} = \frac{5.25}{0.4\%} - 1 = 12.1$$

Add 1 part of 5.25% bleach to 12 parts of water
(i.e., 1 liter of bleach + 12 liters of water = 13 liters of use solution).

Attachment 2

Rapid Site Assessment Form for Land Application or Trench Burial of Liquid Waste from Cadaver Processing

Location and Geography

Distance of disposal site from:

Feature	Distance	Measured by
Nearest surface water If closer than 30 meters, seek another site	_____ meters	Measuring tape Survey instrument Pacing Estimated from map
Nearest water source If closer than 250 meters, seek another site	_____ meters	Measuring tape Survey instrument Pacing Estimated from map
Nearest residential area If closer than 450 meters, seek another site	_____ meters	Measuring tape Survey instrument Pacing Estimated from map

Topography

Is the site relatively flat?
Yes
No → seek another site
Gradient of site (if possible to measure): _____% slope, as measured by __________
Any gradient steeper than a 5% grade should be avoided if possible.

Soils

Texture: if soil is thoroughly wetted, does it remain in a ball when squeezed together?
Yes
No → seek another site

Depth: is the soil at least 1.5 meters deep?
Yes
No → seek another site
Method of determining soil depth:
auger   drill   dug pit   other (specify)_____________

Depth to Groundwater

Depth: is the depth to groundwater from the ground surface (for land application) or the bottom of the trench (for trench burial) at least 1.5 meters?

- Yes
- No → seek another site

Method of determining depth to groundwater:

auger drill dug pit other (specify)_____________

Access

Can access to the site be controlled both during and after disposal?

- Yes
- No → seek another site

Method for controlling access (check all that apply):

fence signs guard other (specify)_____________