SAFETY, HEALTH, AND SECURITY IN WASTEWATER SYSTEMS

Prepared by the **Safety, Health, and Security in Wastewater Systems Task Force** of the **Water Environment Federation®**

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The WEF Technical Practice Committee (formerly the Committee on Sewage and Industrial Wastes Practice of the Federation of Sewage and Industrial Wastes Associations) was created by the Federation Board of Control on October 11, 1941. The primary function of the Committee is to originate and produce, through appropriate subcommittees, special publications dealing with technical aspects of the broad interests of the Federation. These publications are intended to provide background information through a review of technical practices and detailed procedures that research and experience have shown to be functional and practical.

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Preface

Since the Triangle Shirtwaist Factory fire in 1911, health and safety has been an upfront management tool spoken in the same context as productivity, quality, and cost. The fire showed that fatalities and injuries, if prevented, have a direct effect on the bottom line and the workforce.

This Manual of Practice will serve as an injury-reduction tool to all those working in the wastewater field. There are guidelines for creating written programs and procedures as well as guidelines that describe how to perform a confined space entry, lockout/tagout, and chemical deliveries. From the laboratory to sewer system collection applications, this manual has recommendations that could help you reduce injuries and mishaps to ensure the ultimate safety of employees.

This publication was produced under the direction of Tim Page-Bottorff, CSP, *Chair*.

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Chapter 8

Biological Hazards at Wastewater Treatment Facilities

1.0 TYPES OF HAZARDS

1.1 Bacteria

Unlike viruses, bacteria do not require a living host cell to reproduce. Pathogenic bacteria are microscopic and are extremely common in wastewater. Because bacteria can reproduce outside the body, microorganisms can be present in large quantities in the collection system. Bacterial infections, therefore, will result from their proliferation in an aqueous environment. Table 8.1 provides a summary of the various diseases associated with wastewater-contaminated environments.

Because of their daily exposure to wastewater-contaminate environments, wastewater personnel have a higher incidence of potential exposure to pathogens than the general public. For most workers, however, the risk of developing a disease is relatively low. Proper personal hygiene is critical, however, because infections may occur

TABLE 8.1 Diseases associated with wastewater-contaminated environments.

Disease	Organism	Mode of transmission
Bacillary dysentery	*Shigella spp.*	Ingestion[b]
Asiatic cholera	*Vibrio cholerae*	Ingestion
Typhoid fever	*Salmonella typhi*	Ingestion
Tuberculosis	*Mycobacterium tuberculosis*	Inhalation[c]
Tetanus	*Clostridium tetani*	Wound contact
Infectious hepatitis	Hapatitis A virus	Ingestion
Poliomyelitis	Poliovirus	Ingestion
Common cold[a]	Echovirus	Inhalation
Hookworm disease	*Necator americanus*/*Ancylostoma duodenale*	Skin contact
Histoplasmosis	*Histoplasma capsulatum*	Inhalation
Leptrospirosis	Leptospira	Wound contact/inhalation

[a]The common cold is typically associated with various rhinovirus types, several coronaviruses, and some unknown viruses.

[b]Inhalation is by way of mouth and nose and taken through the lungs and into the bloodstream.

[c]Ingestion is by way of mouth or nose and taken in through the stomach and intestine and into the bloodstream.

without symptoms and antibodies to bacteria and viruses may develop without illness symptoms (latent infection) being readily apparent.

The most common bacterial pathogens found in wastewater are *Salmonella* and *Shigella*. Other bacterial microorganisms include *Vibrio, clostridium, Yersinia, Campylobacter, and Leptospira. Escherichia coli (E. coli),* which can cause gastroenteritis, is generally not considered a pathogen because it is a microorganism that naturally inhabits that gastrointestinal tract of humans. The most common bacterial pathogens found in wastewater are listed in Table 8.2.

1.1.1 Salmonella

Salmonella is a significant cause of food poisoning from improperly prepared products. *Salmonella* can cause infections of the stomach and intestinal tract (acute gastroenteritis), typhoid fever, and paratyphoid fever. *Salmonella* infection results from oral ingestion, although large numbers of these microorganisms are required to cause illness.

Salmonella are routinely isolated from wastewater treatment processes, compost operations, sludge handling facilities, and associated landfills. Isolation of *Salmonella* from treatment plant effluent and sludge varies from plant to plant and season to season (Ottolenghi and Hamparian, 1982). Infection is unlikely in the wastewater field without direct ingestion of waste (Niederinghaus, 1986). The risk of infection

Table 8.2 Bacterial pathogens found in wastewater.

Microorganism	Disease
Salmonella	Salmonellosis (gastroenteritis)
	Typhoid fever
Shigella	Shigellosis (gastroenteritis)
	Bacillary dysentery
Clostridium	Tetanus
	Gas gangrene
	Gastroenteritis
Vibrio	Asiatich cholera
Leptospira	Weil's disease (Leptospirosis)
Campylobacter	Acute bacterial enteritis
Yersinia	Acute gastroenteritis

from *Salmonella* and all other pathogens is significantly reduced with proper hygienic practices.

1.1.2 Shigella

Shigella infection (shigellosis) is responsible for bacillary dysentery and is the primary cause of infectious diarrhea in the United States (Niederinghaus, 1986). Like *Salmonella*, *Shigella* is typically transmitted through oral ingestion of contaminated food and water or through hand-to-mouth contact. Few organisms are required to cause infection, which makes this bacteria a common biological hazard to wastewater workers (Niederinghaus, 1986). *Shigella* survives for only a short time in the sewer system, however, and generally represents a greater potential hazard for collection system workers than treatment plant operators.

1.1.3 Vibrio

Asiatic cholera is caused by *Vibro cholerae*, which produce a poison or endotoxin that results in vomiting, diarrhea, and loss of body fluids. Cholera can be spread by the ingestion of fecal-contaminated water and is typically present in many developing countries and communities with inadequate sanitation practices. Control of this disease is achieved through proper measures such as water disinfection and wastewater treatment.

1.1.4 Clostridium

Tetanus results from a localized infection of a deep or puncture wound by *Clostridium tetani*. Symptoms of infection include contraction of the muscles controlling the jaw, body muscle spasms, and paralysis of the throat muscle, which can lead to death from respiratory failure. The organism is commonly found in fecal-contaminated environments and in soils. Infection may occur whenever a deep wound is contaminated with wastewater-contaminated material. The general public, including wastewater system personnel, should make sure that tetanus vaccines are taken every 10 years after initial doses and after wounds, unless it has been fewer than 5 years since the last dose. A booster tetanus toxoid given at the time of injury will also provide immunity to the disease.

1.1.5 Yersinia

Yersinia entercolitica is an enteric pathogen that causes acute gastroenteritis. The most common symptoms are fever and diarrhea, with moderate dehydration. The fecal-oral route is the most common mode of transmission.

1.1.6 Campylobacter

Campylobacter fetus and *C. jejuni* cause acute bacterial enteritis (Tortora et al., 1982). These organisms are transmitted by the fecal-oral route through contaminated water sources and other modes. Most outbreaks of enteritis caused by *Campylobacter* have been associated with surface and drinking water supplies (Carter et al., 1987).

1.1.7 Leptospira

Leptospira bacteria are responsible for leptospirosis, or Weil's disease, which infects the liver, kidneys, and central nervous system. This disease was known as "the illness of the wastewater worker" in England before the 1950s. Recent studies, however, have not verified this bacteria as a current problem for wastewater workers. Infection typically occurs by way of contact with mucous membranes or skin abrasions (Hunter et al., 1987). Although *Leptospira* are killed rapidly in wastewater carrying detergent byproducts, this may represent an infection risk to collection system workers in some instances.

1.2 Viruses

A virus is any of a group of ultramicroscopic agents that reproduce only in living cells. This characteristic of viruses is important because viruses cannot reproduce without a host cell and, therefore, will not reproduce in wastewater. The primary source of viruses that are infectious to man is from human waste that has been discharged to the sewer (Hunter et al., 1987).

More than 100 different types of viruses are found in human waste. Human viruses commonly found in wastewater are listed in Table 8.3 (WEF, 2001). These viruses multiply in the living cells of the intestinal tract and end up in human feces. Because millions of viruses can be produced by an infected cell, they are found in large quantities in wastewater (Niederinghaus, 1986). Characteristics of various wastewater viruses and their mode of transmission and communicability are found in Table 8.4 (WEF, 2001).

While there are many types of viruses present in wastewater, the general category that has received the most study is the enteric, or intestinal, virus. This group includes varieties that are responsible for diseases such as infectious hepatitis, meningitis, poliomyelitis, respiratory diseases, gastroenteritis, and the common cold. Along with these various diseases, almost all of the viruses produce latent infections, which can go undetected because no symptoms may be present.

TABLE 8.3 Human viruses found in wastewater.

Virus group	Disease
Norwalk	Acute gastroenteritis
Rotavirus	Acute gastroenteritis
Adenovirus	Acute respiratory disease, conjunctivitis, pharynoconjunctival fever
Coxsackie A	Upper respiratory tract infection
Coxsackie B	Upper respiratory tract infection, myocarditis, aspectic meningitis, Bornholm's disease
Echovirus	Common cold, aseptic meningitis, conjunctivitis, gastroenteritis
Hepatitis A	Infectious hepatitis
Poliovirus	Poliomyelitis
Reovirus	Upper respiratory tract infection

TABLE 8.4 Characteristics of various wastewater viruses.

Virus group	Mode of transmission	Incubation period	Period of communicability
Adenovirus	Inhalation	5–7 days	Short
Echovirus	Inhalation	1–2 days	Short
Hepatitis A	Ingestion	15–40 days	Long
Poliovirus	Ingestion	5–20 days	Long
Norwalk	Ingestion		
Rotavirus	Ingestion		
Coxsackie A	Ingestion or inhalation		
Coxsackie B	Ingestion or inhalation		

1.2.1 Hepatitis A

The main waterborne disease resulting from viral infection is hepatitis A. The hepatitis A virus is the causative agent of infectious hepatitis, a systemic disease primarily involving the liver. The virus is commonly associated with fecal-oral transmission

through wastewater contamination and contaminated food. An infected person generally exhibits flu-like symptoms, cramps, vomiting, high fever, and jaundice.

The hepatitis A infectious agent is resistant to heat, acid, and chemical treatment, including low levels of chlorine (Kowal, 1986). Thus, wastewater personnel have a higher potential incidence of exposure to the hepatitis A virus because of their daily contact with wastewater.

1.2.2 Norwalk Virus

Another common type of virus that has been associated with inadequately treated wastewater is the Norwalk agent. The Norwalk agent produces an acute gastrointestinal disease consisting of vomiting, diarrhea, low-grade fever, and body aches. Symptoms generally last for a short period of time, typically 24 to 48 hours. During this time, the virus can be passed through the stool and has the potential to affect other members of the family if appropriate hygiene is not practiced in the home. Outbreaks of the illness have been associated with septage disposal, municipal water supplies, and recreational water contact.

1.2.3 Adenovirus

Adenoviruses have been associated with respiratory tract infections and conjunctivitis (eye infection). The virus has been isolated from wastewater and sludges and can cause acute diarrheal disease and viral gastroenteritis.

1.2.4 Rotavirus

Rotaviruses are a common cause of acute viral gastroenteritis. Outbreaks of this common illness have been associated with wastewater-contaminated water resources. Raw wastewater and chlorinated wastewater effluents from activated sludge plants treating domestic wastes have been shown to discharge high densities of these viruses each day (Hejkal et al., 1984).

1.2.5 Coxsackieviruses A and B

Coxsackievirus A causes aseptic meningitis and conjunctivitis and is one of the causes of the common cold (Jawetz et al., 1982). Coxsackievirus B causes several types of diseases, including heart disease (Jawetz et al., 1982). The primary modes of transmission for coxsackieviruses are through inhalation and ingestion of contaminated materials.

1.2.6 Poliovirus

The poliovirus is associated with poliomyelitis, which affects the central nervous system. The primary mode of transmission is ingestion of fecal-contaminated water

containing the virus. The poliovirus is a more stable virus than most other viruses and can remain infectious for relatively long periods of time in contaminated food and water (Tortora et al., 1982).

Poliovirus vaccines have reduced the incidence of poliomyelitis and have contributed to the decline in reported cases of the disease. Outbreaks typically occur only in segments of the population lacking proper immunization.

1.2.7 Acquired Immune Deficiency Syndrome

Acquired immune deficiency syndrome (AIDS) is caused by the human immunodeficiency virus (HIV) that attacks the body's immune system, leaving the body susceptible to numerous diseases. The AIDS virus is a delicate virus that cannot survive for long periods of time outside of the human body. The virus exists in low concentrations in the blood of infected persons and after entering the wastewater sewer system, it is subjected to enormous dilution factors and harsh environments (low levels of heat, pH extremes, surfactants, and chemical agents) that are not conducive to AIDS virus survival (Gerardi et al., 1988).

Operators have been concerned with the possible transmission of AIDS from human wastes such as urine, excrement, and blood that are discharged to sewer lines serviced by municipal wastewater treatment facilities (Clark, 1987). Fears have been raised over the handling of raw wastewater during routine contact and during repairs and maintenance to lift station pumps, bar screens, broken sewer lines, and clogged laterals. Further contact with contaminated wastewater originating from prisons, hospitals, and institutions and uneasiness over the removal of hypodermic needles, condoms, feminine napkins, and aborted fetuses have added to the growing apprehension about disease transmission (Clark, 1987).

Acquired immune deficiency syndrome and hepatitis B are both blood-borne viruses and cannot reproduce outside the human body. To be transmitted, AIDS and hepatitis B must enter the bloodstream directly. A blood-borne virus from contaminated wastewater can gain direct access through an open wound or abrasion of the skin. Merely coming in contact with contaminated wastewater does not imply exposure to AIDS or hepatitis B.

The Centers for Disease Control and Prevention has stated that there is no scientific evidence that HIV is spread in wastewater or its aerosols. The virus has never been recovered from wastewater and it is believed that the pH, temperature, and other conditions of the collection system are not suitable to its survival. There have been no known cases of wastewater workers or plumbers who have contracted AIDS where the mode of transmission was judged to be from occupational exposure.

The scientific evidence to date indicates that AIDS cannot be contracted through occupational exposure associated with wastewater treatment. Generally, infected body fluids that are discharged to sewers are immediately diluted to the point where they do not represent a significant risk to wastewater workers. The AIDS virus, in particular, is not well suited to the collection system environment and is likely to become deactivated upon contact with wastewater. Wastewater workers should, however, pay close attention to personal hygiene and exercise caution and common sense whenever they are working in and around contaminated wastewater to minimize exposure to bacteria and viruses.

1.3 Parasites

A parasite lives on or in another organism of a different species, from which it derives its nourishment. The organism is called the parasite's *host*. Parasites typically do not kill their hosts because the life of the parasite would also be terminated.

In many instances, however, parasites will weaken the host or cause symptoms similar to disease caused by bacteria or viruses. Waterborne parasites found in wastewater consist of various types of protozoa and worms. These organisms often do not survive the journey through the wastewater collection system and treatment facilities. The cysts and eggs, in which the protozoa and worms reproduce, are often resistant to adverse conditions. These resistant cysts and eggs, therefore, may show up in wastewater or sludge samples.

The number and variety of parasitic forms present in wastewater or sludges depend heavily on the origin of wastes entering the treatment plant. The most commonly studied protozoa are *Entamoeba histolytica* and *Giardia lamblia*. *E. histolytica* is the agent that causes amoebic dysentery, a disease with symptoms that include varying degrees of abdominal cramps and diarrhea, alternated with constipation. *G. lamblia* is also contracted orally and can lead to a variety of intestinal symptoms. *Giardia* is hardy protozoa that exists in a cyst stage and can be resistant to chlorination. The most common parasites found in wastewater are listed in Table 8.5 (Clark, 1987; Niederinghaus, 1986).

The eggs of many varieties of roundworms, hookworms, and tapeworms have also been found in wastewater. Infestation of roundworms and tapeworms is typically transmitted orally and typically results in abdominal pain and weight loss. Hookworms are generally transmitted through cracks in bare skin (such as between the toes), although oral infestation is also possible. Hookworms cause a general loss of energy and anemia (Niederinghaus, 1986).

Table 8.5 Parasites found in wastewater.

Organism	Disease
Protozoa	
Entamoeba histolytica	Amoebic dysentery
Giardia lamblia	Giardiasis
Roundworms (nematodes)	Abdominal pain and weight loss
Hookworms (ancylostomatodes)	Anemia
Tapeworms (cestodes)	Abdominal pain and weight loss

Parasite survival rates are affected by the wastewater or sludge treatment processes to which they are subjected. In general, each process that exposes a parasite to a different or hostile environment may shorten its survival time.

In instances of parasitic infestation, it is possible that the host's symptoms may be nonexistent. Because hand-to-mouth contact is the principal cause of infection, it is important that hands are washed frequently.

1.4 Macroorganisms

There are numerous places where rodents can be attracted to wastewater facilities. The most common areas where this occurs are screening, grit collection, and sludge treatment and disposal areas. Screenings and grit should be collected and stored in containers that minimize rodents from entering and congregating. General good housekeeping practices should also minimize rodents from becoming a problem.

Insects can also become a problem at wastewater treatment plants. Any areas of standing water or ponding can become breeding grounds for insects such as mosquitoes. Standing water, therefore, should be eliminated. If possible, tanks that contain water or wastewater and are not being used should be drained. Good housekeeping practices should be followed to prevent attraction of insects.

2.0 HOW INFECTIONS CAN SPREAD

There are three basic routes that may lead to infection: ingestion through splashes, contaminated food, or cigarettes; inhalation of infectious agents or aerosols; and infection caused by an unprotected cut or abrasion. Wastewater workers often come in physical contact with raw wastewater and sludge during their daily activities. Even when direct physical contact is avoided, the worker may handle objects that are

contaminated. Cuts and abrasions, including those that are minor, should be cared for properly. Open wounds invite infection from many of the viruses and bacteria present in wastewater. Table 8.6 summarizes significant routes of infection.

Ingestion is generally the primary route of wastewater worker infection. The common practice of touching the mouth with the hand will contribute to the possibility of infection. Workers who eat or smoke without washing their hands have a much higher risk of infection. Most surfaces near wastewater equipment are likely to be covered with bacteria or viruses. These potentially infectious agents may be deposited on surfaces in the form of an aerosol or may come from direct contact with the wastewater or sludge. A good rule of thumb for a worker to follow is to never touch oneself above the neck whenever there is contact with wastewater. Table 8.7 lists methods to prevent ingestion of pathogenic organisms.

At locations where wastewater or sludge is sprayed, the possibility of inhaling infectious agents will increase. Workers should avoid prolonged exposures at those areas where contact with such aerosols are likely. In instances where prolonged

Table 8.6 Routes of infection.

Ingestion	Eating, drinking, or accidentally swallowing a pathogenic organism (e.g., hepatitis A)
Inhalation	Breathing spray or mist containing pathogenic organisms (e.g., common cold)
Direct contact	Entry of pathogenic organism to body via cut or break in the skin (e.g., tetanus)

Table 8.7 Methods to prevent ingestion of pathogenic organisms.

Wash hands
Never eat, drink, or use tobacco products before washing hands;
Avoid touching face, mouth, eyes, or nose before washing hands; and
Wash hands immediately after any contact with wastewater or sludge.
Control activities
Eat only in designated areas of the plant and away from treatment facilities and
Do not smoke or use chewing tobacco while working in direct contact with wastewater or sludge.

Table 8.8 Methods to prevent direct contact entry of pathogenic organisms.

Body
Wear protective clothing and equipment;
Shower and change clothes before going home;
Leave work clothes, gloves, and boots on-site to prevent possible disease transmission to family or friends;
Use separate lockers for street and work clothes to minimize contamination; and
If work clothes are washed at home, separate from the family wash and use chlorine bleach.
Hands
Wear gloves whenever there is contact with wastewater or sludge;
Use thin, disposable latex gloves for light work and reinforced rubber gloves for heavy activities, and discard gloves that become torn; and
Do not submerge hand below top of glove.
Face
Never touch face, mouth, eyes, ears, or nose while working with wastewater or sludge;
Wear goggles in the presence of heavy aerosols; and
Wear surgical-type masks or respirators in the presence of heavy aerosols.

exposure to aerosols is anticipated, use of surgical masks and goggles may help to minimize contact. Methods to prevent direct entry of pathogenic organisms by contact are included in Table 8.8.

3.0 HOW TO PREVENT INFECTIONS

3.1 Personal Protection Measures

The safety precautions required to significantly reduce the possibility of biological contamination by wastewater are outlined in Table 8.9. The most important consideration is the use of good common sense. If collection systems and treatment plant workers are aware of hazards, they can protect themselves simply by following correct personal hygiene habits. Laboratory workers also must be aware of the potential for infection because of the nature of the samples being handled.

Although there has been no evidence that wastewater workers have transmitted infection to their families, good personal hygiene is still important. Workers

Table 8.9 Workplace precautions and personal hygiene guidelines (Gerardi et al., 1998).

- Wash hands frequently with soap and water after contacting wastewater; visiting restrooms; before eating, drinking, or smoking; and at end of work shift.
- Promptly treat cuts and abrasions using appropriate first aid measures.
- Wear heavy duty gloves (or double gloving) and boots that are waterproof and puncture resistant.
- Wear surgical-type masks and goggles or face shields for prolonged exposure to wastewater aerosols.
- Change soiled uniforms or protective clothing as soon as the job is completed.
- Shower before changing into clean work clothes and shoes.
- Launder work clothes at work not at home.
- Handle sharp items with extra care to prevent accidental injuries.
- Clean contaminated tools after use.
- Follow good common sense and exercise extra caution whenever there is contact with contaminated water or sludge.
- Wherever possible, use dual lockers to separate work and street clothes.
- Promptly clean body parts that contact wastewater or sludges.

should thoroughly clean up at the end of the work day before going home. Ideally, soiled clothing should be laundered before it is taken home or it should be handled separately from domestic laundry and washed with hot water and disinfected. Dual locker systems are desirable for all wastewater workers, allowing one locker for work clothes and one for street clothes.

Another important key to preventing exposure is the proper use of personal protective equipment (PPE). Waterproof and puncture-resistant gloves should be worn whenever working with wastewater or sludge. If prolonged exposure to aerosols or dusts is anticipated, respiratory and eye protection should be worn. First aid kits should be readily available at the jobsite to allow for the immediate treatment of minor cuts. All tools contaminated with wastewater should be cleaned with a common cleaner or a mild solution of sodium hypochlorite.

3.2 Immunizations

The Centers for Disease Control and Prevention recommends that immunizations for diphtheria and tetanus be current for the general public, including all wastewater

workers. Boosters are recommended every 10 years after the initial immunizations (typically during childhood years) are administered. The tetanus booster needs to be repeated if a wound or puncture becomes dirty and if boosters have not been given within 5 years.

Primary vaccinations for polio and typhoid are presently considered to be sufficient unless there is a regional outbreak. The preventive effect of the vaccine immune serum globulin for hepatitis A is short-lived (about 3 weeks) and is not routinely recommended for wastewater workers unless there has been direct exposure to wastewater splashed into an open wound or the mouth or a severe outbreak has occurred in the community. The vaccine for hepatitis B is also not routinely recommended for wastewater workers because the risk of transmission by wastewater is extremely remote. Vaccinations are available from physicians, health clinics, and county health departments.

Presently, no additional immunizations above those recommended by the U.S. Public Health Service for adults in the general population are advised for workers in contact with wastewater. Wastewater workers and all other adults should be adequately vaccinated against diphtheria and tetanus. Poliovirus and typhoid vaccines and immune globulin are not routinely recommended for wastewater workers. Table 8.10 summarizes immunizations recommended by the U.S. Public Health Service (CDC, 1984).

3.3 Work Procedures

As discussed previously, when working at wastewater treatment facilities, the most important practice is personal hygiene. Workers should avoid direct contact with wastewater as much as possible by wearing PPE such as gloves, boots, respirators, face shields, and so on. In short, workers should assess the risk of exposure to wastewater and wear the proper PPE. When a cut or abrasion does occur, the worker should seek medical attention as soon as possible to clean and dress the affected area.

4.0 HOW TO TREAT INFECTIONS

All injuries should be treated promptly to prevent infection or illness. Potential entry points will exist for microorganisms to cause infection if minor breaks in the skin or mucous membranes resulting from burns, rashes, cuts, and insect bites are left untreated. Soap and water are the best initial first aid measures that can be used for

TABLE 8.10 Immunizations recommended by the U.S. Public Health Service (CDC, 1984).

Disease	Who needs immunization	Immunization
Hepatitis A	Individuals with close personal contact with hepatitis A	Hepatitis A immune globulin treatment
Hepatitis B	Homosexual males, household and sexual contacts with carriers, and those who have had direct exposure to blood of a person known or suspected to be a carrier	Hepatitis A immune globulin treatment and hepatitis B vaccine
Influenza Measles	Adults 65 years or older Adults born in 1957 or later, unless they have evidence of vaccination on or after their first birthday, documentation of physician diagnosed disease, or laboratory evidence of disease	Annual influenza vaccine Combined measles, mumps, and rubella (MMR)
Mumps	Adults, especially males, who have not been previously infected	Mumps vaccine
Pneumococcal disease	Adults 65 years or older	Pneumococcal polysaccharide vaccine
Rubella	Women of childbearing age, unless proof of vaccination or laboratory evidence of immunity is available	Rubella vaccine
Tetanus and diphtheria	Adults every 10 years after initial doses and after wounds, unless it has been fewer than 5 years since last dose.	TD vaccine

minor cuts. Table 8.11 lists recommended contents of a standard first aid kit. The first aid kit should include a variety of antibacterial ointments or disinfectants, dressings, waterless soap, antiseptic wipes, and sterile eyewash solution. An antibiotic ointment or disinfectant should be applied to the wound after thorough washing. Adhesive bandages, tape, and sterile gauze should also be used to further protect the treated area and to keep the wound clean and dry. Generally, prompt medical attention is

TABLE 8.11 Suggested contents of a first aid kit.

Variety of bacterial ointments/disinfectants
Dressings
Waterless soap
Antiseptic wipes
Sterile eyewash solution
Adhesive bandages
Tape
Scissors
Sterile gauze
Splint
Aspirin

required if the skin or mucous membrane is severely injured and in contact with contaminated wastewater or sludge or if severe wounds or punctures do not respond to methods to control bleeding.

Because wastewater workers frequently expose their hands to water and wastewater, occasional skin problems such as fungal infections, rashes, chapping, and cracking may occur. Protective hand creams or lotions can typically be used to minimize such problems. If these medications are ineffective or if contact dermatitis becomes a problem, an occupational physician should be consulted. If wastewater gets splashed into the eyes, ears, or nose of a worker, they should be immediately flushed with fresh potable water or solution from the first aid kit.

5.0 WORKERS WHO ARE AT RISK

Several studies have been conducted on the actual infection rate of wastewater workers. During early years of employment, wastewater workers may be more prone to illness than more experienced workers. Newer employees may experience increased rates of gastrointestinal and upper respiratory illnesses, which are thought to be related to biological exposures (Clark, 1987). Table 8.12 shows the results of various studies of health effects of biological hazards to wastewater

Table 8.12 Summary of biological health risks to wastewater workers.

Type of hazard	Effects observed
Hepatitis A	Evidence of increased risk when working with raw wastewater and primary sludge.
Other viral infections	May indicate infection in the most exposed workers. Other factors contributing to infection should not be overlooked.
Leptospirosis	Formerly considered a problem; risks now appear minimal.
Gastrointestinal illness	Increased rates, especially among new workers. Other factors contributing to infection should not be overlooked.
Compost-related factors	Excess nasal, ear, and skin abnormalities and eye irritation.

workers (Clark, 1987). Although areas of higher risk exist, the risk of contamination is not overwhelming. Simple procedures involving personal hygiene and work methods, however, can reduce these risks to far below other common occupational hazards.

Most studies have indicated that areas with the greatest risk for infection involve routine and direct contact with untreated wastewater or sludge. Included in this category are workers involved in sewer maintenance and raw sludge handling. Various treatment processes designed for solids or biochemical oxygen demand (BOD) removal will provide varying degrees of disinfection, as shown in Table 8.13 (Metcalf and Eddy, 2003). Risk of infection will rapidly decline as wastewater undergoes various treatment steps.

5.1 Collection System Personnel

Because of their direct high exposure to raw wastewater, collection system workers have greater risks of infection than do treatment plant employees. Although various studies have indicated evidence of increased risk of viral infections (including hepatitis A), parasite infection, and gastrointestinal illness in these workers, improved and modern work practices can reduce these risks. Leptospirosis, transmitted through the urine of infected rats, was considered to be the British sewer worker's disease before the 1950s (see Section 1.1.7). Recent investigations have revealed that the risk of this particular bacterial infection is minimal. Present-day wastewater characteristics and probable lower infection rates in rats may have contributed to the reduced prevalence of this disease.

Table 8.13 Percent removal of bacterial pathogens by individual different treatment processes.

Process	Percent removal
Course screens	0–5
Fine screens	10–20
Grit chambers	10–25
Plain sedimentation	25–75
Chemical precipitation	40–80
Trickling filters	90–95
Activated sludge	90–98

5.2 Treatment Plant and Laboratory Personnel

All operators at wastewater treatment facilities do not necessarily fall into the high-exposure group. Studies have shown increased risk for those operators involved with raw sludge handling or in enclosed areas where wastes are aerated or agitated. While all operators have the opportunity to come in contact with various infectious agents, those handling digested sludge or outdoor wet processes appear to have lower risk of infection.

Laboratory personnel are required to perform analyses on a variety of wastewater and sludge samples. Although the risk of infection from wastewater samples is not as high in the laboratory environment as in sewers or outside facilities, infectious agents that are commonly found in such samples are nevertheless a biological hazard.

The risk of laboratory-acquired infection results from any procedure that releases infective organisms to the environment or affords access for such organisms to the human body (Hurrell, 1982). The most widespread mechanism for laboratory-acquired infection is typically by airborne contamination of the infective agent. The laboratory environment, therefore, should be properly ventilated by a plenum and exhaust air system to minimize exposure to chemical or biological risks. Exhaust air should be routed from the laboratory to the outside of the building and discharged to the atmosphere.

Laboratory workers must be provided with adequate training in proper microbiological techniques and safety. Workers should be familiar with aseptic handling techniques and the biology of the organisms under evaluation to fully appreciate the

potential hazard. An emergency procedure should also be developed to deal with accidental contamination of personnel and work areas and appropriate vaccinations should be administered if known pathogens are being evaluated. All laboratory apparatuses and waste should also be decontaminated by disinfection or sterilization to keep the environment free from microorganisms. Table 8.14 lists recommended safe laboratory practices.

5.3 Biosolids Personnel

Specific studies have been conducted on workers who deal with wastewater sludge composting. The heat generated in a properly managed composting operation is sufficient to significantly reduce levels of all pathogens of concern in the wastewater industry. The conditions created in composting, however, allow for the proliferation of many thermophilic microorganisms such as *Aspergillus fumagatus*. *A. fumagatus* grows well at 45 °C (113 °F) and higher, which makes it prevalent at composting sites. The mode of infection is by way of inhalation of *A. fumagatus* spores in the dust at the site. Symptoms that have been reported by workers include abnormal skin, ear, and nose infections. Higher rates of eye and skin irritations have also been noted (Clark et al., 1984). Although it is unknown whether these symptoms were attributable to the composting operation, appropriate eye and respiratory protective measures should be used.

Table 8.14 Safe laboratory practices.

- Do not eat, drink, or smoke while handling wastewater or sludge samples.
- Wash hands before and often while working in the laboratory.
- Wear protective clothing, laboratory coats, eye protection, and latex gloves, as required.
- Do not place hands on face, eyes, nose, or mouth while working in the laboratory; always keep your hands below the collar.
- Use bulb to pipette samples; do not pipette by mouth.
- Wipe up spills immediately.
- Discard all unused samples immediately.
- Store non-compatible or highly reactive chemicals separately. Acids, alkalies, and chlorine should not be stored next to each other.
- Take extra precautions when handling glassware to prevent breakage injury.

Extensive studies pertaining to health effects associated with long-term exposure to sludge compost have not been conducted. Studies of these workers that have been conducted show a susceptibility to fungal infection from microorganisms grown in the composting process. However, these studies are of groups of compost workers in only four areas and may not be universally representative of the composting process. Further studies will be needed (e.g., some varieties of *Nocardia* are pathogenic to man) to determine if there are any significant biological hazards associated with long-term use of the sludge composting process.

6.0 SUMMARY

A number of occupational hazards confront treatment plant and wastewater collection system workers. The danger of infection to these workers through contact with wastewater is real if proper safety precautions are not observed. Although the possibility of infection is greatest for workers in high-exposure areas, such as collection systems and raw sludge processing, all workers who handle or come in contact with wastewater are susceptible to infection.

The incidence of occupational illness or disease among experienced wastewater workers is comparable to other non-wastewater-related professions. Wastewater workers, however, must be alert to the potential for illness and should use common sense and follow safe work procedures. The implementation of strong safety programs, good personal hygiene practices, and PPE and clothing will minimize the risk of exposure to infectious agents commonly found in wastewater and sludge.

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