Exposure to Biohazards

An emerging concern for construction workers in sewer lines and wastewater treatment plants

By Donald J. Garvey

MOST SEWAGE COLLECTION and treatment systems in the U.S. are 30 to 100 years old [EPA(b)] with a total estimated value exceeding $1 trillion [EPA(a)]. EPA estimates that in the year 2000, more than 1.2 billion gallons of raw sewage poured into waterways due to overflow, blockage, leakage or other system faults [EPA(b)]. The construction projects needed to correct these problems will be many and enormous. Upgrades to the City of Atlanta sewage system alone are estimated to cost around $3 billion (Copeland A3).

The problem is not limited to large metropolitan areas. A study by the Minnesota Pollution Control Agency suggests that $1.2 billion must be invested in wastewater facilities in rural Minnesota over the next 20 years (Franklin B3). As the nation's urban infrastructure continues to expand, age and deteriorate, and as the public's concern for environmental quality increases, construction work in active sewer lines and wastewater treatment plants (WWTPs) will grow. As a result, more construction contractors and workers will be exposed to the hazards associated with working in these locations.

Most construction contractors are aware of the obvious health hazards of working in sewers or WWTP. For many, it is standard procedure to monitor sewers and WWTPs for combustible gas, oxygen deficiency and hydrogen sulfide, and to take appropriate precautions to minimize these hazards. However, because of the publicity surrounding diseases such as AIDS and the hepatitis B virus (HBV), as well as regulations such as OSHA's Bloodborne Pathogens Standard, new concerns and questions are being raised about the biohazards that may be present in these environments.

Construction safety professionals must also be aware of the potential for exposure to chemicals used in WWTPs (e.g., chlorine, ozone) or those that may contaminate raw sewage (e.g., solvents, heavy metals). In some cases, these may pose a greater risk to workers than the biohazards.

Wastewater Treatment Plant Operations

Most modern WWTPs consist of four main units:

- Pretreatment: Bar racks, grit chambers and equalization chambers. These are used primarily to protect a WWTP itself. Bar racks and grit chambers remove large objects (e.g., rags, logs, glass) that could damage pumps or valves. The equalization chamber improves the plant's efficiency by smoothing out the variation in flow rates during the day.
- Primary treatment: Settling tank that uses gravity to remove light organic suspended solids. The settled solid that is produced is called raw sludge.
- Secondary treatment: Primary purpose is to reduce the biological oxidative demand (BOD) of the wastewater and to remove more suspended solids. Bacteria inherent in the sewage and sludge are used to reduce the BOD through "trickle filters" or more commonly through a process called "activated sludge."
- Disinfection: Adding disinfectant is usually the last step in wastewater treatment. In the U.S., chlorine or a chlorine compound is typically used; ozone may be used as well.

Some WWTPs use advanced or tertiary treatment to control specific pollutants such as phosphorus or nitrogen compounds that could adversely affect water quality if discharged into the receiving body of water (Davis and Cornwall 364).

The waste sludge produced is usually handled through a process of:

- dewatering, which involves removing water by gravity;
- stabilization, which converts organic solids to a more inert form so they can be safely handled;
- conditioning, in which chemicals and heat are used to prepare the sludge for further water removal;

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• dewatering, which uses a vacuum or pressure to separate water from the sludge.

Remaining biosolids are then landfilled or disposed of by land spreading (applying residuals to soil). EPA has published regulations regarding the use or disposal of sewage sludge in 40 CFR Part 503.

Wastewater Biology

Raw sewage may contain various disease organisms including bacteria, viruses, fungus, worms and protozoa (McCunney 273; Weldon, et al 821; Schlosser, et al 261). The composition of the sewage can vary greatly based on geographical location, time (both weekly and seasonal basis) and location within a WWTP.

Airborne bacteria concentrations are typically highest wherever sewage is agitated, such as near incoming wastewater inlets and sludge treatment areas (Laitinen, et al 1055). However, contractors and workers should not assume that any area is necessarily clean. Airborne bacteria have been found in "clean" areas such as control rooms, although at much lower levels relative to other areas of a WWTP (Laitinen, et al 1057). Table 1 lists several organisms that may be present as well as typical signs and symptoms of exposure.

The primary route of exposure to these organisms is hand-to-mouth contact or the "fecal-oral route" (McCunney 273). This can occur during eating, drinking or smoking, or by touching the face with contaminated hands or gloves (HSE 2). Inhalation of aerosols containing microorganisms is a less-common yet important method of entry. Skin absorption is unlikely unless the skin has been previously damaged by cuts, blisters, burns or puncture wounds (Laitinen, et al 1055; McCunney 273). Mucous membranes (such as in the eyes and nose) may also provide a portal of entry for certain organisms.

Disease Studies

In general, studies have not shown higher infection rates (i.e., diagnosed disease) for sewage workers compared to similar populations of workers not exposed to sewage (McCunney 265). One study compared the rate of parasitic organism infections between 125 sewage workers and 125 highway workers. After one year, no differences in infection rates were found. Another study involving 150 wastewater treatment workers found no cases of polio, salmonellosis, leptospirosis, shigellosis, typhoid fever, hepatitis A, giardiasis or amoebiasis (Khuder, et al 573).

Abstract: *Urban expansion, aging infrastructure and environmental awareness have greatly increased the need for construction work in existing sewer and wastewater treatment plants (WWTPs). This article reviews the general process of wastewater treatment, microorganisms that may be in wastewater, the risk of infection by these organisms and preventive steps SH&E professionals can implement to protect workers and minimize risks. Chemical hazards that may be found in wastewater or a WWTP are also reviewed.*

Table 1

Organisms that May Be Found in WWTPs or Sewage

Organism	Signs & Symptoms	Average Latency Period
Bacteria		
Salmonella	Nausea, headache, diarrhea and vomiting; almost always with a fever.	6 to 72 hours
Tetanus (lockjaw)	Muscular stiffness in jaw, neck. Sweating, fever, difficultly swallowing.	8 days
Shigella	Cramps, diarrhea, fever, bloody stool, nausea, vomiting.	1 to 3 days
Leptospirosis (Weil's Disease)	Intestinal problems, liver and kidney disease, jaundice.	4 to 10 days
E. coli	Diarrhea, vomiting, little or no fever, blood often seen in stool.	Approximately 3 days
Tulareisis	Chills, fever, swollen lymph nodes, stomach pain, diarrhea, vomiting.	3 to 5 days
Yersinia	Diarrhea, fever, abdominal pain that resembles appendicitis.	1 to 14 days
Viruses		
Hepatitis A	Fever, abdominal pain, nausea, jaundice, dark-colored urine.	Approximately 30 days
Hepatitis B	Nausea, vomiting, loss of appetite, jaundice, joint pain.	60 to 90 days
Hepatitis C	Develops slowly, loss of appetite, stomach pain, nausea and vomiting. Jaundice is less common.	6 to 9 weeks
HIV	Destroys immune system, prone to opportunistic infections.	1 to 2 years
Polio	Fever, headache, nausea, muscle pain and stiffness, paralysis.	6 to 20 days
Parasites		
Entameoeba histolytica (amebiasis)	Mild nausea, loose stool, abdominal tenderness. In severe cases can spread throughout the body and attack other organs, especially the liver.	14 to 28 days
Giardia lamblia	Cramps, weight loss, loose/greasy stool, bloating. Fever is rare.	7 to 10 days

Sources: AFSCME; Utah Dept. of Health.

However, studies have shown increased risk of occurrence of symptoms associated with infection (e.g., headache, gastrointestinal upset, dizziness, eye irritation), and with indications of subclinical infection such as the presence of antibodies to a particular disease organism (Glas, et al 762; Khuder, et al 571).

Many subjects who reported symptoms or illnesses were relatively new, inexperienced workers (less than two years) in WWTP. For example, one study of 500 workers indicated that new employees (less than two years' experience) had a higher rate of gastrointestinal symptoms—although the symptoms were mild and transitory (McCunney). These findings may be significant for construction safety professionals because most construction workers will likely have limited experience working in WWTP environments and, therefore, may be at greater risk of experiencing adverse symptoms.

No cases of HBV have been linked with sewage exposure. HBV would be very diluted in sewage and is not transmitted by inhalation or the oral-fecal route. Similarly, human immunodeficiency virus (HIV) would be extremely diluted and is not transmitted by either of these two mechanisms. One study indicated that HIV is "fairly stable" in raw (nonchlorinated) sewage for up to 12 hours, but quickly loses its infectivity after that (Casson, et al 213). The risk for contracting either disease by contact with sewage appears to be extremely low (California Dept. of Health Services 1; AFSCME 2).

While hepatitis A virus (HAV) can be stable at room temperature for up to three months (Shakespeare and Poole 364), studies have not shown an increased risk for workers contracting a clinical case of the disease (Levin, et al 7; Venczel, et al 172). However, there appears to be a slightly increased risk of subclinical infection as noted by the presence of anti-HAV antibodies (Glas, et al 762). Other authors, while stating that HAV is an occupational hazard in WWTP, concede the incident rate is low (DeSerres and Laliberte 61).

Hepatitis C virus (HCV) is a growing public health concern. One study discussed two cases of HCV in sewer workers. While neither was proven to be work-related, the authors felt all other known risk factors were absent, which suggests an occupational source (Brautbar and Navizadeh 329). HCV can remain viable on environmental surfaces for at least

16 hours, but for no longer than four days [CDC(b)]. At this point, Centers for Disease Control and Prevention (CDC) does not recommend routine testing for HCV among sewer workers.

Another study concluded that there was no clear increase in the risk of infection by hepatitis E (HEV) and Heliobacter pylori in workers exposed to sewage. Heliobacter is a major cause of gastric and duodenal ulcers. The researchers cautioned that their results need to be confirmed by follow-up studies (Jeggli, et al 622).

Precautions

Although risk of infection among sewage workers appears to be low, contractors and their workers should take precautions to ensure a safe worksite. As in the healthcare industry, construction workers should assume that all surfaces are contaminated with potentially infectious materials and use precautions when working in wastewater areas. Following are several safeguards.

•Disinfect work areas. This will depend on the situation. Areas can be disinfected with various detergents or products designed for that purpose. However, the practicality of this will be limited by size of the work area, surfaces to be treated and the potential for recontamination after disinfecting. Proper use of disinfectants along with use of any required PPE are critical.

•Avoid direct contact with raw sewage. For pipelines or other inspections, remote-controlled robotic cameras can minimize human exposure.

•Avoid aerosolizing sewage water and minimize exposure time in areas where this is occurring. As noted, bacteria levels in a WWTP are highest where the water is agitated. Make sure in-place ventilation is functioning when working around areas that may aerosolize sewage (e.g., sedimentation basin inflow, sludge treatment).

•Use liquid-proof gloves, boots and eye/face protection when in direct contact with raw sewage. Faceshields should be used where splashing is anticipated. One study showed a significant relationship between increased use of faceshields and decreased presence of antibodies to HAV (Weldon, et al 825). All PPE should remain at the jobsite and be cleaned with soap and hot water (160ºF) after each use. Skin protection is especially important if skin is chapped, burned, cut or otherwise damaged. Puncture-resistant gloves should be used when working with items that may cause cuts.

•Wash reusable clothing commercially at high temperatures (160ºF) to ensure that all organisms are destroyed (AFSCME). Contaminated clothing and PPE should be kept away from eating and food storage areas.

•Wear respirators when necessary. In most cases, respirators will not be necessary. However, American Federation of State, County and Municipal Employees (AFSCME) recommends that "a disposable dust mask be worn in dusty sludge areas or areas with heavy aerosols" (AFSCME).

•Wash hands and face regularly with soap and water, especially before eating, smoking and drinking, and at the end of the shift. The California Dept. of Health Services considers frequent handwashing to be the most important safeguard that WWTP workers can take (1). Proper technique is also important. Soap, warm water and time are the critical components. According to CDC, most people do not wash their hands for a sufficient duration. CDC recommends at least 15 to 20 seconds of washing with attention paid to both sides of the hands and between the fingers. Singing "Happy Birthday" twice is an easy way to approximate 20 seconds [CDC(c) 1].

•Keep hands out of nose, mouth, eyes and ears.

•Keep fingernails short.

•Shower daily.

•Store and consume food only in designated areas. One study found that workers who always ate in a designated dining area and used PPE were significantly less likely to have antibodies to HAV (Weldon, et al 825).

•Keep adequate first-aid supplies on hand, including clean water, wipes for cleaning wounds and sterile dressings.

•Clean, treat and report any cuts or punctures immediately. Consider all wounds as potentially infected.

•Provide periodic worker training on these topics: types of diseases; how organisms can enter the body; disease symptoms; high-risk areas; personal hygiene; need to receive immediate medical attention for injuries (especially puncture wounds and lacerations); proper use of PPE (e.g., regular cleaning or change out and removal before eating, drinking or smoking); and hazard communication (HSE 2). While OSHA's Hazard Communication Standard (29 CFR 1910.1200) does not apply to biological hazards, some state-plan states (e.g., Minnesota) require that exposures to biohazards be covered during hazard communication or right-to-know training.

These recommendations can also apply to workers handling portable toilets on jobsites.

For long-term workers, contractors may want to consider a preplacement medical exam that includes:

•medical history—limb mobility, skin disorders, asthma, disorders that could produce unconsciousness (e.g., diabetes, stroke);

•physical exam;

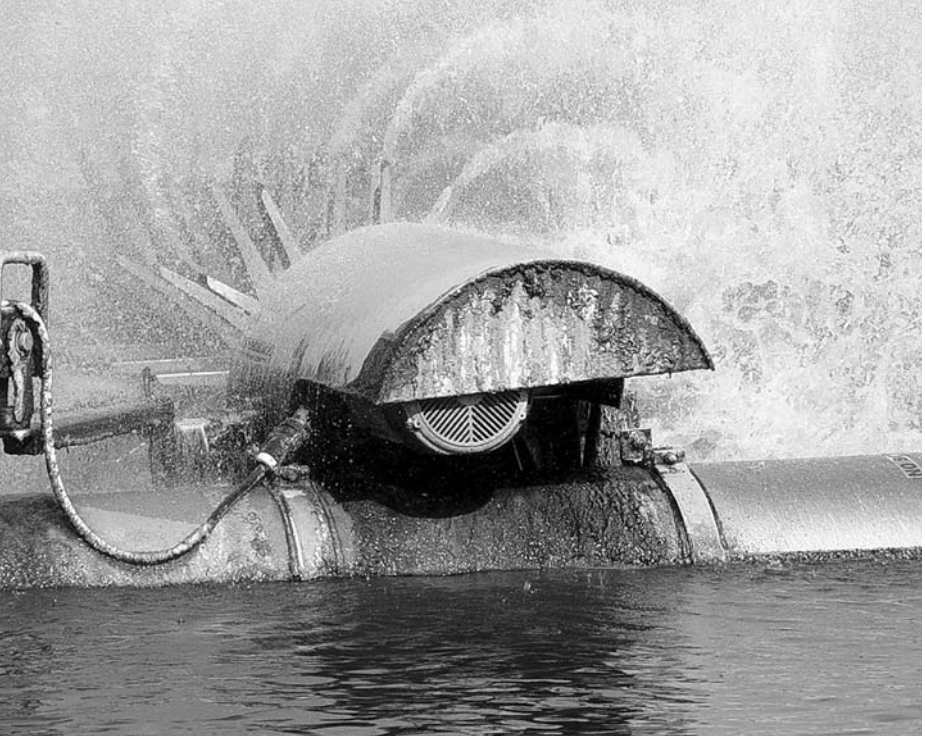
•liver, kidney and hematologic function;

•immunization review.

In addition, contractors should review the feasibility of implementing an ongoing healthcare review (McCunney 278; Alberta 2).

With the influx of foreign-born workers in the construction trades, contractors should not assume that everyone has the same vaccinations considered routine in the U.S. While no federal regulations require immunization of construction workers exposed to sewage, states, counties or municipalities may have their own regulations. Contractors should check with these entities to determine what requirements may apply in their regions. The California Dept. of Health Services offers these recommendations:

Working in or around raw sewage may expose construction workers to various disease organisms. Preplanning, careful attention to personal hygiene and proper use of PPE can reduce the related risks.



Airborne bacteria concentrations are typically highest wherever sewage is agitated, such as near incoming wastewater inlets and sludge treatment areas.

•Strongly recommend: tetanus-diphtheria (booster every 10 years).

•Optional: polio and typhoid fever. These must be discussed on a case-by-case basis with an occupational physician before taking any action.

•Not recommended: HBV, cholera (1).

Currently, neither CDC nor the Alberta Resource & Employment Workplace Health and Safety recommend that sewage workers be routinely vaccinated for HAV. However, Alberta does state that there is no reason not to provide the vaccination if workers and employers agree (Alberta 2).

Infection Investigation

If it is suspected that a worker has been infected with a microbe of potential occupational origin, the first step is to determine the likelihood that the organism is present in wastewater or sewage. Not every microbe can survive in this very aggressive environment. It must survive both the physical environment (e.g., pH, temperature) and competition from other microbes. In addition, the organism must survive in sufficient numbers to present a threat of an infectious dose.

In the case of bacteria, gram-negative enteric organisms predominate, with Escherichia coli (E. coli) being the most common example. Therefore, a gram-positive bacterial infection would be much less likely to originate from exposure to sewage. If an infection of occupational origin is suspected, response and investigation steps may address the following questions:

•Has the microbe in question been identified in the person? What tests were used to make the diagnosis? Are symptoms consistent with the suspected microbe?

•Could the microbe be present and in significant amounts in the environment where the worker was allegedly exposed?

•Could exposure have occurred? Was there an opportunity for the worker to be exposed to the microbe?

•Was there an opportunity for the microbe to enter the body (e.g., puncture wound)?

Chemical Hazards

In addition to biohazards in sewage and WWTPs, potential chemical hazards should also be addressed.

•Chlorine gas. Many WWTPs use chlorine or chlorine products to disinfect the water before discharge. Workers should be trained to take precautions when working around chlorine, to recognize a chlorine leak and alarm signals, and to take proper action (e.g., evacuation) if a leak occurs.

•Hydrogen sulfide. For work in sludge tanks, monitoring for hydrogen sulfide and combustible gas should be mandatory. The need for nonsparking tools should also be reviewed.

•Those involved should anticipate heavy metal contamination of the sludge.

•Carbon monoxide and carbon dioxide can be present because of improperly located gasoline engines used on the worksite (Alberta 1).

Contractors also need to be aware of chemicals that may be present in the sewage itself. EPA has established "prohibited discharge standards" (40 CFR 403.5) for all industrial discharges into WWTPs and "categorical pretreatment standards" for specific industries (40 CFR 405-471). However, improper disposal—whether accidental or deliberate—still occurs (Davis and Cornwall 363). For example, gasoline vapors from nearby leaking underground storage tanks may seep into sewage lines; in other cases, heavy metals, solvents or other contaminants may be present as a result of industrial operations connected to the system.

Examples of Chemical Exposure

Hexachlorocyclopentadiene, an intermediate in the manufacture of several pesticides, was dumped into a Kentucky sewage system in 1977. Workers at the WWTP reported acute eye and throat irritation (Morse, et al 217). In Cincinnati, a mixture of Stoddard Solvent and hydrochloric acid was implicated in an incident involving sewer repairmen. The workers reported nausea, headache, vomiting, and eye and throat irritation (McGlothlin 89). In a New York City WWTP, workers complained of unusual odors. Air monitoring when the odor was present detected toluene concentrations of up to 200 parts per million (ppm) and benzene concentrations ranging from 30 to 300 ppm (Kraut, et al 263). The current American Conference of Governmental Industrial Hygienists threshold limit value for toluene is 50 ppm and 0.5 ppm for benzene (ACGIH).

Before a project begins, the contractor should work with the sewage system owners/operators to assess whether any industrial facilities or other sources of chemical release may be upstream of the facilities that will be part of the project.

OSHA & Bloodborne Pathogens

The construction industry is currently exempt from the federal Bloodborne Pathogens Standard [OSHA(c)]. However, the General Duty Clause [Section 5(a)(1)] of the OSH Act requires that contractors provide a workplace free from known hazards—such as bloodborne pathogens. With one

exception, OSHA does not consider sewage to be "other potentially infectious material" as defined in 29 CFR 1910.1030 [OSHA(b)]. That exception is sewage within or coming directly from a healthcare facility or other facility where blood or blood products are discarded (i.e., not yet junctioned with other sewage lines).

Workers exposed to this material may be covered under 5(a)(1) or other standards with regard to bloodborne pathogens. These standards include:

•29 CFR 1926.21(b)(2), which requires an employer to instruct each employee to recognize and avoid unsafe conditions. The employer would be required to train workers in the hazards of bloodborne pathogens.

•29 CFR 1926.25, which requires collection and separation of sharps and other waste that may be contaminated.

•29 CFR 1926.28, which requires use of appropriate PPE. The contractor is required to provide gloves, boots, coveralls and eye/face protection where appropriate [OSHA(a)].

It should be noted that construction workers who are designated first-aid responders are covered under these provisions regardless of jobsite location or exposure to sewage.

Conclusion

Working in or around raw sewage may expose construction workers to various disease organisms. While the risk of infection appears to be low, headache, gastrointestinal distress and other symptoms may appear that could negatively impact worker comfort, safety and productivity. Preplanning, careful attention to personal hygiene and proper use of PPE can greatly reduce the related risks. ■

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