# Wastewater Treatment Processes

by Assistant Chief Ronald R. Spadafora

The process of removing contaminants from wastewater--both run-off (effluents) and domestic--is called sewage treatment. It can be processed close to where it is created or collected and transported via a network of pipes and pump stations to a municipal treatment plant. The purpose of wastewater management is to discharge water efficiently and remove solids from the wastewater to permit additional treatments, if necessary, depending upon its intended reuse. Removed solids are normally organic, but may include inorganic materials. Treatment also must be provided for the solids and liquids that are removed as sludge. Additionally, controlling odors, retarding biological activity, destroying pathogenic organisms and disinfection may be required.

Wastewater treatment methods can be categorized by the nature of the treatment process operation. They are broadly presented below. A comprehensive treatment system may consist of several physical, biological and chemical processes. Levels of wastewater treatment include *primary*, *secondary* and *tertiary* processes. Primary methods are designed to physically remove suspended particulate matter. Implementing microorganism and biological techniques, a secondary step is used to stabilize organic matter. Lastly, tertiary treatment includes disinfection, incorporating chemicals, ozone or ultraviolet (UV) irradiation procedures.

**Primary**

This method involves physical processes where no gross chemical or biological actions are undertaken. It entails the removal of materials that can be collected from raw wastewater before they damage/clog pumps and skimmers. One way this is accomplished is by screening received wastewater to remove all large objects carried in the stream. Using automated mechanical screens, the process is commonly performed in modern facilities serving large populations. The solids are collected and later disposed in a landfill or incinerated.

Primary treatment also may include funneling water through a filter medium (filtration) to separate solids. In certain industrial wastewater treatment processes, solid waste "slugs" sometimes are produced. Slugs are physically removed, mixed with other wastewaters and gradually released. This is known as equalization. Screening equipment is an entanglement hazard for workers who perform maintenance on them. The lower level of this equipment also may be considered a confined space. Members should become familiar with the location of these screens and evaluate the dangers if it becomes necessary for them to extricate victims.

Sedimentation is another physical method used to remove solid materials. It involves controlling the velocity of the incoming wastewater. Holding wastewater in containers for short periods of time under stable conditions allow heavy particulate to settle via gravity. During this process, greases and oils will float to the surface of the wastewater. This residue is skimmed off manually.

**Secondary**

Biological decomposition of wastewater for stabilization of organic matter is performed subsequent to solid particulate removal and, therefore, is called secondary treatment. It uses indigenous, water-borne microorganisms (bacteria) in a managed containment area. More microorganisms are created and a percentage of the waste is converted to carbon dioxide, water and other end products. A separation process to remove the microorganisms from the treated water may be required prior to discharge or before tertiary treatment. Generally, biological treatment methods can be divided into aerobic and anaerobic processes, based on availability of dissolved oxygen.

During aerobic wastewater treatment, microorganisms that thrive in oxygen-rich environments feed on organic materials in the wastewater. This process is called aerobic "digestion." Aerobic treatment systems use compressed air that is injected near the bottom of open tanks to mix the microorganisms and bring them into contact with organic materials. Oxygen in the air also is used by the microorganisms during their life cycle.

An aerobic tank can be as long as a football field and more than 10 feet deep. Drowning is a real threat should a worker or Firefighter (especially when wearing bunker gear) inadvertently falls into one. Ensure that proper precautions (safety railings, portable ladders, life preservers, etc.) are in place and in good condition when inspecting the facility. Units must consider adding water rescue equipment (buoys, throw ropes, portable ladders, etc.) to the complement of tools brought to the scene during incidents involving these tanks. Empty tanks negate the danger of

**(Left) Mechanical screens are an entanglement, as well as a confined space, hazard for facility personnel and FDNY members. They are used in primary wastewater treatment processes. (Center) Aerobic wastewater treatment tanks are used as a secondary process. (Right) Biogas storage poses flammability and toxicity hazards.**

**Biogas-fed electrical generator.**

drowning, but, unfortunately, introduce a grave fall hazard.

In the anaerobic wastewater treatment method, biological agents are used to remove the contaminant from water in the absence of oxygen. Microbiological reactions occur in closed tanks containing organic sludge after it is filtered from the wastewater. The microorganisms break down biodegradable material present in sludge. The conversion process, known as anaerobic "digestion," occurs through a series of reactions caused by enzymes and bacteria. Organic acids are formed and eventually converted to biogas (methane and carbon dioxide). This method reduces organic matter by 45 to 60 percent.

Biological treatment offers the chance to recover some of the costs of wastewater treatment facility operation through the formation and utilization of biogas. The biogas has a calorific value typically between 50 and 70 percent of that of natural gas and can be combusted directly in modified natural gas boilers or used to run combustion engines and electrical generators. Biogas utilization, generation and storage, however, can create both flammability and toxicity hazards.

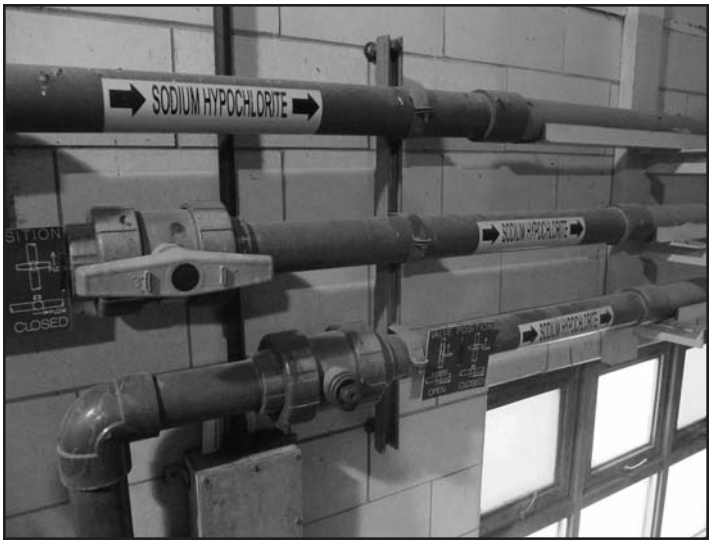
**Tertiary**

Disinfection is considered a tertiary treatment. Chemical methods use chemical reactions to act as disinfectants and improve water quality. The most commonly used chemical process is chlorination. Chlorine is a strong oxidizing gas that is used to kill bacteria and reduce the rate of wastewater decomposition.

Chlorine gas is delivered to wastewater sites in pressurized cylinders. A ventilation system should be provided inside the storage area, along with the installation of gas detectors for monitoring and alarm purposes in case of a system leak. Detectors also should be placed at other critical locations (meter room, HVAC system) at the facility. Piping identification for all connections to the cylinders should include color-coding (yellow), labeling and

| Physical Characteristics | Chlorine | Sodium Hypochlorite Solution |
|---|---|---|
| *Appearance:* | greenish/yellow gas or amber liquid | colorless/ pale yellow liquid |
| *Odor:* | pungent, suffocating bleach-like odor | pungent chlorine odor |
| *Solubility in Water:* | slight | 100% |
| *Physical State:* | gas (liquid under pressure) | liquid |
| *Gas-Specific Gravity:* | 2.486 (Air = 1) | 2.6 |

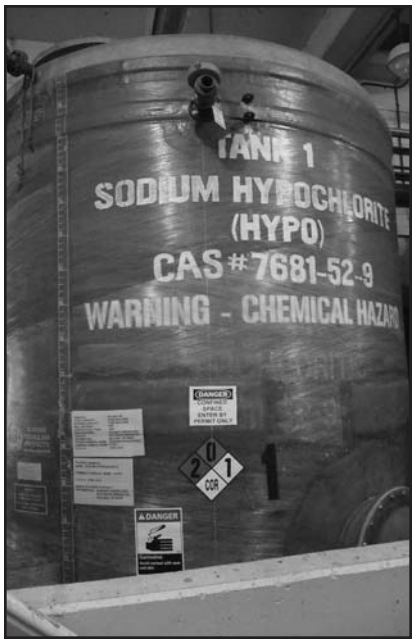
**Sodium hypochlorite solution delivery area.**




**Labeling and signs denoting product identification, flow direction and valve positioning information.**

arrows, indicating direction of flow. Chlorine is highly toxic and corrosive. It can be fatal if inhaled. Most combustibles will burn in chlorine as they do in oxygen!

Personal protective equipment (PPE) provides limited protection in fire situations only. Fully encapsulating (Level A) suits should be worn for spills and leaks. Skin moisture and chlorine can form acids that are corrosive. Water spray should be used to direct escaping gas away from potential victims and keep fire-exposed cylinders cool. If feasible, Firefighters should shut down cylinder valves to stop the flow of gas. Cylinders heated by fire can explode. Small fires involving chlorine should be extinguished using dry chemical




**Container holding sodium hypochlorite solution used for disinfection of wastewater during tertiary treatment.**

Members are urged to review the following references:
- Buzzle.com. "Wastewater Treatment: Industrial and Anaerobic," 2010. Retrieved November 19, 2011, from: http://www.buzzle.com/articles/wastewater-treatment-industrial-and-anaerobic.html
- Cheremisinoff, Nicholas P. *Handbook of Water and Wastewater Treatment Technologies*. Woburn, Massachusetts: Butterworth-Heinemann, 2002.
- Earthpace, LLC. "Wastewater Treatment Technology Tutorial," 2009. Retrieved October 22, 2011, from: http://www.earthpace.com/resources/wwt/index.html
- HALMA Trading and Services India Pvt. Ltd. "Wastewater Reuse Using UV Disinfection," June 2009. Retrieved November 29, 2011, from: http://halmapr.com/news/india/2009/06/11/wastewater-reuse-using-uv-disinfection/
- Hill Brothers Chemical Company. "Material Safety Data Sheet-Product Name: Sodium Hypochlorite," revision issued September 24, 2008. Retrieved December 2, 2011, from: http://www.hillbrothers.com/msds/pdf/sodium-hypochlorite.pdf
- Jantrania, Anish R., and Mark A. Gross. Advanced Onsite Wastewater Systems Technologies. Boca Raton, Florida: CRC Press, 2006.
- Long, Harriett. "Lesson 4: Aerobic and Anaerobic Digestion and Types of Composition." Retrieved November 20, 2011, from: http://water.me.vccs.edu/courses/ENV149/lesson4b.htm
- National Institute for Occupational Safety and Health (NIOSH). "Emergency Response Card: Chlorine," last updated August 22, 2008. Retrieved December 7, 2011, from: http://www.cdc.gov/niosh/ershdb/PrintableERC_29750024.html
- "Sodium Hypochlorite." Retrieved December 1, 2011, from: http://www.talas-nyc.com/photos/msds/sodiumhypochlorite.pdf
- Spellman, Frank R. *Choosing Disinfection Alternatives for Water/Wastewater Treatment*. Lancaster, Pennsylvania: Technomic Publishing Company, Inc., 1999.
- Sperling, Marcos von. *Biological Wastewater Treatment* Volume 2: Basic Principles of Wastewater Treatment. London: IWA Publishing, 2007.
- The Guides Network. "Ozone Wastewater Treatment." Retrieved December 5, 2011, from: http://water-pollution.wp.fubra.vc.catn.com/ozonewastewatertreatment.html
- Tillman, Glenn M. *Primary Treatment at Wastewater Treatment Plants*. Chelsea, Michigan: Lewis Publishers, Inc., 1992.
- U.S. Department of the Interior (U.S. Geological Survey). "Water Science for Schools--A Visit to a Wastewater-Treatment Plant: Primary Treatment of Wastewater." Last modified October 6, 2009. Retrieved November 24, 2011, from: http://ga.water.usgs.gov/edu/wwvisit.html
- Walsh, James L., Jr., Charles C. Ross, Michael S. Smith, Stephen R. Harper, and W. Allen Wilkins. *Handbook on Biogas Utilization*. Atlanta: Georgia Tech Research Institute and Georgia Institute of Technology, February 1988.
- Westlake.com. "Material Safety Data Sheets: Chlorine," revised November 1, 1999. Retrieved November 22, 2011, from: http://www.westlake.com/_filelib/FileCabinet/pdfs/MSDS_Chlorine.pdf

portable fire extinguishers. Large chlorine fires will necessitate using water spray or foam.

Many wastewater treatment plants substitute less toxic sodium hypochlorite solution for chlorine. This is due, in part, to the passage of stricter hazardous chemical regulations pushed forth in recent years by the U. S. Environmental Protection Agency (EPA) and the U.S. Occupational Health and Safety Administration (OSHA). Sodium hypochlorite solution is a strong oxidizer and products of the oxidation reaction are corrosive. It is, however, still considered less hazardous than chlorine.

Household bleach sold in stores for use in laundering clothes is a three to six percent solution of sodium hypochlorite. Wastewater treatment plants typically use a 15 percent solution. Solutions burn skin and can cause eye damage. Inhalation of vapors may burn the respiratory system, leading to pulmonary edema up to 48 hours after exposure. Ingestion may cause irritation of the membranes of the mouth and throat, stomach pain and possible ulceration. Delivery areas for replenishing sodium hypochlorite solution storage tanks should be clearly identified and protected from extraneous vehicular traffic during transfer operations.

Sodium hypochlorite solution is not considered to be a fire hazard. It can, however, release oxygen when heated, which may increase the severity of an existing fire. Containers can rupture from pressure build-up. Use fog streams to cool fire-exposed containers. Spills can be mitigated using low pressure water spray. Contain the liquid for neutralization and disposal. A dike may have to be constructed to hold large spills. Dry chemical or foam should be used to extinguish surrounding fire.

**Entrance to Owls Head (DEP) Water Pollution Control Plant in Brooklyn.**

Ozone is another strong oxidizing agent that is employed as a disinfectant. An ozone generator is used to convert oxygen into ozone by employing high voltage. Ozone is a very reactive gas that can oxidize bacteria, organic material and other contaminants found in wastewater. Ozone converts back into oxygen quickly and leaves no trace once it has been used. Ozone treatment can produce by-products that also can pose a health hazard. Members should shut down electrical power to the ozone generator during fires involving this equipment.

Ultraviolet germicidal irradiation (UVGI) also can be used for disinfectant purposes instead of chlorine and other chemicals. The UV radiation causes damage to the genetic structure of bacteria, viruses and other pathogens, making them incapable of reproduction. At certain wavelengths, however, UV is harmful (skin cancer, vision impairment) to humans. UVGI wastewater design may have interlocks, which automatically shut off the UV lamps if the system is breached. Nonetheless, members should shut down power and not attempt to open this equipment during fire/overhaul operations.

**Summary**

The wastewater treatment process is varied. Chief Officers should know what methods are being used to pre-plan strategy and tactics. This can negate the potential hazards inherent in the design. Familiarization is the key to successful and safe fire or emergency operations at these facilities.

***Author's Note:*** *A tip of the helmet to Frank Loncar, chief--division of East Operations; and William Grandner, senior stationary engineer--electric, at the Owls Head Plant (NYC Department of Environmental Protection).*

***About the Author...***

*Assistant Chief Ronald R. Spadafora has served the FDNY since 1978. He is the Chief of Logistics. He holds a masters degree in Criminal Justice from LIU-C.W. Post Center, a BS degree in Fire Science from CUNY-John Jay College and a BA degree in Health Education from CUNY-Queens College. He is an Editorial Advisor and regular contributor to* WNYF. *He teaches fire science at John Jay College as an adjunct lecturer and is the senior instructor for Fire Tech Promotions.*