Center for Sustainable Systems

University of Michigan
440 Church Street, Ann Arbor, MI 48109-1041
phone: 734-764-1412 fax: 734-647-5841
email: css.info@umich.edu
http://css.snre.umich.edu

factsheets

U.S. Wastewater Treatment

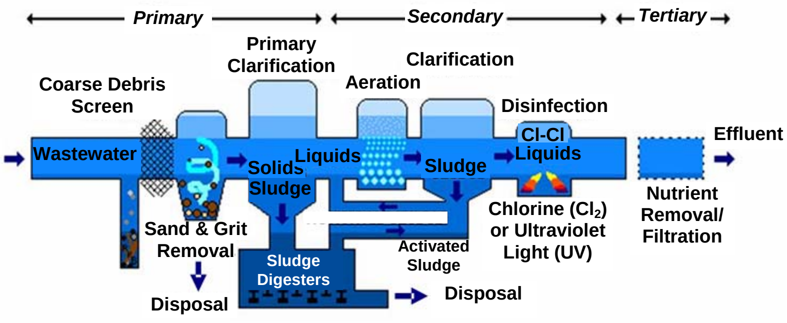
Patterns of Use

For many years, humans have treated wastewater to protect human and ecological health from waterborne diseases. Since the early 1970s, effluent water quality has been improved at Publicly Owned Treatment Works (POTWs) and other point source discharges through major public and private investments prescribed by the Clean Water Act (CWA). Despite the improvement in effluent quality, point source discharges continue to be a significant contributor to degradation of surface water quality. In addition, much of the existing wastewater infrastructure, including collection systems, treatment plants and equipment, has deteriorated and is in need of repair or replacement.

Contamination and Impacts

- Pollutants contaminate receiving water via many pathways: point sources; non-point sources – air deposition, agriculture; sanitary sewer overflows; stormwater runoff; combined sewer overflows; and hydrologic modifications – channelization and dredging.
- A 2009 EPA report to Congress classifies 44% of river and stream miles, 64% of lake acres, 30% of estuarine square miles, and 93% of Great Lakes shoreline miles as impaired (unacceptable for at least one designated use).[1]
- 20% of households are not served by public sewers and usually depend on septic tanks to treat and dispose of wastewater.[2] Failing septic systems may contaminate surface and groundwater.

Wastewater Treatment Process



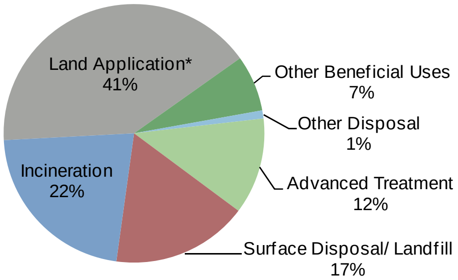
Treatment of Municipal Wastewater

- An estimated 21,594 POTWs provide wastewater collection, treatment and disposal service to 226.4 million people.[3]
- 1 billion gallons (~2.5%) per day of treated wastewater is reclaimed to meet non-potable water needs, such as irrigation of golf courses and public parks.[4] However, use of reclaimed water is becoming more common, particularly in the fast-growing southwest region.
- POTWs generate over 8 million tons (dry weight) of sludge annually. Sludge requires significant energy to treat – about 30-80% of total electricity use by a wastewater treatment system.[5,6]
- Chlorination is the most common means of disinfection. In the U.S., chlorination is usually followed by dechlorination with sulfur dioxide to avoid deteriorating ecological health of the receiving stream and the production of carcinogenic by-products.
- Ultraviolet (UV) disinfection is the most common alternative to chlorination and has comparable energy consumption.[7]
- Chemical additions of ferric salts and lime enhance coagulation and sedimentation processes for improved solids removal as well as removal of toxic pollutants. However, their production and transport have life cycle impacts.
- Classes of unregulated organic compounds known as "emerging organic contaminants" are becoming a concern for water treatment engineers. These contaminants, including pharmaceuticals, cosmetics, hormones, nanomaterials, and others, have been shown to have adverse effects on aquatic life and may pose a potential risk for humans. Some of these chemicals are endocrine disruptors, a class of compounds that perturb the normal functioning of endocrine systems including those that affect growth, reproduction and behavior. Studies are ongoing to determine risks and potential solutions for these contaminants. Many of these chemicals pass through POTWs.

Biosolids (Sludge) End-of-Life

- Qualified biosolids can be beneficially used after stabilization – killing pathogens and decomposing vector attractive substances.
- 60% of biosolids are beneficially used. Most of this is applied to agricultural sites, with minor amounts applied to forestry and reclamation sites, e.g., Superfund and Brownfield lands as well as in urban areas, e.g., maintaining parklands.[8] However, given the almost 50% reduction in EPA enforcement resources devoted to biosolids, the Office of the Inspector General for the EPA reported that, "EPA cannot assure the public that current land application practices are protective of human health and the environment."[9]

Biosolids Use and Disposal[8]



*Without further processing or stabilization such as composting

Life Cycle Impacts

Wastewater treatment systems reduce environmental impacts in the receiving water, but create other life cycle impacts mainly through energy consumption. The figure below shows the greenhouse gas (GHG) emissions associated with wastewater treatment, and those generated from the degradation of organic materials in the POTW.

Electricity Consumption, GHGs, and Related Emissions

- Nearly 4% of the nation's electricity use goes towards moving (80%) and treating water/wastewater.[10]
- In 2000, energy-related emissions resulting from POTW operations – excluding organic sludge degradation – led to a global warming potential of 15.5 teragrams (Tg) CO_2-equivalents (CO_2-eq.), an acidification potential of 145 gigagrams (Gg) SO_2 equivalents, and eutrophication potential of 4 Gg PO_4^{3-} equivalents.[11]
- CH_4 and N_2O are mainly emitted during organic sludge degradation by anaerobic bacteria in the soil environment, wastewater treatment plant, and receiving water body.
- In 2009, an estimated 24.5 and 5.0 Tg CO_2-eq. of CH_4 and N_2O, respectively, resulted from organic sludge degradation in wastewater treatment system, over 0.5% of total U.S. GHG emissions.[12]

Life Cycle Impact of Wastewater Treatment Systems

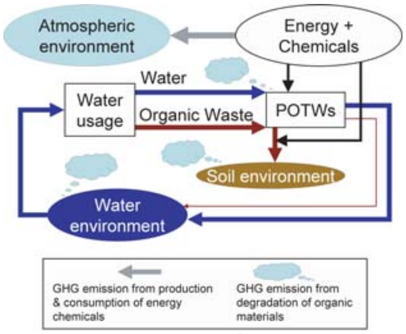


Image courtesy of Arkansas Watershed Advisory Group http://www.awag.org/Education.html.

Social and Economic Impacts

- Population growth and urban sprawl increase the collection (sewer) system needed.
- Although the 50-year life expectancy of a sewer system is longer than that of treatment equipment (15 to 20 years), renovation needs of a sewer system can be more costly. If there is no renewal or replacement of existing 600,000 miles of sewer systems, the amount of deteriorated pipe will increase from 10% to 44% of the total network from 1980 to 2020.[13]
- In 2008 U.S. clean water needs for building new and updating existing wastewater treatment plants, pipe repair and new pipes, and combined sewer overflow corrections were $105.2, $82.6, and $63.6 billion, respectively.[3]

Solutions and Sustainable Alternatives

Administrative Strategy

- Investment in wastewater treatment systems is shifting from new construction projects to maintenance of original capacity and function of facilities (asset management). Life cycle costing should be embedded in capital budgeting and combined sewer overflow, sanitary sewer overflow corrections, and storm water management programs need to be conducted continuously.
- In order to meet ambient water standards, total maximum daily loads (TMDLs) considering both point and non-point source pollutant loadings can be developed to manage bodies of water to achieve fishable and swimmable water quality. Watershed-based management of clean water is expected to facilitate establishment of these TMDLs.

Reduce Loading

- Examples of projects to reduce or divert wastewater flow include disconnecting household rainwater drainage from sanitary sewers, installing green roofs, and replacing impervious surfaces – use porous pavement, swales, French drains.
- Toilets, showers, and faucets combined represent 60% of all indoor water use.[14] Install high-efficiency flush toilets, composting toilets, low-flow showerheads, faucet aerators and rain barrels. (One study found that water-efficient appliances have largely contributed to a 10% decline in household water use since 1990.)[15]
- Gray water – wash water from kitchen sinks, tubs, clothes washers, and laundry tubs – can be used for home gardening, lawn maintenance, landscaping and other uses.

Technological Improvement and System Design

Technological improvement is necessary for increasing energy efficiency, particularly in:

- Oxygen transfer from vapor phase to liquid phase within the activated sludge basin.
- Dewatering capability and optimization of extent of dewatering – dewatering is a key process reducing energy consumption in the transportation and incineration of sludge.
- Developing energy-efficiency technology suitable for smaller plants.

Rain Barrel

Green Roof at Ford Motor Company's River Rouge Plant†

Images courtesy of www.urbangardencenter.com° and www.greenroofs.org†

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[1] U.S. Environmental Protection Agency (EPA) (2009) *National Water Quality Inventory 2004 Report.*
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[3] U.S. EPA (2008) Clean Watersheds Needs Survey 2008.
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[7] SBW Consulting, Inc. (2002) *Energy Benchmarking Secondary Wastewater Treatment and Ultraviolet Disinfection Processes at Various Municipal Wastewater Treatment Facilities.* Pacific Gas and Electric Company.
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Cite as: Center for Sustainable Systems, University of Michigan. 2011. "*U.S. Wastewater Treatment Factsheet*." Pub No. CSS04-14.

September 2011