Chapter Seven

A Day in the Life of a Turd

In my youth I listened to army veterans talking about their stints in the Korean War. Usually after a beer or two, they'd turn their conversation to the "outhouses" used by the Koreans. They were amazed, even mystified about the fact that the Koreans tried to lure passersby into their latrines by making the toilets especially attractive. The idea of someone wanting someone else's poop always brought out a hearty laugh from the vets. This opinion sums up the attitude of almost anyone raised with a flush toilet. Humanure is a waste product that we must dispose of and only fools would think otherwise. One of the effects of this attitude is that Americans don't know and probably don't care where their "human waste" goes after it emerges from their back ends as long as they don't have to deal with it.

Open Defecation

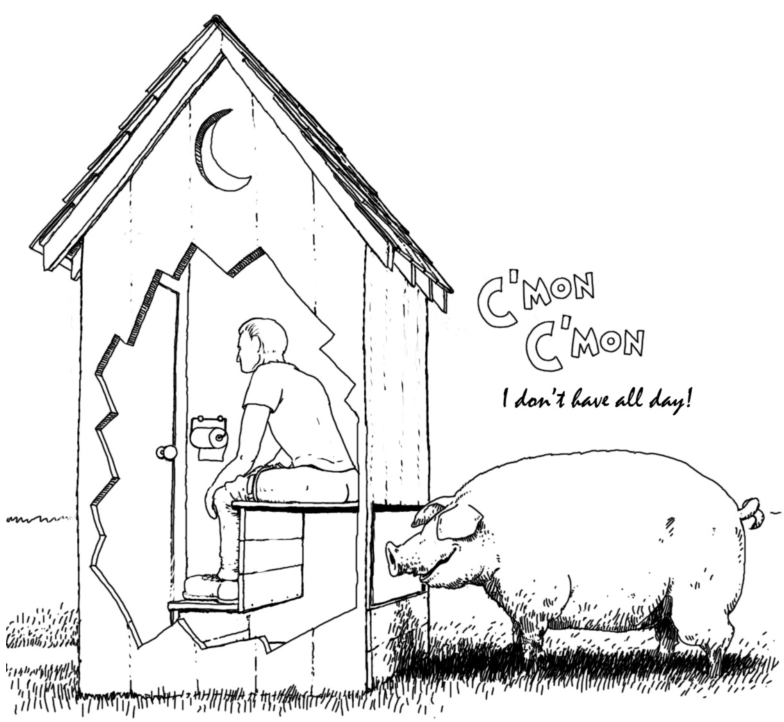
Where it goes depends on the type of "waste disposal system" used. Let's start with the simplest: the Mexican biological digester, also known as the stray dog. I spent a few months in southern Mexico in the late 1970s in Quintana Roo on the Yucatan peninsula. There, toilets were not available; people simply used the sand dunes along the coast. No problem, though. One of the small, unkempt, and ubiquitous Mexican dogs would wait nearby with watering mouth until you did your thing. Burying your excrement in that situation would have been an act of disrespect to the dog. No one wants sand in their food. A good, healthy, steaming turd at the crack of dawn on the Caribbean coast never lasted more than sixty seconds before it became a hot meal for a human's best friend. Yum.

Today, roughly 892 million people still practice open defecation, down from over 1.2 billion in 2000. Of those who still go outdoors, 90 percent live in Central and Southern Asia and in sub-Saharan Africa.[1]

Pit Latrines

Next up the ladder of sophistication is the old-fashioned outhouse, also known as the pit latrine. Simply stated, one digs a hole in the ground and then defecates in it and does so again and again until the hole fills up; then it's usually covered with dirt. It's nice to have a small building or "privy" over the hole to provide some privacy and shelter. Today, pit latrines are used worldwide by the millions. In America, we still bury our excrement in the form of sewage sludge, in landfill holes.

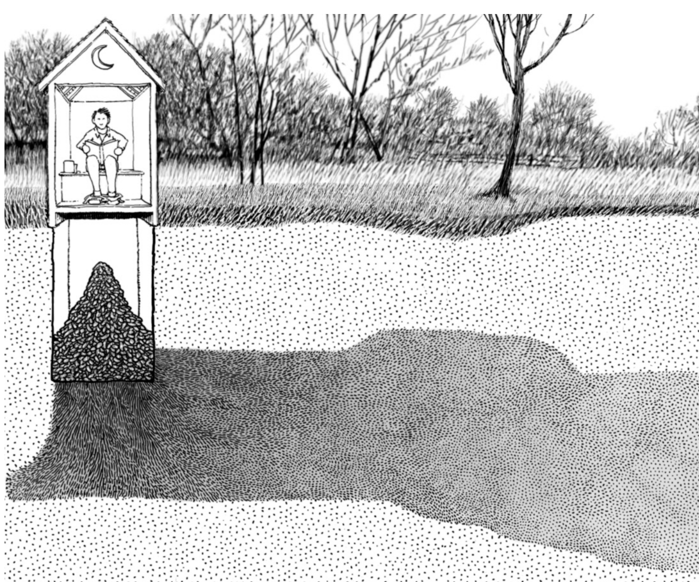
Pit latrines create health, environmental, and aesthetic problems. The hole is accessible to flies and mosquitoes, which can transmit diseases. The pits leak pollutants even in dry soil. And the smell can be punishing; kids in developing countries would rather open defecate than use a stinky latrine. In dry soil, pit latrines can transmit pollution ten feet underneath the hole and three feet sideways. In wet soils, they can leak fifty feet sideways following the direction of groundwater flow.



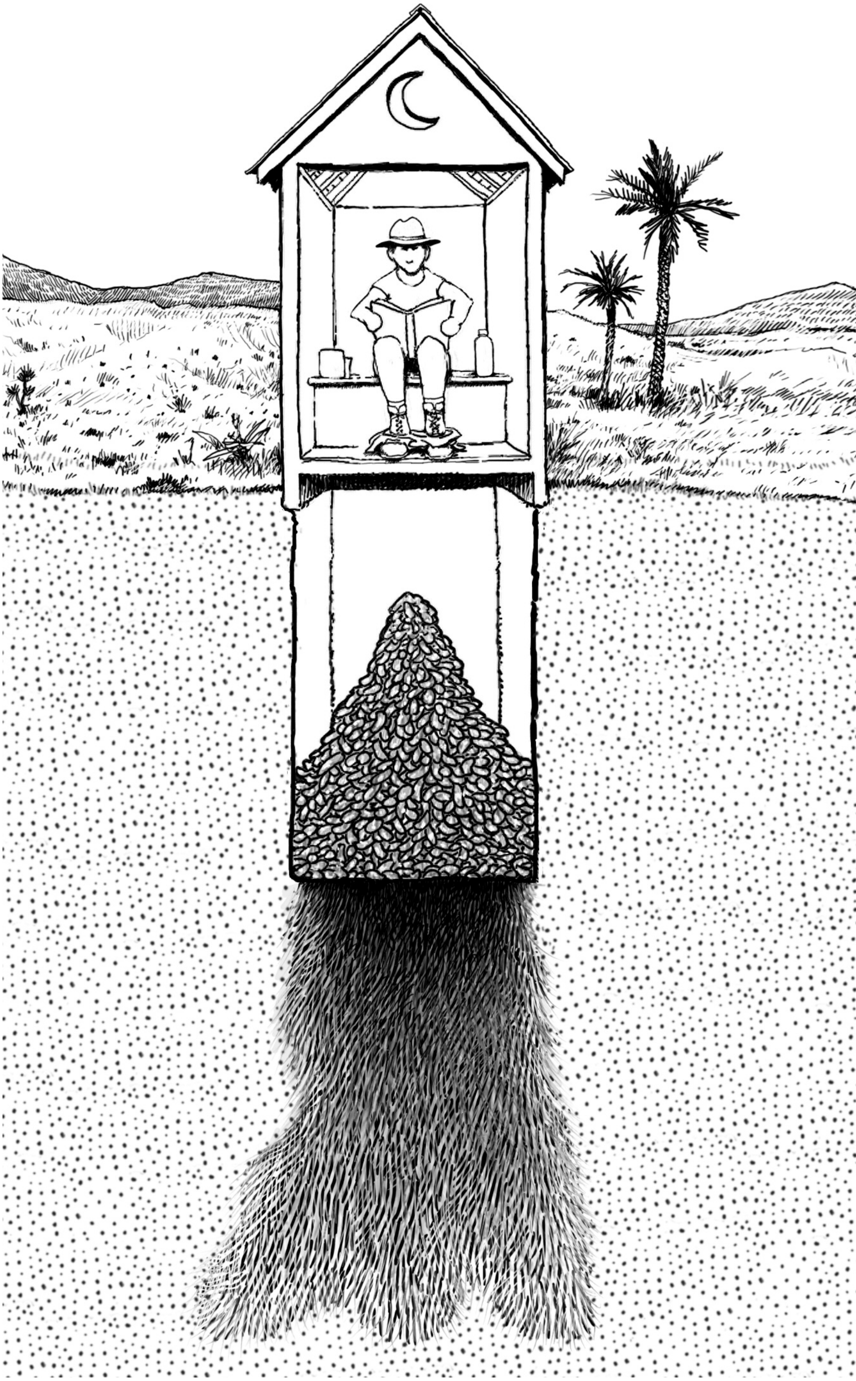
Another step up the sanitation ladder, one finds the septic tank, a common method of human excrement and wastewater disposal in rural and suburban areas of the United States. In this system the turds are excreted into a bowl of what is typically drinkable water, then flushed down a drain. The word "septic" comes from the Greek *septikos*, which means "to make putrid." Today it still means "causing putrefaction," which is "the decomposition of organic matter resulting in the formation of foul-smelling products."

In 1700 BC, almost four thousand years ago, King Minos of Crete used water toilets flushed by rain. Over three thousand years later, in 1596, the modern flush toilet was invented. Almost three hundred years after that, in 1872, Thomas Crapper invented an improved design that is still in use today. In 1855, George Vanderbilt had the first bathroom with a bathtub, sink, and flush toilet inside an American home.[2]

Septic tanks, designed to collect the wastewater from flush toilets, appeared in the late 1800s. It became common practice in the mid-



Underground pollution plume from a pit latrine in wet soil.



Underground pollution plume from a pit latrine in dry soil.

1900s to discharge the overflow from these tanks into gravel-lined leach fields.[3] Turds travel through sewage pipes then plop into the large underground storage tanks made of concrete, fiberglass, or plastic. In Pennsylvania, a nine-hundred-gallon tank is the minimum size allowed for a home with three or fewer bedrooms.[4] The heavier solids settle to the bottom of the tank, while the overflow liquids drain off into a leach field, which consists of an array of perforated drain pipes situated below the ground surface, allowing the liquid to seep into the soil. The wastewater is expected to undergo anaerobic decomposition while in the tank. When septic tanks fill up, they're pumped out by septage haulers, and the septage is supposed to be trucked to a sewage treatment plant for disposal.

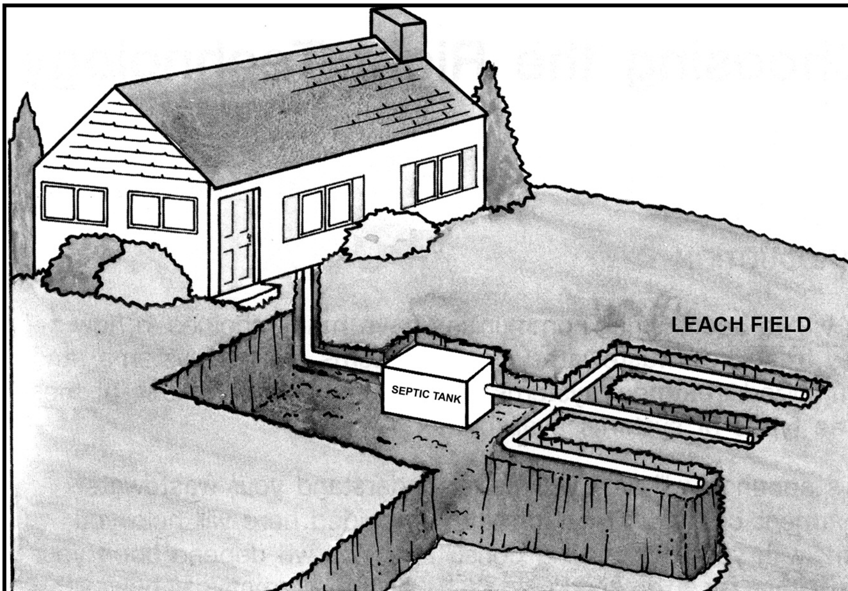
In poorly drained soil, either low lying or with a high clay content, a standard leach field won't work, especially when the ground is already saturated with rainwater or snow melt. Wastewater won't drain into soil that's already saturated with water. That's when the sand mound sewage disposal system is utilized. When the septic tank isn't draining properly, a pump will kick in and pump the overflow liquid into a pile of sand and gravel above ground. Perforated pipes in the pile allow the effluent to drain down through the mound. Sand mounds are usually covered with soil and grass. In Pennsylvania, sand mounds must be at least one hundred feet downslope from a well or spring, fifty feet from a stream, and five feet from a property line.[5] According to local excavating contractors, sand mounds cost $5,000 to $12,000 to construct in the early twenty-first century. They must be built to exact government specifications and aren't usable until they pass an official inspection.

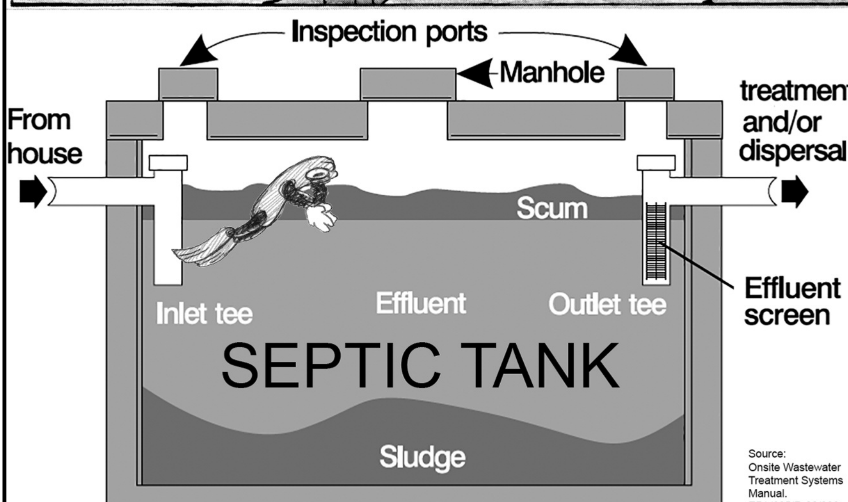
Although septic systems are widely used today and are considered important and necessary waste disposal systems, they do have their problems. At the end of the 20th century, there were 22 million septic system sites in the United States, serving one-fourth to one-third of the US population, many of which were leaching contaminants such as bacteria, viruses, nitrates, phosphates, chlorides, and organic compounds such as trichloroethylene into the environment. An EPA study of chemicals in septic tanks found toluene, methylene chloride, ben-

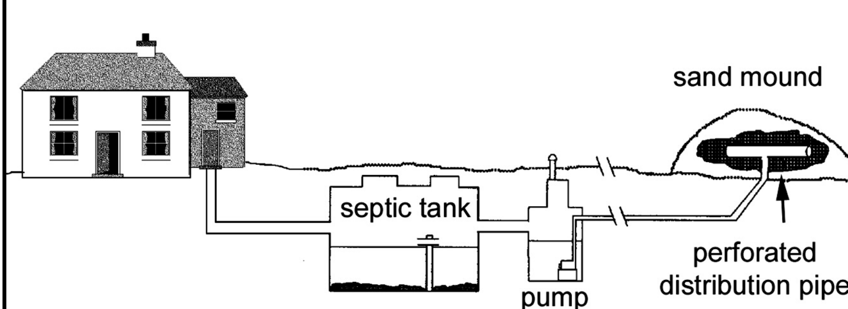
zene, chloroform, and other volatile synthetic organic compounds related to home chemical use, many of them cancer-causing.[6]

Toxic chemicals are commonly released into the environment from septic systems because people dump them down their drains. The chemicals are found in pesticides, paint, toilet cleaners, drain cleaners, disinfectants, laundry solvents, antifreeze, rust proofers, septic tank and cesspool cleaners, and many other cleaning solutions. In fact, over four hundred thousand gallons of septic tank cleaner liquids containing synthetic organic chemicals were used in one year by the residents of Long Island alone. Furthermore, some toxic chemicals can corrode metal pipes, thereby causing heavy metals to enter the septic systems as well.[7]

In 1960 fourteen million American homes had septic systems. The number increased to seventeen million by 1970 and about twenty-six million by 2005, producing about four billion gallons of wastewater every day. Failure of septic systems, mostly due to poor maintenance, is associated with the pollution of groundwater, lakes, and coastal waters. A study of Chesapeake Bay found that the two million neighboring septic systems discharged about nine million pounds of nitrogen into the bay every year. The Indian River Lagoon in Florida receives about a million and a half pounds of nitrogen annually from its forty-five thousand surrounding septic systems. Three fourths of the nitrogen entering the Buttermilk Bay in Massachusetts comes from septic systems. Systems were failing at a rate of 50 to 70 percent in Minnesota, 60% in West Virginia, 50% in Louisiana, 40% in Nebraska, 30–50 percent in Missouri, 25 to 30 percent in Ohio, and 25 percent in Massachusetts. In Indiana one study reported that as many as 70 percent of the eight hundred thousand systems in that state were failing. Meanwhile, according to the EPA, 168,000 viral and 34,000 bacterial illnesses


LEACH FIELD
SEPTIC TANK


Inspection ports
Manhole
From house
treatment and/or dispersal
Scum
Inlet tee
Effluent
Outlet tee
Effluent screen
SEPTIC TANK
Sludge
Source:
Onsite Wastewater
Treatment Systems
Manual.
EPA/625/R-00/008


sand mound
septic tank
pump
perforated distribution pipe

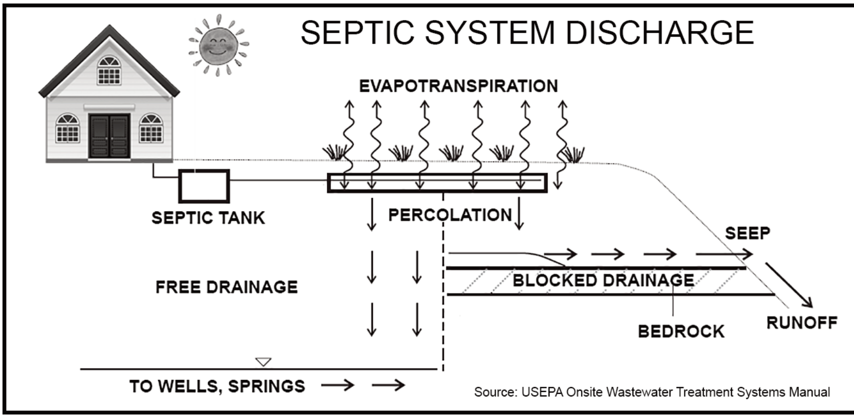
can be traced to badly maintained septic systems every year.[8]

Septic systems are not designed to eliminate human pathogens that may enter the septic tank. Instead, septic systems are designed to collect human wastewater, settle out the solids and anaerobically digest them to some degree, then leach the effluent into the soil. Therefore, septic systems can be highly pathogenic, allowing the transmission of disease-causing bacteria, viruses, protozoa, and intestinal parasites through the system. Too many septic systems in any given area will overload the soil's natural purification capabilities and allow large amounts of wastewater to contaminate the underlying water table. A density of more than forty household septic systems per square mile will cause an area to become a likely target for subsurface contamination, according to the EPA.[9]

In many cases, people who have septic tanks are forced to connect to sewage lines when the lines become available. A US Supreme Court case in 1992 reviewed a situation whereby town members in New Hampshire had been forced to connect to a sewage line that simply discharged untreated, raw sewage into the Connecticut River, and had done so for fifty-seven years. Despite the crude method of disposal, the law required properties within one hundred feet of the town sewer system to connect to it. This barbaric sewage disposal system continued to operate until 1989, when state and federal sewage treatment laws forced a stop to the dumping of raw sewage into the river. The residents sued the town for compensation when the sewage disposal system was terminated — and they won![10]

Wastewater Treatment Plants

There's still another step up the ladder of wastewater treatment sophistication: the wastewater treatment plant, or sewage plant. The wastewater treatment plant is like a huge, very sophisticated septic tank because it collects the waterborne excrement of large numbers of people. Inevitably, when one defecates or urinates into water, one pollutes the water. To avoid environmental pollution, that "wastewater" must



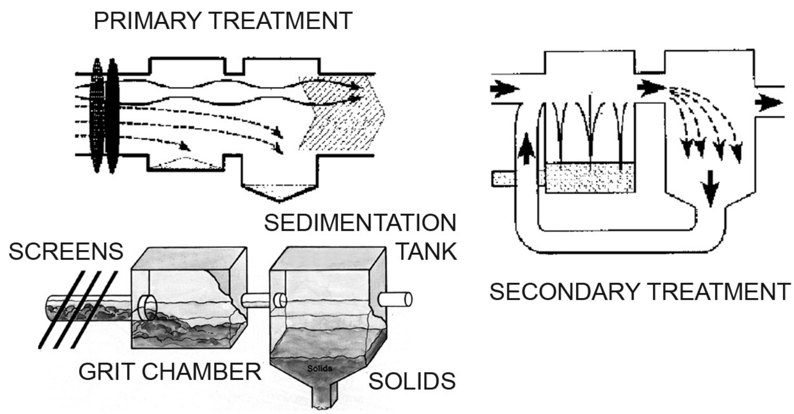
somehow be rendered fit to return to the environment. The wastewater entering the treatment plant is 99 percent liquid because all sink water, bath water, and everything else that goes down one's drain ends up at the plant, too. In some cases, storm water runoff also enters wastewater treatment plants via combined sewers. Industries, hospitals, gas stations, and any other place with a drain add to the contaminant blend in the wastewater stream.

There are nearly fifteen thousand wastewater treatment plants in the US that provide wastewater collection, treatment, and disposal service to almost 240 million people.[11] These sewer systems have a fifty-year life expectancy, but the equipment used in the treatment system only lasts fifteen to twenty years. Of our six hundred thousand miles of sewer lines, 44 percent are expected to become deteriorated by 2020.[12] In 2012, expenses for updating America's existing wastewater treatment plants were estimated to be $102 billion. Add another $96 billion to repair or replace sewage pipes, and almost $50 billion to correct combined sewer overflows,[13] and it's obvious we need to start saving our money. By comparison, that roughly $250 billion we need for all of our wastewater infrastructure in the United States is spent by the Department of "Defense" in about fourteen weeks. Yet due to the poor condition of many of our wastewater systems, with aging pipes and inadequate capacity, an estimated nine hundred billion gallons of untreated sewage is discharged into our environment every year.[14] While we're spending money on "defense," how about we defend ourselves from environmental pollution and use some of that money to upgrade our sewer systems? Instead, 53 percent of EPA assessed river and stream miles, 71 percent of assessed lake acres, 79 percent of assessed estuarine square miles, and 98 percent of assessed Great Lakes shoreline miles are classified as impaired due to pollution.[15]

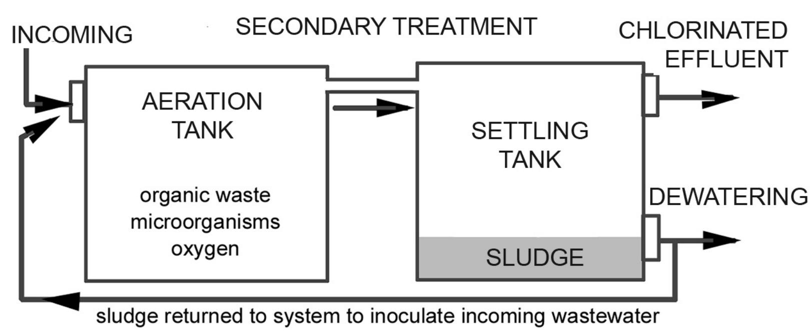
Many modern wastewater plants use a process of activated sludge treatment whereby oxygen is vigorously bubbled through the wastewater to activate the microbial digestion of the solids. The microbes that digest the sludge consist of bacteria, fungi, protozoa, rotifers, and nematodes.[16] This aeration stage is combined with a settling stage that allows the solids to settle out and be removed. The removed solids, known as sewage sludge or euphemistically as "biosolids," are either used to reinoculate the incoming wastewater or dewatered to the consistency of a dry mud. Over 50 percent of all biosolids are now being recycled to farmland for agricultural purposes according to the EPA, although the biosolids are used on less than 1 percent of the nation's agricultural land.[17] Some of it is composted.

About 7.2 million dry tons of biosolids were beneficially used or disposed of in the United States in 2004.[18] New York City alone produces twelve hundred tons of biosolids every day. They once dumped the sludge in the ocean, but that was banned in 1988. New York's biosolids are now disposed of in landfills in Pennsylvania, Virginia, and New York. Some of New York City's biosolids are lime stabilized at facilities in Pennsylvania or Colorado.[19] The lime raises the pH, which kills the bacteria. The lime stabilized sludge can then be composted with other organic materials, or simply applied directly to land where lime is needed in the soil.

The remaining wastewater is treated and discharged into a body of water. Municipal wastewater effluent in the US in 2012 amounted to thirty-two billion gallons per day, only 7 to 8 percent of which was reused.[20] In North America, according to a UN report, 18.7 trillion gallons of wastewater are produced annually; 13.4 trillion of these are treated (some estimate this to be roughly equivalent to the annual flow of Niagara Falls). Only 3.8 percent of the treated wastewater is reused.[21]

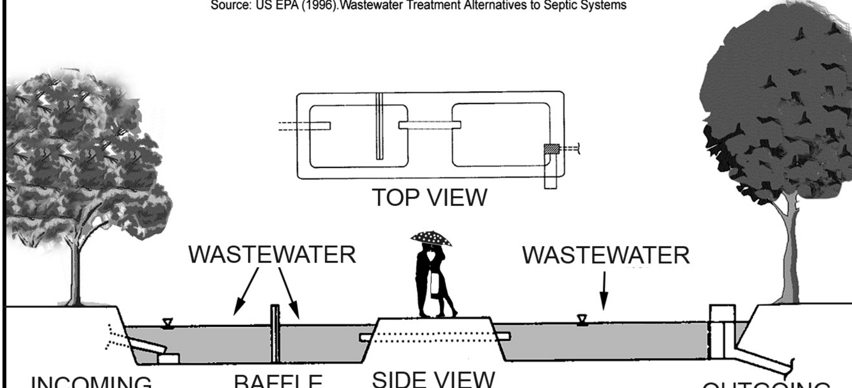


ACTIVATED SLUDGE BIOSOLIDS



TYPICAL 3-CELL LAGOON SYSTEM

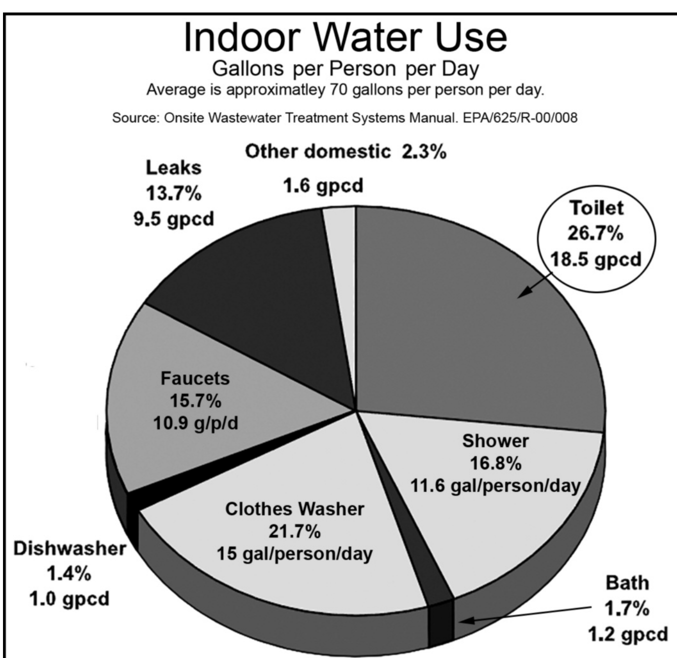
Source: US EPA (1996).Wastewater Treatment Alternatives to Septic Systems



On a global scale, 80 percent of the wastewater humans create is discharged into the Earth's waterways, creating not only health and environmental problems, but also contributing significantly to greenhouse gas emissions in the form of nitrous oxide and methane. Untreated sewage produces three times the emissions of treated wastewater, representing a significant percentage of the global greenhouse gas emissions produced by cities around the world.[22]

Severe *pathogen* pollution affects about 25 percent of Latin American rivers, 10 to 25 percent of African rivers, and up to 50 percent of Asian rivers, largely due to sewer systems discharging untreated wastewater. The largest source of pathogen pollution in Latin America is sewers; in Africa it is non-sewered domestic waste; and in Asia it is sewers, followed closely by non-sewered domestic waste. By taking the wastewater away from populated areas, sewers have reduced health risks there, but by dumping the wastewater into surface waters, sewers have simply moved the health risks from one place to another.

Severe *organic* pollution affects about 14 percent of all river stretches in Latin America, Africa, and Asia, affecting poor rural peo-



ple who rely on fish as a main source of protein in their diets. Organic pollution is caused by the release of large quantities of organic materials into surface waters. The breakdown of these materials in water starves the fish of oxygen.[23]

Although wastewater treatment plants prevent raw sewage from polluting the Earth's waterways, they are obviously not used in many places around the world. On the other hand, the effluent from wastewater treatment plants can contain bacteria, viruses, protozoa, and intestinal worm pathogens (helminths). There can be significant amounts of bacteria in *treated* wastewater even after sedimentation, secondary clarification, coagulation, and flocculation (separation of the solids from the liquids). Bacteria can be destroyed by using ultraviolet radiation, chlorine, or ozone, although viruses are harder to eliminate than bacteria due to their small size and resistance to chlorine. Protozoa and helminths can also be resistant to chlorine.[24]

Here's a bit of trivia: in 2014 Americans used close to $10 billion worth of toilet paper to flush all that poo down the toilet, with sales expected to increase about 2 percent per year.[25] By some estimates, Americans each use about 50 pounds of toilet paper per year, or about 16.5 billion pounds annually, 50 percent more than Europeans use. Each American's annual amount of toilet paper would stretch 2.8 miles, using 284 trees in a lifetime. Contemplate these facts while you're spending the average of *three years* of your life sitting on a toilet![26]

Waste Stabilization Ponds

Perhaps one of the oldest wastewater treatment methods known are waste stabilization ponds, also known as oxidation ponds or lagoons. They're often found in rural areas where land is available and cheap. Such ponds tend to be only three to four feet deep, but they vary in size and can have a depth of ten or more feet.[27] They rely on algae, bacteria, and zooplankton to reduce the organic content of the wastewater. A "healthy" lagoon will appear green in color because of the dense algae population. These lagoons require about one acre for every two hundred people served. Mechanically aerated lagoons only need one-third to one-tenth the land that unaerated stabilization ponds require. It's a good idea to have several smaller lagoons in series rather than one big one; normally, a minimum of three "cells" are used. Sludge collects in the bottom and may have to be removed every five or ten years, then disposed of in an approved manner.[28]

Chlorine

Wastewater leaving treatment plants is often treated with chlorine before being released into the environment. Used since the early 1900s, chlorine is one of the most widely produced industrial chemicals. More than 10 million metric tons are manufactured in the US each year — $72 billion worth.[29] Annually, approximately 5 percent, or 1.2 billion pounds, of the chlorine manufactured is used for wastewater treatment and drinking water "purification." The lethal liquid or green gas is mixed with the wastewater from sewage treatment plants to kill disease-causing microorganisms before the water is discharged into streams, lakes, rivers, and seas. It is also added to household drinking water via water treatment systems. Chlorine kills microorganisms by damaging their cell membranes.[30]

Chlorine (Cl_2) doesn't exist in nature. It's a potent poison that reacts with water to produce a strongly oxidizing solution that can damage the moist tissue lining of the human respiratory tract. Ten to twenty parts per million (ppm) of chlorine gas in air rapidly irritates the respiratory tract; even brief exposure at levels of one thousand ppm (one part in a thousand) can be fatal.[31]

In 1976, the US EPA reported that chlorine not only poisoned fish, but could also cause the formation of cancer-causing compounds such as chloroform. Some known effects of chlorine-based pollutants on animal life include memory problems; stunted growth and cancer in humans; reproductive problems in minks and otters; reproductive problems, hatching problems and death in lake trout; and embryo abnormalities and death in snapping turtles.[32]

In a national study of 6,400 municipal wastewater treatment plants, the EPA estimated that two thirds of them used too much chlorine, exerting lethal effects at all levels of the aquatic food chain. Chlorine damages the gills of fish, inhibiting their ability to absorb oxygen. It also can cause behavioral changes in fish, thereby affecting migration and reproduction. Chlorine in streams can create chemical "dams" that prevent the free movement of some migratory fish. Fortunately, since 1984, there has been a 98 percent reduction in the use of chlorine by sewage treatment plants, although chlorine use continues to be a widespread problem because a lot of wastewater plants are still discharging it into small receiving waters[33]

Another controversy associated with chlorine use involves "dioxin," which is a common term for a large number of chlorinated chemicals that are classified as possible human carcinogens by the EPA. It's known that dioxins cause cancer in laboratory animals, but their effects on humans are still being debated. Dioxins, byproducts of the chemical manufacturing industry, are concentrated up through the food chain where they're deposited in human fat tissues. A key ingredient in the formation of dioxin is chlorine, and indications are that an increase in the use of chlorine results in a corresponding increase in the amount of dioxin in the environment, even in areas where the only dioxin source is the atmosphere.[34]

In the upper atmosphere, chlorine molecules from air pollution gobble up ozone; in the lower atmosphere, they bond with carbon to form organochlorines. Some of the eleven thousand commercially used organochlorines include hazardous compounds such as DDT, PCBs, chloroform, and carbon tetrachloride. Organochlorines rarely occur in nature, and living things have little defense against them. They've been linked not only to cancer, but also to neurological damage, immune suppression, and reproductive and developmental effects. When chlorine products are washed down the drain into a septic tank, they're producing organochlorines. Although beneficial microorganisms can degrade and make harmless many toxic chemicals, highly chlorinated compounds are disturbingly resistant to such biodegradation.[35]

It's estimated that 79 percent of the US population is exposed to chlorine, and we're not talking about table salt (sodium chloride).[36] Over 98 percent of US water supply systems that disinfect drinking water use chlorine. The EPA *requires* treated tap water to have a detectable level of chlorine (up to four parts per million), which, according to the EPA, poses "no known or expected health risk [including] an adequate margin of safety." Yet one study suggested that at least forty-two hundred cases of bladder cancer and sixty-five hundred cases of rectal cancer each year in the US are associated with consumption of chlorinated drinking water.[37] This association is strongest in people who have been drinking chlorinated water for more than fifteen years.[38] The US Public Health Service reported that pregnant women who routinely drink or bathe in chlorinated tap water are at a greater risk of bearing premature or small babies, or babies with congenital defects.[39]

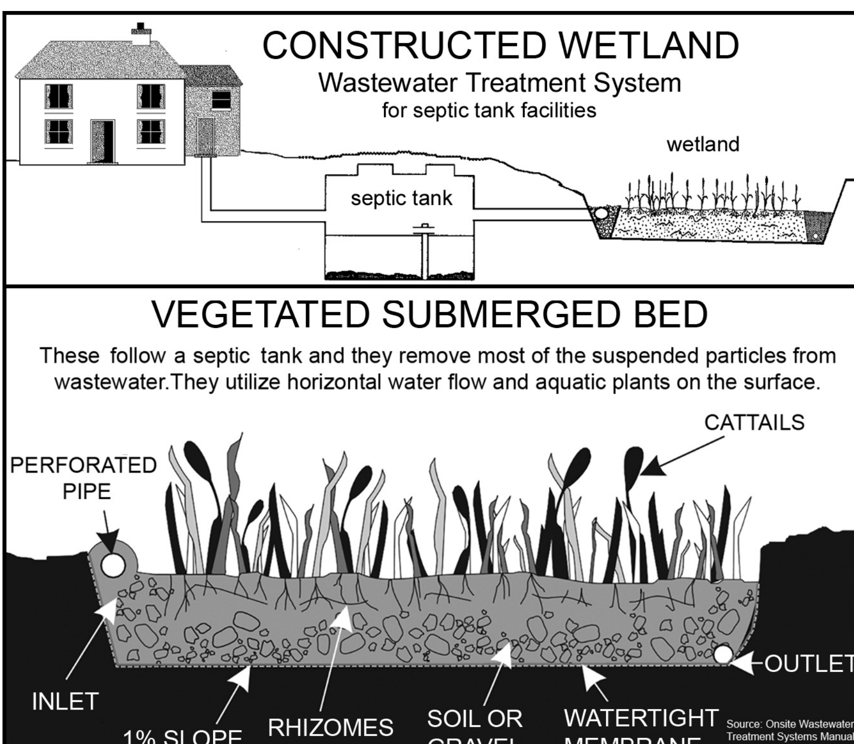
According to the chlorine industry, 87 percent of water systems in the US use free chlorines while 11 percent use chloramines, a combination of chlorine and ammonia. The chloramine treatment is becoming more widespread because of the health concerns over chlorine.[40]

Constructed Wetlands

New systems are being developed to purify wastewater. One such system is the constructed, or artificial wetlands system, which diverts wastewater through an aquatic environment consisting of plants such as water hyacinths, bulrushes, duckweed, lilies, and cattails. The plants act as marsh filters, and the microbes that thrive on their roots break down nitrogen and phosphorus compounds as well as toxic chemicals. The plants also absorb heavy metals; they can then be harvested later for incineration or sent to a landfill.[41]

According to the EPA, the emergence of constructed wetlands technology shows great potential as a cost-effective alternative to wastewater treatment. The wetlands method is said to be relatively affordable, energy-efficient, practical, and effective. The treatment efficiency of properly constructed wetlands is said to compare well with conventional treatment systems.[42]

Another system uses solar-powered, greenhouse-like technology to treat wastewater. This system uses hundreds of species of bacteria, fungi, protozoa, snails, plants, and fish, among other things, to produce advanced levels of wastewater purification. These "solar aquatics" systems are experimental, but hopeful.[43]



Agricultural Use of Sewage Sludge

When I asked the supervisor of my local wastewater plant if the one million gallons of sludge the plant produces each year, from a population of eight thousand people, were being applied to agricultural land, he said, "It takes six months and $5,000 to get a permit for a land application. Another problem is that due to regulations, the sludge can't lie on the surface after it's applied, so it has to be plowed under shortly after application. When farmers get the right conditions to plow their fields, they plow them. They can't wait around for us, and we can't have sludge ready to go at plowing time." So it goes to a landfill.

It may be just as well. Problems associated with the agricultural use of sewage sludge include groundwater, soil, and crop contamination with pathogens, heavy metals, nitrates, and toxic and carcinogenic organic compounds.[44] Sewage sludge is a lot more than organic material. It can contain DDT, PCBs, and mercury and other heavy metals.[45] One scientist alleges that more than twenty million gallons of used motor oil are dumped into sewers every year in the United States.[46]

America's largest industrial facilities released over 550 million pounds of toxic pollutants into US sewers in 1989 alone, according to the US Public Interest Research Group. Between 1990 and 1994, an additional 450 million pounds of toxic chemicals were dumped into sewage treatment systems, although the actual levels of toxic discharges are said to be much higher than these.[47]

Studies have shown that heavy metals accumulate in the vegetable tissue of the plant to a much greater extent than in the fruits, roots, or tubers. Therefore, if one must grow food crops on soil fertilized with sewage sludge contaminated with heavy metals, one might be wise to produce carrots or potatoes instead of lettuce.[48] Guinea pigs experimentally fed with Swiss chard grown on soil fertilized with sewage sludge showed no observable toxicological effects. However, their adrenals showed elevated levels of antimony, their kidneys had elevated levels of cadmium, the livers had elevated manganese, and other tissues had elevated tin.[49]

Ironically, when sludge is *composted*, it may help to keep heavy metals out of the food chain. According to one research study, composted sludge lowered the uptake of lead in lettuce that had been deliberately planted in lead-contaminated soil. The lettuce grown in the contaminated soil that was amended with composted sludge had a 64 percent lower uptake of lead than lettuce planted in the same soil but without the compost. The composted soil also lowered lead uptake in spinach, beets, and carrots by more than 50 percent.[50]

Composted sewage sludge that is microbiologically active can also be used to detoxify areas contaminated with nuclear radiation, or oil spills, according to researchers. Clearly, the composting of sewage sludge is a grossly underutilized alternative to landfill application, and it should be strongly promoted.[51]

Heavy metal concentrations in compost made with sludge seem to be low enough that they are not considered to be a problem largely because metal-contaminated sludge is greatly diluted by other clean organic materials when composted.[52]

On the other hand, sewage sludge is estimated to contain ten billion microorganisms per gram and may contain many human pathogens.[53] For example, over 140 enteric viruses are known to potentially enter into domestic sewage and sludge, some with an infectious dose as low as ten viral particles.[54] Numerous investigations in different parts of the world have confirmed the presence of intestinal pathogenic bacteria and animal parasites in sewage and sludge.[55]

Because of their size and density, parasitic worm eggs settle into and concentrate in sewage sludge at

BRAND NAMES OF SEWAGE SLUDGE FERTILIZERS ONCE MARKETED

SOURCE CITY	NAME*
Akron, OH	Akra-Soilite
Battle Creek, MI	Battle Creek Plant Food
Boise, ID	B.I. Organic
Charlotte, NC	Humite & Turfood
Chicago, IL	Chicagro & Nitroganic
Clearwater, FL	Clear-O-Sludge
Fond du Lac, WI	Fond du Green
Grand Rapids, MI	Rapidgro
Houston, TX	Hu-Actinite
Indianapolis, IN	Indas
Madison, WI	Nitrohumus
Massillon, OH	Greengro
Milwaukee, WI	Milorganite
Oshkosh, WI	Oshkonite
Pasadena, CA	Nitroganic
Racine, WI	Ramos
Rockford, IL	Nu-Vim
San Diego, CA	Nitro Gano
San Diego, CA	San-Diegonite
S. California	Sludgeon
Schenectady, NY	Orgro & Gro-hume
Toledo, OH	Tol-e-gro

*Names are registered brand names.

Sources: Rodale, J. I. et al. (Eds.). (1960). The Complete Book of Composting. Rodale Books Inc.: Emmaus, PA. pp. 789, 790. and Collins, Gilbeart H., (1955). Commercial Fertilizers - Their Sources and Use, Fifth Edition. McGraw-Hill Book Co., New York wastewater treatment facilities. One study indicated that microscopic roundworm eggs could be recovered from sludge at all stages of the wastewater treatment process, and that two-thirds of the samples examined had viable eggs.[56] Agricultural use of the sludge can therefore infect soil with six thousand to twelve thousand viable parasitic worm eggs per square meter per year. These eggs, which are quickly killed if composted, can persist in some soils for five years or more.[57] Furthermore, *Salmonellae* bacteria in sewage sludge can remain viable on grassland for several weeks, making it necessary to restrict grazing on pastureland after a sludge application. Beef tapeworm (*Taenia saginata*), which uses cattle as its intermediate host and humans as its final host, can also infect cattle that graze on pastureland fertilized with sludge. The tapeworm eggs can survive on sludged pasture for a year.[58]

Bacteria surviving in sewage sludge show a high level of resistance to antibiotics, especially penicillin. Any bacterium capable of genetic transfer can spread antibiotic resistance genes to other bacteria. As antibiotics are now a major contaminant in sewage sludge, mutations

MINIMIZE WASTEWATER

• **Never connect stormwater drains to the sewerage system or sewerage drains to stormwater.** Stormwater drains take large amounts of water from roofs, buildings, land, and paved areas after rain. Connecting toilets and other domestic waste drains to stormwater drains could result in wastewater flowing down open gutters. This is harmful to the environment and a serious heath hazard.

• **Compost your kitchen scraps.** Disposing of kitchen scraps via an in-sink style garbage disposal units can place additional loads on sewage treatment systems and add nitrogen and phosphorus into our waterways. Try composting at home to convert your kitchen scraps and garden clippings into compost.

• **Conserve water.** Turn off the tap when brushing your teeth. Take shorter showers. Fix leaking faucets. Use the washing machine only when you have a full load. Install a dual-flush toilet and water-saving shower nozzle.

• **Never put harmful substances down sinks, toilets or stormwater drains.** Gasoline, grease, oil, pesticides, herbicides, and solvents such as paint strippers should not be poured down sinks, toilets or stormwater drains.

• **Use biodegradable and phosphate-free detergents or soap.** Detergents that are phosphate free add fewer nutrients to the sewerage system.

[https://environment.des.qld.gov.au/water/monitoring/wastewater.html] may spread to organisms in the sludge and to natural microbes.[59]

Researchers at Cornell have suggested that sewage sludge can be disposed of by surface applications in forests, and that brief and intermittent applications of sludge to forestlands won't adversely affect wildlife. They point out that the need to get rid of sludge is compounded by the fact that many landfills are expected to close, and ocean dumping is banned. Under the Cornell model, one dry ton of sludge could be applied to an acre of forest each year.[60] New York State alone produces 370,000 tons of dry sludge per year, which would require 370,000 acres of forest annually for sludge disposal. Forty-nine other states produce 7 million dry tons of sludge. Then there's figuring out how to get the sludge into the forests and how to spread it around.

Let's assume that the whole world adopted the sewage philosophy we have in the United States: defecate into drinkable water and then try to purify the polluted water. What would that scenario be like? Well, for one thing it can't happen. It takes between 1,000 and 2,000 tons of water at various stages in the process to flush 1 ton of humanure. In a world of just six billion people producing a conservative estimate of 1.3 million tons of human excrement daily, the amount of water required to flush it is not obtainable.[61] Considering the increasing landfill space that would be needed to dispose of the increasing amounts of sewage sludge, and the tons of toxic chemicals required to "sterilize" the wastewater, one can realize that this system of human waste disposal is far from sustainable and cannot serve the needs of humanity in the long term.

According to Barbara Ward, president of the International Institute for Environment and Development, "Conventional 'Western' methods of waterborne sewerage are simply beyond the reach of most [of the world's] communities. They are far too expensive. And they often demand a level of water use that local water resources cannot supply."

According to Lattee Fahm in his book *The Waste of Nations — The Economic Utilization of Human Waste in Agriculture*, "In today's world [1980], some 4.5 billion people produce excretal matters at about 5.5 million metric tons every twenty-four hours, close to two billion metric tons per year. [Humanity] now occupies a time/growth dimension in which the world population doubles in thirty-five years or less. In this new universe, there is only one viable and ecologically consistent solution to the body waste problems — the processing and application of [humanure] for its agronutrient content."[62] This sentiment is echoed by World Bank researchers, who state, "[I]t can be estimated that the backlog of over one billion people not now provided with water or sanitation service will grow, not decrease. It has also been estimated that most developing economies will be unable to finance water carriage waste disposal systems even if loan funds were available." [63]

The 1 billion people without toilets the researchers were talking about in 1980 did in fact grow in numbers. In 2018 the number was 2.3 billion. The World Health Organization and UNICEF issued a report in 2017 stating 4.5 billion people lack safely managed sanitation, including the 892 million still people practicing open defecation.[64] A 2016 report indicated that the lack of access to sanitation cost the global economy $222.9 billion in 2015 alone. More than half of those costs were related to premature deaths.[65] Water pollution caused 1.8 million deaths in 2015, while unsafe water continues to sicken about a billion people every year. Pathogenic microbes from human and animal excrements are a major source of water contamination.

Accidental, illegal, or intentional discharges from sewage facilities contribute many of the harmful pathogens to waterways. Every year 3.5 million Americans have health issues such as skin rashes, pink eye, respiratory infections, and hepatitis from sewage-laden coastal waters alone, according to the EPA.[66]

But humanure is a natural substance that can be returned to the earth to produce food for humans. It doesn't have to be a pollutant.