Chapter 2: BACKGROUND OF ON-SITE WASTEWATER SYSTEMS (SEPTIC SYSTEMS).

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Background of On-Site Wastewater Systems (Septic Systems)

2.1 MANAGEMENT IN 21ST-CENTURY NORTH CAROLINA

As defined by the Rules for Sewage Treatment and Disposal Systems, "Sewage" means the liquid and solid human body waste and liquid waste generated by water-using fixtures and appliances, including those associated with food handling.

"Effluent" means the liquid discharge of a septic tank or other sewage treatment device.

Reference
15A NCAC18A.1935(11),(39)

The large volumes of domestic wastewater generated in the United States can be a serious threat to public health and the environment if the wastewater is disposed of improperly. Due to the increasing number of labor-saving appliances and changes in lifestyles, people use more water than ever before. This increasing usage, of course, increases the average daily flow of wastewater from a home.

People living outside municipalities or in rural communities often use on-site systems for wastewater disposal. Because water use is increasing, on-site systems must handle ever-greater volumes of wastewater. Additionally, much of the current land being developed for suburban and rural housing is less than ideal for supporting on-site systems. Thus, more on-site systems are being installed on marginal sites than ever before.

To assist in addressing these complex problems, this chapter provides basic information about on-site wastewater systems and their management. The first section of this chapter addresses how the increasing volume of wastewater and the development of less-suitable land affect us. The second section covers some general history of on-site wastewater management. The latter sections present the basic science of on-site wastewater treatment and disposal, along with current research, reports, and resources.

Wastewater management in the 21st century is more complicated than just two choices: septic versus sewer. A wide variety of wastewater treatment options are available for decentralized wastewater management. Choices range from individual septic systems to community systems and package plants. These systems may apply effluent subsurface (septic systems), to the surface (land application), or to water bodies (discharge systems). The primary function of septic systems in wastewater management performance is to discharge to a subsurface soil dispersal drain field sited in suitable soils. All septic systems in North Carolina are permitted by local health departments. Surface applications of wastewater to land or water are permitted by the Division of Water Quality in the N.C. Department of Environmental and Natural Resources.

INTRODUCTION TO DECENTRALIZED ON-SITE WASTEWATER

Decentralized wastewater treatment systems are managed individual on-site wastewater systems (commonly referred to as septic systems, private sewage systems, individual sewage treatment systems, on-site sewage disposal systems or "package" plants) used to collect, treat and disperse or reclaim wastewater from individual dwellings, businesses, or small communities or service areas."
--U.S. Environmental Protection Agency, EPA-832-B-03-001, 1980.

On-site systems can be a *permanent* means of wastewater disposal that protects public health and has minimal effect on the environment when properly designed, located, installed and maintained. Most on-site systems function satisfactorily; however, a significant number of systems fail to perform as designed and pressure is increasing to install on-site systems on less suitable sites.

The following estimates from 2008 show the scope of on-site system activities by local health departments in North Carolina:

- 215, 000 total site visits, including consultations and permitting;
- 42,000 site evaluations for both new systems, expansions (e.g. added bedrooms) and the repair of malfunctioning systems;
- 4,400 malfunctioning septic systems repaired;
- 5,200 sewage complaint investigations; and
- 18,200 non-conventional systems installed.

Septic systems fall under the major pollutant category of Nonpoint Source Pollution (NPS). It is estimated that as much as 70 percent of water pollution in the United States comes from nonpoint sources. Nonpoint sources of pollution can contaminate local and regional surface and ground waters. Pollutants that potentially come from on-site systems include nutrients, pathogens, and emerging contaminants such as endocrine-disrupting chemicals and pharmaceuticals. Pollutants such as nitrates are important in designated nutrient-sensitive river basins in North Carolina, (e.g. Neuse and Tar-Pamlico). *Web links and Other Resources* are listed for further study at the end of this section.

On-site systems treat vast amounts of wastewater so all on-site systems must be properly installed. Proper installation ensures that wastewater will receive the best treatment possible for protecting the environment and public health.

Although many agencies and authorities in North Carolina are involved in decentralized wastewater management, this manual's focus is on sub-surface on-site wastewater (septic systems).

More than 25,000 new on-site systems are installed in North Carolina annually. These new housing, commercial and industrial developments add to the existing 1.5 million on-site systems currently in use in North Carolina. Combined, these systems treat more than 360 million gallons of wastewater every day.

2.2

2.3 HISTORY OF ON-SITE WASTEWATER MANAGEMENT

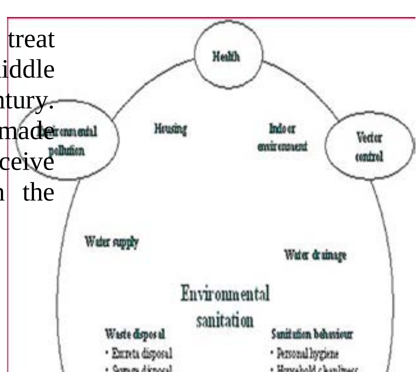
The use of septic tanks to treat wastewater goes back to the middle of the nineteenth century. Frenchman J.L. Mouras first made a masonry tank to receive wastewater from a home in the town of Vesoul, France. After 12 years of operation, the tank was found to contain only a small amount of solids. Mouras had expected that the tank would be very full, so he concluded that some process must occur to reduce the volume of solids. He and A. Moigno, a priest and scientist, experimented with the tank to learn more about processes occurring in the tank. Mouras patented the tank in 1881.

The use of septic tanks in the United States began around 1883 in Boston, Massachusetts. There, Edward S. Philbrick designed a two-chamber, round, vertical-cylindrical tank with a dosing siphon.

Although these early developments showed promise, on-site wastewater disposal continued to operate at a crude level well into the 20th century in both Europe and the United States. During the first quarter of the 20th century, most development work on improving on-site systems was conducted in the United States. By the mid-1920s, Henry Ryon, an employee of the New York State Department of Health, began to study methods to improve on-site system performance. He realized that the most critical part of the system is the treatment and disposal field. To help ensure adequate soil absorption, he developed the percolation test. This test was widely used to help determine the level of soil absorption possible for an on-site system. However, the percolation test has recently shown to provide inconsistent and unreliable information.

The next significant effort to improve on-site wastewater management occurred in the late 1940s. Until that time, only the percolation test and a few guidelines were used to determine soil and site suitability for on-site system installation. Rural electrification gave farm families indoor plumbing and the need to install on-site wastewater disposal systems. Soldiers returning from World War II spawned a housing boom in suburban areas where on-site systems were the only choice for wastewater disposal. However, due to the lack of knowledge of on-site system operation, failures were common. In 1946, the explosion in housing growth and the growing threat to public health brought about the first study of on-site systems by the U.S. Public Health Service.

Since that 1946 landmark effort, many studies have been conducted on conventional, (i.e. gravel) modified conventional, alternative, innovative and experimental on-site systems. That research reaffirmed Ryon's assertion that the most crucial aspect of conventional on-site system performance is the treatment and disposal field. There are now better ways to determine the suitability of a site for an on-site system, and more is known about improving the performance of on-site systems. The next sections address potential impact and research findings regarding on-site systems.



NONPOINT SOURCE POLLUTION

Pollution from on-site systems is categorized as Nonpoint Source Pollution (NPS). Nonpoint source pollution is pollution from sources that can't be targeted to a specific location. Point Source Pollution, on the other hand, comes from a single point such as a pipe discharging from a municipal wastewater treatment plant. Figure 1 demonstrates that there are many activities involved in environmental sanitation. Waste disposal is critical, yet just one aspect of the sanitation picture. Malfunctioning on-site systems and installations in marginal sites are some of the other major concerns.

Figure 2.3.1 is the World Health Organization's schematic of the many variables involved in environmental sanitation.

Much of today's public health knowledge regarding on-site systems was gained during the early part of the 20th century. Until that time, many outbreaks of contagious diseases occurred because sources of and/or exposure to disease (drinking or coming into contact with contaminated water) were not yet known or understood. These contagious diseases are called w*aterborne diseases* because they are spread by contaminated water. Other diseases were found to result from human contact with improperly disposed human and animal wastes.

A basic principle learned in those early years was that in order to improve overall public health, humans must not come into contact with sources of disease. On-site systems apply this principle by dispersing human wastes underground into suitable soils. This allows the soils and soil organisms to disperse and treat the wastewater. In addition, *pathogens* remain in the soils to be eaten, inactivated or die before they can reach a water body (groundwater, surface water or well water). If pathogens were to reach a water body, they could make people and wildlife sick. If on-site systems malfunction, the improperly treated wastewater becomes a potential source of disease and a genuine public health threat.

Public Health Impacts

Diseases carried in wastewater.

Improper disposal of human waste creates ideal conditions for outbreaks of many contagious diseases. Waterborne diseases include typhoid fever, cholera, dysentery, hepatitis, giardiasis, cryptosporidiosis, hookworm, tapeworm and other diseases that have plagued humankind since ancient times. Because proper means to treat and dispose of human wastes and wastewater exist, these previously-common diseases are no longer as great of a threat in the United States but are still present. Currently, many diseases are re-emerging in the United States, and outbreaks of many major diseases still occur. If on-site systems malfunction or are overloaded, the wastewater can contribute significant quantities of untreated sewage, including pathogens, to both surface and ground waters. Some of the most important activities protecting public health are the proper siting, use, and maintenance of septic systems.

Bad bugs/germs that may be found in wastewater cause a variety of diseases, such as diarrhea, hepatitis, cholera, typhoid fever, cryptosporidiosis, and hookworms (see Table 2.3.2).

On-site wastewater treatment aims to reduce the number of pathogens introduced into ground and surface waters. However, reductions are not effective unless pathogen levels are reduced below the infectious doses of viruses, bacteria, protozoa, fungi, nematodes and tapeworms. These pathogens can cause the waterborne diseases listed in Table 2.3.1 as well as many others. The potential for outbreaks increases when people travel, population density increases, and people become exposed to the many wildlife hosts that potentially carry human diseases.

POTENTIAL IMPACT OF ON-SITE WASTEWATER POLLUTION—

Immuno-compromised (e.g. AIDS) and immuno-supressed individuals (e.g. with organ transplants and cancer patients) are at a higher risk for contracting diseases from pathogens carried in wastewater. Children and the elderly are also more susceptible to contracting diseases. Any conditions that weaken the immune system put humans at a higher risk.

Figure 2.3.2
Images of Selected Pathogens

Many different pathogens can be in wastewater and may enter into on-site systems, potentially contaminating ground and surface waters. Viruses, bacteria, fungi, protozoa, and worms (Figure 2.3.2) cause a wide variety of diseases. Because of the differences in these organisms, one fate and transport model and/or one pathogen indicator does not fit all pathogens. Because these pathogens are microscopic, a table of metric (microscopic) measurements (Table 2.3.2) is included.

Table 2.3.1
Metric Measurement Chart Scale of Pathogens
(From smallest unit to largest unit)

Unit Name	Unit Measurement
Nanometer (nm)	1,000 nm = 1 µm
Micrometer (µm)	1,000 µm = 1mm
Millimeter (mm)	10 mm = 1 cm
Centimeter (cm)	100 cm = 1 m

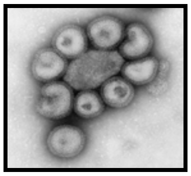
Viruses. Viruses are tiny, non-living pathogenic particles that cannot live outside the body of a host organism. They do not reproduce in soil or wastewater. Viruses have a resistant stage called a particle and may persist in the environment for months to years. Figure 2.3.2(a) shows a transmission electron micrograph of some influenza virus particles (www.cdc.gov).

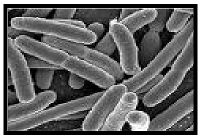
Bacteria. These primitive cells may reproduce in soil or wastewater. Their life cycle may include a resistant spore stage. Bacteria can persist in wastewater and soils for days to weeks. Bacteria like *E. coli 0157:H* , *Salmonella* and *Shigella* cause diseases like Shigellosis (Dysentery), Typhoid Fever and Gastroenteritis. Figure 2.3.2(b) shows a scanning electron micrograph of *Escherichia coli* bacteria (www.epa.gov).

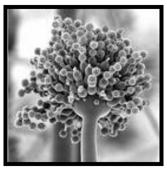
Fungi. Fungi feed on decaying matter. Their life cycles include a resistant spore stage, and they often spread via water or air. Examples of potential fungal pathogens are *Candida (*yeast) and *Aspergillus (*black bread mold). Many fungi can become invasive in the human body. Figure 2.3.2(c) shows a scanning electron micrograph of the black bread mold with spores (www.fungalcell.org).

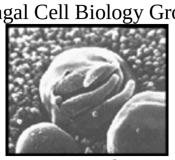
Protozoa. Though protozoa are single-celled organisms, they physiologically resemble humans more than viruses and bacteria. This makes protozoa such as *Cryptosporidium parvum* and G*iardia lamblia* very difficult to treat during an infection. A protozoan pathogen forms a resistant stage called an oocyst during their complex life cycles and can persist for up to 23 months in the aquatic environment. Many are resistant to disinfection. For example, *Cryptosporidium*, one of the top four emerging pathogens, is extremely resistant to chlorination, has many routes of infection, and is harbored by many hosts (humans, cattle, swine, geese, etc.). Outbreaks have occurred in many scenarios (e.g., daycare facilities, drinking water, handling infected animals and contaminated food.) Figures 2.3.2(d) and 2.3.2(e) show scanning electron micrographs of two common protozoan pathogens:
(d) *Cryptosporidium parvum* (www.dpweb.state.pa.us./dep/site/default.asp) and (e) G*iardia lamblia* (www.cdc.gov).

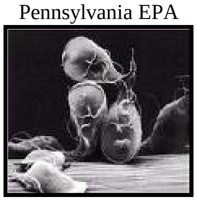
Worms. Helminths—roundworms (nematodes) and tapeworms—are complex, multi-cellular organisms that range in size from micrometers (egg stage) to meters (adult stage) over their life cycles. These worms have a resistant egg stage often with an embryo, which can live for months or years. Figures 2.3.2(f) and 2.3.2(g) show two worm stages: a light micrograph of a tapeworm egg (f) (www.path.caimac.uk~schisto/Tapes/Hymenolepis .html) and a scanning electron micrograph of the anterior end of an adult hookworm (g) (www.cdc.gov).


a) *Influenza Virus* particles
TEM 10-300 nm
CDC


b) *Escherichia coli NIAID*
SEM 1-2 µm
EPA


c) *Aspergillus niger*
SEM 2-10 µm
Fungal Cell Biology Group


d) *Cryptosporidium parvum*
Oocysts with feeding stages
SEM 3-5 µm
Pennsylvania EPA


e) *Giardia lamblia*
Feeding stage
SEM 15 µm
CDC


f) *Hymenolepis diminuta*
Tapeworm Egg with hooks
LM 40 µm
Cambridge Schistosome
Research Group


g) *Ancyclostoma*
Adult Hookworm
SEM 7-12 mm
CDC

Pathogen Category	Pathogen	Disease(s)
VIRUSES	Enteroviruses (many types)	Gastroenteritis (gut bug) respiratory infections,
	Coxsackie A, B	Meningitis, other diseases
	Hepatitis A	Infectious hepatitis
	Adenovirus (more than 40 types)	Respiratory disease, Eye infections
	Rotavirus	Gastroenteritis
	Parvovirus	Gastroenteritis
	Norwalk virus	Diarrhea, fever, vomiting
	Reovirus	Respiratory disease
	Astrovirus	Gastroenteritis
	Calcivirus	Gastroenteritis
	Coronavirus	Gastroenteritis
FUNGI	*Aspergillus fumigatus*	Respiratory infection
	Candida albicans	Skin/membrane infections
BACTERIA	*Shigella*	Shigellosis (dysentery)
	Salmonella typhi	Typhoid fever
	and S. paratyphi (more than 1,000 serotypes)	Salmonellosis
	Vibrio cholerae	Cholera
	Escherichia coli	Gastroenteritis
	Yersinia enterocolitica	Yersiniosis/ Gastroenteritis
	Leptospira spp.	Leptospirosis
	Campylobacter jejeuni	Gastroenteritis
	Clostridium perfringens	Gastroenteritis
PROTOZOA	*Balantidium coli*	Dysentery/ gastrointestinal ulcers
	Cryptosporidium species:	Diarrhea/nausea/fever (Cryptosporidiosis)
	*C. parvum (*animal)	Diarrhea/nausea/fever
	C. hominis (human & animal)	Diarrhea/nausea/fever
	Entamoeba histolytica	Amoebic dysentery
	Giardia lamblia	Giardiasis (diarrhea)
ROUNDWORMS	*Ancyclostoma duodenale*	Hookworm
	Necator americanus	Necatoriasis/hookworm
	Toxacara	Roundworms
TAPEWORMS	*Taenia saginata*	Taeniasis
	Taenia soleum	Taeniasis Neurocysticercosis
	Vampyrolepis (*Hymenolepis*) *V. nana and V. diminuta*	Worm infection (brain) and tapeworms

SELECTED POTENTIAL WASTEWATER PATHOGENS/DISEASES

Table 2.3.2: Selected Wastewater Pathogens and Their Diseases.

With the proper conditions, free-living microbes in soils and

wastewater may treat and eat many pathogens. In soil dispersal systems, aerobic soils are lethal to most pathogens. Soil treatment effectiveness varies by soil types, degree of saturation and many other variables.

Pathogen Indicators.

The presence of pathogens is tested in wastewater by measuring the number of fecal coliform bacteria or colony forming units. Fecal coliform bacteria are found in all vertebrate animal intestines and may enter the surface and ground waters. Ducks, raccoons and mice are likely high-potency contributors of fecal coliform bacteria to local water bodies. The number of fecal coliform bacteria produced varies with each host species. Fecal coliform bacteria can also regrow in sewage, mud and water bodies. Wastewater literature shows that fecal coliform bacteria are not indicators of all pathogen groups, particularly viruses and protozoa.

Disease, Wastewater and On-site Systems.

There are two very dangerous types of on-site system failures concerning public health. The first occurs when the wastewater does not infiltrate the ground, but instead ponds or comes to the land’s surface, and forms a small pool or wet, mushy area. This unabsorbed wastewater may contain many disease-causing bacteria, viruses and parasites. There are many ways in which humans can become sick when wastewater ponds in or over a treatment and disposal field. Malfunctioning on-site systems can pollute wells, streams, rivers and lakes, any of which may be used as water supplies. Ponded wastewater can flow into nearby streams to contaminate water bodies downstream.

A second type of on-site system failure occurs when an on-site system pollutes a well or the groundwater. This type of failure happens when a well and/or septic system is not properly sited or constructed. In some cases, the on-site system may not be ponded on the surface: the wastewater flows through cracks in the soil or underlying rock into the well or groundwater. If wastewater enters a well or the groundwater that supplies the well, people may get sick by drinking water from that well. The on-site system, the well or both may have to be moved or rebuilt to ensure a clean supply of water.

The following methods of spreading disease - fecal-oral, contact, and vector transmission - are pathways where pathogens can enter the body and make someone sick.

Fecal-oral transmission. Humans can come into contact with pooled wastewater. Children and pets are most likely to play over the pools or wet soil but adults may have to walk through or work in the area. Once the wastewater is on the person’s hands, the germs can enter their mouth, where they can be swallowed. Examples of fecal-oral transmission are:

- Hand-to-mouth
- Ingestion of food and water: Humans may drink contaminated water or consume food made with contaminated water or may be exposed to pathogens during food preparation;
- Airborne inhalation and swallowing. Small droplets of sprayed wastewater with pathogens in the air (aerosols) can be inhaled and swallowed; and
- Fomites (solid objects e.g. probe, shovel). This risk of exposure to contaminants through this mode of transmission dramatically increases for septic tank operators and environmental health specialists working with contaminated wastewater and soils. Always make sure you clean your tools before putting them away, or leave them out in the sunshine to dry or be disinfected.

Contact transmission. Contact transmission is the touching of a body part to an infectious pathogen which results in contracting the infectious disease. Direct contact involves person to person touching while indirect contact involves touching a pathogen-contaminated surface. The following are examples of contact transmission pathways of diseases:

- Cracks and cuts in the skin;
- Some pathogens burrow through skin (e.g. hookworms); and
- Mucous membranes that are found in the eyes and nose, where the moist epithelium is very thin.

Vector Transmission. Disease organisms can be spread by insects or other animals to human food or drinking water. The animals that spread disease germs are called vectors. One of the best known vectors is the common housefly. Filth-flies can spread disease by landing in fecal material or drinking from pooled wastewater, and then landing on food that humans later eat. The pathogens from the fly may then be eaten with the food. Vectors include:

- Filth-flies (well-documented in the public health literature);
- Beetles and other insects; and
- Two-and four-legged creatures such as humans and pets.

Chemicals and Septic Systems.

Wastewater not only carries many disease-causing organisms, it also contains chemicals that can cause poor health, cancer or death. A wealth of information exists about the different chemicals found in the effluent from on-site systems.

Nutrients and nitrates. Nutrients such as nitrates and phosphates can have harmful effects on humans and the environment. We can reduce the potential for toxicity and damage to the environment by lowering levels of ammonia, nitrates and phosphates leaching to surface and ground waters. Lowered amounts result in lowered effects.

1) These nutrients make their way into surface and ground waters via runoff from farms, domestic animals and unsewered urban areas. Animal waste and agriculture are some of the biggest contributors of nutrients to nonpoint source pollution via runoff. Ammonia - the product of degradation of organic material - can be toxic to larval fish. This chemical is also an irritant to skin and mucous membranes. Nitrates have long been known to affect health (e.g. blue baby syndrome).

2) Ammonia in wastewater is converted to nitrate by the bacteria in the septic tank and drain field during decomposition. This nitrate moves rapidly with water through the soil. If nitrates get into a drinking water well, they will be drunk by the site's residents or neighbors.

3) Nitrates and phosphates can cause harmful algal blooms and cultural eutrophication in aquatic habitats. This process can be described as "human activity over-nourishing." Low levels of nitrates have proven to be toxic to amphibian tadpoles.

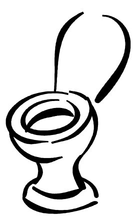
4) Infants younger than six months are most susceptible to nitrate's harmful effects. Bacteria that live in the digestive tracts of newborn babies convert nitrate to nitrite. Nitrite then reacts with hemoglobin, which carries oxygen to the blood, to form methemoglobin. Methemoglobin cannot carry oxygen, thus the affected baby suffers oxygen deficiency. The resulting condition is referred to as methemoglobinemia or blue baby syndrome. Some research evidence indicates that nitrates may also contribute to spontaneous miscarriages.

5) The EPA standard for nitrates is 10 milligrams per liter as nitrogen in drinking water.

6) These chemicals are produced in on-site systems by normal processing of wastewater. Homeowners and environmental health specialists can prevent harmful levels of these chemicals being released by the proper design, siting, and operation of on-site systems.

Emerging contaminants. Emerging contaminants include endocrine disrupting chemicals (EDCs) and personal care products and pharmaceuticals (PPCPs) in the waste stream. These are largely unregulated contaminants, and until recently, they have not been part of the waste treatment discussion. The effects of EDCs and PPCPs on human health, wildlife and ecology are currently being observed. These contaminants can also cause prenatal and postnatal health issues in humans, and may contribute to antibiotic resistance in harmful bacteria.

Endocrine disrupting chemicals. These chemicals affect hormones and hormone receptors in humans and animals by mimicking or blocking natural hormones in both vertebrates and invertebrates. A wide variety of chemicals fall under this category like arsenic, nonylphenol and bisphenol A. Although their chemical structure may be very different, their hormonal activity might be the same. Some examples of the hormonal activity might be estrogenic or anti-estrogenic.



Nonpoint source pollution experts who study wastewater seek to identify the treatment by on-site systems by EDCs in wastewater; compare these levels of EDCs to those found in wastewater in general; and identify and evaluate wastewater treatment technologies and reduce pollution from these chemicals. Organizations like the United States Geological Survey (USGS) and the N.C. Division of Environmental Health are gathering data on EDCs from surface and groundwater, as well as treatment in on-site systems.

Pharmaceuticals and Personal Care Products. These chemicals come from wastewater and other nonpoint sources. The EPA includes "prescription and over-the-counter therapeutic drugs, fragrances, cosmetics, sunscreen agents, diagnostic agents, nutraceuticals [and] biopharmaceuticals" in this category. According to the EPA, "This broad collection of substances refers, in general, to any product consumed by individuals for personal health or cosmetic reasons". Chemicals from personal care products have been found in surface waters across the nation, and some of them are also EDCs. Pharmaceuticals have been implicated in increasing rates of environmental microbial antibiotic resistance and in the reduction of microbial activity in septic tanks.

Artificial chemicals. Many man made chemicals can be found in on-site wastewater effluent. Examples are substances found in household cleaning products, hobby activities or laundry additives. Many chemicals are not biodegradable or broken down by bacteria in the septic tank and field. Because these chemicals are not broken down, they may flow into groundwater or surface water and eventually into drinking water.

Due to the wide variety of man-made chemicals, it is difficult to say what types of problems these chemicals may cause. Some chemicals are toxic or poisonous; others may cause cancer or other diseases or have sub-clinical effects at low levels.

Waste Treatment in On-site Systems

Wastewater must be dispersed into aerobic soil and allowed adequate contact time so the action of native microbes in the soil reduces the number of disease germs or amounts of toxic chemicals. When the wastewater is held in the soil and the soil is suitable for on-site wastewater treatment, neither humans or animals can come into contact with it. It should not contribute to the pollution of streams or groundwater. Thus, a properly operating on-site system protects public health. A crucial part of the operation of a septic system is what the homeowners put in the toilet and sink. Table 2.3.3 describes what not to flush in the toilet or put in the sink.

Table 2.3.3
What not to Flush
What not to Allow
Down the Sink:
Guidelines for a
Healthy Septic System

	Don't Flush It	
Plastics/Latex	**Paper/Materials***	**Other Materials**
Wrappers	Baby wipes	All medicines
Feminine product covers	Paper towels	Coffee grounds
Lids/liners/rings	Towelettes	Cigarettes
Condoms	Facial tissues	Leftover food
Bandages	Napkins	Hair clippings
	Gauze	Kitty litter/pet wastes
	Dental floss	Grease
	Matches	Oils/Solvents
	Feminine products/ paper covers	
	Don't Sink It	
Greases	**Liquid Wastes**	**Other Materials**
Fats	Pesticides	Coffee grounds
Butter	Drain cleaners	Excess food waste
Wax	Household chemicals**	
Cheese	Paints	
Heavy cream	Paint thinners	
	Oils	
	Photographic solutions	
	Solvents (e.g. hobbies)	

*other than toilet tissue

**unless specified safe for septic systems

Environmental Impacts

On-site wastewater systems are installed so they will not pose a threat to the environment. Presently, more than 50 percent of North Carolina housing units (representing about 3.5 million people) depend upon on-site wastewater disposal. Based on these figures, on-site systems distribute 360 million gallons of wastewater into the environment each day.

NPS pollution, unlike pollution from industrial and sewage treatment plants, emerges from many diffuse sources. It is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters and even our underground sources of drinking water.
EPA-841-F-94-005, 1994

Most nonpoint source pollution results from common activities regarding land use. Examples of nonpoint source pollution sources are:

- agricultural runoff (fertilizer and pesticides from farming);
- human, pet and animal wastes;
- atmospheric deposition and leaky sewer lines;
- on-site wastewater treatment systems;
- stormwater runoff and surface application of wastes;
- oil, grease and toxic metals from parking lots, roads and automobiles;
- sediment from bare land, construction sites and newly developed areas; and
- industrial and commercial chemicals from spills and leaks at industrial sites and commercial zones.

If on-site systems malfunction or are overloaded, the wastewater can contribute significant quantities of raw sewage, pathogens and chemicals to surface and ground waters. In addition, the wastewater from on-site systems contains certain pollutants, which are not biodegradable in the on-site system but act as pollutants in water bodies. Thus, even systems that appear to be functioning properly can contribute to the pollution of streams, lakes, marshes or groundwater.

Potential Impacts on the Environment

Pollutants in wastewater may affect animals, plants and their habitats and the long-term effects can be very serious. Some environmental impacts of wastewater are discussed below.

Nitrates and phosphorus from on-site systems can cause *cultural eutrophication*, an overgrowth of algae and plants in water bodies. Eutrophication often appears as algae blooms in streams, rivers, estuaries or marshes and even in sounds and bays in the ocean. Overgrowth causes fish kills, a result of nighttime oxygen use, and occurs more often where the water moves slowly.

On-site systems are inspected annually and triannually in some areas of North Carolina (e.g., near shellfish growing areas) to ensure that the systems do not fail. (There is a 3 percent to 4 percent annual failure rate.) The Shellfish Sanitation Section produces reports to document all known sources of pollution in these areas.

Wastewater from on-site systems can cause certain parts of a stream to become *anaerobic*, which means there is no oxygen in the water. Pollutants in the on-site wastewater serve as food for bacteria and algae. The bacteria and algae grow rapidly, depleting all the oxygen in the stream. This lack of oxygen suffocates fish, other animals and plants.

Toxic and synthetic chemicals from on-site systems can enter shallow groundwater. This happens most often where the soil is sandy, or the water table is very high. Under these conditions, the wastewater does not receive adequate treatment to biodegrade the pollutants in the wastewater.

2.4 SCIENCE OF ON-SITE WASTEWATER TREATMENT AND DISPOSAL (SOIL DISPERSAL SYSTEMS)

During the early years of the 20th century, on-site wastewater management was basically a trial-and-error process. Systems that failed were not of critical concern because on-site wastewater disposal was generally used in rural areas with sparse populations. There was little need for detailed knowledge; on-site wastewater treatment and disposal received little attention.

As rural electrification enabled more people to install indoor plumbing and as rural and suburban populations grew, a greater need arose for concise information about proper installation and operation of on-site systems. More than 80 years have passed since Henry Ryon first suggested that the performance of an on-site system depended on the percolation rate of the soil. Since that time, many studies have been conducted on on-site system requirements and performance.

This section presents the most important principles and guidelines regarding on-site wastewater treatment and disposal. These principles are based on the many studies conducted to determine the best ways to provide safe and reliable wastewater treatment and disposal.

Dispersal, absorption, and treatment of wastewater by soils.

The vast majority of on-site treatment and disposal systems depend on the soil for dispersal, absorption, and treatment of sewage. Although some on-site systems use surface discharge or land application to dispose of wastewater, such systems are relatively few in number.

Principals of Wastewater Treatment And Disposal

Research conducted over the last 40 years has demonstrated that the treatment and soil dispersal field is the most critical aspect of an on-site system. Devices that receive sewage upstream of the treatment and dispersal field pretreat the sewage to prevent clogging of the individual treatment and dispersal fields.

The following five principles are the most important concepts regarding on-site wastewater treatment and disposal. The design and installation of all on-site wastewater systems should be guided by these principles.

OSWW: FIRST PRINCIPLE. ***On-site systems should ensure that the effluent is absorbed by the soil.***

The effluent should not come to the land surface or flow directly into streams, rivers, lakes, the ocean or ground waters.

Sewage carries many disease-causing bacteria or germs. As long as the sewage effluent remains in the soil, people are protected because the pathogens remain in the soil where there is no contact with humans. However, if the effluent surfaces on the ground, children and adults may come in contact with pathogens and may become ill or die. On-site systems that malfunction may cause effluent to puddle or pool on the ground, which is dangerous to public health.

On-site systems not only dispose of sewage, but also treat the sewage to remove pathogens and pollutants. The treatment of wastewater occurs in the soil, so the wastewater must remain in the soil for an extended period of time for the pollutants to be removed.

<u>OSWW: SECOND PRINCIPLE.</u> ***On-site systems should only apply effluent to suitable soil***.

Sewage undergoes <u>aerobic</u> treatment in soil layers that are not saturated with water. These soil layers are called the *unsaturated zone* or *vadose zone* because the soil is dry or damp but not completely wet. The unsaturated zone is aerobic because air and oxygen enter and help kill pathogens and remove pollutants from the sewage. Aerobic treatment is the fastest and most complete treatment the effluent can receive in the soil. On-site systems should be located where the effluent must travel the farthest distance possible before getting to the water table or wet soil layers. Long travel distance helps prevent pollution of groundwater.

<u>OSWW: THIRD PRINCIPLE.</u> ***On-site systems should apply effluent only in a suitable and prepared treatment and disposal field.***

A treatment and disposal field is an area of land where effluent flows through pipes with holes into specially prepared trenches or beds to be absorbed by the soil. The treatment and disposal field is where the main treatment of the effluent occurs and where all the liquid effluent is absorbed.

Only certain soils and certain locations should be used as treatment and disposal fields. These areas are selected by environmental health specialists to provide the safest and most reliable place to absorb liquid effluent.

Septic tanks, pump tanks or piping should not leak. Effluent leaks have resulted in contamination of groundwater, wells, land surfaces and surface waters.

<u>OSWW: FOURTH PRINCIPLE.</u> ***Treatment and disposal field trenches should be as long and narrow as possible to maximize the effluent's contact with the soil, which increases treatment.***

Short and wide field trenches may have the same amount of trench bottom area as a long, narrow trench, but the long, narrow trench has much more side wall area that can absorb effluent and spread the effluent out through more soil with oxygen. In addition, sloping sites with contoured long trenches will spread the effluent over a much broader "window" than stacked shorter trenches, lessening the likelihood of hydraulic overload downslope.

<u>OSWW: FIFTH PRINCIPLE.</u> ***Treatment and disposal field trenches should have level bottoms and should be level along their entire length to distribute the effluent as evenly as possible.***

Field trenches with slanted bottoms or trenches that slope along their length allow the effluent flow to the lowest area and may result in ponding. All treatment and disposal of the effluent must occur in that lowest area which could cause early failure of the field and threaten public health if the effluent surfaces.

Pre-treatment of sewage before soil absorption.

To protect the treatment and disposal field from clogging, some pre-treatment is necessary. The conventional on-site system uses a septic tank to pre-treat sewage before it flows to the field. Septic tanks operate on the following principles.

SEPTIC TANKS: FIRST PRINCIPLE. ***Septic tanks remove solids suspended in sewage.***

The large volume of the septic tank slows the wastewater flow while increasing the time it is in the septic tank. Heavy solids can settle to the bottom and buoyant materials, such as oil and grease, can float to the top.

Heavy solids form a layer of sludge on the bottom of the tank, while oil and grease make a scum layer that floats on the wastewater. Various types of baffles, such as walls and filters, are used to keep the settled and floating solids from moving out into the treatment and disposal field. A septic tank that is working well removes about half of the pollutants in the sewage by either letting them settle out in the solids or float on the surface of the wastewater.

SEPTIC TANKS: SECOND PRINCIPLE. ***The second important function of the septic tank is to store solids.***

Because the solids are stored in the large volume of the septic tank, the tank has to be pumped out every few years. The tank must be large enough to store the solids and still allow additional solids to settle out. The pumping frequency of a septic tank depends on occupancy and usage.

SEPTIC TANKS: THIRD PRINCIPLE. ***Some of the solids in the septic tank are digested by bacteria and other microbes in the tank*.**

Certain bacteria are called *anaerobes* because they live in areas where there is no oxygen, digest the sewage, and produce various gases and chemicals (e.g. ammonia). Recently, a wide variety of higher organisms such as protozoans and nematodes have been discovered in the septic tank biota. This has led scientists to conclude there is stratification in the tank of aerobic and anaerobic zones.

Considerable differences of opinion exist with respect to how much digestion of solids occurs. Regardless of how much digestion occurs, a beneficial aspect of digestion includes the reduction of bacteria in the sludge volume and in the strength of the wastewater. However, the gas produced by the bacteria rises through the wastewater and causes the sludge to be stirred up and possibly flow out to the treatment and disposal field. Gases produced by the bacteria are poisonous and can burn or explode, making the air inside a septic tank lethal. The gases are also highly corrosive and can deteriorate the tank and outlet tees.

Improving septic tank performance

The following points will enable septic tanks to perform more efficiently:

- For maximum settling to occur, septic tanks should be much longer than they are wide. A longer length allows the water to flow along a longer path, leaving plenty of time for the solids to settle. The tank should be at least twice as long as it is wide. Two compartment tanks also allow for more settling in the compartments;
- Shallow, flat tanks allow for better settling than deep, narrow tanks;
- Larger septic tanks work better than small tanks because they retain wastewater longer and have more storage volume for sludge and scum;
- For best performance, the inlet and outlet of the septic tank must be separated by a long flow path for the wastewater. If the inlet and outlet are too close, the wastewater flows rapidly to the outlet before the solids can settle and the grease can separate from the water;
- Outlets work best if they are equipped with a fitting to keep the scum from flowing out into the treatment and disposal field;
- Filters should be sized properly and cleaned regularly to aid in filtering out solids; and
- Current research shows that wide varieties of micro-organisms and macro-organisms live and reproduce in the septic tank. More research is needed to understand the effects of household products on the system and tank ecology.

FOR MORE INFORMATION PLEASE SEE THE OSWP WEBSITE.