ONSITE SEWAGE DISPOSAL SYSTEMS

How & Why They Work The Way They Do

Maine Center for Disease Control and Prevention

An Office of the Department of Health and Human Services

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Division of Environmental Health

Subsurface Wastewater Unit

ONSITE SEWAGE DISPOSAL SYSTEMS

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Onsite sewage disposal systems are a viable method of sewage disposal, provided that they are designed, installed, and maintained properly. However, to many the operation of such systems is very much an "out of sight, out of mind" issue. This discussion will include:

- **Background information on sewage characteristics.**
- **Primary Treatment.**
- **Effluent Quality.**
- **Secondary Treatment.**
- **Tertiary Treatment.**

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BACKGROUND

Primary treatment consists of temporarily holding the sewage in a quiescent condition where heavy solids can settle to the bottom while oil, grease and lighter solids float to the surface.

Secondary treatment removes dissolved and suspended biological matter by indigenous, water-borne micro-organisms in a managed habitat. Secondary treatment may require a separation process to remove the micro-organisms from the treated water prior to discharge or tertiary treatment.

Tertiary treatment is sometimes defined as anything more than primary and secondary treatment. If it is sufficiently clean, tertiary effluent from municipal treatment plants can be used for groundwater recharge or agricultural purposes in some states.

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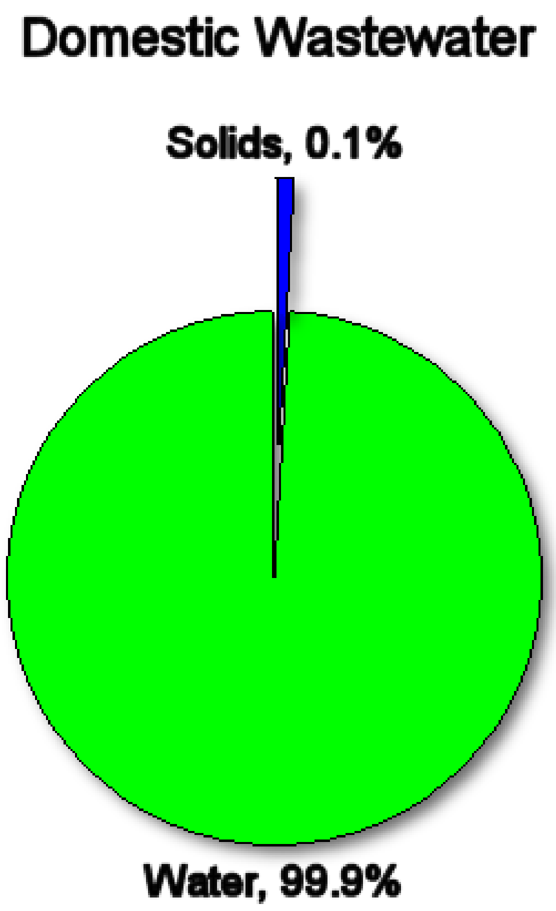
BACKGROUND

Normal household wastewater consists of all the liquid household waste which is generated from the toilet, bath, kitchen and laundry. This material is composed of about 99.9 percent liquids and about 0.1 percent solids. The small percentage of solids and the microorganisms in wastewater are the cause of health hazards and nuisances.



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BACKGROUND

Approximately two-thirds of the solids in domestic wastewater are organic compounds, primarily carbohydrates and fats. The organic compounds are the primary source of odors and nuisances, requiring large volumes of oxygen to render them stable, inoffensive and non-hazardous.

Other substances in wastewater that are undesirable and potentially harmful are:

- **pathogenic bacteria,**
- **infectious viruses,**
- **decomposing organic matter,**
- **toxic chemicals, and**
- **excess nutrients, such as nitrogen and phosphorus.**

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EFFLUENT QUALITY

Biochemical oxygen demand (BOD) is a water quality measurement listed as a conventional pollutant in the U.S. Clean Water Act. It measures the rate of oxygen uptake by micro-organisms in a sample of water at a temperature of 20°C and over an elapsed period of five days in the dark. To ensure that all other conditions are equal, a very small amount of micro-organism seed is added to each sample being tested.

The BOD test is carried out by diluting the sample with oxygen saturated de-ionized water, inoculating it with a fixed amount of seed, measuring the dissolved oxygen (DO) and then sealing the sample to prevent further oxygen dissolving in. The sample is kept at 20 °C in the dark to prevent photosynthesis (and thereby the addition of oxygen) for five days, and the dissolved oxygen is measured again. The difference between the final DO and initial DO is the BOD. The loss of dissolved oxygen in the sample, once corrections have been made for the degree of dilution, is called the BOD_5.

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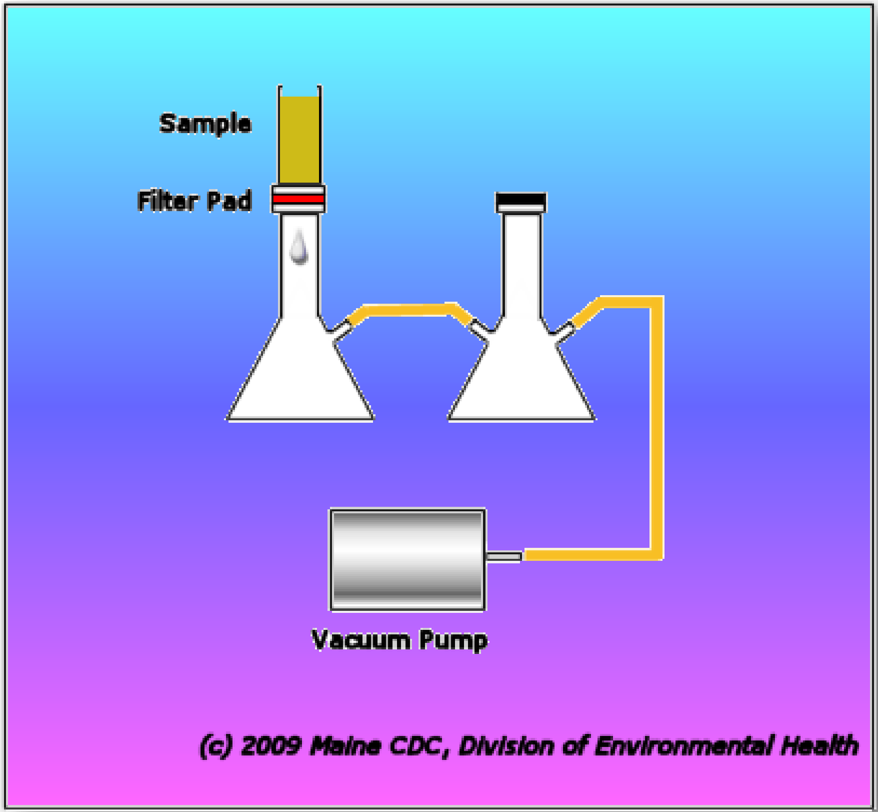
EFFLUENT QUALITY

Total suspended solids (TSS) is a water quality measurement listed as a conventional pollutant in the U.S. Clean Water Act. TSS of a water sample is determined by pouring a carefully measured volume of water through a pre-weighed filter of a specified pore size, then weighing the filter again after drying to remove all water. The gain in weight is a dry weight measure of the particulates present in the water sample expressed in units derived or calculated from the volume of water filtered, typically milligrams per liter or mg/l.



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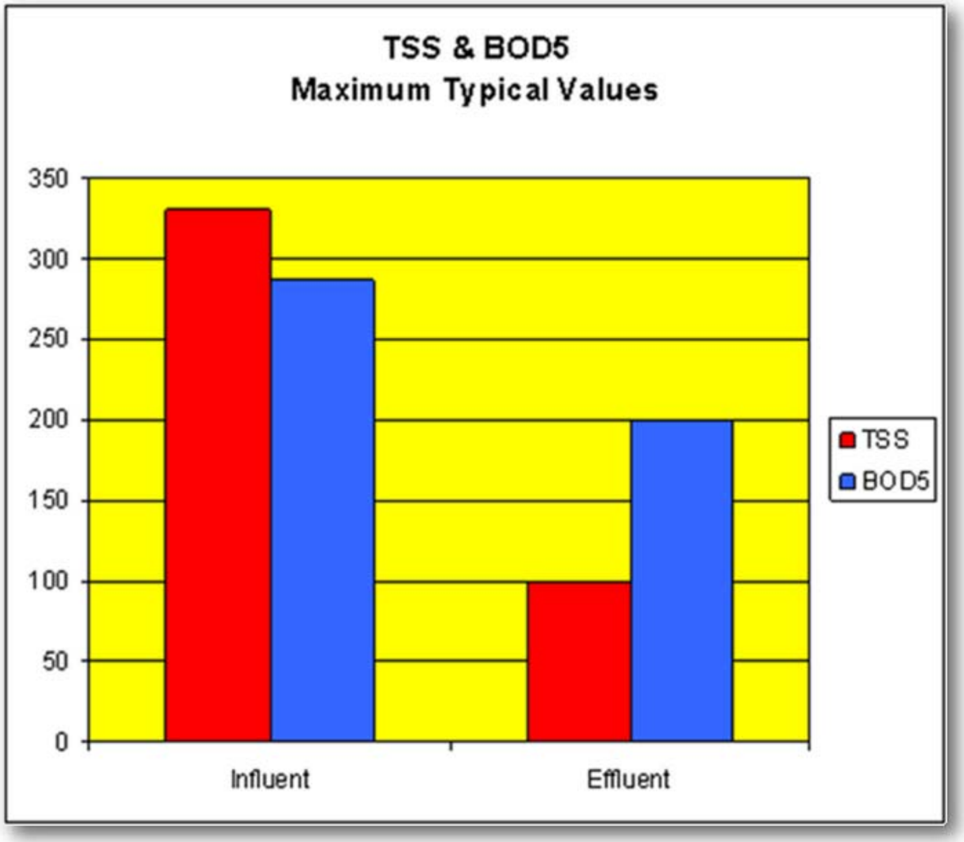
EFFLUENT QUALITY

Typical residential septic tank effluent has a combined 5-day biochemical oxygen demand (BOD_5), and total suspended solids (TSS) of 250 ppm.

A typical septic tank removes about 40% to 50% of the BOD_5, 50% to 70% of the TSS, 20% to 30% of the nitrogen, and up to 30% of the phosphates, by holding the pollutants with the retained solids.

Disease organisms do not multiply in the septic tank. They can only survive or be reduced.



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EFFLUENT QUALITY

The Subsurface Wastewater Disposal Rules' criteria for calculating the size of wastewater disposal fields assume that the waste being treated is of the same quality as normal household wastewater in terms of combined 5-day biochemical oxygen demand (BOD_5), and total suspended solids (TSS).

When it is suspected that the wastewater to be treated is weaker or stronger than domestic wastewater, the BOD_5 and TSS should be measured and considered for adjusting the disposal field size.

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EFFLUENT QUALITY

The primary advantage of aerobic treatment units is a very high level of treatment, with significant reductions in BOD_5 and TSS, and in many cases, pathogen destruction. Because the resulting effluent is low in organic loading, onsite sewage disposal system disposal areas can be reduced in size under provisions of the Subsurface Wastewater Disposal Rules. The size reduction varies according to the strength of the effluent, as measured in combined BOD_5 and TSS, to as low as 50 percent.

TABLE 603.1
ADJUSTMENT FACTOR FOR WASTEWATER STRENGTHS DIFFERENT FROM TYPICAL DOMESTIC WASTEWATER

Strength of wastewater entering the disposal field (BOD5 plus TSS)	Adjustment factor (AF)
30 or less milligrams/liter	0.5
52	0.6
82	0.7
122	0.8
175	0.9
240	1.0
320	1.1
420	1.2
530	1.3
660	1.4
810	1.5
985	1.6
1180	1.7
1400	1.8
1645	1.9
2000	2.0

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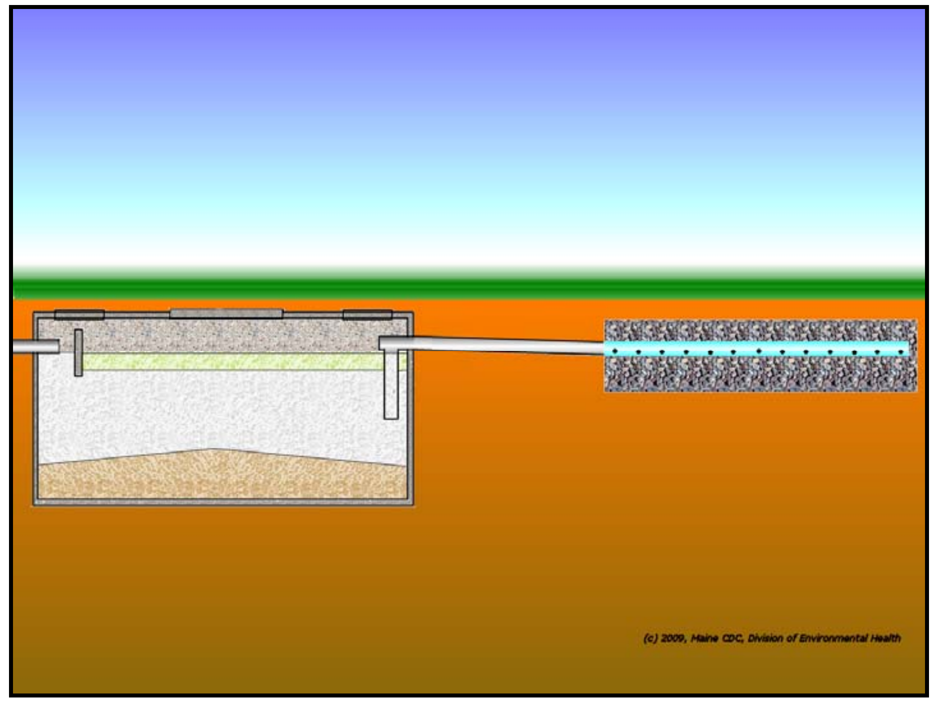
The effluent from a septic tank is delivered to a disposal field where it leaches into the soil under unsaturated flow conditions, and removes pollutants from effluent.



This process includes physical filtration, adsorption of viruses and bacteria by clay and organic matter, pathogen destruction by microorganisms, chemical fixation or precipitation of phosphorous, biochemical transformations of nitrogen compounds, and biological assimilation of nitrogen and phosphorous.

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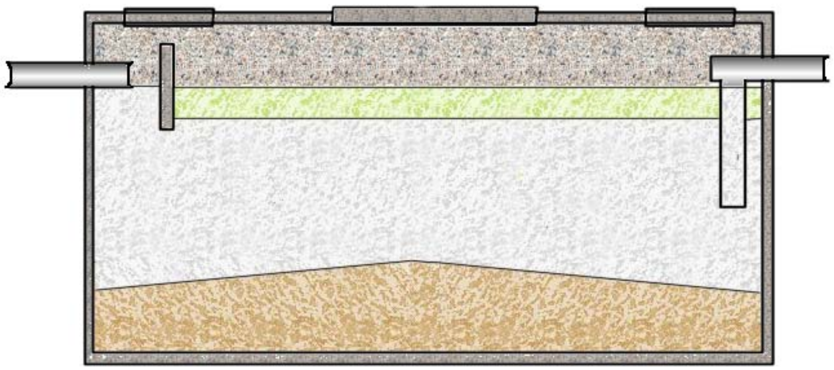
PRIMARY TREATMENT

Primary treatment, which takes place in the treatment tank, is a settling process in which the settleable solids sink to the bottom by gravitation and lighter elements float to the top.

The total solids in wastewater consist of dissolved or soluble solids, suspended or colloidal solids, and settleable solids. The dissolved and suspended solids remain in the wastewater and do not settle out, while the settleable solids are removed from the wastewater by gravity if allowed sufficient time.



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PRIMARY TREATMENT

Septic tank cleaners are designed to liquefy or emulsify the fats, grease, and solids in the septic tank, to reduce or eliminate the need for pumping the tank. These preparations defeat the septic tank's purpose, which is to separate and contain these materials. The septic tank effluent should be relatively light in color and free of obvious solids.

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PRIMARY TREATMENT

When septic tank additives are used, instead of remaining in the tank, the liquefied fats, grease, and solids leave in the effluent and enter the field. Much of this material is not subject to bacterial breakdown in the absence of oxygen, can significantly shorten the life of the field by reducing soil permeability.

Some of these additives themselves have the potential to pollute.

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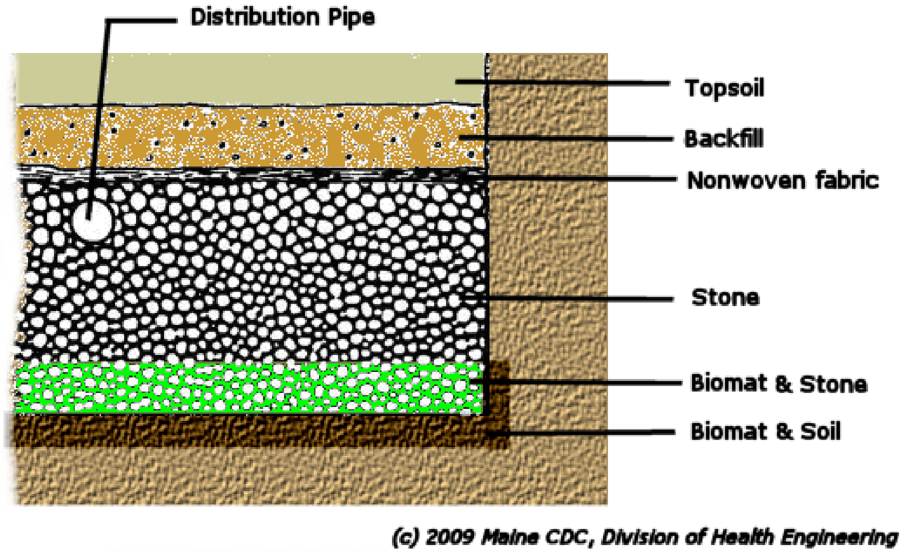
PRIMARY TREATMENT

Continuous or frequent ponding of septic tank effluent on the bottom of the disposal field results in the growth of a biological layer that filters out more and more solid particles and dissolved pollutants from the septic tank effluent. A biomat is formed at the point of infiltration into the soil.



This mat normally penetrates 1/2 to 6 centimeters into the soil. It consists of a slimy mass of septic tank effluent solids, mineral precipitates, microorganisms, and the by-products of decomposition.

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How & Why They Work The Way They Do

PRIMARY TREATMENT

The biomat is in constant flux, that is, building, degrading, and creeping downward into the soil as a viscous fluid where it is dispersed. The process is self-cleaning, as microbes metabolize the biomass and each other during periods of low inflow. This self-cleaning property, along with a constant septic tank effluent load, allows a properly designed disposal field to be passive and function without maintenance. The biomat develops at a rate dependent upon the septic tank effluent load.

As the biomat matures, the septic tank effluent infiltration rate through the biomat decreases. A biomat's average infiltration rate, or disposal field application rate, is usually reached after a period of 3 to 36 months. This is sometimes referred to as the long term acceptance rate, although the term is more accurately associated with soil permeability.

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PRIMARY TREATMENT

The biomat acts as a hydraulically restrictive horizon. Its limited permeability is accounted for in the disposal field application rates used for designing systems. The acceptance rate of the biomat is dependent on the texture, structure, and consistence of the soil. This rate typically ranges somewhere between 0.2 to 0.8 gallons per day per square foot of bottom and sidewall area.

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PRIMARY TREATMENT

Once the biomat is established, the organisms in the mat are extremely effective in stabilizing organic waste, removing particulates, and removing pathogenic organisms. Bacterial indicators of pathogenic contamination are total coliforms, fecal coliforms, and fecal streptococci.

Total coliform concentrations of 57,000 colonies per milliliter within the disposal field are typically reduced to less than 200 colonies per milliliter at or beyond a foot of the biomat.

Fecal coliforms concentrations of 19,000 colonies per milliliter within the disposal field are typically reduced to less than 2 colonies per milliliter at or beyond a foot of the biomat.

Fecal streptococci concentrations of 1,600 colonies per milliliter within the disposal field are typically reduced to less than 2 colonies per milliliter at or beyond a foot of the biomat. The biomat typically removes approximately 10% of the nitrogen but is less effective in removing phosphates.

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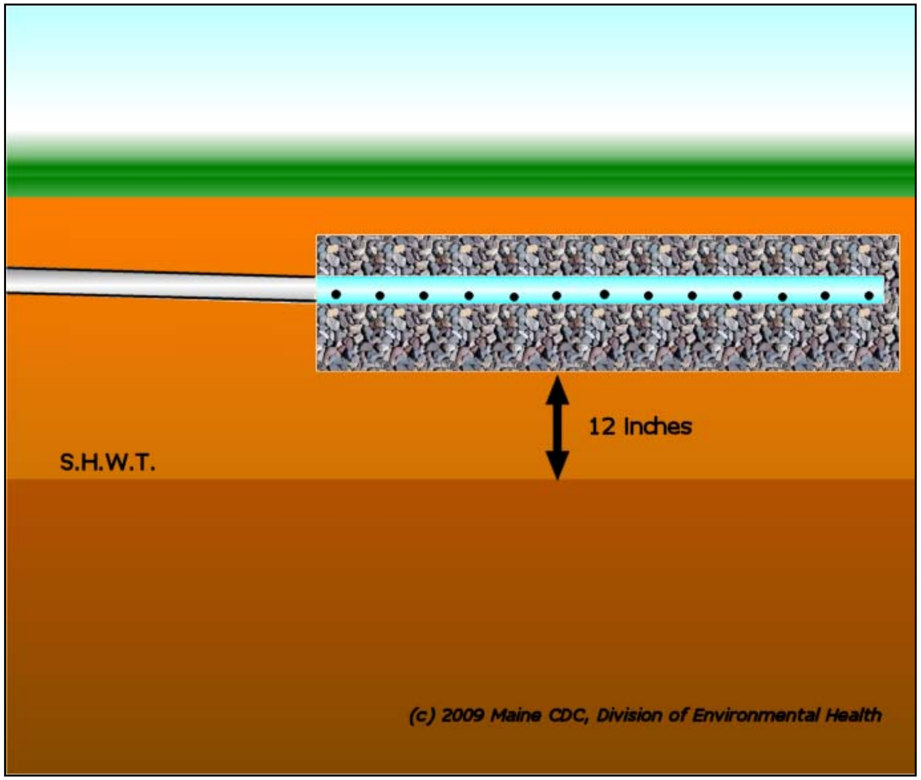
PRIMARY TREATMENT

The Subsurface Wastewater Disposal Rules require a minimum 12 inch zone of treatment in the soil column below the bottom of the disposal field. This allows a reaction time as the partially treated septic tank effluent passes through the soil under unsaturated conditions and assures adequate treatment. This 1 foot of unsaturated suitable soil, fill material, or combination thereof below the level of the bottom of the disposal field removes pollutants from the septic tank effluent by processes including physical filtration, and ionic-anionic attraction.



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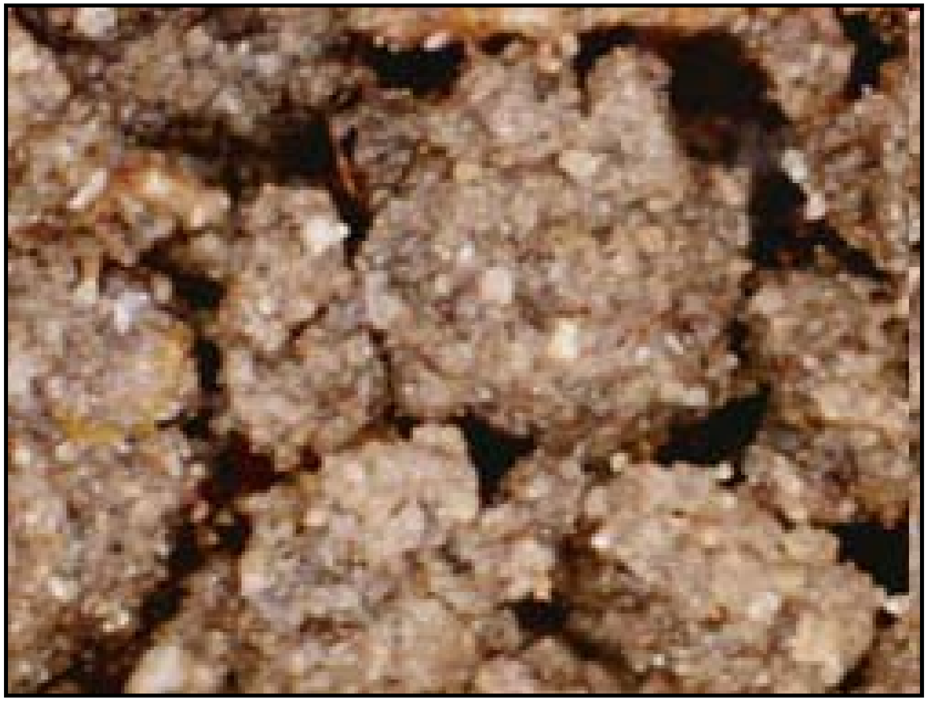
How & Why They Work The Way They Do

PRIMARY TREATMENT

The movement of septic tank effluent through the biomat is due to the hydrostatic or gravity head pushing the septic tank effluent down through the biomat, and the capillary tension force or matrix potential pulling the septic tank effluent through the biomat. In many soils the capillary potential of the soil itself is more effective than the small hydrostatic heads in forcing the septic tank effluent through the biomat.



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PRIMARY TREATMENT

Long, narrow disposal fields should be used whenever possible. Such designs increase the sidewall area to bottom area ratio. These can be stone trenches, fabric wrapped pipes, or cuspated block systems.

A narrow disposal area reduces the potential for water mounding under the disposal field and, by spreading out the septic tank effluent plume, increases the potential for dilution as the plume travels down slope.

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SECONDARY TREATMENT

The majority of municipal plants in the U.S. use aerobic biological processes, known broadly as secondary treatment. Secondary treatment has long been used in municipal wastewater treatment plants to treat sewage. For this to be effective, the biota require both oxygen and a substrate on which to live. There are several ways in which this is done.

This is an aeration basin that utilizes pressured air and bubble dispersal to aerate the wastewater.

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SECONDARY TREATMENT

In suspended-growth systems, the sewage is mixed by aeration within an aeration basin, or in a treatment tank in the case of a residential scale system. This produces a mixture of water, microbes, and sewage known as activated sludge.

This photo shows a municipal suspended-growth system using mechanical impellers to aerate the wastewater instead of bubblers. The residential version of suspended-growth systems is a simple aerated tank.

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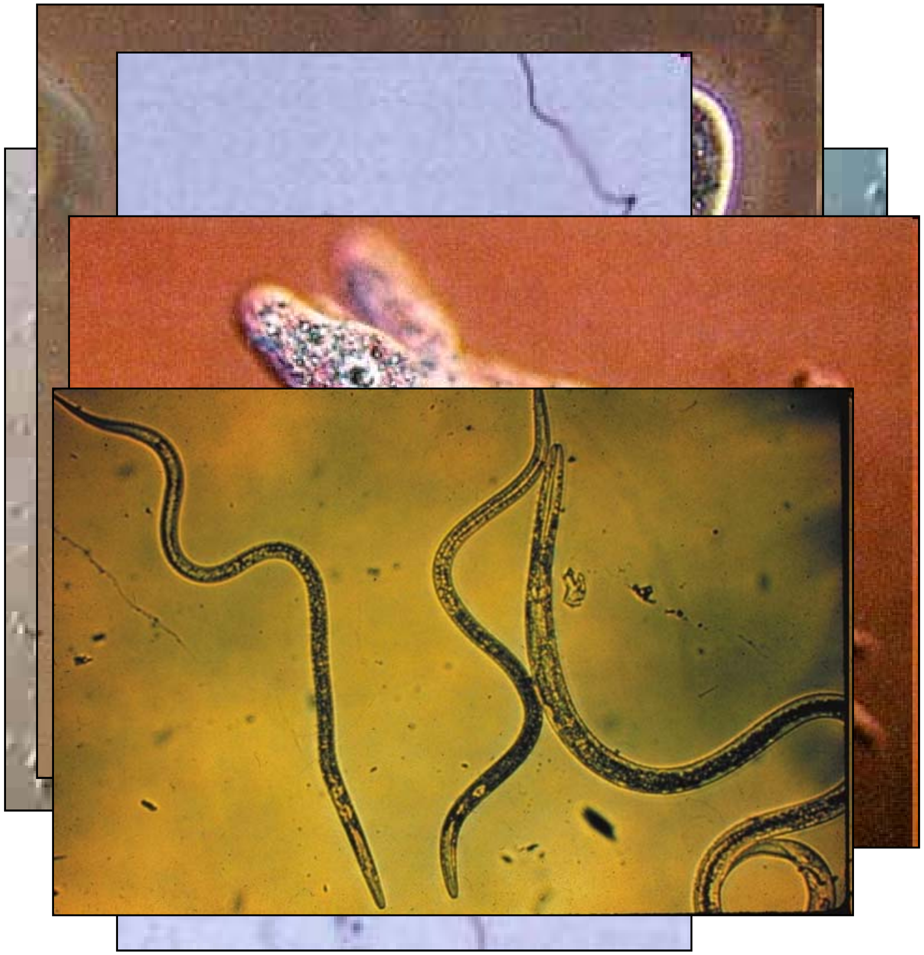
SECONDARY TREATMENT

Municipal secondary treatment systems generally are classified as either fixed-film or suspended-growth. These systems are used on a much smaller scale for onsite sewage disposal systems.

Not only are the biota more metabolically active, they are more diverse than in a septic system. Here is a simple organism called a rotifer grazing on organic matter. Other microbes in aerobic systems include paramecia, flagellates, and amoebae. Nematodes and other worms may be present as well.



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SECONDARY TREATMENT

Fixed-film processes entail circulating primary treatment effluent on media where the biomass grows.

The two most common fixed film processes used in the US are trickling filters, above, and rotating biological contactors, below. Trickling filters are dosed by a process that resembles irrigation systems used in agriculture. RBCs continuously rotate through a basin of wastewater.

Residential scale systems using these principles are available.

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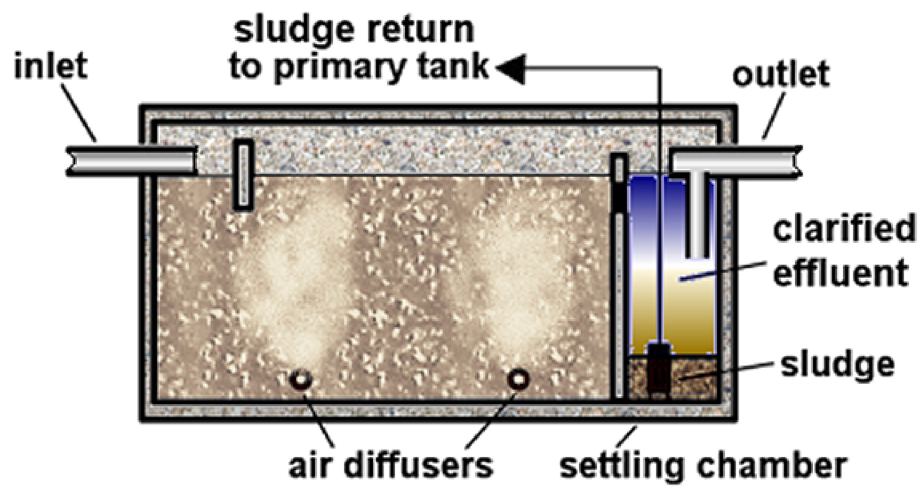
ONSITE SECONDARY TREATMENT

Aerobic treatment units, also known as aerated tanks or extended treatment plants, utilize an aerobic (oxygen rich) process, and remove substantial amounts of BOD_5 and TSS not removed by primary treatment.

Aerobic treatment units can be thought of as small scale versions of municipal treatment plants. They use the same underlying process of oxygenation of the wastewater to promote microbial treatment. Aerobic treatment units are not in as common use as they once were, due to the advent of more sophisticated equipment.



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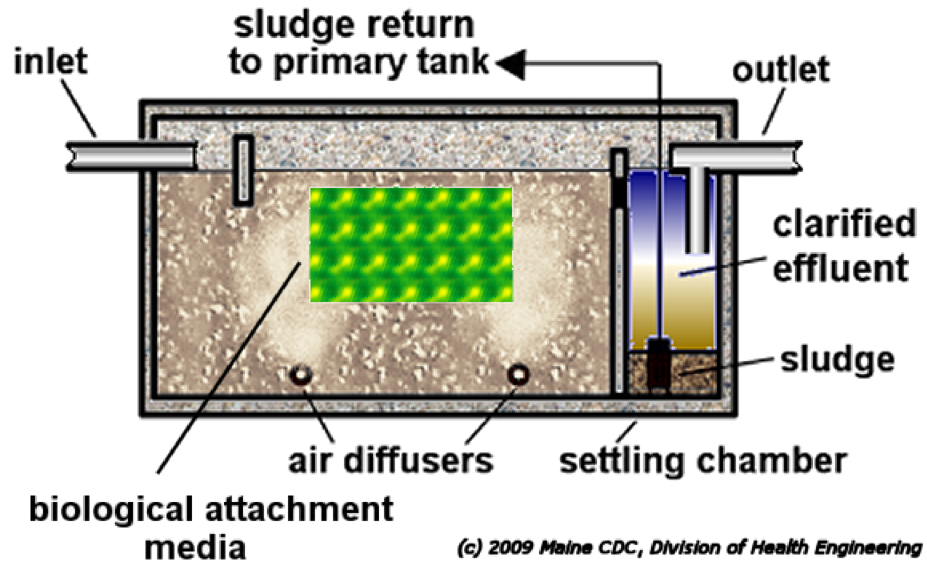
ONSITE SECONDARY TREATMENT

Fixed film units operate under the same general principal as aerobic treatment tanks, in that they utilize oxygen to promote microbial treatment of the wastes. Unlike standard aerobic treatment tanks, however, a permanent growth media, generally some type of plastic or foam material immersed in or suspended above the wastewater, is provided upon which the microbes attach and form a layer of biological matter. As the biological matter thickens, it sloughs off and settles with the suspended solids in the settling chamber, and is recirculated back to the primary treatment tank.



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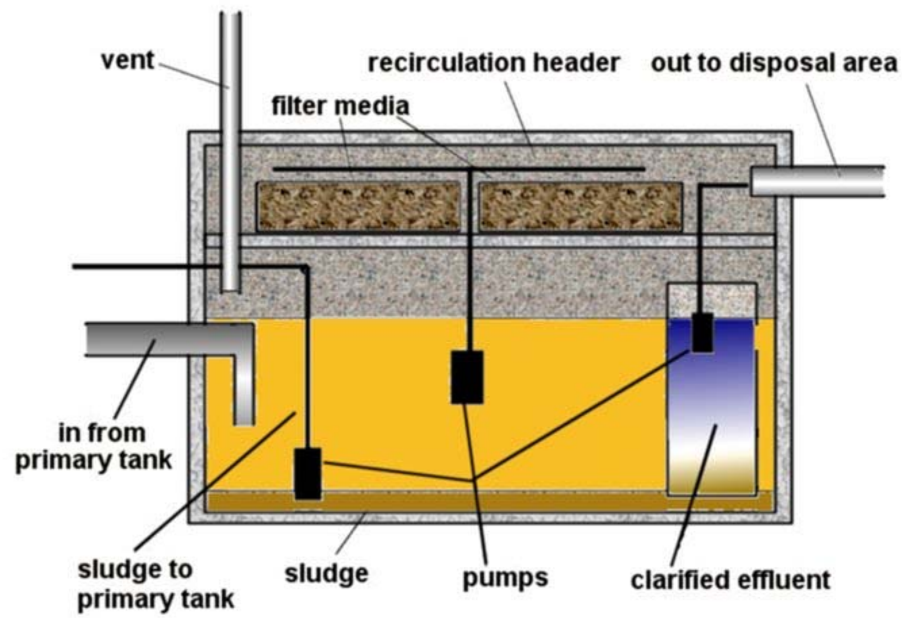
ONSITE SECONDARY TREATMENT

Recirculating aerobic treatment units take the concept of the fixed film treatment aerobic treatment units one step further, by spraying the wastewater onto porous filter media. Microbes in the media have access to large quantities of both food and oxygen, and provide an extremely high level of treatment. The treated wastewater then trickles back into the main compartment of the tank, where it provides oxygen to waste stream. The wastewater may be sprayed on the filter media several times before the final effluent is conducted to a disposal area.



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TERTIARY TREATMENT

One form of tertiary treatment available for residential uses is the Busse MF System. It consists of two cabinets, one of which aerates wastewater and provides storage. The second one contains reverse osmosis membrane filters. These membrane filters eliminate suspended material, even bacteria and germs, ensuring that only clear, odorless water (filtrate) leaves the system. The manufacturer claims rain water quality for the filtrate.

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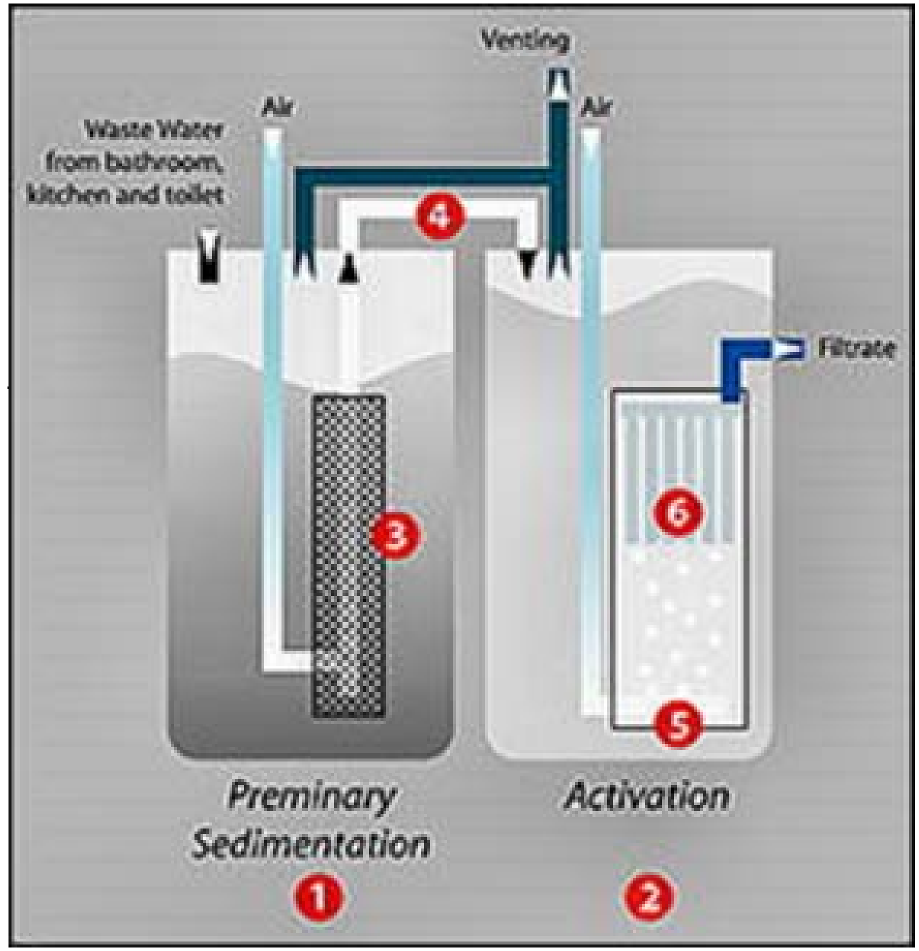
TERTIARY TREATMENT

The Busse MF System has two treatment steps: pre-treatment (1) and aeration (2). At the pretreatment step, degradable solids are dissolved, and the non-dissolving components separated from the wastewater by an aerated sieve (3). A pump (4) pumps the wastewater, from which the coarse material has been separated, to the aeration section. At this step the organic matter in the waste water is degraded biologically by aerobic microorganisms (5). The waste water then is treated physically by microfiltration membranes (6) with 0.4 µm pore size.



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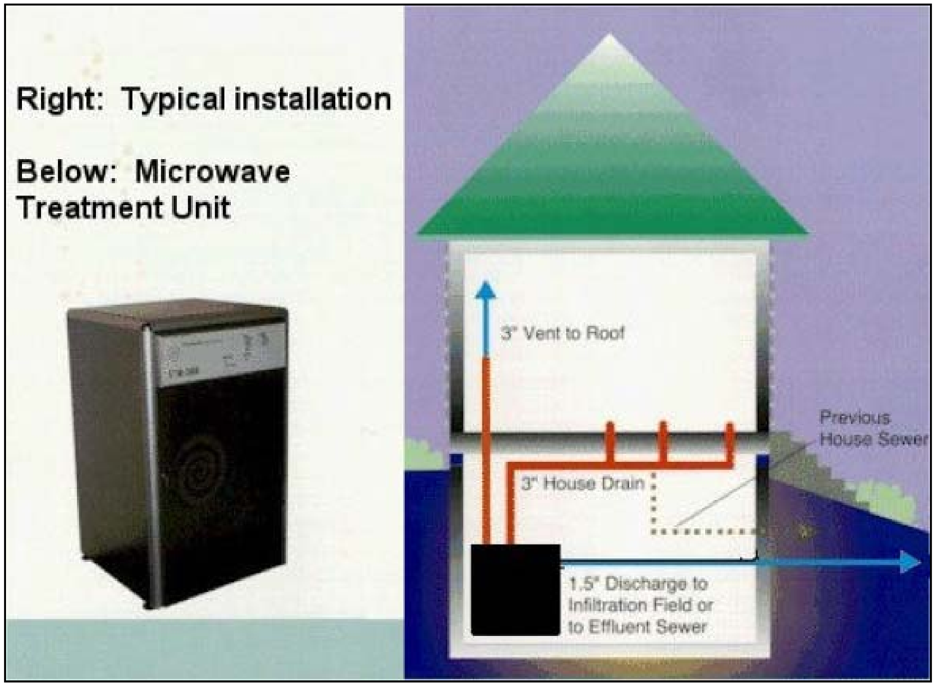
TERTIARY TREATMENT

There was a microwave treatment system available for residential uses for a brief time about 10 years ago. The company decided to concentrate on containerized systems for 5,000 gpd and above, however.



The technology essentially resulted in water vapor, sterile ash, and a small amount of clean water.

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SUMMARY

Wastewater mostly is comprised of water, with a miniscule solids component which can cause disproportionately serious pollution and health problems.

Wastewater strength is measured by BOD5 and TSS levels.

Primary treatment consists of separating heavy and light materials from the influent, and provides the least treatment.

Secondary treatment consists of oxygenating the waste flow to promote a metabolically active biota, and provides better treatment.

Tertiary treatment consists of treating the waste flow to remove dissolved solids as well as BOD5 and TSS, and provides the best treatment.

Conventional septic tank effluent receives the bulk of its treatment in an established biomat and through soil absorption and adsorption.

ATUs treat the waste flow to a high degree, thereby reducing reliance on the biomat and soil characteristics.

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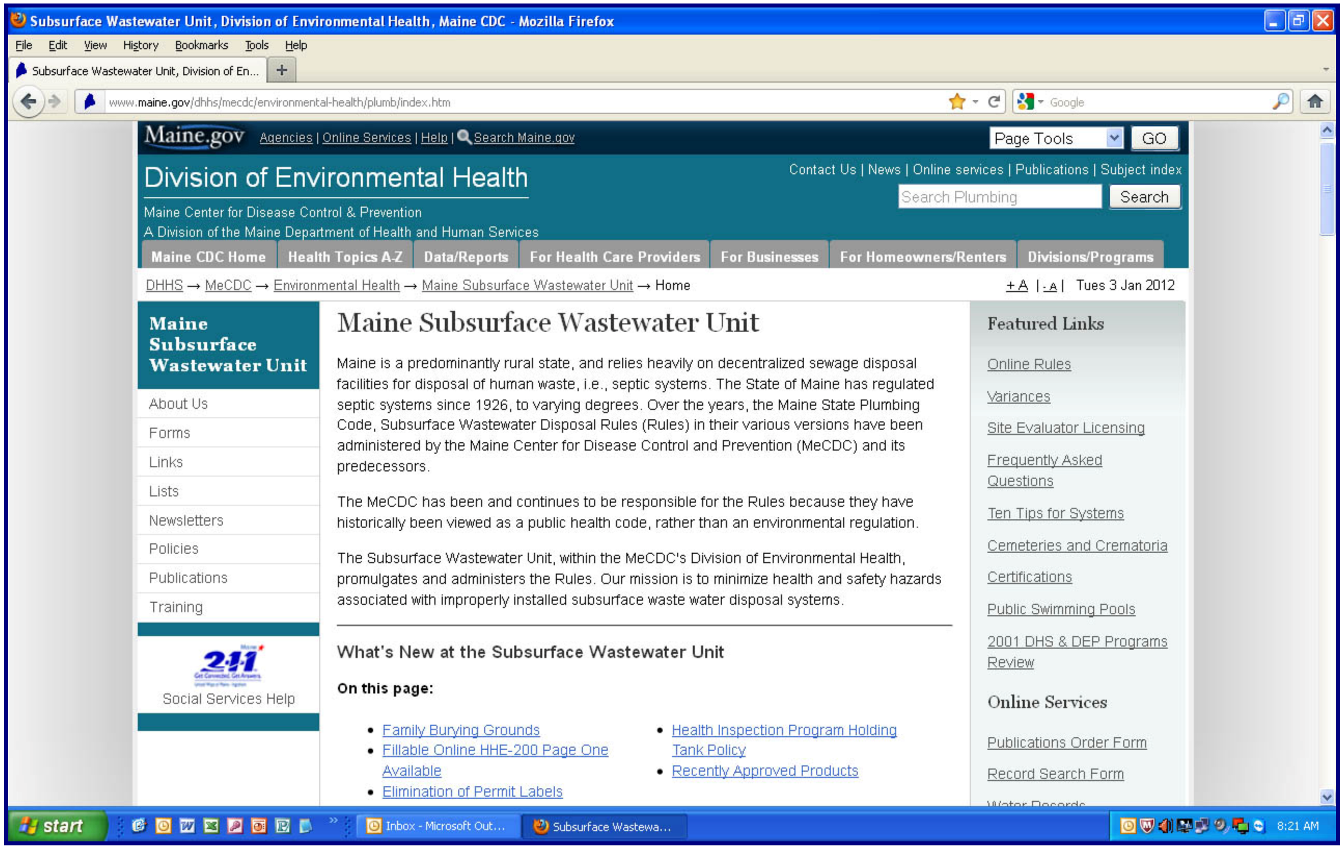
www.mainepublichealth.gov/septic-systems



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