SEWAGE POLLUTION
Most sewage treatment plants receive waste produced by industrial and municipal sources. After a greater or lesser amount of treatment, depending on the design of the plant, the treated waste is discharged into a watercourse that eventually leads to the ocean, the final depository for most sewage wastes initially produced on land. By far the greatest volume of waste discharged to aquatic and marine ecosystems is sewage. Without treatment, raw sewage flowing into natural waters will cause pollution.

Sewage effluent contains industrial waste, rainwater and water from domestic baths and washing machines, food wastes, fecal matter and any other liquid or solid material that is washed down drains or flushed down the toilet. Sewage also contains a relatively large amount of paper-based bathroom wastes such as toilet tissue and sanitary products. In a British national beach litter survey, sewage related debris constituted 7.8% of the total litter collected.

Fecal material in low concentrations has little effect on the marine environment and may actually benefit the ecosystem through the input of particulates and nutrients. Sewage pollution is caused when high concentrations of untreated industrial and domestic waste enter the marine environment.

ECOLOGICAL DAMAGE
Sewage is primarily organic in nature and therefore subject to bacterial decay. As a result of this bacterial activity, the oxygen concentration in the water is reduced, and sewage is said to have a high Biological Oxygen Demand (BOD). This can starve aquatic life of the oxygen it needs and also leads to the breakdown of proteins and other nitrogenous compounds, releasing hydrogen sulfide and ammonia, both of which are potentially toxic to aquatic and marine organisms in low concentrations. Solids suspended in sewage may also blanket river and sea beds preventing respiration of the benthic flora and fauna.

Decaying organic matter and nutrients in sewage enhance plant growth. Excessive plant growth, and the subsequent oxygen depletion that occurs as it decomposes, can lead to alterations in ecosystem structure. This process is known as eutrophication (see below).

The dumping of sewage sludge at sea is another cause of ecological damage. Dependent on the hydrography, sludge can smother the benthos, increase biomass, decrease species biodiversity and increase heavy metal concentrations. This practice is now illegal in many places, however ecological damage may still exist at historic dumpsites.

HEALTH RISKS
There are a number of strains of bacteria and viruses that are found in raw sewage. Coliform bacteria occur naturally in the environment and are excreted by wild and domestic animals as well as existing in the human gut. Numerous studies have indicated that the greater the sewage contamination and exposure of people, the higher the risk of contracting ear, nose and
throat infections and stomach upsets such as gastroenteritis. Fecal streptococci bacteria are more closely associated with human sewage and their presence in a sample is believed to be a better indicator of sewage contamination than Coliforms. Fecal streptococci can cause illness, especially gastroenteritis. Other disease-causing agents that may be present in sewage include enteric viruses, salmonella and the Hepatitis A virus.

SEWAGE TREATMENT
Sewage is comprised of a solid component (consisting of both living and dead organic matter), which is suspended in a liquid, effluent component. The effluent component also contains dissolved organic and inorganic compounds. Sewage pollution can be reduced and avoided by the application of various levels of treatment to remove solids, dissolved compounds, and harmful microbes. These treatments aim to produce a final effluent that, when discharged into a natural body of water, is clean enough to achieve certain water quality standards.

There are 5 possible stages in sewage treatment. Most sewage treatment plants do not use all possible stages.

Preliminary Treatment (includes screening and maceration)
The settlement of sewage to separate the suspended solids involves two preliminary stages - grit removal and screening. This attempts to remove the larger solid debris that is disposed of as landfill. Many smaller items such as cigarette filters, Q-tips, etc. are not screened out and end up in sewage sludge.

Primary Treatment
This is a settlement process to remove the suspended solids, called sludge. Effective sedimentation removes 50 - 70% of the suspended matter as sludge. Before leaving the sewage plant, the sludge is dewatered to reduce its volume, and then sent to another facility for disposal. The discharged effluent after sludge removal will still contain high levels of dissolved and suspended organic matter, dissolved minerals, such as nitrates and phosphates, and pathogens, such as bacteria and viruses. The discharged effluent will present a high Biological Oxygen Demand (BOD) if introduced into natural waters. This is due to the large amount of organic matter in the effluent becoming readily available to decomposers that quickly deplete dissolved oxygen levels during the decomposition process.

The process that takes place in rural home septic systems is primary treatment. Sludge is allowed to settle in a large underground tank where it slowly decomposes anaerobically (or is pumped out by a septage hauler). The sewage effluent flows into a subsurface trickle infiltration bed that permits the suspended and dissolved organic matter and mineral nutrients to be utilized by microbes naturally present in the soil.

Secondary Treatment
Secondary treatment is a biological purification stage in which the effluent from primary treatment is digested by microorganisms, mainly bacteria. The digestion process is usually aided by providing aeration to encourage rapid growth and respiration of the microbes. While bacteria are responsible for most of the decomposition of organic matter in the effluent, the sewage plant operator closely monitors the species diversity of the decomposer microbial community, especially the protistan members of the community, to insure that maximum amounts of suspended and dissolved materials are removed from the effluent. Aerobic decomposition is desired because it is much more efficient than the anaerobic decomposition.
that occurs naturally in the sediments of aquatic ecosystems. Secondary treatment removes over 90% of suspended solids and BOD in the effluent. Because many human pathogens cannot survive exposure to sunlight and oxygen, it also removes up to 99% of bacteria and 90% of enteroviruses originally present in the sewage.

**Tertiary Treatment**
Tertiary treatment removes minerals from the water, to restore it to a more natural state. Because of its high costs, tertiary treatment is not incorporated in most treatment plants. The most damaging dissolved minerals are usually nitrates and phosphates. These are especially damaging to water bodies because they cause eutrophication. The general process of eutrophication results in a population explosion of algal cells, referred to as an algal bloom. As these algal cells eventually die and decompose, oxygen depletion occurs and causes the subsequent death of many aerobic organisms in the aquatic ecosystem. To prevent eutrophication, some treatment plants use a sort of half tertiary treatment that removes some minerals. Algae and rotifers are grown in a "clarifier" tank, or perhaps in a trickle filter with a trickle of water over "biofilms" grown on limestone chips. Such "half-tertiary" treatment is used in Orange County, California, to protect the water quality of coastal swimming beaches.

**Disinfection Treatment**
Before being discharged into natural waters, the final effluent from the plant is treated to reduce the numbers of pathogens and non-pathogens entering the water body. The disinfection is commonly accomplished by exposing the effluent to chlorine in one form or another.

**COMPOSTING OF SEWAGE SLUDGE AT HAWK RIDGE**

**Background**
Simply stated, composting is the biological decomposition of the organic constituents of wastes under controlled conditions. The term "decomposition" is used instead of "stabilization", because when applied to a practical usage, the process is rarely carried on to the point at which the waste is completely stabilized. The term "biological" distinguishes composting from other types of decomposition, such as chemical or physical. Organic is applicable because, with few exceptions, only the organic portion of wastes is subject to biological breakdown. A very important term in the definition of composting is "controlled". It is the application of control that distinguishes composting from the natural rotting, putrefaction, or other decomposition, that takes place in an open dump, a sanitary landfill, in a manure heap, or in an open field.

**Principles**
Probably all of the principles involved in composting wastes can be traced to the single all-inclusive fact that composting is a biological process. Two broad inferences can be drawn from this fundamental: (1) Composting has the limitations of biological systems; and (2) the process is affected by the basic environmental conditions that influence all biological activity.

**Classification**
Compost systems can be classified on three general bases: oxygen usage, temperature, and technological approach. Oxygen usage is divided into aerobic and anaerobic. When temperature serves as the basis, the division becomes mesophilic and thermophilic. Finally, using technology as the key, the classification is divided into static pile or windrow, and mechanical or "enclosed" (bioreactor) composting.
Aerobic composting involves the activity of aerobic microbes, and hence the provision of oxygen during the composting process. Aerobic composting generally is characterized by high temperatures, the absence of foul odors, and is more rapid than anaerobic composting. Anaerobic composting is characterized by low temperatures, the production of odorous intermediate products, and generally proceeds at a slower rate than does aerobic composting.

In mesophillic composting the temperatures are kept at intermediate temperatures (15 degrees to 40 degrees C.), which in most cases is the ambient temperature. Thermophillic composting is conducted at temperatures from 45 degrees C to 65 degrees C.

**Essential Factors**
Briefly stated, essential factors are those features of the physical, chemical, and biological background that are necessary to the establishment and proliferation of the microorganisms specific to the desired process. Five essential factors that have become key design features in recent compost technology are suitable microbial population, aeration (oxygen availability), temperature, moisture content, and carbon availability.

**Municipal Sludge**
Most municipalities are composting a dewatered sludge or sand bed dried sludge. Belt filter presses appear to be the most common type of dewatering system used. The four most common methods for composting sewage sludge are aerated static pile, windrow, aerated windrow, and in vessel (also known as bioreactor). The Hawk Ridge facility uses bioreactors for composting.

The general economic climate for sludge composting is healthy. More cities are turning to composting because of the public’s perception of recycling. As it gets increasingly difficult to site waste combustion facilities, and where land application is not feasible, composting is becoming the preferred method for handling municipal and industrial sewage sludge.

**Table 1. Municipal Sludge Composting Facilities in Maine in 2003**
(A-SP = aerated static pile)

<table>
<thead>
<tr>
<th>Plant Name</th>
<th>Status</th>
<th>Type</th>
<th>Sludge Volume dry ton / day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bangor</td>
<td>Operational</td>
<td>A-SP</td>
<td>1,964 / year</td>
</tr>
<tr>
<td>Bar Harbor</td>
<td>Operational</td>
<td>A-SP</td>
<td>365 / year</td>
</tr>
<tr>
<td>Gardiner</td>
<td>Operational</td>
<td>A-SP</td>
<td>1</td>
</tr>
<tr>
<td>Kennebunkport</td>
<td>Operational</td>
<td>A-SP</td>
<td>50 / year</td>
</tr>
<tr>
<td>Kittery</td>
<td>Operational</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Lisbon</td>
<td>Operational</td>
<td>A-SP</td>
<td>3,234 / year</td>
</tr>
<tr>
<td>Old Orchard Beach and Saco</td>
<td>Operational</td>
<td>A-SP</td>
<td>24 / week</td>
</tr>
<tr>
<td>Old Town</td>
<td>Operational</td>
<td>A-SP</td>
<td>Small Quantity 16.2</td>
</tr>
<tr>
<td>Portland</td>
<td>Operational</td>
<td>A-SP</td>
<td></td>
</tr>
<tr>
<td>Scarborough</td>
<td>Operational</td>
<td>A-SP</td>
<td>.75</td>
</tr>
<tr>
<td>South Portland</td>
<td>Pilot</td>
<td>Windrow</td>
<td></td>
</tr>
<tr>
<td>Yarmouth</td>
<td>Operational</td>
<td>A-SP</td>
<td>219 / year</td>
</tr>
</tbody>
</table>

Biodiversity Laboratory

Study Questions for Human Waste Management Field Trip

Answers to these study questions are due to me electronically by the beginning of lab during the week of Oct. 26. The assignment name is HUMANWASTESTUDYQUEST. You may submit your work individually or with one other lab partner. Make sure to follow the rules for electronic submissions outlined in the lab syllabus posted on the lab webpage. Failure to follow the rules for submitting homework will result in a grade penalty.

1) In a wastewater treatment facility what is meant by 'primary treatment'?

2) What is meant by 'secondary treatment'?

3) While the KSTD facility does not use it, what is meant by 'tertiary treatment'?

4) What is the function of the chlorination chamber?

5) What is another name for sewage sludge?

6) The microbes involved in the 'secondary treatment' of sewage are known as saprophytes. What are saprophytes?

7) What are the major microbial taxa represented in the saprophyte community of a sewage treatment plant?

8) Approximately how many pounds of saprophytes are produced during each day of operation of the secondary treatment tanks at KSTD?
9) How many cubic yards of sewage sludge does KSTD send to the Hawk Ridge composting facility per week? (How many dump truck loads does this represent?)

10) How much money does KSTD pay the Hawk Ridge composting facility per year to accept their sewage sludge?

11) What are the advantages of aerobic composting to anaerobic composting?

12) What specific type of composting is used at the Hawk Ridge facility?

13) What are the five essential factors that are important to control in the production of compost?

14) At Hawk Ridge what ingredients are mixed with sewage sludge to produce compost?

15) Breaking it down into steps, how much time is involved to complete the composting process at Hawk Ridge?

16) On an annual basis, how much sewage sludge does the Hawk Ridge facility process, and how much compost does it produce?

17) In New England Organics’ business plan, what two roles does it defines for the company with respect to Class B biosolids (sewage sludge)?