Sewage Treatment

Yuechuan Yu

Abstract

Modern sewage treatment process is an efficient method to treat large amounts of sewage. Increased sewage treatment leads to lower health risks from contaminated water and untreated sewage. Better sewage treatment, in conjunction with other modern sanitation measures, have reduced the prevalence of various sanitation-related diseases.

Introduction

Sewage treatment is the process of removing contaminants and toxic wastes from raw sewage, including run-off from rains and domestic wastes, and the treated water may be used for industry or agriculture. Toxic wastes are processed and distributed into the soil to be absorbed. Sewage treatment is essential to good sanitation and preventing disease outbreaks, such as cholera, in large population centers. The key of this process is to prevent infectious bacteria and toxins from contacting water sources that supply urban locations.

Ancient civilizations, such as the Sumerians, the Indus Civilization and the Minoans were the first to develop sewage systems to remove wastes from urban areas to reduce disease outbreaks and maintain cleanliness. Their concept of sewer systems did not develop further than systems of pipes and underground tunnels to channel wastes away from cities. After the fall of the Roman Empire in 496, the concept of sewage systems was lost and not used again until the mid-19th Century.

The origin of modern sewage treatment can be traced to various methods devised between 1860 and 1910. The first was the septic tank, which was a large container that collected and allowed sewage to settle, so the liquid and solids of the sewage would separate. Then, the liquid portion would be drained off into a water source, such as a lake or river, while the solids were either digested by bacteria or compacted into soil as nutrients.

The septic tank did not solve the problem of pollution in important water sources. Sewage continued to contaminate urban water supplies, causing cholera and other diseases. In 1882, sewage farming was implemented for Sydney, Australia, where the farm soil served as a filter and the sewage collected in the soil acted as a fertilizer. Despite early success, the farmlands could not handle large amounts of sewage and often became flooded with sewage. At the time sewage farming was introduced, chemical precipitation was another sewage treatment concept. The English experimented with this idea, where sewage was first collected in tanks and chemicals, such as lime and sulfate solids, were added to precipitate the sewage solids out. Then the precipitated sewage was pressed to dry and burnt. Chemical precipitation, however, proved to be too expensive. By the 1950's, sewage treatment methods had developed into the modern form with large chemical treatment plants.

Before the implementation of efficient sewage treatment methods, large cities were always at the risk of contaminated water supplies. In developed countries, cholera used to be the major health concern due to unclean water. With efficient water treatment plants, these countries have effectively eradicated naturally occurring cholera. However, cholera is still a problem for most of the world's population. Untreated sewage collected in sewer systems is directly expelled into lakes, nearby bays and rivers. This pollutes the environment with toxins and allows bacterial and algae growth due high bacterial and nutrient (nitrogen and phosphorus) content of sewage. Natural habitats, wildlife and aqua cultural farms are endangered by sewage outflows.

Cholera, if not quickly treated, has a mortality rate of about 50%. Before 1910, cholera outbreaks were frequent in Europe and North America. In 1854, over a million Russians died due to a cholera outbreak. Four major cholera pandemics (disease outbreaks that affect large areas) ravaged Europe and parts of North America between 1816 and 1875. Due to Industrial Revolution and rapid population growth in urban centers, cities became highly unsanitary. The sewer systems overflowed with sewage that contaminated water supplies. In these densely packed cities, cholera spread quickly. More than two million people died in Europe and North America during the four major pandemics. After the implementation of sewage treatment techniques in the late 19th century, cholera is no longer a health concern in developed countries.

The Process

The modern sewage treatment process includes three main stages, called *primary*, *secondary* and *tertiary treatment*. The outline of this process begins by separating the solid (undissolved) and liquid portions of sewage using filtration. Then, the solids are treated and either disposed or re-used (as fertilizer, for example). The liquid portion is also treated and can be re-used for agriculture or industry.

Primary treatment is mainly a mechanical procedure necessary to prevent large or hard particles from damaging treatment equipment in later stages of the process. This step begins with filtration of large, separable objects in sewage. These materials are strained with a screen filter. Then, small, hard particles, such as sand and stones, are separated using a grit classifier machine. In the machine, the sewage is pumped into a container, and the sand and grit (heavy particles) settle at the bottom, where it is pumped out. Another filtration procedure is 'maceration', where sewage is pumped into tanks with rotating screen filters. Here, the screens will filter out floating objects, such as rags and smaller particles, such as peas and corn. Then, rotating knives on the screen will cut the particles into smaller pieces. The final step is 'sedimentation', where the sewage is pumped into large tanks, and fecal solids settle to bottom and grease/floating objects settle to the surface of the sewage. They are removed by scrapers. Afterwards, the sewage is homogeneous enough for secondary treatment.

Secondary treatment is designed to biodegrade the sewage (into basic compounds) using bacteria and other organisms (protozoans). These organisms will grow and reproduce in large numbers so that biodegradation will occur quickly. In order to stimulate the bacterial/protozoan growth, oxygen is pumped into the sewage and growth surfaces (to allow the organisms to grow) are added.

Tertiary treatment treats the sewage (now called effluent as most solids and complex molecules are removed or digested by bacteria), so that it may be discharged into the environment or reused. First, the sewage is filtered through a sieve with a layer of sand, so the remaining particles in sewage are removed. Then, it is filtered through activated carbon to remove toxic heavy metals (the activated carbon has high surface area and will collect the metal atoms within the carbon atoms). Afterwards, small man-made

ponds with small organisms (daphnia) and plants will collect the effluent to further digest organic materials in the sewage.

The effluent contains very high amounts of phosphorus and nitrogen. If these elements are released into the environment, algae will feed off these nutritious elements and propagate. This will cause ‘algae blooms’, which is detrimental to waterlife, because algae will consume the dissolved oxygen quickly. Nitrogen is present in sewage primarily in the form of ammonia (NH3). Special bacteria (*nitrospira* species) will consume the ammonia and convert it into nitrate. Then, methanol or sulfide is added to reduce the nitrates into nitrogen gas, which bubbles out.

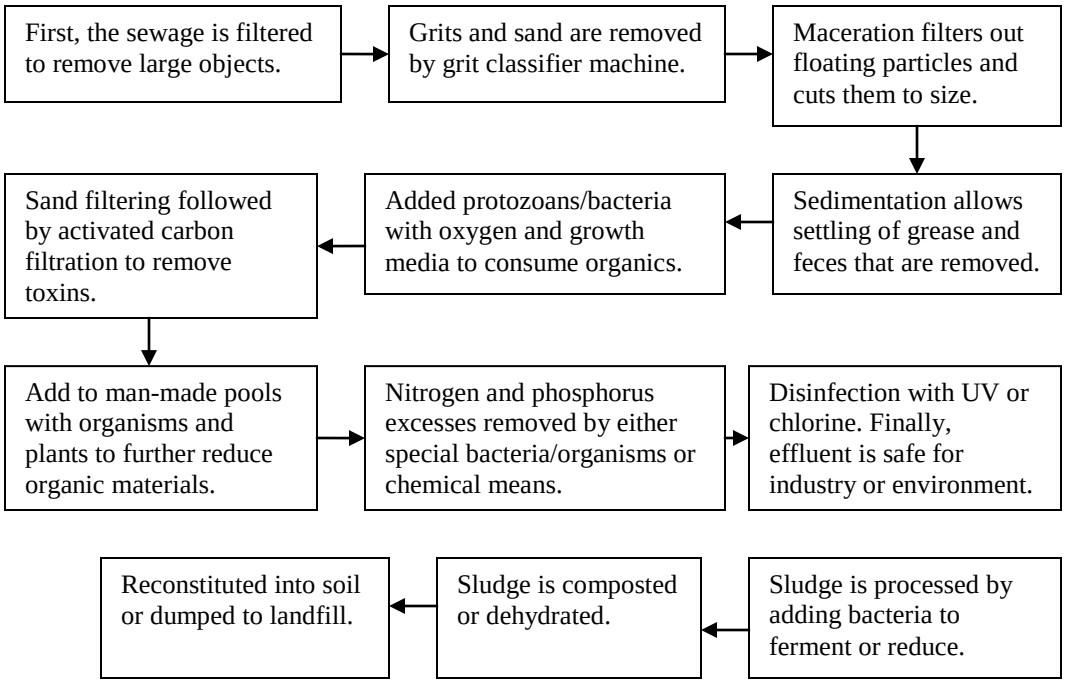
Phosphorus can be removed using biological or chemical means. Special organisms called polyphosphate accumulating organisms are added into the effluent and can consume high amounts of phosphorus. Their cells have a 20% mass capacity for phosphorus. Afterwards, these organisms are filtered out and dried for use as fertilizer. The chemical method is using metal salts, such as alum or ferric chloride to precipitate the phosphorus. The chemical method is more expensive.

Finally, there are still organisms in the effluent that need to be killed or reduced in number. Disinfection is the process involving chemicals (chlorine) or radiation (UV light) to kill or reduce the number of bacteria and other organisms in the effluent. The effluent is now safe for the environment or for industry/agriculture.

The sludge or solids accumulated from sewage treatment are first reduced by adding bacteria. One method is to ferment the sludge with no oxygen. This method may produce biogas. Using aerobic reduction, the sludge yields carbon dioxide. The third method reduces sludge by using composting with sawdust and other waste wood. Sludge may be reconstituted into soil this way. Finally, the sludge is dehydrated to reduce volume and is often transported to landfills.

A large modern sewage plant can effectively treat sewage from large population centers with 500,000-1,000,000 people.

Flow Chart



Consequences

Due to sewage treatment advances in the late 19th century and early 20th century, sanitation is much improved in developed countries. It is difficult to quantify the reduction of epidemics due to sewage treatment. Sewage treatment allows for effective disposal of sewage without contamination and waste buildup around cities.

Before 1900's, cholera was the main waterborne disease that is due to water sources contaminated by sewage. In four major epidemics in the 19th century, over two million people died in Europe and North America. There are no exact numbers for China and India (two largest population countries), but historical records reveal constant epidemics due to unclean water.

Besides cholera, other sanitation-related illnesses, such as the bubonic plague and typhus were common before the sanitation revolution of the late 1800s and early 1900s. Typhus bacteria, carried by the louse, killed 10% of the English population between 1557 and 1559. Between 1900 and 1920, over three million people died in Eastern Europe due to typhus. Bad sanitation can lead to bubonic plague because of the prevalence of rats, who are the main carriers of the plague bacteria. Fleas then bite the rats and transmit the bacteria to humans when they bite again. Rats are common in areas with poor sanitation and sewage management. Other a third of Europe's population was killed by bubonic plague in the mid to late 14th century. The plague occurred fairly often in Europe before modern sanitation. In the 1660s, the plague killed over 100,000 in London. In the 1850s, the plague killed over 12 million in India and China.

With better sanitation and sewage treatment, cholera, the bubonic plague and typhus are eradicated in developed countries, such as Europe and North America. Improving sanitation in developing countries has limited the deadly force of these diseases and large outbreaks are no longer common. It is still a problem in undeveloped or poorly developed countries, such as many African countries and Bangladesh.

Conclusion

Chemical engineering has led to the modern sewage treatment system. The modern system is able to serve population centers and effectively reduce sewage contamination of water sources, which lead to diseases and environmental damage. Many serious sanitation-related diseases are either eradicated or significantly reduced due to better sewage management. Cholera, typhus and bubonic plague are serious diseases related to poor water quality and bad sewage disposal. They have claimed the lives of millions. Better sewage management and treatment have reduced the danger of these diseases in developing countries and eradicated them in developed countries.