SEWAGE TREATMENT

Sewage treatment is the process that removes the majority of the contaminants from waste-water or sewage and produces both a liquid effluent, suitable for disposal to the natural environment, and a sludge.

To be effective, sewage must be conveyed to a treatment plant by appropriate pipes and infrastructure and the process itself must be subject to regulation and controls. Other wastewaters require often different and sometimes specialised treatment methods. At the simplest level, treatment of sewage and most wastewaters is through separation of solids from liquids, usually by settlement. By progressively converting dissolved material into solid, usually a biological flock, and settling this out, one produces an effluent stream of increasing purity.

Description

Sewage is the liquid waste from toilets, baths, showers, kitchens, etc, that is disposed of via sewers. In many areas sewage also includes some liquid waste from industry and commerce. In the UK, the waste from toilets is termed foul waste, the waste from items such as basins, baths, kitchens is termed sullage water, and the industrial and commercial waste is termed trade waste. The division of household water drains into greywater and blackwater is becoming more common in the developed world, with greywater being permitted to be used for watering plants or recycled for flushing toilets. Much sewage also includes some surface water from roofs or hard-standing areas. Municipal wastewater therefore includes residential, commercial, and industrial liquid waste discharges, and may include stormwater runoff.

Sewerage systems that transport liquid waste discharges and stormwater together to a common treatment facility are called combined sewer systems. The construction of combined sewers is a less common practice in the U.S. and Canada than in the past and is no longer accepted within Building Regulations in the UK and other European countries. Instead, liquid waste and storm water are collected and conveyed in separate sewer systems, referred to as "sanitary sewers" and "storm sewers" in the U.S. and as "foul sewers" and "surface water sewers" in the UK. (In New Zealand, the terms "sanitary sewer" and "stormwater sewer" are generally used, but the former is replaced by "foul sewer" in Otago.) Overflows from foul sewers designed to relieve pressure from heavy rainfall are termed storm sewers or combined sewer overflows.

As rainfall runs over the surface of roofs and the ground, it may pick up various contaminants including soilparticles (sediment), heavy metals, organic compounds, animal waste, and oil and grease. Some jurisdictionsrequire storm water to receive some level of treatment before being discharged to the environment. Examples of treatment processes used for storm water include sedimentation basins, wetlands, and vortex separators (to remove coarse solids).

The site where the process is conducted is called a sewage treatment plant. The flow scheme of a sewage treatment plant is generally the same for all countries:

- Mechanical treatment;
  - Influx (Influent)
  - Removal of large objects
  - Removal of sand
  - Pre-precipitation
- Biological treatment;
  - Oxidation bed (oxidizing bed) or Aerated systems
  - Post precipitation
  - Effluent
- Chemical treatment (this step is usually combined with settling and other processes to remove solids, such as filtration. The combination is referred to in the US as physical-chemical treatment. It is rarely used along with biological treatment.).

Treatment stages

Primary treatment

Primary treatment is to reduce oils, grease, fats, sand, grit, and coarse (settleable) solids. This step is done entirely with machinery, hence the name mechanical treatment.

Influx (influent) and removal of large objects

In the mechanical treatment, the influx (influent) of sewage water is strained to remove all large objects that are deposited in the sewer system, such as rags, sticks, condoms, sanitary towels (sanitary napkins) ortampons, cans, fruit, etc. This is most commonly done using a manual or automated mechanically raked screen. This type of waste is removed because it can damage the sensitive equipment in the sewage treatment plant.

Sand and grit removal

This stage typically includes a sand or grit channel where the velocity of the incoming wastewater is carefully controlled to allow sand grit and stones to settle but still maintain the majority of the organic material within the flow. This equipment is called a detritor or sand catcher. Sand grit and stones need to be removed early in the process to avoid damage to pumps and other equipment in the remaining treatment stages. Sometimes there is a sand washer (grit classifier) followed by a conveyor that transports the sand to a container for disposal. The contents from the sand catcher may be fed into the incinerator in a sludge processing plant but in many cases the sand and grit is sent to a land-fill.

Screening or maceration

The grit free liquid is then passed through fixed or rotating screens to remove floating and larger material such as rags. Screenings are collected and may be returned to the sludge treatment plant or may be disposed of off site by landfilling or incineration. Maceration, in which solids are cut into small particles through the use of rotating knife edges mounted on a revolving cylinder, is used in plants that are able to process this particulate waste. Macerators are, however, more expensive to maintain and are less reliable than physical screens.

Primary sedimentation tank at a rural treatment plant

Sedimentation

In almost all plants there is a sedimentation stage where the sewage is allowed to pass through large circular or rectangular tanks. The tanks are large enough that faecal solids can settle and floating material such as grease and plastics can rise to the surface and be skimmed off. The main purpose of the primary stage is to produce a generally homogeneous liquid capable of being treated biologically and a sludge that can be separately treated or processed. Primary settlement tanks are usually equipped with mechanically driven scrapers that continually drive the collected sludge towards a hopper in the base of the tank from where it can be pumped to further sludge treatment stages.

Secondary treatment

Secondary treatment is designed to substantially degrade the biological content of the sewage such as are derived from human waste, food waste, soaps and detergent. The majority of municipal and industrial plants treat the settled sewage liquor using aerobic biological processes. For this to be effective, the biota require both oxygen and a substrate on which to live. There are number of ways in which this is done. In all these methods,

the bacteria and protozoa consume biodegradable soluble organic contaminants (e.g. sugars, fats, organic short-chain carbon molecules, etc.) and bind much of the less soluble fractions

into floc particles. Secondary treatment systems are classified as fixed film or suspended growth. In fixed film systems - such as roughing filters - the biomass grows on media and the sewage passes over its surface. In suspended growth systems - such as activated sludge - the biomass is well mixed with the sewage. Typically, fixed film systems require smaller footprints than for an equivalent suspended growth system; however, suspended growth systems are more able to cope with shocks in biological loading and provide higher removal rates for BOD and suspended solids than fixed film systems.

Roughing filters

Roughing filters are intended to treat particularly strong or variable organic loads, typically industrial. They are typically tall, circular filters filled with open synthetic filter media to which sewage is applied at a relatively high rate. The design of the filters allows high hydraulic loading and a high flow-through of air. On larger installations, air is forced through the media using blowers. The resultant liquor is usually within the normal range for conventional treatment processes.

Activated sludge

Activated sludge plants use a variety of mechanisms and processes to use dissolved oxygen to generate a biological floc that substantially removes organic material. It also traps particulate material and can, under ideal conditions, convert ammonia to nitrite and nitrate and ultimately to nitrogen gas, (see also denitrification).

Filter Beds (Oxidising beds)

Trickling filter bed using plastic media

In older plants and plants receiving more variable loads, tricklingfilter beds are used where the settled sewage liquor is spread onto the surface of a deep bed made up of coke (carbonised coal), limestone chips or specially fabricated plastic media. Such media must have high surface areas to support the biofilms that form. The liquor is distributed through perforated rotating arms radiating from a central pivot. The distributed liquor trickles through this bed and is collected in drains at the base. These drains also provide a source of air which percolates up through the bed, keeping it aerobic. Biological films of bacteria, protozoa and fungi form on the medias' surfaces and eat or otherwise reduce the organic content.

Rotating plates and spirals

In some smaller plants slowly revolving plates or spirals are used which are partially submerged in the liquor. A biotic floc is created which provides the required substrate.

Secondary sedimentation

The final step in the secondary treatment stage is to settle out the biological floc or filter material and produce an effluent with very low levels of organic material and suspended matter.

Secondary Sedimentation tank at a rural treatment plant

Tertiary treatment

Tertiary treatment provides a final stage to raise the effluent quality to the standard required before it is discharged to the receiving environment (sea, river, lake, ground, etc.) More than one tertiary treatment process may be used at any treatment plant. If disinfection is practiced, it is always the final process.

Effluent polishing

Filtration

Sand filtration removes much of the residual suspended matter. Filtration over activated carbon removes residual toxins.

Lagooning

Lagooning provides settlement and further biological improvement through storage in large man-made ponds or lagoons. These lagoons are highly aerobic and colonization by native macrophytes, especially reeds, is often encouraged. Small filter feeding invertebrates such as Daphnia and species of Rotiferagreatly assist in treatment by removing fine particulates

Constructed wetlands

Constructed wetlands include engineered reedbeds and a range of similar methodologies, all of which provide a high degree of aerobic biological improvement and can often be used instead of secondary treatment for small communities, also see phytoremediation.

Nutrient removal

Wastewater may also contain high levels of nutrients (nitrogen and phosphorus) that in certain forms may be toxic to fish and invertebrates at very low concentrations(e.g. ammonia) or that can create nuisance conditions in the receiving environment (e.g. weed or algal growth). Weeds and algae may seem to be anaesthetic issue, but algae can produce toxins, and their death and consumption by bacteria (decay) can deplete oxygen in the water and suffocate desirable fish. Where receiving rivers discharge to lakes or shallow seas, the added nutrients can cause severe eutrophication losing many sensitive clean water fish. The removal of nitrogen and/or phosphorus from wastewater can be achieved either biologically or by chemical precipitation.

Nitrogen removal is effected through the biological reduction of nitrogen from the ammonia to nitrate (nitrification), and then from nitrate to nitrogen gas (denitrification), which is released to the atmosphere. These conversions require carefully controlled conditions to encourage the appropriate biological communities to form. Sand filters, lagooning and reed beds can all be used to reduce nitrogen. Sometimes the conversion of toxic ammonia to nitrate alone is referred to as tertiary treatment.

Phosphorus removal can be effected biologically in a process called enhanced biological phosphorus removal. In this process specific bacteria, called Polyphosphate accumulating Organisms, are selectively enriched and accumulate large quantities of phosphorus within their cells. When the biomass enriched in these bacteria is separated from the treated water, the bacterial biosolids have a high fertilizer value. Phosphorus removal can also be achieved, usually by chemical precipitation with salts of iron (e.g. ferric chloride) or aluminum (e.g. alum). The resulting chemical sludge, however, is difficult to dispose of, and the use of chemicals in the treatment process is expensive and makes operation difficult and often messy.

Disinfection

The purpose of disinfection in the treatment of wastewater is to substantially reduce the number of living organisms in the water to be discharged back into the environment. The effectiveness of disinfection depends on the quality of the water being treated (e.g., turbitidy, pH, etc.), the type of disinfection being used, the disinfectant dosage (concentration and time), and other environmental variables. Turbid water will be treated less successfully since solid matter can shield organisms, especially from Ultraviolet light or if contact times are low. Generally, short contact times, low doses and high flows all militate against effective disinfection. Common methods of disinfection include ozone, chlorine, or UV light. Chloramine, which is used for drinking water, is not used in waste water treatment because of its persistence.

Chlorination remains the most common form of wastewater disinfection in North America due to its low cost and long-term history of effectiveness. One disadvantage is that chlorination of residual organic material can generate chlorinated-organic compounds that may be carcinogenic or harmful to the environment. Residual chlorine or chloramines may also be capable of chlorinating organic material in the natural aquatic environment. Further, because residual chlorine is toxic to aquatic species, the treated effluent must also be chemically dechlorinated, adding to the complexity and cost of treatment.

Ultraviolet (UV) Light is becoming the most common means of disinfection in the UK because of the concerns about the impacts of chlorine in chlorinating residual organics in the wastewater and in chlorinating organics in the receiving water. UV radiation is used to damage the genetic structure of bacteria, viruses, and other pathogens, making them incapable of reproduction. The key disadvantages of UV disinfection are the need for frequent lamp maintenance and replacement and the need for a highly treated effluent to ensure that the target microorganisms are not shielded from the UV radiation (i.e., any solids present in the treated effluent may protect microorganisms from the UV light).

Ozone (O_3) is generated by passing oxygen (O_2) through a high voltage potential resulting in a third oxygen atom becoming attached and forming O_3. Ozone is very unstable and reactive and oxidizes most organic material it comes in contact with, thereby destroying many disease-causing microorganisms. Ozone is considered to be safer than chlorine because, unlike chlorine which has to be stored on site (highly poisonous in the event of an accidental release), ozone is generated on site as needed. Ozonation also produces fewer disinfection by-products than chlorination. A disadvantage of ozone disinfection is the high cost of the ozone generation equipment and the requirements for highly skilled operators.

Source : http://engineering.wikia.com/wiki/Sewage_treatment