An Introduction to Wastewater Treatment

By Mengying Li

Introduction

Wastewater, also called used water, mostly comes from domestic, industrial, commercial, agricultural activities or surface runoff. Main components in the wastewater are:

- Decaying organic matter
- Excessive nutrients
- Chlorine compounds
- Heavy metals
- Pharmaceutical and personal care products.
- Pesticides

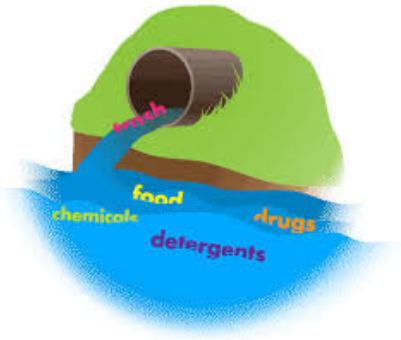

Figure 1 Components in wastewater

These substances are extremely dangerous for the environment and human health. For example, excessive amount of nutrients, such as phosphorous and ammonia, can cause excessive growth of algae in the receiving waters. These algae use up most of the dissolved oxygen in the water and block lights by spreading all over the surface of water. Without oxygen and lights, other aquatic organisms cannot survive. Also, the minerals in the water are capable of causing diseases and producing physiological effects. (2) Research shows that too much lead will cause serious damage to the kidneys and nervous systems.

Wastewater treatment is the process of converting wastewater into an effluent that can either be returned to the water cycle or reused. The major goal of wastewater treatment is to remove as much pollutants as possible from the wastewater.

Process of Wastewater Treatment

For a typical wastewater treatment plant that deals with sewage water, physical, chemical and biological processes are the three main processes that need to be considered.

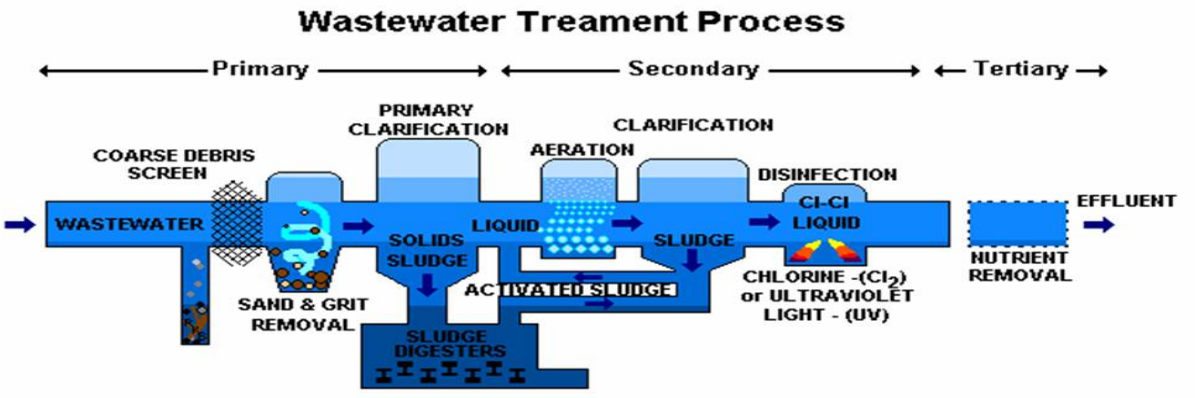

Figure 2 Wastewater Treatment Process

Primary Treatment

Primary treatment, or mechanical treatment, is the first step in the wastewater treatment designed to remove suspended or floating solids from the original sewage water.

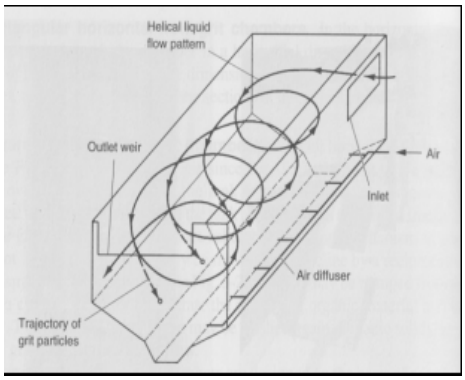

Figure 3 Perpendicular spiral velocity pattern

The most effective way to get rid of the unwanted large solids is to let water first pass through a coarse screen. The screen can remove large solids such as rags, sticks whose diameters ranging from 0.25 to 6 inches. Grit, including sand, gravel, cinder, is heavy but relative small solid particles in the wastewater that can easily pass through coarse debris screen. Grit is the main reason for the abrasion to the mechanical equipment. To remove grit, air is infused into the grit chamber, causing a perpendicular spiral velocity pattern to flow through the tank. The air forces the particles into the water and make the heavier grit drop to the bottom of the tank by gravity, thus completes the separation. (3)

In the following sedimentation step, solid sludge is placed along with sludge digester. This is an anaerobic digestion that can convert organic pollutants into gaseous products such as methane that have potential for reuse. Around 50-60% of the suspended solids can be removed from primary treatment.

Secondary Treatment

Secondary treatment uses biological methods to remove dissolved organic compounds in the wastewater. Microbes, or microscopic living organisms, are used in this process to consume the organic substances as food and convert them into carbon dioxide and water.

In the following step of aeration, air is introduced into the bottom of the water. It increases the concentration of oxygen at the surface of water and helps release excessive gases such as carbon dioxide, methane and hydrogen sulfide. A second sedimentation follows the aeration to remove more sludge. More than 85% of the suspended solids can be removed from secondary treatment.

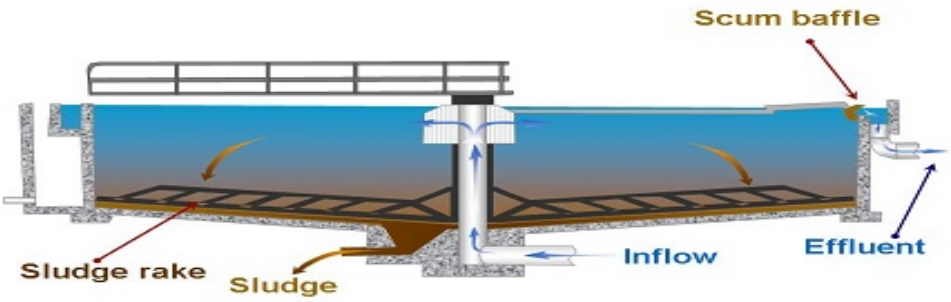

Figure 4 Sedimentation Tank

Tertiary Treatment

Tertiary treatment uses microfiltration and disinfection to remove the remaining inorganic compounds such as nitrogen and phosphorous and microorganisms including bacteria, viruses and parasites.

Activated carbon and semipermeable membranes are usually used as filter medium. Activated carbon has a high degree of microporosity and a large surface area. As result, it is a perfect choice for purifying water by absorbing organic and inorganic molecules via chemical reactions. Semipermeable membrane is a type of biological membrane that has a high selectivity. It only allows certain particles such as water molecules to pass through by diffusion while other contaminants such as salts or organic compounds are left behind. Active carbon and semipermeable membranes not only remove a variety of organic and inorganic compounds, but also eliminate the taste and odor in the water.

On the other hand, chloride or ultraviolet light (UV) is often used for disinfection. Chloride oxidizes the enzymes in the cells and causes the death of the microorganisms. UV light, a high frequency electromagnetic radiation, can penetrate the thin-walls of germs and destroy DNA in living microorganisms. In tertiary treatment, more than 99% of the impurity is removed from the water. The effluent has almost drinking water quality.

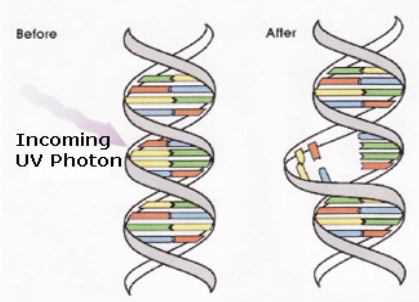

Figure 5 Direct DNA damage

Safety and concerns

The methods used in the tertiary treatment have brought a lot of safety concerns. Chlorine used in the disinfection process is highly toxic. Chlorine gas can cause acute damage in the upper and lower respiration tract. The chlorine residual in the water might also pose serious hazard to human beings. The byproducts produced in water chlorination such as bromoform and dibromochloromethane can cause serious liver and kidney cancer, heart diseases or even death when they are used in high doses.

In addition, when skin is expose to UV light for a long time during the disinfection, the DNA on the skin will be damaged or mutated, producing rapid sunburn and skin cancer. UV light can also lead to the production of ozone, which can be harmful to health. In addition, UV light will not be effective if the microorganisms are buried with the particles. They are shielded from the UV lights and can pass through the tank unaffected.

Improvement for efficiency

Lots of ideas have been proposed to balance energy demand with supply from the recoverable energy. To reduce energy demand, development of better screening equipment, reduction in the load from the side screen and the discovery of anaerobic ammonia oxidizing bacteria can prevent the loss of chemical energy. On the other hand, to increase the energy production opportunities, unprocessed biosolids can be converted to biogases such as methane and carbon dioxide. Also, the energy can be recovered from the heat generated during the oxidation reactions.

Conclusion

Physical, chemical and biological methods play important roles in wastewater treatment. Though the treatment can remove almost all of the impurities from the water, some chemical compounds used in the process are hazardous and need to be treated carefully. In addition, balancing energy demand with supply can improve efficiency of the whole process.

References

1. *Wastewater treatment water use.* The USGS Water Science School http://water.usgs.gov/edu/wuww.html (accessed July 24, 2016)

2. Journal (American Water Works Association), 10/1973, Volume 65, Issue 10

3. *Wastewater technology fact sheet: Screening and grit removal.* EPA https://www3.epa.gov/npdes/pubs/final_sgrit_removal.pdf (accessed July 24, 2016)

4. *Energy Production and Efficiency Research- The Roadmap to Net-Zero* Energy Water Environment Research Foundation file:///Users/Limengying/Downloads/ENER1factsheet.pdf (accessed July 24, 2016)

5. Figure 1 Components in wastewater [Image] http://www.kinetico.com/blog/post/clues-from-waste-water.aspx (accessed Aug 8, 2016)

6. Figure 2 Wastewater Treatment Process [Image] http://watertreatmentprocess.net/waste-water-treatment-process/waste-water-treatment-process/ (accessed Aug 8, 2016)

7. Figure 3 Perpendicular spiral velocity pattern [Image] Crites, R. and G. Tchobanoglous, 1998. Small and Decentralized Wastewater Management Systems. The McGraw-Hill Companies. Boston, Massachusetts. (accessed Aug 8, 2016)

8. Figure 4 Sedimentation tank [Image] http://www.ewisa.co.za/eWISAWaterworks/misc/WaterTreatment/defaultsed1.htm (accessed Aug 8, 2016)

9. Figure 4 Direct DNA damage [Image] www.americanaquariumproducts.com (accessed Aug 8, 2016)