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1. Evolution of the sewer

Sewerage systems started to accept human waste besides rainwater and domestic wastewater. Initially a combined sewer system was used. After wastewater from toilets and industry was allowed, the hygienic status of urban areas improved but water bodies such as rivers and water channels in urban areas became polluted. Because the sewer system did not include facilities to treat collected sewage, but carried and directly discharged sewage into water bodies in urban areas. Pollution of water bodies caused pollution of water resources, which threatened people's lives in urban areas.

2. Development of sewage treatment technology

Construction of new sewer systems accelerated pollution of water bodies in urban areas and resulted in malfunction of water circulation systems. The demand for sewage treatment increased to stop river pollution and various kinds of physicochemical and biological treatment processes were proposed.

A report which was publicized by E. Arden and W.T.Lockett in 1914 described that sewage is mixed with *activated sludge*. Then, the mixed solution is aerated for a short period of time. This produced clean treated water. The activated sludge process had been modified and upgraded and a variety of activated sludge processes were proposed. From the research, it was found that having a deeper aeration tank led to some advantages such as smaller land requirements and lower energy consumption.

3. Water circulation using sewerage systems

Many cities in Japan faced water shortages because of increasing water demand due to expanding urban areas and the pursuit of a comfortable life. Treated effluent from sewage treatment plants is a good water resource to meet the big demand for parks, biotopes, waterways (artificial streams and rivers) and so on in cities. It can be said that the water circulation system was established again in urban areas by the concept of recycling of treated effluent (wastewater recycling.)

To meet water quality requirements when recycling treated effluent in cities, new reclamation technologies were developed for advanced treatment of effluent. For instance, they are a membrane bioreactor, a rapid-sand filter, ozone oxidation, membrane filtration and so on.

4. Sewerage systems in a sustainable society

At present, they are focused on easing global warming. CO₂ emission should be decreased to stop the global warming. Sewerage systems consume much electricity and petroleum even for maintenance of treatment plants. Some plants in Osaka City constructed power generation facilities using digester gas (biogas), which has a composition of about 65% methane and 35% CO₂ after removing hydrogen sulfide. On the other hand, Kobe City uses biogas for automobile fuel after raising the methane concentration to about 90%. Suzu City, Ishikawa constructed new biogas plants receiving five kinds of organic wastes such as sewage sludge, sludge from community plants, night soil, sludge from personal septic tanks and organic waste from several food processing factories. Biogas in Suzu City is used for steam generation to warm a biogas plant.

5. Summary and future scope

The sewer was a key facility of water circulation in urban areas, which removed both rainwater and domestic wastewater in early days. But the sewers did not accept any human waste until 1815. The City of London permitted toilet wastewater to be discharged into sewers in 1815. Since then, river water was polluted by the sewage discharged from sewers. After a century, the sewer regained again a key position of water circulation in urban areas by the diffusion of sewage treatment technology. High water quality standards were then proposed for both safety of life and environmental preservation. Eventually, sewage treatment technology was promoted. In the modern age, environment-friendly sewerage systems should be pursued to stop the global warming. Energy savings and resource recycling technology are important design factors. Low cost technology for the management of sewer and treatment system should be developed to respond to advanced society.

In the future, sewerage systems should also accept kitchen garbage and pursue more effective material and energy production through innovative technology to support the convenient life of advanced living in urban towers. It should not be forgotten to look at reconstruction or renewal of sewerage systems. Finally, it is important to consider that all components of sewage should be recovered and recycled to produce effective materials and/or to generate energy with appropriate and affordable technology in sewage treatment processes.