Review of Sewage and Sewage Sludge Treatment in Korea

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Abstract. China's economic growth rate has averaged 9.7% annually since the 1970s. However, unlike the increase in economic growth, water shortage and water pollution, which are getting worse day by day, are increasingly threatening socio-economic development. About 700 million people drink contaminated water with drinking water. It is a very serious problem in China that contaminated water is continuously used as drinking water. Therefore, mature sewage treatment technology is an important component of municipal sewage treatment system, so it is necessary to develop sewage treatment process gradually. Therefore, China's sewage treatment business needs to be improved with the introduction of high-tech overseas.

At present, China has favorable policies only in the fields of sewage treatment and sewage disposal, which require technical expertise, and the rest are dominated by local government-owned enterprises. [3] With the rapid economic growth of China, demand for sewage treatment is expected to grow, and the sewage treatment plant constructed with China's own technology is expected to continue to support the Chinese government in the future. [6]

South Korea achieved 92.1% penetration rate of sewage into the advanced countries through the 1st National Sewage Comprehensive Plan (2007 ~ 2015) through continuous expansion of sewage treatment facilities. The establishment of a sewerage system for sewerage systems, expansion of public sewage treatment facilities to improve sewage maintenance, enhancement of sewage management, improvement of sewerage management and management, improvement of sewerage management, establishment of water resources circulation utilization system, sewage treatment technology and sewage sludge treatment The technology has already reached a high level.

Japan has implemented projects such as semi-reclamation, food waste disposal, and water purification facilities in Asian countries. Also the Japanese government plans to promote the development of long-term recycling technologies and has called and implemented these plans as the LOTUS project (2004 ~ 2007). [15]

Therefore, it would be better to look for ways to incorporate these Korean and Japan technologies with China's current situation.

Keywords: sewage, sludge, treatment

1. Introduction

The environmental market of China’s sustainable development plans is growing and is one of the future maritime industries in the future. China's policy is also a dynamic field in which excellent technologies from all over the world coexist to the extent that foreign environmental technologies are actively accepted or require technology transfer. The Chinese environment sector is rapidly reorganizing all sectors through close communication and cooperation between the government, enterprises and companies and enterprises, with the analysis of the government's 12th Five Year Plan and the announcement of the new 13th Five Year Plan, The field of sludge disposal is one of the most popular issues. [1]
This study examines the status of sludge treatment in sewage treatment and sewage treatment plants in Korea and Japan. And it shows that the better treatment technology of sewage and sewage sludge treatment technology in Korea and Japan. The purpose of this study is to suggest a method for the sustainable treatment of sewage sludge treatment.

2. Sewage and Sewage Sludge

2.1. Sewage

In the definition of "sewage law" in Korea, "sewage" is defined as "contaminated water (hereinafter referred to as" sewage") mixed with liquid or solid substances due to human life or economic activity and from sites of buildings, roads and other facilities Rainwater or groundwater that flows into the sewerage system.". [12]

The above-mentioned treatment of sewage is important because sewage discharged from a home or a factory contains suspended solids, colloids, and soluble substances, and if released to the natural waters in that state, destroys the ecosystem or spreads the waterborne epidemic. To prevent these phenomena, sewage must be purified by artificially physicochemical or biological methods. Korea has invested heavily in comprehensive measures for the 1988 Seoul Olympics and for the supply of clean water in 1989. As a result, sewerage penetration rate reached 92.5% at the end of 2014.

Generally, in the sewage generation stage, the first generation is divided into sewage and rain water, the second generation is treated with organic substances, the third generation is treated with nutrient salts, the fourth generation is recycled with resources, and the fifth generation is treated with trace amounts of harmful substances. The number of advanced sewerage countries in the world is increasing from 4th to 5th, while Korea is in 2nd and 4th generation. [11].

![Fig. 1: A stage of sewer development][10]

2.2. Sewage Sludge

2.2.1. Types of sewage sludge

Sewage sludge can be divided into activated sludge, surplus sludge, mixed sludge, concentrated sludge, digested sludge and dehydrated sludge in accordance with the Waste Management Act. The types and characteristics of sludge generated during the sewage treatment by the standard activated sludge method, which is the main sewage treatment method adopted in Korea's sewage treatment plants, are shown in the table below. [13]

Table.1. Sludge type and Characteristics
2.2.2. Characteristics of sewage sludge

① pH
The pH of the dehydrated cake was measured in domestic sewage treatment plants. The pH of the dehydrated cake was generally in the range of 6.1 ~ 8.2.
This pH value depends heavily on the operating condition of the digester and the coagulant used. [13]

② Moisture content
The moisture content of sludge investigated at present is 77 ~ 85% and the average moisture content is about 80%. Moisture content is significantly different depending on the characteristics of sludge, dehydrator and coagulant type in each sewage treatment plant. [13]

③ VS (Volatile Solids) content
The organic matter content depends on the type of sewer, the living standard of the people in the sewage treatment area, the effluent of wastewater and the application of the digester. In Korea, there are not many places where separate sewer pipes are installed. Most of sewage treatment plants have anaerobic digesters, so it is known that the organic matter content is relatively low and the concentration range is about 40 ~ 70%. [13]

④ C/N ratio
In the composting of sewage sludge, carbon and nitrogen ratios serve as important control factors for nutritional balance. Unlike other organic materials, sewage sludge is known to have high nitrogen content in organic matter. According to the results of actual analysis, the nitrogen consumption is observed to be considerably high, and the C/N ratio is maintained at a low value. [13]

⑤ Heavy metal content
When the sewage treatment plant is divided into the rural type, the urban type and the industrial type, the heavy metal concentration is higher in the sludge generated in the industrial sewage treatment plant. [13]

⑥ Calorific value
The maximum calorific value of domestic sewage sludge was 434.96kcal/kg, the minimum value was -284.41kcal/kg and the average value was -47.94kcal/kg (Minus means endothermic reaction.)

Unlike other wastes, sewage sludge has a low calorific value due to the amount of ash and water contained in the sludge, and it is impossible to control the amount of sludge during the sludge disposal process. Therefore, it is necessary to control the water content to increase the calorific value. [13]

3. Sewage and Sewage Sludge Treatment Status

3.1. Sewage
Through the 1st National Sewage Comprehensive Plan (07 ～ 15'), Korea has achieved the sewerage penetration rate of 92.1% at the level of developed countries through continuous expansion of sewage treatment facilities. In addition, by upgrading the sewage treatment facilities, the clean water environment was created by reducing the pollutant burden of 3,071 tons / day in the public water discharge by the BOD standard.
In addition, the efficiency of the sewage treatment system was improved through the sewerage maintenance of the sewer line, and the private market was opened for the sewage technology diagnosis and operation management. [8]

As of the end of 2014, the sewerage penetration rate calculated as the ratio of sewage treatment population in the sewage treatment area treated through the public sewage treatment facilities and public sewage treatment facilities is 92.5%, and the public sewage treatment facilities operating in the whole country are 500m3/day, 597 places, the capacity of the facility is 24,751,820m3/day, 3,160 places less than 500m3/day, the capacity of the facility is 247,578m3/day. [9]

The rates of sewerage penetration by provinces were higher in Seoul (100.0%), Busan (99.2%), Gwangju (98.6%) and Daegu (98.3%). In contrast, Chungcheongnam-do (72.7%) and Jeollanam-do (75.1%) were relatively low. [9]

![Fig. 2: Sewage treatment facility capacity][8]

### 3.2. Sewage Sludge

The amount of sewage sludge generated is determined by sewage treatment plant capacity, sewerage maintenance, inflow and outflow characteristics, and sewage treatment method. [14]

It is expected that the amount of sewage sludge will be continuously increased due to the establishment and expansion of sewage treatment plants, sewage pipe maintenance, and strengthening of water quality standards of discharged water.

Table 2: Estimated generation amounts of sewage sludge by year (Ton/day) [15]

<table>
<thead>
<tr>
<th>Year</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>amount</td>
<td>7,745</td>
<td>8,158</td>
<td>8,907</td>
<td>9,414</td>
<td>9,698</td>
<td>10,071</td>
</tr>
</tbody>
</table>

According to the final disposal status of sewage sludge in Japan, sewage sludge of 1.7 million tons per year is generated. Approximately 70% of the sewage sludge generated is treated by the incineration method and 61% of the treated sewage sludge is landfilled and 33% is effectively used. On the other hand, 41% of the recycled effective capacity is used as agricultural land, and the raw materials used are diversified and used as dehydrated cake, dried sludge and compost. These results suggest that the final product of sewage sludge is recycled in a larger amount than in Korea. For this reason, when sewage sludge is reused, sewage sludge is not regulated and used in various forms.

### 4. Sewage and Sewage Sludge Treatment Method

#### 4.1. Sewage

Sewage facilities consist of sewage lines that discharge sewage and rainwater, sewage treatment plants that purify sewage, and sewage sludge treatment facilities that treat sewage sludge.

The sewage treatment can be roughly divided into primary treatment, secondary treatment and tertiary treatment. The first treatment removes the impurities, the second treatment removes the soluble organics by the microbial oxidation (activated sludge method), and the third treats the remaining microorganisms such as activated carbon, coagulation sediment, It is the process of removing by separation method.

#### 4.2. Sewage Sludge
Generally, the amount of raw sludge and excess sludge generated by the standard activated sludge process is about 1% of total inflow sewage, 40 ~ 90% of the amount of solid matter is organic matter, and the water content is 97 ~ 99%. There is a problem that drying is necessary. That is, the organic matter contained in a large amount in the sludge is extremely unstable, so it is easy to decay and corruption may cause harmful substances to the human body and organisms as well as the occurrence of odor, which may cause sanitary problems. In addition, sludge with a high water content is not only expensive to transport to the final disposal site but also increases the capacity of the treatment facility. Therefore, stabilization, safety and reduction of sludge are essential. [13]

![Fig. 3: Sewage and sewage sludge treatment process](image)

5. Sewage Sludge Utilization Plan

5.1. Dry

Drying technology is applied for the purpose of lowering the moisture contained in the sludge, and it can be expected to reduce the cost of logistics due to the decrease of the treatment capacity as a result of drying, stabilize the microorganism by the death, and improve the calorific value. However, since it is a heat treatment technology, it is necessary to carefully examine the kind of dry heat source and the odor problem in drying process.

The technology used is direct drying technology in which sludge is directly contacted with hot air, and indirect drying technique in which sludge is contacted with the heat surface heated by heat medium such as steam. Dry sludge is used for land use, cement raw material. And it is supplied to the intermediate treatment facilities such as incineration and melting.

The type of dryer includes a fluidized bed dryer that blows hot air from an air diffuser located at the bottom of the dryer to dry the sludge while flowing the sludge, a drum drier that draws the sludge into a rotating horizontal drum. A disc dryer using a plurality of circular disks as a heat transfer surface, and a paddle dryer using a disc-like paddle. [13]

5.2. Digestion

The incineration technology is a thermal treatment technique for combusting combustible materials in sludge by using oxygen in the air, and is a technique that has merits such as weight reduction and stabilization due to combustion of combustible components, and efficient utilization of heat.

The technologies used include incineration technology for incineration of sludge in a private incinerator, mixed incineration technology for incineration by mixing with other wastes such as household garbage, and technology for use as fuel for other thermal plants or as a raw material for a cement plant.

There are various types of incineration facilities, but there are various types of incineration facilities for sludge only: multi-stage incinerator (Multiple Hearth Furnace) for burning sludge on horizontal fixed stage, heating the filled sand in a vertical cylindrical furnace, (Fluidized Bed Furnace) in which air is used to incinerate by contact between sand and sludge, and a rotary kiln incinerator in which sludge is injected into the kiln at a constant speed (0.5 to 3 rpm) to incinerate it. [13]

5.3. Melting
The melting technology is applied to melt the inorganic matter in the sludge so that the final disposal material is not left. Since the residue to be discharged is glassy crystals, the stabilization treatment of the sludge containing harmful substances such as heavy metals, and the like. However, since the amount of heat used for melting is excessive, it requires a large operating cost and requires a high installation cost due to the high temperature treatment.

Depending on the type of heat source used for melting, the technology used is an electric furnace melting technique using a flame-based melting technique using fossil fuels and electric arc heat, and the discharged slag is mainly used as a building material.

Types of melting furnaces are furnace type melting furnaces such as surface melting furnaces, coke melting furnaces, and pivoting melting furnaces, and furnace type melting furnaces such as plasma melting furnaces, arc melting furnaces, electric resistance melting furnaces, and induction heating melting furnaces. [13]

5.4. Solidification

The solidification technology is a technique to improve the physical and chemical properties by adding a solidifying agent to a material having a loose property such as sludge. Since the solidified product exhibits a considerable degree of strength, the work efficiency at the final disposal is promoted.

It is possible to expect effects such as detoxification and stabilization of harmful substances. However, depending on the kind of solidifying agent, it may cause a bad odor during the solidification process, and careful examination is necessary.

The technology used is solidification using quicklime, solidification of cement, solidification of asphalt, and solidification using slag as fermentation depending on the type of digestion agent to be injected. [13]

5.5. Composting

Composting technology is a technology to decompose easily decomposable organic matter by using soil microorganisms to utilize the fertilizer component contained in sewage sludge. Composted sludge has a high agricultural value, is not infectious, and is stabilized. It is convenient to use because moisture content is about 40% without water. In addition, since it is not subjected to thermal treatment, there is no greenhouse gas generation, which is a preferable method of use. However, since harmful substances such as heavy metals are hardly treated, it is very important to measure the concentration of harmful substances before composting.

The main method is to deposit sludge mixed with aeration agent on the air supply channel and to compost windrow type composting which mechanically manages the supply air amount and excessive temperature rise, and composting sludge mixed with a venting agent on composting pad Aerated Static Pile composting, Vessel System composting method by adding sludge mixed with a ventilating agent in a container. [13]

5.6. Fueling

Fueling technology is a technology to make fuel by raising the amount of heat of sludge to a level that can be used as fuel, and since fueled sludge is used as alternative fuel for coal, it can be expected to replace fuel import. However, since the produced fuel may be different in terms of combustion conditions and general fuels, it is necessary to comprehensively examine the situation of the customer and the supply and demand of additives to increase the amount of heat.

The technologies used are coal-based fueling and plastics-based fueling, depending on what is used as a caloric aid. [13]

5.7. Carbonization

Carbonization technology is a kind of pyrolysis technology that separates fixed carbon by removing residual moisture and volatile matter by applying heat to the material to be treated under hypoxic condition. Since carbide is a state in which odor generating substance is removed, it is not odorous, and can be used as a sound absorbing agent, a deodorant and the like. However, since carbonization technology is also a thermal treatment technology, it is necessary to examine efficient heat utilization methods.
The carbonization process is carried out in a drier at a moisture content of 20 to 30%, and then the carbonized product is treated in a low-oxygen state at 400 to 550 °C. for 20 to 40 minutes to obtain a carbide having a moisture content of 5 to 8%.[13]

6. Conclusion

Some sewage treatment facilities that have already been constructed have been renovated to improve the ability to reduce major pollutants, to eliminate the de-nitrification function, to renovate sewage treatment plants that do not have biological treatment capacity, the wastewater treatment plant in a sensitive watershed area such as watersheds and important water sources. [5]

Environment protection, energy conservation, recycling and sludge disposal facilities should be promoted in accordance with economical and reasonable principles.

First of all, it is necessary to solve the sludge disposal problem in the region where the generation amount is large and the pollution concern is serious, and the construction of the facility should be carried out in an area where the economy is developed and the construction condition is relatively good.

7. Acknowledgment

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