Research on Application of Anaerobic Treatment Technology for Domestic Sewage in Rural Areas

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Abstract. In the view of sewage treatment difficulties in rural areas and the needs of technological development, anaerobic treatment technology is analyzed from two aspects: technical principles and technical applications. Analysis believes that anaerobic treatment technology can strengthen the removal of refractory organic matter, nitrogen pollutants and sulfates, then improve the harmlessness of rural sewage. It has strong convenience in operation and requires less treatment costs. Anaerobic treatment technology is regarded as the most suitable technology foreign countries to treat the water environment in rural areas, and it has been widely used in domestic sewage treatment. Based on this, this article comprehensively analyzes the anaerobic treatment technology, and the application of anaerobic biological filter, UASB, UMAR and others in rural domestic sewage treatment.

1. Introduction
Rural areas have complex topography, and the population is relatively scattered. The use of previous sewage treatment methods requires higher investment in the treatment, and faces more difficulties in subsequent maintenance. For the removal of organic matter and ammonia nitrogen, the biological treatment process has a low operating cost, but the conventional process has a longer hydraulic retention time (HRT), a sewage treatment structure covers a large area, and a biological treatment unit has a higher chemical oxygen demand (COD).

It is difficult to meet the high-standard discharge or reuse requirements, and advanced oxidation, adsorption and other processes are needed to strengthen, resulting in high wastewater treatment costs. Therefore, for economically underdeveloped areas, anaerobic technology is easy to operate and has low treatment costs. It is an advanced technology that can be applied to sewage treatment in rural areas. At present, the technology has been continuously developed and improved and has been widely used in rural areas. In the treatment of domestic sewage, very significant results have been achieved.

2. Principles of Anaerobic Treatment Technology
Anaerobic treatment technology is an efficient sewage treatment method in which organic matter is decomposed, metabolized, and digested by bacteria under anaerobic conditions, so that the content of organic matter in sewage is greatly reduced, and biogas is produced at the same time.

There are many complex organic materials in wastewater, which are degraded in four stages through anaerobic decomposition. The first stage is the hydrolysis stage. Because of its large molecular size, high molecular weight organic matter cannot directly pass through the cell wall of anaerobic bacteria. It
needs to be decomposed into small molecules by extracellular enzymes outside of the microorganism. Typical organic substances in wastewater such as cellulose are decomposed into cellobiose and glucose by cellulase, starch is decomposed into maltose and glucose, and protein is decomposed into short peptides and amino acids. These small molecules after decomposition can enter the body of the cell through the cell wall for the next step of decomposition. The second stage is the acidification stage in which the above-mentioned small-molecule organic matter enters the cell body and is converted into simpler compounds and distributed outside the cell. The main product of this stage is volatile fatty acid (VFA). The third stage is the acetic acid production stage. The products of the previous step are further converted into acetic acid, carbonic acid, hydrogen and new cell materials. The fourth stage is the methane production stage in which stage acetic acid, hydrogen, carbonic acid, formic acid and methanol are all converted into methane, carbon dioxide and new cell materials. This stage is also the most important stage of the entire anaerobic process and the rate-limiting stage of the entire anaerobic reaction process.

Based on the digestion process rules, organic waste can be acidified and hydrolyzed in different containers. The organic waste needs to be classified first. If the waste is liquid, it can be directly fed into the methane stage reactor for digestion, and the hydrolysis tank is mainly used for treatment. The solid part can effectively separate the garbage after 4 hours, so that the liquid enters the methane stage. After a period of digestion in the reactor, most of the organic matter can be converted into biogas.

3. Application of Anaerobic Technology in Sewage Treatment in Rural Areas

3.1. Anaerobic biological filter
As a kind of biofilm method, anaerobic biological filter has the advantages of high concentration of biosolids which can bear higher organic load; long residence time of biosolids with strong shock load resistance; short start-up time with relatively easy restart operation; no need to return sludge; convenient operation and management. According to Zhang Haoran and others, combined with the accelerated process of anaerobic biological activated carbon, the 25% anaerobic biological filter has a 16-day start-up cycle, the methane production rate is stable on the 9th day, and the COD removal rate reaches the maximum on the 16th day [1].

Wu Ye and others used anaerobic biological filter to treat coking wastewater, the COD removal efficiency can be reduced to 40%, the molecular weight of the organic matter in the effluent is reduced, and most polycyclic aromatic hydrocarbons and a small amount of heterocyclic compounds are degraded [2]. The anaerobic biological filter can take advantage of the different temperature to realize the COD volume load of different anaerobic biological filters, which is suitable for rural sewage with high dissolved organic matter.

3.2. UASB
UASB is widely used in anaerobic biological treatment of chemical sewage. It is mainly used to remove refractory organic matter. It has the advantages of small construction area, many kinds of microorganisms and high volume load. It is suitable for rural areas with high organic matter content and small area for treatment structures. The microorganisms in UASB that can degrade phenolic pollutants include methanogenic bacteria consortium, sulfate reducing bacteria, and denitrifying bacteria [3].

The dual-circulation structure of the UASB reactor can ensure a reasonable rising flow rate, promote full contact between wastewater and sludge, improve the overall operational stability of the reactor and shock load resistance, and improve wastewater treatment efficiency [4]. In order to quickly start the UASB in the actual project, the raw water can be diluted in the initial stage of commissioning and the pollutant load can be gradually increased to the designed amount.

3.3. UMAR
UMAR technology, also known as rotating up-flow multi-stage anaerobic reaction process, is developed on the basis of anaerobic biological filter and UASB that combines the advantages of both. The
microorganisms inside can not only be attached to biological fillers in the form of biofilms, but also can exist in the form of activated sludge, effectively intercepting and adsorbing the organic pollutants and degrading them.

The conversion of organic matter improves the degradation efficiency of organic pollutants while also shortening the HRT, thereby saving land and equipment investment costs. The biological filler not only maintains a high amount of microbial solids, but also avoids reactor blockage and reduces operating costs. The denitrifying bacteria inside can reduce the nitrate nitrogen from the molecular sieve catalytic filter returned to nitrogen, achieving the fundamental purpose of removing ammonia nitrogen.

3.4. Nitrification deep bed filter
Nitrification deep-bed filter is developed on the basis of traditional biological filter and biological activated carbon PACT process. It uses artificial modified molecular sieve instead of traditional biological filter material and PAC (particulate carbon) as microbial carrier. Artificial modified molecular sieve is not only an excellent biological carrier, but also a good physical adsorption and ion exchanger.

It can be modified according to different water quality characteristics, so that it can be selectively adsorbed or exchanged the pollutants in the water, thereby further improving the biochemical properties of wastewater. Furthermore, it can also be regenerated through the action of microorganisms without backwashing and regular replacement, which greatly reduces operating costs and is an indispensable optimal process for advanced biochemical treatment.

3.5. Technology of enhanced organic matter removal
Bio-enhancement technology can improve the removal effect of refractory organics in anaerobic reactors and shorten the time of start-up process. Zhao Wei and others used activated sludge rich with H.S.B flora to degrade coal gasification wastewater anaerobically. Under the condition of HRT=48 h, the COD removal rate reached 43.9% [5]. Chen Chunmao and others found that peat soil can strengthen the treatment effect of UASB on phenol-containing wastewater and promote EPS secretion, then improve the stability of sludge. And the peat soil can be beneficial to the enrichment of hydrolytic bacteria, phenol-reducing bacteria and filamentous bacteria [6]. Li Yajie used biochar to strengthen the anaerobic activated sludge system, and improved the removal of total phenols in coal gasification wastewater through adsorption and biological oxidation [7].

Compared with the original sewage treatment technology, bioaugmentation technology introduces microorganisms with specific functions into the traditional biological treatment system, increases the concentration of effective microorganisms, enhancing the ability to degrade refractory organic matter and degradation rate. Bioaugmentation technology improves the removal efficiency of the original biological treatment system for refractory organic matter, which can reduce the output of sludge in rural sewage, accelerate the degradation of grease in sewage, and be beneficial to the restoration of rivers, lakes and groundwater.

4. Conclusions
From the analysis of construction cost, compared with domestic sewage, septic tank requires the least investment, and the cost of anaerobic combined process is the highest with the operating cost is higher than other treatment modes.

But comparing with septic tank, anaerobic digestion technology plays a vital role in the treatment of rural domestic sewage. It can economically treat domestic sewage in a harmless way and pass it through the anaerobic digestion site to ensure that most of the pollutants are degraded the complying with harmlessness standards.
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