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THE EVOLVING TREND OF MOBILE INTEGRATED DOMESTIC SEWAGE TREATMENT EQUIPMENT

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Abstract: With the rapid development of science and technology in our country, domestic sewage treatment equipment is also gradually upgraded, and underground or semi-underground integrated domestic sewage treatment equipment is increasingly widely used. However, for the treatment of domestic sewage in temporary construction camps and post-disaster reconstruction camps, underground treatment equipment has shortcomings such as large area and easy idle resources. In contrast, mobile domestic sewage treatment equipment has the advantages of convenience, resource saving, and high flexibility, and has good application prospects in emergency treatment of domestic sewage. The article summarizes the treatment technology of mobile integrated domestic sewage treatment equipment in recent years; introduces the specific structure and treatment effect of mobile domestic sewage treatment equipment with physical and chemical methods, biological methods, combined technology and constructed wetlands as core technologies; Compare mobile and underground domestic sewage treatment devices from the perspective of resource utilization and long-term planning, highlighting the flexibility, economical and practicality of mobile domestic sewage treatment devices; by analyzing the situation of rural domestic sewage treatment, we can predict the future of rural domestic sewage treatment The model was discussed, and the operation mode of coexistence of small sewage treatment plants and mobile domestic sewage treatment units was proposed. The development trend of mobile domestic sewage treatment units was prospected, with an emphasis on the advancement of advanced catalytic oxidation and membrane separation processes. It has important theoretical and practical guiding significance.
Keywords: Domestic sewage; Mobile treatment device; Sewage treatment; Technological progress; Integration

1 INTRODUCTION TO MOBILE INTEGRATED DOMESTIC SEWAGE TREATMENT TECHNOLOGY

With the rapid development of my country's economy, farmers' living standards continue to improve, and water consumption is also gradually increasing. According to the "China Urban and Rural Construction Statistical Yearbook 2021" released by the Ministry of Housing and Urban-Rural Development, the domestic water consumption in organized towns is 649,082. 0.79 L, but the treatment rate of rural domestic sewage is only 61. 95%. The level of environmental protection construction in rural areas does not match the level of economic construction, and the random discharge of domestic sewage has led to increasing water pollution problems [1-2]. If the drainage pipe network is used to collect and process rural domestic sewage in a unified manner, it will increase the financial burden and is economically undesirable. Underground integrated sewage treatment equipment has the advantages of easy installation, low operating costs, and low construction investment, and is suitable for rural domestic sewage treatment [3-4]. However, for the temporary storage of domestic sewage in construction camps and post-disaster reconstruction camps, underground integrated sewage treatment equipment still has limitations. This is because underground integrated sewage treatment equipment is difficult to move and cannot be disassembled, and it cannot follow the construction after the construction is completed. The team evacuated, resulting in a waste of resources. In comparison, mobile domestic sewage treatment equipment has the advantages of small footprint, simple equipment, high treatment efficiency and can be moved at any time, and is suitable for the treatment of this type of wastewater. In addition, as the efficiency of water treatment processes gradually increases, the size of sewage treatment equipment gradually decreases, which greatly increases the mobility of integrated domestic sewage treatment equipment and will have more extensive application scenarios in the future. Therefore, it is necessary to summarize the technology of existing mobile domestic sewage treatment equipment to provide a theoretical basis for subsequent upgrades of mobile domestic sewage treatment equipment.

Domestic sewage can be divided into black water and gray water according to its source. Black water consists of feces, urine and toilet flushing water, while gray water consists of bathing water, toilet sewage, laundry water and kitchen water [5]. Domestic sewage usually has the characteristics of large fluctuations in water quality and quantity, poor concentration, and high nitrogen and phosphorus content [6], and usually contains a large amount of suspended solids, dissolved organic matter, and microorganisms. At present, mobile integrated domestic sewage treatment equipment is mainly used for the treatment of dispersed sewage (rural domestic sewage, temporary campground storage sewage).

The core processes of existing mobile integrated domestic sewage treatment equipment can be divided into two categories: biological treatment and physical and chemical treatment based on principles (Table 1). Biological treatment mainly includes anoxic-aerobic (AO) series processes, biofilm methods and their derivative processes, and physical and chemical treatment mainly includes membrane separation technology, coagulation precipitation, electrocoagulation, advanced catalytic oxidation and its derivative processes. The mechanisms and characteristics of each process are as Table 1.

Table 1 Core treatment process of mobile integrated domestic sewage treatment equipment

principle	processing technology	Advantage	Disadvantages
biological treatment	AO series process	High efficiency, simple process, low operation and maintenance costs	It is difficult to satisfy the nitrogen and phosphorus removal effects at the same time
Physical and chemical treatment	Membrane separation technology	Strong impact load resistance and low sludge production	Less operational flexibility
	coagulation	easy to use	Membrane production costs are high and easy to pollute
	sedimentation	easy to use	The treatment effect is poor and often used as pretreatment
	electrocoagulation	High phosphorus removal efficiency	higher cost
	advanced catalytic oxidation	High COD and ammonia nitrogen removal efficiency	Higher energy consumption

1.1 AO Series Process

The AO process is a relatively common domestic sewage treatment process and a type of activated sludge process. The denitrification reaction is carried out in the anoxic tank, reducing nitrate and nitrite into nitrogen and removing it from the sewage. In addition, it can also degrade macromolecules into small molecules to improve the treatment effect of the subsequent aeration tank. Nitrification reaction occurs in the aeration tank to degrade organic matter in sewage. Anaerobic anoxic aerobic (AAO) is to add an anaerobic tank in front of the anoxic tank in the AO treatment process. The main function of the anaerobic tank is to make the returning phosphorus-accumulating bacteria anaerobically release phosphorus, thereby strengthening the phosphorus removal of the reaction facility effect[7]. Hu Junfu et al. [8] used a two-stage AO biological contact oxidation process to treat rural domestic sewage, using flexible biological ropes as biological fillers to improve the adhesion properties of the biofilm and reduce the generation of sludge. The final COD, ammonia nitrogen, and total phosphorus in the effluent were All have reached the Class A discharge standard of the "Pollutant Discharge Standard for Urban Sewage Treatment Plants".

1.2 Biofilm Method

The purification mechanism of the biofilm method is as follows: When sewage flows through the biofilm reactor, microorganisms attach to the filler and grow to form a biofilm. When the sewage flows through the biofilm, the microorganisms come into contact with pollutants in the sewage, completing the purification of the sewage.. The mainstream processes of biofilm method include aerated biological filter, biological turntable, etc. Aerated biological filter is a treatment process developed in the 1980s based on biological filter and biological contact oxidation method [9]. Bao Muping[10] designed a sewage treatment plant with aerated biological filters as the core. Flocculants were added to the high-density sedimentation tank to improve the incoming water quality. After several months of debugging, the effluent water quality reached the "Urban Sewage Treatment Plant Pollution Class A standard of the National Chemical Emission Standards (GB 18918-2002). The difference between the biological turntable and other biofilm processes is that both the disk and the water flow are moving. The AAO process is completed every time the turntable rotates, and the nitrogen and phosphorus removal effect is good [11]. Wei Zhenzhou et al. [12] used the biological turntable method to treat domestic sewage in small towns. The daily water treatment volume was 1500 m3. After passing through the grille, cyclonic grit chamber, and biological turntable, the effluent COD, ammonia nitrogen, total phosphorus, and total nitrogen were all averaged. It reaches the Class I B standard of the "Pollutant Discharge Standard for Urban Sewage Treatment Plants".

1.3 Membrane Separation Technology

Membrane separation technology is a physical and chemical treatment process. Its separation principle is to selectively pass the components in the sewage by generating a pressure difference on both sides of the membrane. When sewage flows through the separation membrane, one or more substances are selectively permeable, and the remaining substances are intercepted to achieve the purpose of separation and purification [13]. Currently, membrane separation technologies that are commonly used in the field of sewage treatment include microfiltration, nanofiltration, ultrafiltration, reverse osmosis, and electrodialysis [14]. Wang Donghe et al. [15] used electrolytic coupling membrane separation technology to treat marine domestic sewage. The water treatment volume can reach 64 m3/d, and the effluent water quality meets the requirements of the IMO. MEPC. 227 (64) resolution. This method selects microfiltration membrane separation technology, in which the membrane separator uses polyvinylidene fluoride hollow fiber membrane modules.

1.4 Electrocoagulation

Physical and chemical methods are used to treat organic matter in sewage, mainly including filtration, coagulation, electrochemical treatment, etc. Among them, coagulation and filtration treatment can not only target wastewater with

low organic matter content and high suspended matter content, but also serve as pretreatment measures for high COD wastewater. Electrocoagulation usually uses iron or aluminum as the anode, and a polymerization reaction occurs under alkaline conditions to generate hydroxide precipitation. During the precipitation process, the effluent quality is further improved through net trapping [16]. Long Kui et al. [17] used electrocoagulation-electrolysis coupling technology to treat ship domestic sewage. Electrocoagulation was used as a pretreatment process to treat sewage, and electrolysis was used as an advanced treatment method to further improve the effluent quality. COD was removed under appropriate conditions such as pH and electrolysis time. The rate can reach 93%.

1.5 Advanced Catalytic Oxidation

In recent years, advanced catalytic oxidation technology has been considered an efficient and reliable sewage treatment technology, and its main purpose is to remove certain new pollutants, such as pesticides, food additives, drugs, etc. [18]. Advanced catalytic oxidation oxidizes pollutants by generating a sufficient amount of hydroxyl radicals [19] and can be used for the treatment of domestic sewage. It mainly includes electro-Fenton, electrocatalysis and photocatalysis. The specific characteristics are shown in Table 2.

Table 2 Advantages and Disadvantages of Advanced Catalytic Oxidation Treatment Process

processing technology	Advantage	Disadvantages
Electric Fenton	Lower cost and good treatment effect	Need to work within a narrow pH range
Electrocatalysis	Strong anti-pollution ability and high energy utilization rate	higher cost
Photocatalytic	Mild reaction conditions and strong oxidizing ability	The effect is limited by multiple factors such as the transmittance of the solution, the nature of the catalyst, and the wavelength of light.

1.5.1 Electric fenton

Electro-Fenton technology uses Fe2+ and H2 O2 produced by electrolysis as Fenton reagents. The two interact to generate hydroxyl radicals.

It should be as formula (1) [20].

$$Fe2+ + H2\ O2 + H+ = Fe3+ + H2\ O + \cdot OH\ (1)$$

The hydroxyl radicals generated by the electro-Fenton method can efficiently remove COD and ammonia nitrogen in sewage. Zhang Feng et al. [21] used the electro-Fenton method to remove COD and phosphorus from nickel plating wastewater. The mass concentration of CODCr and phosphorus in this type of wastewater can reach 2 000 mg/L and 1 000 mg/L. At pH value = 3, The reaction was carried out for 40 minutes at a current density of 10 mA/cm2, so that the CODCr and phosphorus removal rates in the solution were 84. 7% and 91. 5% respectively.

1.5.2 Electrocatalysis

Electrocatalytic oxidation technology can treat domestic sewage with high CODCr and high ammonia nitrogen. During the electrolysis process, a redox reaction occurs, which degrades the organic matter in the sewage [22-23]. Huang Yanfeng et al. [24] used the electrochemical combined membrane bioreactor (MBR) process to treat domestic sewage from offshore platforms, and the treatment effect was best under the conditions of a plate spacing of 2 cm, a current of 52 A, and an electrolysis time of 2 h., the operating cost of the entire device is 67.96 yuan/d, the final degradation rate of CODCr is 87%, and the effluent water quality meets the requirements of the IMO. MEPC227(64) resolution.

1.5.3 Photocatalysis

The principle of photocatalysis is that under ultraviolet or visible light irradiation, electrons on the surface of semiconductor materials are excited from the valence band to the conduction band, thereby forming reactive oxygen species, such as superoxide anion radicals, singlet oxygen and hydroxyl radicals [25]. Ren Chunyan et al. [26] used photo-electric coupling catalysis to reduce CODCr in domestic sewage, operating at a current density of 600 A/m2, an operating current of 940 A, and an ultraviolet radiation intensity of 50 μW/cm2 for 60 d., the water treatment capacity of the entire pilot scale can reach 24 m3/d, and the CODCr mass concentration of the effluent is stable below 125 mg/L, which meets the requirements of IMO. MEPC. 227 (64) resolution.

1.6 Combination Technology

Combining the above single-stage treatment process into a multi-stage treatment process can improve the sewage treatment effect. MBR is a new process that combines membrane separation technology with biological treatment units. The unique MBR flat membrane module is placed in the aeration tank, and the water after aerobic aeration and biological treatment is filtered through the filter membrane by a pump. Extraction, using membrane separation equipment to intercept activated sludge and macromolecular organic matter in the biochemical reaction tank, eliminating the need for a secondary sedimentation tank, can greatly increase the concentration of activated sludge [27]. MBR is usually used in conjunction with other processes to treat sewage, using membrane separation components instead of secondary sedimentation tanks to achieve mud-water separation. Xu Jianyu et al. [28] used AO combined with MBR technology to treat domestic sewage in the faculty park. Compared with the conventional sequential intermittent activated sludge treatment process, the effect of nitrogen and phosphorus removal was improved. Because

MBR was used instead of the secondary sedimentation tank, it saved use of land and reduce energy consumption. The effluent quality after commissioning can reach the Class I B discharge standard of the "Pollutant Discharge Standard for Urban Sewage Treatment Plants". Zuo Yanjun et al. [29] combined coagulation, AO and MBR processes to treat domestic sewage. They first used the coagulation process to remove suspended large particles in the sewage, then used the AO process to remove nitrogen and phosphorus, and finally used the MBR process to strengthen The effluent water quality reaches the Class A discharge standard of the "Pollutant Discharge Standard for Urban Sewage Treatment Plants". There are also studies that couple biological treatment technology with ecological treatment technology to form biological-ecological combination technology. In the past, microorganisms were used to degrade organic matter, and in the latter case, artificial wetland technology was used to carry out deep nitrogen and phosphorus removal. Combining the technical advantages of each other, the quality of effluent water was further improved [30].

2 CLASSIFICATION OF MOBILE INTEGRATED DOMESTIC SEWAGE TREATMENT EQUIPMENT

Based on different domestic sewage treatment processes, mobile integrated domestic sewage treatment equipment can be roughly divided into 4 types, namely treatment equipment with physical and chemical methods, biological methods, combined technology and other technologies (such as constructed wetlands) as the core process. It mainly includes coagulation filtration, membrane separation technology, advanced catalytic oxidation, AO series processes, biofilm methods, constructed wetlands and their combined processes. The characteristics are shown in Table 3.

Table 3 Characteristics of conventional mobile integrated domestic sewage treatment equipment

processing technology	Core craftsmanship	Advantage	Disadvantages
Physical	coagulation, filtration	Lower cost, simple operation and maintenance	Poor processing effect
Chemistry	Membrane separation technology	Good treatment effect, simple operation and maintenance, small footprint	Membrane costs are high and easy to pollute
	Photocatalysis/Electrocatalysis	Good treatment effect, high effluent quality, small footprint	The device is complex and the operation and maintenance costs are high
biological methods	AO, AAO	Low cost, simple operation and maintenance	It occupies a large area and requires sludge return
	biofilm method	Low cost, no sludge backflow, strong impact load resistance	Some processes require backwashing
Combination technology	AO+MBR	High effluent quality	Large floor space and high operation and maintenance costs
other	Artificial wetland	Low cost, beautifying the environment	Poor treatment effect and small water volume

2.1 Treatment Equipment with Physical and Chemical Methods as the Core

Equipment based on physical and chemical methods usually treats gray water, that is, sewage such as washing, washing vegetables, and bathing water, rather than black water with high CODCr and high ammonia nitrogen. This type of gray water can be recycled after coagulation, filtration, and sterilization. Luo Kongcheng [31] invented a mobile sewage filtration truck for gray water treatment. The entire device mainly consists of a mixing box, a submersible pump, a water outlet pipe, a filter box, a water discharge pipe, a blower, an iron pipe, a jet head and an air outlet pipe. The core processing technology is filtration. First store the gray water in the sewage tank, then start the water pump, suck the sewage into the filter box for filtering, and then discharge it into the mixing tank after filtering. At the same time, turn on the blower for stirring. The treated water can be used again.

In addition, domestic sewage from ships can be collected in categories and discharged into the urban sewage collection system for treatment after docking. Wei Helei [32] invented a mobile residential ship domestic sewage treatment device, which collects black water and gray water separately, and regularly disinfects and sterilizes the two types of sewage to prevent the growth of germs. Each collection bin is equipped with an alarm system that will sound an alarm when the capacity exceeds 80%. The device collects sewage by gravity alone, without the need for other equipment.

For the treatment of black water, physical and chemical processes such as microfiltration and ultrafiltration can be selected. In the design of mobile sewage treatment equipment, there are many choices for microfiltration and ultrafiltration processes, because this process takes up very little space and can achieve good sewage treatment effects. Forbis-stokes et al. [33] designed a mobile septic water treatment device to treat black water in septic tanks in Indian cities and empty the septic tanks in a timely manner for subsequent use. The core processes of this device are adsorption, microfiltration and ultrafiltration. After the sewage passes through a mesh fabric to remove large particles, it enters a fiberglass container composed of sand and pebbles for filtration, and then passes through an activated carbon adsorption device to further remove suspended matter in the water. At the same time, the activated carbon can also absorb organic matter and ammonia nitrogen in the sewage, further improving the water quality.. After that, the sewage passes through microfiltration and nanofiltration devices in sequence to realize sewage reuse. After the entire device operates stably, the removal rates of CODCr, total suspended solids and total coliforms are 81%, 80% and 98.4% respectively, reaching the discharge standards of Indian sewage treatment plants.

Wang Lei et al. [34] invented a movable photocatalytic sewage treatment device, which can effectively treat domestic sewage and industrial wastewater. It mainly consists of a water inlet pipe, a photocatalytic filler rod, an outlet pipe, a sewage pump, a mobile platform, and a fixed It consists of racks, etc. According to the different quantity and quality of sewage water, photocatalytic filler rods of different specifications and models can be selected to improve the purification efficiency. The photocatalytic filler rod adopts a translucent shell and uses sunlight for photocatalytic treatment of sewage during the day. It can use a built-in light source for photocatalysis at night. Generally speaking, this process has lower energy consumption, higher processing efficiency, and strong adaptability to impact loads.

2.2 Treatment Equipment with Biological Methods as the Core

Biological sewage treatment equipment is cheap, effective and widely used. Similarly, in the selection of core processes for mobile sewage treatment units, biological processes such as AO, AAO, and MBR are usually given priority. The structure of this type of device usually consists of a grille, a regulating pool, a core process pool, and a disinfection pool. Among them, the function of the grille is to remove floating substances in the sewage, the function of the regulating tank is to uniform the water quality and quantity, the removal of most organic matter and ammonia nitrogen is completed in the core process tank, and finally the function of the disinfection tank is to disinfect and sterilize.

Li Tianyuan [35] developed an intelligent mobile rural sewage treatment device with the core process of AO. Treatment process: The device inhales sewage and performs anaerobic reaction after it reaches the designated liquid level, and then adds an aeration head for aeration to perform aerobic reaction. The whole process is automated. The central box sends instructions to each unit according to the preset data, and the device can run according to the program.

Xin Haibo et al. [36] designed a mobile sewage treatment device with AAO technology as the core. The entire device consists of a regulating tank, anoxic tank, aerobic tank, sedimentation tank, and disinfection tank, and can be used for the treatment of small-scale domestic sewage. The aerobic tank of the mobile sewage treatment device adopts multi-stage segmented contact oxidation, which reduces the reaction load step by step and improves the system's ability to withstand impact loads.

Wang Linghang et al. [37] developed a mobile sewage treatment vehicle based on the AAO process, which consists of a filter press box, an anaerobic box, anoxic box, and an aerobic box. The device is convenient and fast, and can perform secondary treatment of incompletely treated sewage. Among them, the filter press box can be divided into a pressure water area and a water filter area. The water pressure area is composed of pressure blocks and air bags, and the water filter area is adsorbed by an activated carbon layer. A UV lamp is hung on the top of the final aerobic box for disinfection and sterilization.

Wang Yuming et al. [38] developed a movable black and odorous water treatment equipment with aerated biological filter and biological turntable technology as the core, which can treat the overflowing domestic sewage in the drainage pipe network and the black and odorous water in the surrounding ponds. for processing. The entire device consists of a coagulation reaction tank, a sedimentation tank, a regulating tank, an aerated biological filter, and a biological turntable. Fenton's reagent is added to the coagulation sedimentation tank for oxidation treatment. The device is connected to an external solar power generation system and is suitable for the treatment of small-scale black and odorous water bodies. The effluent can reach the Class A emission standard of the "Pollutant Discharge Standard for Urban Sewage Treatment Plants" (GB 18918-2002).

2.3 Mobile Combined Technology Processing Equipment

The water quality and quantity of domestic sewage fluctuate greatly and change significantly with the seasons. In order to maintain the stability of effluent water quality, combined technologies are usually used to treat sewage. Zhong Xudong et al. [39] developed a mobile rural sewage emergency treatment device to temporarily treat domestic sewage. The effluent water quality can reach the Class I B standard of the "Pollutant Discharge Standard for Urban Sewage Treatment Plants" (GB 18918-2002), and can be used for Greening and irrigation. The device consists of a regulating pool, an anoxic pool, an aerobic pool, and an MBR. The size of the device is 7. 28 m × 2. 13 m × 2. 18 m. The hydraulic retention time in the anoxic pool and the aerobic pool is 8 h.. The cleaning box is responsible for cleaning the MBR, and the pipeline is cleaned by adding sodium hypochlorite through the dosing box.

Zhou Jiazheng et al. [40] developed a unit-type membrane biodegradation mobile sewage treatment station. The core treatment device is a biological treatment tank and a hollow fiber membrane filtration device. The structure design is reasonable and compact, and can effectively treat sewage without producing activated sludge. The biological treatment tank is equipped with an aeration tank, a sedimentation tank, and a disinfection and decolorization tank. The domestic sewage first passes through the fence basket to remove floating substances, and then enters the aeration tank for aeration and oxidation. After sterilization and decolorization, it enters the tubular hollow fiber filter for filtration. treatment to improve effluent quality.

Wang Xiaoli et al. [41] developed a mobile integrated sewage treatment equipment, which is composed of modularized mobile treatment devices. The entire device integrates mixing reaction, water distribution and aeration, which can realize integrated sewage treatment and is suitable for treating small-scale rural domestic sewage. The water quality after treatment by this device reaches the surface water quality standard III and can be directly discharged or reused. The mobile integrated device is mainly composed of a hydrolysis acidification tank, a contact oxidation tank, an MBR tank, a disinfection tank, and a sludge tank. The hydrolysis acidification tank contains elastic fiber composite filler to

increase the amount of microorganisms and improve the treatment effect. The hydrolysis acidification tank mainly degrades organic matter into small molecular substances such as fatty acids, and can also perform denitrification reactions under anoxic conditions. The contact oxidation tank is connected to the MBR membrane to reduce the production of activated sludge. The microorganisms attached to the oxidation tank undergo oxidative metabolic reactions to remove pollutants in the sewage. Biochemical oxygen demand (BOD), CODCr and other indicators are also reduced in the treatment tank.. In addition, the nitrification reaction will also occur in the oxidation tank, and the nitrification liquid will flow back to the hydrolysis acidification tank through the return pipeline for denitrification. Disinfection is carried out by adding chlorine dioxide into the disinfection pool.

Zhao Bolton [42] developed a mobile emergency domestic sewage treatment equipment. Different from the above-mentioned device, this device combines biological methods with physical and chemical methods, and is mainly composed of a crushing device, a sand and gravel layer, activated carbon and a photovoltaic power generation device. Domestic sewage first passes through the crushing device to crush larger objects into fine particles, and then flows into the anaerobic chamber for treatment. Different from the above-mentioned device, the anaerobic chamber of this device contains photosynthetic bacteria and fluorescent tubes. Photosynthetic bacteria can decompose organic matter in sewage under conditions of light and anaerobic conditions. After anaerobic treatment, it enters the filter chamber for treatment. The quality of the effluent water is further improved through activated carbon adsorption. The fluorescent tube, crushing motor, and stirring motor of the device are all connected to the photovoltaic power generation device.

2.4 Mobile Constructed Wetland Treatment Equipment

In the design of mobile sewage treatment equipment, constructed wetland technology is rarely used. This is because constructed wetlands occupy a large area and have poor treatment effects. However, constructed wetlands have the characteristics of triple degradation mechanism (substrate, plants, microorganisms) and low energy consumption, which makes this technology have significant advantages in treating domestic sewage, especially in terms of nitrogen and phosphorus removal.

European countries such as Belgium often hold music festivals. Music festival venues usually do not have drainage systems or the capacity of the drainage systems is insufficient, making it difficult to deal with the domestic sewage temporarily generated by the music festivals. Lakho et al. [43] developed a mobile domestic sewage treatment equipment with constructed wetland technology as the core. The mobile device processes black water and gray water through a constructed wetland, and then flows into the drinking water regeneration system to regenerate pure water. It not only solves the problem of domestic sewage pollution, but also recycles water resources. The mobile facility uses a trailer as a carrier, with water inlet tanks installed on both sides and a water level sensing device, which can realize automatic water inflow. The incoming water flows into the wetland through the perforated pipe network. The entire device process consists of constructed wetlands, ultrafiltration, and reverse osmosis. The sewage first passes through a constructed wetland for denitrification and phosphorus removal, and then passes through an activated carbon adsorption device to remove large particulate matter to prevent the subsequent ultrafiltration device from clogging. Ultrafiltration-reverse osmosis removes remaining organic pollutants. Finally, after disinfection and sterilization, the water quality can be improved. Meet drinking water requirements. After adjustment and optimization of the device, the removal rates of CODCr, BOD, total suspended solids, total nitrogen, and total phosphorus can reach 90%, 95%, 97%, 24.7%, and 76%.

Zehnsdorf et al. [44] developed a mobile treatment device with reed roots as the main treatment unit, which is used to treat temporary urban wastewater (for example, domestic sewage from temporary construction sites, domestic sewage from tourist campsites, temporary camping after disasters) local domestic sewage, etc.). The device uses a reaction chamber composed of reed roots as the core treatment process, using plants and microorganisms attached to the plants to treat sewage. Since the reaction roots are relatively dense, the treated wastewater usually requires pretreatment in order to prevent clogging. Therefore, this mobile facility is usually used in conjunction with other pretreatment measures, and the treatment load can reach 1 200 L/d.

3 CHARACTERISTICS OF MOBILE INTEGRATED TREATMENT EQUIPMENT FOR DOMESTIC SEWAGE

3.1 Advantages of Mobile Integrated Treatment Equipment

For dispersed sewage in remote areas or domestic sewage in temporary construction campsites, if the drainage system is not installed or the drainage system has insufficient carrying capacity, it is easy to cause sewage leakage and affect the surrounding environment. The extensive laying of pipelines to remote areas will also cause a waste of resources. In view of the above situation, mobile domestic sewage treatment equipment has irreplaceable advantages. Compared with underground treatment equipment, mobile sewage treatment equipment has the advantages of high treatment efficiency, small footprint, convenient management, and small sludge output. It does not cause waste of resources and is suitable for treating temporary wastewater [45]. Mobile integrated devices have the following advantages when treating domestic wastewater.

3.1.1 Save pipe network laying costs

Remote areas usually have fewer households and are far away from urban sewage treatment plants. If urban drainage pipelines are forcibly laid, the economic benefits will be low and the pressure on the financial department will also increase. In comparison, mobile sewage treatment equipment has low construction prices and low operating costs. It has

unique advantages in treating a small amount of domestic sewage in remote areas. It can adopt different processes for treatment according to local water quality and quantity conditions, and has high flexibility.

3.1.2 Save resources

For domestic sewage discharged from temporary construction or shelter camps, if an underground or semi-underground treatment device is built, the temporary treatment device will remain idle after the construction is completed and the disaster has passed, resulting in a waste of resources. Compared with mobile processing facilities, this underground device will occupy a larger area, require more initial investment, and consume more manpower and material resources. Using mobile sewage treatment equipment will save resources and meet the requirements of sustainable development.

3.2 Disadvantages of Mobile Integrated Processing Equipment

Mobile sewage treatment equipment is characterized by convenience and speed. Therefore, the treatment capacity of the device is limited and it is not suitable for treating large-scale wastewater. The underground device has many structural units, a high water treatment capacity, strong impact load resistance, and low operation and maintenance costs [46]. In comparison, the treatment process of mobile sewage treatment equipment is usually related to the membrane process, which requires regular maintenance and flushing. In order to improve the treatment effect, dosing (coagulant) is usually required. Therefore, the operation and maintenance costs are relatively high.

3.3 Application Status of Mobile Integrated Processing Equipment

According to the "China Urban and Rural Construction Statistical Yearbook 2021" released by the Ministry of Housing and Urban-Rural Development, the annual domestic water consumption, sewage treatment plant processing capacity and sewage treatment devices (integrated treatment devices) of organized towns across the country in the past ten years are summarized, as shown in the table As shown in 4, various indicators show an increasing trend year by year. It is worth noting that the processing capacity of sewage treatment devices in organized towns is similar to that of sewage treatment plants, indicating that integrated domestic sewage treatment devices are widely used in towns and villages.

Table 4 Statistics on domestic sewage treatment in organized towns across the country in the past ten years

years	Annual domestic water consumption/ m^3	Proportion of incorporated towns that can handle domestic sewage	Treatment capacity of sewage treatment equipment/ (m^3 ·d-1)	Number of sewage treatment devices/piece	Treatment capacity of sewage treatment plant/ (m^3 ·d-1)	Number of sewage treatment plants/unit
2011	498 547. 650,000	/	710. 100,000	8 125	1 1.1243 million	1 651
2012	512 288.47 million	/	867.08 million	10 652	1 475.88 million	2 158
2013	536 832. 84 million	18.87%	1 3.0966 million	6 371	1 114.80 million	2 060
2014	558 444. 340,000	21.65%	1 006.34 million	8 667	1 338.71 million	2 961
2015	577 768. 310,000	25.28%	1 131. 100,000	11 573	1 423.65 million	3 076
2016	589 756.06 million	28.02%	1 041.38 million	12 421	1 422.77 million	3 409
2017	590 166.86 million	47.06%	1 3.8369 million	/	1 714.15 million	4 810
2018	589 238. 200,000	53.17%	1 613.43 million	/	2 238.84 million	7 687
2019	616 804. 89 million	59.67%	1 874.88 million	/	2 477.34 million	10 650
2020	641 351.94 million	65.35%	2 1.5736 million	/	2740.05 million	11 374
2021	649 082. 200,000	67.96%	2 361.84 million	/	2 932.71 million	13 462

In recent years, although urban and rural areas have paid more and more attention to the treatment of domestic sewage, as of 2021, the number of incorporated towns with sewage treatment plants or domestic sewage treatment equipment only accounts for about 68%. The reason for this is that there may be the following problems that limit its use develop.

3.3.1 Government financial pressure is too great

Funds for agricultural pollution construction mainly come from national and local finances. The economic level in rural areas is low, and the local area cannot purchase enough equipment or perform routine maintenance, resulting in idle waste of resources. Local governments can use the PPP (public-private-partnership) model to support and encourage the investment of social funds, which can not only help local enterprises develop but also reduce financial pressure.

3.3.2 Lack of reasonable technology and unified emission standards

The quality and quantity of domestic sewage in rural areas fluctuate greatly, and the drainage volume in each region is different. Sufficient research should be conducted in the early stage to use classified treatment methods for domestic sewage in different regions and select appropriate treatment technologies. In addition, urban and rural areas should also adopt unified emission standards, which will also be conducive to the promotion of integrated domestic sewage treatment devices.

3.3.3 Lack of professionals

The operation and maintenance of integrated domestic sewage treatment equipment requires professionals. Most of the staff in rural areas work part-time and do not have a deep understanding of rural domestic sewage treatment, which may cause problems in the operation of the entire system. In view of this situation, we should vigorously develop the intelligent operation of integrated processing equipment, and use cloud operation to detect problems in the operation of the device in time and improve the processing efficiency of the entire device.

3.4 Development Trend of Mobile Integrated Processing Equipment

With the improvement of my country's sewage treatment system, the domestic sewage treatment structure has become more reasonable. For the treatment of domestic sewage in remote areas, when users live together (move into buildings), sewage plants can be built locally, but concentrated living is difficult to achieve in the short term. Therefore, during the transition period, mobile sewage treatment devices can be used to treat the current domestic sewage. At present, mobile integrated treatment equipment is mainly used in the treatment of domestic sewage in construction camps and rural domestic sewage [47-48]. Mobile sewage treatment units can play an important role in the field of emergency rescue. For camping sites after disasters, the drainage pipe network system may be damaged. Mobile sewage treatment devices can temporarily treat domestic sewage in the camp to provide guarantee for the production and life of residents. Li Weixing et al. [49] used mobile integrated sewage treatment facilities to treat contaminated water sources. After flocculation, sedimentation, ultrafiltration, and disinfection, they reached drinking water standards to ensure healthy water use after disasters. For domestic sewage generated from temporary construction camps or large-scale activities in the countryside, mobile sewage treatment devices have irreplaceable advantages. With the development of sewage treatment technology, the performance of mobile sewage treatment equipment will also be optimized to a great extent. Membrane separation technology has the advantages of good separation effect and small space required, and is widely used in the design of mobile sewage treatment equipment. However, as the processing time of the membrane unit reaction device goes by, the membrane pores will become clogged, and the membrane pores need to be cleaned regularly. The membrane components are also easily damaged, making maintenance costs higher. With the continuous deepening of research on membrane pollution removal and membrane modification technology, the anti-pollution and impact resistance of membrane modules have gradually increased, and the application prospects of mobile sewage treatment devices will become wider.

In addition, the article selects two cases that use AO series technology as the core process and meet the Class A emission standard of the "Pollutant Discharge Standard for Urban Sewage Treatment Plants" (GB 18918-2002), and analyze their economic benefits. Their sewage treatment The cost is 1. 5 ~ 2. 0 yuan/m3[50-51], while the treatment cost of urban sewage treatment plants is about 1 yuan/m3[52]. Therefore, rural domestic sewage treatment policies should be flexible and changeable, measuring water quality and quantity and sewage treatment costs. For densely populated areas, sewage treatment plants can be built for unified collection and treatment. For areas with small flow, mobile integrated domestic sewage treatment equipment can be used for "online appointment" treatment.

4 CONCLUSION

Mobile integrated treatment equipment is a key link in my country's sewage treatment system. It makes my country's sewage treatment system more complete and is worthy of discussion and research. The mobile integrated sewage treatment device combines and simplifies the existing complex processes, making the unit structure combination more reasonable, forming an integrated treatment process, and improving the efficiency of sewage treatment. Compared with underground domestic sewage treatment equipment, mobile sewage treatment equipment has more advantages in domestic sewage treatment in remote areas and during construction periods, and will not cause a waste of resources. Most of the existing mobile integrated domestic sewage treatment equipment uses AO as the core process. This is because this technology has low cost and convenient operation and management. However, its hydraulic retention time is long and an additional sedimentation tank is required. In order to improve the water output Water quality still needs to be used in conjunction with other processes, etc. On the premise of ensuring mobility, the treatment efficiency of the device is limited.

The upgrading of mobile integrated domestic sewage treatment equipment is closely related to the research and development of efficient domestic sewage treatment technology. With the rapid development of the environmental field, the types of domestic sewage treatment technologies are gradually increasing, and a variety of high-performance processes are gradually applied in the field of domestic sewage treatment. This provides more possibilities for the development of mobile sewage treatment devices, among which advanced catalytic oxidation and membrane separation processes deserve attention. Advanced catalytic oxidation technology relies on the hydroxyl radicals generated by the reaction to efficiently remove CODCr and ammonia nitrogen in sewage. The device with this process as the core occupies a small area, and when combined with other phosphorus removal processes, the effluent can reach "Urban sewage treatment plant pollutants Class A emission standards of the "Emission Standards" (GB 18918-2002). However, the initial investment in this process is relatively large, and future research can focus on reducing costs, such as developing low-cost electrocatalytic anode coatings and optimizing electro-Fenton and photocatalytic reaction conditions. Membrane separation is a simple and efficient sewage treatment technology. Through the combined use of multiple membrane separation processes, the effluent quality can reach drinking water standards. However, due to the

high production cost and easy pollution of membranes, their application in mobile integrated domestic sewage treatment devices is limited. Future research can be based on reducing membrane pollution, such as the research on self-cleaning membrane materials, to achieve "one machine, one membrane" "To reduce operation and maintenance costs. Due to the high cost performance of biological methods (low price and high efficiency), the treatment method of future mobile integrated sewage treatment equipment will still be a joint treatment model with biological methods as the core process and physical and chemical methods as the advanced treatment process. In addition to technological breakthroughs, rural domestic sewage treatment models and operating mechanisms should also be optimized. Different treatment methods should be adopted according to the water quality and quantity of different regions, and cooperation between local governments and enterprises should be strengthened to drive economic development and reduce local financial pressure.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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