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(54) Title of the Invention: **Integrated inverted A2/O-GDMBR based on external electric field for village sewage treatment device and method**
Abstract Title: **Integrated inverted A2/O-GDMBR based on external electric field for village sewage treatment device and method**

(57) The present invention belongs to the technical field of village and town sewage treatment. Provided are an inverted A^2/O-GDMBR integrated village and town sewage treatment apparatus with an external electric field, and a sewage treatment method thereof. The present invention aims to solve the problems of existing village and town sewage treatment, i.e. a low carbon-nitrogen ratio, high energy consumption, a large operation and maintenance amount, a poor water purification effect, and instability. The apparatus comprises an inverted A^2/O tank housing, a cathode electrode, an anode electrode, a mechanical stirring and lifting mechanism, a first aeration component, an adjustable-angle baffle plate, an inclined flow guide plate, an arc-shaped flow guide plate, a GDMBR tank, a membrane component, a second aeration component, a water collection tank, an air pump, a return pump and a solar power supply apparatus. By means of the research and development of a new configuration, the present invention achieves the three purposes of aeration, i.e. the three functions of oxygenation, nitrification liquid circulation and sludge backflow achieved by aeration are integrated; a rotary microelectrode is used to achieve the function of three-phase quick separation of gas, liquid and solid while providing low-voltage regulation and control for microorganisms, thereby enhancing nitrogen and phosphorus removal; and the apparatus has the advantages of a high water purification efficiency, a low energy consumption and ease of operation.

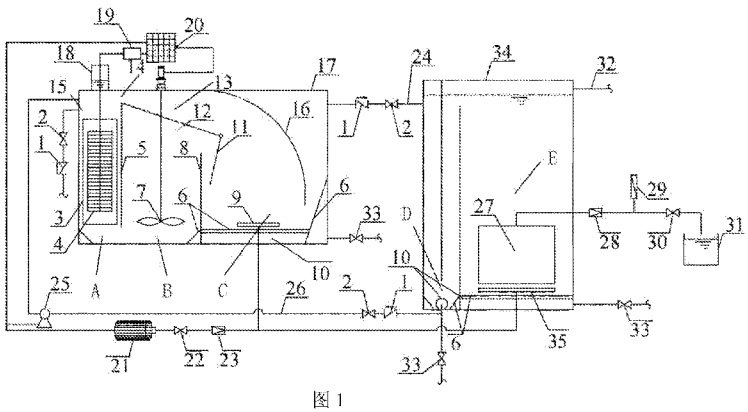


图 1

This international application has entered the national phase early.

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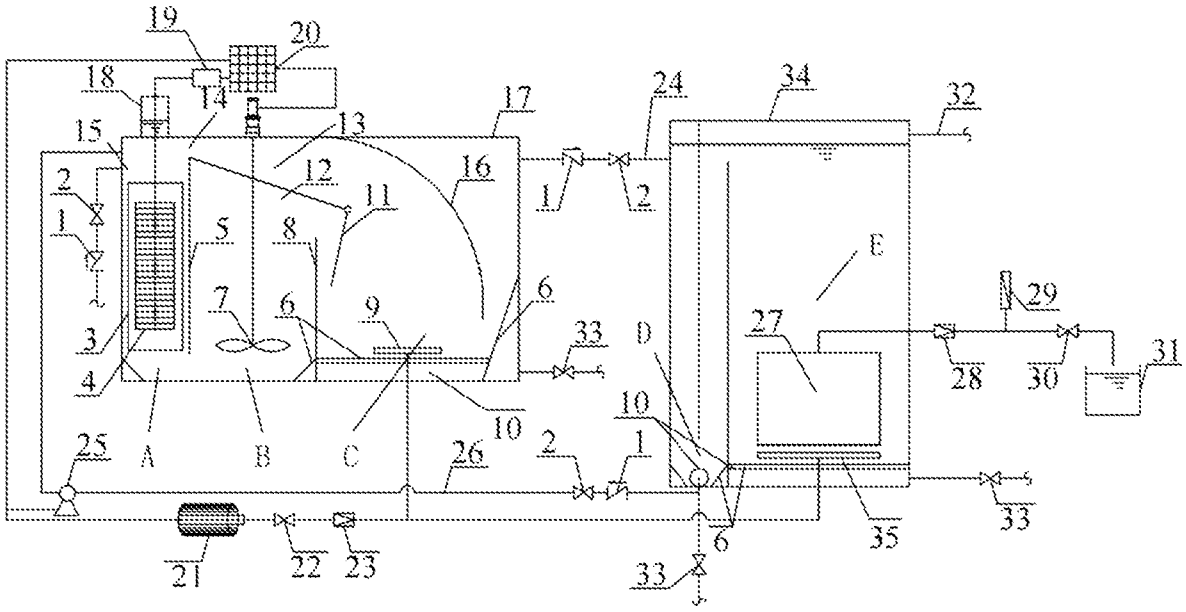

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FIG.1

INTEGRATED INVERTED A^2/O-GDMBR BASED ON EXTERNAL ELECTRIC FIELD FOR VILLAGE SEWAGE TREATMENT DEVICE AND METHOD

TECHNICAL FIELD

[01] The present disclosure belongs to the technical field of village sewage treatment, in particular to an integrated inverted A^2/O-GDMBR device and method based on an external electric field for the village sewage treatment.

BACKGROUND ART

[02] With the combined influences of economic development and the progressive new rural constructions, rural locals' living standards have been greatly improved, and accordingly the production of domestic sewage is also gradually increasing. Rural domestic sewage has become an important factor affecting the safety of surface water conditions. Compared with urban areas, domestic sewage treatment in rural areas has significant geographical differences, water quality and volume differences, the current construction of sewage treatment facilities lags behind seriously, and even sewage treatment facilities are not constructed in most areas. The constructed treatment facilities also have common problems, such as unreasonable design, low operational efficiency, high energy and agent consumption, and required professional operation and maintenance. Therefore, at present, the collection and treatment rate of rural sewage is extremely low, and most of the domestic sewage is discharged directly without any treatment, resulting in wide-spread pollution to rivers and ponds, which generates a huge impact on local ecological conditions, brings inconvenience to life and production of rural residents, and seriously restricts the local economic development and life quality improvement. In consideration of the current situation of rural sewage treatment, problems caused by applying conventional centralized sewage treatment technologies to rural areas, as well as regional characteristics and sewage water quality and quantity characteristics of the rural areas, rural sewage should be collected and treated uniformly from the source of pollution, rather than the way like centralized collection and then end treatment in urban sewage treatment plant. In addition, rural sewage is characterized by its many pollutional sources, low emission load, high decentralization, complex water quality, obviously fluctuant water volume. Based on the consideration of the above characterizations of rural sewage, the corresponding sewage treatment technology has the characteristics of being maneuverable, flexible, simple in operation, less in energy consumption, low in maintenance, and free of personal supervision.

[03] The existing membrane bioreactor (MBR) inherently combined biological treatment and membrane separation, has the advantages of high treatment efficiency, small footprint, high automation degree, and low sludge yield, has become a preferred process for village sewage treatment. However, the defects of undesirable synchronous denitrification and dephosphorization, severe membrane fouling, extra increasing energy consumption and operational costs, limited its widespread application in rural areas. Therefore, it is necessary to design a novel wastewater treatment device to solve the above problems based on MBR technology.

SUMMARY

[04] The present disclosure aims at providing an integrated inverted A2/O-GDMBR device and a method based on an external electric field for the village sewage treatment. A new structure of the device is developed to achieve the synergistic effects of oxygenation, nitrification liquid circulation and sludge reflux only by aeration; The rotary microelectrode is adopted not only to provide a regulation of microorganisms by a low-voltage method, but also achieve a rapid separation function among gas, liquid and solid phases, enhancing denitrification and dephosphorization. The device has the advantages of high water purification efficiency, low energy consumption and simple operation, and are a reliable process to solve the problems of rural sewage treatment in the future.

[05] In order to achieve the above objectives, the process is performed as follows:

[06] An integrated inverted A^2/O-GDMBR device based on an external electric field for the village sewage treatment, includes an inverted A^2/O tank shell, a cathode electrode, an anode electrode, a mechanical stirring and lifting unit, a first aeration module, an angle-adjustable baffle, an inclined flow guide plate, an arc-shaped flow guide plate, a GDMBR tank, a membrane module, a second aeration module, a water collection tank, an air pump, a reflux pump and a solar power supply device; the inverted A^2/O tank shell is sealed, while the GDMBR tank is open on an upper portion, the air pump, the reflux pump and the solar power supply device are all arranged outside the inverted A^2/O tank shell, the water collection tank is arranged outside the GDMBR tank, and the solar power supply device supplies power to the air pump, the anode electrode, the cathode electrode, the mechanical stirring and lifting unit and the reflux pump;

[07] The inverted A^2/O tank shell is orderly divided into an anoxic zone, an anaerobic zone, and an aerobic zone by installing a first partition and a second partition in parallel inside the inverted A^2/O tank shell, an upper end of the first partition is higher than that of the second partition, the bottom of anoxic zone is communicated with the bottom of the anaerobic zone, an upper portion of the anaerobic zone is communicated with the aerobic zone, an upper portion of the anoxic zone is communicated with an external water inflow pipeline by a water inlet, the cathode electrode is arranged inside the anoxic zone, the anode electrode is arranged inside the cathode electrode, and the mechanical stirring and lifting unit is arranged inside the anaerobic zone;

[08] The first aeration module is arranged inside the aerobic zone, an upper end of the inclined flow guide plate is fixedly connected with the upper end of the first partition, a lower end of the inclined flow guide plate extends into the aerobic zone to be connected with an upper end of the angle-adjustable baffle, an upper end of the arc-shaped flow guide plate is fixed to a top wall of the shell, a lower end thereof is a free end, and a reflux passageway is formed among the inclined flow guide plate, the angle-adjustable baffle, the top wall of the shell and the arc-shaped flow guide plate;

[09] The GDMBR tank is internally divided into an adjustment area and a membrane filtration area by arranging two partitions inside the GDMBR tank in a staggered manner, an upper water outlet of the aerobic zone is communicated with an upper portion of the adjustment area by a connecting pipe, a bottom of the adjusting zone is communicated with the upper portion of the anoxic zone by a reflux pipe, the second aeration module and the membrane module are both arranged inside the membrane filtration area, the second aeration module is arranged below the membrane module, an outlet pipeline of the membrane module is

communicated with the water collection tank, an exhaust module and an outlet valve are arranged on the outlet pipeline of the membrane module, gas inflow pipelines of the first aeration module and the aeration module are both connected with the air pump, and air controlling valves are arranged on the gas inflow pipelines;

[10] During aeration of the first aeration module, parts of sludge and liquid in the aerobic zone are refluxed to the anoxic zone via the reflux passageway, the other part of mixed liquid flow the adjustment area through the connecting pipe after passing through the inclined sludge baffles, one part of sludge precipitated in the adjustment area refluxes to the upper portion of the anoxic zone by the reflux pipe and the reflux pump, and the other part thereof is regularly discharged; and the mixed liquid pre-precipitated in the adjustment area enters the membrane filtration area to be filtered via the driven-gravity membrane module, outflow enters the water collection tank, and the membrane module is scoured by aeration of the second aeration module.

[11] Furthermore, the reflux passageway is communicated with a reflux inlet of the anoxic zone, and the reflux inlet is right opposite to the water inlet of the inverted A^2/O tank shell; and an exhaust port is set in the top of the anoxic zone and is 30-200 cm higher than the top of anoxic zone

[12] Furthermore, the inclined sludge baffles are arranged at the bottoms of the anoxic zone, the anaerobic zone, the aerobic zone, the adjustment area, and the membrane filtration area.

[13] Furthermore, the bottom of the inclined flow guide plate is hinged with the upper end of the angle-adjustable baffle, and a circulating reflux ratio is controlled by adjusting an opening and closing angle of the angle-adjustable baffle.

[14] Furthermore, a distance between the cathode electrode and the anode electrode is 0.3-10 cm; the cathode electrode is made of a carbon cloth, carbon felt or graphite plate carbon-based material and a stainless steel mesh, foamed nickel or a titanium plate and other non-precious metal materials; the anode electrode is made of a graphite carbon brush, a graphite rod, a graphite plate or carbon felt carbon-based material; and the electrodes are of rotary structures, and a fixed interval is kept between the cathode electrode getting cylindrical and the anode electrode.

[15] Furthermore, the solar power supply device is electrically connected with a controller, the controller is electrically connected with the cathode electrode and the anode electrode to control an impressed voltage at 0.1-5.0 V.

[16] Furthermore, the mechanical stirring and lifting unit in the anaerobic zone is operated when enhancing a plug flow, and the first aeration module is arranged at the bottom of the aerobic zone to provide gas flow driving force and control dissolved oxygen (DO) concentration at 2-4 mg/L; and the second aeration module with programmed aeration is arranged at the bottom of the membrane filtration area, to oxygenate and scour the membrane module with micro-bubbles.

[17] Furthermore, perforated sludge discharge pipes were installed at the bottoms of the aerobic zone, the adjustment area and the membrane filtration area, respectively, and each perforated sludge discharge pipe is equipped with an atmospheric valve; the perforated sludge discharge pipes and the atmospheric valves are used for discharging sludge precipitated in the device; and part of the sludge in the adjustment area regularly refluxes to the anoxic zone.

[18] Furthermore, the GDMBR membrane module is immersed in the membrane filtration area, which may be flat membrane or a hollow fiber membrane; the membrane module may be made of cellulose acetates, cellulose acetate esters, polyethylenes, polysulfones or polyamides; and the membrane module is performed at an ultra-low pressure of 5-100 KPa, and continuously operated without backflushing and chemical cleaning.

[19] A detailed sewage treatment method of the integrated inverted A^2/O-GDMBR device based on the external electric field for the village sewage treatment, includes the following steps:

[20] In the initial period, making raw sewage water flow into the anoxic zone of the device via the water inlet, flow through the low-voltage electric field formed by the cathode electrode and the anode electrode, and then enter the anaerobic zone from the bottom of the first partition, then lifting the water from the upward side of the second partition into the aerobic zone by the mechanical stirring and lifting unit, and guiding one part of sludge and reflux liquid to reflux to the anoxic zone via the reflux passageway by the arc-shaped flow guide plate under reflux power provided by the first aeration assembly inside the aerobic zone; making the other part of mixed liquid enter the GDMBR tank via the connecting pipe after passing through the large-angle inclined sludge baffles, and making one part of sludge precipitated in the adjustment zone reflux to the upper portion of the anoxic zone by the reflux pipe and the reflux pump, and discharging the other part thereof regularly; making the mixed liquid pre-precipitated in the adjustment area enter the membrane filtration area, oxygenating and scouring the membrane module by the second aeration module, and making water entering the membrane filtration area enter the water collection tank via the water outflow pipeline after being filtered by the membrane module;

[21] During operation, making raw water and the reflux sludge precipitated in the adjustment area enter the anoxic zone of the device from the water inlet, flow through the low-voltage electric field formed by the cathode stainless steel mesh and the anode carbon brush jointly along with the sludge and the reflux liquid refluxing from the aerobic zone via the reflux passageway; making the mixed liquid flowing through the low-voltage electric field enter the anaerobic zone from the bottom of the first partition, and then lifting the mixed liquid into the aerobic zone from the position above the second partition by the mechanical stirring and lifting unit, so that one part of the sludge and the reflux liquid reflux to the anoxic zone via the reflux passageway again to converge with the raw water newly entering the device under the reflux power provided by the first aeration module; making the other part of the sludge and the reflux liquid enter the GDMBR tank via the connecting pipe after passing through the large-angle inclined sludge baffles again, and making the sludge precipitated in the adjustment area reflux to the upper portion of the anoxic zone by the reflux pipe and the reflux pump again to converge with the raw water newly entering the device again; making the mixed liquid pre-precipitated in the adjustment area enter the water collection tank via the water outflow pipeline after being filtered by the membrane module; finally completing the treatment of domestic sewage through such reflux way; and

[22] During normal operation, stopping aeration of the first aeration module and the second aeration module for a period of time when reaching a sludge discharge period, opening the perforated sludge discharge pipes for sludge discharge, and re-operating the device after completing sludge discharge.

[23] The integrated inverted A^2/O-GDMBR device based on the external electric field for the village sewage treatment has the following the advantages:

[24] (1) According to the device, by applying the low-intensity electric field (0.1-5.0 V) to the anoxic zone, mutual transformation among bio-energy, chemical energy and electric energy is achieved, and metabolism behaviours and physiological functions of microorganisms and morphology and surface features of cells are regulated and controlled, so as to improve diversity of microorganism populations, change properties of the sludge mixed liquid and increase activation reaction intensity of enzymes; and from the macroscopic aspect, the implemented low-intensity electric field could enhance absorption of the microorganisms for organic nutrients, promote the degradation of contaminants, and improve the denitrification effect. Furthermore, consumption of the electric energy is low compared with common bio-electro reactors.

[25] (2) The cathode and the anode of the device may be made of a plurality of electrode materials respectively, so that the application range is wide; compared with traditional common electrodes, the device adopts the electrodes of the rotary structures, so the anode electrode not only can transfer electrons and have a large contact area with the mixed liquid, but also can achieve the rapid separation function among gas, liquid, and solid phases, so as to rapidly remove the gas, and reduce the concentration of dissolved oxygen to promote a denitrification process, and then, the gas is exhausted out of the exhaust port; and the small fixed interval is kept between the cathode electrode getting cylindrical and the anode, thereby improving the transfer efficiency of the electrons.

[26] (3) The mechanical stirring and lifting unit and a plus flow device are adopted in the anaerobic zone to mix and lift the mixed liquid in the anaerobic zone, thereby promoting anaerobic denitrification and phosphorus release.

[27] (4) The aeration facilities are arranged in the aerobic zone not only to oxygenate with micro-bubbles, and provide sufficient dissolved oxygen of about 2-4 mg/L for the organisms, but also to promote nitrification and phosphorus absorption of the microorganisms; and meanwhile also provides power for internal reflux of nitrification liquid and sludge.

[28] (5) The reflux of the nitrification liquid and the sludge is achieved by aeration, and the mechanical stirring and lifting unit or the plus flow device (opened when the reflux needs to be enhanced) is arranged only in the anaerobic zone, so that energy consumption is low; and meanwhile a flow state and a flow field of fluids are changed by adjusting the opening and closing angle of the baffle, so as to change different circulating reflux ratios, thereby responding to the influences of changes in water quality and volume and temperature on denitrification and keeping an optimal operating state.

[29] (6) The arc-shaped flow guide plate is arranged on the upper portion of the aerobic zone, so as to adjust the movement of both water and air bubble to achieve the synergistic objectives of oxygenation, sludge reflux and nitrification liquid circulation only by aeration, the gas is escaped from the exhaust port, and the mixed liquid smoothly refluxes to the anoxic zone under the pushing of gas flow to be mixed with the raw water and the reflux sludge.

[30] (7) The inclined flow guide plate is arranged on the middle-upper portion of the anaerobic zone, the nitrification liquid refluxes to the anoxic zone via the internal reflux passageway, the water inlet and an external sludge mixed liquid reflux inlet are right opposite to the reflux inlet in the device, and inflow is rapidly and uniformly distributed by means of the flow rate of the reflux liquid and disturbance of the bubbles; and meanwhile the dissolved oxygen in the water can be rapidly consumed by organic matters with a high concentration in the inflow, so as to promote rapid formation of an anaerobic condition.

[31] (8) The inclined sludge baffles with large angles are arranged on the lower portion of the aerobic zone, and the sludge can be effectively prevented from floating at the large angle, which can achieve good precipitation conditions, minimize the sludge entering a GDMBR pool with the outflow, ensure stable concentration of the sludge in an inverted A^2/O pool and reduce subsequent membrane fouling.

[32] (9) According to the device, the adjustment area is arranged at the GDMBR to perform pre-precipitation adjustment on the inflow firstly, so as to reduce the amount of the sludge entering the membrane filtration area, thereby relieving membrane fouling.

[33] (10) The immersed membrane module is adopted in the device, which may adopt a plurality of types such as a flat membrane and a hollow fiber membrane or membranes made of a plurality of materials such as cellulose acetates, cellulose acetate esters, polyethylenes, polysulfones or polyamides, the application range is wide, and the device is compact and small in volume; the microorganisms are intercepted in a reactor due to the efficient interception effect of the membrane, so as to achieve complete separation of hydraulic retention time (HRT) for 6-8 hours from sludge retention time (SRT) for 5-15 days, which makes the operation control more flexible and stable; and the concentration of the microorganisms in the device is high, and the impact load resistance is high.

[34] (11) The membrane module of the device is operated at a low pressure of 5-100 KPa, the water outflow power consumption cost is low, the energy consumption is low, and the requirements of equipment, pipelines and accessories for water inflow pressure are lowered.

[35] (12) The device adopts a filtration mode without hydraulic cleaning and chemical cleaning, and compared with a traditional MBR process that requires frequent cleaning and complex operation and maintenance, the operating cost and the workload are greatly reduced; and meanwhile, growth of the microorganisms on the surface of the membrane module is not inhibited, and the removal effect of the contaminants is enhanced under the action of the microorganisms, so as to improve the raw water quality, mitigate membrane fouling and increase the water yield.

[36] (13) The membrane module is cleaned by programmed aeration, and sustainable, intermittent or pulse aeration can save the aeration energy consumption while effectively controlling membrane fouling; and the micro-bubble aeration devices are adopted, so as to achieve a higher crossflow velocity and low ascending resistance, and the cleaning effect on the membrane module is good while the membrane module is not damaged.

[37] (14) The device removes gas accumulated inside the pipelines by the special exhaust device, and exhausting can be implemented manually or automatically to ensure smooth water outflow. Gas accumulation inside the pipelines can be observed directly by the exhaust device. The exhaust device has a good exhaust effect, and is more visual than common exhaust valves, the exhaust frequency is reduced, and the operating process is simplified.

[38] (15) An integrated solar power supply system is adopted in the device to supply electric energy for the external electric field, the aeration devices, and the mechanical stirring and lifting unit, which is environmentally friendly; and meanwhile, a municipal power supply circuit is additionally arranged as an emergency circuit, so as to avoid the situation that equipment cannot normally run due to insufficient power supply of solar cells in cloudy and rainy weather.

BRIEF DESCRIPTION OF THE DRAWINGS

[39] Drawings constituting part of the present disclosure are described for further understanding the present disclosure. Schematic embodiments of the present disclosure and descriptions thereof are used for explaining the present disclosure, and are not construed as an improper limitation to the present disclosure. In the drawings:

[40] FIG. 1 is a structural schematic diagram of an integrated inverted A^2/O-GDMBR device based on an external electric field for the village sewage treatment according to an embodiment of the present disclosure.

[41] Brief description of reference signs:

[42] A-anoxic zone, B-anaerobic zone, C-aerobic zone, D-adjustment area, and E-membrane filtration area;

[43] 1-check valve, 2-water inflow valve, 3-cathode electrode, 4-anode electrode, 5-first partition, 6-sludge baffle, 7-mechanical stirring and lifting unit, 8-second partition, 9-first aeration module, 10-perforated sludge discharge pipe, 11-angle-adjustable baffle, 12-inclined flow guide plate, 13-reflux passageway, 14-reflux inlet, 15-water inlet, 16-arc-shaped flow guide plate, 17-inverted A^2/O tank shell, 18-exhaust port, 19-controller, 20-solar power supply device, 21-air pump, 22-air valve, 23-gas flow meter, 24-connecting pipe, 25-reflux pump, 26-reflux pipe, 27-membrane module, 28-liquid flow meter, 29-exhaust module, 30-water outflow valve, 31-water collection tank, 32-overflow pipe, 33-vent valve, 34-GDMBR tank, and 35-second aeration module.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[44] It should be noted that embodiments in the present disclosure and features in the embodiments may be mutually combined without conflicts.

[45] The present disclosure will be described in detail below with reference to the drawings and combination of the embodiments.

[46] FIG. 1 shows an integrated inverted A^2/O-GDMBR device based on an external electric field for the village sewage treatment, and sludge is added into the device during sewage treatment; the device includes an inverted A^2/O tank shell 17, a cathode electrode 3, an anode electrode 4, a mechanical stirring and lifting unit 7, a first aeration module 9, an angle-adjustable baffle 11, an inclined flow guide plate 12, an arc-shaped flow guide plate 16, a GDMBR tank 34, a membrane module 27, a second aeration module 35, a water collection tank 31, an air pump 21, a reflux pump 25 and a solar power supply device 20; the inverted A^2/O tank shell 17 is a sealed tank shell, which is in a micro-pressure state and can enhance the solubility of oxygen and the mass transfer efficiency of contaminants and enhance the removal efficiency of the contaminants; the GDMBR tank 34 is a tank with an opening on an upper portion, the air pump 21, the reflux pump 25 and the solar power supply device 20 are all arranged outside the inverted A^2/O tank shell 17, the water collection tank 31 is arranged outside the GDMBR tank 34, and the solar power supply device 20 supplies power to the air pump 21, the anode electrode 4, the cathode electrode 3, the mechanical stirring and lifting unit 7 and the reflux pump 25;

[47] The inverted A^2/O tank shell 17 is sequentially and internally divided into an anoxic

zone A, an anaerobic zone B and an aerobic zone C by a first partition 5 and a second partition 8 arranged in parallel inside the inverted A^2/O tank shell 17, an upper end of the first partition 5 is higher than that of the second partition 8, the anoxic zone A is communicated with a bottom of the anaerobic zone B, an upper portion of the anaerobic zone B is communicated with the aerobic zone C, an upper portion of the anoxic zone A is communicated with an external water inflow pipeline by a water inlet 15, the cathode electrode 3 is arranged inside the anoxic zone A, the anode electrode 4 is arranged inside the cathode electrode 3, and the mechanical stirring and lifting unit 7 is arranged inside the anaerobic zone B;

[48] The first aeration module 9 is arranged inside the aerobic zone C, an included angle of 30° is formed between the inclined flow guide plate 12 and a horizontal direction, an upper end of the inclined flow guide plate 12 is fixedly connected with that of the first partition 5, a lower end of the inclined flow guide plate 12 extends into the aerobic zone C to be connected with an upper end of the angle-adjustable baffle 11, an upper end of the arc-shaped flow guide plate is fixed to a top wall of the shell, a lower end thereof is a free end, and a reflux passageway 13 is formed among the inclined flow guide plate 12, the angle-adjustable baffle 11, the top wall of the shell and the arc-shaped flow guide plate 16;

[49] The GDMBR tank 34 is internally divided into an adjustment area D and a membrane filtration area E by two partitions arranged inside the GDMBR tank 34 in a staggered manner, a water outlet in an upper portion of the aerobic zone C is communicated with an upper portion of the adjustment area D by a connecting pipe 24, a bottom of the adjustment area D is communicated with the upper portion of the anoxic zone A by a reflux pipe, the second aeration module 35 and the membrane module 27 are both arranged inside the membrane filtration area E, the second aeration module 35 is arranged below the membrane module 27, a water outflow pipeline of the membrane module 27 is communicated with the water collection tank 31, an exhaust module 29 and a water outflow valve 30 are arranged on the water outflow pipeline of the membrane module 27, gas inflow pipelines of the first aeration module 9 and the second aeration module 35 are both connected with the air pump 21, and air valves 22 are arranged on the gas inflow pipelines; the membrane module 27, namely GDMBR, is of an immersed type, which may be a flat membrane or a hollow fiber membrane and may be made of cellulose acetates, cellulose acetate esters, polyethylenes, polysulfones or polyamides; a working pressure is provided by a gravity head of water, which is about 5-100 KPa, and the membrane module 27 achieves continuous water outflow (or intermittent operation) without arranging hydraulic cleaning and chemical cleaning devices; the exhaust module 29 may be a manual exhaust valve or a regular exhaust valve, and gas accumulated in the pipelines is removed by regularly turning on the exhaust valve manually (once every 8-12 hours) or automatically, so as to ensure smooth water outflow;

[50] During aeration of the first aeration module 9, one part of sludge and liquid in the aerobic zone C reflux to the anoxic zone A along the reflux passageway 13, the other part of mixed liquid enters the adjustment area D via the connecting pipe 24 after passing through inclined sludge baffles, one part of sludge precipitated in the adjustment area D refluxes to the upper portion of the anoxic zone A by the reflux pipe 26 and the reflux pump 25, and the other part thereof is regularly discharged; and the mixed liquid pre-precipitated in the adjustment area D enters the membrane filtration area E to be filtered by the driven-gravity membrane module 27, outflow enters the water collection tank 31, and the membrane module 27 is scoured by aeration of the second aeration module 35.

[51] The inverted A^2/O tank shell 17 is sealed, the mechanical stirring and lifting unit in the

anaerobic zone B operates when enhancing a plus flow, and the first aeration module is arranged at the bottom of the aerobic zone C to provide gas flow driving force by aeration while controlling dissolved oxygen concentration at 2-4 mg/L; and the second aeration module is arranged at the bottom of the membrane filtration area E for programmed aeration to form micro-bubbles for oxygenating and scouring the membrane module.

[52] The inverted A^2/O-GDMBR coupled process is adopted in the present application, and a new structure is developed to achieve the synergistic effects of oxygenation, nitrification liquid circulation and sludge reflux only by aeration, so that energy consumption is saved; an external weak electric field-mediated process is constructed, the cathode and the anode are both established in rotary structures, the outer cylinder is the cathode, the anode is arranged in the centre of the cathode, and the contact area between microorganisms and the electrodes is increased due to cylindrical placement, so as to improve the utilization efficiency of electrons, thereby increasing the denitrification rate and improving the denitrification efficiency; the microorganisms are located in the low-voltage electric field, their metabolism behaviours and physiological functions and morphology and surface features of cells change, the diversity of microorganism populations is improved, and properties of the sludge mixed liquid are changed, thereby reducing membrane fouling; a gravity driven membrane system (GDM) is adopted, a filtration head of water is far less than that required by traditional membrane filtration equipment, and pressure is provided only under gravity of water without pumping, so that the energy consumption is low during operation; and as hydraulic backwashing and chemical cleaning are not needed, the device is easy to operate and convenient to operate, maintain and manage.

[53] The reflux passageway 13 is communicated with a reflux inlet 14 of the anoxic zone A, the reflux inlet 14 is right opposite to the water inlet 15 of the inverted A^2/O tank shell 17, and inflow is rapidly and uniformly distributed by means of the flow rate of the reflux liquid and disturbance of the bubbles; and meanwhile, the dissolved oxygen in the water can be rapidly consumed by organic matters with a high concentration in the inflow, so as to promote rapid formation of an anaerobic condition.

[54] The inclined sludge baffles are arranged at bottoms of the anoxic zone A, the anaerobic zone B, the aerobic zone C, the adjustment area D and the membrane filtration area E. Specifically, one inclined sludge baffle 6 is arranged at each of the bottoms of the anoxic zone A and the anaerobic zone B, and such inclined sludge baffles are right opposite to each other; two inclined sludge baffles right opposite to each other are arranged at the bottom of the aerobic zone C, the sludge baffles at the bottom of the aerobic zone C are perpendicular to the sludge baffle in the anoxic zone A in space, one sludge baffle with a large inclination angle is arranged on a side wall of the aerobic zone C and used for making water flow to the GDMBR tank 34, two inclined sludge baffles are symmetrically arranged at the bottom of the adjustment area D, and two inclined sludge baffles are symmetrically arranged at the bottom of the membrane filtration area E; the sludge baffles in the adjustment area D are perpendicular to the sludge baffles in the membrane filtration area E in space; and due to the arrangement, sludge is prevented from being accumulated in dead corners of the device, and when the device operates, the sludge on the inclined sludge baffles slips from the inclined baffles into the anaerobic zone B or the aerobic zone C, the adjustment area D and the membrane filtration area E, is slowly precipitated and accumulated, and finally is removed after being collected via perforated sludge discharge pipes.

[55] The lower end of the inclined flow guide plate 12 is hinged to the upper end of the

angle-adjustable baffle 11, and a circulating reflux ratio is controlled by adjusting an opening and closing angle of the angle-adjustable baffle 11; and a flow state and a flow field of fluids are changed by adjusting the opening and closing angle of the baffle, so as to change different circulating reflux ratios, and usually, the circulating reflux ratio is controlled at 0.5: 1-3: 1, which aims at making response targeting at the influences of changes in water quality and volume and temperature on denitrification and keeping an optimal operating state.

[56] The external water inflow pipeline, the connecting pipe 24 and the reflux pipe 26 are respectively provided with a water inflow valve 2 and a check valve 1, and a liquid flow meter 28 is further arranged on the water outflow pipeline of the membrane module 27. Gas flow meters 23 are further arranged on the air inflow pipelines of the aeration modules. An exhaust port 18 is formed in the top of the anoxic zone A and is higher than a pool top by 30-200 cm; and the upper portion of the GDMBR tank 34 is communicated with an overflow pipe 32. The perforated sludge discharge pipes 10 are respectively arranged at bottoms of the aerobic zone C, the adjustment area D and the membrane filtration area E are respectively provided with one perforated sludge discharge pipe 10, and a vent valve 33; and the perforated sludge discharge pipes 10 and the vent valves 33 are used for discharging sludge precipitated in the device.

[57] The solar power supply device 20 is electrically connected with a controller 19, and the controller 19 is electrically connected with the cathode electrode 3 and the anode electrode 4; electric energy is supplied by the solar power supply device, the electrodes fill up the anaerobic zone as much as possible, and the cathode electrode is made of a carbon cloth, carbon felt or graphite plate carbon-based material and a stainless steel mesh, foamed nickel or a titanium plate and other non-precious metal materials; the anode electrode is made of a graphite carbon brush, a graphite rod, a graphite plate or carbon felt carbon-based material; the electrodes are of rotary structures, and a fixed interval is kept between the cathode electrode getting cylindrical and the anode electrode; and a distance between the stainless steel mesh cathode and the graphite carbon brush anode is 0.3-10 cm.

[58] A sludge treatment method of the integrated inverted A^2/O-GDMBR device based on the external electric field for the village sewage treatment, specifically includes the following steps:

[59] At an initial stage, the angle of the angle-adjustable baffle 11 is adjusted, a low voltage of 0.1-5.0 V is applied to the cathode stainless steel mesh and the anode carbon brush in the anoxic zone, raw water enters the anoxic zone A of the device from the water inlet 15, flows through the low-voltage electric field formed by the cathode electrode 3 and the anode electrode 4, and then enters the anaerobic zone B from a bottom of the first partition 5, the anode electrode also achieves the rapid separation function among gas, liquid and solid phases, so as to rapidly remove the gas, and reduce the concentration of dissolved oxygen, thus promoting a denitrification process, and then, the gas is exhausted out of the exhaust port; the water is lifted into the aerobic zone C from a position above the second partition 10 by the mechanical stirring and lifting unit 7, the aerobic zone is oxygenated by micro-bubbles generated by the first aeration module 9, and sufficient dissolved oxygen with a concentration of about 2-4 mg/L is provided for the microorganisms, so as to promote nitrification and phosphorus absorption of the microorganisms and meanwhile provide power for internal reflux of nitrification liquid and sludge; the gas is rapidly exhausted out of the exhaust port via the arc-shaped flow guide plate, beneficial hydraulic conditions are provided for the internal reflux of the nitrification liquid, and one part of sludge and reflux liquid reflux to the anoxic zone A via the reflux passageway 13 by the arc-shaped flow guide plate 16 under reflux power provided by the first aeration module 9 inside the aerobic zone C; the other part

of mixed liquid enters the GDMBR tank 34 via the connecting pipe 24 after passing through the large-angle inclined sludge baffles 6, and the sludge can be effectively prevented from floating due to the arrangement of the large-angle inclined sludge baffles (included angle with a horizontal line is 70°), which can achieve good precipitation conditions, minimize the sludge entering a GDMBR pool with the outflow, ensure stable concentration of the sludge in an inverted A^2/O pool and reduce subsequent membrane fouling; one part of sludge precipitated in the adjustment area D refluxes to the upper portion of the anoxic zone A by the reflux pipe 26 and the reflux pump 25, and the other part thereof is discharged regularly; the mixed liquid pre-precipitated in the adjustment area D enters the membrane filtration area E, the membrane module 27 is oxygenated and scoured by the second aeration module 35, and water entering the membrane filtration area E enters the water collection tank 31 via the water outflow pipeline after being filtered by the membrane module 27; sludge refluxes during normal operation of the adjustment area D to the anoxic zone A of the inverted A^2/O pool; when a sludge discharge period (5-15 days) is reached, reflux stops, and an emptying pipe is opened for sludge discharge; the working pressure is provided under the gravity head of the water, which is about 5-100 KPa, and the membrane module achieves continuous water outflow (or intermittent operation) without arranging the hydraulic cleaning and chemical cleaning devices;

[60] During operation, the raw water and the reflux sludge precipitated in the adjustment area D enter the anoxic zone A of the device from the water inlet 15, and flow through the low-voltage electric field formed by the cathode electrode 3 and the anode electrode 4 jointly along with the sludge and the reflux liquid refluxing from the aerobic zone via the reflux passageway 13, the mixed liquid flowing through the low-voltage electric field enters the anaerobic zone B from the bottom of the first partition 5, and then the mixed liquid is lifted into the aerobic zone C from the position above the second partition 8 by the mechanical stirring and lifting unit 7, so that one part of the sludge and the reflux liquid reflux to the anoxic zone A via the reflux passageway 13 again to converge with the raw water newly entering the device under the reflux power provided by the first aeration module 9; the other part of the mixed liquid enters the GDMBR tank 34 via the connecting pipe 24 after passing through the large-angle inclined sludge baffles 6 again, and one part of the sludge precipitated in the adjustment area D refluxes to the upper portion of the anoxic zone A by the reflux pipe 26 and the reflux pump 25 again to converge with the raw water newly entering the device again; the mixed liquid pre-precipitated in the adjustment area D enters the water collection tank 31 via the water outflow pipeline after being filtered by the membrane module 27; finally sewage treatment is completed through such reflux way; and gas accumulated in the pipelines is removed by regularly turning on the exhaust valve manually (once every 8-12 hours, which may be 10 hours) or automatically, so as to ensure smooth water outflow of the pipelines;

[61] During normal operation, aeration of the first aeration module 9 and the second aeration module 35 stops for 5-60 minutes when a sludge discharge period (once every 5-15 days which may be 10 days) is reached, the perforated sludge discharge pipes 10 are opened for sludge discharge, and the device re-operates after completing sludge discharge.

[62] Water quality of the raw water is as follows: COD: 200 mg/L; ammonia-nitrogen: 30±5 mg/L; TP: 4±0.5 mg/L; and pH: 7.0-7.5.

[63] Raw water quality of the sewage treatment device is as follows: COD: 20.02±3.95 mg/L; ammonia-nitrogen: 4.3±0.5 mg/L; and TP: 0.32±0.05 mg/L. The device of the present application has a good effect of removing organic matters and good denitrification and dephosphorization effects, the quality of the outflow meets the First-grade A standard in

Discharge Standard of Pollutants for Municipal Wastewater Treatment Plant, meanwhile, pathogenic bacteria can be removed, and high impact load resistance is achieved.

[64] The above descriptions are merely preferred embodiments of the present disclosure, which are not intended to limit the present disclosure. Any modification, equivalent replacement, improvement. etc. made within the spirit and principle of the present disclosure should fall within the scope of protection of the present disclosure.

WHAT IS CLAIMED IS:

1. An integrated inverted A^2/O-GDMBR device based on an external electric field for the village sewage treatment, characterized by comprising an inverted A^2/O tank shell (17), a cathode electrode (3), an anode electrode (4), a mechanical stirring and lifting unit (7), a first aeration module (9), an angle-adjustable baffle (11), an inclined flow guide plate (12), an arc-shaped flow guide plate (16), a GDMBR tank (34), a membrane module (27), a second aeration module (35), a water collection tank (31), an air pump (21), a reflux pump (25) and a solar power supply device (20), wherein the inverted A^2/O tank shell (17) is a sealed tank shell, the GDMBR tank (34) is a tank with an opening on an upper portion, the air pump (21), the reflux pump (25) and the solar power supply device (20) are all arranged outside the inverted A^2/O tank shell (17), the water collection tank (31) is arranged outside the GDMBR tank (34), and the solar power supply device (20) supplies power to the air pump (21), the anode electrode (4), the cathode electrode (3), the mechanical stirring and lifting unit (7) and the reflux pump (25);

the inverted A^2/O tank shell (17) is sequentially and internally divided into an anoxic zone (A), an anaerobic zone (B) and an aerobic zone (C) by a first partition (5) and a second partition (8) arranged in parallel inside the inverted A^2/O tank shell (17), an upper end of the first partition (5) is higher than that of the second partition (8), the anoxic zone (A) is communicated with a bottom of the anaerobic zone (B), an upper portion of the anaerobic zone (B) is communicated with the aerobic zone (C), an upper portion of the anoxic zone (A) is communicated with an external water inflow pipeline by a water inlet (15), the cathode electrode (3) is arranged inside the anoxic zone (A), the anode electrode (4) is arranged inside the cathode electrode (3), and the mechanical stirring and lifting unit (7) is arranged inside the anaerobic zone (B);

the first aeration module (9) is arranged inside the aerobic zone (C), an upper end of the inclined flow guide plate (12) is fixedly connected with the upper end of the first partition (5), a lower end of the inclined flow guide plate (12) extends into the aerobic zone (C) to be connected with an upper end of the angle-adjustable baffle (11), an upper end of the arc-shaped flow guide plate is fixed to a top wall of the shell, a lower end thereof is a free end, and a reflux passageway (13) is formed among the inclined flow guide plate (12), the angle-adjustable baffle (11), the top wall of the shell and the arc-shaped flow guide plate (16);

the GDMBR tank (34) is internally divided into an adjustment area (D) and a membrane filtration area (E) by two partitions arranged inside the GDMBR tank (34) in a staggered manner, a water outlet in an upper portion of the aerobic zone (C) is communicated with an upper portion of the adjustment area (D) by a connecting pipe (24), a bottom of the adjustment area (D) is communicated with the upper portion of the anoxic zone (A) by a reflux pipe, the second aeration module (35) and the membrane module (27) are both arranged inside the membrane filtration area (E), the second aeration module (35) is arranged below the membrane module (27), a water outflow pipeline of the membrane module (27) is communicated with the water collection tank (31), an exhaust module (29) and a water outflow valve (30) are arranged on the water outflow pipeline of the membrane module (27), gas inflow pipelines of the first aeration module (9) and the second aeration module (35) are both connected with the air pump (21), and air valves (22) are arranged on the gas inflow pipelines;

during aeration of the first aeration module (9), one part of sludge and liquid in the aerobic zone (C) reflux to the anoxic zone (A) along the reflux passageway (13), the other part of mixed

liquid enters the adjustment area (D) via the connecting pipe (24) after passing through inclined sludge baffles, one part of sludge precipitated in the adjustment area (D) refluxes to the upper portion of the anoxic zone (A) by the reflux pipe (26) and the reflux pump (25), and the other part thereof is regularly discharged; and the mixed liquid pre-precipitated in the adjustment area (D) enters the membrane filtration area (E) to be filtered by the driven-gravity membrane module (27), outflow enters the water collection tank (31), and the membrane module (27) is scoured by aeration of the second aeration module (35).

2. The integrated inverted A^2/O-GDMBR device based on the external electric field for the village sewage treatment according to claim 1, characterized in that the reflux passageway (13) is communicated with a reflux inlet (14) of the anoxic zone (A), and the reflux inlet (14) is right opposite to the water inlet (15) of the inverted A^2/O tank shell (17); and an exhaust port (18) is formed in the top of the anoxic zone (A) and is higher than a pool top by 30-200 cm.

3. The integrated inverted A^2/O-GDMBR device based on the external electric field for the village sewage treatment according to claim 1, characterized in that the inclined sludge baffles are arranged at bottoms of the anoxic zone (A), the anaerobic zone (B), the aerobic zone (C), the adjustment area (D) and the membrane filtration area (E).

4. The integrated inverted A^2/O-GDMBR device based on the external electric field for the village sewage treatment according to claim 1, characterized in that the lower end of the inclined flow guide plate (12) is hinged to the upper end of the angle-adjustable baffle (11), and a circulating reflux ratio is controlled by adjusting an opening and closing angle of the angle-adjustable baffle (11).

5. The integrated inverted A^2/O-GDMBR device based on the external electric field for the village sewage treatment according to claim 1, characterized in that a distance between the cathode electrode (3) and the anode electrode (4) is 0.3-10 cm; the cathode electrode is made of a carbon cloth, carbon felt or graphite plate carbon-based material and a stainless steel mesh, foamed nickel or a titanium plate and other non-precious metal materials; the anode electrode is made of a graphite carbon brush, a graphite rod, a graphite plate or carbon felt carbon-based material; and the electrodes are of rotary structures, and a fixed interval is kept between the cathode electrode getting cylindrical and the anode electrode.

6. The integrated inverted A^2/O-GDMBR device based on the external electric field for the village sewage treatment according to claim 1, characterized in that the solar power supply device (20) is electrically connected with a controller (19), and the controller (19) is electrically connected with the cathode electrode (3) and the anode electrode (4) to control an impressed voltage at 0.1-5.0 V.

7. The integrated inverted A^2/O-GDMBR device based on the external electric field for the village sewage treatment according to claim 1, characterized in that the inverted A^2/O tank shell (17) is sealed, the mechanical stirring and lifting unit in the anaerobic zone (B) operates when enhancing a plug flow, and the first aeration module is arranged at the bottom of the aerobic zone (C) to provide gas flow driving force by aeration while controlling dissolved oxygen concentration at 2-4 mg/L; and the second aeration module is arranged at the bottom of the membrane filtration area (E) to perform programmed aeration to form micro-bubbles to oxygenate and scour the membrane module.

8. The integrated inverted A^2/O-GDMBR device based on the external electric field for the village sewage treatment according to claim 1, characterized in that perforated sludge discharge pipes (10) are respectively arranged at bottoms of the aerobic zone (C), the adjustment area (D) and the membrane filtration area (E), and a vent valve (33) is arranged on each perforated sludge discharge pipe (10); the perforated sludge discharge pipes (10) and the vent valves (33) are used for discharging sludge precipitated in the device; and part of the sludge in the adjustment area (D) regularly refluxes to the anoxic zone (A).

9. The integrated inverted A^2/O-GDMBR device based on the external electric field for the village sewage treatment according to claim 1, characterized in that GDMBR is an immersed membrane module, which may be a flat membrane or a hollow fiber membrane; the membrane module may be made of cellulose acetates, cellulose acetate esters, polyethylenes, polysulfones or polyamides; and the membrane module is driven by low-pressure gravity flow, has a working pressure of 5-100 kPa, and achieves continuous water outflow without arranging hydraulic cleaning and chemical cleaning devices.

10. A sludge treatment method of the integrated inverted A^2/O-GDMBR device based on the external electric field for the village sewage treatment according to any one of claims 1-9, characterized by specifically comprising the following steps:

at an initial stage, making raw water enter the anoxic zone (A) of the device from the water inlet (15), flow through the low-voltage electric field formed by the cathode electrode (3) and the anode electrode (4), and then enter the anaerobic zone (B) from a bottom of the first partition (5), then lifting the water into the aerobic zone (C) from a position above the second partition (8) by the mechanical stirring and lifting unit (7), and guiding one part of sludge and reflux liquid to reflux to the anoxic zone (A) via the reflux passageway (13) by the arc-shaped flow guide plate (16) under reflux power provided by the first aeration module (9) inside the aerobic zone (C); making the other part of mixed liquid enter the GDMBR tank (34) via the connecting pipe (24) after passing through the large-angle inclined sludge baffles (6), and making one part of sludge precipitated in the adjustment area (D) reflux to the upper portion of the anoxic zone (A) by the reflux pipe (26) and the reflux pump (25), and thereof discharging the other part regularly; making the mixed liquid pre-precipitated in the adjustment area (D) enter the membrane filtration area (E), oxygenating and scouring the membrane module (27) by the second aeration module (35), and making water entering the membrane filtration area (E) enter the water collection tank (31) via the water outflow pipeline after being filtered by the membrane module (27);

during operation, making the raw water and the reflux sludge precipitated in the adjustment area (D) enter the anoxic zone (A) of the device from the water inlet (15) and flow through the low-voltage electric field formed by the cathode electrode (3) and the anode electrode (4) jointly with the sludge and the reflux liquid refluxing from the aerobic zone (C) via the reflux passageway (13), making the mixed liquid flowing through the low-voltage electric field enter the anaerobic zone (B) from the bottom of the first partition (5), and then lifting the mixed liquid into the aerobic zone (C) from the position above the second partition (8) by the mechanical stirring and lifting unit (7), so that one part of the sludge and the reflux liquid reflux to the anoxic zone (A) via the reflux passageway (13) again to converge with the raw water newly entering the device under the reflux power provided by the first aeration module (9); making the other part of the sludge and the reflux liquid enter the GDMBR tank (34) via the connecting pipe (24) after passing through the large-angle inclined sludge baffles (6) again, and making the sludge precipitated in the adjustment area (D) reflux to the upper portion of the anoxic zone (A) by the reflux pipe (26) and the reflux pump (25) again to converge with the

raw water newly entering the device again; making the mixed liquid pre-precipitated in the adjustment area (D) enter the water collection tank (31) via the water outflow pipeline after being filtered by the membrane module (27); finally, completing treatment on sewage through reflux in this way; and

during normal operation, stopping aeration of the first aeration module (9) and the second aeration module (35) for 5-60 minutes when reaching a sludge discharge period, opening the perforated sludge discharge pipes (10) for sludge discharge, and re-operating the device after completing sludge discharge.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2022/117406

A. CLASSIFICATION OF SUBJECT MATTER

C02F 9/14(2006.01)i; C02F 3/12(2006.01)n; C02F 1/48(2006.01)n; C02F 3/30(2006.01)n

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C02F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNABS, CNTXT, WPABSC, ENTXTC, VEN, OETXT, CNKI, 读秀, DUXIU, ISI_Web of Science, Elsevier Science: 哈尔滨工业大学, 唐小斌, 梁恒, 蒋林巧, 马晓斌, 程文君, 王金龙, 厌氧, 好氧, 缺氧, 倒置, A2/O, 调节区, 隔板, 挡板, 折板, 分隔, 隔开, 回流, 板, 斜, 弧, 圆, 电压, 电场, 阳极, 阴极, 曝气, 膜生物反应器, aerobic, anaerobic+, invert+, inversion, back flow, reflux, refluence, circumfluence, anoxic+, hypoxia, MBR, GDMBR, baffle, plate?, flap?, separat+, distinct+, divisi+, space, partit+, slant, inclina+, electro+, electri+, cathode?, anode?, membrane bio-reactor, membrane bioreactor

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	CN 114315037 A (HARBIN INSTITUTE OF TECHNOLOGY) 12 April 2022 (2022-04-12) description, paragraphs 4-60, and figure 1	1-10
A	CN 110790374 A (JIANGSU LONG-LEAPING ENGINEERING DESIGN CO., LTD.) 14 February 2020 (2020-02-14) description, paragraphs 5-59, and figures 1-2	1-10
A	CN 208561848 U (ANHUI SHUNYU WATER AFFAIRS CO., LTD.) 01 March 2019 (2019-03-01) entire document	1-10
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A	CN 108298690 A (OCEAN UNIVERSITY OF CHINA) 20 July 2018 (2018-07-20) entire document	1-10

☑ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
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"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
01 November 2022	**17 November 2022**
Name and mailing address of the ISA/CN **China National Intellectual Property Administration (ISA/CN)** **No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088, China** Facsimile No. **(86-10)62019451**	Authorized officer Telephone No.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 207608464 U (CHINA GEZHOUBA GROUP WATER OPERATION CO., LTD.) 13 July 2018 (2018-07-13) entire document	1-10
A	JP 2006212505 A (MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.) 17 August 2006 (2006-08-17) entire document	1-10
A	CN 203999260 U (HARBIN INSTITUTE OF TECHNOLOGY SHENZHEN GRADUATE SCHOOL) 10 December 2014 (2014-12-10) entire document	1-10
A	US 2016326031 A1 (KING ABDULLAH UNIVERSITY OF SCIENCE AND TECHNOLOGY) 10 November 2016 (2016-11-10) entire document	1-10

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2022/117406

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				WO	2015103590	A1	09 July 2015
				US	10059609	B2	28 August 2018