

BIOLOGICAL TREATMENT DEVICE

Technical Field

[0001]

The present invention relates to a biological treatment device having a biological treatment water tank configured to treat organic substances contained in treatment water such as human waste.

This application claims priority based on JP 2015-242329 filed in Japan on December 11, 2015, of which the contents are incorporated herein by reference.

Background Art

[0002]

When treating organic wastewater such as human waste, it is common to use membrane separation such as microfiltration (MF) or ultrafiltration (UF) for solid-liquid separation.

A known membrane separation device is a device of a type which uses a plurality of membrane modules including a casing with a cylindrical shape and a plurality of tubular filter membranes (hollow fiber membranes) housed in the casing so as to perform filtration while circulating raw water to the inside of the tubular filter membranes (for example, see Patent Document 1). In a water treatment system provided with such a membrane separation device, permeated water passing through the tubular filter membranes is sucked by a suction pump and stored in a storage tank, for example, so that the permeated water may be used as needed.

[0003]

A filter separation device using tubular filter membranes suppresses sludge deposition in the membranes and ensures FLUX (outflow of permeated water), which increases the membrane surface flow velocity (velocity at which raw water flows through the inside of the tubular filter membranes). For example, the membrane surface flow velocity is set to 2.5 m/s.

Citation List

Patent Literature

[0004]

Patent Document 1: JP 2013-052338 A

Summary of Invention

Technical Problems

[0005]

In the conventional water treatment system described above, the amount of flow of water circulating through the water treatment system including the membrane separation device becomes large due to the increase in membrane surface flow velocity, which results in a configuration requiring a tank for temporarily storing circulating water.

[0006]

An object of the present invention is to provide a biological treatment device capable of reducing installation costs by eliminating the need for a tank for storing circulating water.

Solution to Problem

[0007]

According to a first aspect of the present invention, the biological treatment device includes: a biological treatment water tank configured to treat organic substances contained in treatment water; a membrane separation device including a casing and a tubular filter membrane having a single-layer structure formed by copolymerization of hydrophilic monomers and configured to partition the casing into a concentrated-side space to which outflow water flowing out from the biological treatment water tank is supplied and a permeation-side space in which permeated water separated from the outflow water is housed; a pressurizing pump configured to pressurize the outflow water and supply water that is pressurized to the concentrated-side space; a suction pump configured to suck the permeated water from the permeation-side space; a pressure gauge configured to measure a pressure of the permeation-side space; a return line configured to allow the concentrated water to return to the biological treatment water tank; and a control device configured to control a supply amount of the outflow water supplied by the pressurizing pump on the basis of a measurement value of the pressure gauge.

[0008]

Such a configuration can reduce the membrane surface flow velocity because the tubular filter membranes are hydrophilic. This makes it possible to reduce the circulating flow rate of treatment water, which eliminates the need for a tank for temporarily storing large volumes of circulating water.

In addition, control of the supply amount of the outflow water supplied to the concentrated-side space based on the pressure of the permeation-side

space allows concentrated water (return sludge) to be stably supplied to the biological treatment water tank.

[0009]

In the biological treatment device described above, the control device may increase the flow rate of the outflow water pressurized by the pressurizing pump in a case where an absolute value of the measurement value of the pressure gauge is greater than a threshold value.

[0010]

With such a configuration, even if foreign substances are accumulated on the inner peripheral surfaces of the tubular filter membranes, the function of the tubular filter membranes can be restored by washing out the accumulated foreign substances.

[0011]

In the biological treatment device described above, the control device may control the flow rate of the permeated water sucked by the suction pump.

Such a configuration makes it possible to compensate for the increased flow rate of the outflow water.

[0012]

The biological treatment device described above may include an excess sludge discharge part configured to draw out excess sludge from the return line and a water level measuring device configured to measure a water level of the biological treatment water tank, and the control device may control an amount of excess sludge drawn out from the excess sludge discharge part on the basis of a measurement value of the water level measuring device.

[0013]

The biological treatment device described above may include a water level measuring device configured to measure the water level of the biological treatment water tank, and the control device may control the flow rate of treatment water supplied to the biological treatment water tank on the basis of a measurement value of the water level measuring device.

[0014]

In the biological treatment device described above, the biological treatment water tank may be a methane fermentation tank, microorganisms in the methane fermentation tank breaking down organic substances contained in the treatment water.

[0015]

With such a configuration, by efficiently collecting the methane gas generated by methane fermentation, the energy of the methane gas can be used for power generation or the like.

Advantageous Effects of Invention

[0016]

With the present invention, the membrane surface flow velocity can be reduced because the tubular filter membranes are hydrophilic. This makes it possible to reduce the circulating flow rate of treatment water, which eliminates the need for a tank for temporarily storing large volumes of circulating water.

In addition, control of the supply amount of the outflow water supplied to the concentrated-side space based on the pressure of the permeation-side space allows concentrated water (return sludge) to be stably supplied to the biological treatment water tank.

Brief Description of Drawings

[0017]

FIG. 1 is a schematic configuration diagram of a biological treatment device of a first embodiment of the present invention.

FIG. 2 is a schematic cross-sectional view of a membrane module of the first embodiment of the present invention.

FIG. 3 is a flowchart for explaining a control method of the biological treatment device of the first embodiment of the present invention.

FIG. 4 is a schematic cross-sectional view of a membrane module of a modification of the first embodiment of the present invention.

FIG. 5 is a schematic configuration diagram of a biological treatment device of a modification of the first embodiment of the first embodiment of the present invention.

FIG. 6 is a schematic configuration diagram of a biological treatment device of a modification of the first embodiment of the first embodiment of the present invention.

FIG. 7 is a schematic perspective view of a membrane separation device of a second embodiment of the present invention.

FIG. 8 is a schematic cross-sectional view of a membrane module of the second embodiment of the present invention.

FIG. 9 is a perspective view of a reinforcing member of the second embodiment of the present invention.

FIG. 10 is a side view of the reinforcing member of the second embodiment of the present invention as viewed from the axial direction of the reinforcing member.

FIG. 11 is a perspective view of a reinforcing member of a third embodiment of the present invention.

Description of Embodiments

[0018]

First Embodiment

A biological treatment device 10 of a first embodiment of the present invention will be described in detail hereinafter with reference to the drawings.

As illustrated in FIG. 1, the biological treatment device 10 of this embodiment includes a biological treatment water tank 11 configured to treat organic substances contained in treatment water W1 (organic waste water including human waste and septic tank sludge), a membrane separation device 13 configured to separate outflow water W2 flowing out from the biological treatment water tank 11 into permeated water PW and concentrated water W3, and a control device 12.

[0019]

The biological treatment water tank 11 is a device for separating and removing BOD, nitrogen compounds, and the like in liquids by the actions of nitrifying bacteria and denitrifying bacteria. Wastewater W1 is supplied to the biological treatment water tank 11 via a water treatment pipe 15.

[0020]

The biological treatment water tank 11 of this embodiment uses a circulation-type nitrification-denitrification process. The biological treatment water tank 11 has a structure in which a denitrification tank 24, a nitrification tank 25, a secondary denitrification tank 26, and a re-aeration tank 27 are sequentially disposed in series. In addition, the biological treatment water tank 11 has a circulation line 29 configured to allow a portion of the treatment water W1 discharged from the nitrification tank 25 to circulate to the denitrification tank 24 as a circulating liquid.

The biological treatment water tank 11 is provided with a water level measuring device 56 configured to measure the water level of any of the tanks constituting the biological treatment water tank 11. The water level measuring device 56 of this embodiment is provided in the re-aeration tank 27. In addition, the water level measuring device 56 electrically transmits the value of the measured water level to the control device 12.

[0021]

The denitrification tank 24 is a device for reducing oxidation state nitrogen such as nitrate nitrogen or nitrite nitrogen to nitrogen gas primarily by the action of denitrifying bacteria in the presence of an organic carbon source while the inside of the tank is maintained in an anaerobic state. The organic carbon source may also be added externally as necessary.

The denitrification tank 24 includes an oxidation-reduction potential (ORP) measuring device 51 (51A) configured to measure the ORP of treatment water W1 flowing into the denitrification tank 24 and a pH measuring device 52 (52A) configured to measure the hydrogen ion index (pH) of the treatment water W1.

[0022]

The nitrification tank 25 is a device for performing aeration with air in the treatment liquid inside the tank and oxidizing ammonia nitrogen in the treatment liquid primarily into oxidation state nitrogen by the action of nitrifying bacteria under aerobic conditions.

The nitrification tank 25 includes an aeration device 57 (57B) configured to perform aeration with air in the treatment liquid inside the tank, a dissolved oxygen (DO) measuring device 53 (53B) configured to measure the DO of the treatment water W1 flowing into the nitrification tank 25, an ORP measuring device 51 (51B), and a pH measuring device 52 (52B).

[0023]

The secondary denitrification tank 26 is a device for reducing oxygen state nitrogen remaining in the treatment liquid to nitrogen gas by adding an organic carbon source such as methanol while the inside of the tank is maintained in an anaerobic state.

The secondary denitrification tank 26 includes an ORP measuring device 51 (51C) and a pH measuring device 52 (52C). In addition, the secondary denitrification tank 26 includes an organic carbon source supply device 54 configured to inject an organic substance serving as an organic carbon source for a denitrification reaction such as methanol.

[0024]

The re-aeration tank 27 is a device primarily for oxidizing ammonia nitrogen remaining in the treatment liquid into oxygen state nitrogen while the tank is maintained under aerobic conditions by aeration with air.

The re-aeration tank 27 includes an aeration device 57 (57D) and a DO measuring device 53 (53D) configured to measure the dissolved oxygen concentration.

[0025]

The control device 12 controls the aeration device 57 on the basis of the value of the dissolved oxygen concentration measured by the DO measuring device 53, the value of the oxidation-reduction potential measured by the ORP measuring device 51, and the value of the pH measured by the pH measuring device 52. Specifically, the ORP measuring device 51, the pH measuring device 52, and the DO measuring device 53 transmit their respective measurement values to the control device 12 as electrical signals, and after receiving these measurement values, the control device 12 increases or reduces the aeration air flow rate of the aeration device 57 on the basis of these measurement values so as to adjust the values of the dissolved oxygen concentration, the oxidation-reduction potential, and the pH to within prescribed ranges.

Note that the oxidation-reduction potential is preferably controlled from 10 to 50 mV in order to suppress an air lock (phenomenon in which air bubbles block flow) inside the tubular filter membranes 3 described below and the decomposition of sludge.

The control device 12 also adjusts the pH, which makes it possible to prevent the obstruction of the nitrification/denitrification reaction due to a low pH level.

[0026]

The membrane separation device 13 includes a plurality of membrane modules 1.

As illustrated in FIG. 2, the membrane module 1 includes a casing 2 and a plurality of tubular filter membranes 3 disposed inside the casing 2. The membrane separation device 13 is a device for extracting permeated water PW from outflow water W2 using a method of filtering the outflow water W2 while circulating the water through the inside of the tubular filter membranes 3.

The tubular filter membranes 3 partition the casing 2 into a concentrated-side space S to which outflow water W2 is supplied and a permeation-side space P in which permeated water PW separated from the outflow water W2 is housed.

[0027]

The biological treatment water tank 11 and the membrane separation device 13 are connected by an outflow water supply pipe 17.

That is, the outflow water W2 is introduced into the membrane separation device 13 via the outflow water supply pipe 17.

A pressurizing pump 21 is provided in the outflow water supply pipe 17. The outflow water W2 flowing out from the biological treatment water tank 11

is supplied to the membrane separation device 13 while being pressurized by the pressurizing pump 21.

[0028]

The permeated water PW separated from the membrane separation device 13 is introduced into a permeated water pipe 18. The permeated water pipe 18 is connected to a storage tank 20. That is, a permeated water discharge port 9 of the membrane module 1 (see FIG. 2) is connected to the permeated water pipe 18. A suction pump 22 configured to set the permeation-side space P to a negative pressure is provided in the permeated water pipe 18.

A pressure gauge 23 configured to measure the pressure (water pressure) of the permeation-side space P is provided in the permeated water pipe 18. The value of the pressure measured by the pressure gauge 23 is electrically transmitted to the control device 12 and is processed as described below.

[0029]

The entire amount of concentrated water W3 discharged from the membrane separation device 13 after the permeated water PW is separated, excluding excess sludge M, is returned to the biological treatment water tank 11 via a return pipe 19 (return line) as activated sludge. That is, a concentrated water discharge port 8 (see FIG. 2) of the membrane module 1 is connected to the return pipe 19.

An excess sludge pipe 28 (excess sludge discharge part) configured to allow a portion of the concentrated water W3 (activated sludge) to be drawn out as excess sludge M branches off from the return line 19. An excess sludge adjustment device 67 (for example, a pump or a valve) configured to adjust the flow rate of the excess sludge M is provided in the excess sludge pipe 28.

Note that a flow velocimeter 66 is disposed in the return pipe 19 between the location of the branch and the concentrated water discharge port 8. The flow velocimeter 66 electrically transmits the value of the measured flow velocity of the concentrated water W3 to the control device 12.

The outflow water W2 flowing out from the biological treatment water tank 11 returns to the biological treatment water tank 11 via the membrane separation device 13. That is, the treatment water W1 circulates through the pipe of the biological treatment device 10.

[0030]

As described above, the plurality of membrane modules 1 are arranged in parallel. Specifically, the outflow water supply pipe 17, the permeated water pipe 18, and the return pipe 19 are connected to each of the membrane modules 1.

[0031]

As illustrated in FIG. 2, the membrane module 1 includes the casing 2 with a cylindrical shape and the plurality of tubular filter membranes 3.

The casing 2 includes a casing main body 4 having a cylindrical shape, a first sidewall 5 configured to seal the upper end of the casing main body 4, a second sidewall 6 configured to seal the lower end of the casing main body 4, an outflow water introduction port 7 formed in the upper portion of the casing main body 4, a concentrated water discharge port 8 formed in the lower portion of the casing main body 4, and a permeated water discharge port 9 formed in the casing main body 4.

The membrane module 1 of this embodiment has a configuration in which the outflow water W2 introduced into the tubular filter membranes 3 from above flows downward through the inside of the tubular filter membranes 3.

[0032]

The membrane module 1 includes a first partition wall 30 and a second partition wall 31 configured to divide the inside of the casing 2 into three spaces. A plurality of insertion holes 32 are formed in the first partition wall 30 and the second partition wall 31. The insertion holes 32 are holes passing in the plate thickness direction of the first partition wall 30 and the second partition wall 31. The inner diameter of the insertion holes 32 is slightly greater than the outer diameter of the tubular filter membranes 3.

The plurality of tubular filter membranes 3 extend in the direction of axial line A, which is the vertical direction in this embodiment, inside the casing 2. One end (first end) is jointed to the first partition wall 30, and the other end (second end) is jointed to the second partition wall 31.

[0033]

The first partition wall 30 is a member having a plate-like shape and is fixed to the upper part (first sidewall 5 side) in the extending direction of the casing 2. The space enclosed by the casing main body 4, the first partition wall 30, and the first sidewall 5 is a first header space S1. The first header space S1 is a space further above the first partition wall 30 of the internal space of the casing 2.

The second partition wall 31 is a member having a plate-like shape and is fixed to the lower part (second sidewall 6 side) in the extending direction of the casing 2. The space enclosed by the casing main body 4, the second partition wall 31, and the second sidewall 6 is a second header space S2. The second

header space S2 is a space further below the second partition wall 31 of the internal space of the casing 2.

[0034]

The space which is enclosed by the casing main body 4, the first partition wall 30, and the second partition wall 31 and is on the outer peripheral side of the tubular filter membranes 3 is a permeation-side space P. After the permeated water PW extracted from the plurality of tubular filter membranes 3 is discharged into the permeation-side space P, the water is introduced into the permeated water pipe 18 (see FIG. 1) via the permeated water discharge port 9.

[0035]

The outflow water introduction port 7 is an opening for connecting the outside of the casing 2 and the first header space S1. The outflow water introduction port 7 is formed in the casing main body 4. The outflow water introduction port 7 is provided between the first partition wall 30 and the first sidewall 5 in the direction of axial line A of the casing 2.

The concentrated water discharge port 8 is an opening for connecting the outside of the casing 2 and the second header space S2. The concentrated water discharge port 8 is formed in the casing main body 4. The concentrated water discharge port 8 is provided between the second partition wall 31 and the second sidewall 6 in the direction of axial line A of the casing 2.

[0036]

The permeated water discharge port 9 is an opening for connecting the outside of the casing 2 and the permeation-side space P. The permeated water discharge port 9 is formed in the casing main body 4. The permeated water discharge port 9 is provided between the first partition wall 30 and the second partition wall 31 in the direction of axial line A of the casing 2.

The permeated water discharge port 9 is provided in the lower part of the permeation-side space P. In other words, the permeated water discharge port 9 is provided slightly above the second partition wall 31. The permeated water discharge port 9 is preferably provided at the lower end of the permeation-side space P. The permeated water discharge port 9 is formed at a position where permeated water PW passing through the plurality of tubular filter membranes 3 can be discharged as much as possible without being accumulated in the permeation-side space P.

In addition, the permeated water pipe 18 connected to the permeated water discharge port 9 is inclined downward.

That is, the permeated water pipe 18 has a shape which prevents the permeated water PW that is discharged from the permeated water discharge port 9 from returning due to gravity.

[0037]

In addition, an openable/closable air vent hole 33 for connecting the outside of the casing 2 and the permeation-side space P is provided in the casing main body 4. The air vent hole 33 is provided in the upper part of the permeation-side space P.

[0038]

The concentrated-side space S is a space into which the outflow water W2 is introduced, and includes the first header space S1, a filter membrane internal space S3, which is the space on the inner peripheral side of the tubular filter membranes 3, and the second header space S2.

The permeation-side space P is a space in which the permeated water PW separated from the outflow water W2 is housed.

[0039]

The first end of each of the tubular filter membranes 3 is inserted into the insertion hole 32 of the first partition wall 30 and is then fixed to the inner peripheral surface of the insertion hole 32. The area between the inner peripheral surface of the insertion hole 32 and the outer peripheral surface of the tubular filter membrane 3 is sealed with a seal material (not illustrated). The seal material is preferably a material which initially has viscosity and hardens over time, such as an epoxy resin or a urethane resin.

The second end of each of the tubular filter membranes 3 is fixed to the insertion hole 32 of the second partition wall 31 with the same method as that used for the first end of the tubular filter membrane 3.

[0040]

The tubular filter membranes 3 have a cylindrical shape and are formed by a polymer filter membrane with a single-layer structure in which a hydrophilic monomer is copolymerized with a simple main component.

That is, the main material of the tubular filter membranes 3 is formed by one type of based material. What it means for the main material to be formed by one type of base material is that one type of resin, which is a base material, for example, used to form the tubular filter membrane 3, accounts for not less than 50 mass% of the base material.

What it also means for the main material to be formed by one type of base material is that the properties of the one type of base material dominate the properties of the constituent base material. Specifically, this refers to a base

material in which one type resin accounts for from 50 to 99 mass% of the material.

[0041]

The main material constituting the tubular filter membranes 3 may be a vinyl chloride resin or a polymer material such as a polysulfone (PS), polyvinylidene fluoride (PVDF), polyolefin such as polyethylene (PE), polyacrylonitrile (PAN), polyether sulfone, polyvinyl alcohol (PVA), or polyimide (PI) based polymer material.

[0042]

A vinyl chloride resin is particularly preferable as the main material constituting the tubular filter membranes 3. Examples of vinyl chloride resins include vinyl chloride homopolymers, copolymers of vinyl chloride monomers and monomers having unsaturated bonds which are copolymerizable with vinyl chloride monomers, graft copolymers formed by graft-polymerizing vinyl chloride monomers with polymers, and (co)polymers made of materials formed by chlorinating these vinyl chloride monomers.

[0043]

Examples of hydrophilic monomers include the following:

(1) cationic group-containing vinyl monomers such as amino groups, ammonium groups, pyridyl groups, imino groups, and betaine structures and/or salts thereof;

(2) hydrophilic non-ionic group-containing vinyl monomers such as hydroxyl groups, amide groups, ester structures, and ether structures;

(3) anionic group-containing vinyl monomers such as carboxyl groups, sulfonic acid groups, and phosphoric acid groups and/or salts thereof; and

(4) other monomers.

[0044]

The tube diameter of the tubular filter membranes 3 can be selected appropriately in accordance with the characteristics of the outflow water W2 or the like. For example, when the crude fiber volume α of the outflow water W2 is less than or equal to 200 mg/liter, the inner diameter of the tubular filter membranes 3 may be set to not greater than 5 mm; when the crude fiber volume α is greater than 200 mg/liter and less than 500 mg/liter, the inner diameter of the tubular filter membranes 3 may be set to from 5 to 10 mm; and when the crude fiber volume α is greater than or equal to 500 mg/liter, the inner diameter of the tubular filter membranes 3 may be set to 10 mm or greater. Selection of the tube diameter makes it possible to suppress the blockage of the tubular filter membranes 3 by the crude fiber content.

[0045]

Next, the operation of the biological treatment device 10 of this embodiment will be described.

After treatment water W1 such as human waste is subjected to pretreatment at a pretreatment facility (not illustrated), the treatment water W1 is sent to the biological treatment water tank 11 via the treatment water pipe 15. The treatment water W1 is treated in the biological treatment water tank 11. Specifically, organic substances contained in the treatment water W1 are decomposed by microorganisms.

Next, the outflow water W2 flowing out from the biological treatment water tank 11 is supplied to the membrane separation device 13 via the pressurizing pump 21. The outflow water W2 supplied to the membrane separation device 13 is fed into the tubular filter membranes 3 of the membrane module 1. The operation of the pressurizing pump 21 is controlled by a control device 12, as described below.

[0046]

On the other hand, the permeation-side space P inside the casing 2 of the membrane module 1 assumes a negative pressure due to the activation of the suction pump 22. The suction pump 22 sucks in a direction roughly perpendicular to the flow of the outflow water W2 flowing through the tubular filter membranes 3 via the permeated water discharge port 9. The operation of the suction pump 22 is controlled by a control device 12, as described below. The permeated water PW passing through from the tubular filter membranes 3 is stored in the storage tank 22 via the permeated water discharge port 9 and the permeated water pipe 18.

In addition, the air vent hole 33 is closed during the operation of the suction pump 22.

[0047]

The entire amount of the concentrated water W3 (return sludge) discharged from the membrane separation device 13, excluding excess sludge M, is returned to the biological treatment water tank 11 via the return pipe 19 and is treated once again.

In addition, when the biological treatment device 10 is stopped, the entire amount of permeated water PW inside the permeation-side space P of the membrane module 1 is discharged to the outside of the permeation-side space P. In other words, even when the flow of outflow water W2 stops as a result of the pressurizing pump 21 being stopped by the control device 12, the permeated water PW is never accumulated in the permeation-side space P.

[0048]

Next, the control method of the biological treatment device 10 of this embodiment will be described.

As illustrated in FIG. 3, the control method of the biological treatment device 10 of this embodiment includes: an outflow water pressurizing step P1 of pressurizing the outflow water W2 in the concentrated-side space S using the pressurizing pump 21 after the control device 12 initiates the operation of the biological treatment device 10; a permeated water suction step P2 of sucking the permeated water PW in the permeation-side space P of the membrane separation device 13 using the suction pump 22; a pressure determining step P3 in which the control device 12 determines whether the absolute value of the pressure in the permeation-side space P is greater than a threshold value; an outflow water flow rate increasing step P4 in which the control device 12 increases the flow rate of the outflow water W2 pressurized by the pressurizing pump 21 if the absolute value of the pressure in the permeation-side space P is greater than the threshold value; and an outflow water flow rate adjusting step P5 in which the control device 12 adjusts the flow rate of the outflow water W2.

[0049]

In the outflow water pressurizing step P1 and the permeated water suction step P2, the control device 12 controls the pressurizing pump 21 and the suction pump 22 on the basis of the value of the flow velocity received from the flow velocimeter 66 so that the membrane surface flow velocity and the FLUX (outflow amount of the permeated water PW) are within ranges satisfying the planned values. The membrane surface flow velocity is the velocity at which the outflow water W2 flows through the inside of the tubular filter membranes 3. The membrane surface flow velocity is, for example, from 0.15 to 0.30 m/s.

[0050]

In the pressure determining step P3, the control device 12 determines whether the value of the pressure (water pressure) in the permeation-side space P measured by the pressure gauge 23 is greater than a threshold value.

Here, in a state in which foreign matter such as sludge has accumulated on the inner peripheral surface 35a of the tubular filter membranes 3, the permeated water PW does not sufficiently pass through the tubular filter membranes 3. Therefore, the absolute value of the pressure in the permeation-side space P, which assumes a negative pressure due to the operation of the suction pump 22, increases because the permeated water PW does not sufficiently pass through the tubular filter membranes, and the value becomes greater than the threshold value.

The threshold value of the pressure in the permeation-side space P can be determined appropriately in accordance with experiments or the like performed in advance, for example.

[0051]

Therefore, to recover from this state, in the outflow water flow rate increasing step P4, the control device 12 controls the pressurizing pump 21 so as to increase the flow rate of the outflow water W2 supplied to the concentrated-side space S. At this time, the control device 12 ordinarily operates the suction pump 22 in the same manner as in the permeated water suction step P2 and does not perform control to increase power. As a result of the increase in the flow rate of the outflow water W2 (increase in the pressure of the outflow water W2), the foreign matter accumulated on the inside of the tubular filter membranes 3 is washed out to the downstream side.

This allows the function of the tubular filter membranes 3 to recover so that the permeated water PW flows into the permeation-side space P. As a result of this recovery, the value of the pressure transmitted by the pressure gauge 23 to the control device 12 becomes the threshold value or less.

[0052]

In the outflow water flow rate adjusting step P5, control is performed to adjust the flow rate of the outflow water W2 increased in the outflow water flow rate increasing step P4.

The control device 12 controls the pressurizing pump 21 to return the flow rate of the outflow water W2 to the original level in response to the value of the pressure received from the pressure gauge 23 falling below the threshold value.

[0053]

In addition, as a result of the temporary increase in the flow rate of the outflow water W2 due to the outflow water flow rate increasing step P4, the amount of concentrated water W3 (return sludge) increases, and the value of the water level measured by the water level measuring device 56, which is received by the control device 12, therefore becomes greater than a prescribed value. Therefore, the control device 12 controls the excess sludge adjustment device 67 (for example, a pump or a valve) so as to increase the amount of excess sludge M drawn out from the excess sludge pipe 28 so that the value of the water level measured by the water level measuring device 56 is adjusted to a prescribed value.

[0054]

In addition, the control device 12 can control the flow rate of the treatment water W1 supplied to the biological treatment water tank 11 on the basis of the measurement value of the water level measuring device 56.

[0055]

With the embodiment described above, the membrane surface flow velocity can be reduced by forming the tubular filter membranes 3 with hydrophilic materials. The membrane surface flow velocity may be, for example, from 0.15 to 0.30 m/s.

[0056]

When the tubular filter membranes 3 are hydrophobic, it is necessary to make the membrane surface flow velocity high (for example, 2.5 m/s). Therefore, the circulating flow rate increases, and a tank for temporarily storing circulating water or a pipe for introducing circulating water into the tank becomes necessary.

[0057]

The biological treatment device 10 of this embodiment can reduce the membrane surface flow velocity, which can reduce the circulating flow rate. This makes it possible to reduce the power of the pressurizing pump 21.

In addition, a tank for temporarily storing circulating water or a pipe for introducing circulating water into the tank becomes unnecessary. Further, a reduction in the flow rate of circulating water makes it possible to reduce the diameter of the pipe.

[0058]

In addition, by controlling the amount of outflow water W2 supplied to the concentrated-side space S on the basis of the pressure in the permeation-side space P, even if foreign substances are accumulated on the inner peripheral surfaces of the tubular filter membranes 3, the biological treatment device 10 of this embodiment can restore the function of the tubular filter membranes 3 by washing out the accumulated foreign substances. Further, the operation of the suction pump 22 can be stabilized by operating the pump so that the suction force of the suction pump 22 does not fluctuate. However, in the outflow water flow rate increasing step P4, the control device 12 may perform control to increase or reduce the suction force of the suction pump 22 so as to oscillate the tubular filter membranes 3.

This is because such oscillation promotes the separation of foreign substances.

[0059]

When the membrane surface flow velocity is low, the MLSS (suspended substance) concentration difference between the inlets and the outlets of the tubular filter membranes is typically large, which allows sludge to easily accumulate on the outlet side. This causes a decrease in the amount of permeated water at the outlets.

On the other hand, the membrane module 1 of this embodiment is configured so as to be positioned vertically so that the outflow water W2 flowing through the tubular filter membranes 3 flows downward from above. Such a configuration makes it possible to compensate for the amount of permeated water at the outlets due to the head difference. That is, effectively utilizing all of the tubular filter membranes 3 makes it possible to reduce the power of the pressurizing pump 21.

[0060]

In addition, selection of the inner diameter of the tubular filter membranes 3 in accordance with the crude fiber volume of the outflow water W2 makes it possible to suppress the blockage of the tubular filter membranes 3 by the crude fiber content.

[0061]

Note that in this embodiment, the membrane module 1 in which the tubular filter membranes 3 are arranged in parallel is employed, but the present invention is not limited to this configuration. For example, as illustrated in FIG. 4, a plurality of tubular filter membranes 3 may be connected in series. That is, a configuration is possible in which a plurality of U-shaped first connection members 46 are configured to connect the first ends of the plurality of tubular filter membranes 3 to one another and the second ends of the tubular filter membranes 3 to one another so that the plurality of tubular filter membranes 3 are connected in series.

[0062]

At this time, the plurality of tubular filter membranes 3 connected in series and the outflow water introduction port 7 may be connected in series by a tubular second connection member 59, and the plurality of tubular filter membranes 3 connected in series and the concentrated water discharge port 8 may be connected in series by a tubular third connection member 60. In this case, the first header space S1 and the second header space S2 may be omitted. The configuration of the casing 2 can thus be modified by eliminating the first sidewall 5 and the second sidewall 6 or the like.

[0063]

In addition, the membrane module 1 of this embodiment has a configuration in which the outflow water W2 introduced into the tubular filter membranes 3 from above flows downward through the inside of the tubular filter membranes 3 so that a pressurizing pump with a small amount of power can be used, but the present invention is not limited to this configuration. When a pressurizing pump with a large amount of power is used, the configuration may be such that the outflow water introduction port 7 is provided in the lower portion of the casing 2 and the concentrated water discharge port 8 is provided in the upper portion of the casing 2 so that the outflow water W2 flows upward through the tubular filter membranes 3.

[0064]

Modification of First Embodiment

A biological treatment device 10B of a modification of the first embodiment of the present invention will be described hereinafter with reference to the drawings. Note that, in the present embodiment, points that are different from the above-described first embodiment will be mainly described, and a description will be omitted of the portions that are the same.

As illustrated in FIG. 5, the biological treatment water tank 11B of this embodiment uses an activated sludge method.

The biological treatment water tank 11B includes an aerobic tank 62 configured to mix the treatment water W1 and return sludge. The aerobic tank 62 includes an ORP measuring device 51 (51E), a pH measuring device 52 (52E), and a DO measuring device 53 (53E). The aerobic tank 62 includes an aeration device 57 (57E).

The treatment water W1 is mixed with activated sludge and aerated so as to be purified.

[0065]

With the modification described above, the biological treatment water tank 11B can not only achieve the effects described in the first embodiment, but also perform biological treatment at a lower cost.

[0066]

The following such modification is also possible, for example.

A biological treatment device 10C of a modification of the first embodiment of the present invention will be described hereinafter with reference to the drawings. Note that, in the present embodiment, points that are different from the above-described first embodiment will be mainly described, and a description will be omitted of the portions that are the same.

As illustrated in FIG. 6, the biological treatment water tank 11C of this embodiment uses methane fermentation.

The biological treatment water tank 11C includes a methane fermentation tank 63, which is a sealed container. The methane fermentation tank 63 is a piece of equipment configured to generate methane gas (biogas) by decomposing polymer organic substances with anaerobes (microorganisms) in the methane fermentation tank 63. In addition, the biological treatment water tank 11C includes an alkali agent supply device 68 configured to supply an alkali agent into the methane fermentation tank 63.

[0067]

The methane fermentation tank 63 includes a gas circulation line 64 configured to allow methane gas to circulate to the lower part of the methane fermentation tank 63. The gas circulation line 64 includes a gas diversion line 65 configured to allow a portion of the methane gas flowing through the gas circulation line 64 to be extracted. In addition, when the measurement value of the pH measuring device 52 (52F) becomes excessively acidic in comparison to a prescribed value, the control device 12 controls the alkali agent supply device 68 to supply an alkali agent so that the measurement value of the pH measuring device 52 (52F) becomes the prescribed value.

The methane gas extracted via the gas diversion line 65 can be fed to a power generation device or the like and used. Note that the entire amount of methane gas may be fed to a power generation device or the like without providing a gas circulation line 64. A stirring device configured to stir the treatment water W1 stored in the methane fermentation tank 63 may also be provided in the methane fermentation tank 63.

[0068]

With such a configuration, in addition to the effects described in the first embodiment, methane gas generated by methane fermentation can be recovered so that the energy of the methane gas can be used for power generation or the like. In addition, further providing a heat recovery system in a power generator makes it possible to further enhance the energy recovery rate.

[0069]

Second Embodiment

A biological treatment device of a second embodiment of the present invention will be described hereinafter with reference to the drawings. Note that, in the present embodiment, points that are different from the above-described first embodiment will be mainly described, and a description will be omitted of the portions that are the same. This embodiment differs from the first

embodiment in that in the biological treatment device 10 of the first embodiment, the membrane separation device 13D illustrated in FIG. 7 is used instead of the membrane separation device 13.

As illustrated in FIG. 7, in the membrane separation device 13D of this embodiment, a plurality of membrane modules 1D are disposed laterally inside a case 14 of the membrane separation device 13D. That is, in contrast to the first embodiment, the axial line A (see FIG. 8) of the cylindrically-shaped casing 2 of the membrane modules 1D extends in the horizontal direction.

[0070]

As illustrated in FIG. 8, the membrane module 1D includes a casing 2 with a cylindrical shape, a plurality of tubular filter membranes 3, and reinforcing members 34 configured to reinforce the tubular filter membranes 3.

[0071]

The membrane modules 1D of this embodiment include the reinforcing members 34 configured to reinforce each of the tubular filter membranes 3. The reinforcing members 34 are cylindrical members which cover each of the tubular filter membranes 3 from the outer peripheral side. The tubular filter membranes 3 are inserted through the inner peripheral side of the reinforcing members 34.

[0072]

As illustrated in FIG. 9, each reinforcing member 34 includes a cylindrical main body portion 35 disposed on the outer peripheral side of the tubular filter membrane 3, a plurality of supports 36 provided on the inner peripheral surface 35a of the cylindrical main body portion 35, and a plurality of through-holes 37 formed in the cylindrical main body portion 35.

The cylindrical main body portion 35 has a cylindrical shape. As illustrated in FIG. 10, the inner diameter of the cylindrical main body portion 35 (diameter of the inner peripheral surface 35a) is greater than the outer diameter of the tubular filter membrane 3. A gap G is formed between the inner peripheral surface 35a of the cylindrical main body portion 35 and the outer peripheral surface of the tubular filter membrane 3. The outer diameter of the tubular filter membrane 3 may be set to 5 mm, for example, and the inner diameter of the cylindrical main body portion 35 may be set to 7 mm, for example. In this case, the gap G between the inner peripheral surface 35a of the cylindrical main body portion 35 and the outer peripheral surface of the tubular filter membrane 3 is 2 mm. The cylindrical main body portion 35 is formed so that the gap G relative to the tubular filter membrane 3 is constant.

[0073]

The length of the cylindrical main body portion 35 is the same as the gap between the first partition wall 30 and the second partition wall 31. That is, the length of the cylindrical main body portion 35 is the same as the length of the tubular filter membrane 3 exposed to the permeation-side space P.

The cylindrical main body portion 35 may be formed, for example, from a light metal such as titanium or aluminum or a plastic such as a polyacetal resin. The plate thickness of the cylindrical main body portion 35 is preferably as thin as possible within a range that does not diminish the strength of the reinforcing member 34.

[0074]

The supports 36 are protrusions extending in the direction of the axial line A (extending direction) of the cylindrical main body portion 35. A plurality (eight in this embodiment) of supports 36 are formed with spacing in the circumferential direction of the cylindrical main body portion 35. The height of each support 36 is roughly the same as the width of the gap G between the inner peripheral surface 35a of the cylindrical main body portion 35 and the outer peripheral surface of the tubular filter membrane 3.

[0075]

Note that although the reinforcing members 34 of this embodiment have eight supports 36, the present invention is not limited to this configuration as long as the tubular filter membranes 3 can be supported. To secure a wider space between the cylindrical main body portion 35 and the tubular filter membrane 3, that is, the space into which the permeated water PW is discharged, it is preferable to keep the number of supports 36 as small as possible, such as three supports.

In addition, although the supports 36 are formed continuously in the direction of the axial line A of the cylindrical main body portion 35 in the embodiment described above, the present invention is not limited to this configuration. The supports 36 should be able to support the tubular filter membrane 3 while securing the space between the cylindrical main body portion 35 and the tubular filter membrane 3 as much as possible without filling the space. For example, the supports 36 may be formed intermittently in the direction of the axial line A. In addition, the configuration may also be such that the tubular filter membranes 3 are point-supported by a plurality of supporting protrusions positioned at a distance from one another.

[0076]

The through-holes 37 are openings for connecting the outer peripheral side of the cylindrical main body portion 35 and the inner peripheral side of the

cylindrical main body portion 35. A plurality of through-holes 37 are disposed regularly (uniformly) over the entire outer surface of the cylindrical main body portion 35. As many through-holes 37 as possible are preferably formed within a range that does not diminish the strength of the reinforcing member 34. The positions of the through-holes 37 in the circumferential direction of the cylindrical main body portion 35 preferably differ from those of the supports 36.

[0077]

With the embodiment described above, by disposing the membrane modules 1D laterally, that is, so that the casing 2 extends in the horizontal direction, the replacement of the membrane modules 1D can be accomplished easily even when a plurality of membrane modules 1D are provided. This facilitates the maintenance of a membrane separation device 13D including a plurality of membrane modules 1D.

[0078]

In addition, the reinforcing members 34 that reinforce the plurality of tubular filter membranes 3 can prevent the tubular filter membranes 3 from bending, even when the tubular filter membranes 3 are disposed so as to extend in the horizontal direction.

Further, since a gap G is formed between the inner peripheral surface 35a of the reinforcing members 34 and the outer peripheral surface of the tubular filter membranes 3 by the supports 36 of the reinforcing members 34, the supports 36 can support the tubular filter membranes 3 without bending and without obstructing the flow of the permeated water PW passing through from the tubular filter membranes 3.

[0079]

In addition, when the membrane modules 1D are disposed vertically, the head difference (resistance) between the first and second ends of the tubular filter membranes 3 becomes large. By disposing the membrane modules 1D horizontally, the head difference becomes small in comparison to when the membrane modules 1D are disposed vertically, which makes it possible to reduce the FLUX (outflow amount) distribution.

[0080]

In addition, disposing the membrane modules 1D horizontally makes it possible to connect a plurality of membrane modules 1D to one another in series. According to the horizontal disposition of membrane modules 1D, the plurality of membrane modules 1D of the membrane separation device 13D can be also easily arranged in series.

[0081]

Note that in the embodiment described above, the length of the reinforcing members 34 is the same as the spacing between the first partition wall 30 and the second partition wall 31, but the present invention is not limited to this configuration. For example, the length of the reinforcing members 34 may be made longer than the spacing between the first partition wall 30 and the second partition wall 31, and the reinforcing members 34 may be inserted into the insertion holes 32 of the first partition wall 30 and the second partition wall 31. Using such a configuration makes it possible to further alleviate the burden on the tubular filter membranes 3.

[0082]

In addition, the reinforcing members 34 may have a cylindrical shape and may be disposed in contact with the tubular filter membranes 3 on the outer peripheral side of the tubular filter membranes 3 so as to form a mesh-like network structure. The network structure may be plastic tubes formed by combining a plurality of linear pieces of plastic with one another in a lattice shape.

[0083]

A wire formed from a metal such as stainless steel, for example, may also be used instead of the linear plastic described above. In addition, a wire coated with vinyl or the like may also be used.

Further, the manner in which the plurality of linear pieces of plastic are combined is not limited to a lattice shape, and the plurality of linear pieces of plastic may also be woven hexagonally.

[0084]

Third Embodiment

The reinforcing members used in the membrane modules of a third embodiment of the present invention will be described hereinafter with reference to the drawings. Note that, in the present embodiment, points that are different from the above-described second embodiment will be mainly described, and a description will be omitted of the portions that are the same. This embodiment differs from the second embodiment in that in the biological treatment device 10 of the first embodiment, not only the membrane separation device 13D illustrated in FIG. 7 is used instead of the membrane separation device 13, but the reinforcing members 34E illustrated in FIG. 11 are also used instead of the reinforcing members 34 of the membrane separation device 13D.

As illustrated in FIG. 11, the reinforcing members 34E of this embodiment include a plate-like main body portion 48 having a cylindrical

plate shape and a plurality of membrane insertion holes 49 formed in the plate-like main body portion 48. The respective tubular filter membranes 3 are inserted into the plurality of membrane insertion holes 49. Three reinforcing members 34E are provided with spacing in the direction of the axial line A of the casing 2.

[0085]

The outer circumferential surfaces 48a of the plate-like main body portions 48 of the reinforcing members 34E touch the inner peripheral surface of the casing 2. The reinforcing members 34E are supported as a result of the lower portions of the reinforcing members 34E touching the inner peripheral surface of the casing 2. The outer peripheral surfaces 48a of the lower portion of the reinforcing members 34E function as reinforcing member supports for supporting the reinforcing members 34E. In addition, notches 55 are preferably present in portions of the reinforcing members 34E, for example, so that the permeated water PW can flow through the permeation-side space P.

[0086]

With the embodiment described above, the plurality of tubular filter membranes 3 are mechanically connected by the reinforcing members 34E. This makes it possible to prevent the tubular filter membranes 3 from bending, even when the tubular filter membranes are disposed so as to extend in the horizontal direction.

In addition, since the reinforcing members 34E in this embodiment support the tubular filter membranes 3 at only three points in the extending direction, the permeated water PW can be permeated to a greater degree than in the case of the reinforcing members 34 of the second embodiment.

[0087]

Note that although the outer peripheral surfaces 48a of the reinforcing members 34E of the embodiment described above touch the inner peripheral surface of the casing 2, the reinforcing members 34E are not limited to this configuration. That is, as long as the reinforcing members 34E are supported by the inner peripheral surface of the casing 2, it is unnecessary for the upper portions of the reinforcing members 34E to touch the inner peripheral surface of the casing 2. In addition, a shape in which portions of the outer perimeter touch the casing 2, such as a polygonal shape, for example, may also be used.

Further, the number of reinforcing members 34E is not limited to three, and the number may be adjusted appropriately in accordance with the strength of the tubular filter membranes 3.

[0088]

The embodiments of the present invention have been described above in detail, but various modifications can be made within a range that does not deviate from the technical ideas of the present invention.

For example, with regard to the number of tubular filter membranes 3, although five tubular filter membranes 3 are illustrated in FIG. 2 and the like, the number of tubular filter membranes 3 is not limited to this number.

In addition, the configurations illustrated in the modifications of the first embodiment may also be applied to the second and third embodiments.

Industrial Applicability

[0089]

The biological treatment device can reduce the membrane surface flow velocity because the tubular filter membranes are hydrophilic. This makes it possible to reduce the circulating flow rate of treatment water, which eliminates the need for a tank for temporarily storing large volumes of circulating water.

In addition, control of the supply amount of the outflow water supplied to the concentrated-side space based on the pressure of the permeation-side space allows concentrated water (return sludge) to be stably supplied to the biological treatment water tank.

Reference Signs List

[0090]

- 1, 1D Membrane module
- 2 Casing
- 3 Tubular filter membrane
- 4 Casing main body
- 5 First sidewall
- 6 Second sidewall
- 7 Outflow water introduction port
- 8 Concentrated water discharge port
- 9 Permeated water discharge port
- 10, 10B, 10C Biological treatment device
- 11, 11B Biological treatment water tank
- 12 Control device
- 13, 13D Membrane separation device
- 15 Treatment water pipe
- 17 Outflow water supply pipe
- 18 Permeated water pipe

- 19 Return pipe (return line)
- 20 Storage tank
- 21 Pressurizing pump
- 22 Suction pump
- 23 Pressure gauge
- 24 Denitrification tank
- 25 Nitrification tank
- 26 Secondary denitrification tank
- 27 Re-aeration tank
- 28 Excess sludge pipe (excess sludge discharge part)
- 30 First partition wall
- 31 Second partition wall
- 32 Insertion hole
- 33 Air vent hole
- 34 Reinforcing member
- 35 Cylindrical main body portion
- 36 Support
- 37 Through-hole
- 48 Plate-like main body portion
- 49 Membrane insertion hole
- 51 ORP measuring device
- 52 pH measuring device
- 53 DO measuring device
- 54 Organic carbon source supply device
- 55 Notch
- 56 Water level measuring device
- 57 Aeration device
- 62 Aerobic tank
- 63 Methane fermentation tank
- 64 Gas circulation line
- 65 Gas diversion line
- 66 Flow velocimeter
- 67 Excess sludge adjustment device (valve, pump)
- 68 Alkali agent supply device
- G Gap
- M Excess sludge
- PW Permeated water
- S Concentrated-side space

S1 First header space

S2 Second header space

S3 Filter membrane internal space

P Permeation-side space

W1 treatment water

W2 Outflow water

W3 Concentrated water

Claims

[Claim 1]

A biological treatment device comprising:

- a biological treatment water tank configured to treat organic substances contained in treatment water;
- a membrane separation device including
 - a casing, and
 - a tubular filter membrane configured to partition the casing into a concentrated-side space to which outflow water flowing out from the biological treatment water tank is supplied and a permeation-side space in which permeated water separated from the outflow water is housed, and having a single-layer structure formed by copolymerization of hydrophilic monomers;
- a pressurizing pump configured to pressurize the outflow water and supply water that is pressurized to the concentrated-side space;
- a suction pump configured to suck the permeated water from the permeation-side space;
- a pressure gauge configured to measure a pressure of the permeation-side space;
- a return line configured to allow concentrated water discharged from the membrane separation device to return to the biological treatment water tank; and
- a control device configured to control a supply amount of the outflow water supplied by the pressurizing pump on the basis of a measurement value of the pressure gauge.

[Claim 2]

The biological treatment device according to claim 1, wherein the control device increases the flow rate of the outflow water pressurized by the pressurizing pump in a case where an absolute value of the measurement value of the pressure gauge is greater than a threshold value.

[Claim 3]

The biological treatment device according to claim 2, wherein the control device controls the flow rate of the permeated water sucked by the suction pump.

[Claim 4]

The biological treatment device according to claim 2 or 3 further comprising:

an excess sludge discharge part configured to draw out excess sludge from the return line; and

a water level measuring device configured to measure a water level of the biological treatment water tank;

wherein the control device controls an amount of excess sludge drawn out from the excess sludge discharge part on the basis of a measurement value of the water level measuring device.

[Claim 5]

The biological treatment device according to any one of claims 2 to 4 further comprising a water level measuring device configured to measure the water level of the biological treatment water tank;

wherein the control device controls the flow rate of treatment water supplied to the biological treatment water tank on the basis of the measurement value of the water level measuring device.

[Claim 6]

The biological treatment device according to any one of claims 1 to 5, wherein the biological treatment water tank is a methane fermentation tank, microorganisms in the methane fermentation tank breaking down organic substances contained in the treatment water.