

{ DESCRIPTION}

{ Title of Invention}

COMPLEX DESALINATION SYSTEM

{ Technical Field}

5 { 0001}

The present invention relates to a complex desalination system including a first water treatment system that filters a first raw water of a high salinity concentration with use of a reverse osmosis membrane device and a second water treatment
10 system that filters a second raw water of a lower salinity concentration than the first raw water with use of the reverse osmosis membrane device. In the above system, the first raw water is, for example, seawater, brackish water, or brine water. In particular, it relates to a technology which utilizes a
15 hydraulic energy of the nonpermeate water discharged from the reverse osmosis membrane device of the second water treatment system and improves an operation availability of the first water treatment system.

{ Background Art}

20 { 0002}

Japanese Patent Publication No. 4,481,345 (hereinafter, referred to as "Patent Document 1") discloses a technology which decreases the driving power required for a pressure pump (corresponding to "high-pressure pump" in this specification)

in the seawater desalination device desalinating the seawater by filtering with use of the reverse osmosis membrane device. The wastewater containing organic matter (hereinafter, referred to as "organic wastewater") such as sewage is processed
5 in a biological treatment, and had been usually discharged into an ocean or a river. The organic wastewater processed in the biological treatment is mixed with the seawater taken in by the seawater desalination device to decrease (dilute) the salinity concentration contained in a "water to be treated" of the
10 seawater desalination device, and the above-mentioned "water to be treated" having diluted salinity concentration is pumped to the reverse osmosis membrane device of the seawater desalination device, so that the driving power required for the pressure pump is decreased.

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Further, Japanese Patent Application Publication No. 2010-274243 (hereinafter, referred to as "Patent Document 2") discloses a technology generating fine bubbles by pumping and depressurizing air or the like dissolved in water.
20 Incidentally, in water treatment, it is a well known technology to generate fine bubbles, for example, microbubbles and nanobubbles in the "water to be treated", allow the fine bubbles to stay relatively long in the "water to be treated", and decompose the organic matter in the "water to be treated" by

a shock wave generated in a process of crush of the fine bubbles.

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Furthermore, Japanese Patent Application Publication No.
H09-290260 (hereinafter, referred to as "Patent Document 3")

5 discloses a technology sterilizing the "water to be treated"
by injecting ozone gas thereinto.

{ Citation List}

{ Patent Literature}

{ 0005}

10 { Patent Document 1}

Japanese Patent No. 4481345

{ Patent Document 2}

Japanese Patent Application Publication No. 2010-274243

{ Patent Document 3}

15 Japanese Patent Application Publication No. H09-290260

{ Summary of Invention}

{ Technical Problem}

{ 0006}

However, in the technology described in the Patent
20 Document 1, the pressure in case of using the reverse osmosis
membrane device in the water treatment process of the organic
wastewater is lower than the pressure in case of using the
reverse osmosis membrane device in the water treatment process
of the seawater desalination device. Then, it has been

described to decrease the salinity concentration relative to the seawater by directly mixing the nonpermeate water discharged from the reverse osmosis membrane device in the water treatment system of the organic wastewater with the seawater taken in. Thus, the energy of the nonpermeate water discharged from the reverse osmosis membrane device in the water treatment process of the organic wastewater is comparatively low in pressure and wasted without effective utilizations. In addition, there is a problem that the frequency of fouling of a reverse osmosis membrane in the seawater desalination device is increased, because the organic matter in the "water to be treated" is increased by using the organic wastewater to dilute the seawater.

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The present invention is intended to solve the conventional problems described above, and a purpose thereof is to provide a complex desalination system which can effectively utilize the energy of the nonpermeate water of the reverse osmosis membrane device in the complex desalination system and reduce the frequency of the fouling.

{ Solution to Problem}

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To solve the above problems, a complex desalination system according to the present invention includes a first water

treatment system that filters a first raw water of high salinity concentration with use of a first reverse osmosis membrane device, and a second water treatment system that filters a second raw water of lower salinity concentration than the first raw water with use of a second reverse osmosis membrane device, wherein the first water treatment system comprises a fine bubble generation unit that generates and discharges fine bubbles into the first raw water taken in, by rapidly decompressing a nonpermeate water discharged from the second reverse osmosis membrane device in the second water treatment system.

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And the fine bubble generation unit is preferably configured to include a first piping that connects an outlet of the nonpermeate water of the second reverse osmosis membrane device and a first raw water tank storing the first raw water taken in, a first valve provided on the side of the first raw water tank of the first piping, and a fine bubble generation part that is provided on a downstream side of the first valve of the first piping, and generates and discharges gases dissolved in the first raw water as the fine bubbles by rapidly decompressing the nonpermeate water of the second reverse osmosis membrane device when introducing the nonpermeate water into the first tank. Further, the fine bubble generation unit is preferably configured to include a second piping that is

bifurcated from the first piping at an upstream position of the first valve and connected to the first raw water tank, and a second valve that is provided on the second piping and regulates a flow rate of the nonpermeate water of the second reverse osmosis membrane device.

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Further, the complex desalination system preferably includes an ozone generator that generates ozone gas, wherein an ozone injection portion, through which the ozone gas generated by the ozone generator is injected, is provided on the first piping between the first valve and the fine bubble generation part.

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Conventionally, it has been required a power separately to blow compressed air into a raw water for generating the fine bubbles, or generate dissolved gases as the fine bubbles by rapid decompression. In contrast, according to the present invention, it is possible to generate the fine bubbles sufficiently only by decompression of a relatively low pressure of the permeate water discharged from the second reverse osmosis membrane device in the second water treatment system, thereby saving power required for an operation of the complex desalination system without requiring a new power for generating the fine bubbles.

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Further, it may not be possible to regulate the flow rate of the nonpermeate water discharged from the second reverse osmosis membrane device in the second water treatment system by only flowing total amount of the nonpermeate water discharged from the second reverse osmosis membrane device in the second water treatment system to the fine bubble generation part. In contrast, according to the present invention, it is also possible to regulate the flow rate of the nonpermeate water discharged from the second reverse osmosis membrane device by configuring the fine bubble generation unit to include a second piping that is bifurcated from the first piping at an upstream position of the first valve and connected to the first raw water tank, and a second valve that is provided on the second piping and regulates a flow rate of the nonpermeate water of the second reverse osmosis membrane device.

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Furthermore, according to the present invention, it is possible to generate the fine bubbles including the ozone gas in the fine bubble generation part by including the ozone generator that generates ozone gas in the complex desalination system, and providing the ozone injection portion, through which the ozone gas generated by the ozone generator is injected, on the first piping between the first valve and the fine bubble

generation part. And it is possible to obtain not only decomposition of the organic matter by a shock wave generated in a process of the crush of the fine bubbles but also sterilization effect by the ozone for the "water to be treated"

5 including the first raw water.

{Advantageous Effects of Invention}

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According to the present invention, it is possible to provide a complex desalination system which can effectively
10 utilize the energy of the nonpermeate water of the reverse osmosis membrane device in the complex desalination system.

{Brief Description of Drawings}

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FIG. 1 is a schematic block diagram of a complex
15 desalination system according to a basic embodiment of the present invention.

FIG. 2 is a schematic block diagram of a complex desalination system according to a first embodiment of the present invention.

20 FIG. 3 is an enlarged explanatory diagram of an X portion in FIG. 2, and an explanatory diagram of a complex desalination system according to a second embodiment which is the complex desalination system according to the first embodiment further combined with an ozone generator and an ozone injection pump.

FIG. 4 is an enlarged explanatory diagram of an X portion in FIG. 2, and an explanatory diagram of a complex desalination system according to a third embodiment which is the complex desalination system according to the first embodiment combined with a reaction tank, and a complex desalination system according to a fourth embodiment which is the complex desalination system according to the third embodiment further combined with an ozone generator and an ozone injection pump.

{Description of Embodiments}

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Hereinafter, complex desalination systems according to embodiments of the present invention will be described in detail with reference to accompanying drawings.

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15 <<Complex Desalination System of Basic Embodiment >>

First, a complex desalination system 100 according to a basic embodiment of the present invention will be described with reference to FIG. 1. FIG. 1 is a schematic block diagram of the complex desalination system 100 according to the basic embodiment. The complex desalination system 100 is designed to be installed in coastal areas, near saltwater lakes, near brackish water zones, or the like. The compound desalination system 100 is configured to include a wastewater treatment system (second water treatment system) 1 which treats

wastewater (second raw water) A (hereinafter, simply referred to as "wastewater A") such as industrial wastewater and urban wastewater having lower salinity concentration than seawater, brackish water, brine water, or the like, so as to be reused
5 as recycled wastewater (referred to as "permeate water B" or "product water B") such as industrial water other than drinking water, a seawater desalination treatment system (first water desalination system) 3 which purifies water (first raw water) D such as seawater, brackish water, and brine water having
10 comparatively high salinity concentration, so as to be reused as recycled wastewater (referred to as "permeate water E" or "product water E") such as industrial water other than drinking water, and a control device 6 which actuates pumps and valves included in the wastewater treatment system 1 and the seawater
15 desalination treatment system 3. Hereinafter, "water D such as sea water, brackish water, and brine water having comparatively high salinity concentration" is referred to as a "seawater D", and the desalination treatment system for the "seawater D" is referred to as a "seawater desalination
20 treatment system 3" in the same meaning as described above.

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<Configuration of Wastewater Treatment System 1>

First, a schematic configuration of the wastewater treatment system 1 will be described with reference to FIG. 1.

The wastewater A containing organic matter or the like is introduced from a wastewater intake pipe 51 to a water treatment device (hereinafter, referred to as "MBR water treatment device 11", and simply indicated as "MBR" in FIG. 1) using, for example, a membrane bioreactor (MBR), and treated primarily. A "water to be treated" primarily treated at the MBR water treatment device 11 is introduced to a treated water tank 13 functioning as a buffer of flow of the "water to be treated" through piping 52 by a transfer pump 12, and temporarily stored therein. Furthermore, "water to be treated" stored in the treated water tank 13 is sucked by a supply pump 14 and supplied to a high-pressure pump 15 through a piping 53. Then, the "water to be treated" is boosted up by the high-pressure pump 15 and supplied to a supply port 16a of the "water to be treated" of a low-pressure reverse osmosis membrane device (second reverse osmosis membrane device) 16.

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The low-pressure reverse osmosis membrane device 16 is configured to be arranged with a plurality of membrane module units in parallel as described, for example, in FIGS. 3 and 4 of Japanese Patent Application Publication No. 2001-149932. The "water to be treated" supplied under pressure from the supply port 16a is separated into the permeate water B purified through the reverse osmosis membrane (RO membrane) and the

nonpermeate water C which is the "water to be treated" not permeated through the reverse osmosis membrane, in the low-pressure reverse osmosis membrane device 16. The permeate water B is supplied from the permeate port 16b through a piping 54 for an external use corresponding to the water quality level as the product water B.

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The nonpermeate water C is supplied from an outlet port (outlet of the nonpermeate water of the second reverse osmosis membrane device) 16c of the low-pressure reverse osmosis membrane device 16 through a piping 56 to the intake tank (first raw water tank) 32 described later. The flow rate of the nonpermeate water C is regulated by a back pressure valve 18 provided in the middle of the piping 56. TDS (Total Dissolved Solids) of the condensed nonpermeate water of the wastewater treatment system 1 is about 1,200 mg/l and an extremely low concentration compared with about 30,000 mg/l of TDS of the seawater D. Therefore, the low-pressure reverse osmosis membrane device 16 described above is operated under pressure ranging from 0.8 to 1.5 MPa. Incidentally, a range of this operation pressure is to increase the operation pressure in order to obtain the predetermined flow rate of the permeate water B, when fouling of the reverse osmosis membrane of the low-pressure reverse osmosis membrane device 16 increases.

Then, the pressure of nonpermeate water C is about 0.8 to 1.5 MPa. This pressure is released by the back pressure valve 18 described above. An ultrafiltration device may be used in place of the MBR water treatment device 11 of the wastewater treatment system 1. In addition, the piping 56 on a downstream side of the back pressure valve 18 may be configured to generate fine bubbles at a stage where the nonpermeate water C of the low-pressure reverse osmosis membrane device 16 is introduced into the intake tank 32. The detailed configurations will be described from the first embodiment to the fourth embodiment.

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<Seawater Desalination Treatment System 3>

Next, a schematic configuration of the seawater desalination treatment system 3 will be described with reference to FIG. 1. The seawater D is taken in by the intake pump 31 from an intake pipe 81 and is supplied through the intake pipe 82 to the intake tank 32 and stored therein. As described above, since the nonpermeate water C in the wastewater treatment system 1 is supplied to the intake tank 32 through the piping 56, the seawater D and nonpermeate water C are mixed in the intake tank 32 to become the "water to be treated" having lower salinity concentration than the seawater. Namely, the value of TDS also becomes a lower value than that of the seawater D. The "water to be treated" stored in the intake tank 32 is supplied through

the piping 83 to a pretreatment filtration device 34 under a predetermined pressure applied by the filtration pump 33. The pretreatment filtration device 34 may be, for example, any one of a UF device using Ultra Filtration membrane (UF membrane),
5 an MF device using Micro Filtration membrane (MF membrane), and a sand filtration device. In FIG. 1, "UF" meaning the UF device is typically shown in the pretreatment filtration device 34. In case of a use of the UF device as the pretreatment filtration device 34, the UF device is generally operated at 50 to 150 kPa.

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The "water to be treated" filtered by the pretreatment filtration device 34 is transferred through the piping 84 to a treated water tank 35 functioning as a buffer of flow of the "water to be treated", and temporarily stored therein. The
15 "water to be treated" in the treated water tank 35 is sucked by the supply pump 36 and supplied to the high-pressure pump 37 through the piping 85. The "water to be treated" is boosted up to about 3.5 to 6 MPa for example, and supplied to the supply port 38a of the "water to be treated" of the seawater reverse
20 osmosis membrane device (first reverse osmosis membrane device) 38. The seawater reverse osmosis membrane device 38 is configured to be arranged, for example, with a plurality of membrane module units in parallel as described in FIGS. 3 and 4 of Japanese Patent Application Publication No. 2001-149932.

Since the seawater reverse osmosis membrane device 38 is operated under higher pressure than the low-pressure reverse osmosis membrane device 16, material of the reverse osmosis membrane of the seawater reverse osmosis membrane device 38 has a performance which can withstand higher pressure than the low-pressure reverse osmosis membrane device 16. In addition, it is designed to increase the operation pressure in order to obtain the predetermined flow rate of the permeate water E, when the fouling or a value of TDS of the "water to be treated" supplied to the reverse osmosis membrane of the seawater reverse osmosis membrane device 38 increases.

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The "water to be treated" supplied under pressure from the supply port 38a is separated into the permeate water E purified through the reverse osmosis membrane, and the nonpermeate water G which is the "water to be treated" not permeated through the reverse osmosis membrane in the seawater reverse osmosis membrane device 38. The permeate water E is supplied from the permeate port 38b through the piping 87 for an external use corresponding to the water quality level as the product water E.

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The nonpermeate water G under the operation pressure of the seawater reverse osmosis membrane device 38 described above

is supplied from an outlet port 38c through a piping 89 to a high-pressure supply port 39d of a pressurized end portion 39b described later in an energy recovery device 39. The nonpermeate water G exchanges pressure directly with the "water to be treated" supplied pressure from the supply pump 36. Then, the nonpermeate water G is discharged from an outlet port 39e of the pressurized end portion 39b under regulation of the flow rate by a back pressure valve 40 provided in the middle of a piping 90. The nonpermeate water G is the seawater, brackish water, or brine water having concentrated salinity. The energy recovery device 39 is a device of direct pressure-exchange method in this basic embodiment, and is a well-known device mainly composed of a rotor part 39a rotationally driven by a motor (not shown) at a predetermined rotation speed, a pressurizing side end portion 39b, and a pressurized side end portion 39c.

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The piping 91 is bifurcated from the piping 85 at a branch point P1 of the piping 85 between the supply pump 36 and the high-pressure pump 37. A part of low-pressure "water to be treated" supplied by the supply pump 36 is supplied to the supply port 39g of the pressurized side end portion 39c in the energy recovery device 39. After the "water to be treated" supplied to the supply port 39g is pressurized by direct exchange of

pressure with the nonpermeate water G from the seawater reverse osmosis membrane 38, the "water to be treated" is further supplied to a booster pump 41 provided in the middle of the piping 92 from an outlet port 39f of the pressurized side end portion 39c. The booster pump 41 boosts up the "water to be treated" pressurized by the energy recovery device 39 to the same pressure as the high-pressure pump 37. The "water to be treated" from the piping 92 and the "water to be treated" supplied by the high-pressure pump 37 are joined together at a branch point P2 of the piping 86 on a downstream side of the high-pressure pump 37, and supplied to the supply port 38a of the seawater reverse osmosis membrane device 38.

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Thus, as the nonpermeate water G of the seawater reverse osmosis membrane device 38 has extremely high pressure, it is possible to recover and reuse the energy as energy supplying the "water to be treated" to the seawater reverse osmosis membrane device 38, thereby saving the power cost by decreasing a volume of the high-pressure pump 37. It is also possible to decrease the salinity concentration of the seawater D by mixing with the nonpermeate water C of the wastewater treatment system 1, thereby reducing the boost-up pressure required for the high-pressure pump 37 to about 3.5 MPa if the nonpermeate water C and the seawater D are diluted at approximately the same volume,

while the required pressure is about 6 MPa in case of only seawater. As a result, the power cost can be also reduced corresponding to the pressure decrease. In other words, the operation pressure of the seawater reverse osmosis membrane device 38 is higher than the operation pressure of the low-pressure reverse osmosis membrane device 16, so that the energy of the nonpermeate water G of the seawater reverse osmosis membrane device 38 can be recovered and the operation pressure of the seawater reverse osmosis membrane device 38 can be decreased.

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In addition, the transfer pump 12, the supply pump 14, the high-pressure pump 15, the intake pump 31, the filtration pump 33, the supply pump 36, the high-pressure pump 37, the booster pump 41, the rotor portion 39a of the energy recovery device (ERD) 39, and the like are integrated to be connected to a rotation axis of an unillustrated driving motor. An inverter device (not shown) supplying power to the driving motor is installed as a local panel or integrally attached to the driving motor. Then, the control device 6 is configured to control the rotation of the driving motor through the inverter.

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<Control Device 6>

Next, a summary of control of the control device 6 in the

basic embodiment will be described. The control device 6 is, for example, composed of a plurality of control units 60, 61, 63. Each of the control units 60, 61, 63 is provided with a CPU board including unillustrated CPU, ROM, RAM, and the like, I/O interface board, and the like. It is so configured that the control unit 60 controls a whole operation of the complex desalination system 100, the control unit 61 controls the wastewater treatment system 1, and the control unit 63 controls the seawater desalination treatment system 3. Therefore, the control unit 60 is connected communicably to the control units 61, 63 with one another. The control unit 61 includes a flow rate control part (not shown) as a function part that regulates a flow rate of the nonpermeate water C by regulating an open degree of the back pressure valve 18.

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The control unit 60 of the control device 6 is inputted from the outside with required flow rate commands C1, C2 of the product water B and the product water E in the complex desalination system 100. For example, the control unit 60 sets a target flow rate of the permeate water B of the wastewater treatment system 1 and controls the wastewater treatment system 1 by the control unit 61 on the basis of a flow rate of the wastewater supplied to the wastewater treatment system 1 (flow rate detected by a flow rate sensor S1 described later) and a

flow rate of the permeate water B (flow rate detected by the flow rate sensor S6 described later) in accordance with the required flow rate command C1. Further, the control unit 60 calculates a target flow rate of the permeate water E of the seawater desalination treatment system 3 and controls the seawater desalination treatment system 3 by the control unit 63 in accordance with the required flow rate command C2.

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The wastewater intake pipe 51 is provided with the flow rate sensor S1 detecting a flow rate of the wastewater A. The piping 54 is provided with the flow rate sensor S6 detecting a flow rate of the permeate water B. Then, the flow rate of the wastewater A and the flow rate of the permeate water B are inputted through the control unit 61 to the control unit 60. In addition, the piping 87 is provided with a flow rate sensor S20 detecting the flow rate of the permeate water E and the flow rate of the permeate water E is inputted to the control unit 60 through the control unit 63.

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The MBR water treatment device 11 is provided with, for example, a water level sensor S2. The control unit 61 controls a start and stop of the transfer pump 12 based on a water level signal from the water level sensor S2. The treated water tank 13 is provided with, for example, a water level sensor S3. The

control unit 61 controls a start and stop of the supply pump 14 and a rotation speed of the supply pump 14 in operation on the basis of a water level signal of the water level sensor S3 and a pressure signal from a pressure sensor S4 provided in the piping 53 on the suction side of the high-pressure pump 15. The control of the rotation speed of the supply pump 14 based on the pressure signal from the pressure sensor S4 is performed in order to apply a predetermined suction pressure to the high-pressure pump 15.

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The control unit 61 controls the rotation speed of the high-pressure pump 15 so that the flow rate of the permeate water B becomes the target flow rate thereof inputted from the control unit 60 on the basis of the flow rate signal of the permeate water B from the flow rate sensor S6 provided in the piping 54. Then, the control unit 61 performs the feedback control of the rotation speed of the high-pressure pump 15 so that the flow rate signal becomes constant on the basis of the flow rate signal from the flow rate sensor S5 provided in the piping 53 on the discharge side of the high-pressure pump 15. In addition, the feedback control of the rotation speed of the high-pressure pump 15 by the control unit 61 is appropriately corrected based on the deviation between the flow rate signal of the permeate water B and the target flow rate of the permeate water B.

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The piping 56 is provided with a flow rate sensor S7 detecting a flow rate of the nonpermeate water C of the low-pressure reverse osmosis membrane device 16. The above
5 flow rate control part of the control unit 61 controls the open degree of the back pressure valve 18 based on the flow rate signal from the flow rate sensor S7 so that a flow rate of the nonpermeate water C becomes a constant rate relative to the flow rate shown by the flow rate sensor S5 of the "water to be
10 treated".

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The intake pipe 82 is provided with a flow rate sensor S11 and the intake tank 32 is provided with a water level sensor S12. The control unit 63 controls a start and stop of the intake
15 pump 31 based on the water level signal from the water level sensor S12, sets a target intake flow rate of the seawater D based on the flow rate of the nonpermeate water C discharged from the wastewater treatment system 1 to the intake tank 32, and controls the rotation speed of the intake pump 31 based on
20 a flow rate signal from the flow rate sensor S11. For example, in a case where the flow rate of the nonpermeate water C and an intake flow rate of the seawater D are almost the same and the salinity concentration is decreased by mixing the seawater D and the nonpermeate water C in the intake tank 32, the operation

pressure of the seawater reverse osmosis membrane device 38 can be maintained, for example, at about 3.5 to 4 MPa.

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5 The control unit 63 controls a start and stop of the filtration pump 33 based on the water level signal from a water level sensor S14 provided in the treated water tank 35, controls the rotation speed of the filtration pump 33 to be a predetermined rotation speed based on the flow rate signal from the flow rate sensor S13 provided in the piping 84, pumps the 10 "water to be treated" in the intake tank 32 to the pretreatment filtration device 34 under a predetermined pressure, performs a primary treatment, and stores the primarily treated " water to be treated" in the treated water tank 35.

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15 Furthermore, the control unit 63 controls a start and stop of the supply pump 36 and the rotation speed of the supply pump 36 in operation based on the pressure signal from the pressure sensor S15 provided in the piping 85 on the suction side of the high-pressure pump 37. The control of the rotation speed of 20 the supply pump 36 based on the pressure signal from the pressure sensor S15 is performed in order to apply a predetermined suction pressure to the high-pressure pump 37.

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The control unit 63 regulates the rotation speeds of the

supply pump 36, high-pressure pump 37, and the booster pump 41 so that the flow rate of the permeate water E becomes the target flow rate thereof inputted from the control unit 60 based on a flow rate signal of the permeate water E from the flow rate sensor S20 provided in the piping 87. Then, the control unit 63 performs the feedback control of the rotation speed of the high-pressure pump 37 and the booster pump 41 so that the flow rate signal becomes constant on the basis of the flow rate signal from the flow rate sensor S16 provided in the piping 86 on the discharge side of the high-pressure pump 37 and the booster pump 41. In addition, the feedback control of the rotation speed of the high-pressure pump 37 and the booster pump 41 by the control unit 63 is appropriately corrected based on the deviation between the flow rate signal of the permeate water E and the target flow rate of the permeate water E.

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The piping 89 is provided with a flow rate sensor S19 detecting a flow rate of the nonpermeate water G of the seawater reverse osmosis membrane device 38. The control unit 63 controls an open degree of the back pressure valve 40 so that the flow rate of the nonpermeate water G becomes a constant rate relative to the flow rate shown by a flow rate sensor S16 of the "water to be treated".

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In this manner, the complex desalination system 100 of the basic embodiment mixes the seawater D taken in with the nonpermeate water C of the low-pressure reverse osmosis membrane device 16 discharged from the wastewater treatment system 1 to be the "water to be treated" in the seawater desalination system 3. Then the salinity concentration of the "water to be treated" in the seawater desalination system 3 can be reduced to about half of the salinity concentration of the seawater D taken in. Therefore, it is possible to decrease the operation pressure for operating the seawater reverse osmosis membrane device 38 largely compared with about 6MPa required for treating 100% seawater only, thereby saving the power cost.

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<<First Embodiment>>

Next, a complex desalination system 100A according to the first embodiment of the present invention will be described with reference to FIG. 2. FIG. 2 is a schematic block diagram of the complex desalination system according to the first embodiment of the present invention. Although a basic configuration of the complex desalination system 100A of the present embodiment is substantially the same as the complex desalination system 100 of the basic embodiment shown in FIG. 1, there are differences in which the control unit 6 is added with some functions, and as shown in X portion in FIG. 2, at

a branch point P5 of the piping 56 on the side of the intake tank 32, the piping 56 is bifurcated to a piping 57 (first piping) and a piping 58 (second piping), a pressure reducing valve (first valve) 17 is provided on the piping 57, a pressure sensor (fine bubble generation pressure detection unit) S9 is provided on the piping 57 on the downstream side, and a fine bubble generation part 19 is provided on the outlet portion of the piping 57 positioned below the water surface in the intake tank 32. In addition, the piping 58 is provided with a back pressure valve (second valve) 18. The fine bubble generation part 19 decompresses the nonpermeate water C rapidly from a predetermined pressure, so that the gases dissolved in the nonpermeate water C are generated as fine bubbles 105 of the sizes of the microbubbles and the nanobubbles and released into the "water to be treated" in the intake tank 32.

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Here, the piping 57, 58, the pressure reducing valve 17, the back pressure valve 18, and the fine bubble generation part 19 correspond to a "fine bubble generation unit" described in claims.

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Functions of the control units 60, 63 of the control device 6 according to the present embodiment are the same as the functions of the control units 60, 63 of the control device 6

in the complex desalination system 100 according to the basic embodiment. Although a function of the control unit 61 of the control device 6 in the present embodiment is substantially the same as the control unit 61 of the control device 6 in the complex desalination system 100, there are differences in which a flow rate control part (not shown) as the function part thereof regulates the flow rate of the nonpermeate water C by regulating the open degree of the back pressure valve 18, and has a control function of the fine bubbles generation at the fine bubble generation part 19. A duplicated description will be omitted by designating the same reference numerals in the same configuration as the complex desalination system 100, and a duplicated description will be also omitted in the same control function as the control device 6 in the basic embodiment.

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The flow rate control part as the above-mentioned function part of the control unit 61 in the present invention regulates the open degree of the pressure reducing valve 17 based on the pressure signal from the pressure sensor S9, decompresses the nonpermeate water C to a pressure suitable for generating the fine bubbles 105, for example, 0.5 MPa, and supplies the decompressed nonpermeate water C to the fine bubble generation part 19. Further, the above-mentioned flow rate control part of the control unit 61 regulates the open degree

of the back pressure valve 18 based on the flow rate signal of the flow rate sensor (flow rate detection unit) S7 so that the flow rate of the nonpermeate water C becomes a constant rate relative to the flow rate shown by the flow rate sensor S5 of the "water to be treated".

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According to the present embodiment, since the seawater desalination treatment system 3 uses the pretreatment filtration device 34 such as a UF membrane device, an MF membrane device, and a sand filtration device as a preceding treatment of the seawater reverse osmosis membrane device 38, it is possible to process to remove the organic matter contained in the nonpermeate water C and the seawater D. In particular, since the nonpermeate water C contains the organic matter more than double of that in the seawater D, the organic matter can be efficiently removed. In addition, the seawater D taken in may contain a large amount of organic matter and microorganisms depending on marine area or season, and normally contains the organic matter metabolized by the microorganisms.

{ 0045}

Then, by regulating the open degree of the pressure reducing valve 17 by the above-mentioned flow control part of the control unit 61 and introducing the nonpermeate water C into the intake tank 32 to decompress the pressure 0.8 to 1.5 MPa

of the nonpermeate water C to a pressure, for example, 0.5 MPa required for generating the fine bubbles 105 at the fine bubble generation part 19, it is possible to release the nonpermeate water C containing the fine bubbles 105 into the intake tank 32 without requiring any power. Further, since the pressure of the nonpermeate water C varies depending on the operation pressure of the low-pressure reverse osmosis membrane device 16, there is a case in which all of a predetermined flow rate of the nonpermeate water C cannot be released to the intake tank 32 through the piping 57 only by regulating the open degree of the pressure reducing valve 17. If the operation pressure of the low-pressure reverse osmosis membrane device 16 is high, the above-mentioned flow control part of the control unit 61 performs the feedback control of the open degree of the back pressure valve 18 so that the flow rate shown by the flow rate sensor S7 equals to a target flow rate of the nonpermeate water C. As a result, the generation control of the fine bubbles 105 by the above-mentioned flow control part of the control unit 61 does not cause any external disturbance to a processing amount of the wastewater treatment system 1.

{ 0046}

Further, by releasing the fine bubbles 105, i.e., the microbubbles and the nanobubbles from the fine bubble generation part 19 into the intake tank 32, it is possible to

decompose the organic matter in the intake tank 32 by the shock wave generated at the time of crush of the fine bubbles 105, and generate radicals to facilitate the decomposition of the organic matter. Therefore, clogging of the pretreatment
5 filtration device 34 is decreased and a treatment amount of the "water to be treated" increases before a backwash of the pretreatment filtration device 34 is necessary. In other words, it is possible to increase the time until the backwash of the pretreatment filtration device 34 is necessary, thereby
10 improving an operation availability of the complex desalination system 100A. Although the organic matter in the "water to be treated" increases by using the wastewater A as the organic wastewater for dilution of the seawater D, it is possible to decrease the frequency of the fouling of the reverse osmosis
15 membrane of the seawater reverse osmosis membrane device 38 in the seawater desalination treatment system 3, because the organic matter is decomposed by the fine bubbles 105.

{ 0047}

<<Second Embodiment>>

20 Next, a complex desalination system 100B according to a second embodiment will be described with reference to FIGS. 2 and 3. FIG. 3 is an enlarged explanatory diagram of an X portion in FIG. 2, and an explanatory diagram of a complex desalination system according to the second embodiment which is the complex

desalination system according to the first embodiment further combined with an ozone generator and an ozone injection pump. The complex desalination system 100B according to the second embodiment is different from the complex desalination system 100A according to the first embodiment in that, as shown in FIG. 3 as the X portion in FIG. 2, an ozone generator 45 and an ozone injection pump 46 are further provided, and the ozone gas generated by the ozone generator 45 is injected through an ozone injection portion P11 disposed on the piping 57 and dissolved into the nonpermeate water C which is decompressed to the above-mentioned predetermined pressure by the pressure reducing valve 17. Further, the complex desalination system 100B is different from the complex desalination system 100A in that the control device 6 in the second embodiment is added with a function of controlling the ozone generator 45 and the ozone injection pump 46 to the control unit 63 of the control device 6 in the first embodiment.

{ 0048}

The function of the control unit 63 in the second embodiment is different from the function of the control unit 63 in the first embodiment only in that the control unit 63 in the second embodiment is configured to newly include an ozone injection control part (not shown) as the function part of the control unit 63 in the complex desalination system 100 according

to the basic embodiment. Then, the above-mentioned ozone injection control part of the control unit controls the ozone generator 45 so as to generate the ozone gas corresponding to the target flow rate of the nonpermeate water C, and injects the generated ozone gas through the ozone injection portion P11 by controlling the rotation speed of the ozone injection pump 46 in response to the generation amount of the ozone gas.

{ 0049}

According to the present embodiment, the fine bubbles 105 has an effect of sterilizing the "water to be treated" in the intake tank 32 because it contains the ozone.

{ 0050}

<<Third and Fourth Embodiments>>

Next, the complex desalination systems 100C, 100D according to a third and fourth embodiments will be described with reference to FIGS. 2 and 4. FIG. 4 is an enlarged explanatory diagram of an X portion in FIG. 2, and an explanatory diagram of a complex desalination system according to the third embodiment which is the complex desalination system according to the first embodiment combined with a reaction tank, and a complex desalination system according to a fourth embodiment which is the complex desalination system according to the third embodiment further combined with an ozone generator and an ozone injection pump.

<Third Embodiment>

First, the complex desalination system 100C according to the third embodiment will be described. The complex desalination system 100C according to the third embodiment is different from the complex desalination system 100A according to the first embodiment in that, as shown in FIG. 4 as the X portion in FIG. 2, a reaction tank (first raw water tank) 47 is disposed at a preceding stage of the intake tank 32, and the fine bubble generation part 19 as the outlet portion of the piping 57 and the outlet of the piping 58 are disposed as with the first embodiment in a first compartment 47c₁ of the reaction tank 47. And, an outlet 96 of the reaction tank 47 is directly in communication with the intake tank 32. Then, the control device 6 in the first embodiment is used as the control device 6 in the present embodiment. In the present embodiment, the reaction tank 47 corresponds to a "first raw water tank" described in claims.

{ 0051}

The reaction tank 47 is divided into a plurality of compartments (partitioned compartments) 47c₁, 47c₂, 47c₃, and 47c₄ by a plurality of partition plates 47a and 47b. The partition plate 47a has a communication passage between itself and the bottom of the reaction tank 47, and the partition plate 47b is configured to have the lower portion connected to the

bottom of the reaction tank 47 and the upper portion which allows the "water to be treated" to move beyond the upper portion and be communicated with a neighboring compartment. The partition plates 47a, 47b are configured to be arranged so that the flow direction of the "water to be treated" is changed alternately in the vertical direction as shown by arrows Y in FIG. 4. The "water to be treated" flows into the intake tank 32 through the outlet 96 from the last compartment 47c₄ as shown by an arrow Z in FIG. 4.

10 { 0052}

By providing the reaction tank 47 at the preceding stage of the intake tank 32 in this manner, mixing of the fine bubbles 105 and the "water to be treated" is facilitated, and decomposition of the organic matter by the fine bubbles 105 is facilitated.

{ 0053}

<Fourth Embodiment>

Next, the complex desalination system 100D according to the fourth embodiment will be described. The complex desalination system 100D according to the fourth embodiment is the complex desalination system 100C according to the third embodiment which is added with the ozone generator 45 and the ozone injection pump 46 shown by dashed lines in FIG. 4, and controlled by the above-mentioned ozone injection control part

of the control unit 63 of the control device 6 in the second embodiment. In the present embodiment, the reaction tank 47 corresponds to a "first raw water tank" described in claims. { 0054}

5 According to the present embodiment, mixing of the ozone gas and the "water to be treated" in the reaction tank 47 is facilitated, and the sterilization effect for the "water to be treated" is higher than a case in the second embodiment. In the present embodiment, since there is a possibility that
10 surplus ozone gas is separated from a water surface of the "water to be treated" and released into the atmosphere, it is desirable that the separated ozone gas is collected by a cover over the reaction tank 47, treated, and released into the atmosphere. { 0055}

15 As understood from the above, according to the first to fourth embodiments, since the relatively low pressure 0.8 to 1.5 MPa of the nonpermeate water C of the wastewater treatment system 1 is utilized as the energy for generating the fine bubbles 105, the power is not necessary as in the conventional
20 cases in which the "water to be treated" is compressed by a motor pump and rapidly decompressed to generate the fine bubbles, or the air is compressed and released from micropores into the "water to be treated" to generate the fine bubbles, and it is possible to provide the complex desalination systems 100A to

100D which are reduced in the power cost. Further, it is possible to provide the complex desalination systems 100A to 100D which have the operation availability improved by reducing the frequency of the fouling of the reverse osmosis membrane of the seawater reverse osmosis membrane device 38 in the seawater desalination system 3.

{ 0056}

Although the device of the direct pressure-exchange method is described as the energy recovery device 39 in FIG. 2 in the first to fourth embodiments and the booster pump 41 is combined at a subsequent stage, it is not limited thereto. A turbocharger pump may be driven by the nonpermeate water G. In this case, the piping 89 and the piping 90 are respectively connected to an inlet and an outlet of turbine portion (driving portion) of the turbocharger pump, the downstream side of the piping 86 is connected to an inlet of the pump portion of the turbocharger pump, and an outlet of pump portion of the turbocharger pump is connected through piping to the supply port 38a. In such a method, the pressure of the nonpermeate water G can be also recovered. Incidentally, the piping 91, 92 and the booster pump 41 are not required in this case.

{ 0057}

Although the examples in which the fine bubble generation part 19 is provided in the intake tank 32 have been described

in the first to fourth embodiments, the fine bubble generation part 19 may be provided in the middle of the piping 57 on the downstream side of the pressure reducing valve 17, and generate the fine bubbles 105. Further, by providing a junction of the piping 57 and the piping 82, the fine bubble generation part 19 may be provided on a portion where the seawater D and the nonpermeate water C of the low-pressure reverse osmosis membrane device 16 are mixed, and generate the fine bubbles 105, and then the "water to be treated", which includes the fine bubbles 105 and is a mixture of the seawater D and the nonpermeate water C of the low-pressure reverse osmosis membrane device 16, may be stored in the intake tank 32. Furthermore, only the seawater D may be introduced and stored in the intake tank 32, a junction with the piping 57 may be provided on the upstream side of the filtration pump 33 of the piping 83, and the fine bubble generation part 19 may be provided on the junction or a portion where the seawater D and the nonpermeate water C of the low-pressure reverse osmosis membrane device 16 are mixed, and generate the fine bubbles 105.

20 (0058)

In the above-mentioned basic embodiment and the first to fourth embodiments, although the product water B and the product water E are supplied outside depending on each of water quality level, the product water B and the product water E may be mixed

and supplied outside.

{ Reference Signs List }

{ 0059 }

- 1: wastewater treatment system (second water treatment
5 system)
- 3: seawater desalination treatment system (first water
treatment system)
- 6: control device
- 11: MBR water treatment device
- 10 12: transfer pump
- 13: treated water tank
- 14: supply pump
- 15: high-pressure pump
- 16: low-pressure reverse osmosis membrane device (second
15 reverse osmosis membrane device)
- 16c: outlet port (outlet of nonpermeate water of second
reverse osmosis membrane device)
- 17: pressure reducing valve (first valve, fine bubble
generation unit)
- 20 18: backpressure valve (second valve, fine bubble generation
unit)
- 19: fine bubble generation part (fine bubble generation unit)
- 31: intake pump
- 32: intake tank (first raw water tank)

- 33: filtration pump
- 34: pretreatment filtration device
- 35: treated water tank
- 36: supply pump
- 5 37: high-pressure pump
- 38: seawater reverse osmosis membrane device (first reverse osmosis membrane device)
- 39: energy recovery device
- 40: backpressure valve
- 10 41: booster pump
- 45: ozone generator
- 46: ozone injection pump
- 47: reaction tank (first raw water tank)
- 47a, 47b: partition plate
- 15 81: intake pipe
- 56: piping (first piping, fine bubble generation unit)
- 57: piping (first piping, fine bubble generation unit)
- 58: piping (second piping, fine bubble generation unit)
- 60: control unit
- 20 61: control unit
- 63: control unit
- 100, 100A, 100B, 100C, 100D: complex desalination system
- 105: fine bubble
- A: wastewater (second raw water)

D: seawater (first raw water)

P5: branch point

P11: ozone injection portion

S7: flow rate sensor (flow rate detection unit)

5 S9: pressure sensor (fine bubble generation pressure
detection unit)

CLAIMS

1. A complex desalination system, comprising:

a first water treatment system that filters a first raw water of high salinity concentration with use of a first reverse osmosis membrane device; and

a second water treatment system that filters a second raw water of lower salinity concentration than the first raw water with use of a second reverse osmosis membrane device, wherein

the first water treatment system comprises a fine bubble generation unit that generates and discharges fine bubbles into the first raw water taken in, by rapidly decompressing a nonpermeate water discharged from the second reverse osmosis membrane device in the second water treatment system.

2. The complex desalination system as set forth in claim 1, wherein

the fine bubble generation unit comprises:

a first piping that connects an outlet of the nonpermeate water of the second reverse osmosis membrane device and a first raw water tank storing the first raw water taken in;

a first valve provided on the side of the first raw water tank of the first piping; and

a fine bubble generation part that is provided on a downstream side of the first valve of the first piping, and

generates and discharges gases dissolved in the first raw water as the fine bubbles by rapidly decompressing the nonpermeate water of the second reverse osmosis membrane device when introducing the nonpermeate water into the first raw water tank.

5

3. The complex desalination system as set forth in claim 2, wherein

the fine bubble generation unit further comprises:

a second piping that is bifurcated from the first piping at an upstream position of the first valve and connected to the first raw water tank; and

a second valve that is provided on the second piping and regulates a flow rate of the nonpermeate water of the second reverse osmosis membrane device.

15

4. The complex desalination system as set forth in claim 3, further comprising:

a flow rate detection unit that is provided on an upstream side of a branch point of the first piping to the second piping, and detects the flow rate of the nonpermeate water of the second reverse osmosis membrane device;

a fine bubble generation pressure detection unit that is provided on the first piping between the first valve and the fine bubble generation part, and detects a pressure of the

nonpermeate water of the second reverse osmosis membrane device which is decompressed by the first valve; and

a control unit that regulates a decompression degree of the first valve on the basis of a pressure signal from the fine bubble generation pressure detection unit, and regulates an open degree of the second valve so as to adjust the flow rate of the nonpermeate water of the second reverse osmosis membrane device to a predetermined flow rate on the basis of a flow rate signal from the flow rate detection unit.

10

5. The complex desalination system as set forth in claim 2, wherein the first raw water tank is divided into a plurality of compartments by a plurality of partition plates, allows a raw water discharged with the fine bubbles to change the flow direction thereof up and down alternatively, facilitates mixing of the raw water with the fine bubbles, and facilitates sterilization and decomposition of organic matter by crush of the fine bubbles.

15

20

6. The complex desalination system as set forth in claim 3, wherein the first raw water tank is divided into a plurality of compartments by a plurality of partition plates, allows a raw water discharged with the fine bubbles to change the flow direction thereof up and down alternatively,

facilitates mixing of the raw water with the fine bubbles,
and facilitates sterilization and decomposition of organic
matter by crush of the fine bubbles.

5 7. The complex desalination system as set forth in claim 4,
wherein the first raw water tank is divided into a plurality
of compartments by a plurality of partition plates, allows
a raw water discharged with the fine bubbles to change the
flow direction thereof up and down alternatively,
10 facilitates mixing of the raw water with the fine bubbles,
and facilitates sterilization and decomposition of organic
matter by crush of the fine bubbles.

8. The complex desalination system as set forth in claim 2,
15 further comprising
an ozone generator that generates ozone gas, wherein
an ozone injection portion, through which the ozone gas
generated by the ozone generator is injected, is provided on
the first piping between the first valve and the fine bubble
20 generation part.

9. The complex desalination system as set forth in claim 3,
further comprising
an ozone generator that generates ozone gas, wherein
25 an ozone injection portion, through which the ozone gas

generated by the ozone generator is injected, is provided on the first piping between the first valve and the fine bubble generation part.

5 10. The complex desalination system as set forth in claim 4, further comprising

an ozone generator that generates ozone gas, wherein
an ozone injection portion, through which the ozone gas
generated by the ozone generator is injected, is provided on
10 the first piping between the first valve and the fine bubble generation part.

11. The complex desalination system as set forth in claim 5, further comprising

15 an ozone generator that generates ozone gas, wherein
an ozone injection portion, through which the ozone gas
generated by the ozone generator is injected, is provided on
the first piping between the first valve and the fine bubble generation part.

20

12. The complex desalination system as set forth in claim 6, further comprising

an ozone generator that generates ozone gas, wherein
an ozone injection portion, through which the ozone gas
25 generated by the ozone generator is injected, is provided on

the first piping between the first valve and the fine bubble generation part.

13. The complex desalination system as set forth in claim 7,

5 further comprising

an ozone generator that generates ozone gas, wherein

an ozone injection portion, through which the ozone gas generated by the ozone generator is injected, is provided on the first piping between the first valve and the fine bubble

10 generation part.