SEAWATER DESALINATION SYSTEM
AND
SEAWATER DESALINATION METHOD

TECHNICAL FIELD

[0001]

The present invention relates to a seawater desalination system and a seawater desalination method.

BACKGROUND ART

[0002]

There have been known seawater desalination apparatuses that subject seawater to membrane separation treatment for generating fresh water. The seawater desalination apparatus, in which seawater is pressurized and supplied to a reverse osmosis membrane unit by a pump or the like for membrane separation treatment, requires more energy as the salt concentration of the seawater increases.

[0003]

With this being the situation, there has been proposed a seawater desalination system including a first processing part and a second processing part. The first processing part separates sewage that has a lower salt concentration than seawater into permeate and concentrate through membrane separation treatment. The second processing part separates a water mixture of seawater and the concentrate generated by the first processing part into permeate and concentrate through membrane separation treatment. The first processing part and the second processing part are controlled according to the quantity of the sewage (see Patent Document 1).

The seawater desalination system of Patent Document 1, in which a mixture of the sewage concentrate and seawater is subjected to membrane separation treatment and thus an increased amount of sewage reduces the salt concentration of the mixture, enables a reduction in the amount of energy required to treat the mixture to produce fresh water when compared to the case where seawater alone is subjected to membrane separation treatment.

PRIOR ART DOCUMENT

PATENT DOCUMENT

[0004]

Patent Document 1: Japanese Patent No. 4499835

SUMMARY OF THE INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[0005]

In the seawater desalination system of Patent Document 1, however, the first processing part and the second processing part are controlled according to the quantity of the sewage, and thus the quality of the generated fresh water depends on the quantity of the sewage. Here, the sewage is effluent obtained by filtrating organic waste water containing organic substances, inorganic waste water at manufacturing facilities, or the like water. This means that the quality and quantity of the sewage to be supplied is not stable. Accordingly, the seawater desalination system of Patent Document 1 has difficulty in ensuring the quality of the generated fresh water.

[0006]

The object of the present invention is to provide a seawater desalination system that enables a reduction in the energy required for generating fresh water and that ensures the quality of the generated fresh water.

MEANS TO SOLVE THE PROBLEM

[0006a]

In an aspect, there is provided a seawater desalination system comprising: a sewage-associated reverse osmosis membrane processing means that subjects sewage to membrane separation treatment for generating sewage-associated permeate and sewage-associated concentrate; and a seawater-associated reverse osmosis membrane processing means that subjects a water mixture of the sewage-associated concentrate and collected seawater to membrane separation treatment for generating seawater-associated permeate and seawater-associated concentrate and that has a salt concentration measuring means for measuring the salt concentration of the generated seawater-associated permeate, wherein the generated seawater-associated permeate is supplied to the sewage-associated reverse osmosis membrane processing means if the

salt concentration of the seawater-associated permeate measured by the salt concentration measuring means does not meet a predetermined reference value therefor.

[0006b]

In another aspect, there is provided a seawater desalination system comprising: a sewage-associated reverse osmosis membrane processing means that subjects sewage to membrane separation treatment for generating sewage-associated permeate and sewage-associated concentrate; the system further comprising: a seawater-associated reverse osmosis membrane processing means that pressurizes a water mixture of the sewage-associated concentrate and collected seawater using a pressure pump and subjects the pressurized water mixture to membrane separation treatment for generating seawater-associated permeate and seawater-associated concentrate wherein the seawater-associated reverse osmosis membrane processing means has a salt concentration measuring means for measuring the salt concentration of the generated seawater-associated permeate; and a control means that slows down the operation of the pressure pump of the seawater-associated reverse osmosis membrane processing means if the salt concentration of the seawater-associated permeate measured by the salt concentration measuring means does not meet a predetermined reference value therefor, wherein the control means controls to supply the seawater-associated permeate to the sewage-associated reverse osmosis membrane processing means according to the salt concentration of the seawater-associated permeate measured by the salt concentration measuring means, and the sewage-associated reverse osmosis membrane processing means subjects a water mixture of sewage and the seawater-associated permeate supplied from the seawater-associated reverse osmosis membrane processing means to membrane separation treatment.

[0006c]

In another aspect, there is provided a seawater desalination method comprising: a sewage-associated reverse osmosis membrane processing step of subjecting sewage to membrane separation treatment for generating sewage-associated permeate and sewage-associated concentrate; a seawater-associated reverse osmosis membrane processing step of subjecting a water mixture of the sewage-associated concentrate and

collected seawater to membrane separation treatment for generating seawater-associated permeate and seawater-associated concentrate; a salt concentration measuring step of measuring the salt concentration of the seawater-associated permeate; and a seawater-associated permeate recycling step of returning the seawater-associated permeate to the sewage-associated reverse osmosis membrane processing step according to the salt concentration of the seawater-associated permeate.

[0006d]

In another aspect, there is provided a seawater desalination method comprising: a sewage-associated reverse osmosis membrane processing step of subjecting sewage to membrane separation treatment for generating sewage-associated permeate and sewage-associated concentrate; a seawater-associated reverse osmosis membrane processing step of pressurizing a water mixture of the sewage-associated concentrate and collected seawater using a pressure pump and subjecting the pressurized water mixture to membrane separation treatment for generating seawater-associated permeate and seawater-associated concentrate; a salt concentration measuring step of measuring the salt concentration of the seawater-associated permeate; a continuation determination step of stopping continuation of the operation of the pressure pump in the seawater-associated reverse osmosis membrane processing step if the salt concentration of the seawater-associated permeate does not meet a predetermined reference value therefor; and a seawater-associated permeate recycling step of returning the seawater-associated permeate to the sewage-associated reverse osmosis membrane processing step according to the salt concentration of the seawater-associated permeate measured in the salt concentration measuring step, wherein the sewage-associated reverse osmosis membrane processing step is a step of subjecting a water mixture of sewage and the seawater-associated permeate returned in the seawater-associated permeate recycling step to membrane separation treatment.

[0007]

(1) A seawater desalination system characterized by comprising: a sewage-associated reverse osmosis membrane processing means that subjects sewage to membrane separation treatment for generating sewage-associated permeate and sewage-associated concentrate; and a seawater-associated reverse osmosis membrane processing means that subjects a water mixture of the sewage-associated concentrate and collected seawater to membrane separation treatment for generating seawater-associated permeate and seawater-associated concentrate and that has a salt concentration measuring means for measuring the salt concentration of the seawater-associated permeate, wherein the seawater-associated permeate is supplied to the sewage-associated reverse osmosis membrane processing means according to the salt concentration of the seawater-associated permeate measured by the salt concentration measuring means.

[0008]

According to the invention (1): the sewage-associated reverse osmosis membrane processing means subjects the sewage to membrane separation treatment for generating the sewage-associated permeate and the sewage-associated concentrate; and the seawater-associated reverse osmosis membrane processing means subjects the water mixture of the sewage-associated concentrate and the collected seawater to membrane separation treatment for generating the seawater-associated permeate and the seawater-associated concentrate and has a salt concentration measuring means for measuring the salt concentration of the seawater-associated permeate. The seawater-associated permeate is supplied to the sewage-associated reverse osmosis membrane processing means according to the salt concentration of the seawater-associated permeate.

[0009]

In the above configuration, in the seawater-associated reverse osmosis membrane processing means, the water mixture of the seawater and the sewage-associated concentrate having a lower salt concentration than the seawater is subjected to membrane separation treatment to generate the seawater-associated permeate as fresh water. Accordingly, energy required to generate the fresh water is reduced when compared to the case where the seawater that has a higher salt concentration than the water mixture is subjected to membrane separation treatment to generate the fresh water.

Further, for example, even when the quantity of the sewage decreases to cause a reduction in the quantities of the sewage-associated permeate and the sewage-associated concentrate generated by the sewage-associated reverse osmosis membrane processing means, leading to an increase in the salt concentration of the seawater-associated permeate, the sewage-associated reverse osmosis membrane processing means, the working ratio of which is dropped, can be used to subject the seawater-associated permeate with the high salt concentration to membrane separation treatment to enable the supply of the seawater-associated permeate that has a predetermined salt concentration.

Accordingly, there is provided a seawater desalination system that enables a reduction in the energy required for generating fresh water and that ensures the quality of the generated fresh water.

[0010]

(2) A seawater desalination system comprising: a sewage-associated reverse osmosis membrane processing means that subjects sewage to membrane separation treatment for generating sewage-associated permeate and sewage-associated concentrate, the system characterized by further comprising: a seawater-associated reverse osmosis membrane processing means that subjects a water mixture of the sewage-associated concentrate and collected seawater to membrane separation treatment for generating seawater-associated permeate and seawater-associated concentrate and that has a salt concentration measuring means for measuring the salt concentration of the seawater-associated permeate; and a control means for controlling operation of the sewage-associated reverse osmosis membrane processing means and the seawater-associated reverse osmosis membrane processing means according to the salt concentration of the seawater-associated permeate measured by the salt concentration measuring means.

[0011]

According to the invention (2), the sewage-associated reverse osmosis membrane processing means subjects the sewage to membrane separation treatment for generating the sewage-associated permeate and the sewage-associated concentrate; the seawater-associated reverse osmosis membrane processing means subjects the water mixture of the sewage-associated concentrate and the collected seawater to membrane separation treatment for generating the seawater-associated permeate and the seawater-associated concentrate and has the salt concentration measuring means for measuring the salt concentration of the seawater-associated permeate; and the control means controls operation of the sewage-associated reverse osmosis membrane processing means and the seawater-associated reverse osmosis membrane processing means according to the salt concentration of the seawater-associated permeate.

[0012]

In the above configuration, in the seawater-associated reverse osmosis membrane processing means, the water mixture of the seawater and the

sewage-associated concentrate having a lower salt concentration than seawater is subjected to membrane separation treatment to generate the seawater-associated permeate as the fresh water. Accordingly, the energy required to generate the fresh water is reduced when compared to the case where the seawater that has a higher salt concentration than the water mixture is subjected to membrane separation treatment to generate fresh water.

Further, since the sewage-associated reverse osmosis membrane processing means and the seawater-associated reverse osmosis membrane processing means are controlled according to the salt concentration of the seawater-associated permeate, which is the generated fresh water, the operation of the seawater-associated reverse osmosis membrane processing means can be slowed down to bring the salt concentration of the seawater-associated permeate back to a predetermined reference value, for example, when the salt concentration of the seawater-associated permeate is higher than the predetermined reference value.

Accordingly, there is provided a seawater desalination system that enables a reduction in the energy required for generating fresh water and that ensures the quality of the generated fresh water.

[0013]

(3) The seawater desalination system (2) characterized in that it further comprises a second seawater-associated reverse osmosis membrane processing means that subjects the seawater-associated permeate to membrane separation treatment, wherein the control means supplies the seawater-associated permeate to the second seawater-associated reverse osmosis membrane processing means according to the salt concentration of the seawater-associated permeate measured by the salt concentration measuring means.

[0014]

The invention (3) comprises the second seawater-associated reverse osmosis membrane processing means that subjects the seawater-associated permeate to membrane separation treatment.

In the above configuration, for example, even when the quantity of the sewage decreases to cause a reduction in the quantities of the sewage-associated permeate and the sewage-associated concentrate generated by the sewage-associated reverse osmosis

membrane processing means, leading to an increase in the salt concentration of the seawater-associated permeate, the second seawater-associated reverse osmosis membrane processing means subjects the seawater-associated permeate to membrane separation treatment to enable the supply of the seawater-associated permeate that has a predetermined salt concentration.

[0015]

(4) The seawater desalination system (2) characterized in that the control means controls to supply the seawater-associated permeate to the sewage-associated reverse osmosis membrane processing means according to the salt concentration of seawater-associated permeate measured by the salt concentration measuring means, and the sewage-associated reverse osmosis membrane processing means subjects a water mixture of the seawater-associated permeate supplied from the seawater-associated reverse osmosis membrane processing means and the sewage to membrane separation treatment.

[0016]

According to the invention (4), the seawater desalination system is configured such that the sewage-associated reverse osmosis membrane processing means subjects the seawater-associated permeate to membrane separation treatment according to the salt concentration of the seawater-associated permeate.

In the above configuration, for example, even when the quantity of the sewage decreases to cause a reduction in the quantities of the sewage-associated permeate and the sewage-associated concentrate generated by the sewage-associated reverse osmosis membrane processing means, leading to an increase in the salt concentration of the seawater-associated permeate, the sewage-associated reverse osmosis membrane processing means, the working ratio of which is dropped, can be used to subject the seawater-associated permeate to membrane separation treatment to enable the supply of the seawater-associated permeate that has a predetermined salt concentration.

[0017]

(5) Any one of the seawater desalination systems (2)-(4) characterized in that the seawater-associated reverse osmosis membrane processing means includes a reverse osmosis membrane having a proper desalination rate determined based on: a quantity and the salt concentration of the sewage supplied to the sewage-associated

reverse osmosis membrane processing means; a quantity and a salt concentration of the seawater supplied to the seawater-associated reverse osmosis membrane processing means; and a preset quantity and a preset salt concentration of the seawater-associated permeate to be generated by the seawater-associated reverse osmosis membrane processing means.

[0018]

Here, the reverse osmosis membrane varies in desalination rate ranging from approximately 55% to approximately 99%. In general, the reverse osmosis membrane processing means requires a pump that has a higher head capacity and consumes more energy as the desalination rate of the reverse osmosis membrane processing means increases.

According to the invention (5), by selecting the reverse osmosis membranes each having the proper desalination rate determined based on the quantity and the salt concentration of the sewage supplied to the sewage-associated reverse osmosis membrane processing means, and the quantity and the salt concentration of the seawater supplied to the seawater-associated reverse osmosis membrane processing means, and the preset quantity and the preset salt concentration of the seawater-associated permeate to be generated by the seawater-associated reverse osmosis membrane processing means, the pumps can be used with a proper energy efficiency, resulting in a further reduction in the energy required for generating the fresh water.

[0019]

(6) A seawater desalination system characterized by comprising: a sewage-associated reverse osmosis membrane processing means that subjects sewage to membrane separation treatment for generating sewage-associated permeate and sewage-associated concentrate; a seawater-associated reverse osmosis membrane processing means that subjects seawater to membrane separation treatment for generating seawater-associated permeate and seawater-associated concentrate; and a reserving system having a tank for reserving a permeate mixture of the sewage-associated permeate and the seawater-associated permeate and a water level gauge for measuring a water level of the permeate mixture reserved in the tank, wherein the reserving system activates or stops the seawater-associated reverse osmosis

membrane processing means according to the water level measured by the water level gauge.

[0020]

According to the invention (6), the sewage-associated reverse osmosis membrane processing means subjects the sewage to membrane separation treatment for generating the sewage-associated permeate and the sewage-associated concentrate; the seawater-associated reverse osmosis membrane processing means subjects the seawater to membrane separation treatment for generating the seawater-associated permeate and the seawater-associated concentrate; the reserving system has the tank for reserving the permeate mixture of the sewage-associated permeate and the seawater-associated permeate and a water level gauge for measuring the water level of the permeate mixture reserved in the tank; and the reserving system activates or stops the seawater-associated reverse osmosis membrane processing means according to the water level measured by the water level gauge.

[0021]

In the above configuration, in the seawater-associated reverse osmosis membrane processing means, the water mixture of the seawater and the sewage-associated concentrate having a lower salt concentration than seawater is subjected to membrane separation treatment to generate the seawater-associated permeate as a fresh water. Accordingly, energy required to generate the fresh water is reduced when compared to the case where the seawater that has a higher salt concentration than the water mixture is subjected to membrane separation treatment to generate the fresh water.

Further, since the seawater-associated reverse osmosis membrane processing means is activated or stopped according to the water level in the tank of the permeate mixture of the sewage-associated permeate and the seawater-associated permeate, for example if a sufficient quantity of the sewage-associated permeate is generated and a desired quantity of the fresh water is ensured, the seawater-associated reverse osmosis membrane processing means that requires more energy than the sewage-associated reverse osmosis membrane processing means can be stopped.

Accordingly, there is provided a seawater desalination system that enables a reduction in the energy required for generating fresh water and that ensures the quality of the generated fresh water.

[0022]

(7) The seawater desalination system (6) characterized in that the reserving system has a first salt concentration measuring means for measuring the salt concentration of the permeate mixture reserved in the tank, the sewage-associated reverse osmosis membrane processing means has a second salt concentration measuring means for measuring the salt concentration of the sewage-associated permeate generated, the seawater-associated reverse osmosis membrane processing means has a third salt concentration measuring means for measuring the salt concentration of the seawater-associated permeate generated and is activated or stopped according to the salt concentration of the seawater-associated permeate, the salt concentration of the sewage-associated permeate, and the salt concentration of the permeate mixture.

[0023]

According to invention (7), since the seawater-associated reverse osmosis membrane processing means is activated or stopped according to the salt concentration of the seawater-associated permeate, the salt concentration of the sewage-associated permeate, and the salt concentration of the permeate mixture, for example if either one of the salt concentration of the sewage-associated permeate and the salt concentration of the permeate mixture is higher than a predetermined reference value, the seawater-associated reverse osmosis membrane processing means can be stopped to bring the salt concentration of the permeate mixture back to the predetermined reference value or a lower value.

Accordingly, there is provided a seawater desalination system that enables a reduction in the energy required for generating fresh water and that ensures the quality of the generated fresh water.

[0024]

(8) A seawater desalination method characterized by comprising: a sewage-associated reverse osmosis membrane processing step of subjecting sewage to membrane separation treatment for generating sewage-associated permeate and sewage-associated concentrate; a seawater-associated reverse osmosis membrane

processing step of subjecting a water mixture of the sewage-associated concentrate and collected seawater to membrane separation treatment for generating seawater-associated permeate and seawater-associated concentrate; a salt concentration measuring step of measuring the salt concentration of the seawater-associated permeate; and a seawater-associated permeate recycling step of returning the seawater-associated permeate to the sewage-associated reverse osmosis membrane processing step according to the salt concentration of the seawater-associated permeate.

The invention (8) has the same effects as the invention (1).

[0025]

(9) A seawater desalination method characterized by comprising: a sewage-associated reverse osmosis membrane processing step of subjecting sewage to membrane separation treatment for generating sewage-associated permeate and sewage-associated concentrate, the seawater desalination method comprising: a seawater-associated reverse osmosis membrane processing step of subjecting a water mixture of the sewage-associated concentrate and collected seawater to membrane separation treatment for generating seawater-associated permeate and seawater-associated concentrate; a salt concentration measuring step of measuring the salt concentration of the seawater-associated permeate; and a continuation determination step of determining continuation of the sewage-associated reverse osmosis membrane processing step and the seawater-associated reverse osmosis membrane processing step according to the salt concentration of the seawater-associated permeate.

The invention (9) has the same effects as the invention (2).

[0026]

(10) The seawater desalination method (9) characterized in that it further comprises a second seawater-associated reverse osmosis membrane processing step of subjecting the seawater-associated permeate to membrane separation treatment, wherein in the second seawater-associated reverse osmosis membrane processing step, the seawater-associated permeate is treated according to the salt concentration of the seawater-associated permeate measured in the salt concentration measuring step.

The invention (10) has the same effects as the invention (3).

[0027]

(11) The seawater desalination method (9) characterized in that it further comprises a seawater-associated permeate recycling step of returning the seawater-associated permeate to the sewage-associated reverse osmosis membrane processing step according to the salt concentration of seawater-associated permeate measured in the salt concentration measuring step, wherein the sewage-associated reverse osmosis membrane processing step is a step of subjecting a water mixture of the sewage and the seawater-associated permeate returned to the seawater-associated permeate recycling step to membrane separation treatment.

The invention (11) has the same effects as the invention (4).

[0028]

(12) A seawater desalination method characterized by comprising: a sewage-associated reverse osmosis membrane processing step of subjecting sewage to membrane separation treatment for generating sewage-associated permeate and sewage-associated concentrate; a seawater-associated reverse osmosis membrane processing step of subjecting seawater to membrane separation treatment for generating seawater-associated permeate and seawater-associated concentrate; a reserving step of reserving a permeate mixture of the sewage-associated permeate and the seawater-associated permeate in a tank; a water level measuring step of measuring a water level of the permeate mixture reserved in the tank; and a determining step of determining whether or not to carry out the seawater-associated reverse osmosis membrane processing step according to the water level measured in the water level measuring step.

The invention (12) has the same effects as the invention (6).

[0029]

(13) The seawater desalination method (12) characterized in that it further comprises: a first salt concentration measuring step of measuring the salt concentration of the permeate mixture reserved in the tank; a second salt concentration measuring step of measuring the salt concentration of the sewage-associated permeate generated in the sewage-associated reverse osmosis membrane processing step; and a third salt concentration measuring step of measuring the salt concentration of the seawater-associated permeate generated in the seawater-associated reverse osmosis membrane processing step, wherein the determining step determines whether or not to

carry out the seawater-associated reverse osmosis membrane processing step according to the salt concentration of the seawater-associated permeate, the salt concentration of the sewage-associated permeate, and the salt concentration of the permeate mixture.

The invention (13) has the same effects as the invention (7).

EFFECTS OF THE INVENTION

[0030]

The present invention provides a seawater desalination system and a seawater desalination method that enable a reduction in the energy required for generating fresh water and that ensure the quality of the generated fresh water.

BRIEF DESCRIPTION OF THE DRAWINGS

[0031]

FIG. 1 is a schematic view showing a configuration of a seawater desalination system according to First Embodiment of the present invention.

FIG. 2 is a schematic view showing a configuration of a seawater desalination system according to Second Embodiment of the present invention.

FIG. 3 is a schematic view showing a configuration of a seawater desalination system according to Third Embodiment of the present invention.

EMBODIMENTS FOR CARRYING OUT THE INVENTION

[0032]

<First Embodiment>

With reference to FIG. 1, there will be described a seawater desalination system 1A according to First Embodiment of the present invention. FIG. 1 is a schematic view showing the configuration of the seawater desalination system 1A according to the First Embodiment of the present invention.

[0033]

As shown in FIG. 1, the seawater desalination system 1A according to the First Embodiment includes a sewage-associated reverse osmosis membrane processing means 10A, a seawater-associated reverse osmosis membrane processing means 20A, and a control means 100A. The seawater desalination system 1A is an apparatus that subjects sewage W10 to membrane separation treatment for generating

sewage-associated permeate W11 as fresh water and seawater W20 to membrane separation treatment for generating seawater-associated permeate W21 as fresh water.

The seawater W20 in the present specification refers to water present in the sea, lakes, swamps, ponds, etc., and having a salt concentration of approximately 1.0 mass % to approximately 4.0 mass %. The sewage W10 in the present specification refers to effluent obtained by filtrating organic waste water containing organic substances, inorganic waste water produced at manufacturing facilities, or the like water and having a salt concentration lower than the seawater W20. Fresh water in the present specification refers to water having a low salt concentration.

[0034]

The sewage-associated reverse osmosis membrane processing means 10A subjects the sewage W10 to membrane separation treatment for generating the sewage-associated permeate W11 and sewage-associated concentrate W12.

The seawater-associated reverse osmosis membrane processing means 20A subjects a water mixture of the sewage-associated concentrate W12 and the seawater W20 to membrane separation treatment for generating the seawater-associated permeate W21 and seawater-associated concentrate W22.

The seawater-associated reverse osmosis membrane processing means 20A has an electric conductivity meter (hereinafter, referred to as the "EC meter") 230 for measuring a salt concentration of the generated seawater-associated permeate W21.

The control means 100A controls the operation of the sewage-associated reverse osmosis membrane processing means 10A and the seawater-associated reverse osmosis membrane processing means 20A according to the measured salt concentration of the seawater-associated permeate W21.

[0035]

The seawater desalination system 1A operates in such a manner that if the salt concentration of the seawater-associated permeate W21 satisfies criteria for allowing the seawater-associated permeate W21 to flow to a supplying system (not shown) that uses permeate, the seawater-associated permeate W21 is supplied to the supplying system, and if the salt concentration of the seawater-associated permeate W21 does not satisfy the criteria for allowing the seawater-associated permeate W21 to flow to the

supplying system, the seawater-associated permeate W21 is recycled through the sewage-associated reverse osmosis membrane processing means 10A.

In the following paragraphs, the configurations of the components of the seawater desalination system 1A will be described in detail.

[0036]

The sewage-associated reverse osmosis membrane processing means 10A includes at least a sewage line L10, a sewage-associated pretreatment module 11, a sewage-associated reverse osmosis membrane module 12, a pressure pump 13, a sewage-associated permeate line L11A, and a sewage-associated concentrate line L12.

The sewage line L10 introduces the sewage W10 from the outside of the seawater desalination system 1.

The sewage-associated pretreatment module 11 is disposed on the sewage line L10 and filters out sludge contained in the sewage W10.

The sewage-associated reverse osmosis membrane module 12 is connected to the sewage line L10 and subjects the sewage W10 to membrane separation treatment for generating the sewage-associated permeate W11 and the sewage-associated concentrate W12.

The pressure pump 13 is disposed upstream from the sewage-associated reverse osmosis membrane module 12 on the sewage line L10.

The sewage-associated permeate line L11A is connected to the sewage-associated reverse osmosis membrane module 12.

The sewage-associated concentrate line L12 is connected to the sewage-associated reverse osmosis membrane module 12.

It should be noted that the term "line" in the present specification refers to a line that enables a fluid to flow through it, and is meant to include a channel, a pathway, a pipe line, etc.

[0037]

The sewage line L10 extends from the outside of the seawater desalination system 1A to the sewage-associated reverse osmosis membrane module 12 via the sewage-associated pretreatment module 11. The sewage line L10 supplies the sewage W10 to the sewage-associated reverse osmosis membrane module 12 after the sludge is removed from the sewage W10 by the sewage-associated pretreatment module 11.

[0038]

The sewage-associated pretreatment module 11 is disposed upstream from the sewage-associated reverse osmosis membrane module 12 on the sewage line L10 and filters out and removes the sludge from the sewage W10 by a membrane-separation activated sludge treatment method. In the present embodiment the sewage-associated pretreatment module 11 includes a microfiltration membrane or an ultrafiltration membrane (not shown) serving as a filtration medium.

It should be noted that the filtration membrane used in the sewage-associated pretreatment module 11 of the present embodiment is not limited to the microfiltration membrane or the ultrafiltration membrane but may be any filter device that can remove the sludge from the sewage W10.

[0039]

The sewage-associated reverse osmosis membrane module 12 is connected to the end on the downstream side of the sewage line L10. The sewage-associated reverse osmosis membrane module 12 subjects the sewage W10 to membrane separation treatment using a reverse osmosis membrane (hereinafter, also referred to as the "RO membrane") after the sludge is removed from the sewage W10 by the sewage-associated pretreatment module 11 and thereby generates the sewage-associated permeate W11 and the sewage-associated concentrate W12.

The sewage-associated reverse osmosis membrane module 12 includes a single or a plurality of RO membrane elements (not shown) for removing dissolved salts from the water. The RO membrane element has a membrane with a proper desalination rate that is selected based on the quantity and the salt concentration of the sewage W10 supplied to the sewage-associated reverse osmosis membrane processing means 10A.

The pressure pump 13 is disposed on the sewage line L10. The pressure pump 13 pressurizes the sewage W10 and supplies the sewage W10 to the sewage-associated reverse osmosis membrane module 12.

[0040]

The sewage-associated permeate line L11A and the sewage-associated concentrate line L12 are connected to the downstream side of the sewage-associated reverse osmosis membrane module 12.

The sewage-associated permeate line L11A is a line for the sewage-associated permeate W11 to flow through to be discharged to the outside of the seawater desalination system 1A. The sewage-associated permeate W11 is water having permeated through the RO membrane.

The sewage-associated concentrate line L12 is a line for the sewage-associated concentrate W12 to flow through. The sewage-associated concentrate W12 is water having not permeated through the RO membrane. The sewage-associated concentrate line L12 is connected to the seawater-associated reverse osmosis membrane processing means 20A. The sewage-associated concentrate line L12 supplies the sewage-associated concentrate W12 to the seawater-associated reverse osmosis membrane processing means 20A.

[0041]

The seawater-associated reverse osmosis membrane processing means 20A includes a seawater line L20A, a seawater-associated pretreatment module 21, a seawater-associated reverse osmosis membrane module 22, a pressure pump 23, a seawater-associated permeate line L21A, a seawater-associated concentrate line L22, a seawater-associated salt concentration measurement line L23, the EC meter 230, a seawater-associated permeate discharging line L24, and a seawater-associated permeate recycling line L25.

The seawater line L20A supplies the seawater W20 from the outside of the seawater desalination system 1.

The seawater-associated pretreatment module 21 is disposed on the seawater line L20A. The seawater-associated pretreatment module 21 has a sand filter, UF (ultrafiltration membrane), etc., to filter out suspended bacteria, etc. (hereinafter, also referred to as the "bacteria, viruses, SS (suspended substances), etc.") that are contained in the seawater W20.

The seawater-associated reverse osmosis membrane module 22 is connected to the seawater line L20A. The seawater-associated reverse osmosis membrane module 22 subjects the seawater W20 to membrane separation treatment for generating the seawater-associated permeate W21 and the seawater-associated concentrate W22.

The pressure pump 23 is disposed upstream from the seawater-associated reverse osmosis membrane module 22 on the seawater line L20A.

The seawater-associated permeate line L21A is connected to the seawater-associated reverse osmosis membrane module 22.

The seawater-associated concentrate line L22 is connected to the seawater-associated reverse osmosis membrane module 22.

The seawater-associated salt concentration measurement line L23 branches from the seawater-associated permeate line L21A.

The EC meter 230 measures the salt concentration of the seawater-associated permeate W21 supplied to the seawater-associated permeate line L21A through the seawater-associated salt concentration measurement line L23.

The seawater-associated permeate discharging line L24 branches from the seawater-associated permeate line L21A.

The seawater-associated permeate recycling line L25 branches from the seawater-associated permeate line L21A.

[0042]

The seawater line L20A extends from the outside of the seawater desalination system 1A to the seawater-associated reverse osmosis membrane module 22 via the seawater-associated pretreatment module 21. The sewage-associated concentrate line L12 is connected to the seawater line L20A at a sewage-associated concentrate line junction J12 between the seawater-associated pretreatment module 21 and the seawater-associated reverse osmosis membrane module 22.

The pressure pump 23 is disposed on the seawater line L20A. The pressure pump 23 pressurizes and supplies to the seawater-associated reverse osmosis membrane module 22 a water mixture of the seawater W20 from which the bacteria, SS, etc. have been removed by the seawater-associated pretreatment module 21 and the sewage-associated concentrate W12 supplied from the sewage-associated reverse osmosis membrane processing means 10A.

[0043]

The seawater-associated pretreatment module 21 is disposed upstream from the seawater-associated reverse osmosis membrane module 22 on the seawater line L20A. The seawater-associated pretreatment module 21 filters out and removes the bacteria, viruses, SS, etc., from the seawater W20 through membrane separation treatment. In the present Embodiment, the seawater-associated pretreatment module 21 filtrates the

seawater W20 through a sand bed, and then subjects the resulting seawater W20 to membrane separation treatment using the ultrafiltration membrane (not shown).

It should be noted that the filtration membrane used in the seawater-associated pretreatment module 21 of the present embodiment is not limited to the ultrafiltration membrane but may be any that can remove the bacteria, viruses, SS from the seawater W20 such as the microfiltration membrane.

[0044]

The seawater-associated reverse osmosis membrane module 22 is disposed on the downstream side of the seawater line L20A. The seawater-associated reverse osmosis membrane module 22 subjects the water mixture of the seawater W20 from which the bacteria, viruses, SS, etc. have been removed by the seawater-associated pretreatment module 21 and the sewage-associated concentrate W12 supplied from the sewage-associated reverse osmosis membrane processing means 10A to membrane separation treatment using a reverse osmosis membrane for generating the seawater-associated permeate W21 and the seawater-associated concentrate W22.

The seawater-associated reverse osmosis membrane module 22 includes a single or a plurality of RO membrane elements (not shown) for removing dissolved salts from the water. The RO membrane element has a membrane with a proper desalination rate that is selected based on the quantity and the salt concentration of the seawater W20 supplied to the seawater-associated reverse osmosis membrane processing means 20A, and the preset quantity and the preset salt concentration of the seawater-associated permeate W21 to be generated by the seawater-associated reverse osmosis membrane processing means 20A.

[0045]

The seawater-associated permeate line L21A and the seawater-associated concentrate line L22 are connected to the downstream side of the seawater-associated reverse osmosis membrane module 22.

The seawater-associated permeate line L21A is a line for the seawater-associated permeate W21 to flow through. The seawater-associated permeate W21 is water having permeated through the RO membrane. Connected to the seawater-associated permeate line L21A are the seawater-associated salt concentration measurement line L23 and the seawater-associated permeate discharging line L24 in

this order from the upstream side. A seawater-associated permeate recycling valve 250 is disposed at the end on the downstream side of the seawater-associated permeate line L21A. The seawater-associated permeate line L21A is connected via the seawater-associated permeate recycling valve 250 to the seawater-associated permeate recycling line L25. The seawater-associated permeate line L21A enables the seawater-associated permeate W21 to be recycled through the sewage-associated reverse osmosis membrane processing means 10A.

[0046]

The seawater-associated concentrate line L22 is a line for the seawater-associated concentrate W22 to flow through to be discharged to the outside of the seawater desalination system 1A. The seawater-associated concentrate W22 is water having not permeated through the RO membrane.

The seawater-associated salt concentration measurement line L23 branches from the seawater-associated permeate line L21A at a salt concentration measuring line branch point J23 and supplies the seawater-associated permeate W21 to the seawater-associated permeate EC meter 230 that serves as the salt concentration measuring means.

The seawater-associated permeate EC meter 230, in a salt concentration measuring step, measures the conductivity of the seawater-associated permeate W21 flowing through the seawater-associated salt concentration measurement line L23 and converts the measured conductivity into salt concentration. The seawater-associated permeate EC meter 230 is connected to the control means 100A and the measured conductivity or calculated salt concentration of the seawater-associated permeate W21 is transmitted to the control means 100A.

[0047]

The seawater-associated permeate discharging line L24 branches from the seawater-associated permeate line L21A at a seawater-associated permeate discharging line branch point J24 and enables the seawater-associated permeate W21 to be discharged via a seawater-associated permeate discharging valve 240 to the supplying system (not shown).

The seawater-associated permeate discharging valve 240 is a solenoid valve or a motor-operated valve controlled by the control means 100A. The seawater-associated

permeate discharging valve 240 allows the flow of the seawater-associated permeate W21 to the supplying system if the salt concentration of the seawater-associated permeate W21 satisfies the criteria for allowing the seawater-associated permeate W21 to flow to the supplying system, and prevents the flow of the seawater-associated permeate W21 to the supplying system if the salt concentration of the seawater-associated permeate W21 does not satisfy the criteria for allowing the seawater-associated permeate W21 to flow to the supplying system.

[0048]

The seawater-associated permeate recycling line L25 extends from the seawater-associated permeate recycling valve 250 to a seawater-associated permeate recycling line junction J25 on the sewage line L10. The seawater-associated permeate recycling line L25 enables the recycling of the seawater-associated permeate W21 through the sewage-associated reverse osmosis membrane processing means 10A.

The seawater-associated permeate recycling valve 250 is a solenoid valve or a motor-operated valve controlled by the control means 100A. The seawater-associated permeate recycling valve 250 prevents the recycling of the seawater-associated permeate W21 through the sewage-associated reverse osmosis membrane processing means 10A if the salt concentration of the seawater-associated permeate W21 satisfies the criteria for allowing the seawater-associated permeate W21 to flow to the supplying system (not shown). The seawater-associated permeate recycling valve 250 allows the recycling of the seawater-associated permeate W21 through the sewage-associated reverse osmosis membrane processing means 10A if the salt concentration of the seawater-associated permeate W21 does not satisfy the criteria for allowing the seawater-associated permeate W21 to flow to the supplying system.

[0049]

The control means 100A is connected electrically to components of the seawater desalination system 1A that the control means 100A controls. More specifically, the control means 100A controls the pressure pump 13, the pressure pump 23, the seawater-associated permeate discharging valve 240, and the seawater-associated permeate recycling valve 250 according to the salt concentration of the seawater-associated permeate W21 measured by the seawater-associated permeate EC meter 230.

[0050]

Now, the operations of the seawater desalination system 1A will be described.

First, the control means 100A controls the operation of the pressure pump 13 and the pressure pump 23.

With this control, the sewage-associated reverse osmosis membrane processing means 10A is started and the sewage W10, which has been supplied from the outside of the seawater desalination system 1A, and from which the sludge has been removed by the sewage-associated pretreatment module 11, is introduced into the sewage-associated reverse osmosis membrane module 12. The sewage W10 introduced in the sewage-associated reverse osmosis membrane module 12 is subjected to membrane separation treatment to generate the sewage-associated permeate W11 and the sewage-associated concentrate W12. The sewage-associated permeate W11 is discharged to the outside of the seawater desalination system 1A and the sewage-associated concentrate W12 is supplied to the seawater-associated reverse osmosis membrane processing means 20A.

When the seawater-associated reverse osmosis membrane processing means 20A is started, the seawater W20, which has been supplied from the outside of the seawater desalination system 1A, and from which the bacteria, viruses, SS, etc. have been removed by the seawater-associated pretreatment module 21, is mixed with the sewage-associated concentrate W12, which has been supplied from the sewage-associated reverse osmosis membrane processing means 10A. The resulting water mixture is introduced into the seawater-associated reverse osmosis membrane module 22. In the seawater-associated reverse osmosis membrane module 22, the water mixture of the seawater W20 and the sewage-associated concentrate W12 is subjected to membrane separation treatment to generate the seawater-associated permeate W21 and the seawater-associated concentrate W22. The generated seawater-associated permeate W21 is supplied to the seawater-associated permeate line L21A and the generated seawater-associated concentrate W22 is discharged to the outside of the seawater desalination system 1A.

[0051]

The seawater-associated permeate EC meter 230 measures the salt concentration of the seawater-associated permeate W21 supplied to the

seawater-associated permeate line L21A. The measured salt concentration is transmitted to the control means 100A.

The control means 100A carries out the following processing in a continuation determined step.

In the step, the control means 100A opens the seawater-associated permeate discharging valve 240 and closes the seawater-associated permeate recycling valve 250 if the salt concentration of the seawater-associated permeate W21 transmitted from the seawater-associated permeate EC meter 230 satisfies the criteria for allowing the seawater-associated permeate W21 to flow to the supplying system (not shown).

With this control, the seawater-associated permeate W21 is supplied to the supplying system.

[0052]

The control means 100A, in a seawater-associated permeate recycling step, controls to open the seawater-associated permeate recycling valve 250, close the seawater-associated permeate discharging valve 240 and reduce the output of the pressure pump 23 to lower the flow rate of the water mixture if the salt concentration of the seawater-associated permeate W21 transmitted from the seawater-associated permeate EC meter 230 does not satisfy the criteria for allowing the seawater-associated permeate W21 to flow to the supplying system.

With this control, the seawater-associated permeate W21 is recycled through the seawater-associated permeate recycling line L25 in the sewage-associated reverse osmosis membrane processing means 10A and is subjected again to membrane separation treatment by the sewage-associated reverse osmosis membrane processing means 10A and by the seawater-associated reverse osmosis membrane processing means 20A. Further, the quantity of the seawater W20 to flow into the seawater-associated reverse osmosis membrane processing means 20A is reduced.

[0053]

The seawater desalination system 1A according to the First Embodiment has the following effects.

Since in the seawater-associated reverse osmosis membrane processing means 20A, the water mixture of the seawater W20 and the sewage-associated concentrate W12 having a lower salt concentration than seawater W20 is subjected to membrane

separation treatment to generate the seawater-associated permeate W21 as the fresh water, the energy required to generate the fresh water is reduced when compared to the case where the seawater W20 that has a higher salt concentration than the water mixture is subjected to membrane separation treatment to generate fresh water.

Further, for example, when the quantity of the sewage W10 decreases to cause a reduction in the quantities of the sewage-associated permeate W11 and the sewage-associated concentrate W12 generated by the sewage-associated reverse osmosis membrane processing means 10A, leading to an increase in the salt concentration of the seawater-associated permeate W21, the sewage-associated reverse osmosis membrane processing means 10A, the working ratio of which is dropped, can be used to subject the seawater-associated permeate W21 that has an increased salt concentration to membrane separation treatment to enable the supply of the seawater-associated permeate W21 that has a predetermined salt concentration.

Accordingly, there is provided a seawater desalination system 1A that enables a reduction in the energy required for generating fresh water and that ensures the quality of the generated fresh water.

[0054]

Further, since the sewage-associated reverse osmosis membrane processing means 10A and the seawater-associated reverse osmosis membrane processing means 20A are controlled according to the salt concentration of the seawater-associated permeate W21 as the generated fresh water, the operation of the seawater-associated reverse osmosis membrane processing means 20A can be slowed down to return the salt concentration of the seawater-associated permeate to a predetermined value, for example, when the salt concentration of the seawater-associated permeate W21 does not satisfy the criteria for allowing the seawater-associated permeate W21 to flow to the supplying system.

[0055]

Moreover, by selecting reverse osmosis membranes each having a desalination rate determined to be proper based on the quantity and the salt concentration of the sewage W10 supplied to the sewage-associated reverse osmosis membrane processing means 10A, and the quantity and the salt concentration of the seawater W20 supplied to the seawater-associated reverse osmosis membrane processing means 20A, and the

preset quantity and the preset salt concentration of the seawater-associated permeate W21 to be generated by the seawater-associated reverse osmosis membrane processing means 20A, the pumps 13, 23 can be used with a proper energy efficiency, resulting in a further reduction in the energy required for generating the fresh water.

[0056]

<Second Embodiment>

Now, Second Embodiment of the present invention will be described. In the following description, differences of the Second Embodiment from the First Embodiment will be mainly described. Like components of the Second Embodiment are referred to by like numerals of First Embodiment and detailed descriptions of the components will be omitted. With regards to features of the Second Embodiment not specifically described, the descriptions of the First Embodiment will apply to the Second Embodiment.

[0057]

With reference to FIG. 2, a seawater desalination system 1B according to the Second Embodiment will be described. FIG. 2 is a schematic view showing the configuration of the seawater desalination system 1B according to the Second Embodiment of the present invention.

The seawater desalination system 1B according to the Second Embodiment differs from the seawater desalination system 1A according to the First Embodiment in the configurations of the seawater line, the seawater-associated permeate line, and the control means of the seawater-associated reverse osmosis membrane processing means. Further, the seawater desalination system 1B according to the Second Embodiment includes a second seawater-associated reverse osmosis membrane processing means 30 that is absent in the seawater desalination system 1A according to the First Embodiment.

The seawater desalination system 1B allows the flow of the seawater-associated permeate W21 to the supplying system (not shown) if the salt concentration of the seawater-associated permeate W21 satisfies criteria for allowing the flow of the seawater-associated permeate W21 to the supplying system. The seawater desalination system 1B allows the seawater-associated permeate W21 to be subjected further to membrane separation treatment in the second seawater-associated

reverse osmosis membrane processing means 30 if the salt concentration of the seawater-associated permeate W21 does not satisfy the criteria for allowing the seawater-associated permeate W21 to flow to the supplying system.

[0058]

A seawater-associated reverse osmosis membrane processing means (a first seawater-associated reverse osmosis membrane processing means) 20B has a seawater line L20B extending from the outside of the seawater desalination system 1B via the seawater-associated pretreatment module 21 to the seawater-associated reverse osmosis membrane module (a first seawater-associated reverse osmosis membrane module) 22. The sewage-associated concentrate line L12 is connected to the seawater line L20B at the sewage-associated concentrate line junction J12 between the seawater-associated pretreatment module 21 and the seawater-associated reverse osmosis membrane module 22. Further, a seawater-associated re-concentrate line L32 is connected to the seawater line L20B at a seawater-associated re-concentrate line junction J32 between the sewage-associated concentrate line junction J12 and the seawater-associated reverse osmosis membrane module 22.

[0059]

The seawater-associated reverse osmosis membrane processing means 20B has a seawater-associated permeate line L21B connected to the downstream side of the seawater-associated reverse osmosis membrane module 22.

The seawater-associated permeate line L21B is a line for the seawater-associated permeate W21 to flow through. The seawater-associated permeate W21 is water having permeated through the RO membrane. Connected to the seawater-associated permeate line L21B are the seawater-associated salt concentration measurement line L23 and the seawater-associated permeate discharging line L24 in this order from the upstream side. A seawater-associated valve 210 is disposed at the end on the downstream side of the seawater-associated permeate line L21B. The seawater-associated permeate line L21B is connected via the seawater-associated valve 210 to the second seawater-associated reverse osmosis membrane processing means 30 and supplies the seawater-associated permeate W21 to the second seawater-associated reverse osmosis membrane processing means 30.

[0060]

The seawater-associated valve 210 is a solenoid valve or a motor-operated valve controlled by a control means 100B. The seawater-associated valve 210 supplies the seawater-associated permeate W21 to the second seawater-associated reverse osmosis membrane processing means 30 if the salt concentration of the seawater-associated permeate W21 does not satisfy criteria for allowing the seawater-associated permeate W21 to flow to the supplying system, and supplies the seawater-associated permeate W21 to the supplying system if the salt concentration of the seawater-associated permeate W21 satisfies the criteria for allowing the seawater-associated permeate W21 to flow to the supplying system.

[0061]

The second seawater-associated reverse osmosis membrane processing means 30 includes a seawater-associated permeate supply line L30, a second seawater-associated reverse osmosis membrane module 32, a pressure pump 33, a seawater-associated re-permeate line L31, and the seawater-associated re-concentrate line L32.

The seawater-associated permeate supply line L30 supplies the seawater-associated permeate W21 from the seawater-associated reverse osmosis membrane processing means 20B.

The second seawater-associated reverse osmosis membrane module 32 is connected to the seawater-associated permeate supply line L30 and subjects the seawater-associated permeate W21 to further membrane separation treatment for generating a seawater-associated re-permeate W31 and a seawater-associated re-concentrate W32.

The pressure pump 33 is disposed upstream from the second seawater-associated reverse osmosis membrane module 32 on the seawater-associated permeate supply line L30.

The seawater-associated re-permeate line L31 is connected to the second seawater-associated reverse osmosis membrane module 32.

The seawater-associated re-concentrate line L32 is connected to the second seawater-associated reverse osmosis membrane module 32.

[0062]

The seawater-associated permeate supply line L30 extends from the seawater-associated valve 210 of the seawater-associated reverse osmosis membrane processing means 20B to the second seawater-associated reverse osmosis membrane module 32. The seawater-associated permeate supply line L30 introduces the seawater-associated permeate W21 into the second seawater-associated reverse osmosis membrane module 32.

[0063]

The second seawater-associated reverse osmosis membrane module 32 is connected to the end on the downstream side of the seawater-associated permeate supply line L30.

The second seawater-associated reverse osmosis membrane module 32 subjects the seawater-associated permeate W21 to membrane separation treatment using the reverse osmosis membrane for generating the seawater-associated re-permeate W31 and the seawater-associated re-concentrate W32 when the seawater-associated permeate W21 has a salt concentration exceeding a predetermined reference value.

The second seawater-associated reverse osmosis membrane module 32 includes a single or a plurality of RO membrane elements (not shown) for removing dissolved salts from the water.

The RO membrane element has a membrane having a desalination rate that is determined to be proper based on the quantity and the salt concentration of the seawater-associated permeate W21 supplied to the second seawater-associated reverse osmosis membrane processing means 30, and the preset quantity and the preset salt concentration of the seawater-associated re-permeate W31 to be generated by the second seawater-associated reverse osmosis membrane processing means 30.

The pressure pump 33 is disposed on the seawater-associated permeate supply line L30 and pressurizes the seawater-associated permeate W21 to supply the seawater-associated permeate W21 to the second seawater-associated reverse osmosis membrane module 32.

[0064]

The seawater-associated re-permeate line L31 and the seawater-associated re-concentrate line L32 are connected to the downstream side of the second seawater-associated reverse osmosis membrane module 32. The seawater-associated

re-permeate line L31 is a line for the seawater-associated re-permeate W31 to flow through to be supplied to the supplying system (not shown). The seawater-associated re-permeate W31 is water having permeated through the RO membrane. The seawater-associated re-concentrate line L32 is a line for the seawater-associated re-concentrate W32 to flow through. The seawater-associated re-concentrate W32 is water having not permeated through the RO membrane. The seawater-associated re-concentrate line L32 is connected to the seawater-associated reverse osmosis membrane processing means 20B and supplies the seawater-associated re-concentrate W32 to the seawater-associated reverse osmosis membrane processing means 20B.

[0065]

The control means 100B is connected electrically to components of the seawater desalination system 1B that the control means 100B controls. More specifically, the control means 100B controls the pressure pump 13, the pressure pump 23, the pressure pump 33, the seawater-associated valve 210, and the seawater-associated permeate discharging valve 240 according to the salt concentration of the seawater-associated permeate W21 measured by the seawater-associated permeate EC meter 230.

[0066]

Now, the operations of the seawater desalination system 1B will be described.

The operations of the seawater desalination system 1B before the generation of the sewage-associated permeate W11 and the seawater-associated permeate W21 are the same as those of the seawater desalination system 1A according to the First Embodiment, and descriptions thereof are omitted.

[0067]

The seawater-associated permeate EC meter 230 measures the salt concentration of the seawater-associated permeate W21 supplied to the seawater-associated permeate line L21B and the measured salt concentration is transmitted to the control means 100B.

The control means 100B carries out the following processing in the continuation determination step.

The control means 100B controls to open the seawater-associated permeate discharging valve 240 and close the seawater-associated valve 210 if the salt

concentration of the seawater-associated permeate W21 transmitted from the seawater-associated permeate EC meter 230 satisfies criteria for allowing the flow of the seawater-associated permeate W21 to the supplying system (not shown).

With this control, the seawater-associated permeate W21 is supplied to the supplying system.

[0068]

The control means 100B, in a second seawater-associated reverse osmosis membrane processing step, controls to open the seawater-associated valve 210, drive the pressure pump 33 and drive the second seawater-associated reverse osmosis membrane processing means 30 if the salt concentration of the seawater-associated permeate W21 transmitted from the seawater-associated permeate EC meter 230 does not satisfy the criteria for allowing the seawater-associated permeate W21 to flow to the supplying system.

With this control, the seawater-associated permeate W21 is supplied to the second seawater-associated reverse osmosis membrane processing means 30.

The supplied seawater-associated permeate W21 is introduced into the second seawater-associated reverse osmosis membrane module 32. In the second seawater-associated reverse osmosis membrane module 32, the seawater-associated permeate W21 is subjected to membrane separation treatment to generate the seawater-associated re-permeate W31 and the seawater-associated re-concentrate W32. The seawater-associated re-permeate W31 is supplied to the supplying system. Since the seawater-associated re-concentrate W32 has a lower salt concentration than the seawater-associated concentrate W22, the seawater-associated re-concentrate W32 is not discharged to the outside of the seawater desalination system 1B but is returned to the seawater-associated reverse osmosis membrane processing means 20B.

[0069]

The seawater desalination system 1B according to the Second Embodiment has the following effects.

For example, when the quantity of the sewage W10 is lowered to cause a reduction in the quantities of the sewage-associated permeate W11 and the sewage-associated concentrate W12 generated by the sewage-associated reverse osmosis membrane processing means 10B, leading to an increase in the salt

concentration of the seawater-associated permeate W21, the second seawater-associated reverse osmosis membrane processing means 30 can be used to subject the seawater-associated permeate W21 to membrane separation treatment to enable the supply of the seawater-associated permeate W21 that has a salt concentration not exceeding the predetermined reference value.

[0070]

<Third Embodiment>

Now, Third Embodiment according to the present invention will be described. In the following description of the Third Embodiment, the descriptions of the First Embodiment apply unless specifically mentioned and only the differences of the Third Embodiment from the First Embodiment will be described, and like components are referred to by like numerals and detailed description thereof will be omitted.

[0071]

With reference to FIG. 3, there will be described a seawater desalination system 1C according to the Third Embodiment of the present invention. FIG. 3 is a schematic view showing the configuration of the seawater desalination system 1C according to the Third Embodiment of the present invention.

The seawater desalination system 1C according to the Third Embodiment differs from the seawater desalination system 1A according to the First Embodiment in the configurations of the sewage-associated permeate line of the sewage-associated reverse osmosis membrane processing means, the seawater-associated permeate line of the seawater-associated reverse osmosis membrane processing means, and the control means. Further, the seawater desalination system 1C according to the Third Embodiment includes a reserving system 40 that is absent in the seawater desalination system 1A according to the First Embodiment.

[0072]

The sewage-associated reverse osmosis membrane processing means 10C has a sewage-associated permeate line L11C connected to the downstream side of the sewage-associated reverse osmosis membrane module 12. The sewage-associated permeate line L11C is a line for the sewage-associated permeate W11 to flow through. The sewage-associated permeate W11 is water having permeated through the RO membrane. Connected to the sewage-associated permeate line L11C are a

sewage-associated salt concentration measuring line L13 and the reserving system 40 in this order from the upstream side for supplying the sewage-associated permeate W11 to the reserving system 40.

The sewage-associated salt concentration measuring line L13 branches from the sewage-associated permeate line L11C at a salt concentration measuring line branch point J13. The sewage-associated salt concentration measuring line L13 is a line for the sewage-associated permeate W11 to flow through. The sewage-associated salt concentration measuring line L13 is connected to a sewage-associated permeate EC meter 130 serving as a second salt concentration measuring means.

The sewage-associated permeate EC meter 130, in a second salt concentration measuring step, measures the conductivity of the sewage-associated permeate W11 flowing through the sewage-associated salt concentration measuring line L13 and converts the measured conductivity into salt concentration. The sewage-associated permeate EC meter 130 is connected to a control means 100C and the measured conductivity or calculated salt concentration of the sewage-associated permeate W11 is transmitted to the control means 100C.

[0073]

A seawater-associated reverse osmosis membrane processing means 20C has a seawater-associated permeate line L21C connected to the downstream side of the seawater-associated reverse osmosis membrane module 22. The seawater-associated permeate line L21C is a line for the seawater-associated permeate W21 to flow through. The seawater-associated permeate W21 is water having permeated through the RO membrane. Connected to the seawater-associated permeate line L21C are the seawater-associated salt concentration measurement line L23 and the reserving system 40 in this order from the upstream side for supplying the seawater-associated permeate W21 to the reserving system 40.

The seawater-associated salt concentration measurement line L23 branches from the seawater-associated permeate line L21C at the salt concentration measuring line branch point J23. The seawater-associated salt concentration measurement line L23 is a line for the seawater-associated permeate W21 to flow through. The seawater-associated salt concentration measurement line L23 is connected to the

seawater-associated permeate EC meter 230 serving as a third salt concentration measuring means.

The seawater-associated permeate EC meter 230, in a third salt concentration measuring step, measures the conductivity of the seawater-associated permeate W21 flowing through the seawater-associated salt concentration measurement line L23 and converts the measured conductivity into salt concentration. The seawater-associated permeate EC meter 230 is connected to a control means 100C and the measured conductivity or calculated salt concentration of the seawater-associated permeate W21 is transmitted to the control means 100C.

[0074]

The reserving system 40 includes a tank 41, a tank discharging line L41, a water level gauge 42, a tank salt concentration measuring line L43, and a tank EC meter 430 serving a first salt concentration measuring means. The tank 41 is connected to the sewage-associated permeate line L11C of the sewage-associated reverse osmosis membrane processing means 10C and to the seawater-associated permeate line L21C of the seawater-associated reverse osmosis membrane processing means 20C. The tank discharging line L41 is connected to the tank 41. The water level gauge 42 measures the water level in the tank 41. The tank salt concentration measuring line L43 is connected to the tank 41. The tank EC meter 430 is connected to the tank salt concentration measuring line L43.

[0075]

The tank 41 reserves a permeate mixture W40 of the sewage-associated permeate W11 supplied from the sewage-associated reverse osmosis membrane processing means 10C and the seawater-associated permeate W21 supplied from the seawater-associated reverse osmosis membrane processing means 20C.

The tank discharging line L41 is connected to the bottom of the tank 41 and supplies the permeate mixture W40 to the supplying system (not shown).

The water level gauge 42 measures the water level of the permeate mixture W40 reserved in the tank 41. The water level gauge 42 is connected to the control means 100C and the measured water level of the permeate mixture W40 is transmitted to the control means 100C. The water level gauge 42 includes a pressure sensor disposed at the bottom of the tank 41 for detecting the water pressure. The water level

gauge 42 is embodied as a pressure-type water level gauge for measuring the water level based on changes in water pressure, but is not limited to it and may be an optical water level gauge or an ultrasonic water level gauge.

[0076]

The tank salt concentration measuring line L43 extends to the vicinity of the bottom of the tank 41. The tank salt concentration measuring line L43 is a line for the permeate mixture W40 to flow through. The tank salt concentration measuring line L43 is connected to the tank EC meter 430.

The tank EC meter 430, in a first salt concentration measuring step, measures the conductivity of the permeate mixture W40 flowing through the tank salt concentration measuring line L43 and converts the measured conductivity into salt concentration. The tank EC meter 430 is connected to the control means 100C and the measured conductivity or the salt concentration of the permeate mixture W40 obtained by the conversion is transmitted to the control means 100C.

[0077]

The control means 100C is connected to components of the seawater desalination system 1C that the control means 100C controls. More specifically, the control means 100C controls the pressure pump 13 or the pressure pump 23 according to the water level of the permeate mixture W40 measured by the water level gauge 42, the salt concentration of the sewage-associated permeate W11 measured by the sewage-associated permeate EC meter 130, the salt concentration of the seawater-associated permeate W21 measured by the seawater-associated permeate EC meter 230, or the salt concentration of the permeate mixture W40 measured by the tank EC meter 430.

[0078]

Now, the operations of the seawater desalination system 1C will be described.

The operations of the seawater desalination system 1C before the generation of the sewage-associated permeate W11 and the seawater-associated permeate W21 are similar to those of the seawater desalination system 1A according to the First Embodiment, and descriptions thereof are omitted.

The sewage-associated permeate W11 generated by the sewage-associated reverse osmosis membrane processing means 10C and the seawater-associated permeate

W21 generated by the seawater-associated reverse osmosis membrane processing means 20C are mixed to make the resulting permeate mixture W40, which is reserved in the tank 41 of the reserving system 40. The permeate mixture W40 reserved in the tank 41 is discharged through the tank discharging line L41 to the supplying system. If the sum of the quantities of the sewage-associated permeate W11 generated and the seawater-associated permeate W21 generated (the quantity of the permeate mixture W40 generated) is greater than the quantity of the permeate mixture W40 discharged, the permeate mixture W40 is reserved in the tank 41.

The water level gauge 42 measures the water level of the permeate mixture W40 reserved in the tank 41 and the measured water level is transmitted to the control means 100C.

[0079]

The control means 100C carries out the following processing in a determining step.

The control means 100C controls to stop the pressure pump 23 and stop the operation of the seawater-associated reverse osmosis membrane processing means 20C if the water level of the permeate mixture W40 transmitted from the water level gauge 42 reaches a predetermined seawater-associated reverse osmosis membrane processing means stopping water level.

With this control, the seawater desalination system 1C is brought into a state in which only the sewage-associated reverse osmosis membrane processing means 10C is operated, and the tank 41 is supplied only with the sewage-associated permeate W11.

[0080]

Then, for example, if the quantity of the sewage-associated permeate W11 generated (the quantity of the permeate mixture W40 generated) becomes smaller than the quantity of the permeate mixture W40 discharged, the water level of the permeate mixture W40 in the tank 41 lowers.

The control means 100C starts the pressure pump 23 to activate the seawater-associated reverse osmosis membrane processing means 20C if the water level of the permeate mixture W40 transmitted from the water level gauge 42 reaches a predetermined seawater-associated reverse osmosis membrane processing means activating water level. It should be noted that the predetermined seawater-associated

reverse osmosis membrane processing means activating water level is set at a lower position than the predetermined seawater-associated reverse osmosis membrane processing means stopping water level.

With this control, the seawater desalination system 1C is brought back again into a state in which the sewage-associated reverse osmosis membrane processing means 10C and the seawater-associated reverse osmosis membrane processing means 20C are operated, and the tank 41 is supplied with the sewage-associated permeate W11 and the seawater-associated permeate W21.

[0081]

On the other hand, for example, if the quantity of the sewage-associated permeate W11 generated (the quantity of the permeate mixture W40 generated) is greater than the quantity of the permeate mixture W40 discharged, the water level of the permeate mixture W40 in the tank 41 further rises.

The control means 100C controls to stop the pressure pump 13 and the pressure pump 23 and stop the operation of the sewage-associated reverse osmosis membrane processing means 10C and the seawater-associated reverse osmosis membrane processing means 20C if the water level of the permeate mixture W40 transmitted from the water level gauge 42 reaches a predetermined all reverse osmosis membrane processing means stopping water level. It should be noted that the all reverse osmosis membrane processing means stopping water level is set at a higher position than the predetermined seawater-associated reverse osmosis membrane processing means stopping water level.

With this control, the seawater desalination system 1C is brought into a complete suspension state in which the sewage-associated reverse osmosis membrane processing means 10C and the seawater-associated reverse osmosis membrane processing means 20C are both stopped, and the permeate mixture W40 is prevented from overflowing the tank 41. The control means 100C controls to resume the driving of the pressure pump 13 and activate the sewage-associated reverse osmosis membrane processing means 10C if in the complete suspension state, the water level of the permeate mixture W40 transmitted from the water level gauge 42 lowers to reach the predetermined seawater-associated reverse osmosis membrane processing means stopping water level.

[0082]

Further, the control means 100C controls to stop the pressure pump 23 and stop the seawater-associated reverse osmosis membrane processing means 20C if any one of the salt concentration of the sewage-associated permeate W11 measured by the sewage-associated permeate EC meter 130, the salt concentration of the seawater-associated permeate W21 measured by the seawater-associated permeate EC meter 230, and the salt concentration of the permeate mixture W40 measured by the tank EC meter 430 does not satisfy the criteria for allowing the seawater-associated permeate W21 to flow to the supplying system.

With this control, the seawater desalination system 1C is brought into the state in which only the sewage-associated reverse osmosis membrane processing means 10C is operated, and the tank 41 is supplied with only the sewage-associated permeate W11.

[0083]

The seawater desalination system 1C according to the Third Embodiment has the following effects.

Since in seawater-associated reverse osmosis membrane processing means 20C, the water mixture of the sewage-associated concentrate W12 having a lower salt concentration than seawater and the seawater W20 is subjected to membrane separation treatment to generate the seawater-associated permeate W21 as the fresh water, the energy required to generate the fresh water is reduced when compared to the case where the seawater W20 that has a higher salt concentration than the water mixture is subjected to membrane separation treatment to generate fresh water.

Since the seawater-associated reverse osmosis membrane processing means 20C is activated or stopped according to the water level in the tank 41 of the permeate mixture W40 of the sewage-associated permeate W11 and the seawater-associated permeate W21 as the generated fresh water, the seawater-associated reverse osmosis membrane processing means 20C that requires more energy than the sewage-associated reverse osmosis membrane processing means 10C can be stopped, for example if the generated sewage-associated permeate W11 is sufficient in quantity to ensure the desired quantity of the generated fresh water.

Accordingly, there is provided a seawater desalination system 1C that enables a reduction in the energy required for generating fresh water and that ensures the desired quantity of the generated fresh water.

[0084]

Further, since the seawater-associated reverse osmosis membrane processing means 20C is activated or stopped according to the salt concentration of the seawater-associated permeate W21, the salt concentration of the sewage-associated permeate W11, and the salt concentration of the permeate mixture W40, for example if either one of the salt concentration of the sewage-associated permeate W11 and the salt concentration of the permeate mixture W40 is higher than a predetermined reference value, the seawater-associated reverse osmosis membrane processing means 20C can be stopped to bring the salt concentration of the permeate mixture W40 back to the predetermined reference value.

Accordingly, there is provided a seawater desalination system 1C that enables a reduction in the energy required for generating fresh water and that ensures the quality of the generated fresh water.

[0085]

While the present invention has been described in its preferred embodiments, obviously various modifications and variations may be made without departing from the spirit and the scope of the invention as hereinafter claimed.

DESCRIPTION OF REFERENCE NUMERALS

[0086]

1A, 1B, 1C seawater desalination system

10A, 10B, 10C sewage-associated reverse osmosis membrane processing means

20A, 20B, 20C seawater-associated reverse osmosis membrane processing means

100A, 100B, 100C control means

230 seawater-associated permeate EC meter

W10 sewage

W11 sewage-associated permeate

W12 sewage-associated concentrate

W20 seawater

W21 seawater-associated permeate

W22 seawater-associated concentrate

CLAIMS

1. A seawater desalination system comprising:

a sewage-associated reverse osmosis membrane processing means that subjects sewage to membrane separation treatment for generating sewage-associated permeate and sewage-associated concentrate; and

a seawater-associated reverse osmosis membrane processing means that subjects a water mixture of the sewage-associated concentrate and collected seawater to membrane separation treatment for generating seawater-associated permeate and seawater-associated concentrate and that has a salt concentration measuring means for measuring the salt concentration of the generated seawater-associated permeate,

wherein the generated seawater-associated permeate is supplied to the sewage-associated reverse osmosis membrane processing means if the salt concentration of the seawater-associated permeate measured by the salt concentration measuring means does not meet a predetermined reference value therefor.

2. A seawater desalination system comprising:

a sewage-associated reverse osmosis membrane processing means that subjects sewage to membrane separation treatment for generating sewage-associated permeate and sewage-associated concentrate;

the system further comprising:

a seawater-associated reverse osmosis membrane processing means that pressurizes a water mixture of the sewage-associated concentrate and collected seawater using a pressure pump and subjects the pressurized water mixture to membrane separation treatment for generating seawater-associated permeate and seawater-associated concentrate wherein the seawater-associated reverse osmosis membrane processing means has a salt concentration measuring means for measuring the salt concentration of the generated seawater-associated permeate; and

a control means that slows down the operation of the pressure pump of the seawater-associated reverse osmosis membrane processing means if the salt concentration of the seawater-associated permeate measured by the salt concentration measuring means does not meet a predetermined reference value therefor,

wherein the control means controls to supply the seawater-associated permeate to the sewage-associated reverse osmosis membrane processing means according to the salt concentration of the seawater-associated permeate measured by the salt concentration measuring means, and

the sewage-associated reverse osmosis membrane processing means subjects a water mixture of sewage and the seawater-associated permeate supplied from the seawater-associated reverse osmosis membrane processing means to membrane separation treatment.

3. The seawater desalination system of Claim 2 further comprising a second seawater-associated reverse osmosis membrane processing means that subjects the seawater-associated permeate to membrane separation treatment,

wherein the control means supplies the seawater-associated permeate to the second seawater-associated reverse osmosis membrane processing means according to the salt concentration of the seawater-associated permeate measured by the salt concentration measuring means.

4. The seawater desalination system of Claim 2 or 3 wherein the seawater-associated reverse osmosis membrane processing means includes a reverse osmosis membrane having a desalination rate predetermined based on:

the quantity and the salt concentration of the sewage supplied to the sewage-associated reverse osmosis membrane processing means;

the quantity and the salt concentration of the seawater supplied to the seawater-associated reverse osmosis membrane processing means; and

a preset quantity and a preset salt concentration of the seawater-associated permeate to be generated by the seawater-associated reverse osmosis membrane processing means.

5. A seawater desalination method comprising:

a sewage-associated reverse osmosis membrane processing step of subjecting sewage to membrane separation treatment for generating sewage-associated permeate and sewage-associated concentrate;

a seawater-associated reverse osmosis membrane processing step of subjecting a water mixture of the sewage-associated concentrate and collected seawater to membrane separation treatment for generating seawater-associated permeate and seawater-associated concentrate;

a salt concentration measuring step of measuring the salt concentration of the seawater-associated permeate; and

a seawater-associated permeate recycling step of returning the seawater-associated permeate to the sewage-associated reverse osmosis membrane processing step according to the salt concentration of the seawater-associated permeate.

6. A seawater desalination method comprising:

a sewage-associated reverse osmosis membrane processing step of subjecting sewage to membrane separation treatment for generating sewage-associated permeate and sewage-associated concentrate;

a seawater-associated reverse osmosis membrane processing step of pressurizing a water mixture of the sewage-associated concentrate and collected seawater using a pressure pump and subjecting the pressurized water mixture to membrane separation treatment for generating seawater-associated permeate and seawater-associated concentrate;

a salt concentration measuring step of measuring the salt concentration of the seawater-associated permeate;

a continuation determination step of stopping continuation of the operation of the pressure pump in the seawater-associated reverse osmosis membrane processing step if the salt concentration of the seawater-associated permeate does not meet a predetermined reference value therefor; and

a seawater-associated permeate recycling step of returning the seawater-associated permeate to the sewage-associated reverse osmosis membrane processing step according to the salt concentration of the seawater-associated permeate measured in the salt concentration measuring step,

wherein the sewage-associated reverse osmosis membrane processing step is a step of subjecting a water mixture of sewage and the seawater-associated permeate

returned in the seawater-associated permeate recycling step to membrane separation treatment.

7. The seawater desalination method of Claim 6 further comprising a second seawater-associated reverse osmosis membrane processing step of subjecting the seawater-associated permeate to membrane separation treatment,

wherein in the second seawater-associated reverse osmosis membrane processing step, the seawater-associated permeate is treated according to the salt concentration of the seawater-associated permeate measured in the salt concentration measuring step.