WATER TREATMENT SYSTEM, APPARATUS, WATER TREATMENT METHOD, AND MEASURING METHOD

BACKGROUND

1. TECHNICAL FIELD

[0001] The present disclosure relates to a water treatment system, an apparatus, a water treatment method, and a measuring method.

2. RELATED ART

[0002] Patent document 1 describes that "an agent addition mean 30 adds chloramines to any of paths (a pipe 15, a pipe 17, or the like) before it is supplied to a storage tank 20" (paragraph 0027) and "addition of chloramines is performed such that the concentration after addition is 1 to 5 ppm" (paragraph 0028). Patent document 2 describes that "an oxidation-based slime suppressing agent is intermittently added to water to be treated, and the water to be treated that contains the oxidation-based slime suppressing agent is intermittently supplied to a reverse osmosis membrane apparatus" (paragraph 0021). Patent document 3 describes that "the water treatment system 1A of the present invention further includes a biofilm amount estimation unit 12 which estimates the amount of biofilm generated in a reverse osmosis membrane module 10 and an agent addition control unit 30 controls addition of a first agent and a second agent based on the amount of biofilm estimated by the biofilm amount estimation unit 12" (paragraph 0075).

RELATED ART DOCUMENTS

Patent Documents

Patent Document 1: Patent No. 5190908

Patent Document 2: Patent No. 7248046

Patent Document 3: Patent No. 6822164

SUMMARY

[0003] (1) A first aspect of the present disclosure provides a water treatment system including: an addition apparatus which adds a fungicide to water to be treated; at least one reverse osmosis membrane which separates the water to be treated, to which the fungicide has been added, into permeated water and a concentrated water; and a measuring apparatus which measures water quality of the water to be treated at an inlet side, and at least one of the permeated water or the concentrated water at an outlet side of the at least one reverse osmosis membrane.

[0004] (2) In the water treatment system of the above-described (1), the measuring apparatus may measure the water quality that includes at least one of an amount of the fungicide, an oxidation-reduction potential, or pressure.

[0005] (3) The water treatment system of the above-described (2) may further include a calculating apparatus which calculates at least one of a difference in the amount of the fungicide, a difference in the oxidation-reduction potential, or a difference in the pressure between the water to be treated at the inlet side, and at least one of the permeated water or the concentrated water at the outlet side.

[0006] (4) The water treatment system of the above-described (3) may further include an adjusting apparatus which adjusts an addition amount of the fungicide by the addition apparatus according to a calculation result of the calculating apparatus.

[0007] (5) The water treatment systems of the above-described (1) to (4) may further include an adjusting apparatus which adjusts the addition amount of the fungicide by the addition apparatus according to a measurement result of water quality of at least one of the water to be treated at the inlet side, the permeated water at the outlet side, or the concentrated water at the outlet side of the reverse osmosis membrane.

[0008] (6) In the water treatment system of the above-described (4) or (5), the adjusting apparatus may adjust the addition amount of the fungicide to the water to be treated by the addition apparatus, according to a change in the difference in the amount of the fungicide between the water to be treated at the inlet side, and at least one of the permeated water or the concentrated water at the outlet side, measured according to variation of the addition amount of the fungicide to the water to be treated by the addition apparatus.

[0009] (7) In the water treatment system according to any of the above-described (1) to (6), the measuring apparatus may have a measuring instrument which measures water quality of water to be measured; and a switching unit which switches which of the water to be treated at the inlet side, the permeated water at the outlet side, and the concentrated water at the outlet side of the at least one reverse osmosis membrane is to be supplied to the measuring instrument.

[0010] (8) In the water treatment system of the above-described (7), the measuring apparatus may further include a buffer bath which stores the water to be measured.

[0011] (9) A second aspect of the present disclosure provides an apparatus including: a measuring instrument which measures water quality of water to be measured; and a switching unit which switches which of waters of multiple locations in a water treatment system is to be supplied to the measuring instrument.

[0012] (10) The apparatus of the above-described (9) may further include a buffer bath which stores the water to be measured.

[0013] (11) In the apparatus of the above-described (10), the buffer bath includes a plurality of inflow pipes which allow the water to be measured to flow in; a first pipe which drains water in the buffer bath; a second pipe which discharges at least one of air or water in the buffer bath; a supply pipe which supplies the water in the buffer bath to the measuring instrument; and a valve that is provided at each of the plurality of inflow pipes, the first pipe, and the second pipe, and wherein the second pipe may be provided above the plurality of inflow pipes and the first pipe.

[0014] (12) In the apparatus of the above-described (11), the switching unit may open a valve provided at an inflow pipe which allows water supplied to the measuring instrument to flow among valves each provided at the plurality of inflow pipes, and may close a valve provided at another inflow pipe.

[0015] (13) In the apparatus of the above-described (11) or (12), when the water to be measured is switched from water of a first location to water of a second location among waters of the multiple locations, the switching unit may temporarily store the water of the second location in the buffer bath and may drain the water of the second location through the first pipe.

[0016] (14) A third aspect of the present disclosure provides a water treatment method including: adding a fungicide to water to be treated; separating the water to be treated, to which the fungicide has been added, into permeated water and a concentrated water by at least one reverse osmosis membrane; and measuring water quality of the water to be treated at an inlet side, and at least one of the permeated water or the concentrated water at an outlet side of the at least one reverse osmosis membrane.

[0017] (15) A fourth aspect of the present disclosure provides a measuring method including: switching which of waters of multiple locations in a water treatment system is to be supplied to a measuring instrument; and measuring, by the measuring instrument, water quality of supplied water.

[0018] Note that, the above-described summary of the invention does not necessarily describe all features of the embodiments of the present disclosure. The present invention may also be a sub-combination of the features described above.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] Fig. 1 shows a configuration of a system 100 according to the present embodiment.

Fig. 2 shows a configuration of a calculating apparatus 180 together with a measuring instrument 172 and an adjusting apparatus 190.

Fig. 3 shows a configuration of the adjusting apparatus 190 together with a valve 110 and the calculating apparatus 180.

Fig. 4 shows a process flow of the system 100.

Fig. 5 shows an example of a computer 1200 in which a plurality of aspects of the present invention may be entirely or partially embodied.

DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0020] The present invention will be described below through embodiments of the invention, but the following embodiments do not limit the invention according to the claims. Not all combinations of features described in the embodiments are essential for the solution of the invention.

[0021] Fig. 1 shows a configuration of the system 100 according to the present embodiment. The system 100 separates water to be treated that has been subjected to a pretreatment into permeated water and a concentrated water by using a reverse osmosis membrane. In an example of the present illustration, the system 100 includes a pipe 102, a water storage tank 104, an addition apparatus 106, a pipe 108, a valve 110, a pipe 112, a meter 114, a pump 116, a pretreatment apparatus 118, a pipe 120, a water storage tank 122, a pipe 124, a pump 126, a filter 128, a pump 130, a first reverse osmosis membrane 132, a pipe 134, a pipe 136, a second reverse osmosis membrane 138, a pipe 140, a pipe 142, a valve 144, a measuring apparatus 150, a calculating apparatus 180, and an adjusting apparatus 190. In place of the example of the present illustration, the system 100 may not include a part of the configuration.

[0022] The pipe 102 is a passage which allows water to be treated to flow. The water to be treated may be wastewater, seawater, or river water. The pipe 102 may

have a fixed shape. In place of the pipe 102, a flexible tube may be used. The pipe 102 may have a constant cross-sectional area from upstream to downstream. The pipe 102 may have a circular or polygonal cross section.

[0023] The water storage tank 104 is connected to the pipe 102, and the water storage tank 104 stores the water to be treated that has flowed in from the pipe 102. The shape and material of the water storage tank 104 are not particularly limited as long as the water to be treated can be stored.

[0024] The addition apparatus 106 adds a fungicide to the water to be treated. When the addition apparatus 106 adds a fungicide, biofouling in a downstream process can be suppressed. The fungicide may be a chlorine-based agent, or may be chloramine. The addition apparatus 106 may add the fungicide housed inside itself.

[0025] The pipe 108 is connected to the water storage tank 104 and the addition apparatus 106. The pipe 108 flows a fungicide supplied from the addition apparatus 106 to the water storage tank 104, to thereby add the fungicide to the water to be treated stored in the water storage tank 104. The shape and material of the pipe 108 may be similar to those of the pipe 102.

[0026] The valve 110 is provided at the pipe 108. The valve 110 adjusts an amount of the fungicide that flows in the pipe 108.

[0027] In an example of the present illustration, the system 100 includes a plurality of addition apparatuses 106 (an addition apparatus 106-1 and an addition apparatus 106-2), a plurality of pipes 108 (a pipe 108-1 and a pipe 108-2), and a plurality of valves 110 (a valve 110-1 and a valve 110-2). The system 100 may include a same number of pipes 108 as the addition apparatuses 106 and a same number of valves 110 as the

addition apparatuses 106. The addition apparatus 106-1 and the addition apparatus 106-2 may add different kinds of fungicides or chemicals from each other. The chemical added by the addition apparatus 106-1 may react with the chemical added by the addition apparatus 106-2 to generate a fungicide. As one example, the addition apparatus 106-1 may add sodium hypochlorite and the addition apparatus 106-2 may add ammonium sulfate. In this case, sodium hypochlorite reacts with ammonium sulfate to generate chloramine. In place of this, the addition apparatus 106-1 and the addition apparatus 106-2 may add a fungicide at different concentrations from each other.

[0028] The pipe 112 is connected to the water storage tank 104. The pipe 112 is a passage which allows water to be treated, to which a fungicide has been added, to flow. The shape and material of the pipe 112 may be similar to those of the pipe 102.

[0029] The meter 114 is provided at the pipe 112. The meter 114 measures at least one of a volumetric flow rate or hydraulic pressure of the water to be treated that flows in the pipe 112.

[0030] The pump 116 is provided at the pipe 112. In an example of the present illustration, the pump 116 is provided at a downstream side from the meter 114. In place of this, the pump 116 may be provided at an upstream side from the meter 114. The pump 116 supplies the water to be treated that has flowed in to downstream equipment.

[0031] The pretreatment apparatus 118 is connected to the pipe 112. The pretreatment apparatus 118 performs a pretreatment of the water to be treated. The

pretreatment apparatus 118 may be at least one of an MF membrane or a UF membrane.

[0032] The pipe 120 is connected to the pretreatment apparatus 118. The pipe 120 is a passage which allows water to be treated after the pretreatment to flow. The shape and material of the pipe 120 may be similar to those of the pipe 102.

[0033] The water storage tank 122 is connected to the pipe 120. The water storage tank 122 stores the water to be treated that has flowed in from the pipe 120. The shape and material of the water storage tank 122 are not particularly limited as long as the water to be treated can be stored.

[0034] The pipe 124 is connected to the water storage tank 122. The pipe 124 is a passage which allows the water to be treated stored in the water storage tank 122 to flow. The shape and material of the pipe 124 may be similar to those of the pipe 102.

[0035] The pump 126 is provided at the pipe 124. The pump 126 supplies the water to be treated that has flowed in to downstream equipment.

[0036] The filter 128 is provided at the pipe 124. The filter 128 is provided downstream from the pump 126. The filter 128 may be a membrane having coarser meshes than those of the pretreatment apparatus 118. For example, the filter 128 may be a cartridge filter. The system 100 shown in the present illustration can include the filter 128, to thereby prevent foreign matter such as rust or the like generated from the pipe from flowing in to downstream equipment (the pump 130, the first reverse osmosis membrane 132, the second reverse osmosis membrane 138, or the like).

[0037] The pump 130 is provided at the pipe 124. The pump 130 is provided downstream from the filter 128. The pump 130 supplies the water to be treated that has flowed in to downstream equipment.

[0038] The first reverse osmosis membrane 132 is connected to the pipe 124. The first reverse osmosis membrane 132 separates the water to be treated, to which the fungicide has been added, into permeated water and a concentrated water. Impurities (ions, salts, or the like) are removed from the permeated water, and the concentrated water includes concentrated impurities. The permeated water may include a very small amount of impurities.

[0039] The pipe 134 is connected to the first reverse osmosis membrane 132. The pipe 134 is a passage which allows the permeated water separated by the first reverse osmosis membrane 132 to flow. The pipe 134 may supply the permeated water separated by the first reverse osmosis membrane 132 or the second reverse osmosis membrane 138 to a UV/advanced oxidation process (UV/AOP) apparatus. The shape and material of the pipe 134 may be similar to those of the pipe 102.

[0040] The pipe 136 is connected to the first reverse osmosis membrane 132. The pipe 136 is a passage which allows the concentrated water separated by the first reverse osmosis membrane 132 to flow. The shape and material of the pipe 136 may be similar to those of the pipe 102.

[0041] The second reverse osmosis membrane 138 is connected to the pipe 136. The second reverse osmosis membrane 138 separates the concentrated water separated by the first reverse osmosis membrane 132 into permeated water and a concentrated water. The second reverse osmosis membrane 138 may have a same

characteristic (area, film thickness, or the like) as the first reverse osmosis membrane 132, or may have a different characteristic. For example, the second reverse osmosis membrane 138 may have an area smaller than the first reverse osmosis membrane 132. In an example of the present illustration, the system 100 includes two reverse osmosis membranes (the first reverse osmosis membrane 132 and the second reverse osmosis membrane 138), but, in place of this, may have only one reverse osmosis membrane or 3 or more reverse osmosis membranes.

[0042] The pipe 140 is connected to the second reverse osmosis membrane 138 and the pipe 134. The pipe 140 is a passage which allows the permeated water separated by the second reverse osmosis membrane 138 to flow to the pipe 134. The shape and material of the pipe 140 may be similar to those of the pipe 102.

[0043] The pipe 142 is connected to the second reverse osmosis membrane 138. The pipe 142 discharges the concentrated water separated by the second reverse osmosis membrane 138 outside of the system 100. In place of this, the pipe 142 may supply the concentrated water separated by the second reverse osmosis membrane 138 to the water storage tank 104. The shape and material of the pipe 142 may be similar to those of the pipe 102.

[0044] The valve 144 is provided at the pipe 142. The valve 144 adjusts the amount of the concentrated water discharged outside of the system 100.

[0045] The measuring apparatus 150 measures the water quality of water in the system 100. The measuring apparatus 150 may measure the water quality of at least one of the water to be treated at the inlet side, the permeated water at the outlet side, or the concentrated water at the outlet side of at least one reverse osmosis membrane.

In an example of the present illustration, the measuring apparatus 150 has a buffer bath 152, a switching unit 170, and a measuring instrument 172.

[0046] The buffer bath 152 stores water to be measured. The buffer bath 152 may be provided almost vertically. The buffer bath 152 may be cylindrical or polyangular. The material of the buffer bath 152 is not particularly limited as long as the water to be measured can be stored. In an example of the present illustration, the buffer bath 152 includes a plurality of inflow pipes 154-1, 154-2, 154-3, 154-4, and 154-5, a first pipe 158, a second pipe 162, a supply pipe 168, and a plurality of valves (a valve 156-1, a valve 156-2, a valve 156-3, a valve 156-4, a valve 156-5, a valve 160, and a valve 164).

[0047] The plurality of inflow pipes 154-1, 154-2, 154-3, 154-4, and 154-5 are each connected to the buffer bath 152. The plurality of inflow pipes 154-1, 154-2, 154-3, 154-4, and 154-5 may be each connected on a side of the buffer bath 152. The water to be measured flows in to the plurality of inflow pipes 154-1, 154-2, 154-3, 154-4, and 154-5. In an example of the present illustration, the water to be treated at the inlet side of the first reverse osmosis membrane 132 flows in to the inflow pipe 154-1 from the measurement location P1. The concentrated water at the outlet side of the first reverse osmosis membrane 132 flows in to the inflow pipe 154-2 from the measurement location P2. The permeated water at the outlet side of the first reverse osmosis membrane 132 flows in to the inflow pipe 154-3 from the measurement location P3. The concentrated water at the outlet side of the second reverse osmosis membrane 138 flows in to the inflow pipe 154-4 from the measurement location P4. The permeated water at the outlet side of the first reverse osmosis membrane 132 and the permeated water at the outlet side of the second reverse osmosis membrane 138

flow in to the inflow pipe 154-5 from the measurement location P5. The shape and material of the plurality of inflow pipes 154-1, 154-2, 154-3, 154-4, and 154-5 may be each similar to those of the pipe 102.

[0048] The plurality of valves 156-1, 156-2, 156-3, 156-4, and 156-5 are provided at the plurality of inflow pipes 154-1, 154-2, 154-3, 154-4, and 154-5, respectively. The plurality of valves 156-1, 156-2, 156-3, 156-4, and 156-5 adjust the amount of water to be measured that flows in from the plurality of inflow pipes 154-1, 154-2, 154-3, 154-4, and 154-5, respectively.

[0049] The first pipe 158 is connected to the buffer bath 152. The first pipe 158 may be connected to the bottom surface of the buffer bath 152. The first pipe 158 drains water in the buffer bath 152. The shape and material of the first pipe 158 may be similar to those of the pipe 102. The valve 160 is provided at the first pipe 158. The valve 160 adjusts the amount of water drained from the buffer bath 152.

[0050] The second pipe 162 is connected to the buffer bath 152. The second pipe 162 discharges at least one of air or water in the buffer bath 152. The second pipe 162 may cause air to flow in into the buffer bath 152. The second pipe 162 may be provided on a side of the buffer bath 152. The shape and material of the second pipe 162 may be similar to those of the pipe 102. The second pipe 162 may be provided above the plurality of inflow pipes 154-1, 154-2, 154-3, 154-4, and 154-5, and the first pipe 158. By providing the second pipe 162 above the plurality of inflow pipes, when water to be measured flows in to the buffer bath 152 from any of the plurality of inflow pipes, air in the buffer bath 152 is discharged, and therefore pressure in the buffer bath 152 can be kept constant. By providing the second pipe 162 above the first pipe 158,

when water in the buffer bath 152 is drained from the first pipe 158, air is allowed to flow in the buffer bath 152, and therefore pressure in the buffer bath 152 can be kept constant.

[0051] The valve 164 is provided at the second pipe 162. The valve 164 adjusts the amount of air passing through the second pipe 162.

[0052] The supply pipe 168 is connected to the buffer bath 152. The supply pipe 168 may be connected to the upper surface of the buffer bath 152. The supply pipe 168 supplies the water in the buffer bath 152 to the measuring instrument 172. The supply pipe 168 may be provided above the second pipe 162. The shape and material of the supply pipe 168 may be similar to those of the pipe 102.

[0053] The switching unit 170 is connected to the plurality of valves 156-1, 156-2, 156-3, 156-4, and 156-5. The switching unit 170 may be further connected to the valve 160 and the valve 164. The switching unit 170 switches which of waters of the multiple locations in the water treatment system is to be supplied to the measuring instrument 172 by controlling a valve to switch between the waters that flow in to the buffer bath 152. The switching unit 170 may switch which of water to be treated at the inlet side, permeated water at the outlet side, and concentrated water at the outlet side of at least one reverse osmosis membrane is to be supplied to the measuring instrument 172.

[0054] The measuring instrument 172 is connected to the supply pipe 168. The measuring instrument 172 measures the water quality of water to be measured. The measuring instrument 172 includes one or more flow cells 174, one or more sensors 176, and a pipe 178.

[0055] The flow cell 174 is connected to the supply pipe 168. The flow cell 174 is a passage through which the water to be measured, which flows in from the supply pipe 168, flows. The sensor 176 measures the water quality of the water that flows in the flow cell 174. The sensor 176 may be in direct contact with water. The sensor 176 may be at least one of a chlorine densitometer, an oxidation-reduction potential (ORP) sensor, a hydraulic pressure gauge, or a pH sensor. A number of the sensors 176 may correspond to a number of the flow cells 174. Accordingly, the sensor 176 may be provided at each of the flow cells 174 one by one. In this case, each of the plurality of sensors 176 may be a different kind of sensor.

[0056] The pipe 178 is connected to the flow cell 174. The pipe 178 may be connected to the flow cell 174 positioned at the most downstream side among the plurality of flow cells 174. The pipe 178 discharges water after measurement outside of the system 100. The shape and material of the pipe 178 may be similar to those of the pipe 102.

[0057] Since the measuring apparatus 150 as described above can measure water at a plurality of measurement locations using one measuring instrument 172, cost can be reduced.

[0058] Fig. 2 shows a configuration of the calculating apparatus 180 together with the measuring instrument 172 and the adjusting apparatus 190. The calculating apparatus 180 and the adjusting apparatus 190 may be a computer such as a personal computer (PC), a tablet computer, a smartphone, a workstation, a server computer, a general purpose computer, or the like, or may be a computer system to which a plurality of computers are connected. Such a computer system is also a computer in a

broad sense. In addition, the calculating apparatus 180 and the adjusting apparatus 190 may be implemented by one or more executable virtual computer environments in a computer. In place of this, the calculating apparatus 180 and the adjusting apparatus 190 may be a dedicated computer designed for the system 100, or may be dedicated hardware achieved by dedicated circuitry. The calculating apparatus 180 calculates a difference in the water quality at the multiple locations in the system 100 based on a measurement result of the measuring apparatus 150. The calculating apparatus 180 has a first acquisition unit 210, a calculation unit 220, and an output unit 230.

[0059] The first acquisition unit 210 is connected to the measuring instrument 172. The first acquisition unit 210 acquires a measurement result by the measuring instrument 172. The first acquisition unit 210 may have receive circuitry which receives measurement data from the measuring instrument 172, and may have an AD converter which samples an analog measurement value output by each sensor 176 in the measuring instrument 172 and converts it to digital.

[0060] The calculation unit 220 is connected to the first acquisition unit 210. The calculation unit 220 calculates a difference in the water quality at the multiple locations in the system 100 based on a measurement result acquired by the first acquisition unit 210.

[0061] The output unit 230 is connected to the calculation unit 220 and the adjusting apparatus 190. The output unit 230 may transmit the calculation result by the calculation unit 220 to the adjusting apparatus 190. The output unit 230 may perform a process which displays the calculation result by the calculation unit 220 on a

screen or the like of an output apparatus. Here, performing a process which displays the calculation result on a screen or the like is not particularly limited to actually displaying a screen on a display apparatus, and also includes generating a display datum in order to display a screen on a remote display apparatus.

[0062] Fig. 3 shows a configuration of the adjusting apparatus 190 together with the valve 110 and the calculating apparatus 180. The adjusting apparatus 190 adjusts the addition amount of the fungicide based on a calculation result of the calculating apparatus 180. The adjusting apparatus 190 has a second acquisition unit 310 and an adjustment unit 320.

[0063] The second acquisition unit 310 is connected to the calculating apparatus 180. The second acquisition unit 310 may be connected to the output unit 230 of the calculating apparatus 180. The second acquisition unit 310 acquires a calculation result by the calculating apparatus 180. The second acquisition unit 310 may have receive circuitry which receives measurement data from the calculating apparatus 180. In place of the present illustration, the second acquisition unit 310 may be connected to the measuring instrument 172.

[0064] The adjustment unit 320 is connected to the second acquisition unit 310 and the valve 110. The adjustment unit 320 may adjust the addition amount of the fungicide by the addition apparatus 106, by controlling opening and closing of the valve 110 based on the calculation result acquired by the second acquisition unit 310. The adjustment unit 320 may adjust the addition amount of the fungicide by controlling a degree of the opening and closing of the valve 110. In place of this, when the system 100 includes a plurality of addition apparatuses 106 which include fungicides having

different concentrations from each other, the amount of the fungicide added may be adjusted by switching the valve 110 and changing the addition apparatus 106 which adds the fungicide. The adjustment unit 320 may remove biofouling adhering to the reverse osmosis membrane by temporarily increasing the addition amount of the fungicide. The adjustment unit 320 may remove biofouling adhering to the reverse osmosis membrane by decreasing the pressure applied to the reverse osmosis membrane and keeping such a state that water does not pass through reverse osmosis membrane.

[0065] Fig. 4 shows a process flow of the system 100. The system 100 starts the flow of the present illustration according to the water to be treated being stored in the water storage tank 104. In step 410 (S410), the addition apparatus 106 adds a fungicide to water to be treated in the water storage tank 104 via the pipe 108.

[0066] In S420, the switching unit 170 drains water in the buffer bath 152. The switching unit 170 may drain water in the buffer bath 152 by opening the valve 160 provided at the first pipe 158 and the valve 164 provided at the second pipe 162 and closing the valves (valves 156-1, 156-2, 156-3, 156-4, and 156-5 in Fig. 1) provided at the plurality of inflow pipes, respectively.

[0067] In S430, the switching unit 170 opens a valve provided at an inflow pipe which allows water supplied to the measuring instrument 172 to flow among valves each provided at the plurality of inflow pipes, and closes a valve provided at another inflow pipe. For example, when water at the measurement location P1 is supplied to the flow cell 174, the switching unit 170 opens the valve 156-1 provided at the inflow pipe 154-1 which allows the water at the measurement location P1 to flow, and closes

valves 156-2, 156-3, 156-4, and 156-5 provided at other inflow pipes 154-2, 154-3, 154-4, and 154-5, respectively. The switching unit 170 may close the valve 160 provided at the first pipe 158 in order to store water in the buffer bath 152. When the water is stored in the buffer bath 152, the switching unit 170 may open the valve 164 provided at the second pipe 162. Since the supply pipe 168 is provided above the second pipe 162, water, in which impurities (for example, water that has flowed in from another inflow pipe in the past) are contained, remaining inside the buffer bath 152 can be discharged from the second pipe 162 by opening the valve 164 by the switching unit 170. Thereby, the switching unit 170 can prevent impurities from entraining in the supply pipe 168 and the measuring instrument 172.

[0068] In S440, when the water to be measured is switched from water of a first location to water of a second location among waters of the multiple locations, the switching unit 170 temporarily stores the water of the second location in the buffer bath 152 and drains the water of the second location through the first pipe 158. The switching unit 170 may drain the water of the second location stored in the buffer bath 152 by opening the valve 160 provided at the first pipe 158. This process can prevent impurities from entraining in water supplied to the measuring instrument 172. According to the water of the second location stored in the buffer bath 152 being drained, the switching unit 170 closes the valve 160 provided at the first pipe 158 and stores the water of the second location again. The switching unit 170 supplies water to be measured to the measuring instrument 172 via the supply pipe 168 by closing the valve 164 provided at the second pipe 162.

[0069] In S450, the measuring instrument 172 measures the water quality of the water to be measured. When the switching unit 170 switches water to be measured from the water of the first location to the water of the second location among waters of the multiple locations, the measuring instrument 172 may measure the water quality of water after constant time passes from when the water of the second location begins to flow in via the supply pipe 168. This can prevent the water of the first location remaining inside the measuring instrument 172 from affecting a measurement result of the water of the second location. The measuring instrument 172 of the measuring apparatus 150 may measure the water quality that includes at least one of an amount of the fungicide, an oxidation-reduction potential, or pressure. When the sensor 176 is a chlorine densitometer, the measuring instrument 172 may calculate the amount of the fungicide based on a chlorine concentration measured by the sensor 176. The measuring instrument 172 may calculate the amount of the fungicide by dividing the chlorine concentration measured by the sensor 176 by a number of chlorine atoms in one molecule of a component contained in the fungicide. When the sensor 176 is an ORP sensor, the measuring instrument 172 may measure an oxidation-reduction potential. Since the oxidation-reduction potential is associated with the oxidizing power (chlorine concentration), the measuring instrument 172 can estimate the amount of the fungicide in water to be measured by measuring an oxidation-reduction potential. When the sensor 176 is a hydraulic pressure gauge, the measuring instrument 172 may measure pressure. When the amount of the fungicide in the water to be treated is small and biofouling is generated, the reverse osmosis membrane is clogged to thereby change the pressure. Therefore, the measuring instrument 172 can estimate the amount of the fungicide in the water to be

measured and whether the water to be measured sufficiently includes the fungicide by measuring the pressure.

[0070] In S460, the switching unit 170 determines whether the measuring instrument 172 measures all water to be measured. When the measuring instrument 172 of the measuring apparatus 150 measures the water quality of the water to be treated at the inlet side, and at least one of the permeated water or the concentrated water at the outlet side of at least one reverse osmosis membrane, the switching unit 170 may determine that the measuring instrument 172 has measured all water to be measured. In place of this, when the measuring instrument 172 measures the water quality of waters of all measurement locations in the system 100, the switching unit 170 may determine that the measuring instrument 172 has measured all water to be measured. In place of these, when the measuring instrument 172 measures the water quality of water to be treated at the inlet side of the reverse osmosis membrane existing the most upstream (the water at the measurement location P1 in Fig. 1) and the permeated water existing the most downstream (the water at the measurement location P5 in Fig. 1), the switching unit 170 may determine that the measuring instrument 172 has measured all water to be measured. When the measuring instrument 172 determines all water to be measured is not measured (No in S460), the system 100 returns the process to S420.

[0071] When the measuring instrument 172 determines all water to be measured is measured (Yes in S460), the system 100 causes the process to proceed to S470. In S470, the calculating apparatus 180 calculates at least one of a difference in the amount of the fungicide, a difference in the oxidation-reduction potential, or a

difference in the pressure at a plurality of measurement locations. The calculating apparatus 180 may calculate at least one of a difference in the amount of the fungicide, a difference in the oxidation-reduction potential, or a difference in the pressure between the water to be treated at the inlet side, and at least one of the permeated water or the concentrated water at the outlet side in at least one reverse osmosis membrane. Here, the “difference” may be a difference between at two measurement locations at particular time, or may be an integrated value of a difference between at two measurement locations at a predetermine time. The calculating apparatus 180 may calculate a change with time in the difference in the amount of the fungicide, the difference in the oxidation-reduction potential, and the difference in the pressure. The calculating apparatus 180 may acquire the water quality of another measurement location or the like in the system 100 measured by another apparatus (a measuring instrument such as the meter 114 or the like, Supervisory Control And Data Acquisition (SCADA) provided in a facility in which the system 100 is placed, or the like), in addition to the water quality at the measurement location measured by the measuring apparatus 150. The calculating apparatus 180 may calculate the difference in the amount of the fungicide, the difference in the oxidation-reduction potential, and the difference in the pressure between at other measurement locations in the system 100, or between at a measurement location measured by the measuring apparatus 150 and at another measurement location in the system 100. The calculating apparatus 180 may calculate an attenuation amount of the fungicide in at least one reverse osmosis membrane based on a calculated difference. The calculating apparatus 180 may consider the difference in the amount of the fungicide in the water to be treated at the inlet side, and at least one of the permeated water or the concentrated water at the

outlet side of one reverse osmosis membrane as an attenuation amount of the fungicide in the reverse osmosis membrane.

[0072] In S480, the adjusting apparatus 190 adjusts the addition amount of the fungicide to the water to be treated by the addition apparatus 106. The adjusting apparatus 190 may adjust the addition amount of the fungicide by the addition apparatus 106 according to a calculation result of the calculating apparatus 180. When the adjusting apparatus 190 has the functionality as described above, the system 100 can efficiently suppress biofouling. In addition, when an UV/AOP apparatus is provided downstream of the system 100, it can prevent a large amount of the fungicide from being input in the UV/AOP apparatus. After the addition amount of the fungicide by the addition apparatus 106 is changed, the adjusting apparatus 190 may keep the addition amount of the fungicide at the changed value. In place of this, the adjusting apparatus 190 may return the addition amount of the fungicide to the original value following a constant time after the addition amount of the fungicide by the addition apparatus 106 is changed. The adjusting apparatus 190 may adjust the addition amount of the fungicide based on a relationship between a difference in the water quality (the amount of the fungicide, the oxidation-reduction potential, the pressure, or the like) calculated by the calculating apparatus 180, and a predetermine threshold or a calculation result in the past. The adjusting apparatus 190 may decrease the addition amount of the fungicide when a difference in the amount of the fungicide calculated by the calculating apparatus 180 is larger than a predetermine threshold or a calculation result in the past. The adjusting apparatus 190 may increase the addition amount of the fungicide when a difference in the amount of the fungicide calculated by the calculating apparatus 180 is smaller than a predetermine

threshold or a calculation result in the past. When the difference in the amount of the fungicide in one reverse osmosis membrane calculated by the calculating apparatus 180 is within a predetermine threshold but a difference in the amount of the fungicide in another reverse osmosis membrane exceeds the predetermine threshold, the adjusting apparatus 190 may increase the addition amount of the fungicide.

[0073] In place of this, the adjusting apparatus 190 may adjust the addition amount of the fungicide by the addition apparatus according to a measurement result of the water quality of at least one of water to be treated at the inlet side, the permeated water at the outlet side, or the concentrated water at the outlet side of the reverse osmosis membrane. When the adjusting apparatus 190 has the functionality as described above, the system 100 can efficiently suppress biofouling. In addition, when an UV/AOP apparatus is provided downstream of the system 100, it can prevent a large amount of the fungicide from being input in the UV/AOP apparatus. The adjusting apparatus 190 may adjust the addition amount of the fungicide based on a relationship between a measurement result of the water quality of either the water to be treated at the inlet side, the permeated water at the outlet side, or the concentrated water at the outlet side of the reverse osmosis membrane, and a predetermine threshold or a calculation result in the past. When the amount of the fungicide or the oxidation-reduction potential in the permeated water or the concentrated water at the outlet side is larger than a predetermine threshold or a calculation result in the past, the fungicide is excessively added, and therefore the adjusting apparatus 190 may decrease the addition amount of the fungicide. When the pressure of either the water to be treated at the inlet side, the permeated water at the outlet side, or the concentrated water at the outlet side of the reverse osmosis

membrane is larger than a predetermine threshold or a calculation result in the past, there is a high possibility that biofouling is generated, and therefore the adjusting apparatus 190 may increase the addition amount of the fungicide. In place of this, the adjusting apparatus 190 may temporarily increase an input amount of the fungicide every time a constant time passes.

[0074] In S410 that has returned from S480, the addition apparatus 106 may add an additive having an amount adjusted by the adjusting apparatus 190 to the water to be treated. In S470 after the above-described S420 to S460 have been executed, the calculating apparatus 180 calculates a difference in the amount of the fungicide in the water to be treated at the inlet side, and at least one of the permeated water or the concentrated water at the outlet side. In S480, the adjusting apparatus 190 may adjust the addition amount of the fungicide relative to the water to be treated by the addition apparatus 106, according to a change in the difference in the amount of the fungicide in the water to be treated at the inlet side, and at least one of the permeated water or the concentrated water at the outlet side, measured according to variation of the addition amount of the fungicide relative to the water to be treated by the addition apparatus 106. When the adjusting apparatus 190 has the functionality as described above, the addition apparatus 106 can add a suitable amount of the fungicide. The adjusting apparatus 190 may decrease the addition amount of the fungicide when a difference in the amount of the fungicide calculated by the calculating apparatus 180 after the variation of the addition amount is larger than a value before the variation of the addition amount. The adjusting apparatus 190 may increase the addition amount of the fungicide when a difference in the amount of the fungicide calculated by the

calculating apparatus 180 after the variation of the addition amount is smaller than a value before the variation of the addition amount.

[0075] The system 100 described above can estimate an attenuation amount of the fungicide in the reverse osmosis membrane by measuring the water quality of the water to be treated at the inlet side, and at least one of the permeated water or the concentrated water at the outlet side of at least one reverse osmosis membrane.

[0076] Various embodiments of the present invention may be described with reference to flowcharts and block diagrams, where blocks may represent (1) stages of processes in which operations are executed or (2) sections of apparatuses responsible for executing operations. Certain stages and sections may be implemented by a dedicated circuit, a programmable circuit supplied together with computer-readable instructions stored on computer-readable media, and/or processors supplied together with computer-readable instructions stored on computer-readable media. The dedicated circuit may include digital and/or analog hardware circuits, and may include integrated circuits (IC) and/or discrete circuits. The programmable circuit may include a reconfigurable hardware circuit including logical AND, logical OR, logical XOR, logical NAND, logical NOR, and other logical operations, a memory element or the like such as a flip-flop, a register, a field programmable gate array (FPGA) and a programmable logic array (PLA), or the like.

[0077] A computer-readable medium may include any tangible device that can store instructions to be executed by a suitable device, and as a result, the computer-readable medium having instructions stored thereon includes a product including instructions that can be executed in order to create means for executing operations specified in the

flowcharts or block diagrams. Examples of the computer-readable medium may include an electronic storage medium, a magnetic storage medium, an optical storage medium, an electromagnetic storage medium, a semiconductor storage medium, and so on. More specific examples of the computer readable medium may include a FLOPPY (registered trademark) disk, a diskette, a hard disk, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or flash memory), an electrically erasable programmable read-only memory (EEPROM), a static random access memory (SRAM), a compact disc read-only memory (CD-ROM), a digital versatile disc (DVD), a BLU-RAY (registered trademark) disk, a memory stick, an integrated circuit card, or the like.

[0078] The computer-readable instruction may include: an assembler instruction, an instruction-set-architecture (ISA) instruction; a machine instruction; a machine dependent instruction; a microcode; a firmware instruction; state-setting data; or either a source code or an object code described in any combination of one or more programming languages, including an object oriented programming language such as SMALLTALK (registered trademark), JAVA (registered trademark), C++, or the like, and a conventional procedural programming language such as a "C" programming language or a similar programming language.

[0079] The computer-readable instruction may be provided for a processor or programmable circuitry of a programmable data processing apparatus, such as a computer, locally or via a local area network (LAN), a wide area network (WAN) such as the Internet, or the like to execute the computer-readable instruction in order to create means for executing the operations specified in the flowcharts or block diagrams.

Here, the computer may be a personal computer, or PC, a tablet computer, a smartphone, a workstation, a server computer, a general purpose computer, a special purpose computer, or the like, or may be a computer system to which a plurality of computers are connected. Such computer system to which the plurality of computers are connected is also referred to as a distributed computing system, and is a computer in a broad sense. In a distributed computing system, a plurality of computers collectively execute a program by each of the plurality of computers executing a portion of the program, and passing data during the execution of the program among the computers as needed.

[0080] Examples of the processor include a computer processor, a central processing unit (CPU), a processing unit, a microprocessor, a digital signal processor, a controller, a microcontroller, and so on. The computer may include one processor or a plurality of processors. In a multi-processor system including a plurality of processors, the plurality of processors collectively execute a program by each of the processors executing a portion of the program, and passing data during the execution of the program among the processors as needed. For example, in execution of multiple tasks, each of the plurality of processors may execute a portion of each task pieces by pieces by performing task-switching for each time slice. In this case, which portion of one program each processor is responsible for executing dynamically changes. Moreover, which portion of the program each of the plurality of processor is responsible for executing may be determined statically by multiprocessor-aware programming.

[0081] Fig. 5 shows an example of a computer 1200 in which a plurality of aspects of the present invention may be entirely or partially embodied. A program that is installed in the computer 1200 may cause the computer 1200 to function as operations associated with an apparatus according to the embodiment of the present invention or one or more sections in the apparatus, or may cause the computer 1200 to execute the operation or the one or more sections, and/or may cause the computer 1200 to execute processes according to the embodiment of the present invention or stages of the processes. Such a program may be executed by a CPU 1212 in order to cause the computer 1200 to execute particular operations associated with some or all of the blocks of flowcharts and block diagrams described herein.

[0082] The computer 1200 according to the present embodiment includes a CPU 1212, a RAM 1214, a graphics controller 1216, and a display device 1218, which are mutually connected by a host controller 1210. The computer 1200 also includes a communication interface 1222, a storage device 1224 such as a hard disk drive, input/output units such as a DVD-ROM drive 1226 and an IC card drive, which are connected to the host controller 1210 via an input/output controller 1220. The computer also includes legacy input/output units such as an ROM 1230 and a keyboard 1242, which are connected to the input/output controller 1220 via an input/output chip 1240.

[0083] The CPU 1212 operates according to programs stored in the ROM 1230 and the RAM 1214, thereby controlling each unit. The graphics controller 1216 acquires image data generated by the CPU 1212 on a frame buffer or the like provided in the

RAM 1214 or in itself, and causes the image data to be displayed on a display device 1218.

[0084] The communication interface 1222 communicates with other electronic devices via a network. The storage device 1224 stores a program and data used by the CPU 1212 in the computer 1200. The DVD-ROM drive 1226 reads a program or data from a DVD-ROM 1227 and provides the program or data to the storage device 1224 via the RAM 1214. The IC card drive reads the programs and the data from the IC card, and/or writes the programs and the data to the IC card.

[0085] The ROM 1230 stores therein a boot program or the like that is executed by the computer 1200 at the time of activation, and/or a program which depends on the hardware of the computer 1200. The input/output chip 1240 may also connect various input/output units to the input/output controller 1220 via a parallel port, a serial port, a keyboard port, a mouse port, or the like.

[0086] Programs are provided by a computer-readable medium such as the DVD-ROM 1227 or the IC card. The programs are read from the computer-readable medium, are installed in the storage device 1224, the RAM 1214, or the ROM 1230, which are also an example of the computer-readable medium, and are executed by the CPU 1212. Information processing written in these programs is read by the computer 1200, and provides cooperation between the programs and the various types of hardware resources described above. An apparatus or method may be constructed by realizing the operation or processing of information according to the use of the computer 1200.

[0087] For example, when communication is executed between the computer 1200 and an external device, the CPU 1212 may execute a communication program loaded

onto the RAM 1214 to instruct communication processing to the communication interface 1222, based on the processing described in the communication program. Under the control of the CPU 1212, the communication interface 1222 reads transmission data stored in a transmission buffer processing region provided in a recording medium such as the RAM 1214, the storage device 1224, the DVD-ROM 1227, or the IC card, transmits the read transmission data to the network, or writes reception data received from the network in a reception buffer processing region or the like provided on the recording medium.

[0088] In addition, the CPU 1212 may cause the RAM 1214 to read all or a necessary portion of a file or database stored in an external recording medium such as the storage device 1224, the DVD-ROM drive 1226, or the DVD-ROM 1227, the IC card, or the like, and may execute various types of processes on data on the RAM 1214. The CPU 1212 may then write back the processed data to the external recording medium.

[0089] Various types of information such as various types of programs, data, tables, and databases may be stored in a recording medium and subjected to information processing. The CPU 1212 may execute various types of processing on the data read from the RAM 1214, which includes various types of operations, information processing, conditional judging, conditional branch, unconditional branch, search/replace of information, or the like, as described throughout this disclosure and designated by an instruction sequence of programs, and writes the result back to the RAM 1214. In addition, the CPU 1212 may search for information in a file, a database, or the like in the recording medium. For example, when a plurality of entries, each having an attribute value of a first attribute associated with an attribute value of a

second attribute, are stored in the recording medium, the CPU 1212 may retrieve, out of the plurality of entries, an entry with the attribute value of the first attribute specified that meets a condition, read the attribute value of the second attribute stored in said entry, and thereby acquiring the attribute value of the second attribute associated with the first attribute satisfying a predetermined condition.

[0090] The above-described program or software module may be stored in the computer-readable medium on the computer 1200 or near the computer 1200. In addition, a recording medium such as a hard disk or a RAM provided in a server system connected to a dedicated communication network or the Internet may be used as the computer-readable medium, thereby providing the program to the computer 1200 via the network.

[0091] While the present invention has been described above by way of the embodiments, the technical scope of the present invention is not limited to the scope described in the above-described embodiments. It is apparent to persons skilled in the art that various alterations or improvements can be added to the above-described embodiments. It is also apparent from the scope of the claims that the embodiments added with such alterations or improvements can be included in the technical scope of the invention.

[0092] It should be noted that the execution order of each process in operations, procedures, steps, stages, and so on of an apparatus, system, program, and method shown in the scope of claims, specification, and diagrams can be achieved in any order as long as the order is not particularly indicated by "prior to," "before," or the like and as long as the output from a previous process is not used in a later process. Even if

the operation flow is described by using phrases such as "first" or "next" for the sake of convenience in the claims, specification, and drawings, it does not necessarily mean that the process must be performed in this order.

EXPLANATION OF REFERENCES

[0093] 100: system; 102: pipe; 104: water storage tank; 106, 106-1, 106-2: addition apparatus; 108, 108-1, 108-2: pipe; 110: valve; 112: pipe; 114: meter; 116: pump; 118: pretreatment apparatus; 120: pipe; 122: water storage tank; 124: pipe; 126: pump; 128: filter; 130: pump; 132: first reverse osmosis membrane; 134: pipe 136: pipe; 138: second reverse osmosis membrane; 140: pipe 142: pipe; 144: valve; 150: measuring apparatus; 152: buffer bath; P1, P2, P3, P4, P5: measurement location; 154-1, 154-2, 154-3, 154-4, 154-5: inflow pipe; 156-1, 156-2, 156-3, 156-4, 156-5: valve; 158: first pipe; 160: valve; 162: second pipe; 164: valve; 168: supply pipe; 170: switching unit; 172: measuring instrument; 174: flow cell; 176: sensor; 178: pipe; 180: calculating apparatus; 190: adjusting apparatus; 210: first acquisition unit; 220: calculation unit; 230: output unit; 310: second acquisition unit; 320: adjustment unit; 1200: computer; 1210: host controller; 1212: CPU; 1214: RAM; 1216: graphics controller; 1218: display device; 1220: input/output controller; 1222: communication interface; 1224: storage device; 1226: DVD-ROM drive; 1227: DVD-ROM; 1230: ROM; 1240: input/output chip; 1242: keyboard.

WHAT IS CLAIMED IS:

1. A water treatment system comprising:

an addition apparatus which adds a fungicide to water to be treated;

at least one reverse osmosis membrane which separates the water to be treated, to which the fungicide has been added, into permeated water and a concentrated water; and

a measuring apparatus which measures water quality of the water to be treated at an inlet side, and at least one of the permeated water or the concentrated water at an outlet side of the at least one reverse osmosis membrane.

2. The water treatment system according to claim 1, wherein the measuring apparatus measures the water quality that includes at least one of an amount of the fungicide, an oxidation-reduction potential, or pressure.

3. The water treatment system according to claim 2, further comprising a calculating apparatus which calculates at least one of a difference in the amount of the fungicide, a difference in the oxidation-reduction potential, or a difference in the pressure between the water to be treated at the inlet side, and at least one of the permeated water or the concentrated water at the outlet side.

4. The water treatment system according to claim 3, further comprising an adjusting apparatus which adjusts an addition amount of the fungicide by the addition apparatus according to a calculation result of the calculating apparatus.

5. The water treatment system according to any one of claims 1 to 4, further comprising an adjusting apparatus which adjusts the addition amount of the fungicide by the addition apparatus according to a measurement result of water quality of at least one of the water to be treated at the inlet side, the permeated water at the outlet side, or the concentrated water at the outlet side of the reverse osmosis membrane.

6. The water treatment system according to claim 4 or 5, wherein the adjusting apparatus adjusts the addition amount of the fungicide to the water to be treated by the addition apparatus, according to a change in the difference in the amount of the fungicide between the water to be treated at the inlet side, and at least one of the permeated water or the concentrated water at the outlet side, measured according to variation of the addition amount of the fungicide to the water to be treated by the addition apparatus.

7. The water treatment system according to any one of claims 1 to 6,

the measuring apparatus comprises:

a measuring instrument which measures water quality of water to be measured; and

a switching unit which switches which of the water to be treated at the inlet side, the permeated water at the outlet side, and the concentrated water at the outlet side of the at least one reverse osmosis membrane is to be supplied to the measuring instrument.

8. The water treatment system according to claim 7, wherein the measuring apparatus further comprises a buffer bath which stores the water to be measured.

9. An apparatus comprising:

a measuring instrument which measures water quality of water to be measured; and

a switching unit which switches which of waters of multiple locations in a water treatment system is to be supplied to the measuring instrument.

10. The apparatus according to claim 9, further comprising a buffer bath which stores the water to be measured.

11. The apparatus according to claim 10, wherein the buffer bath comprises:

a plurality of inflow pipes which allow the water to be measured to flow in;

a first pipe which drains water in the buffer bath;

a second pipe which discharges at least one of air or water in the buffer bath;

a supply pipe which supplies the water in the buffer bath to the measuring instrument; and

a valve that is provided at each of the plurality of inflow pipes, the first pipe, and the second pipe, and

wherein the second pipe is provided above the plurality of inflow pipes and the first pipe.

12. The apparatus according to claim 11, the switching unit opens a valve provided at an inflow pipe which allows water supplied to the measuring instrument to flow among valves each provided at the plurality of inflow pipes, and closes a valve provided at another inflow pipe.

13. The apparatus according to claim 11 or 12, wherein when the water to be measured is switched from water of a first location to water of a second location among waters of the multiple locations, the switching unit temporarily stores the water of the second location in the buffer bath and drains the water of the second location through the first pipe.

14. A water treatment method comprising:

adding a fungicide to water to be treated;

separating the water to be treated, to which the fungicide has been added, into permeated water and a concentrated water by at least one reverse osmosis membrane; and

measuring water quality of the water to be treated at an inlet side, and at least one of the permeated water or the concentrated water at an outlet side of the at least one reverse osmosis membrane.

15. A measuring method comprising:

switching which of waters of multiple locations in a water treatment system is to be supplied to a measuring instrument; and

measuring, by the measuring instrument, water quality of supplied water.